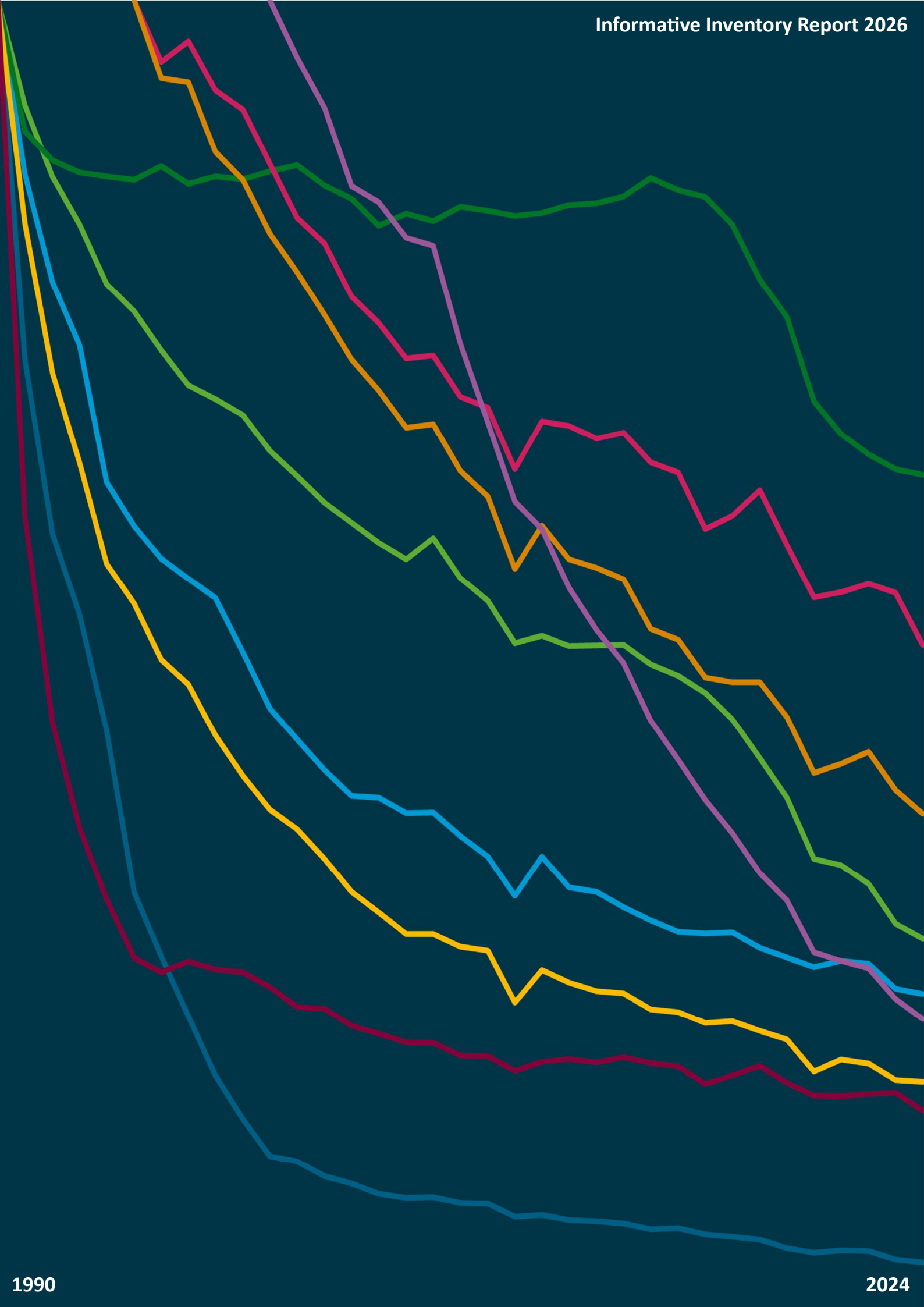




Welcome to Germany's

# Informative Inventory Report 2026

## (IIR 2026)

This report covers the preparation, maintenance, and improvement of the German air pollutant emission inventory.

Emission estimates are provided for the **timeseries from 1990 to 2024**, with exceptions for **fine particulate matter** with aerodynamic diameters of  $\leq 2.5$  (PM<sub>2.5</sub>) or  $\leq 10\mu\text{m}$  (PM<sub>10</sub>) respectively with data as of **1995**, and black carbon (BC) with data as of **2000**.

For faster navigation please refer to the [TABLE OF CONTENTS](#).



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A PDF version of this report is available for download [here](#).

Furthermore, additional information regarding both the current and previous submissions as well as links to our interactive data interface can be found under "[Downloads & Links](#)".



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# EXECUTIVE SUMMARY

## About this report

The Informative Inventory Report (IIR) is providing complementary information to Germany's air pollution inventories under the Geneva Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE/CLRTAP) as well as the EU's National Emission Ceiling Directive (NECD).

Germany's air pollution inventory includes emission data in consistent time-series ranging from 1990 (1995 for PM<sub>10</sub>, PM<sub>2.5</sub> and 2000 for Black Carbon) to the latest reported year for all 26 air pollutants or groups of air pollutants (NO<sub>x</sub>, NMVOC, PCDD/PCDF) considered under UNECE reporting.

This report provides a comprehensive analysis of the inventory data, descriptions of the methods applied, data sources, and carried out QA/QC procedures. It follows the outline established by the latest guidelines for estimating and reporting of emission data and all data presented in this report were compiled according to those same guidelines.

However, this report does *not* provide a comprehensive discussion on air pollution or the measures and politics dealing with it. Such information is included in the published national programs for further emission reductions, e.g. under the NEC directive or the trend and projection reports for green-house gases. Instead, it provides a detailed insight on the process of air pollution and emission inventory preparation. The focus lies on the methods and assumptions used for the German emission reporting and to underpin the “technical” review of the emission data as reported under the CLRTAP convention and its protocol.

## Air pollution trends in Germany

Air pollution in Germany declined significantly over the last few decades. As the figure below illustrates, emissions decreased sharply for most pollutants monitored in the time from 1990 onwards.

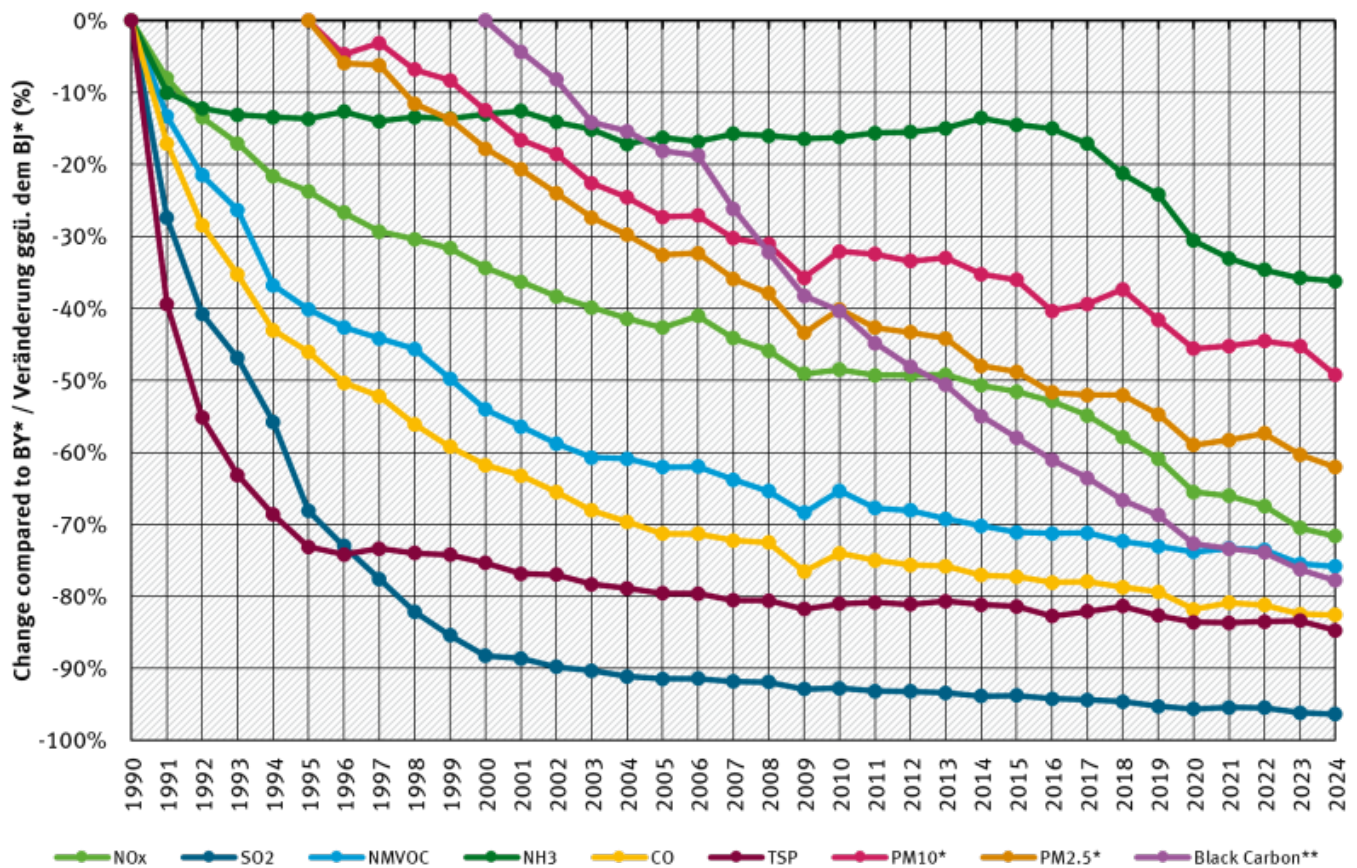
Especially in the 1990s, big improvements have been achieved due to the re-organisation of the former East German economy after the re-unification and the measures applied to German industry. One basic reason is the fuel switch in the former eastern part of Germany, i.e. the replacement of lignite by gaseous and liquid fuels.

A decrease of emissions is seen for all pollutants, though progress varies: Sulphur dioxide and TSP (total suspended particles), for example, saw a rapid decline in the early 1990s while the decrease of other pollutant's emissions developed more or less linear. Values for particulate matter are measured and calculated since 1995 and reveal a slow though steady improvement.



## Air Pollutants / Luftschadstoffe

### Emission Trends / Emissionstrends



\* Base Year (BY) 1990, 1995 for PM10/PM2.5 / Basisjahr (BJ) 1990, 1995 für Feinstaub

\*\* Black Carbon emissions from 2000 / Black Carbon Emissionen erst ab 2000

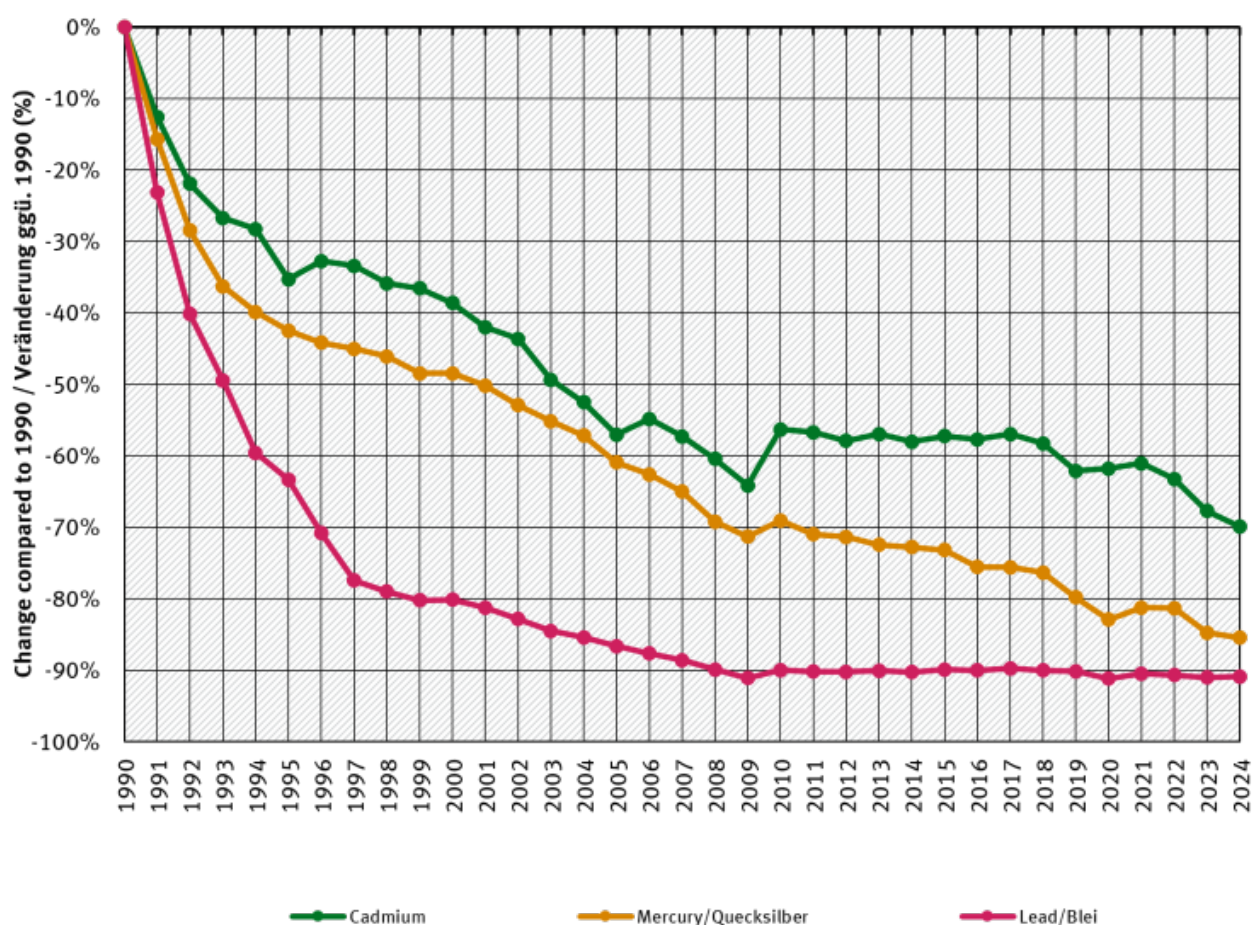
Quelle: German Emission Inventory (04.02.2026)

Nevertheless, the above figure also illustrates that for certain pollutants (namely ammonia, sulphur dioxide, and total suspended particles) only moderate progress can be observed since 2000. This particularly holds true for the development of ammonia, where recent years saw steady or even increasing emissions.

For heavy metal and POP (Persistent Organic Pollutants) emissions, the picture is far more heterogeneous: While the release of these substances generally declined, some trends appear to be less favourable. Generally, data completeness and inventory compatibility remains an issue for these pollutants. For the three priority heavy metals cadmium, mercury, and lead, however, very significant reductions have been achieved in the 1990s (see figure below).

## Heavy Metals / Schwermetalle

### Emission Trends / Emissionstrends



Quelle: German Emission Inventory (04.02.2026)

All trends are analysed and explained in detail in the [Chapter 2 - Explanation of Key Trends](#).

## Major improvements compared to last submission

For more details, please refer to chapters [9.1 - Recalculations](#) and [9.2 - Improvements](#).

## Completeness

With respect to all major air pollutants, the German inventory is generally considered complete. In contrast, for heavy metals and persistent organic pollutants there are still quite a few missing bits and pieces.

For more information, refer to chapter [1.8 General Assessment of Completeness](#).

Completeness of the German inventory can also be assessed by referring to the data submission. All cells marked “NE” (not estimated) within the NFR tables do indicate missing information.

## Priorities for further improvement

For an overview on major improvements introduced with the current submission or planned for future submissions please refer to [Chapter 9.2 - Improvements](#).

Most notably, Germany will seek to improve the completeness of the report, in particular regarding heavy metals and persistent organic pollutants. Moreover, we will continue to provide a comprehensive and up-to-date IIR.

## Structure of this report

This report does not provide a comprehensive discussion on air pollution or the measures and politics dealing with it. This type of information is included in the published national programs for further emission reductions, e.g. under the NEC directive or the trend and projection reports for green-house gases. Instead, it provides a detailed insight on the process of air pollution and emission inventory preparation. The focus lies on the methods and assumptions used for the German emission reporting. The report is intended to underpin the “technical” review of the emission data as reported under the CLRTAP convention and its protocol.

Thus, the [outline of this report](#) follows the recommendations of the CLRTAP emission reporting guidelines.

## **CHAPTER 1: Introduction to the German emission reporting & air pollutants emissions inventory**

The following pages provide an overview on the fundamental inventory work, its backgrounds and basic tasks.

### **1.1 National Inventory Background**

Why we do what we do: The CLRTAP convention and its protocols, Germany's reduction obligations, ...

### **1.2 Institutional Arrangements**

The necessary institutional framework: Inventory preparation, responsibilities of the Single National Entity, ...

### **1.3 Inventory Preparation Process**

How we do it: The process of inventory preparation.

### **1.4 Methods and Data Sources**

Where we get our data from: Main data sources, national statistics, models, plant specific data, ...

### **1.5 Key Categories**

Main emission sources and interesting trends.

### **1.6 QA/QC and Verification methods**

Assuring a high quality inventory: The German Quality System for Emission Inventories.

### **1.7 General Uncertainty Evaluation**

The quality of numbers: specific and over-all uncertainty assessment.

### **1.8 General Assessment of Completeness**

Mind the gap: necessary efforts to achieve the “complete” inventory.

# Chapter 1.1 - National Inventory Background

## Air pollution and the Convention on Long-range Transboundary Air Pollution

Starting in the late 18th century, the industrial revolution caused an ever-growing need for energy and resources. As a result, pollution of the atmosphere, going alongside with threats to environment and health, became a highly visible, undeniable problem waiting to be solved.

As one answer to this situation, the [Convention on Long-Range Transboundary Air Pollution](#) (also: Convention on Air Pollution, CLRTAP) was opened for signature in November 1979 and came into effect about 3 years later in March 1983.

By now, the Convention - identifying the Executive Secretary of the United Nations Economic Commission for Europe (UNECE) as its secretariat - has 51 parties and addresses some of the major environmental problems of the UNECE region through scientific collaboration and policy negotiation and, during the years, has been extended by eight protocols that identify specific measures to be taken by Parties to reduce their emissions of air pollutants.

Aim of the Convention is that parties shall endeavour to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution. Parties develop policies and strategies to combat the discharge of air pollutants through exchanges of information, consultation, research, and monitoring.

Annually, the Parties meet at sessions of the Executive Body to review ongoing work and plan future activities including a work plan for the coming year. The three main subsidiary bodies - the Working Group on Effects, the Steering Body to EMEP and the Working Group on Strategies and Review - as well as the Convention's Implementation Committee, report to the Executive Body each year.

Currently, the Convention's priority activities include review and possible revision of its most recent protocols, implementation of the Convention and its protocols across the entire UNECE region (with special focus on Eastern Europe, the Caucasus and Central Asia and South-East Europe) and sharing its knowledge and information with other regions of the world.

## Germany and the convention protocols

As mentioned above, the Convention on Long-Range Transboundary Air Pollution has, by now, been extended by eight protocols on the reduction of several pollutants such as Sulphur, Nitrogen Oxides or Volatile Organic Compounds. Germany, as a member of the CLRTAP, has signed each additional protocol.

| <b>The Geneva Convention...</b>                                                                                                                                                     | <b>opened / put into force</b> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| <a href="#">Geneva Convention on Long-Range Transboundary Air Pollution, CLRTAP</a>                                                                                                 | 1979 / 1983                    |
| <b>...and its Protocols</b>                                                                                                                                                         |                                |
| <a href="#">Geneva Protocol on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP)</a> | 1984 / 1988                    |
| <a href="#">Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent</a>                                                       | 1985 / 1987                    |
| <a href="#">Sofia Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes</a>                                                                              | 1988 / 1991                    |
| <a href="#">Geneva Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes</a>                                                     | 1991 / 1997                    |
| <a href="#">Oslo Protocol on Further Reduction of Sulphur Emissions</a>                                                                                                             | 1994 / 1999                    |
| <a href="#">Aarhus Protocol on Heavy Metals</a>                                                                                                                                     | 1998 / 2003                    |
| <a href="#">Aarhus Protocol on Persistent Organic Pollutants (POPs)</a>                                                                                                             | 1998 / 2003                    |
| <a href="#">Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone</a>                                                                                   | 1999 / 2005                    |

Today, the last three protocols are the most relevant. All three of them have been updated to foster further reductions of air pollution towards the new milestones in 2020 and 2030.



## Reduction obligations and reporting

Reporting of emission data to the executive body of the Convention on Long-Range Transboundary Air Pollution (CLRTAP) is required in order to fulfil obligations of the protocols under the convention. Parties are required to submit annual national emissions of SO<sub>2</sub>, NO<sub>x</sub>, NMVOC, CO and NH<sub>3</sub>, particulate matter, various heavy metals and persistent organic pollutants (POPs) using the “Guidelines for Estimating and Reporting Emission Data” under the Convention. This process is underlined by activities to review the submitted information by independent experts.

The report at hand contains information on Germany's inventories for all years from 1990 to the latest reporting year including descriptions of methods, data sources, QA/QC activities carried out and a trend analysis. The inventory accounts for anthropogenic emissions of SO<sub>2</sub>, NO<sub>x</sub>, NH<sub>3</sub>, NMVOC, CO, TSP (Total Suspended Particulate matter), PM<sub>10</sub> (particles of size <10µm), PM<sub>2.5</sub> (<2.5µm), BC (Black Carbon), Pb, Cd, Hg, As, Cr, Cu, Ni, Se and Zn, PAH and dioxins. Emission estimates are mainly based on official German statistics, e.g. energy statistics, agricultural statistics and environmental reports from industry. The emission factors used are both nationally developed factors as well as internationally recommended ones. For details please refer to the sector-specific sections.

Germany uses the [EMEP/EEA Air Pollutant Emission Inventory Guidebook](#) for reporting to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and to the Economic Commission for Europe (UNECE). The methodologies used are to some extent also in accordance with the [2006 IPCC Guidelines for National Greenhouse Gas Inventories](#) (IPCC Guidelines) and, in general, in line with [Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories IPCC-NGGIP](#) (IPCC Good Practice Guidance).

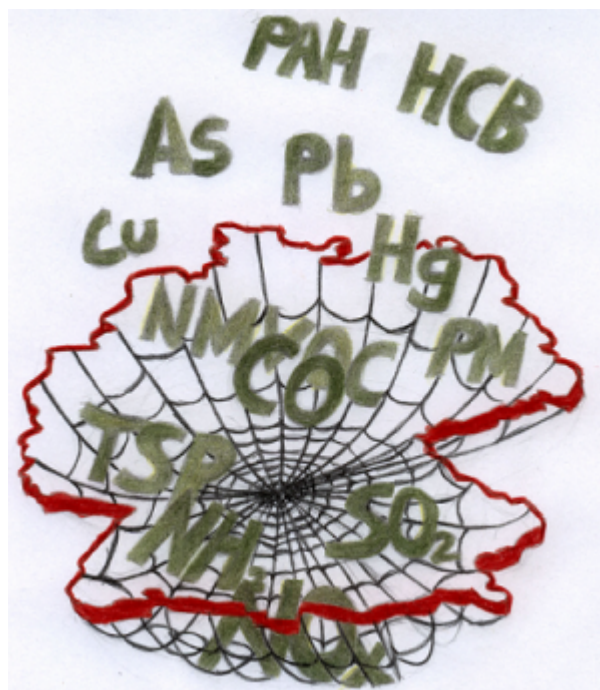
Besides its CLRTAP obligation and as an EU member state, Germany also has to report the full data set and this inventory report under the updated National Emissions Ceilings Directive (EU/2016/2284). Both submissions are fully aligned in format, timing and content. There are no differences when comparing the submissions presented under the CLRTAP convention, the EU's NEC directive and the UNFCCC other than the minor and expected incompatibilities in the reporting of emissions from mobile sources (aviation and marine shipping).

## National territory emissions

All of Germany's emissions occur inside the [EMEP grid domain](#). This excludes international aviation and maritime navigation as shown in [methodical issues](#) and laid out by the CLRTAP guidelines. There is only one offshore island (Helgoland) where all emission relevant activities are included in the national statistics used for the emission estimation. Thus, all numbers for national totals given are considered to be “real totals”.

## Chapter 1.2 - Institutional Arrangements

### Inventory preparation and responsibilities



Article 5.1 of the UNFCCC/Kyoto Protocol mandates the establishment of a National System for preparation of greenhouse-gas emissions inventories. The National System for Germany fulfils the requirements of the revised UNFCCC Reporting Guidelines on National Inventory Arrangements (UNFCCC Decision 24/CP.19), requirements which are binding under the Kyoto Protocol (according to UNFCCC Decision 19/CMP.1) and the European Greenhouse gas Monitoring Mechanism Regulation (525/2013). The German emission inventory as submitted to the Geneva LRTAP Convention is prepared in the very same institutional framework, by the same actors and processes.

The National System provides for the preparation of inventories conforming to the principles of transparency, consistency, comparability, completeness and accuracy. Such conformance is achieved through extensive use of the methodological regulations from the CLRTAP Guidelines and the EMEP/EEA air pollution guidebook, through ongoing quality management and through continuous inventory improvement.

The National System in Germany has been essentially institutionalized at three levels, at the ministerial level, at the level of the German Environmental Agency and the level outside the federal government. At the ministerial level, the system is leaded by the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU) through an agreement of the Secretaries of the ministries involved as policy paper “National System for Emissions Reporting” established from 05.06.2007, extended in December 2014. With the incorporation of the Federal Ministry of the Interior, Building and Community (BMI), the Federal Ministry of Defence (BMVg); the Federal Ministry of Finance (BMF), the Federal Ministry of Economic Affairs and Energy (BMWi), the Federal Ministry of Transport and Digital Infrastructure (BMVI) and the Federal Ministry for Food and Agriculture (BMEL) all the key institutions are included that are in a position to make high-quality specialised contributions to the preparation of the emission inventories.

The policy paper defines the relevant responsibilities of the various departments. In addition, it was resolved that the German Environment Agency (UBA) should serve as the Single National Entity (National Co-ordinating Agency) for Germany. The tasks of the Single National Entity include the planning, preparation, and storage of the inventories and the description of those in the inventory reports as well as the quality control and quality assurance in all relevant process steps. In addition, various other institutions and organizations outside the federal government are integrated into the National System via agreements with the Single National Entity.

### Instruments of the Single National Entity

The German Environment Agency has developed a range of instruments for supporting the Single National Entity in carrying

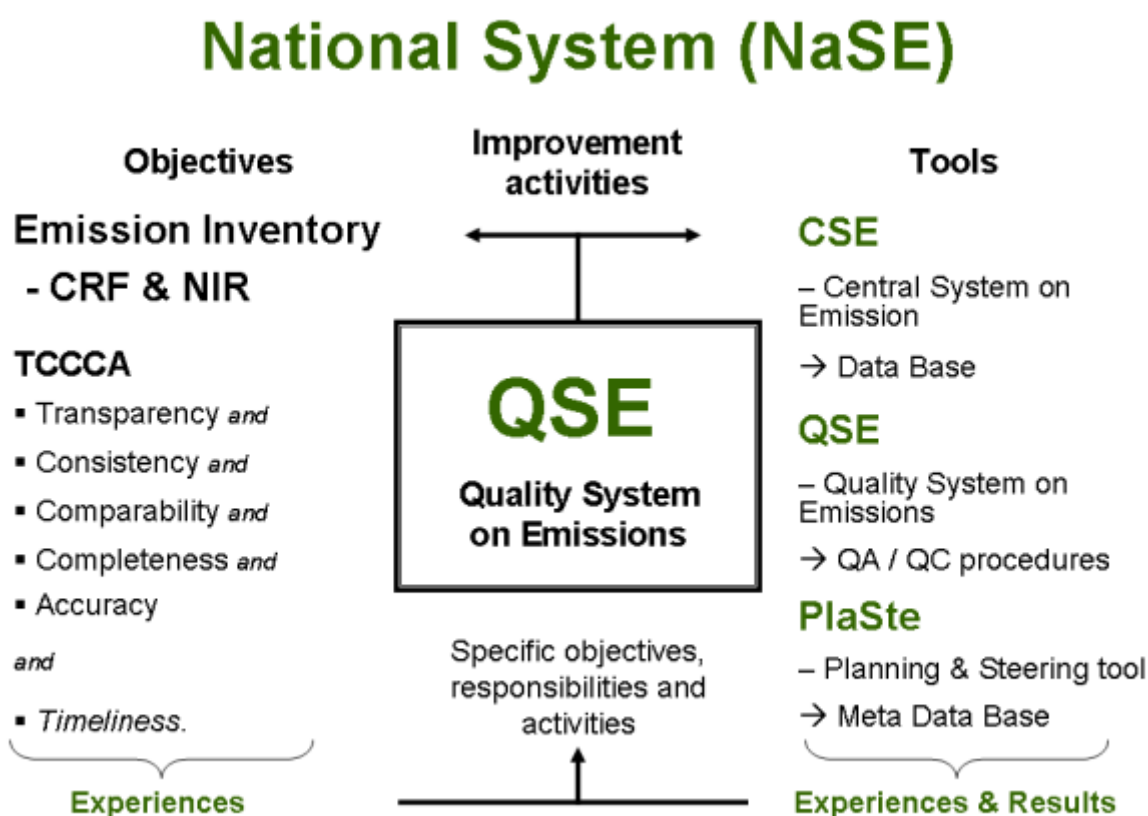
out its tasks.

The German Environment Agency's Central System on Emissions (CSE) database is the national, central database for emissions calculation and reporting. It is used for central storage of all information required for emissions calculation (methods, activity rates, emission factors). The CSE is the main instrument for documentation and quality assurance at the data level. It also tracks data provider responsibilities.

Within the German Environment Agency, the Quality System for Emissions Inventories (QSE) provides the necessary framework for good inventory practice and for routine quality assurance. Established in 2005 via in-house directive 11/2005, within the German Environment Agency it comprises the processes necessary for continually improving the quality of emissions inventories. The framework it provides includes defined responsibilities and quality objectives relative to methods selection, data collection, calculation of emissions and relevant uncertainties and recording of completed quality checks and their results (confirmation that objectives were reached, or, where objectives were not reached, listing of the measures planned for future improvement). The quality control procedures have been developed with the help of external experts, taking special account of the German Environment Agency's work structures, general guidelines for quality assurance and the CLRTAP Reporting Guidelines. Establishment of minimum requirements pertaining to data documentation, QC/QA and archiving ensures that additional authorities, institutions and inventory experts are included in the quality management process.

A searchable Access database – the Planning and Control Instrument (Planungs- und Steuerungsinstrument – PlaSte) – serves as the key instrument for monitoring success within the QSE framework. This database is the repository for all tabular documents emerging from the national QC/QA process (QC/QA plan, checklists, lists of responsibilities, etc.).

The manner in which these instruments interact in implementation of quality measures within the framework of inventory preparation is laid out by the figure below.



## Documentation and archiving

As a general requirement, all data and information used for inventory calculation must be documented (i.e. recorded) and archived, for each report year. The purpose of such documentation (i.e. recording) is to make it possible to completely reconstruct all emissions calculations after the fact.



Consequently, data providers have the obligation to keep records of the following information relative to data they supply to the German Environment Agency, for purposes of inventory calculations:

- Publication/source of activity data and emission factors, with detailed referencing of the relevant table numbers and names, and of the relevant pages in the original sources;
- Survey contents (definitions of the surveyed characteristics, delimitations used, survey units used) and survey methods;
- The legal foundations and ordinances on which surveys are based;
- Chronological and spatial comparability with previous-year data, and any changes with regard to definitions, scopes of validity, cut-off points, sources of activity rates or data collection methods;
- Any revision of previously published data;
- The accuracy or quantitative error of activity data, methods used to estimate errors and the names of experts who have carried out error estimation.
- Secrecy and data protection: suitable notification with regard to any individual data items that are considered secret.

Such materials should be provided to the German Environment Agency on an annual basis, together with pertinent data, and they are centrally archived by the German Environment Agency both electronically and on paper.

## Chapter 1.3 - Inventory Preparation Process



In Germany, emissions reporting is coordinated by a Single National Entity in the German Environment Agency (UBA). Since the mid-1990s, when reporting obligations for preparation of emissions inventories of air pollutants and greenhouse gases increased sharply, efforts to harmonise emissions calculation and reporting have been intensified. At the same time, requirements from reporting obligations relative to the UNECE Geneva Convention on Long-range Transboundary Air Pollution and its protocols, to the EU NEC Directive and to EU plant specific reporting obligations, must be considered.

The National System performed according to the requirements of the Kyoto Protocol provides for the preparation of inventories conforming to the principles of transparency, consistency, comparability, completeness and accuracy. Such conformance is achieved through extensive use of the methodological regulations provided by international institutions (UNECE, UNFCCC, IPCC, IPPC). The institutional arrangements are – like for greenhouse gases – as used for the reporting procedures established under the UNECE Convention and its protocols as well as the European reporting obligations.

The instruments and stakeholder acting in inventory preparation have already been laid out in the previous section [Institutional Arrangements](#). For even more details on the German national system as well as for the methods and processes applied for the preparation of the emission inventory please refer to Germany's [National Inventory Document \(NID\) 2024](#) as submitted under the UNFCCC. The process of inventory preparation depicted there is exactly the same as the one used for air pollution emissions. Where differences occur, namely in the use of emission factors, the NFR-specific chapters of this report will provide further explanation.

In practice, as many experts are involved in the inventory compilation process, an efficient organisation is required. The major advantage of this concept is the provision of additional expertise for quality control and verifications. The co-operation with the technical experts responsible for legislation and Best Available Technology (BAT) ensures a detailed technical knowledge for the inventory compilation process. The knowledge of abatement technologies and limit values is essential for the evaluation of emission factors. Since the German Environment Agency (UBA) operates several analytical laboratories and monitoring stations, it is possible to draw on the specialist expertise in order to get a better understanding of measurements and uncertainties.

Furthermore, the UBA provides expert advice and support for negotiations of National Emission Ceilings, POPs and heavy metal protocols. The information exchange and co-operation with the competent sections of the UBA facilitates the identification of key sources and possible gaps within the current emissions reporting.

## Chapter 1.4 - Methods and Data Sources

This chapter elaborates some methodical issues concerning the inventory preparation process. In addition, it lists the main data sources used for emission calculation. It does not address the calculation methodologies on the detailed level, i.e. information on tiers and emission factors, these are discussed in the source-specific chapters. As a general rule, Germany uses many country-specific process information and emission factors where available.

### Main data sources

The German air pollution emission inventory is based on a large number of sources and publications. Most of the time these are specific for certain source categories.

#### Energy

##### over-all and stationary combustion

For the **energy sector**, the most important data sources for determination of activity rates are the “Energiebilanzen der Bundesrepublik Deutschland” (Energy Balances of the Federal Republic of Germany, hereinafter referred to as: Energy Balance), which are published by the [Working Group on Energy Balances](#) (Arbeitsgemeinschaft Energiebilanzen, AGEB). An energy balance provides an overview of the links within Germany's energy sector, and it supports breakdowns in accordance with fuels and source categories. An energy balance receives data from a wide range of other sources. As a result, publication of energy balances is subject to some delay.

Along with the Energy Balance, the Working Group on Emissions Balances (AGEB) also publishes “Evaluation Tables for the Energy Balance” (Auswertungstabellen zur Energiebilanz (hereinafter referred to as: evaluation tables). In the area of fuels, these tables only list those fuels with the highest activity levels and aggregate lower activity levels to form sum values (such as other solid fuels). Breakdowns according to specific source categories are limited largely to source categories that consume final energy (such as manufacturing sector or transport). Some source categories are not listed (such as production of district heat). The evaluation tables are published relatively promptly (in the summer of the relevant subsequent year). The tables can be used to determine aggregated activities at the source category levels for the most commonly used fuels. Further disaggregation can be achieved via formation of relevant differences using other statistics.

##### mobile combustion

Basically, as already mentioned above, annual data on domestic fuel deliveries is available from (i) the National Energy Balances (as compiled by the Working-Group on National Energy Balances, AGEB) with the specific information on mineral-oil and its products coming from (ii) the Official Oil Data of the [Federal Office of Economics and Export Control](#) (Bundesamt für Wirtschaft und Ausfuhrkontrolle - BAFA).

However, to further distribute and allocate the aggregated fuel deliveries onto the different mobile sources, a variety of models has been developed that are now used for computing the extensive basic data from generally accessible statistics, special surveys, and measurements.

For [road transport \(1.A.3.b\)](#), [railways \(1.A.3.c\)](#), and [inland navigation \(1.A.3.d ii\)](#) specific activity data and country-specific implied emission factors at least for regulated pollutants are calculated within TREMOD (“[Transport Emission Estimation Model](#)”; IFEU).

Here, for 1.A.3.b, highly detailed data on annual mileage together with information on fleet composition and new-registration numbers are applied to allocate the statistically recorded fuel sales to different vehicle types and classes as well as the individual Euro standards. A precise description of the data sources for emission factors used within TREMOD for road transport is provided by the “[Handbook of Emission Factors for Road Transport](#)” (version 4.2, 2022).

For estimating emissions from [civil aviation \(1.A.3.a\)](#), specific fuel consumption data for domestic and international flights further distinguished into landing/take-off (L/TO) and cruise phase as well as corresponding implied emission factors are derived from TREMOD Aviation (TREMOD AV), a standalone module of TREMOD using flight data from the [German Statistical Office](#) (Statistisches Bundesamt, DESTATIS).

Another model ([E.M.M.A. - Emission Modelling for Maritime Activities](#)) is used for national and international maritime navigation, fishing (1.A.4.c iii) and military navigation (1.A.5.b iii) using ship-specific movement data (AIS) for estimating specific fuel consumptions and implied emission factors for domestic trips. Finally, for emissions from [offroad vehicles and machinery as used in 1.A.2.g vii, 1.A.4.a ii, b ii and c ii](#), specific consumption data and IEF are computed within TREMOD Mobile Machinery (TREMOD MM), yet another standalone module of the aforementioned TREMOD.

#### **fugitive emissions from fuels**

Data for calculating **fugitive emissions** principally originates from the Association Fuels & Energie (en2x) and the Federal association of the natural gas, oil and geothermal energy industries (BVEG).

### **Industrial Processes**

Most industrial processes are covered by either the [German Statistical Office](#) (DESTATIS) or branch association publications. These reports are generally available in due time and do have low uncertainty ranges.

Data on product use is drawn from the same sources.

Collaboration between the UBA and DESTATIS have been set on solid ground by agreements of their respective “parent” authorities, the former Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU, currently BMUV) and the Federal Ministry of the Interior, Building and Community (BMI) respectively.

### **Agriculture**

For agriculture, emissions calculations are carried out by the [Thünen Institutes](#) (TI). For calculation of agricultural emissions in Germany, the [Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety](#) (BMUKN) and the Federal Ministry of Agriculture, Food and Regional Identity (BMLEH) initiated a suitable joint project, in the framework of which the former Federal Agricultural Research Institute (FAL) developed a modular model for relevant spread-sheet calculation (GASeous Emissions, GAS-EM). The BMU and BMEL now have a framework ministerial agreement in place for management of relevant data and information exchange and for operation of a joint database at the UBA and the vTI.

### **Waste**

Finally, reports on waste and waste water again originate from publications by the [German Statistical Office](#) (DESTATIS).



More detailed information on data sources is found in the NFR-specific chapters of this report and in the German National Inventory Document (NID, see References).

The table below shows the key category analysis for the current reporting year. Dominant source categories vary largely for different pollutants. The key category analysis was carried out in accordance with the EMEP/UNECE guidebook for the base year (1990/1995/2000) and the actual year. Due to missing information on uncertainties, a tier 1 key category analysis was selected. Thus, the table gives “L” for category-pollutant combinations being key categories because of the high level of emissions. “T” indicates key categories resulting from trend analysis.

|                | Pollutant                                                                                                                                                                                                |        |                 |                 |                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |     |  |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|-----|--|
| Category Code  | NO <sub>x</sub>                                                                                                                                                                                          | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |     |  |
| 1.A.1.a        | L/T                                                                                                                                                                                                      | -/-    | L/T             | -/-             | L/T               | L/T              | L/T | -/- | L/- | -/- | L/T | L/T | L/T | L/T | L/T | L/T | -/- | L/T | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | L/- | L/T  |     |  |
| 1.A.1.b        | -/-                                                                                                                                                                                                      | -/-    | L/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | -/- | L/- | L/- | L/- | -/- | -/- | L/- | L/T | -/- | -/-    | -/-   | IE    | IE    | IE    | IE     | -/- | -/-  | -/- |  |
| 1.A.1.c        | L/T                                                                                                                                                                                                      | -/-    | L/T             | -/-             | -/T               | -/-              | L/T | -/- | -/- | -/- | L/T | L/T | L/T | L/T | L/T | L/T | -/- | L/T | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | -/-  |     |  |
| 1.A.2.a        | -/T                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | NE  | -/- | IE  | IE  | -/- | NE  | NE  | NE  | NE  | NE  | NE  | -/-    | -/-   | NE    | NE    | NE    | -/-    | NA  | NA   |     |  |
| 1.A.2.b        | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | IE                | IE               | IE  | IE  | -/- | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE     | IE    | IE    | IE    | IE    | IE     | IE  | IE   |     |  |
| 1.A.2.c        | IE: Energy-related emissions from power plants and boiler systems are reported in NFR 1.A.2.g vii whereas process related emissions aire reported in NFR 2.B.                                            |        |                 |                 |                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |     |  |
| 1.A.2.d        | IE: Emissions from power plants and boiler systems are reported in NFR 1.A.2.g viii whereas all process-related emissions as well as emissions from black liquor incineration are reported in NFR 2.H.1. |        |                 |                 |                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |     |  |
| 1.A.2.e        | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | IE                | IE               | IE  | IE  | -/- | NE  | NE  | NE  | NE  | NE  | NE  | NE  | NE  | NE  | NE     | NE    | NE    | NE    | NE    | NE     | NE  | NA   | NA  |  |
| 1.A.2.f        | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | IE                | IE               | IE  | IE  | -/- | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 1.A.2.g.vii    | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | L/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NE   | NE  |  |
| 1.A.2.g.viii   | L/T                                                                                                                                                                                                      | -/-    | L/T             | -/-             | L/-               | -/-              | L/T | -/- | -/- | -/- | L/- | L/T | L/T | -/T | -/- | L/T | -/- | L/T | L/T    | -/T   | IE    | IE    | IE    | IE     | -/T | -/-  | L/- |  |
| 1.A.3.a.ii.(i) | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | NE     | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NA   | NA  |  |
| 1.A.3.a.i.(i)  | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | NE     | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NA   | NA  |  |
| 1.A.3.b.i      | L/T                                                                                                                                                                                                      | L/T    | -/-             | -/-             | L/T               | L/T              | -/- | L/T | L/T | L/T | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NE   | -/- |  |
| 1.A.3.b.ii     | L/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | L/T               | L/T              | -/- | L/T | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NE   | -/- |  |
| 1.A.3.b.iii    | L/T                                                                                                                                                                                                      | -/-    | -/-             | -/-             | L/T               | L/T              | -/- | L/T | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NE   | -/- |  |
| 1.A.3.b.iv     | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NE   | -/- |  |
| 1.A.3.b.v      | NA                                                                                                                                                                                                       | L/T    | NA              | NA              | NA                | NA               | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 1.A.3.b.vi     | NA                                                                                                                                                                                                       | NA     | NA              | NA              | L/-               | L/-              | L/- | L/- | NA  | L/- | -/- | NA  | L/- | L/- | L/T | -/- | L/- | L/T | NA     | -/-   | -/-   | -/-   | NE    | -/-    | NA  | NA   |     |  |
| 1.A.3.b.vii    | NA                                                                                                                                                                                                       | NA     | NA              | NA              | L/-               | L/-              | L/- | -/- | -/- | -/- | NA  | -/- | -/- | NA  | -/- | -/- | NE  | -/- | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 1.A.3.c        | -/T                                                                                                                                                                                                      | -/-    | -/-             | -/-             | L/-               | L/-              | L/- | -/- | -/- | -/- | -/- | -/- | -/- | L/- | L/- | L/T | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | -/-  |     |  |
| 1.A.3.di(ii)   | IE                                                                                                                                                                                                       | IE     | IE              | IE              | IE                | IE               | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE     | IE    | IE    | IE    | IE    | IE     | IE  | IE   |     |  |
| 1.A.3.d.ii     | L/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | -/-  |     |  |
| 1.A.3.e.i      | -/-                                                                                                                                                                                                      | -/-    | -/-             | NA              | -/-               | -/-              | -/- | NE  | -/- | NA  | NA  | -/- | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 1.A.3.e.ii     | NA                                                                                                                                                                                                       | NA     | NA              | NA              | NA                | NA               | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
|                | NO <sub>x</sub>                                                                                                                                                                                          | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |     |  |
| 1.A.4.a.i      | -/-                                                                                                                                                                                                      | L/T    | -/-             | -/-             | L/T               | L/T              | L/T | L/- | L/T | L/- | -/- | -/- | L/- | -/- | -/- | -/- | NE  | L/T | L/-    | L/-   | L/-   | L/-   | L/-   | L/-    | L/- | -/-  | -/- |  |
| 1.A.4.a.ii     | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NE   | NE  |  |
| 1.A.4.b.i      | L/-                                                                                                                                                                                                      | L/T    | L/T             | -/-             | L/T               | L/T              | L/T | L/- | L/T | -/- | L/- | L/- | -/- | -/- | -/- | -/- | NE  | L/T | L/-    | L/T   | L/T   | L/T   | L/T   | L/T    | L/T | L/-  | -/- |  |
| 1.A.4.b.ii     | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | L/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NE   | NE  |  |
| 1.A.4.c.i      | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | NE  | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | -/-  | -/- |  |
| 1.A.4.c.ii     | L/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | L/T               | L/T              | L/T | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NE   | NE  |  |
| 1.A.4.c.iii    | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | -/-  |     |  |
| 1.A.5.a        | -/-                                                                                                                                                                                                      | L/T    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | NE  | NE  | -/- | NE  | NE  | NE  | NE  | NE  | NE  | -/-    | -/-   | -/T   | -/-   | -/-   | -/-    | -/- | NE   |     |  |
| 1.A.5.b        | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | -/-  |     |  |
| 1.B.1.a        | NA                                                                                                                                                                                                       | -/-    | NA              | NA              | -/-               | -/T              | -/- | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 1.B.1.b        | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | L/T | -/- | -/- | NA  | NA  | -/- | NA  | NA  | NA  | NA  | NA  | NA  | -/-    | L/T   | -/T   | L/T   | -/T   | L/T    | NA  | NA   |     |  |
| 1.B.1.c        | NA                                                                                                                                                                                                       | NA     | NA              | NA              | NA                | NA               | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 1.B.2.a.i      | NA                                                                                                                                                                                                       | -/-    | NA              | NA              | NA                | NA               | NA  | NA  | NA  | NA  | NA  | -/- | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 1.B.2.a.iv     | -/-                                                                                                                                                                                                      | -/-    | -/-             | NA              | NA                | NA               | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 1.B.2.a.v      | NA                                                                                                                                                                                                       | -/-    | NA              | NA              | NA                | NA               | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 1.B.2.b        | -/-                                                                                                                                                                                                      | -/-    | -/-             | NA              | NA                | NA               | NA  | NA  | -/- | NA  | NA  | -/- | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 1.B.2.c        | -/-                                                                                                                                                                                                      | -/-    | -/-             | NA              | -/-               | -/-              | -/- | -/- | -/- | NA  | NA  | -/- | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 1.B.2.d        | NA                                                                                                                                                                                                       | NA     | NA              | NA              | NA                | NA               | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 2.A.1          | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/T               | -/T              | -/- | NE  | -/- | -/- | -/- | L/- | NE  | NE  | NE  | NE  | NE  | NE  | -/-    | -/-   | IE    | IE    | IE    | -/-    | NA  | -/-  |     |  |
| 2.A.2          | -/-                                                                                                                                                                                                      | -/-    | -/-             | IE              | -/-               | -/-              | -/- | NE  | -/- | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 2.A.3          | -/-                                                                                                                                                                                                      | -/-    | L/-             | -/-             | -/-               | -/-              | -/- | NE  | -/- | -/- | -/- | NA  | -/- | -/- | -/- | -/- | L/T | -/- | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 2.A.5.a        | NA                                                                                                                                                                                                       | NA     | NA              | NA              | L/-               | L/T              | L/- | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 2.A.5.b        | NA                                                                                                                                                                                                       | NA     | NA              | NA              | -/-               | L/T              | L/- | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
| 2.A.5.c        | IE                                                                                                                                                                                                       | IE     | IE              | IE              | IE                | IE               | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE  | IE     | IE    | IE    | IE    | IE    | IE     | IE  | IE   |     |  |
| 2.A.6          | -/-                                                                                                                                                                                                      | -/-    | -/-             | -/-             | -/-               | -/-              | L/- | NA  | IE  | NE  | NE  | NE  | NE  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |
|                | NO <sub>x</sub>                                                                                                                                                                                          | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |     |  |
| 2.B.1          | -/-                                                                                                                                                                                                      | NA     | NA              | -/-             | NA                | NA               | NA  | NA  | -/- | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |     |  |



|             |     |     |     |     |                                                                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|-------------|-----|-----|-----|-----|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 5.C.1.b.iii | NO  |     |     |     |                                                                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 5.C.1.b.iv  | NO  |     |     |     |                                                                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 5.C.1.b.v   | -/- | -/- | -/- | NA  | -/-                                                                                 | -/- | -/- | NE  | -/- | -/- | -/- | -/- | NE  | NE  | NE  | NE  | NE  | -/- | -/- | -/- | NE  | -/- | -/- | -/- | -/- |
| 5.C.1.b.vi  | NO  |     |     |     |                                                                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 5.C.2       | -/- | -/- | -/- | NE  | -/-                                                                                 | -/- | -/- | -/- | -/- | -/- | -/- | NE  | NE  | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | NE  | NE  |
| 5.D.1       | NA  | -/- | NA  | NA  | NA                                                                                  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  |
| 5.D.2       | NA  | -/- | NA  | NA  | NA                                                                                  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  |
| 5.D.3       | NO  |     |     |     |                                                                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 5.E         | NE  | NE  | NE  | NE  | L/-                                                                                 | L/- | -/- | L/- | NE  | -/- | -/- | -/- | -/- | -/- | -/- | NE  | NE  | NE  | L/- | NE  | NE  | NE  | NE  | NE  | NE  |
| 6.A         | NA  | NA  | NA  | -/- | NA                                                                                  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA  |
|             |     |     |     | L/- | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|             |     |     |     | -/T | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|             |     |     |     | L/T | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|             |     |     |     | -/- | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|             |     |     |     | IE  | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|             |     |     |     | NE  | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|             |     |     |     | NA  | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|             |     |     |     | *   | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |

## Qualitative criteria to identify Key Categories

According to guidebook section 2.4.3 parties to the convention have to assess qualitative criteria to identify key categories. The German inventory has been carefully checked and it was found that no additional categories need to be marked as key categories.

## Key Categories and Inventory Improvements

The results of the KCA, as presented above, are carefully checked each year and are an integral part of both the [inventory planning](#) and the [QA/QC activities](#). Key categories receive greater attention when quality control measures are taken and their methods are regularly checked for appropriateness. Where needed, key categories are more likely to have research funded that aims at moving them to a higher tier method.

## Chapter 1.6 - QA/QC and Verification Methods



### The Quality System for Emission Inventories and its contribution to UNECE/CLRTAP reporting

The German Quality System for Emission Inventories (QSE) originally was designed to serve the purposes of emission reporting under the UN Framework Convention on Climate Change (UNFCCC).

It takes account of provisions of the **2006 IPCC (Intergovernmental Panel on Climate Change) Guidelines, Volume 1, Chapter 6: General Guidance and Reporting (GGR)**<sup>1)</sup>, of national circumstances in Germany and of the internal structures and procedures of the German Environment Agency (UBA), the reporting institution.

Thus it can be assumed that by adopting the IPCC Guidelines, the UNECE/CLRTAP seriously facilitated the task of developing a QC/QA system for the reporting of air pollutants. It is likely that all QSE procedures are flexible enough to be able to routinely incorporate these demands in the future as well.

The QSE is designed to cover all participants of the National System on Emissions (NaSE) which are mostly identical to those responsible for the reporting of air pollutants.

Within the German Federal Environment Agency (UBA), the appliance of the QSE and its procedures has been made mandatory for UNFCCC reporting by an internal directive (UBA-Hausanordnung 11/2005). The adoption of the QSE's approach will be useful for CLRTAP reporting too but its implications have to be considered carefully (mostly due to human resources), which is why the appliance of QSE procedures is partly outstanding. Currently few parts are used for reporting under CLRTAP, (see below, "Current State").

The requirements pertaining to a system for quality control and quality assurance (QC/QA system) and to measures for quality control and quality assurance are defined primarily by Chapter 6 of the 2006 IPCC GL, Volume 1: GGR<sup>2)</sup>.

From those provisions, the German Environment Agency derived **"General requirements pertaining to quality control and quality assurance in connection with greenhouse-gas-emissions reporting"**. It is assumed that these requirements completely apply for CLRTAP reporting, too. Therefore, they are briefly given in the following to depict the necessary though partly outstanding trail of action for the development of a consistent QC/QA system under UNECE/CLRTAP.

### Main demands

The 2006 IPCC Guidelines require that QC/QA systems be introduced with the aim of enhancing transparency, consistency, comparability, completeness, accuracy and timeliness and, especially, that such inventories fulfill requirements pertaining to "good inventory practice".

A QC/QA system comprises the following:

- an agency responsible for coordinating QC/QA activities,
- development and implementation of a QC/QA plan,
- general QC procedures,



- source-category-specific QC procedures,
- QA procedures,
- verification activities,
- reporting procedures,
- documentation and archiving procedures

## Agency responsible for coordinating QC/QA activities

A Single National Entity (national coordinating agency) is responsible for the QC/QA system.

The German Single National Entity is established in the German Environment Agency (Umweltbundesamt - UBA). In executing its function, it is good practice to establish the position of a coordinator for the Quality System to be developed. A QC/QA coordinator has responsibility for ensuring that a relevant QC/QA system is developed and implemented. Such implementation should be suitably institutionalised – for example by means of an in-house directive or association agreements.

## QC/QA plan

The purpose of a QC/QA plan is to ensure that QC/QA measures are properly organised and executed. It includes a description of all required QC/QA measures and a schedule for implementation of such measures. It also defines the primary emphasis of such measures.

Good practice calls for establishing a QC/QA plan and then reviewing and updating it each year after the latest inventory has been prepared. On the basis of the results of annual inventory review, the results of QC/QA measures and other informations of which it is aware, the Single National Entity aims to prepare an improvement plan for the entire inventory. On this basis, in turn, it will then derive proposals for a binding inventory plan for the next year to be reported.

## General quality control

Pursuant to the definition used by the 2006 IPCC GL (Volume 1: Chapter 6.1)<sup>3)</sup>, quality control (QC) comprises a system of routine specialised measures for measuring and checking the quality of inventories in preparation.

Requirements pertaining to general (formerly so called Tier-1) QC procedures can be derived from the requirements mentioned in Chapter 6.6, especially Table 6.1 which includes a complete list of general QC measures.

Required quality controls and their results should be recorded and not all quality controls have to be carried out on an annual basis. It should be ensured that all source categories undergo detailed quality control at least periodically.

## Source-category-specific quality control

In addition to undergoing general procedures, particularly relevant source categories (such as key sources), available resources presupposed, should undergo category specific (formerly so called Tier2) quality control with regard to determination of activity data, emissions and uncertainties (cf. Chapter 6.7; GGR). It should be noted that according to UNFCCC Reporting Guidelines, these measures are not mandatory.

The chapters of the 2006 IPCC GL that pertain to the various individual source categories (Volumes 2 to 5) include additional information relative to source-category-specific QC measures. Such guidelines should be considered in preparation of a QC/QA plan.

## Quality assurance procedures

While the primary aim of quality control is to ensure that methods are correctly applied, the primary purpose of quality assurance is to examine methods and data as such and improve or correct it as necessary.

Pursuant to the relevant IPCC definition (Chapter 6.1; GGR), measures for quality assurance (QA) are based “on a planned system of reviews by persons who are not directly involved in preparing the inventory. Such reviews – which are best carried out by independent third parties – should be applied to completed inventories, after QC procedures have been carried out.

The required instrument for quality assurance is the annual “basic” peer review, though additional audits on “strategic points of the inventory” should also be conducted.

## Verification activities

According to the **Chapter 6.10** of Volume 1 - General Guidance and Reporting of the 2006 IPCC Guidelines, “verification activities” refer to emission estimates only.

Verification activities for emission factors and activity data are subsumed under the headword and chapter “quality control”, which is a somewhat confusing approach. Nevertheless, and by leaving this peculiarity aside, verification, next to QC, is undoubtedly one key to ensure confidence and reliability of the estimates, corresponding emission factors and activity data.

## Reporting procedures

The Single National Entity is responsible for initiating, coordinating and globally organising reporting. Provision of data and reports by third parties must conform to applicable requirements pertaining to the scope, form and scheduling for such provision.

## Documentation and Archiving

As a general requirement, all data and information used for inventory calculation must be documented (i.e. recorded) and archived, for each report year. The purpose of such documentation (i.e. recording) is to make it possible to completely reconstruct all emissions calculations. The general requirements pertaining to documentation and archiving for the entire process of inventory preparation are described in Chapter 6.10.1 of the 2006 IPCC GL GGR.

Consequently, **data providers** have the obligation to keep records information relative to data they supply to the UBA for purposes of inventory calculations.

Information to be recorded by the institution supplying the pertinent data include:

- the types of quality control,
- the dates on which those measures were carried out,
- the pertinent results,
- and
- the corrections and modifications triggered by quality control measures.

**Providers of emissions calculations** are obliged to record the calculation methods and the rationale for their appliance. Calculation models, -files and -software, as well as the assumptions and criteria for the appliance of activity data and emission factors and their references have to be archived.

Moreover, quality assurance (QA) and confidentiality issues for data secrecy have to be archived.

## Current state

Information regarding the UBA's current organisational measures for implementing the requirements given above is provided in the following.

### Structural organisation - Role concept

Within the QSE framework, a concept was developed that defines binding responsibilities inside the German Environment Agency for the implementation of the necessary QC and QA measures.

The purpose of defining roles and responsibilities is to facilitate the effective information exchange and the directive-conformal execution of QC and QA.

The following roles are also used for reporting under CLRTAP but not yet on the same mandatory basis as established for GHG reporting.

**Specialised expert at the operational level (FV)**

- source (NFR) specific expert
- tasks: compilation and entry (into the CSE) of activity data (AD)

**Quality control manager (QKV)**

- superior of the FV
- tasks: checking and approving of activity data

**Specialized contact person (source-category specific, FAP)**

- member of the Single National Entity
- tasks: checking of AD, compiling emission factors; data entry (into CSE) & calculation; preparation of texts; facilitation of specialised and technical support (inventory work and reporting).

**IIR co-ordinator (IIRK)**

- member of the Single National Entity
- tasks: co-ordination of IIR editing; establishing the framework for preparation of the IIR from the various relevant contributors.

**CSE co-ordinator (ZSEK)**

- member of the Single National Entity
- tasks: ensuring database integrity; compilation of NFR tables

**NaSE co-ordinator (NaSEK)**

- member of the Single National Entity
- tasks: co-ordination of reporting activities; final emissions reporting (upload of IIR & NFR tables to CDR).

**QSE co-ordinator (QSEK)**

- member of the Single National Entity
- tasks: co-ordination of entire QSE and QA/QC activities; provision of QSE checklists.

## Current workflow management

The workflow specified by the QSE is also applied for activity data and, additionally, emission factors for NFR 3 - Agriculture.

However, in contrast to UNFCCC GHG reporting, no administrative agreement with the data-providing institution is in place yet.

Moreover, these parts of the adopted design are altered to serve the purposes of UNECE/CLRTAP reporting in the present state. For example, FVs are currently responsible for compiling, entry (into the CSE data base) and, if necessary, the calculating of activity data but, in contrast to GHG reporting under UNFCCC, not for compiling of emission factors.

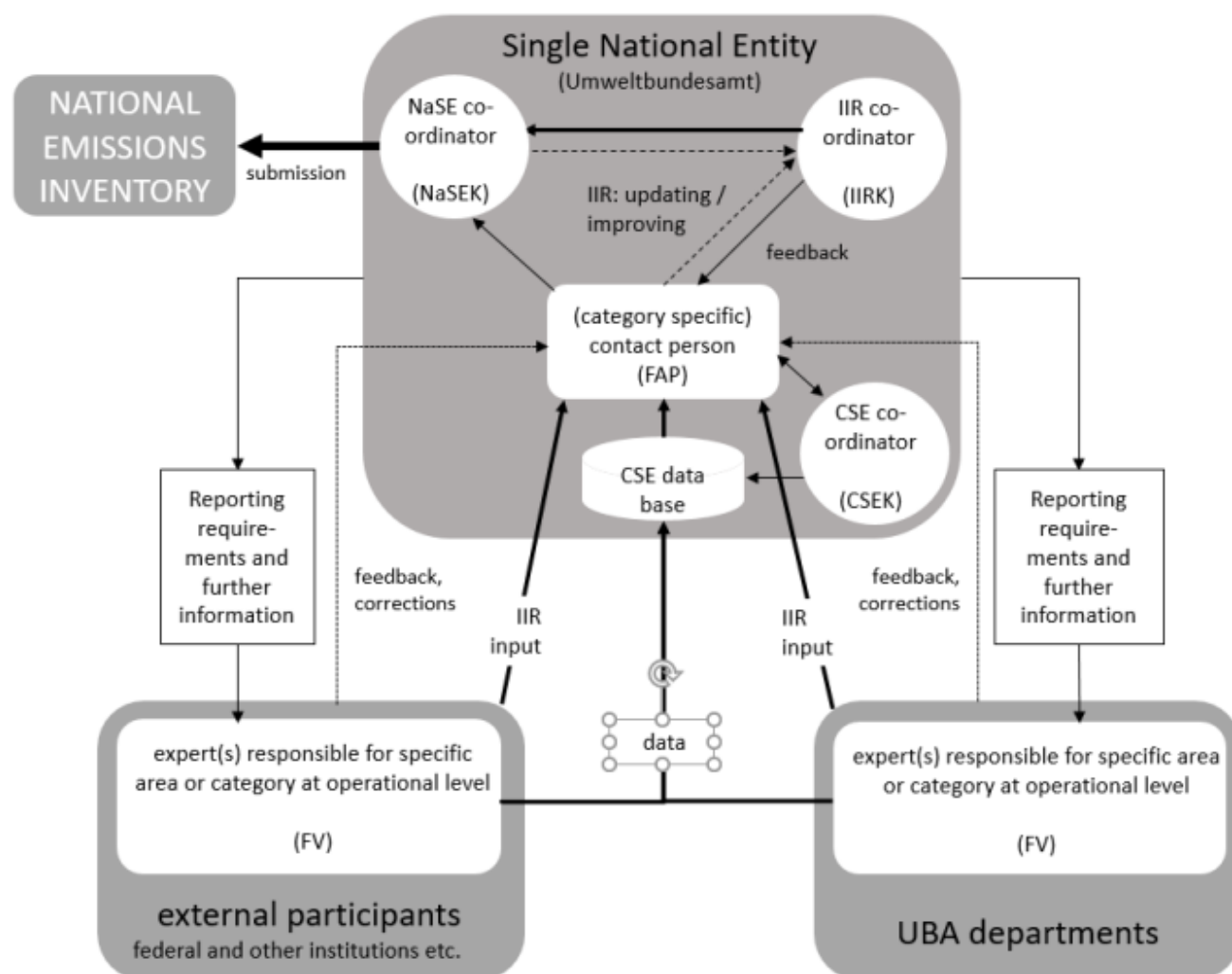


Figure: QSE – Roles, responsibilities and workflow

## General and category-specific quality control (QC)

As all activity data (except for the handling of bulk products) are also applied for UNFCCC GHG reporting, the same general and category-specific quality control of the QSE is already in force for activity data within the UNECE/CLRTAP reporting.

The quality of these activity data is supervised by the appliance of QC checks via special QSE checklists mandatory for all participants. The QSE checklists cover the set of general QC measures given in Table 6.1 of the 2006 IPCC GL GGR plus additional category-specific measures for key-category-specific quality control.

The QSE checklists are to be filled in annually throughout the whole inventory regardless whether or not a specific NFR category is a key source for emissions and by FV, FAP, and QKV consecutively.

## Quality assurance (QA)

Data, methods and estimates are generally derived by staff (FV) who are not member of the Single National Entity (see “Structural organisation - Role concept”). The quality-related activities to be performed by the FV are limited to quality

control (QC).

QA tasks are to be performed by the following roles, starting with the QKV (internal QA). The tasks are given within the already mentioned consecutive and successive QSE checklists for FV, QKV and FAP relying on reviewing and checking of finalized estimates and data. Within these checklists, each role/participant has its own set of QA checks.

The FAP, as a member of the Single National Entity, is the first role that is not directly involved in activity data preparation (external QA) so a “basic annual peer review” is conducted by the FAP. QA independence is guaranteed henceforward.

The QA checks are carried out annually and for the entire emissions inventory.

More intense peer reviews are undertaken whenever necessary and are performed by national experts and, in most cases, conducted by means of a national workshop.

As mentioned above, as all activity data (except for the handling of bulk products) are also applied for UNFCCC reporting, the same QA procedures are already in force for activity data within the UNECE reporting.

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<sup>1), 2), 3)</sup> IPCC (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 1, General Guidance and Reporting: Chapter 6 - Quality Assurance/Quality Control and Verification;  
[https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1\\_Volume1/V1\\_6\\_Ch6\\_QA\\_QC.pdf](https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_6_Ch6_QA_QC.pdf)

# Chapter 1.7 - General Uncertainty Evaluation

## Introduction



Uncertainties are a key part of any emission inventory effort. Recording and assessing the inevitable errors made in estimating emissions allows for the inventory team to direct their attention as well as for the public and the scientific community to work with the results presented. Germany employs the statistical approaches as defined in the EMEP/EEA Guidebook to evaluate its inventory's uncertainties. The Guidebook offers two methods for the combination of individual source uncertainties to the level of categories and national totals, namely error propagation (EP, tier 1) and Monte Carlo simulation (MC, tier 2). Although Germany presents all results from both approaches here, the MC values are generally considered to represent the actual confidence interval more precisely.

An important aspect of an uncertainty analysis concerns the ways on how to express the uncertainties associated with individual estimates or the total inventory. It is recommended to use the same quantity to express uncertainty in a LRTAP Convention inventory as required in a greenhouse gas inventory, namely the 95% confidence interval. The confidence interval is specified by the confidence limits defined by the 2.5 percentile and 97.5 percentile of the cumulative distribution function of the estimated quantity, that means that there is a 95% probability that the actual value of the quantity estimated is within the interval defined by the confidence limits. For a normal distribution, the 95% confidence interval lies between  $\pm 2$  standard deviations around the mean.

The data presented in this chapter are derived from the work of the emissions inventory experts contributing to the German emission inventory, who picked a confidence interval and a probability distribution function for each of the ~2,000 activity data and ~20,000 emission factor time series employed. In practice, every time series receives a metadata record in the database comprised of upper limit, lower limit and distribution function as well as an uncertainty information source reference (e.g. EEA/EMEP GB 2023, other literature or expert judgement). However, while uncertainties are currently considered separately for each individual time series, they remain static for each series across years. On this basis, the combination approaches described above are used to derive uncertainty information at the level of categories and national totals.

## Uncertainty overview

Germany currently reports detailed uncertainty information for five pollutants: NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, NH<sub>3</sub> and PM<sub>2.5</sub>. While

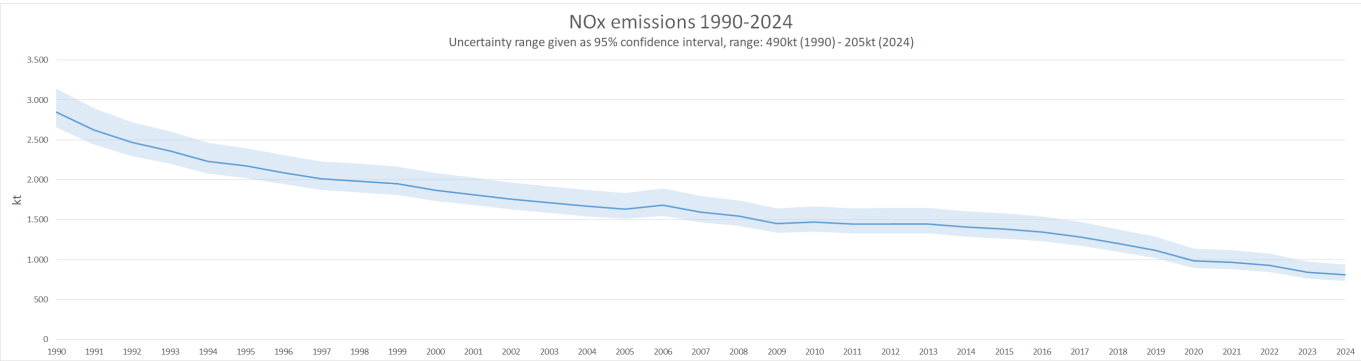
detailed spreadsheet tables are available for download below, the following table offers a quick overview and comparison per pollutants at the level of the national totals:

|                   | Base year [kt] | 2024 [kt] | Trend [%] | Method | Base year uncertainty [%] |       | 2024 uncertainty [%] |       | Trend uncertainty [%] |       |
|-------------------|----------------|-----------|-----------|--------|---------------------------|-------|----------------------|-------|-----------------------|-------|
| NO <sub>x</sub>   | 2.850          | 809       | -71,6     | EP     | ±11,1                     |       | ±16,4                |       | ±8,6                  |       |
|                   |                |           |           | MC     | -6,8                      | +10,4 | -9,1                 | +16,2 | -7,8                  | +10,6 |
| SO <sub>2</sub>   | 5.461          | 199       | -96,4     | EP     | ±8,7                      |       | ±8,1                 |       | ±1,3                  |       |
|                   |                |           |           | MC     | -8,1                      | +8,9  | -6,8                 | +7,0  | -1,4                  | +1,4  |
| NM <sub>VOC</sub> | 3.942          | 953       | -75,8     | EP     | ±18,3                     |       | ±36,9                |       | ±21,0                 |       |
|                   |                |           |           | MC     | -10,0                     | +16,9 | -17,2                | +34,3 | -15,4                 | +25,3 |
| NH <sub>3</sub>   | 827            | 528       | -36,2     | EP     | ±10,1                     |       | ±10,0                |       | ±10,4                 |       |
|                   |                |           |           | MC     | -9,4                      | +10,1 | -8,5                 | +9,1  | -35,5                 | +39,5 |
| PM <sub>2.5</sub> | 196            | 74        | -62,0     | EP     | ±14,4                     |       | ±27,0                |       | ±14,5                 |       |
|                   |                |           |           | MC     | -9,2                      | +11,0 | -17,5                | +20,8 | -12,4                 | +14,8 |

Uncertainties per pollutant

The sections below detail pollutant specific uncertainty interpretations and show the values in the context of the pollutant's emissions and trends.

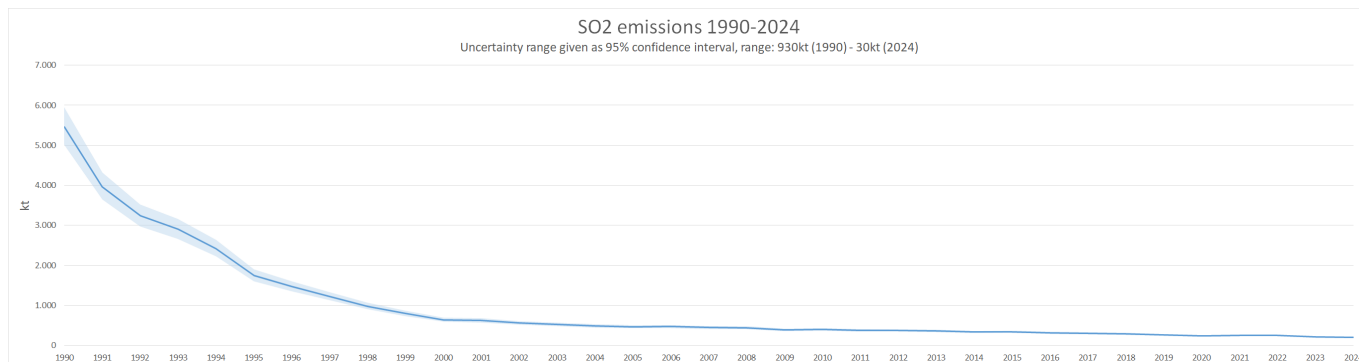
NO<sub>x</sub>



Compared to other pollutants, NO<sub>x</sub> emission uncertainties are moderate. The national total has a 95% confidence interval of about -9.1% to +16.2% in 2024, which amounts to about 205kt of NO<sub>x</sub>. Interestingly, with NO<sub>x</sub>, the differences between the two approaches in uncertainty combination (EP and MC) are particularly visible. This is because of the highest contributing sector [3.D - Agricultural Soils](#), where emissions and uncertainties are high (> +200%) and, crucially, do not follow a normal distribution. Therefore, only the MC simulation, which takes the log-normal distribution of these emissions into account, correctly reflects this source, while the EP yields unrealistic high uncertainties at about 16.4% in both directions.

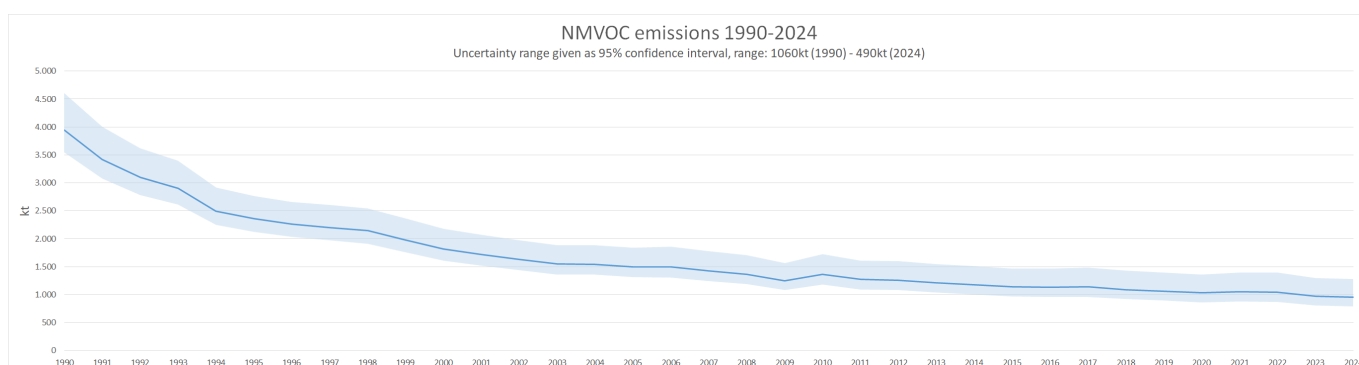
Using the MC simulation, the top three contributors to the overall uncertainty are [3.D.a.1 - Inorganic N-fertilizers](#), [3.D.a.2.a - Animal manure applied to soils](#) and [3.D.a.2.c - Other organic fertilisers applied to soils](#). [1.A.3.b i - Road transport: Passenger cars](#) and [1.A.4.b.i - Residential: Stationary](#) are other important sector in regard to NO<sub>x</sub> overall uncertainties. Please refer to the [spreadsheet file](#) for details.

SO<sub>2</sub>



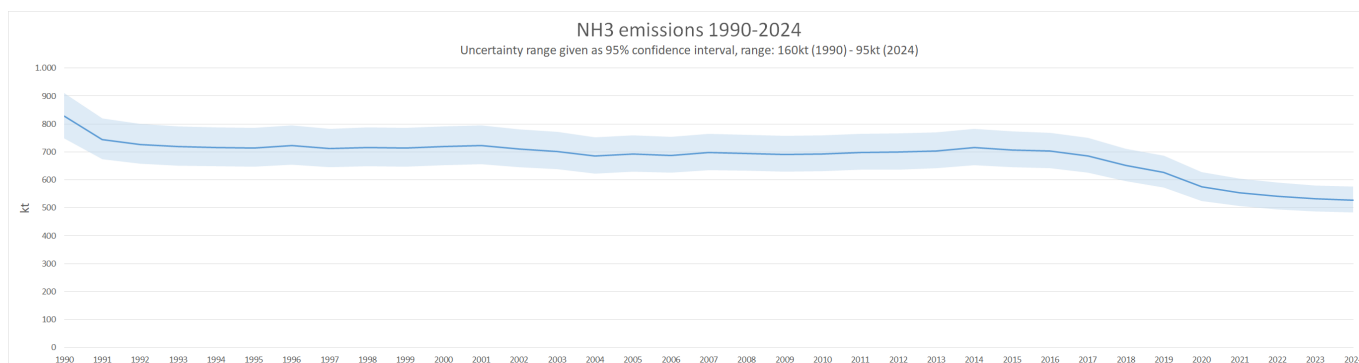
SO<sub>2</sub> emissions are mainly emitted by stationary combustion plants. Since those are heavily regulated and fuel sulphur contents are generally well known, uncertainties in SO<sub>2</sub> emissions are low. The national total has a 95% confidence interval of about -6.8% to +7.0% in 2024, which amounts to about 30kt of SO<sub>2</sub>. The top contributing sector to the SO<sub>2</sub> uncertainties is [1.A.1.a - Public Electricity And Heat Production](#), followed by a rather big margin by [1.A.1.b - Petroleum Refining](#), [1.A.4.b i - Residential: Stationary Combustion](#), as well as [2.C.1 - Iron and Steel Production](#). All data is available in the [spreadsheet file](#).

## NMVOC



NMVOC emissions and trends are driven by solvent use. While solvent contents of most products are well known, application context and use statistics introduce significant model error bars. Agriculture emissions of NMVOC are, while not very high in value, very uncertain and also contribute to the overall error margins. In sum, NMVOC emissions show moderate to high uncertainty. The national total has a 95% confidence interval of about -17.2% to +34.3% in 2024, which amounts to about 490kt of NMVOC. In order of significance, the top five contributors are [3.B - Manure Management - Dairy cattle](#), [3.B.1.b Manure management - Non-dairy cattle](#) and [2.D.3.a - Domestic Solvent Use, including Fungicides](#). As with the other pollutants, details are to be found in the [spreadsheet file](#).

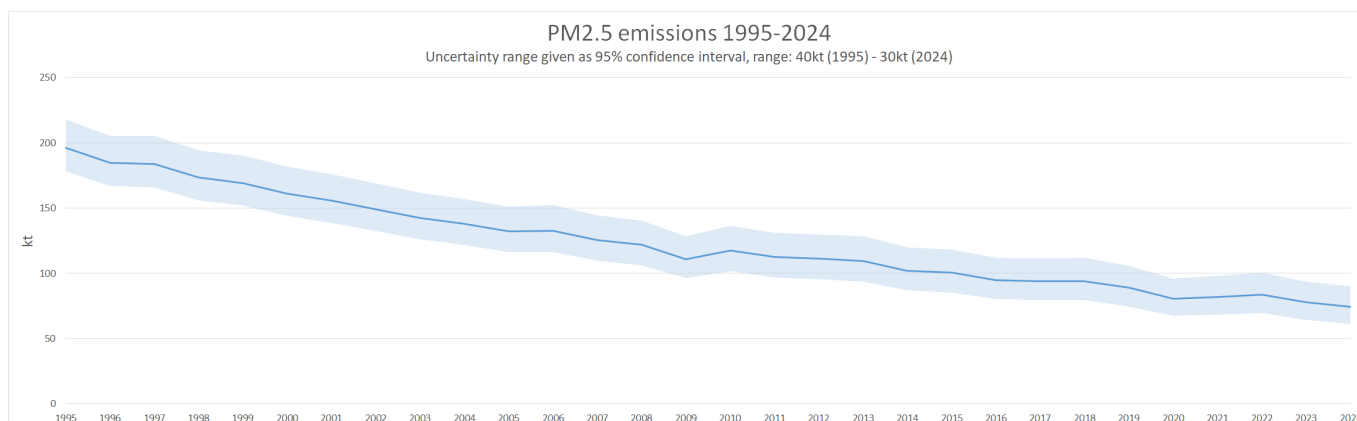
## NH3



Uncertainty in the NH<sub>3</sub> emission national total is moderate and mainly caused by agriculture sources, in particular [3.D.a.2.a - Animal manure applied to soils](#), [3.D.a.3 - Urine and Dung deposited by Grazing Animals](#), [3.B.3 - Manure management - Swine](#) and [3.D.a.2.c - Other Organic Fertilisers applied to Soils \(including Compost\)](#) do also play significant roles. The national total has a 95% confidence interval of about -8.5% to +9.1% in 2024, which amounts to about 95kt of NH<sub>3</sub>. You can drive your own analysis with the numbers found in the [spreadsheet file](#) attached.



## PM2.5



PM<sub>2.5</sub> emissions are associated with high uncertainties. The national total has a 95% confidence interval of about -17.5% to +20.8% in 2024, which amounts to about 30kt of PM<sub>2.5</sub>. Three sectors contribute the bulk of these errors: [1.A.4.b.i - Residential: Stationary Combustion](#), [3.D.3 - Farm-level Agricultural Operations](#) and [2.L - Other production, consumption, storage, transportation or handling of bulk products](#). Please refer to the [spreadsheet file](#) for details.

## Other pollutants

There is currently no uncertainty assessment for additional air pollutants, heavy metals and POPs. Germany seeks to expand the list of pollutants covered as resources allow.

# Chapter 1.8 - General Assessment of Completeness

## Introduction

The German inventory is generally complete regarding the main pollutants, TSP, particulate matter and CO. National total emissions of these pollutants are considered to be representative and to reflect the current emissions situation. Nevertheless, there are some cases where no appropriate method or data is available. It is assumed that these cases do not have a noticeable effect on the national totals and are in the range of its uncertainties.

In terms of heavy metals and POPs, the situation is different due to the low data availability. As additional information, there is a [specific overview on the completeness of the German POP inventory available](#).

Germany does not report any emission data for years prior 1990. Due to the split into the German Democratic Republic and the Federal Republic of Germany before 1990, there are no consistent data sets covering what is now the re-united country. Germany has no plans to work on emission inventories for the years 1980 to 1989 in the future. However, some summarizing information on the time span 1970 to 1989 is presented below, also comparing these data to the current emission inventory.

## Completeness in detail

The completeness of the German inventory as a whole has also been assessed by multiple reviews, both under the CLRTAP and the NECD. These reviews all confirm the good coverage of the German inventory. Where there are small omissions, Germany is working continuously to update and complete its data.

The following sections reflect on a few approaches, by source category, for improving the completeness of the inventory.

### Fuel combustion



In principle, all combustion-related activities (1.A) are recorded in full within the National Energy Balance (NEB) of the Federal Republic of Germany. Nonetheless, where it is evident that complete coverage is not achieved for certain sub-sectors (i.e. non-commercial use of wood, waste fuels), the NEB is supplemented with further statistical data, surveys etc. Moreover, there are frequent changes within the NEB, in particular concerning renewable energies. Such changes in fuel and source categories require considerable research work. Insofar, it's not always possible to implement all data in time. However, based on current information, combustion related activity data can be considered complete.

This also applies for the main pollutants, particulate matter and CO. There may be cases, where a further breakdown of activity data and emission factors would be more appropriate to represent any specific technology. In such cases, where the share of a specific technology is very small, the influence of a missing sub-division on the national totals is considered small, too.

In some source categories, separation of combustion-related and non-combustion-related emissions from industry requires

further verification. In general, for such categories, avoidance of double counting is an important part of quality assurance.

In terms of heavy metals and POPs, emissions are not yet complete in some sectors due to a lack of appropriate emission factors. Since they may not properly reflect the situation in Germany and in order to avoid inconsistencies within the German inventory as a whole, it is not always advisable to use default emission factors. In addition, fixed default EFs do not reflect the influence of technological developments onto the trends of certain emissions. Nevertheless, many country-specific emission factors (which are highly uncertain) are available for all combustion plants. All key categories are reported.

## Industrial processes

In the area of industrial processes, for the application of higher tier approaches some use is made of production data from association statistics and of manufacturers' information. In the interest of the inventory's completeness and reliability those data sets get specific QA/QC procedures. The inventory is considered complete for the main industrial processes.

## Agriculture

In the area of agriculture, while survey data from a past research project on management systems in animal husbandry are available, an effort is being made to carry out periodic, representative data surveys, in the interest of the inventory's continuing completeness and consistency.

## Explanation on the use of notation keys

The use of notation keys in the German inventory is carefully checked each year. All notation keys are used as defined in the guidance documents.

The following tables from the CLRTAP Stage 1 Reviews 2024 and 2025 give a good indication on where and how frequently notation keys are used in Germany's air pollutant reporting.

Though NEs are great in number, the actual emission behind each of the notation keys is estimated to be very small. In some cases, it is actually used instead of NA to make absolutely sure to be on the conservative side of the estimate.

Germany is working continuously to decrease the number of notation keys used and has already made good progress in this regard. The comparison shows that the number of NE notations used in the inventory could be reduced for almost all reported pollutants. However, this is mainly due to two facts:

- For *NFR 1.A.2.b*, all NE notations have been replaced by IE.

and

- The entire *NFR 2.J - Production of POPs* is reported as not occurring in Germany now and all NE have been replaced by NO notations.

| Component | %Value | 0%  | %NO | %NE  | %NA  | %IE | %C  | %NR | %All  |
|-----------|--------|-----|-----|------|------|-----|-----|-----|-------|
| NOx       | 49.0   | 0.0 | 7.0 | 2.0  | 38.0 | 5.0 | 0.0 | 0.0 | 100.0 |
| NM VOC    | 56.0   | 0.0 | 7.0 | 3.0  | 28.0 | 6.0 | 0.0 | 0.0 | 100.0 |
| SOx       | 36.0   | 0.0 | 7.0 | 2.0  | 51.0 | 3.0 | 0.0 | 0.0 | 100.0 |
| NH3       | 44.0   | 0.0 | 7.0 | 2.0  | 42.0 | 5.0 | 0.0 | 0.0 | 100.0 |
| PM2.5     | 52.0   | 0.0 | 7.0 | 3.0  | 29.0 | 9.0 | 0.0 | 0.0 | 100.0 |
| PM10      | 52.0   | 0.0 | 7.0 | 2.0  | 30.0 | 9.0 | 0.0 | 0.0 | 100.0 |
| TSP       | 54.0   | 0.0 | 7.0 | 2.0  | 28.0 | 9.0 | 0.0 | 0.0 | 100.0 |
| BC        | 23.0   | 0.0 | 7.0 | 20.0 | 45.0 | 6.0 | 0.0 | 0.0 | 100.0 |
| CO        | 34.0   | 0.0 | 7.0 | 2.0  | 52.0 | 6.0 | 0.0 | 0.0 | 100.0 |
| Pb        | 27.0   | 0.0 | 7.0 | 4.0  | 57.0 | 5.0 | 0.0 | 0.0 | 100.0 |
| Cd        | 28.0   | 0.0 | 7.0 | 4.0  | 57.0 | 5.0 | 0.0 | 0.0 | 100.0 |
| Hg        | 30.0   | 0.0 | 7.0 | 4.0  | 55.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| As        | 23.0   | 0.0 | 7.0 | 6.0  | 61.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| Cr        | 22.0   | 0.0 | 7.0 | 6.0  | 61.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| Cu        | 23.0   | 0.0 | 7.0 | 6.0  | 61.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| Ni        | 22.0   | 0.0 | 7.0 | 6.0  | 61.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| Se        | 17.0   | 0.0 | 7.0 | 13.0 | 59.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| Zn        | 22.0   | 0.0 | 7.0 | 6.0  | 61.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| DIOX      | 26.0   | 0.0 | 7.0 | 2.0  | 61.0 | 3.0 | 0.0 | 0.0 | 100.0 |
| PAH       | 25.0   | 0.0 | 7.0 | 3.0  | 61.0 | 3.0 | 0.0 | 0.0 | 100.0 |
| HCB       | 11.6   | 0.0 | 7.0 | 9.0  | 69.0 | 3.0 | 0.0 | 0.0 | 100.0 |
| PCB       | 15.0   | 0.0 | 7.0 | 9.0  | 66.0 | 3.0 | 0.0 | 0.0 | 100.0 |

Overview from CLRTAP Stage1 Review 2025

| Component | %Value | 0%  | %NO | %NE  | %NA  | %IE | %C  | %NR | %All  |
|-----------|--------|-----|-----|------|------|-----|-----|-----|-------|
| NOx       | 49.0   | 0.0 | 7.0 | 2.0  | 38.0 | 5.0 | 0.0 | 0.0 | 100.0 |
| NM VOC    | 56.0   | 0.0 | 7.0 | 3.0  | 28.0 | 6.0 | 0.0 | 0.0 | 100.0 |
| SOx       | 36.0   | 0.0 | 7.0 | 2.0  | 51.0 | 3.0 | 0.0 | 0.0 | 100.0 |
| NH3       | 44.0   | 0.0 | 7.0 | 2.0  | 42.0 | 5.0 | 0.0 | 0.0 | 100.0 |
| PM2.5     | 52.0   | 0.0 | 7.0 | 3.0  | 29.0 | 9.0 | 0.0 | 0.0 | 100.0 |
| PM10      | 52.0   | 0.0 | 7.0 | 2.0  | 30.0 | 9.0 | 0.0 | 0.0 | 100.0 |
| TSP       | 54.0   | 0.0 | 7.0 | 2.0  | 28.0 | 9.0 | 0.0 | 0.0 | 100.0 |
| BC        | 23.0   | 0.0 | 7.0 | 20.0 | 45.0 | 6.0 | 0.0 | 0.0 | 100.0 |
| CO        | 34.0   | 0.0 | 7.0 | 2.0  | 52.0 | 6.0 | 0.0 | 0.0 | 100.0 |
| Pb        | 27.0   | 0.0 | 7.0 | 4.0  | 57.0 | 5.0 | 0.0 | 0.0 | 100.0 |
| Cd        | 28.0   | 0.0 | 7.0 | 4.0  | 57.0 | 5.0 | 0.0 | 0.0 | 100.0 |
| Hg        | 30.0   | 0.0 | 7.0 | 4.0  | 55.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| As        | 23.0   | 0.0 | 7.0 | 6.0  | 61.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| Cr        | 22.0   | 0.0 | 7.0 | 6.0  | 61.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| Cu        | 23.0   | 0.0 | 7.0 | 6.0  | 61.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| Ni        | 22.0   | 0.0 | 7.0 | 6.0  | 61.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| Se        | 17.0   | 0.0 | 7.0 | 13.0 | 59.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| Zn        | 22.0   | 0.0 | 7.0 | 6.0  | 61.0 | 4.0 | 0.0 | 0.0 | 100.0 |
| DIOX      | 26.0   | 0.0 | 7.0 | 2.0  | 61.0 | 3.0 | 0.0 | 0.0 | 100.0 |
| PAH       | 25.0   | 0.0 | 7.0 | 3.0  | 61.0 | 3.0 | 0.0 | 0.0 | 100.0 |
| HCB       | 11.6   | 0.0 | 7.0 | 9.0  | 69.0 | 3.0 | 0.0 | 0.0 | 100.0 |
| PCB       | 15.0   | 0.0 | 7.0 | 9.0  | 66.0 | 3.0 | 0.0 | 0.0 | 100.0 |

Overview from CLRTAP Stage1 Review 2026

As for categories, NE notations are used mainly in **Industrial Processes** and **Waste** (please refer to [section 1c of the review report 2025](#) for details). (The correspondig report for 2026 is not yet publically available) Each use is individually justified in the corresponding source category sections of this report as well as in the table below.

## NFR categories reported as 'not estimated' ('NE')

| NFR category  | pollutants effected                                                     | explanation / reasoning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------|-------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.A.1.b       | HCB, PCBs                                                               | no country-specific EF at hand; notation key 'NE' provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.1 Energy industries 2023</a>                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 1.A.1.c       | HCB (as of 2012), PCBs                                                  | no country-specific EF at hand; notation key 'NA' provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.1 Energy industries 2023</a> -> implementation will be checked                                                                                                                                                                                                                                                                                                                                                                                               |
| 1.A.2.a       | BC, Pb, Cd, As, Cr, Cu, Ni, Se, Zn, B[b]F, B[k]F, I[1,2,3-c,d]P         | no country-specific tier2 EFs at hand; notation key 'NE' provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.2 Combustion in manufacturing industries and construction 2023</a> , Tables 3-7 to 3-12                                                                                                                                                                                                                                                                                                                                                               |
| 1.A.2.e       | Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, B[a]P, B[k]F, I[1,2,3-c,d]P | only emissions from process-combustion in sugar industry reported here with no country-specific tier2 EF at hand; only tier1 default EF provided <a href="#">EMEP/EEA GB 2023, Chapter 1.A.2 Combustion in manufacturing industries and construction 2023</a> , Tables 3-2                                                                                                                                                                                                                                                                                           |
| 1.A.2.g vii   | HCB, PCBs                                                               | no country-specific EF at hand; no default provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.4 Non road mobile machinery 2023</a>                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 1.A.3.a i(i)  | PCDD/F                                                                  | no country-specific EF at hand; no default provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.3.a Aviation 2023</a>                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 1.A.3.a ii(i) | PCDD/F                                                                  | no country-specific EF at hand; no default provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.3.a Aviation 2023</a>                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 1.A.3.b i-iv  | HCB                                                                     | no country-specific EF at hand; no default provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.3.b.i-iv Road transport 2023</a>                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 1.A.3.b.vi    | B[k]F                                                                   | no country-specific EFs at hand; no defaults for BC provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.3.b.vi-vii Road tyre and brake wear 2023</a>                                                                                                                                                                                                                                                                                                                                                                                                               |
| 1.A.3.b.vii   | Hg, Se                                                                  | no country-specific EFs at hand; no defaults for BC provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.3.b.vi-vii Road tyre and brake wear 2023</a>                                                                                                                                                                                                                                                                                                                                                                                                               |
| 1.A.3.e.i     | as of 2000: BC                                                          | no EF provided in <a href="#">EMEP/EEA GB 2023</a> Table 2-1: Tier 1 emission factors for pipeline transport                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 1.A.4.a.i     | Se                                                                      | several EFs provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.4 Small combustion 2023</a> -> implementation will be checked                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 1.A.4.a.ii    | HCB, PCBs                                                               | no country-specific EF at hand; no default provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.4 Non road mobile machinery 2023</a>                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 1.A.4.b.i     | Se                                                                      | several EFs provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.4 Small combustion 2023</a> -> implementation will be checked                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 1.A.4.b.ii    | HCB, PCBs                                                               | no country-specific EF at hand; no default provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.4 Non road mobile machinery 2023</a>                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 1.A.4.c.i     | Se                                                                      | several EFs provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.4 Small combustion 2023</a> -> implementation will be checked                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 1.A.4.c.ii    | HCB, PCBs                                                               | no country-specific EF at hand; no default provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.4 Non road mobile machinery 2023</a>                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 1.A.5.a       | Pb, Cd, As, Cr, Cu, Ni, Se, Zn, PCBs                                    | several EFs provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.4 Small combustion 2023</a> -> implementation will be checked                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 2.A.1         | As, Cr, Cu, Ni, Se, Zn as of 2000: BC                                   | no appropriate EFs available                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 2.A.2         | Pb, Cd as of 2000: BC                                                   | no appropriate EFs available                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 2.B.3         | PM <sub>2.5</sub>                                                       | no country-specific EF at hand; no default provided in <a href="#">EMEP/EEA GB 2023, Chapter: 2.B Chemical industry 2023</a> , Table 3.16 - Tier 2 emission factors for source category 2.B.3 Adipic acid production                                                                                                                                                                                                                                                                                                                                                 |
| 2.B.7         | as of 1995: PM <sub>2.5</sub> , PM <sub>10</sub> ; as of 2000: BC       | use of split factors for PM will be checked for following submissions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 2.C.1         | As, Cu, Se, Zn, B[a]P, B[b]F, B[k]F, I[1,2,3-c,d]P, BC (as of 2000)     | use of default EF will be checked for following submissions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 2.C.2         | NO <sub>x</sub> , NMVOC, SO <sub>x</sub> , CO, Pb, Cd, Hg, Cr BC        | <a href="#">EMEP/EEA GB 2023, Chapter 2.C.2 Ferroalloys production</a> , table 3.1: no EFs provided in EMEP GB 2023                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 2.C.3         | NMVOC, Cr, Se BC                                                        | <a href="#">EMEP/EEA GB 2023, Chapter 2.C.3 Aluminium production</a> : no EFs provided in EMEP GB 2023<br>use of default EFs will be checked for following submissions                                                                                                                                                                                                                                                                                                                                                                                               |
| 2.C.4         | NMVOC, TSP, PM <sub>2.5</sub> , PM <sub>10</sub> , BC                   | no primary magnesium production in Germany; only F-Gases are reported under 2.C.4, other occurring emissions from secondary magnesium production are reported in the Energy sector under 1.A.2.b.                                                                                                                                                                                                                                                                                                                                                                    |
| 2.C.5         | BC (as of 2000), Se                                                     | <a href="#">EMEP/EEA GB 2023, Chapter 2.C.5 Lead production</a> no EFs provided in EMEP GB 2023                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 2.C.6         | BC (as of 2000), Se                                                     | <a href="#">EMEP/EEA GB 2023, Chapter 2.C.6 Zinc production</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 2.C.7.a       | Se BC (as of 2000), Ni                                                  | <a href="#">EMEP/EEA GB 2023, Chapter 2.C.7.a Copper production</a> no EF provided in EMEP GB 2023<br>use of default EF will be checked for following submissions                                                                                                                                                                                                                                                                                                                                                                                                    |
| 2.C.7.c       | BC (as of 2000), SO <sub>x</sub>                                        | <a href="#">EMEP/EEA GB 2023, Chapter 2.C.7.c Other metal production</a> for galvanization no EF provided in EMEP GB 2023                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 2.D.3.b       | BC, B[a]P, B[b]F, B[k]F, I[x]P, PAH 1-4, as of 2000: BC                 | no country-specific EF at hand; GB 2023 to be checked; BC: use of 'NA' will be checked                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 2.D.3.c       | as of 2000: BC, B[a]P, B[b]F, B[k]F, I[1,2,3-c,d]P, PAH 1-4             | no country-specific EF at hand; notation key 'NE' provided in <a href="#">EMEP/EEA GB 2023, Chapter 2.D.3.c Asphalt roofing 2023</a> , Table 3-1 to 3-3                                                                                                                                                                                                                                                                                                                                                                                                              |
| 2.H.1         | NH <sub>3</sub> , PCBs, as of 2000: BC                                  | use of default EF will be checked for BC, use of 'NA' for PCB will be checked                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 2.H.2         | as of 2000: BC                                                          | use of default EF will be checked for following submissions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 2.H.3         | as of 2000: BC                                                          | as for all other pollutants, 'NA' will be reported for BC and for the next annual submission                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 2.I           | as of 2000: BC                                                          | no country-specific EF at hand; no information provided in <a href="#">EMEP/EEA GB 2023, Chapter 2.I Wood processing 2023</a>                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 2.K           | PCB                                                                     | EMEP GB 2019, <a href="https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/2-industrial-processes/2-k-consumption-of-pops/2-k-consumption-of-pops/view">https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/2-industrial-processes/2-k-consumption-of-pops/2-k-consumption-of-pops/view</a> , Table 3.1: emissions of PCB could not be ruled out but no data on national level is available and the standard EF (based on capita) will lead to unrealistic high emissions. |
| 2.L           | BC                                                                      | BC emissions unlikely to occur from dry bulk goods; no information <a href="#">EMEP/EEA GB 2023, Chapter 2.L Other production, consumption etc of bulk products 2023</a>                                                                                                                                                                                                                                                                                                                                                                                             |

| NFR category   | pollutants effected                                                     | explanation / reasoning                                                                                                                                                 |
|----------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5.C.1.b v      | BC, As, Cr, Cu, Ni, Se, Zn, B[k]F                                       | BC: 'NE' provided in <a href="#">EMEP/EEA GB 2023, Chapter 5.C.1.b.v Cremation 2023</a> , use of 'NA' will be checked; HM and B[k]F: use of national EF will be checked |
| 5.C.2          | NH <sub>3</sub> , Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDD/F, HCB, PCBs | NH <sub>3</sub> and Heavy Metals: use of 'NA' will be checked; for other pollutants no appropriate EFs available                                                        |
| 1.A.3.a i(ii)  | PCDD/F                                                                  | no country-specific EF at hand; no default provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.3.a Aviation 2023</a>                                                  |
| 1.A.3.a ii(ii) | PCDD/F                                                                  | no country-specific EF at hand; no default provided in <a href="#">EMEP/EEA GB 2023, Chapter 1.A.3.a Aviation 2023</a>                                                  |
| 1.A.5.c        | all pollutants                                                          | no AD available for multilateral military operations                                                                                                                    |

### NFR categories reported as 'included elsewhere ('IE')

| NFR category  | pollutants effected                                                                                                                                                      | included in                                                                | explanation / reasoning                                                                                                                                                                                         |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.A.1.a       | B[b]F, B[k]F, I[1,2,3-c,d]P                                                                                                                                              | PAHs 1-4 total                                                             | only summarized PAH data available                                                                                                                                                                              |
| 1.A.1.b       | B[b]F, B[k]F, I[1,2,3-c,d]P                                                                                                                                              | PAHs 1-4 total                                                             | only summarized PAH data available                                                                                                                                                                              |
| 1.A.1.c       | B[b]F, B[k]F, I[1,2,3-c,d]P                                                                                                                                              | PAHs 1-4 total                                                             | only summarized PAH data available                                                                                                                                                                              |
| 1.A.2.b       | PM <sub>2.5</sub> , PM <sub>10</sub> , TSP, as of 2000 BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, PCDDF, PCDDF B[a]P, B[b]F, B[k]F, I[1,2,3-c,d], PAHs 1-4 total, HCB, PCBs | 2.C                                                                        | considered to be process emissions                                                                                                                                                                              |
| 1.A.2.c       | all emissions                                                                                                                                                            | 1.A.2.g viii (energy related emissions), 2.B (process related emissions)   |                                                                                                                                                                                                                 |
| 1.A.2.d       | all emissions                                                                                                                                                            | 1.A.2.g viii (energy related emissions), 2.H.1 (process related emissions) | Process related part include the complete trend of SO <sub>2</sub> emissions instead a fuel based calculation within this category                                                                              |
| 1.A.2.e       | PM <sub>2.5</sub> , PM <sub>10</sub> , TSP, as of 2000 BC                                                                                                                | 2.H.2 (process related emissions)                                          | Relevant part of emissions of all pollutants from CHP plants and steam boilers are reported under 1.A.2.g viii, so the whole emissions are addressed                                                            |
| 1.A.2.f       | NO <sub>x</sub> , NMVOC, SO <sub>x</sub> , PM <sub>2.5</sub> , PM <sub>10</sub> , TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn,                                           | 2.A.1, 2.A.2 and 2.A.6                                                     | Process related part include complete trends of these emissions instead a fuel based calculation within this category, For a full overview, please see the table within <a href="#">Non-Metallic Minerals</a> . |
| 1.A.2.g viii  | B[b]F, B[k]F, I[1,2,3-c,d]P                                                                                                                                              | PAHs 1-4 total                                                             | only summarized PAH data available                                                                                                                                                                              |
| 1.A.3.d i(ii) | all emissions                                                                                                                                                            | 1.A.3.d ii                                                                 | no separate AD available for international inland navigation                                                                                                                                                    |
| 2.A.1         | CO, B[b]F, B[k]F, I[1,2,3-c,d]P                                                                                                                                          | CO: 1.A.2.f; B[b]F, B[k]F, I[1,2,3-c,d]P in PAHs 1-4 total                 | only summarized PAH data available                                                                                                                                                                              |
| 2.A.2         | NH <sub>3</sub>                                                                                                                                                          | 1.A.2.f                                                                    |                                                                                                                                                                                                                 |
| 2.A.5.c       | PM <sub>2.5</sub> , PM <sub>10</sub> , TSP, BC                                                                                                                           | 2.L                                                                        | emissions from storage, handling and transport of dry bulk products reported in NFR 2.L                                                                                                                         |
| 2.A.6         | CO                                                                                                                                                                       | 1.A.2.f                                                                    |                                                                                                                                                                                                                 |
| 2.B.10.b      | PM <sub>2.5</sub> , PM <sub>10</sub> , TSP                                                                                                                               | 2.L                                                                        | emissions from storage, handling and transport of dry bulk products reported in NFR 2.L                                                                                                                         |
| 2.C.4         | NO <sub>x</sub> , NMVOC, SO <sub>2</sub> , NH <sub>3</sub> , CO                                                                                                          | 1.A.2.b                                                                    | emissions from secondary magnesium production reported in NFR 1.A.2.b                                                                                                                                           |
| 2.C.7.d       | PM <sub>2.5</sub> , PM <sub>10</sub> , TSP                                                                                                                               | 2.L                                                                        | emissions from storage, handling and transport of dry bulk products reported in NFR 2.L                                                                                                                         |
| 2.I           | CO                                                                                                                                                                       | 1.A.2                                                                      |                                                                                                                                                                                                                 |
| 3.D.a.2.a     | NMVOC                                                                                                                                                                    | 3.B explanation see chapter                                                |                                                                                                                                                                                                                 |
| 3.D.a.3       | NMVOC                                                                                                                                                                    | 3.B explanation see chapter                                                |                                                                                                                                                                                                                 |

| NFR category | pollutants effected                                                                   | included in      | explanation / reasoning                                       |
|--------------|---------------------------------------------------------------------------------------|------------------|---------------------------------------------------------------|
| 2.D.3.b      | CO                                                                                    | 1.A.2.f          |                                                               |
| 3.B.4.a      | NO <sub>x</sub> , NMVOC, NH <sub>3</sub> , PM <sub>2.5</sub> , PM <sub>10</sub> , TSP | 3.B.1.a, 3.B.1.b | buffaloes included in the population figures for cattle       |
| 3.B.4.f      | NO <sub>x</sub> , NMVOC, NH <sub>3</sub> , PM <sub>2.5</sub> , PM <sub>10</sub> , TSP | 3.B.4.e          | mules and asses are included in population figures for horses |

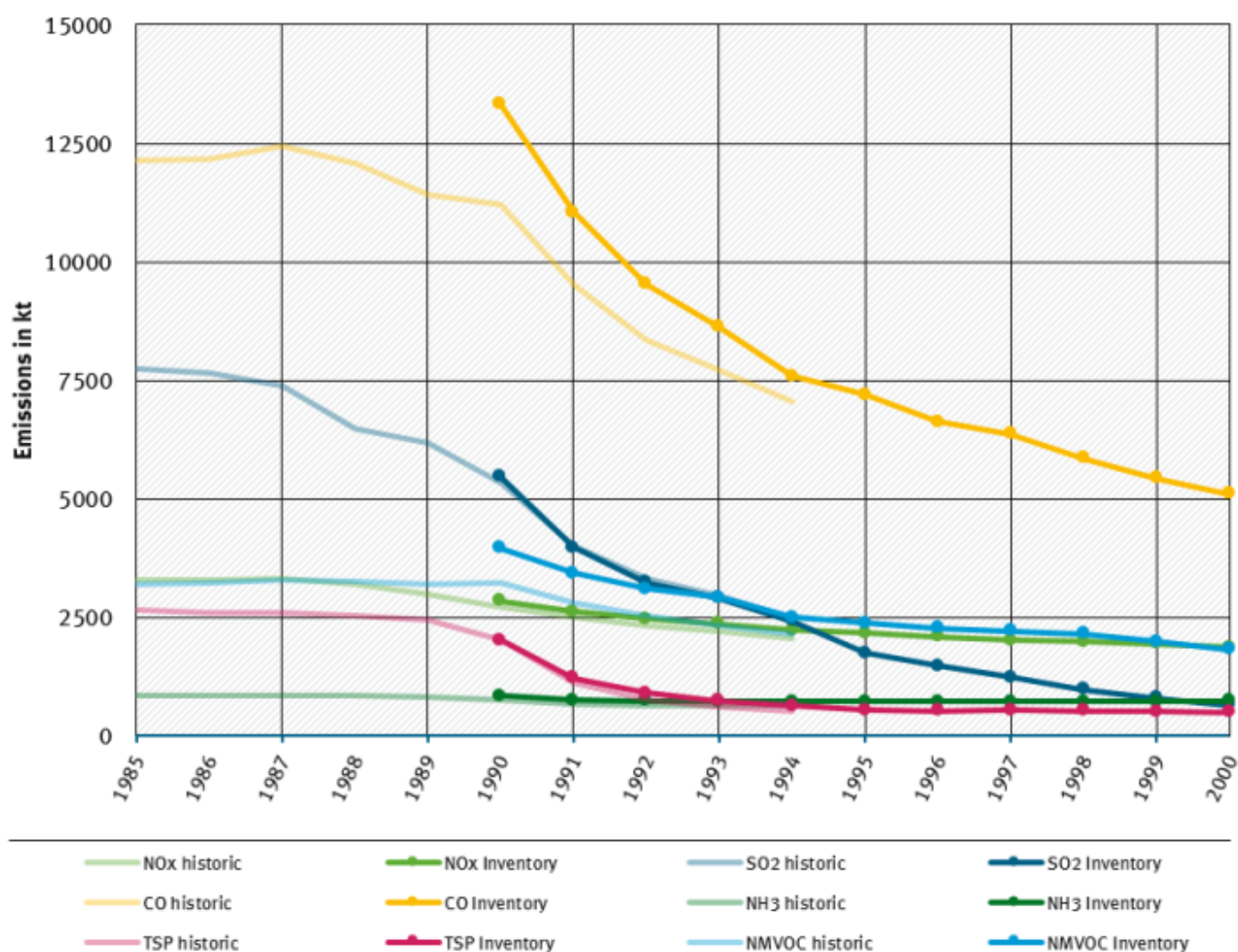
## Emission data for years before 1990

Consistent time series for emissions for years before 1990 are not available.

Up to 1994, Germany calculates some sector's emissions separately for both parts of Germany in distinct procedures, using different substructures and data sources. From 1995 onward, the emissions were calculated for the unified country only.

All inventory improvements coming from our own QA/QC or review recommendations can not be applied for the years before 1990. Insofar, the long-time series is provided only as additional information and to illustrate the general trend since 1970.

### Historic and actual inventory emissions of air pollutants in Germany



\*Historic data and actual inventory data is not comparable due to changes in methodologies & data sources

Quelle: "Long Rows" ("Lange Reihen") 1970-1994 (Stand/von 1999) / German Emission Inventory 1990-2023 (20.03.2025)

Visual comparison of historic data and inventory data for the years 1985 to 2000



## CHAPTER 2: Explanation of Key Trends

This chapter features tabular and graphical representations of emissions and emission trends for CO, NMVOC, NO<sub>x</sub>, SO<sub>2</sub>, NH<sub>3</sub>, TSP, PM<sub>10</sub>, PM<sub>2.5</sub> and Black Carbon.

The covered time scale stretches from 1990 to the latest reporting year for data and further back for general explanation. Emission are listed as totals here and detailed by NFR source category in the pollutant-specific subsections, these also include summaries of the main drivers for the pollutant in question. The subsections also feature details on the inventory preparation process for the individual pollutants and source categories, including the tier of the methods applied and data characterisation.

### Detailed emission trends

- [Nitrogen Oxide \(NO<sub>x</sub>\)](#)
- [Sulfur dioxide \(SO<sub>2</sub>\)](#)
- [Non-Methane Volatile Organic Compounds \(NMVOC\)](#)
- [Ammonia \(NH<sub>3</sub>\)](#)
- [Carbon Monoxide \(CO\)](#)
- [Total suspended particulate matter \(TSP\)](#)
- [Fine Particulate Matter <10µm \(PM<sub>10</sub>\)](#)
- [Fine Particulate Matter <2.5 µm \(PM<sub>2.5</sub>\)](#)
- [Black Carbon \(BC\)](#)
- [Persistent Organic Pollutants \(POP\)](#)
- [Heavy Metals \(HM\)](#)

### Total emission trends

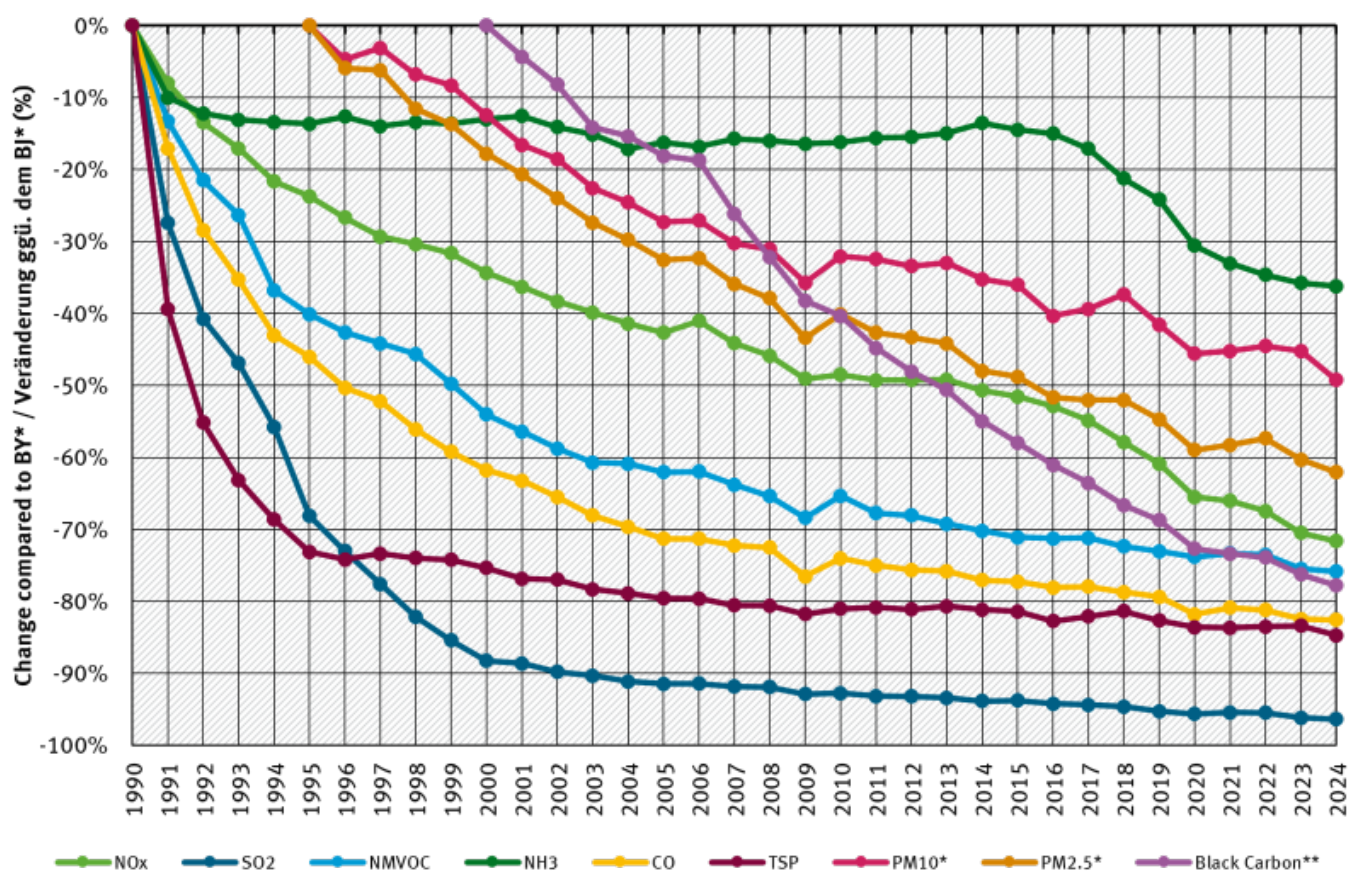
Between the 1950s and 1970s, air pollution in both parts of Germany was considerably higher than today, mainly due to the “traditional” pollutants sulphur dioxide, airborne particulates and to some extent nitrogen oxides. The reduction in the concentration of pollutants has been forced by regulations that induced technological advancements in stationary combustion plants and vehicles and caused the gradual changeover from solid fuels like coal and lignite to oil and gas, the increased use of low-sulphur heating oil, and, later, the desulphurisation of flue gases in large combustion plants (LCP).

Air pollution control measures, regulated by law from 1983 onward, have led to a further major pollutant reduction of average annual levels – to below 25 µg/m<sup>3</sup> in the case of SO<sub>2</sub> concentrations. In eastern Germany, decreases in SO<sub>2</sub> and particulate emissions associated with economic restructuring, redevelopment of smokestack industrial areas, and the construction of advanced, state-of-the-art industrial plants are also reflected in the emission concentrations measured. For example, the annual mean SO<sub>2</sub> pollution levels in the industrial and urban conurbations of West Saxony, southern Saxony-Anhalt, and eastern Thuringia fell from about 150–175 µg/m<sup>3</sup> to 8–15 µg/m<sup>3</sup> between 1990 and 2003. As a result of the reductions achieved, the winter smog alarms that were previously caused by sulphur dioxide emissions have been effectively eliminated. This applies to both East and West Germany, even in topographically unfavourable locations such as valleys and geological basins.

Chart: Total emission trends for the most important pollutants in percent decrease compared to the Base Year<sup>1</sup>

## Air Pollutants / Luftschadstoffe

### Emission Trends / Emissionstrends



\* Base Year (BY) 1990, 1995 for PM10/PM2.5 / Basisjahr (BJ) 1990, 1995 für Feinstaub

\*\* Black Carbon emissions from 2000 / Black Carbon Emissionen erst ab 2000

Quelle: German Emission Inventory (04.02.2026)

<sup>1</sup>: generally 1990 but 1995 for PM<sub>2.5</sub> and PM<sub>10</sub> and 2000 for Black Carbon

Due to the fact that air pollution is not being kept within national borders, the issue has been on both the UN's as well as the European Union's agenda for a long time, resulting in increasingly strict regulations for air quality management, as new knowledge and concepts were taken into consideration. The framework for these regulations is the Council "Framework Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management", the objectives and principles of which are set out in concrete terms in so-called daughter directives.

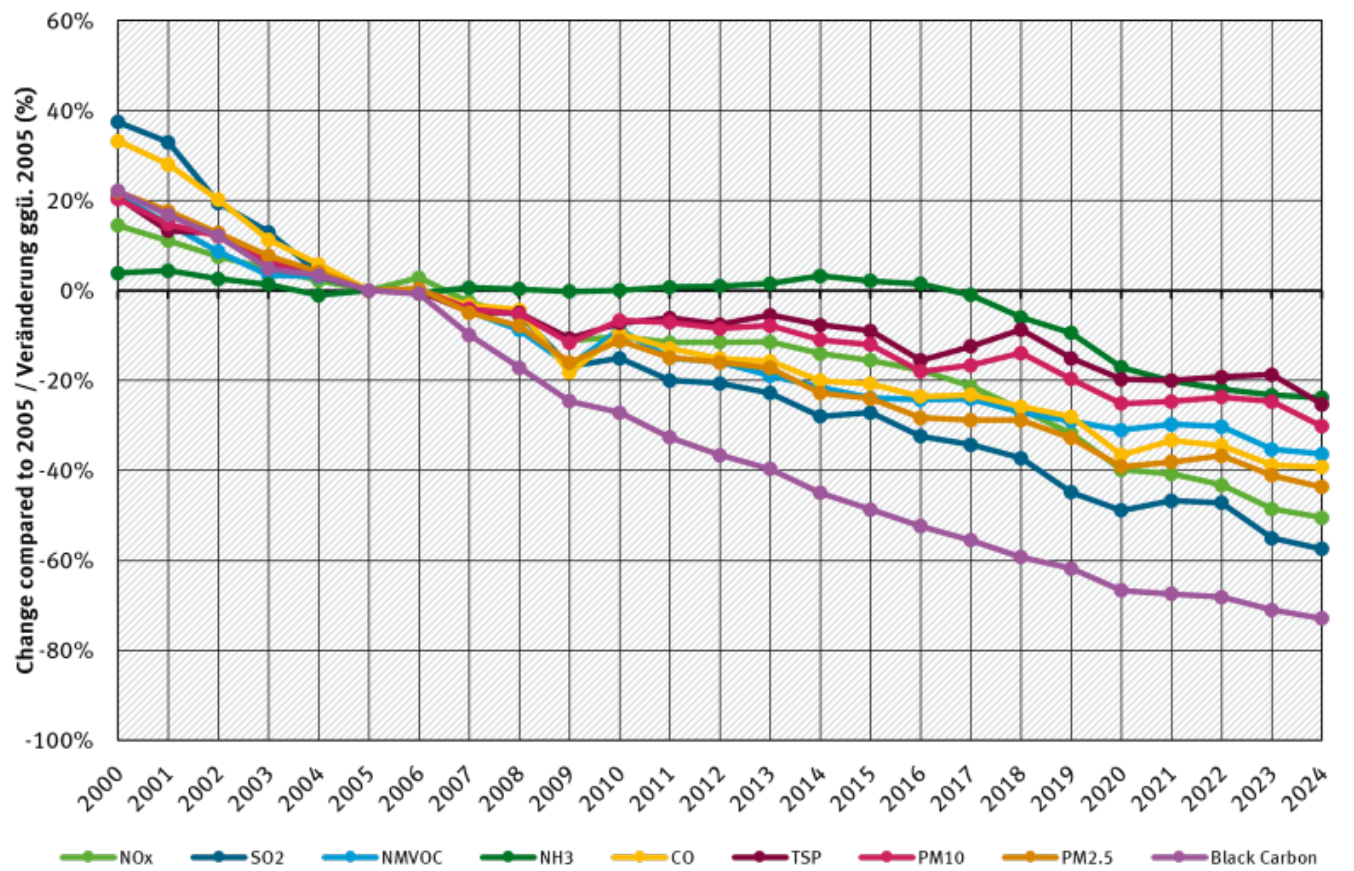
The framework directive and the first two daughter directives were adopted in German law through the 22nd Federal Immission Control Ordinance (22nd BImSchV). The third daughter directive was subsequently adopted through the 33rd Federal Immission Control Ordinance (33rd BImSchV), whilst the fourth daughter directive is currently passing through the legislative process. The limit values specified in the daughter directives are based on the work of the World Health Organisation (WHO) and, in general, are considerably lower than the limits specified in previous regulations. Where particle emissions are considered, new limit values for fine dust (PM<sub>10</sub>) have replaced the previous limit values for total suspended particulate matter (TSP). Another new feature compared to the previous EC directives is that the first daughter directive makes it compulsory to make up-to-date information on ambient air quality and air pollution situation routinely available to the public.

In addition to the air quality directives, the European Commission has also issued Directive 2001/81/EC on national emission ceilings (NEC) for certain atmospheric pollutants, restricting maximum national emission levels for the year 2010. This directive covers sulphur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), ammonia (NH<sub>3</sub>), and volatile organic compounds (VOC), and was adopted into German law through the 33rd BImSchV. In late 2016, the revised NEC Directive EU/2016/2284 has entered into force, establishing emission reduction target for 2020 and 2030.



# Air Pollutants / Luftschadstoffe

## Emission Trends / Emissionstrends



Quelle: German Emission Inventory (04.02.2026)

# Explanation of Key Trends - Nitrogen Oxides

## Obligations

Within the scope of the LRTAP Convention, the Federal Republic of Germany was obliged to reduce emissions of NO<sub>x</sub> to the 1987 level of 3,177kt by 1994. However, this value is inconsistent with the time series data after 1990 because, for example, it does not include any emissions from the agricultural sector. But emissions were successfully reduced by close to 30% to 2,255 kt in this period, exceeding the obligatory requirements of the protocol and also meeting the additional voluntary commitment that was entered into by Germany and 11 other ECE countries (reduction of NO<sub>x</sub> emissions before 1998 by 30% compared to 1986 levels).

More recently, Germany has made a commitment under the multicomponent protocol to further minimise NO<sub>x</sub> emissions. By 2010, it will no longer be permissible to exceed a National Emission Ceiling of 1,081kt NO<sub>x</sub> for Germany as whole. The revised Gothenburg Protocol and the revised NEC Directive both define emission reduction targets relative to a 2005 base year, mandating 39% (2020) and 65% (2030) reductions respectively.

While Germany's compliance with these obligations is not discussed here, further information on this subject can be found in [Chapter 10 - Projections](#) and [Chapter 12 - Adjustments and Emission Ceiling Exceedance](#).

## Main drivers

NO<sub>x</sub> **total emissions** show a falling trend from 1990 onwards, with emission **reductions of 71.6%** between 1990 and 2024 and steadily falling emissions in the last years.

**Main driver** for NO<sub>x</sub> emissions is **Fuel Combustion (NFR 1.A)** with over 91% of 1990 emissions and a 75% reduction from 1990 to 2024. About half of the 1990 emissions from NFR 1.A and a similar reduction (-81%) between 1990 and 2024 comes from **Road Transportation (NFR 1.A.3.b)**, mainly due to increasingly stricter regulations resulting in technical improvements.

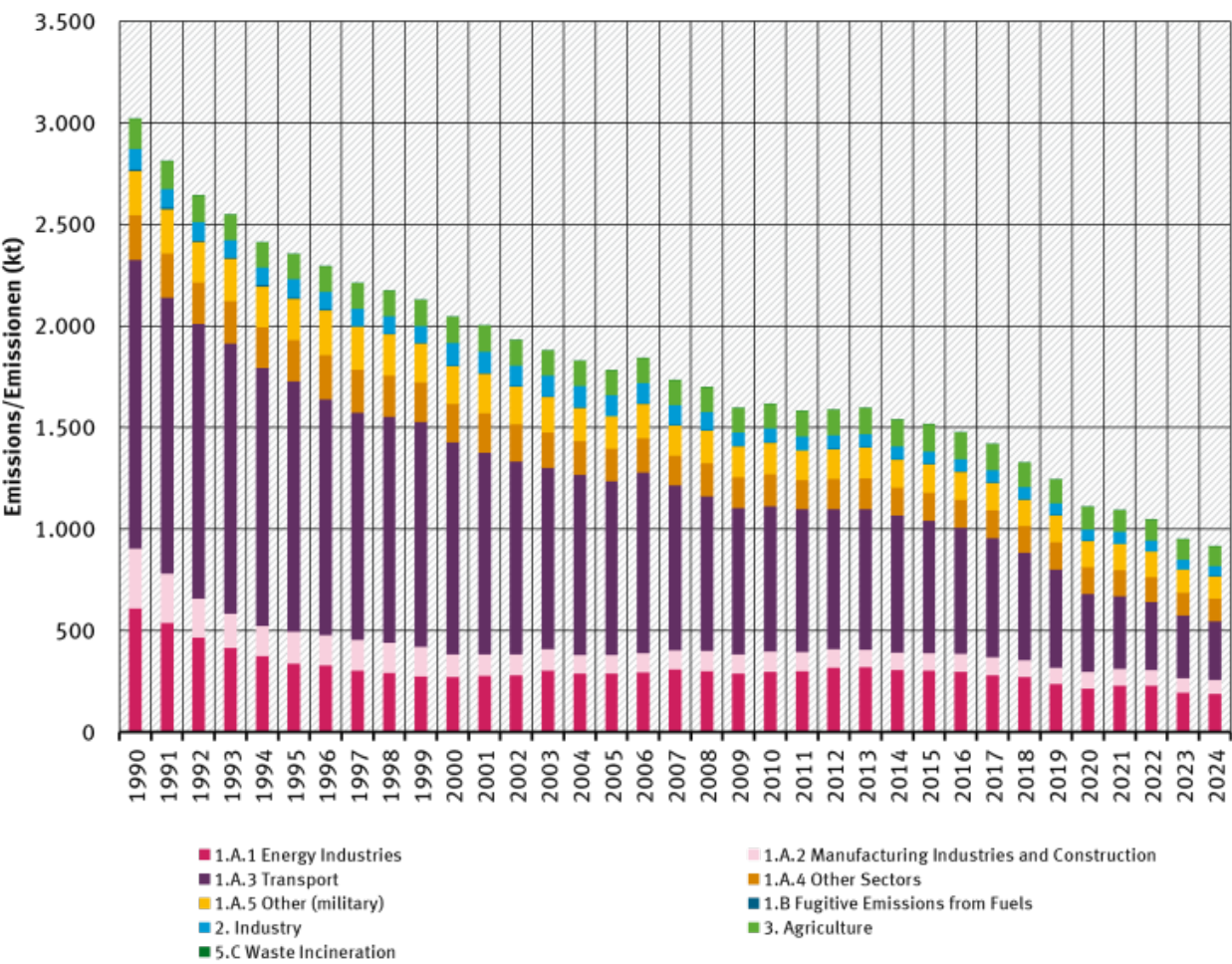
The rest of the 1990 emissions mainly comes from **Energy Industries (NFR 1.A.1)** with a 23% share of 1990 Fuel Combustion (NFR 1.A) emissions and a 69% reduction and, to a lesser extend, from **Manufacturing Industries and Construction (NFR 1.A.2)** with an 11% share and 69% reduction followed by **Other Sectors (NFR 1.A.4)** with a share of 8% and a 50% reduction between 1990 and 2024. For **NFR 1.A.2**, some emissions were reassigned to the **Industrial Processes (NRF 2)** starting from the year 2000, leading to lower emissions from NFR 1 and a similar rise in NRF 2.

Table: NO<sub>x</sub> emissions 1990-2024, in kilotonnes [kt]

|       |       |       |       |       |       |       |       |       |       |      |      |      |      |      | Trend: latest compared to |               |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|---------------------------|---------------|
| 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020 | 2021 | 2022 | 2023 | 2024 | 1990                      | previous year |
| 2 850 | 2 173 | 1 871 | 1 634 | 1 468 | 1 381 | 1 343 | 1 286 | 1 201 | 1 115 | 983  | 969  | 928  | 841  | 809  | -71.6%                    | -3.8%         |

Nitrogen Oxide / Stickstoffoxide

Emissions per Sector / Sektorale Emissionen

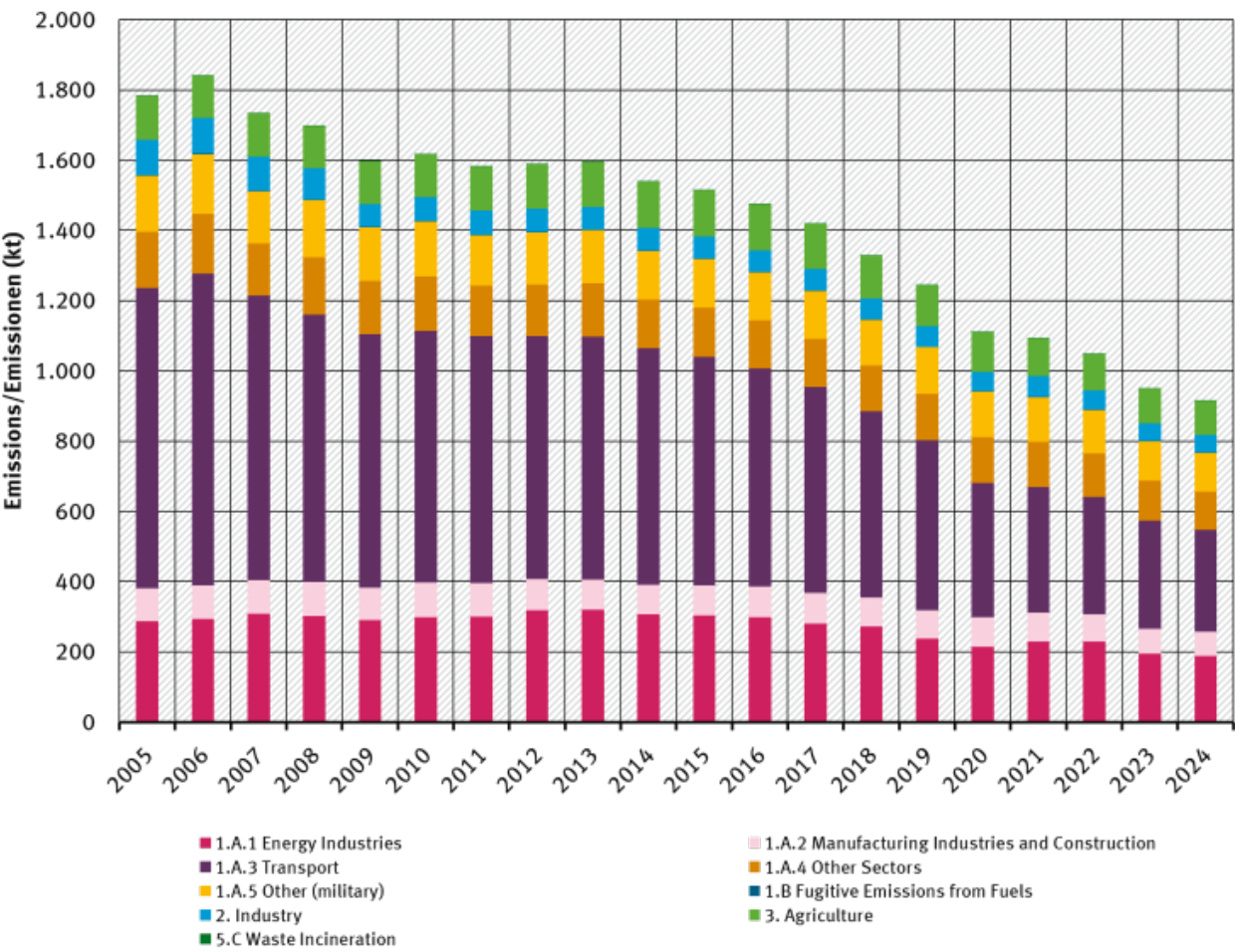


Quelle: German Emission Inventory (04.02.2026)



Nitrogen Oxide / Stickstoffoxide

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)

# Explanation of Key Trends - Sulfur Dioxide

## Obligations

Under the terms of the UN ECE Geneva Convention on Long-range Transboundary Air Pollution Control (CLTRAP, 1979), the Federal Republic of Germany was obliged by the UN ECE Helsinki Protocol to reduce its annual sulphur emissions by at least 30% by 1993, as compared to 1980 levels. In 1993, the SO<sub>2</sub> emissions were 2.9 Mt, compared to approximately 7.5 Mt in 1980. This represents a reduction of 61%. The second UN ECE protocol on the reduction of sulphur emissions obliged Germany to reduce SO<sub>2</sub> emissions to 1300 kt by 2000, and to 990 kt by 2005. The targets set for 2000 & 2005 have already been achieved by 1998.

More recently, Germany has made a commitment under the multicomponent protocol to further minimise SO<sub>2</sub> emissions. Since 2010, it is no longer permissible to exceed a National Emission Ceiling of 550 kt SO<sub>2</sub> for Germany as whole. The revised Gothenburg Protocol and the revised NEC Directive both define emission reduction targets relative to a 2005 base year, mandating 21 % (2020) and 58 % (2030) reductions respectively.

While Germany's compliance with these obligations is not discussed here, further information on this subject can be found in [Chapter 9 - Projections](#) and [Chapter 11 - Adjustments and Emission Ceiling Exceedance](#).

## Main drivers

SO<sub>2</sub> **total emissions** show a falling trend from 1990 onwards, with **emission reductions of over 95% since 1990**.

By far the largest proportion of SO<sub>2</sub> is produced by the oxidation of the sulphur contained in the fuels used in combustion processes, **Fuel Combustion (NFR 1.A)** with a 96% share of total SO<sub>2</sub> emissions in 1990 and a 97% reduction between 1990 and 2023.

In 1990, the biggest source of emissions therein is **Public Electricity and Heat Production (NFR 1.A.1.a)** with about 47% of the emissions from **Fuel Combustion (NFR 1.A)**. Other sources substantially influencing the SO<sub>2</sub> emission trend are **Manufacturing Industries and Construction (NFR 1.A.2)** and **Other Sectors (NFR 1.A.4**, including commercial/institutional and residential sources), each adding about one fifth of 1990 emissions from Fuel Combustion (NFR 1.A).

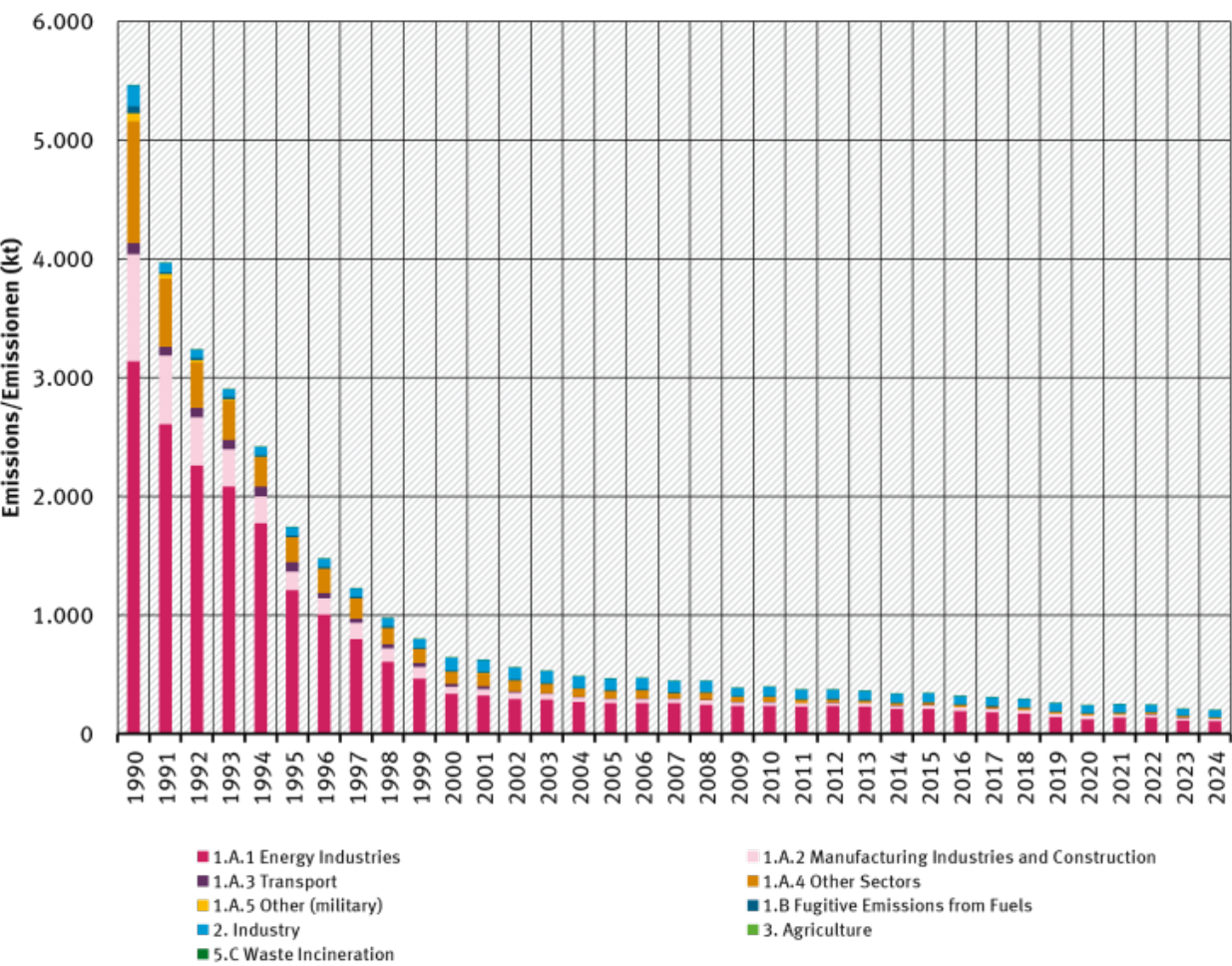
All of these sub-categories show a reduction >95 per cent between 1990 and 2023, due to stricter regulations of West Germany that applied to the New German Länder after the German Reunification and changed the fuel mix from sulphur-rich solid fuels to liquid and gaseous fuels.

Table: SO<sub>2</sub> emissions 1990-2024, in kilotonnes [kt]

|       |       |      |      |      |      |      |      |      |      |      |      |      |      |      | Trend: latest compared to |               |
|-------|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|---------------------------|---------------|
| 1990  | 1995  | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 1990                      | previous year |
| 5 461 | 1 743 | 643  | 468  | 397  | 341  | 316  | 307  | 294  | 258  | 239  | 249  | 247  | 210  | 199  | -96.4%                    | -5.3%         |

# Sulfur Dioxide / Schwefeldioxid

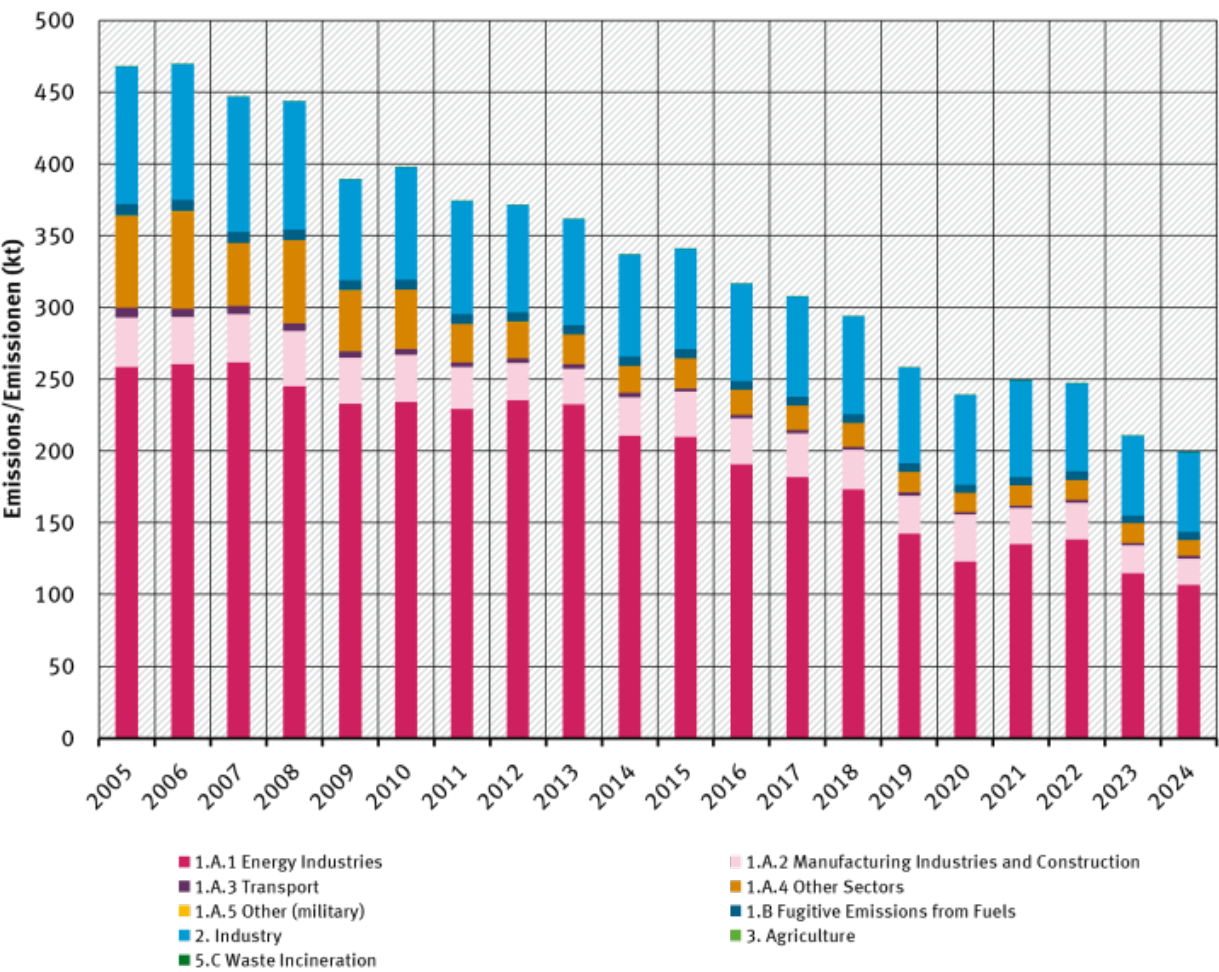
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)

# Sulfur Dioxide / Schwefeldioxid

## Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)



# Explanation of Key Trends - Non Methane Volatile Organic Compounds

## Obligations

Germany has made a commitment under the Gothenburg Protocol to reduce NMVOC emissions. Since 2010, it is no longer permissible to exceed a National Emission Ceiling of 995 kt NMVOC for Germany as whole. The revised Gothenburg Protocol and the revised NEC Directive both define emission reduction targets relative to a 2005 base year, mandating 13% (2020) and 28% (2030) reductions respectively.

While Germany's compliance with these obligations is not discussed here, further information on this subject can be found in [Chapter 9 - Projections](#) and [Chapter 11 - Adjustments and Emission Ceiling Exceedance](#).

## Main drivers

NMVOC **total emissions** show a falling trend from 1990 onwards, with **emission reductions of 75.8% between 1990 and 2024**.

Here, a bump occurs in 2010 after the dent of 2008 and 2009 due to the economic situation. After a period of stagnating emissions, the last few years show a slight annual emission reduction of 3% on average.

Main driver for NMVOC emissions is **NFR 1.A - Fuel Combustion** with about half of total 1990 emissions and a 92% reduction between 1990 and 2024. Within 1.A, **Road Transport (1.A.3.b)** is responsible for about three quarters of the 1990 emissions, with **Passenger Cars (1.A.3.b i)** emitting the vast majority. Reductions of about 95% in those categories between 1990 and 2023 are mainly due to increasingly stricter regulations, especially incentives for automobile users to retrofit/buy cars with catalytic converters.

Furthermore, the implementation of the Technical Instruction on Air Quality Control (TA-Luft 2002), to decreases in emissions from **petrol storage and from fuelling of motor vehicles (1.B.2.a.v)** - as a result of implementation of the 20th and 21st Ordinances on the Execution of the Federal Immission Control Act (BImSchV) - and to reduced petrol consumption play a major role in the reduction of NMVOC emissions within the category **Fugitive Emissions from fossil fuels (NRF 1.B.2)**.

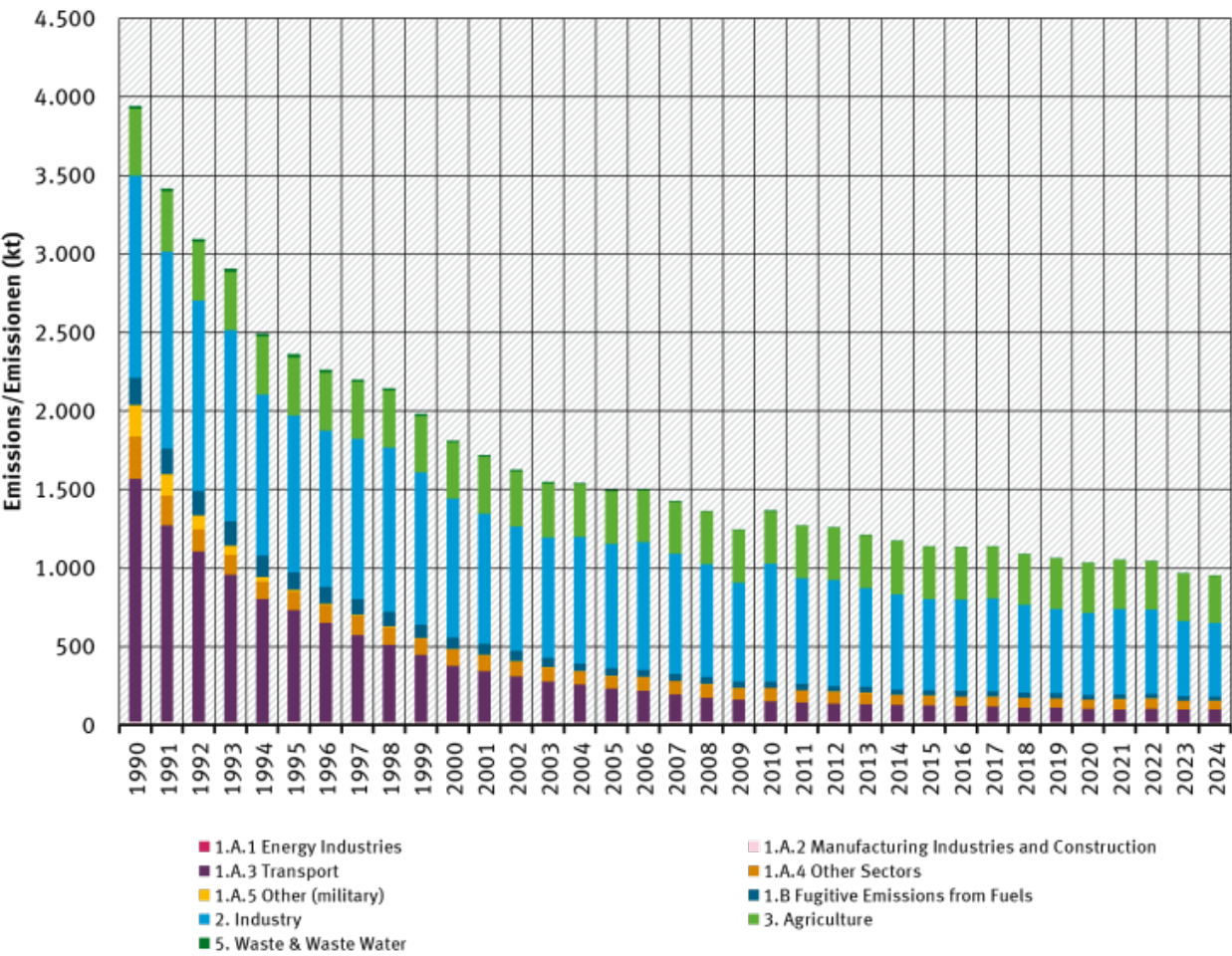
Substantial emissions also come from **Non-Energy Products from Fuels (NFR 2.D)**, emitting 29% of total 1990 emissions and a 65% reduction between 1990 and 2024.

Table: NMVOC emissions 1990-2024, in kilotonnes [kt]

|       |       |       |       |       |       |       |       |       |       |       |       |       |      |      | Trend: latest compared to |               |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|---------------------------|---------------|
| 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023 | 2024 | 1990                      | previous year |
| 3 942 | 2 361 | 1 813 | 1 497 | 1 367 | 1 140 | 1 134 | 1 137 | 1 091 | 1 062 | 1 032 | 1 052 | 1 044 | 968  | 953  | -75.8%                    | -1.6%         |

NMVOC

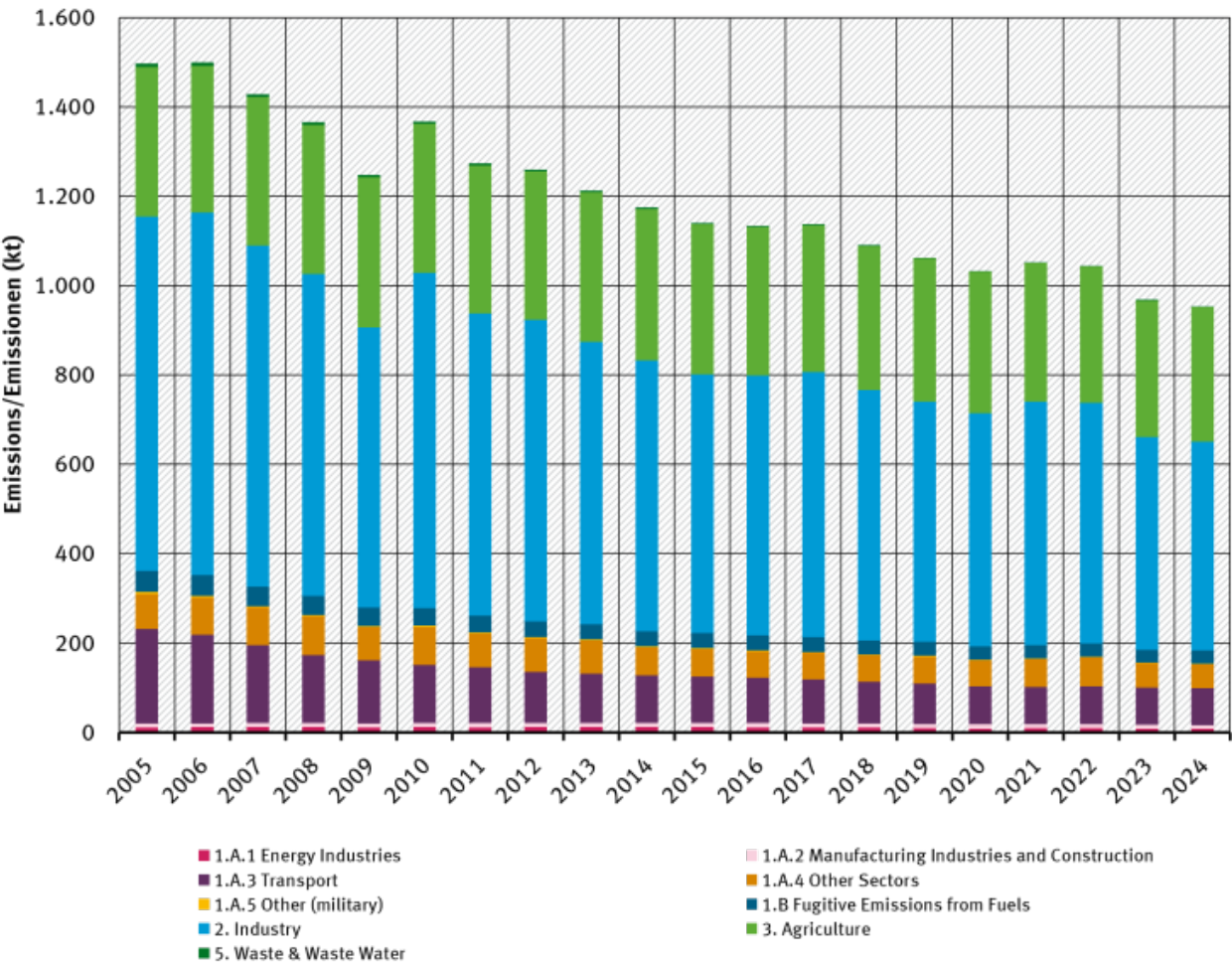
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)

NMVOC

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)

# Explanation of Key Trends - Ammonia

## Obligations

Germany has made a commitment under the Gothenburg Protocol to reduce ammonia emissions. Since 2010, it is no longer permissible to exceed a National Emission Ceiling of 550 kt NH<sub>3</sub> for Germany as whole. The revised Gothenburg Protocol and the revised NEC Directive both define emission reduction targets relative to a 2005 base year, mandating 5% (2020) and 29% (2030) reductions respectively.

While Germany's compliance with these obligations is not discussed here, further information on this subject can be found in [Chapter 9 - Projections](#) and [Chapter 11 - Adjustments and Emission Ceiling Exceedance](#).

## Main drivers

The Main Drivers for NH<sub>3</sub> emissions are agricultural emissions from **Manure Management (NFR 3.B)** with 36% of total 1990 emissions and a 37% reduction between 1990-2024 and **Agricultural Soils (NFR 3.D)** with even 59% of total 1990 emissions and a 39% decrease.

The overall emission trend follows the agricultural emissions closely with a **total reduction of 32% since 1990**.

The decrease of NH<sub>3</sub> emission in the year 1991 is due to a reduced livestock population that followed after the German reunification, while no explicit trend is discernible for the years up to 2014. Between 2015 and 2024 the emissions are dropping every year adding up to a 26% drop. Here, emissions dropped by 8.4% between 2019 and 2020, an decrease only topped by the reduction between 1990 and 1991 (minus 10%).

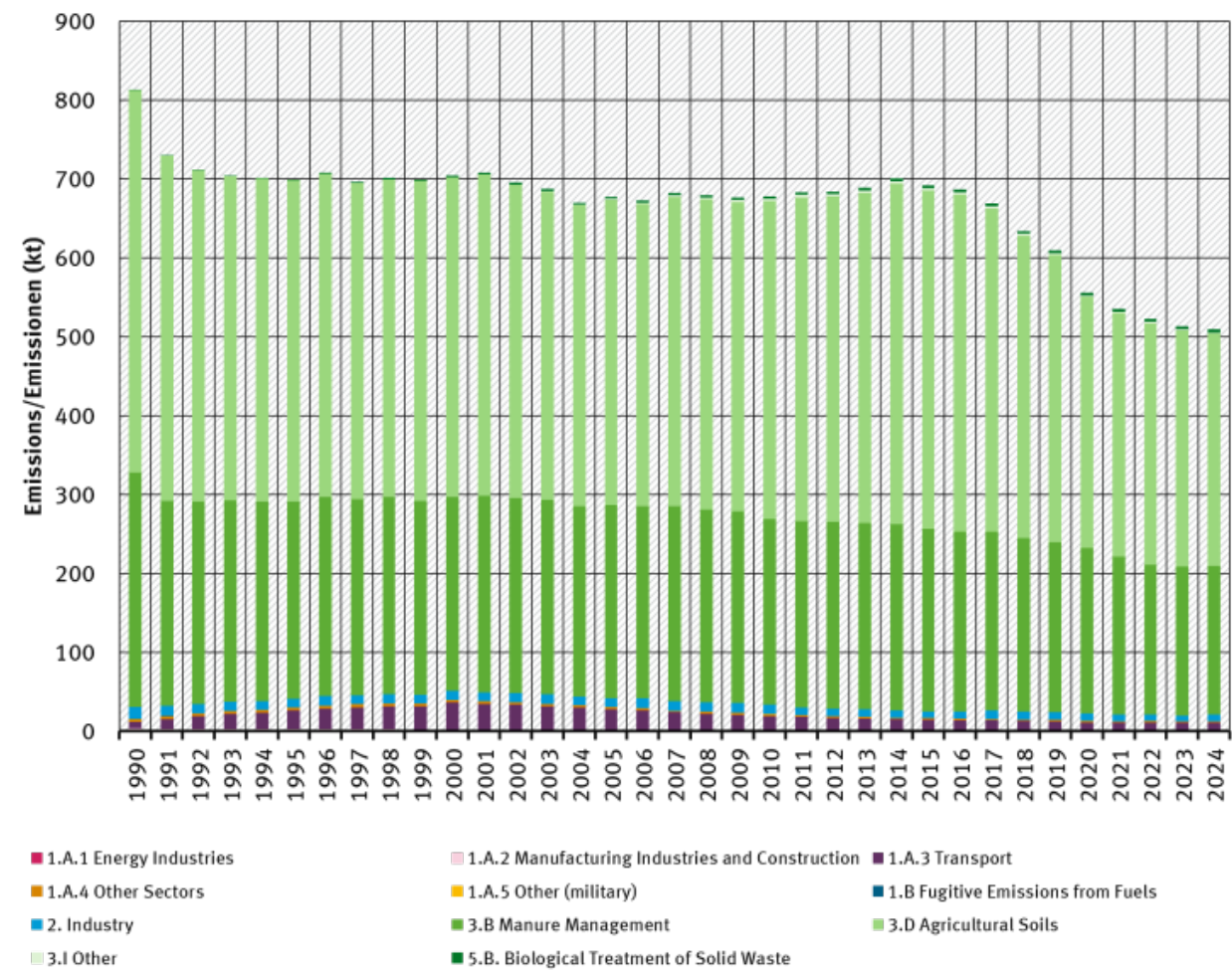
Table: Ammonia emissions 1990-2024, in kilotonnes [kt]

|      |      |      |      |      |      |      |      |      |      |      |      |      |      |      | Trend: latest compared to |               |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|---------------------------|---------------|
| 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 1990                      | previous year |
| 827  | 714  | 720  | 693  | 693  | 708  | 703  | 686  | 651  | 627  | 574  | 554  | 541  | 532  | 528  | -36.2%                    | -0.7%         |



Ammonia / Ammoniak

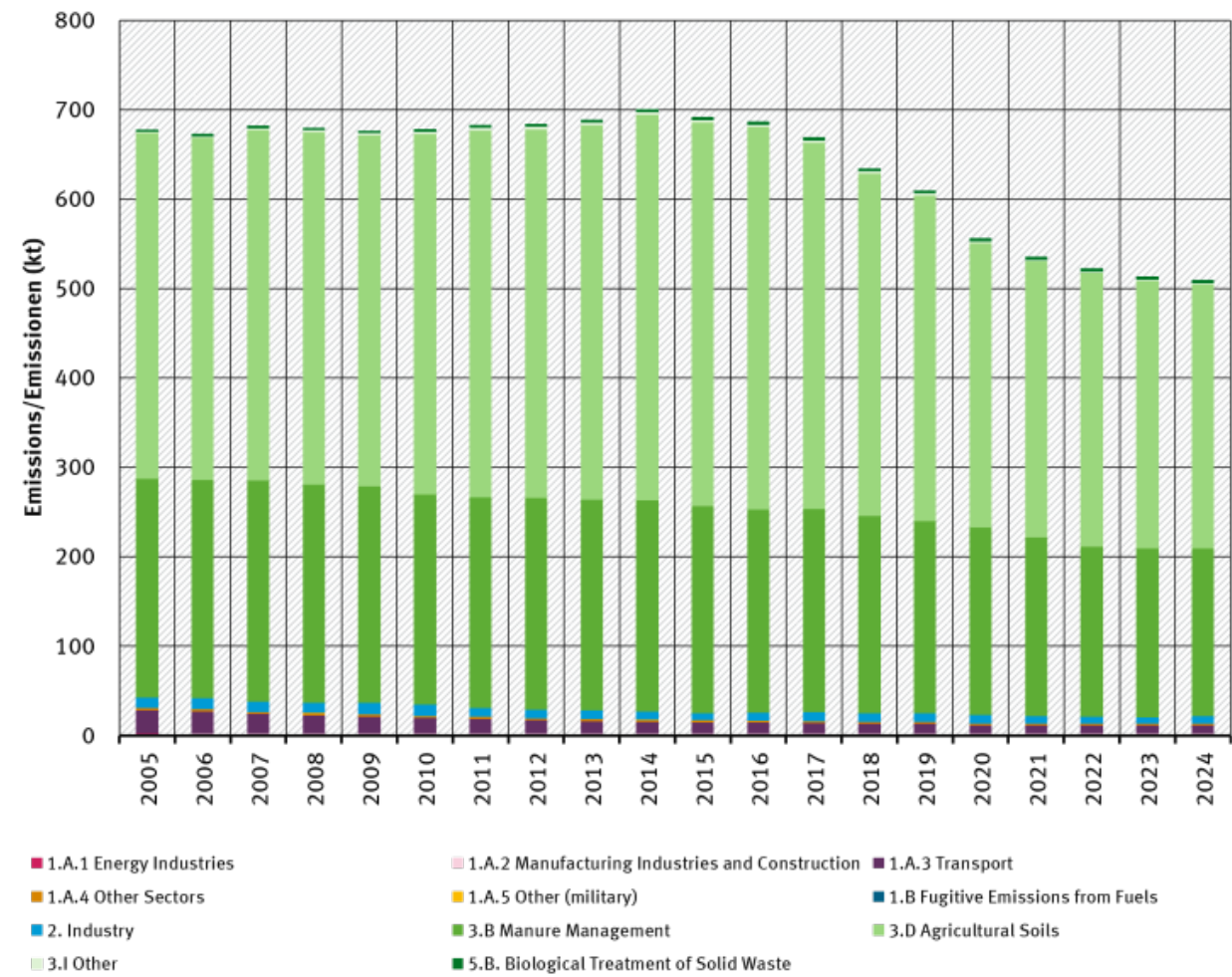
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)

Ammonia / Ammoniak

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)



# Explanation of Key Trends - Carbon Monoxide

## Main drivers

**CO total emissions** show a falling trend over the whole interval, with emission **reductions of 82.6 %** between 1990 and 2024 and a renewed interval of emission reductions in the last years.

**Main driver** for CO emissions is **Fuel Combustion (NFR 1.A)** with 90% of total 1990 emissions and an 87% reduction between 1990 and 2024. Within NFR 1.A, **Road Transport (NFR 1.A.3.b)** is responsible for 63% of the 1990 emissions, with **Passenger Cars (NFR 1.A.3.b.i)** emitting more than 90% of it. Reductions of about 90% between 1990 and 2024 result mainly from constantly improving fuels and increasingly stricter regulations resulting in technical improvements.

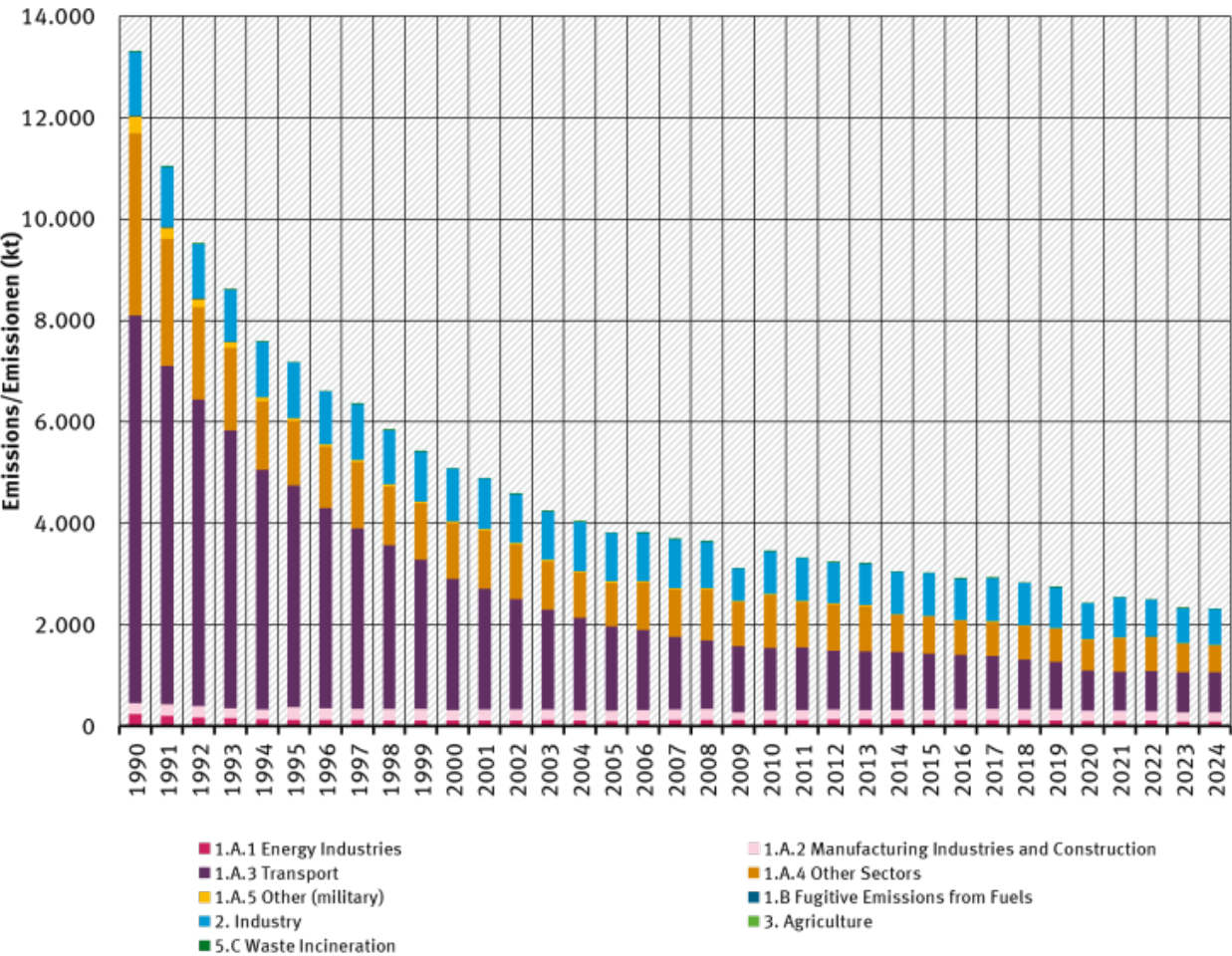
**Other Sectors (NFR 1.A.4**, including commercial/institutional and residential sources) are responsible for about 30% of 1990 Fuel Combustion emissions with a 85% reduction between 1990 and 2024.

Table: Carbon monoxide emissions 1990-2024, in kilotonnes [kt]

|        |       |       |       |       |       |       |       |       |       |       |       |       |       |       | Trend: latest compared to |               |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------------------------|---------------|
| 1990   | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  | 1990                      | previous year |
| 13 319 | 7 187 | 5 096 | 3 825 | 3 461 | 3 033 | 2 923 | 2 938 | 2 838 | 2 751 | 2 428 | 2 551 | 2 507 | 2 340 | 2 322 | -82.6%                    | -0.8%         |

## Carbon Monoxide / Kohlenmonoxid

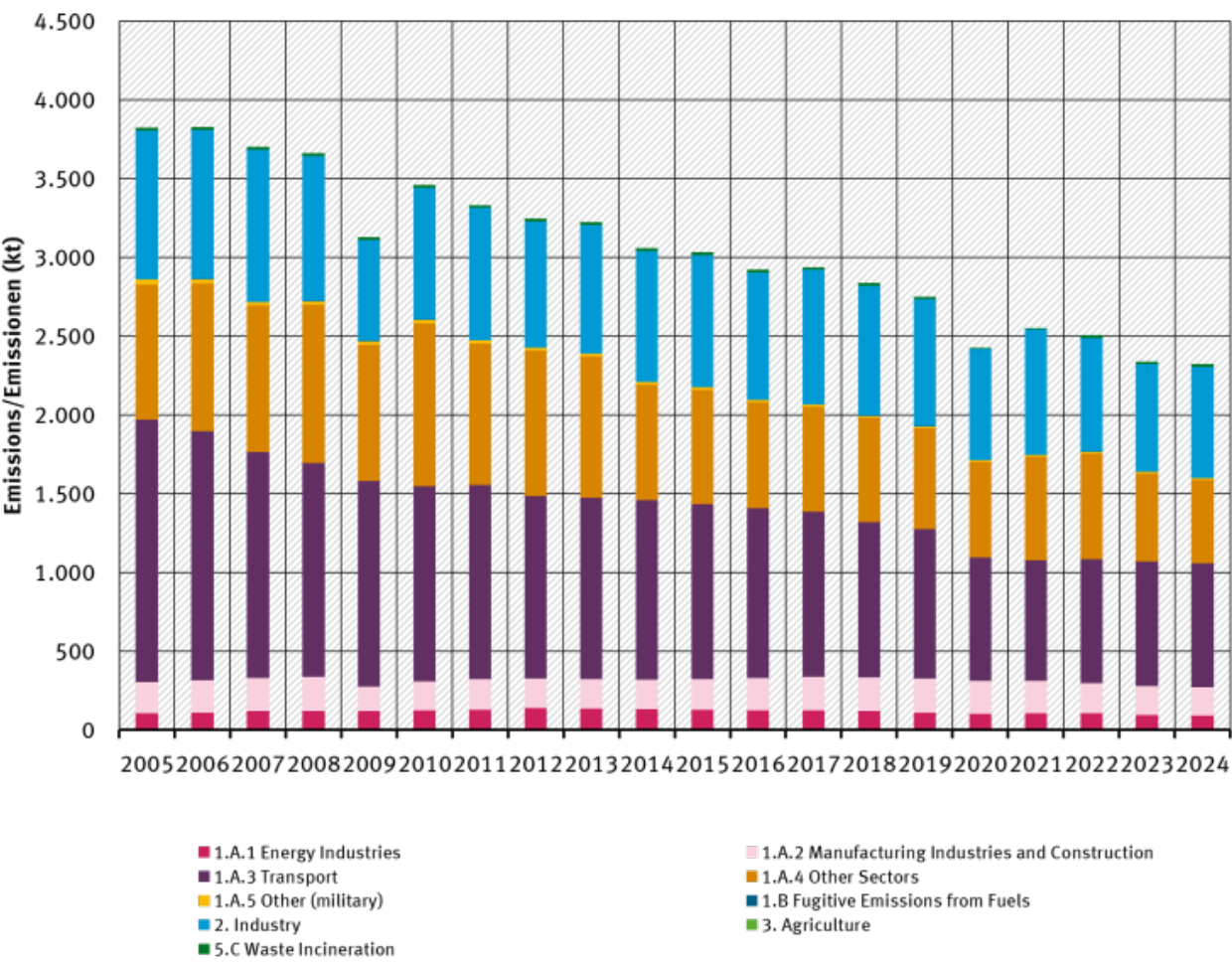
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)

Carbon Monoxide / Kohlenmonoxid

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)

# Explanation of Key Trends - Total Suspended Particulate Matter

## Main drivers

Between 1990 and 2024, **total TSP emissions dropped by 84.7%**, mainly due to stricter regulations of the Old West Germany that applied to the New German Länder after the German Reunification and realized a change-over from solid to gaseous and liquid fuel, as well as advancements in filter technologies of combustion plants and industrial processes.

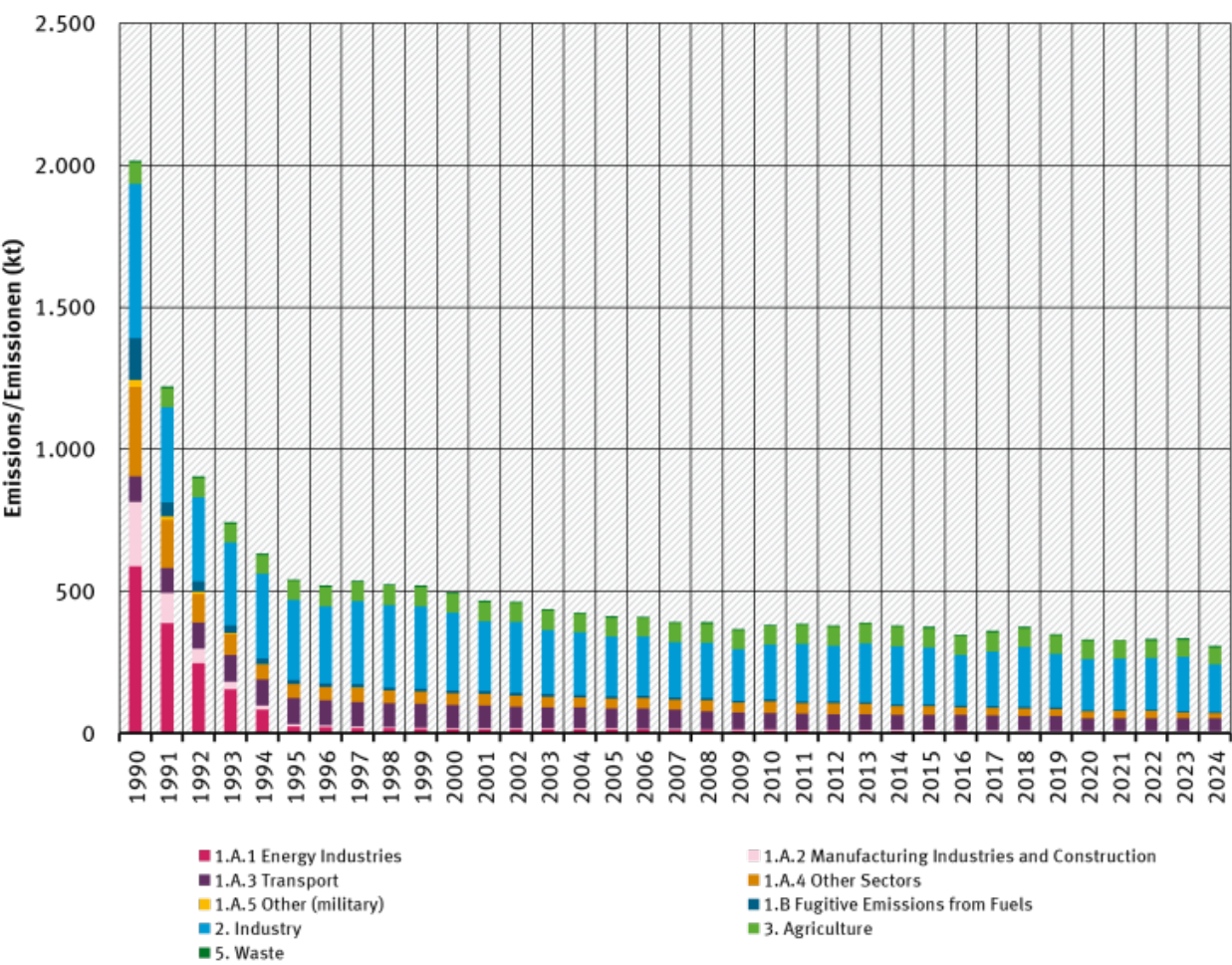
The Main Drivers for TSP emissions are **Fuel Combustion (NFR 1.A)** with 62% of total 1990 emissions and a 94% reduction between 1990 and 2024 and, as a sum, the **Industrial Processes (NFR 2)** with 27% of the total 1990 emissions and a 69% reduction between 1990 ans 2024.

Table: TSP emissions 1990-2024, in kilotonnes [kt]

|       |      |      |      |      |      |      |      |      |      |      |      |      |      |      | Trend: latest compared to |               |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|---------------------------|---------------|
| 1990  | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 1990                      | previous year |
| 2 015 | 542  | 497  | 412  | 382  | 375  | 348  | 361  | 376  | 350  | 331  | 330  | 333  | 335  | 308  | -84.7%                    | -8.1%         |

### Total Suspended Particulate Matter / Gesamtstaub (TSP)

Emissions per Sector / Sektorale Emissionen

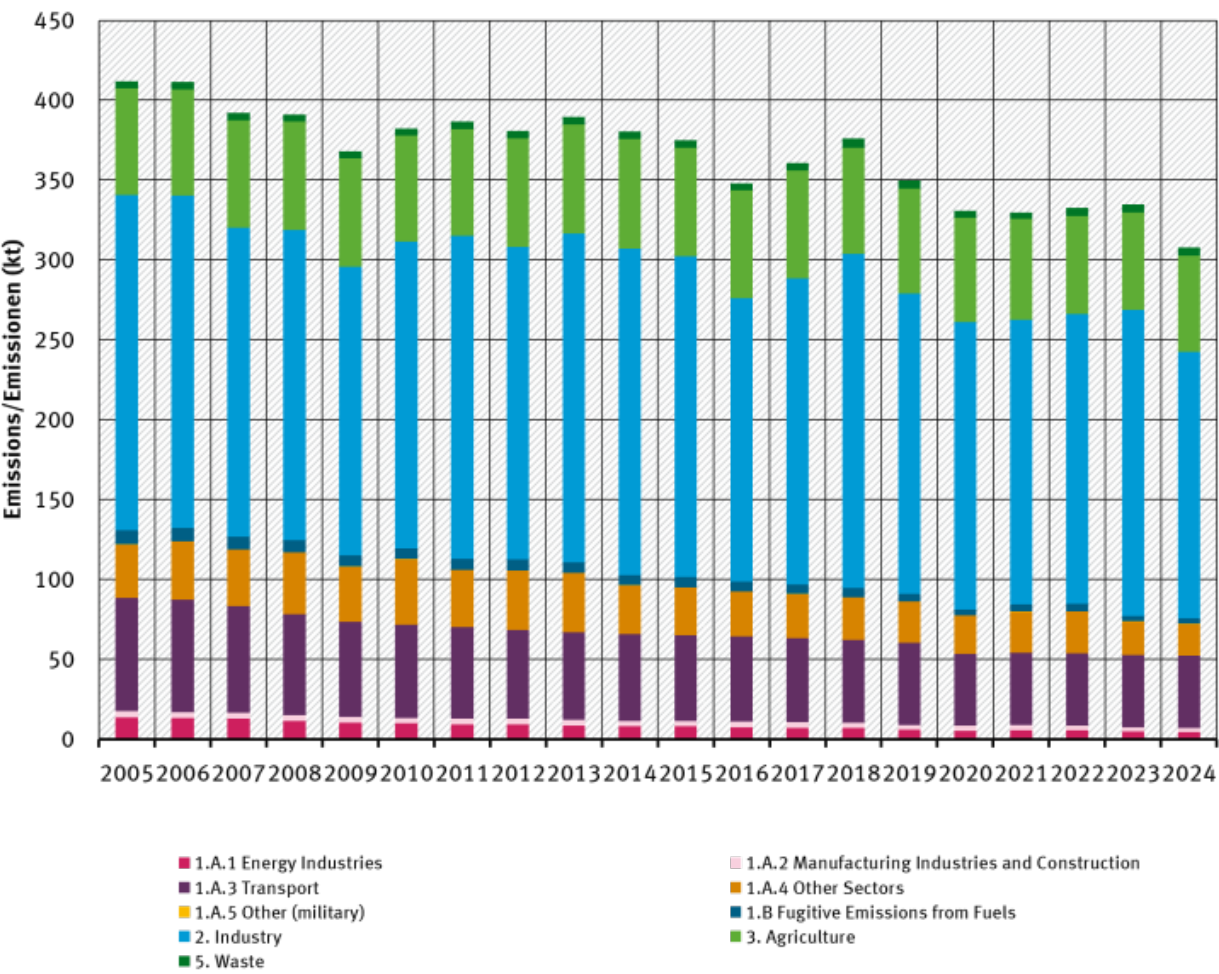


Quelle: German Emission Inventory (04.02.2026)



Total Suspended Particulate Matter / Gesamtstaub (TSP)

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)

# Explanation of Key Trends - Fine Particulate Matter (PM<sub>10</sub>)

## Main drivers

Between 1995 and 2024, **total PM<sub>10</sub> emissions dropped by 49.2%**.

The **main drivers** for PM<sub>10</sub> emissions are **Fuel Combustion (NFR 1.A)** with 48% of total 1995 emissions and a 63% reduction between 1995 and 2024 **and**, as a total, the **Industrial Processes (NFR 2)** (and here especially **Handling of Bulk Products NFR 2.L**) with 38% of total 1995 emissions and a 46% reduction.

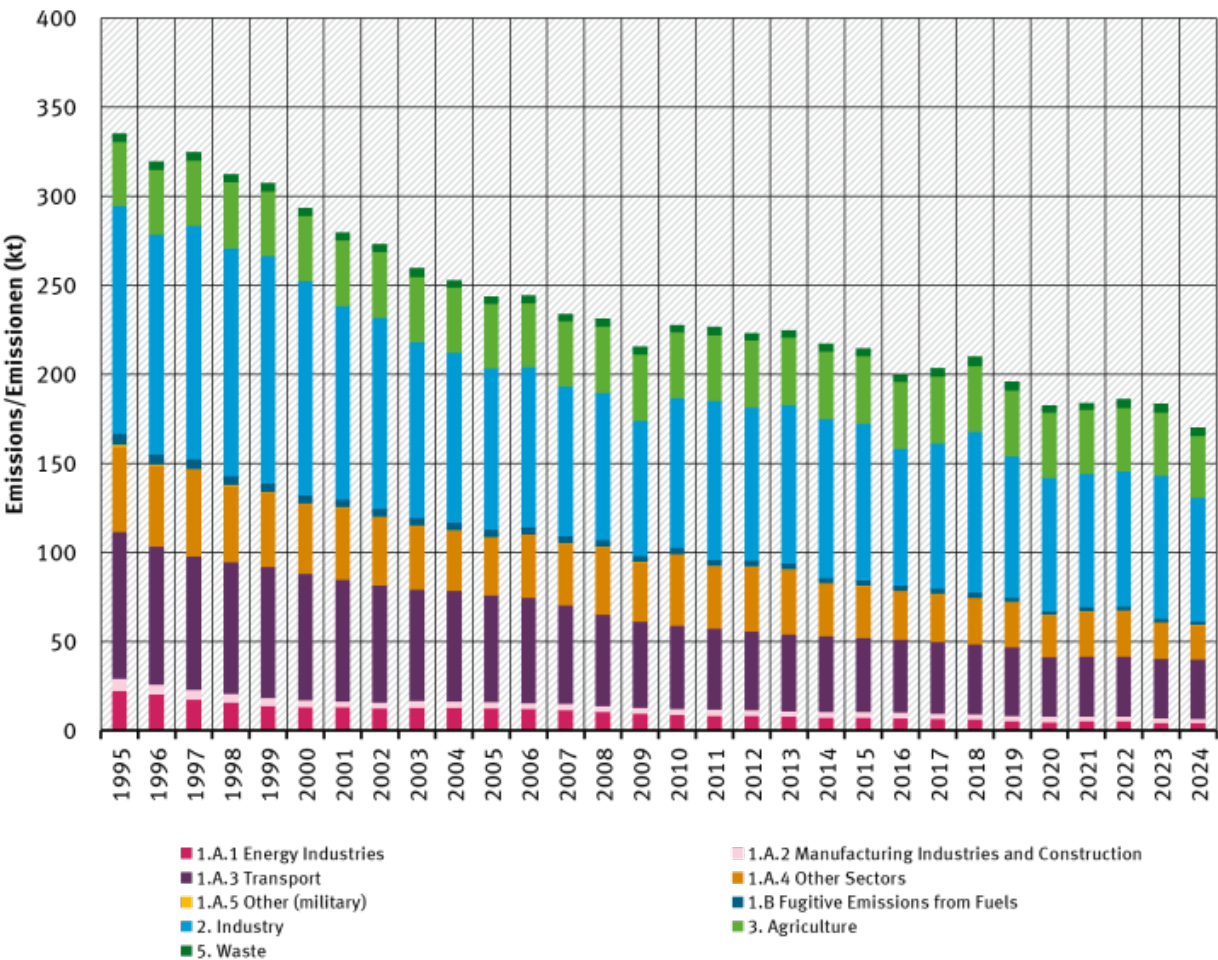
Within NFR 1.A, **Transport (NFR 1.A.3)** produces the biggest part of PM<sub>10</sub> emissions. Here, about 88% of the 2024 Transport PM<sub>10</sub> emissions are caused by **Road Transport (NFR 1.A.3.b)**. About 15% of these emissions are directly caused by **fuel combustion (NFRs 1.A.3.b.i-iv)** whereas 85% stem from **tyre and brake wear (1.A.3.b.vi) and road abrasion (vii)**.

Table: PM<sub>10</sub> Emissions 1990-2024, in kilotonnes [kt]

|      |      |      |      |      |      |      |      |      |      |      |      |      |      | Trend: latest year compared to... |                  |  |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----------------------------------|------------------|--|
| 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | ...BY (1995)                      | ...previous year |  |
| 335  | 294  | 244  | 228  | 215  | 200  | 203  | 210  | 196  | 183  | 184  | 186  | 184  | 170  | -49.2%                            | -7.3%            |  |

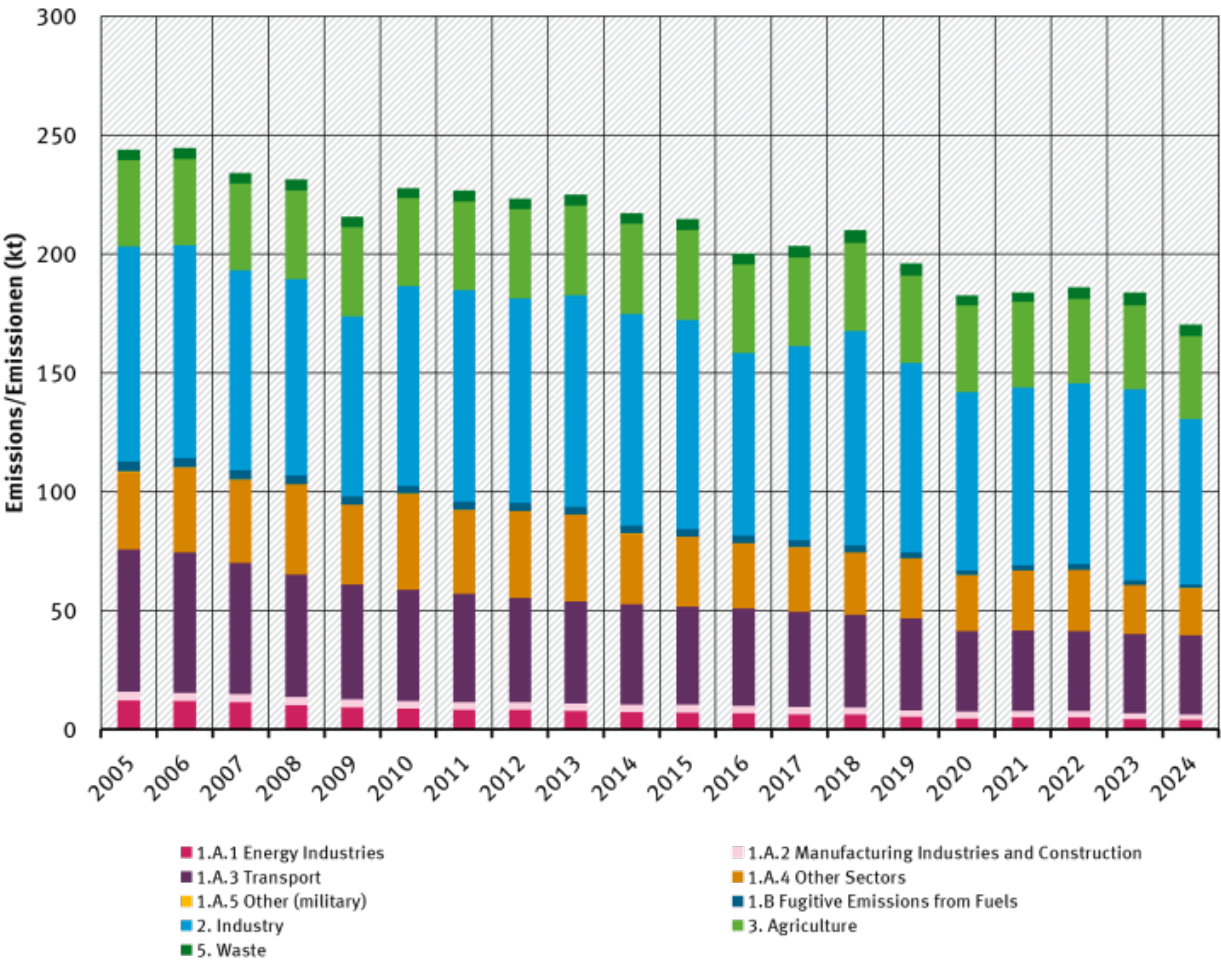
## Fine Particulate Matter / Feinstaub (PM10)

Emissions per Sector / Sektorale Emissionen



Fine Particulate Matter / Feinstaub (PM10)

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)



# Explanation of Key Trends - Fine Particulate Matter (PM<sub>2.5</sub>)

## Obligations

Germany has made a commitment to reduce particulate matter emissions. The revised Gothenburg Protocol and the revised NEC Directive both define emission reduction targets relative to a 2005 base year, mandating 26% (by 2020) and 43% (by 2030) reductions respectively.

While Germany's compliance with these obligations is not discussed here, further information on this subject can be found in [Chapter 9 - Projections](#) and [Chapter 11 - Adjustments and Emission Ceiling Exceedance](#).

## Main drivers

Between 1995 and 2024, **Total PM<sub>2.5</sub> emissions declined by 62.0%**.

The **main drivers** for PM<sub>2.5</sub> emissions are **Fuel Combustion (NFR 1.A)** with 73% of total 1995 emissions and a 69% reduction between 1995 and 2024 and, as a sum, the **Industrial Processes (NFR 2)** with about 21% of total 1995 emissions and a 52% reduction between 1995 and 2024.

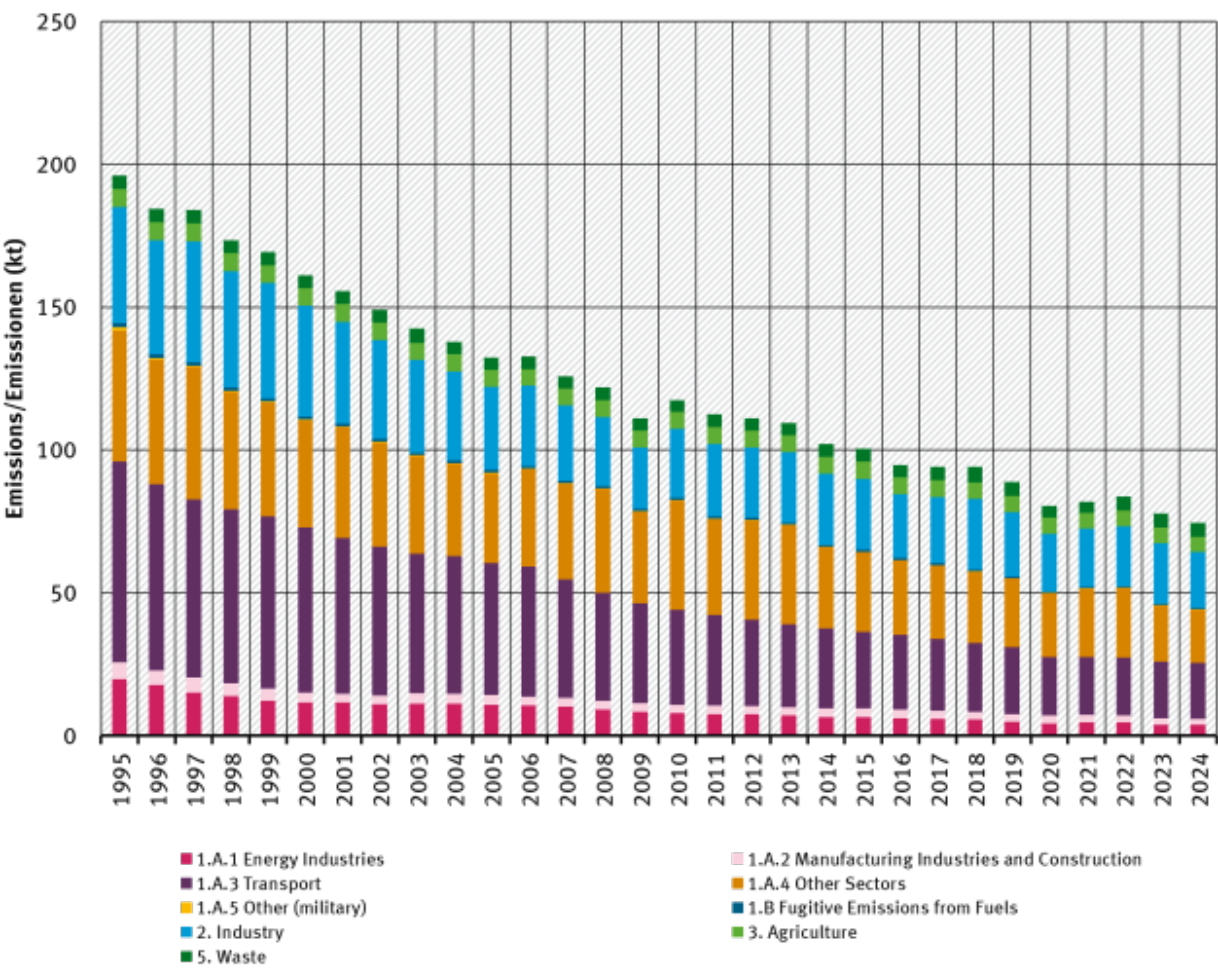
Within both National totals and NFR 1.A, **Transport (NFR 1.A.3)** is responsible for the biggest part of PM<sub>2.5</sub> emissions. Here, about 88% of 2024 PM<sub>2.5</sub> transport emissions are induced by **Road Transport (NFR 1.A.3.b)**. About one quarter (25%) of these emissions are directly caused by **fuel combustion (NFRs 1.A.3.b.i-iv)** whereas 75% stem from **tyre and brake wear (1.A.3.b.vi) and road abrasion (vii)**.

Table: PM<sub>2.5</sub> Emissions 1990-2024, in kilotonnes [kt]

| Trend: latest year compared to... |      |      |      |      |      |      |      |      |      |      |      |      |      |              |                  |
|-----------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|--------------|------------------|
| 1995                              | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | ...BY (1995) | ...previous year |
| 196                               | 161  | 132  | 118  | 100  | 95   | 94   | 94   | 89   | 80   | 82   | 84   | 78   | 74   | -62.0%       | -4.4%            |

Fine Particulate Matter / Feinstaub (PM2.5)

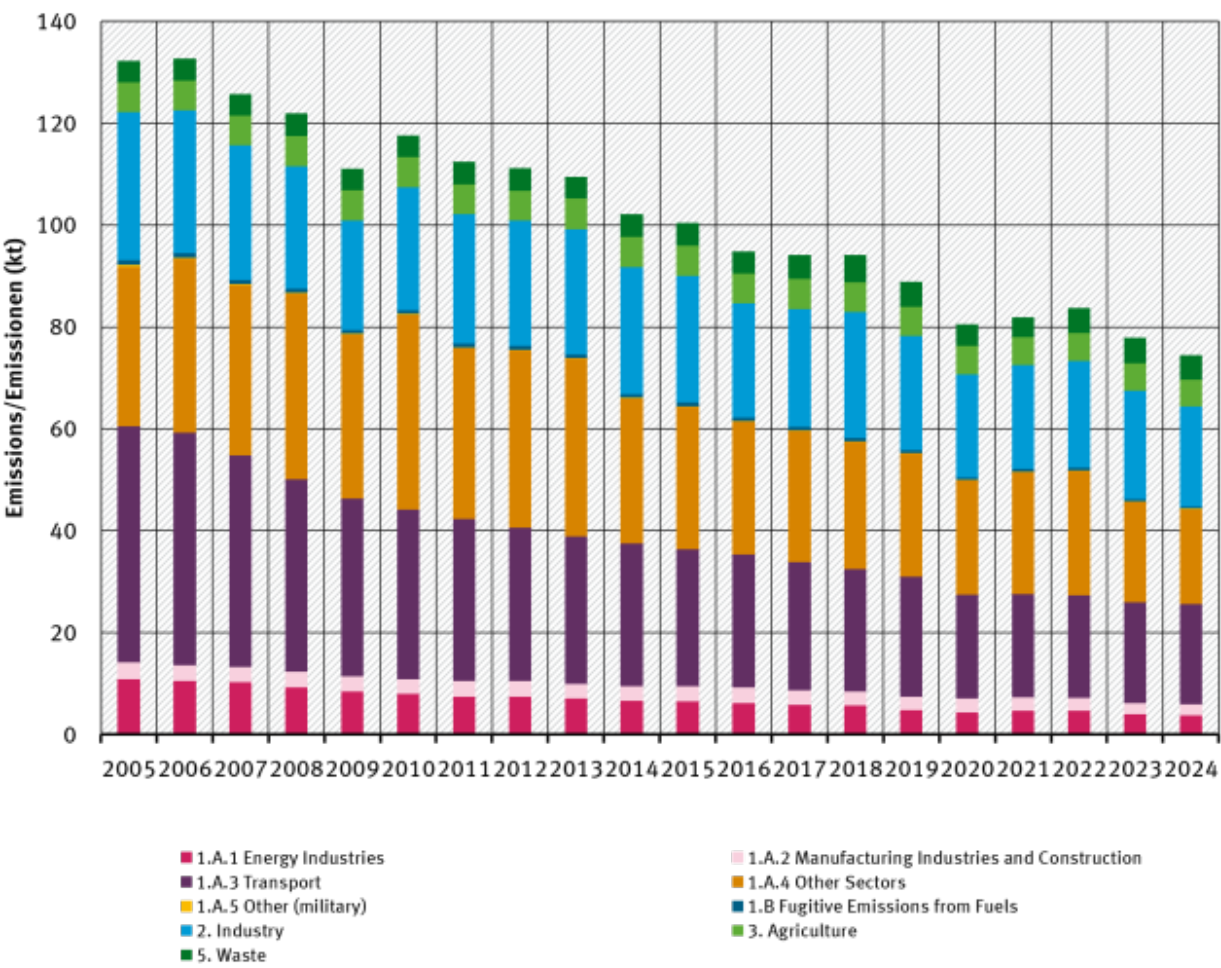
Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)

Fine Particulate Matter / Feinstaub (PM2.5)

Emissions per Sector / Sektorale Emissionen



Quelle: German Emission Inventory (04.02.2026)

# Emission Trends BC

Germany reports Black Carbon (BC) emissions for all years from 2000 onward. The main sources are transport as well as mobile and stationary combustion. Germany uses the EMEP/EEA 2016 Guidebook to estimate BC emissions, augmented by some country specific emission factors, i.e. split factors for the BC portion of PM<sub>2.5</sub>, in particular in road transport.

Between 2000 and 2024, **Total Black Carbon emissions dropped by 78%**.

The main drivers are the **transport emissions (NFR 1.A.3)** with 70% of total 2000 emissions, and a 85% reduction between 2000 and 2024. Over the entire time series, more than 90% of the transport emissions come from **Road Transport (NFR 1.A.3.b)**. The overlying trend towards more diesel cars in the German fleet slowed the decrease in emission over this period (see figure below).

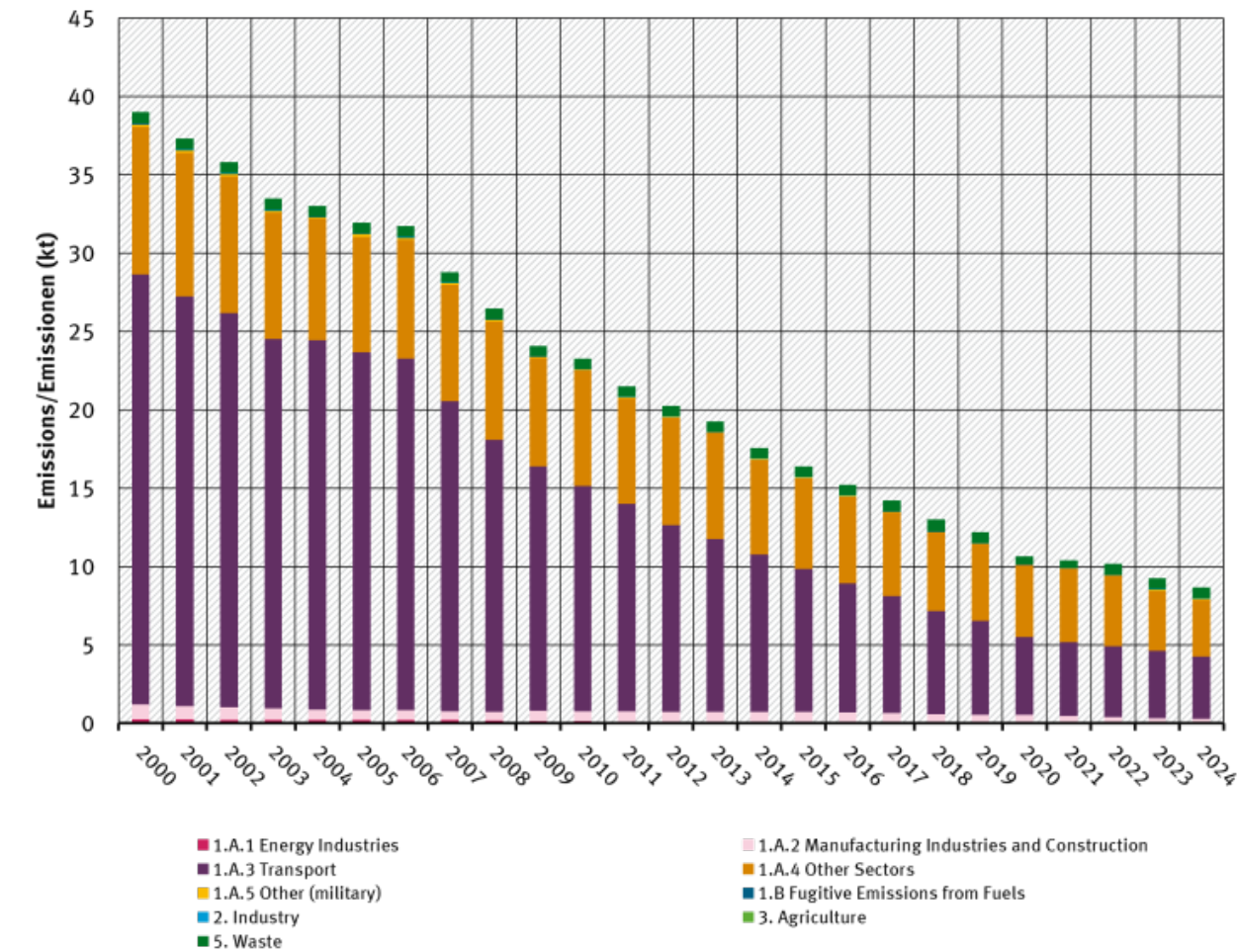
24% of the 2000 total emissions result from **Other Sectors (NFR 1.A.4)**, mostly from residential stationary combustion and mobile sources therein, with a 62% reduction between 2000 and 2024.

Table: Black Carbon emissions 1990-2024, in kilotonnes [kt]

|      |      |      |      |      |      |      |      |      |      |      |      |      | Trend: latest compared to |               |
|------|------|------|------|------|------|------|------|------|------|------|------|------|---------------------------|---------------|
| 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2000                      | previous year |
| 39   | 32   | 23   | 16   | 15   | 14   | 13   | 12   | 11   | 10   | 10   | 9    | 9    | -77.8%                    | -6.5%         |

## Black Carbon (BC)

Emissions per Sector / Sektorale Emissionen





# Explanation of Key Trends - Persistent Organic Pollutants



Please note: Data for persistent organic pollutants may have issues such as missing sources. It features considerably higher uncertainties than data for other pollutants covered in this report. [Read more...](#)

## Obligations

The 1998 Aarhus Protocol on Persistent Organic Pollutants under the CLRTAP entered into force late in 2003. It focuses on a list of 16 substances that have been singled out according to agreed risk criteria. The substances comprise eleven pesticides, two industrial chemicals and three by-products/contaminants. The ultimate objective is to eliminate any discharges, emissions and losses of POPs.

The Protocol bans the production and use of some products outright (aldrin, chlordane, chlordecone, dieldrin, endrin, hexabromobiphenyl, mirex and toxaphene). Others are scheduled for elimination at a later stage (DDT, heptachlor, hexachlorobenzene, PCBs).

Finally, the Protocol severely restricts the use of DDT, HCH (including lindane) and PCBs. The Protocol includes provisions for dealing with the wastes of products that will be banned. It also obliges Germany to reduce its emissions of dioxins, furans, PAHs and HCB below their levels in 1990. For the incineration of municipal, hazardous and medical waste, it lays down specific limit values.

## Main drivers

Persistent organic pollutants give a mixed picture both in terms of development and sources.

All POP emissions **decreased substantially between 1990 and 2024:**

- Dioxins (Teq) by 86,4%,
- PCBs by 88,0%,
- HCB by 99.9%

and

- the PAH Total by 43,4%

However, uncertainties are significantly higher than for the other air pollutants reported.

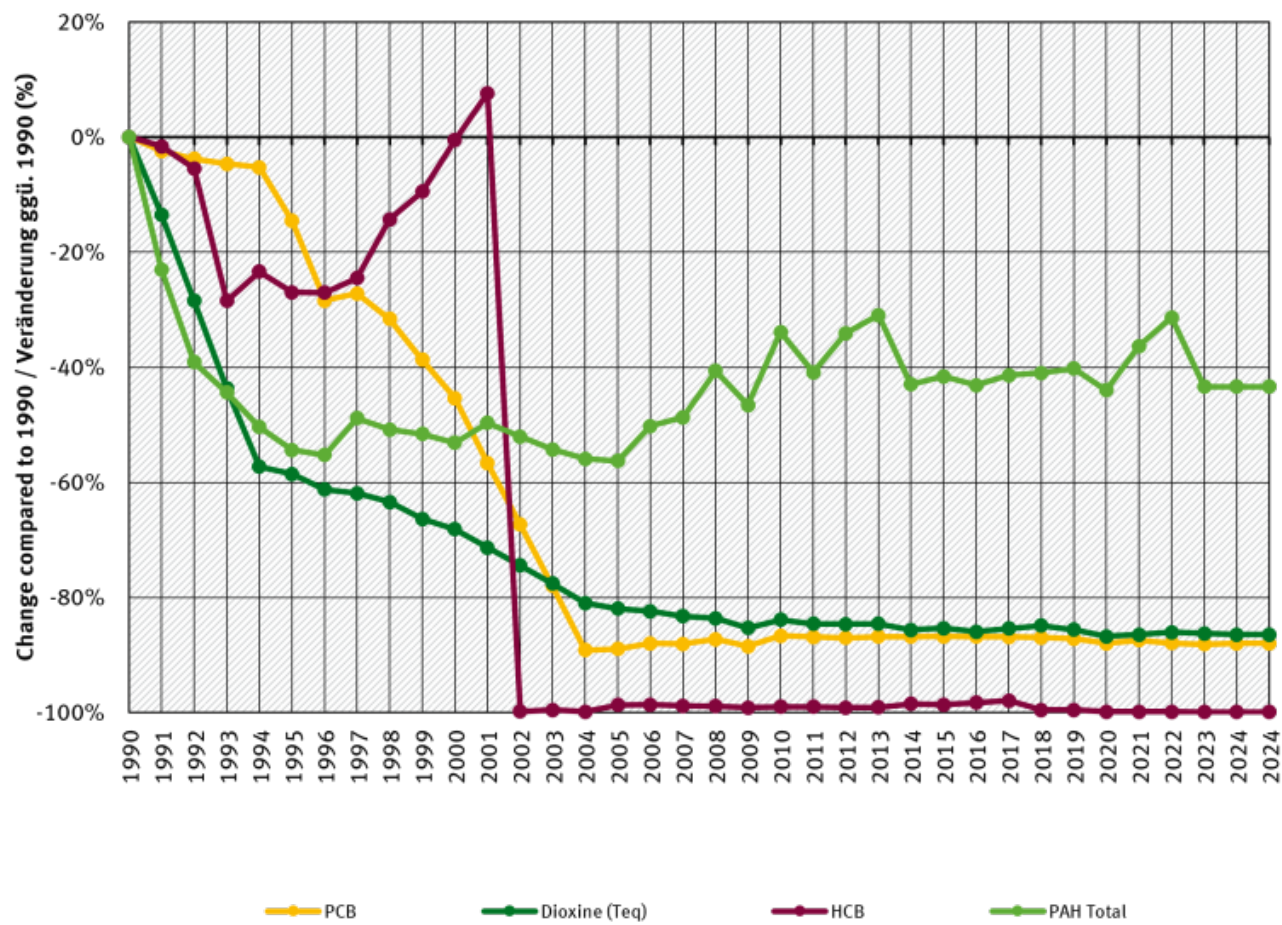
## Trends

The figure below shows trends for the main groups of persistent organic pollutants:



Persistent Organic Pollutants (POP)

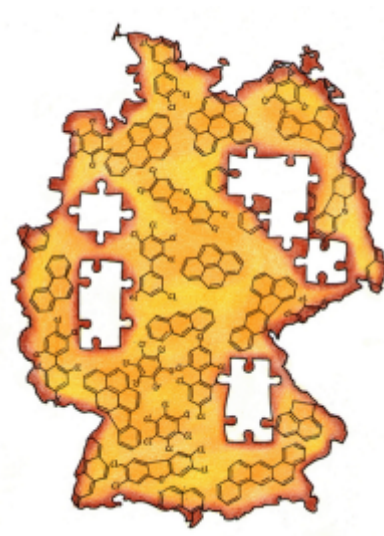
Emission Trends / Emissionstrends



Quelle: German Emission Inventory (04.02.2026)

# State of the German POP inventory

Generally, and despite a lot of improvements implemented in recent years, the German POP inventory is still incomplete. There are some source categories missing, in particular those where data availability is an issue. Measurement data for POP emission factors is hard to come by, and where available these are regularly annotated with high uncertainties. Moreover, creating consistent time series for POP emission factors is challenging, even for sources with EFs measured recently, since historic data (e.g. for 1990) is even harder to find. Not in any case it's possible to fill the gaps with default values, since default POPs emission factors are often very high and not in line with German legislation. In such cases, the default value would be an important source of inconsistency, which may cause an infringement procedure.



## Current reporting

The quality of reporting varies greatly inside the POP inventory, depending on the (group of) pollutant in question:

### Dioxins/ Furans

Due to current legislation, data availability is relatively good. There are measurement data for waste incineration plants and steel industry installations both for 1990 and current years. Therefore, the two most important sources are well covered. For small combustion (in particular wood), where total activity and emissions increased in recent years, measurement data is available. These emission factors come with high uncertainties, since dioxin emissions depend largely on the fuel used and on combustion conditions. Since we have to cover about 9 million small wood combustion installations in Germany, it is hard to model a consistent usage pattern. Furthermore there is a high degree of uncertainty regarding the quality of the firewood, which is used in small combustion plants. Actually the fuel quality is required by law, controlled by the chimney sweeper. However, illegal waste wood burning cannot be averted. But it's not possible to estimate the resulting emissions. Despite these problems, the German POP inventory is reasonably complete for dioxins and furans. The only known missing sources are small scale waste burning (in particular gardening waste burning) and accidental fires (which are very hard to quantify regarding dioxin emissions). Both small scale waste burning and fires are considered to show a decreasing trend and to be less common than in other countries.

### PAHs

PAHs result from incomplete combustion. The by far most important source category in the German inventory for PAHs is small combustion. The same problems as for dioxins apply: emission factors are available but show high uncertainties, usage pattern are hard to model and regulate. Other sources include steel and mineral industry, power plants, and waste incineration plants. The quality of emission factors for these categories is very diverse. Moreover, different PAHs are given for different sectors (Borneff, US EPA, or others). For the 4 expected single substances, very few data are available, with the possible exception of benzo(a)pyrene. As a result, the PAHs emissions in the inventory are likely to be overestimated. Overall, the German PAH inventory is quite complete, since most emissions come from relatively well regulated combustion processes. As for dioxins and furans, small scale waste burning and forest fires are not covered.

### HCB

Data availability for HCB is considerably worse than for dioxins/furans and PAHs. The pollutant is currently not measured at

installations, since it is not subject to regulation. Therefore, the German inventory uses mainly default factors from the EEA/EMEP Guidebook, which do not fit well into time series. In addition, some important sources are missing, such as HCB emission from smoke munitions. With submission 2016 HCB emissions from pesticide use in the agricultural sector are reported the first time. Other categories that might have HCB emission, but are currently not covered due to missing measurements include chemical industry, metal industry and cement production. Nonetheless, some country specific emission factors for key categories are available.

## PCBs

PCBs from waste incineration is well covered and regularly measured at facility level due to current legislation. Data availability is appropriate. For other industry sectors very few measurements are taken and, again, have considerable uncertainties. In particular information for 1990 is hard to come by, rendering the creation of a consistent time series a tough task. All together, the data availability is slightly better than for HCBs. Nevertheless, the PCB inventory is still incomplete and misses out on probably important source categories, such as PCB emissions from electrical equipment (capacitors and transformers). Furthermore, in Germany mainly the Ballschmitter value is measured, which is: (PCB 28, 52, 101, 138, 153, 180 ) \* 5. In contrast to the WHO 2005: (77, 81, 126, 169, 105, 114, 118, 123, 156, 157, 167, 189) TEQ. The measured congeners are completely different. On the basis of currently available information (only a few measurements), Ballschmitter PCBs seem to be remarkable higher than the associated WHO TEQ.

## Future improvements

The first step towards an improved German POP inventory is to thoroughly check existing information (mainly EFs), to bring these up to date and to identify sources and pollutant combinations that need new measurements most. Correlation to immission data (POP trends measured in the local environment) can help to check for trends to be expected for each pollutant. Examination of regional differences in immission data can also give clues pointing at key categories. Working closely with the industry, the German inventory team already had the chance to improve some sources and acquire measurement result for some categories (e.g. HCB from waste incineration and the copper industry). This work should continue. More generally, the goal should be to carry out new measurements in respect to the priorities identified in step 1. This is of course subject to resource availability, since POP measurements are quite expensive. The new measurements should cover the whole spectrum of POPs in order to get a consistent resulting inventory. More knowledge on the relationship between different POPs (in terms of values for emission factors) would possibly allow to close gaps and to infer on historic values currently not available.

Due to the lack of measurement data it's necessary to collect all available information and to exchange experiences at international level. Therefore the "informal network of POPs inventory compiler" is a good opportunity for all participants to varify inventory data.

# Explanation of Key Trends - Heavy Metals



Please note: Data for heavy metals may have issues such as missing sources. It features considerably higher uncertainties than data for other pollutants covered in this report.

## Obligations

The 1998 [Aarhus Protocol on Heavy Metals](#) under the CLRTAP entered into force late in 2003. It targets three particularly harmful metals: cadmium, lead and mercury. According to one of the basic obligations, Germany has to reduce its emissions for these three metals below their levels in 1990.

The Protocol aims to cut emissions from industrial sources (iron and steel industry, non-ferrous metal industry), combustion processes (power generation, road transport) and waste incineration. It defines stringent limit values for emissions from stationary sources and suggests best available techniques (BAT) for these sources, such as special filters or scrubbers for combustion sources or mercury-free processes. The Protocol requires Parties to phase out leaded petrol.

It also introduces measures to lower heavy metal emissions from other products, such as mercury in batteries, and proposes the introduction of management measures for other mercury-containing products, such as electrical components (thermostats, switches), measuring devices (thermometers, manometers, barometers), fluorescent lamps, dental amalgam, pesticides and paint.

## Main drivers

Emission of priority heavy metals (cadmium, lead and mercury) **decreased significantly since 1990**. Most values show reductions by about 50 to 94% compared to the base year, with the majority of the achievements originating from the early 1990's though.

Overview of percental decreases in HM emissions since 1990:

- Arsenic: -94.3%
- Cadmium: -69.9%
- Copper: -2.1%
- Chrome: -56.9%
- Mercury: -85.4%
- Nickel: -61.4%
- Lead: -90.9%
- Selenium: -53.6%
- Zinc: -36.2%

In 2024 the emissions from arsenic, cadmium, mercury and selenium declined between 2% (selenium) und 7% (cadmium). The emissions of copper, chrome, nickel, lead and zinc increased between 0,6% (copper) and 2,1% (zinc).

The main source for most heavy metals is fuel combustion and production processes: **Energy Industries (NFR 1.A.1)** and **Industrial Processes (NFR 2)**, especially, of course, the Metal Industries (NFR 2.C) emit the majority of **arsenic, cadmium, chrome, lead, mercury and nickel**.

In contrast, **copper and zinc** emissions are mostly governed by the **Transport (NFR 1.A.3)** sector, resulting mostly from brake and tyre wear. Thus, trends are connected directly with the annual mileage.

**Selenium** on the other hand originates mainly from **Mineral Industry (NFR 2.A)** and to a lesser degree from Transport (NFR 1.A.3).

Other sources are still to be investigated but generally expected to add little to the total trend.

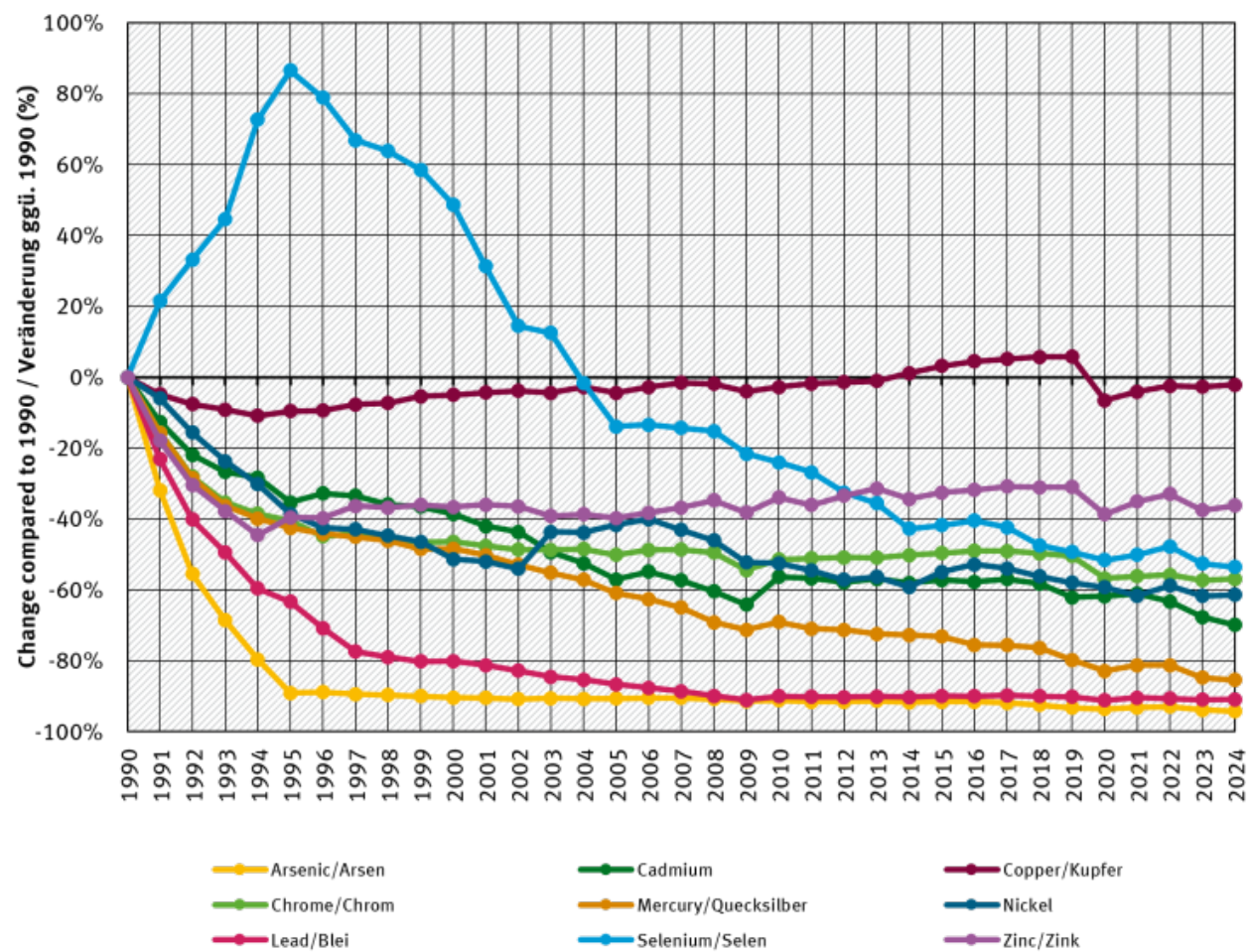


# Trends

The figure below shows emission trends for heavy metals:

## Heavy Metals / Schwermetalle

### Emission Trends / Emissionstrends



Quelle: German Emission Inventory (04.02.2026)



# SECTOR CHAPTERS - OVERVIEW

The following table provides a comprehensive list of the separate sector chapters included in this Informative Inventory Report.

|                                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------|
| <b>NFR 1 - ENERGY</b>                                                                                                |
| <b>1.A - FUEL COMBUSTION ACTIVITIES</b>                                                                              |
| <b>1.A.1 - Energy Industries</b>                                                                                     |
| 1.A.1.a - Public electricity and heat production                                                                     |
| 1.A.1.b - Petroleum refining                                                                                         |
| 1.A.1.c - Manufacture of solid fuels and other energy industries                                                     |
| <b>1.A.2 - Fuel Combustion Activities in Industries and Construction</b>                                             |
| 1.A.2.a - Stationary combustion in manufacturing industries and construction: Iron and Steel                         |
| 1.A.2.b - Stationary combustion in manufacturing industries and construction: Non-ferrous Metals                     |
| 1.A.2.c - Stationary combustion in manufacturing industries and construction: Chemicals                              |
| 1.A.2.d - Stationary combustion in manufacturing industries and construction: Pulp, Paper and Print                  |
| 1.A.2.e - Stationary combustion in manufacturing industries and construction: Food Processing, Beverages and Tobacco |
| 1.A.2.f - Stationary combustion in manufacturing industries and construction: Non-Metallic Minerals                  |
| 1.A.2.g viii - Stationary Combustion in Manufacturing Industries & Construction: Other                               |
| 1.A.2.g vii - Mobile Combustion in Manufacturing Industries & Construction                                           |
| <b>1.A.3 - Transport</b>                                                                                             |
| 1.A.3.a - Civil Aviation                                                                                             |
| 1.A.3.a i (i) - International Civil Aviation: LTO                                                                    |
| 1.A.3.a ii (i) - Domestic Civil Aviation: LTO                                                                        |
| 1.A.3.a i (ii) - International Civil Aviation: Cruise                                                                |
| 1.A.3.a ii (ii) - Domestic Civil Aviation: Cruise                                                                    |
| 1.A.3.b - Road Transport                                                                                             |
| 1.A.3.bi-iv - Emissions from Fuel Combustion in Road Vehicles (Overview)                                             |
| 1.A.3.b i - Road Transport: Passenger Cars                                                                           |
| 1.A.3.b ii - Road Transport: Light duty vehicles                                                                     |
| 1.A.3.b iii - Road Transport: Heavy duty vehicles                                                                    |
| 1.A.3.b iv - Road Transport: Mopeds & Motorcycles                                                                    |
| 1.A.3.b v - Gasoline Evaporation                                                                                     |
| 1.A.3.b vi-vii - Emissions from Wear and Abrasion in Road Transport (Overview)                                       |
| 1.A.3.b vi - Road Transport: Tyre and Brake Wear                                                                     |
| 1.A.3.b vii - Road Transport: Road Abrasion                                                                          |
| 1.A.3.c - Railways                                                                                                   |
| 1.A.3.d - Navigation                                                                                                 |
| 1.A.3.d i - International Maritime Navigation                                                                        |
| 1.A.3.d i (ii) - International Inland Navigation                                                                     |
| 1.A.3.d ii - National Navigation                                                                                     |
| 1.A.3.e - Other Transport                                                                                            |
| 1.A.3.e i - Pipeline Transport                                                                                       |
| <b>1.A.4 - Small Combustion</b>                                                                                      |
| 1.A.4.a i - Commercial and Institutional - Stationary Combustion                                                     |
| 1.A.4.b i - Residential - Stationary Combustion                                                                      |
| 1.A.4.c i - Agriculture, Forestry, Fishing - Stationary Combustion                                                   |
| 1.A.4.a ii - Commercial / Institutional: Mobile                                                                      |
| 1.A.4.b ii - Residential: Household and Gardening: Mobile                                                            |
| 1.A.4.c ii - Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery                                     |
| 1.A.4.c iii - Agriculture/Forestry/Fishing: National Fishing                                                         |
| <b>1.A.5 - Other (including Military)</b>                                                                            |
| 1.A.5.a - Other: Stationary (including Military)                                                                     |
| 1.A.5.b - Other: Mobile (including Military)                                                                         |
| <b>1.B - FUGITIVE EMISSIONS FROM FUELS</b>                                                                           |
| 1.B.1 - Solid Fuels                                                                                                  |

**NFR 1 - ENERGY**

1.B.2.a - Oil

1.B.2.b - Natural Gas

1.B.2.c - Flaring

**NFR 2 - INDUSTRIAL PROCESSES & PRODUCT USE (IPPU)****2.A - MINERAL INDUSTRY - Overview**

2.A.1 - Cement Production

2.A.2 - Lime Production

2.A.3 - Glass Production

2.A.5.a - Quarrying and Mining of Minerals other than Coal

2.A.5.b - Construction and Demolition

2.A.5.c - Storage, Handling and Transport of Mineral Products

2.A.6 - Other Mineral Products

**2.B - CHEMICAL INDUSTRY**

2.B.1 - Ammonia Production

2.B.2 - Nitric Acid Production

2.B.3 - Adipic Acid Production

2.B.5 - Carbide Production

2.B.6 - Titanium Dioxide Production

2.B.7 - Soda Ash Production

2.B.10.a - Other

2.B.10.b - Storage, Handling and Transport of Chemical Products

**2.C - METAL PRODUCTION**

2.C.1 - Iron and Steel Production

2.C.2 - Ferroalloys Production

2.C.3 - Aluminum Production

2.C.4 - Magnesium Production

2.C.5 - Lead Production

2.C.6 - Zinc Production

2.C.7.a - Copper Production

2.C.7.b - Nickel Production

2.C.7.c - Other Metal Production

2.C.7.d - Storage, Handling and Transport of Metal Products

**2.D - OTHER SOLVENT & PRODUCT USE**

2.D.3.a - Domestic Solvent Use including fungicides

2.D.3.b - Road Paving with Asphalt

2.D.3.c - Asphalt Roofing

2.D.3.d - Coating Applications

2.D.3.e - Degreasing

2.D.3.f - Dry Cleaning

2.D.3.g - Chemical Products

2.D.3.h - Printing

2.D.3.i - Other Solvent Use

**2.G - OTHER PRODUCT USE**

2.G.4 - Use of Fireworks

2.G.4 - Use of Tobacco

2.G.4 - Charcoal

**2.H - Other (Pulp & Paper, Food)**

2.H.1 - Pulp and Paper Industry

2.H.2 - Food and Beverages Industry

2.H.3 - Other Industrial Processes

**2.I - Wood Processing****2.J - Production of POPs****2.K - Consumption of POPs and Heavy Metals****2.L - Other Production, Consumption, Storage, Transportation or Handling of Bulk Products**

2.L(a) - Handling of Bulk Products

**NFR 1 - ENERGY**

2.L(b) - Diffuse Emissions From Industrial Establishments

**NFR 3 - AGRICULTURE**

3.B - Manure Management

3.D - Agricultural Soils

3.F - Field Burning Of Agricultural Residues

3.I - Agricultural: Other

**NFR 5 - WASTE**

5.A - Biological Treatment of Waste - Solid Waste Disposal on Land

5.B.1 - Biological treatment of waste - Composting

5.B.2 - Biological treatment of waste - Anaerobic digestion at biogas facilities

5.C.1.b.v - Cremation

5.C.2 - Open Burning of Waste

5.D.1 - Domestic &amp; Commercial Wastewater Handling

5.D.2 - Industrial Wastewater Handling

5.E.1 - Other Waste: Mechanical-biological Treatment of Waste

5.E.2 - Building and Car Fires

**NFR 6 - OTHER SOURCES**

6.A.1 - Emissions from human sweating and breathing

6.A.2 - Ammonia emissions from pets

**NFR 11 - NATURAL SOURCES**

11.B - Forest Fires

## CHAPTER 3: NFR 1 - Energy

Energy and heat generation constitute the most important sources of emissions in Germany. This holds true for almost every pollutant (a prominent exception of this rule being ammonia, mainly from agriculture). Consequently, this section will look into the sub-sectors making up the *NFR 1 - Energy* sector with great detail. For overview information on key activity statistics and the basis for fuel based estimates please refer to [Chapter 1.4 - Methods and Data Sources](#).

NFR 1 consists of the following sub-categories:

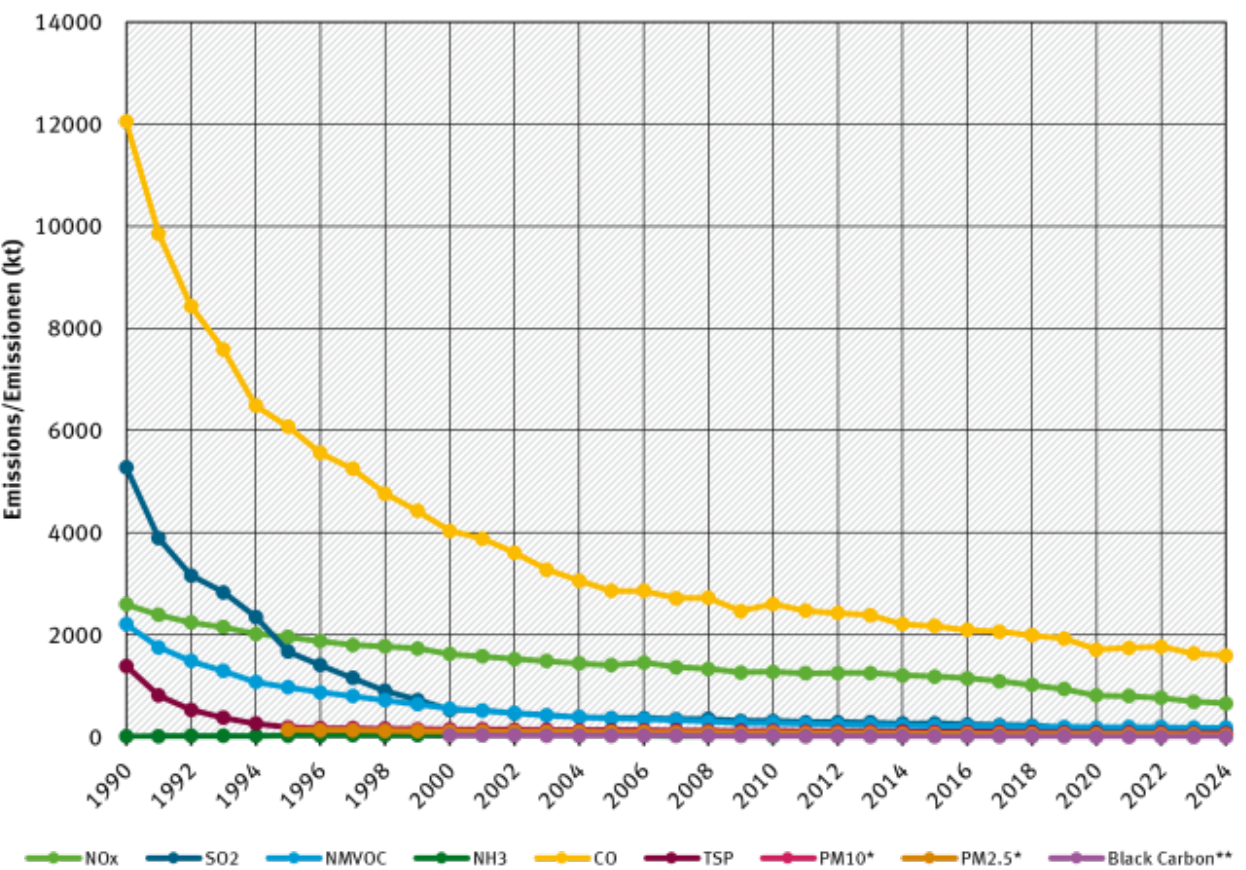
| NFR-Code       | Name of category                                                          |
|----------------|---------------------------------------------------------------------------|
| <b>1.A</b>     | <b>Fuel Combustion Activities</b>                                         |
| <b>1.A.1</b>   | <a href="#">Energy Industries</a>                                         |
| <b>1.A.2</b>   | <a href="#">Fuel Combustion Activities in Industries and Construction</a> |
| <b>1.A.3</b>   | <a href="#">Transport</a>                                                 |
| <b>1.A.4</b>   | <a href="#">Small Combustion</a>                                          |
| <b>1.A.5</b>   | <a href="#">Other (including Military)</a>                                |
| <b>1.B</b>     | <b>Fugitive Emissions</b>                                                 |
| <b>1.B.1</b>   | <a href="#">Solid Fuels</a>                                               |
| <b>1.B.2.a</b> | <a href="#">Liquid Fuels</a>                                              |
| <b>1.B.2.b</b> | <a href="#">Gaseous Fuels</a>                                             |
| <b>1.B.2.c</b> | <a href="#">Flaring</a>                                                   |
| <b>1.B.3</b>   | <a href="#">Geothermal Energy</a>                                         |

### Visual overview

[Emission trends for main pollutants in NFR 1 - Energy:](#)

Energy/Energie (NFR 1)

Emissions by pollutant / Emissionen nach Schadstoff

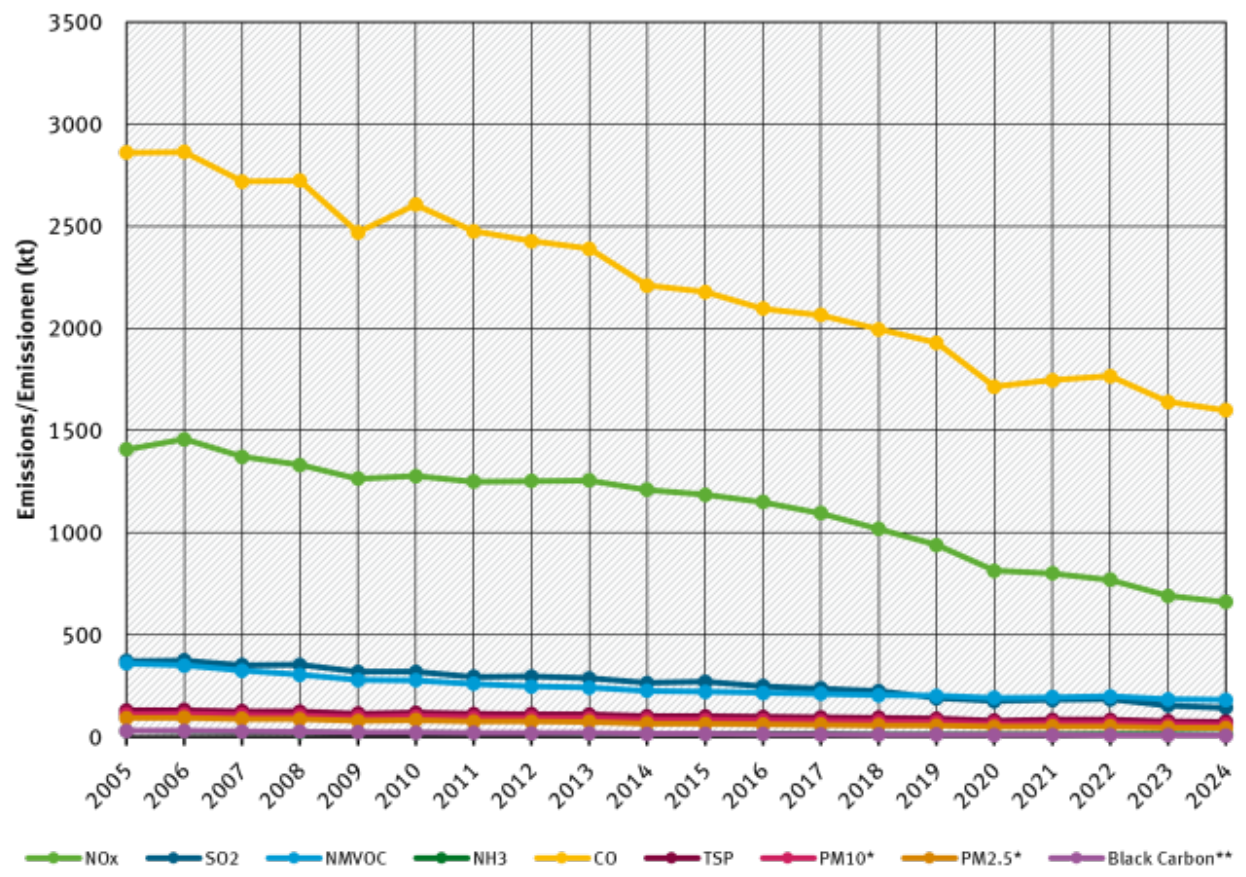


\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995  
\*\* Black Carbon emissions from 2000 / Black Carbon Emissionen erst ab 2000  
Quelle: German Emission Inventory (13.03.2026)



Energy/Energie (NFR 1)

Emissions by pollutant / Emissionen nach Schadstoff

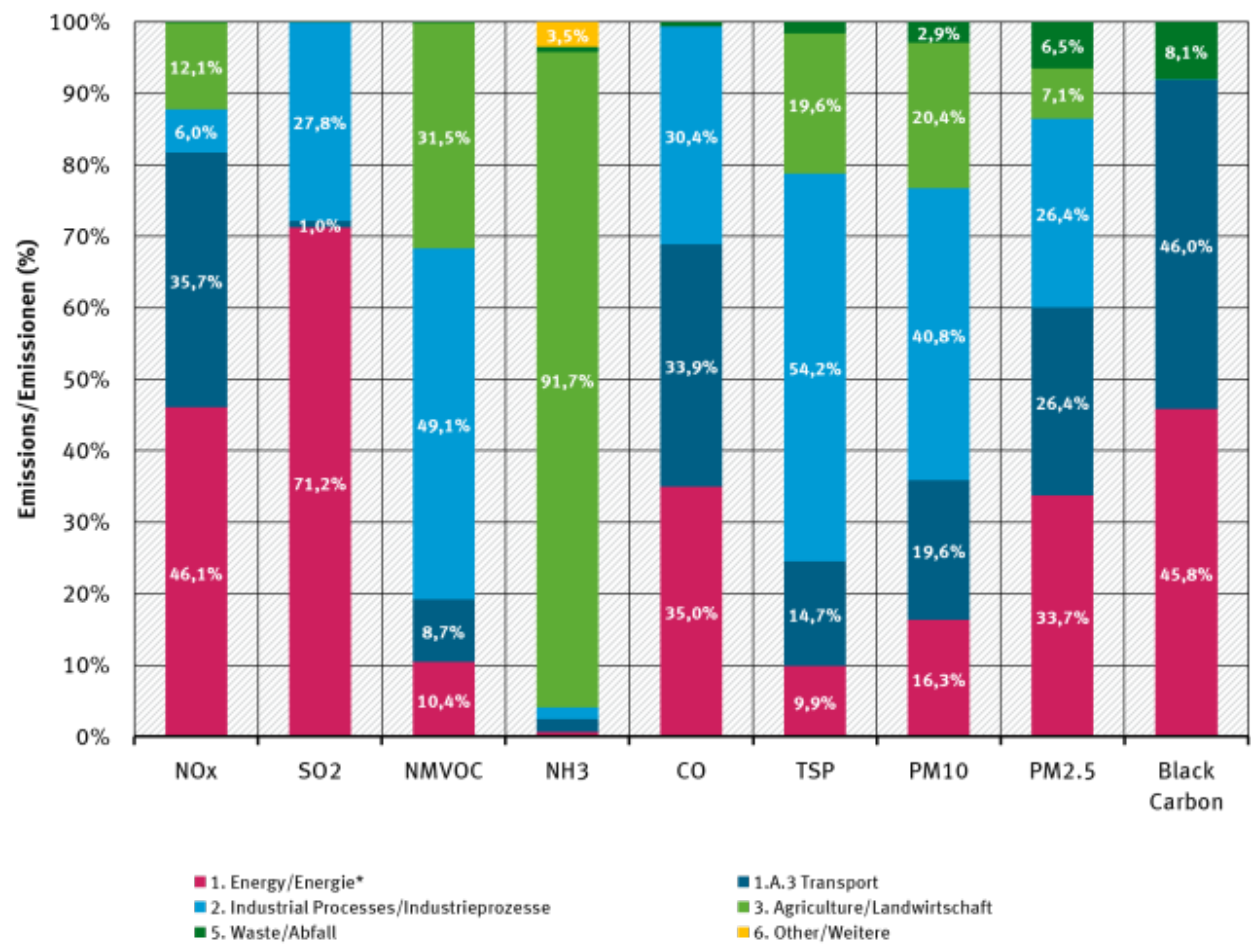


\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995  
\*\* Black Carbon emissions from 2000 / Black Carbon Emissionen erst ab 2000  
Quelle: German Emission Inventory (13.03.2026)

[Contribution of NFRs 1 to 6 to the National Totals](#)

Contribution of NFR categories to the emissions/Anteile der NFR-Kategorien an den Emissionen

2024 percentages per air pollutant / Anteile pro Luftschadstoff für 2024



\* without transport ( ohne Verkehr (1.A.3)

Quelle: German Emission Inventory (06.02.2026)

# 1.A - Fuel Combustion Activities (OVERVIEW)

| NFR-Code                                    | Name of Category                                          |
|---------------------------------------------|-----------------------------------------------------------|
| 1.A                                         | Fuel Combustion                                           |
| consisting of / including source categories |                                                           |
| 1.A.1                                       | Energy Industries                                         |
| 1.A.2                                       | Fuel Combustion Activities in Industries and Construction |
| 1.A.3                                       | Transport                                                 |
| 1.A.4                                       | Small Combustion                                          |
| 1.A.5                                       | Other (including Military)                                |

# 1.A.1 - Energy: Energy Industries (OVERVIEW)

| NFR-Code                                    | Name of Category                                       | Method                   | AD | EF | Key Category |
|---------------------------------------------|--------------------------------------------------------|--------------------------|----|----|--------------|
| 1.A.1                                       | Energy - Energy Industries                             | see sub-category details |    |    |              |
| consisting of / including source categories |                                                        |                          |    |    |              |
| 1.A.1.a                                     | Public electricity and heat production                 | see sub-category details |    |    |              |
| 1.A.1.b                                     | Petroleum refining                                     | see sub-category details |    |    |              |
| 1.A.1.c                                     | Manufacture of solid fuels and other energy industries | see sub-category details |    |    |              |

# 1.A.1.a - Public Electricity And Heat Production

## Short description



Source category 1.A.1.a - *Public Electricity and Heat Production* comprises district heating plants and electricity and heat production of power plants. Waste incineration is also included.

| NFR Code                                                                                  | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 1.A.1.a                                                                                   | T2                                   | NS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |



| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                       | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |     |
|-----------------|--------|-----------------|-----------------|-------------------|----------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|-----|
| L/T             | -/-    | L/T             | -/-             | L/T               | L/T                                                                                    | L/T | -/- | L/- | -/- | L/T | L/T | L/T | L/T | L/T | L/T | -/- | L/T | L/T    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | L/-  | L/T |
|                 |        |                 |                 |                   | L/- key source by <b>Level</b> only                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |     |
|                 |        |                 |                 |                   | -/T key source by <b>Trend</b> only                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |     |
|                 |        |                 |                 |                   | L/T key source by both <b>Level</b> and <b>Trend</b>                                   |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |     |
|                 |        |                 |                 |                   | -/- no key source for this pollutant                                                   |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |     |
|                 |        |                 |                 |                   | IE emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |     |
|                 |        |                 |                 |                   | NE emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |     |
|                 |        |                 |                 |                   | NA specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |     |
|                 |        |                 |                 |                   | * no analysis done                                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |     |

## Methodology

A method amounting to Tier 2 is used for emission reporting. This means the use of country-specific data at a more detailed level. Emission factors and activity data are available for different fuel types, different technologies, plant size, etc. The use of plant-specific data for a bottom-up approach is not possible. There are fuel data including NO<sub>x</sub>, SO<sub>x</sub> and TSP emissions for large combustion plants, but only measured and verified data were used.

### Activity data

#### Conventional fuels

The key source of all conventional fuels is the National Energy Balance (NEB) <sup>1)</sup>. The fuel input for electricity production is given in line 11 ("Public thermal power stations") of the National Energy Balance. The fuel inputs for public heat production are given in lines 15 ("Public cogeneration plants") and 16 ("District heating stations"). Above-mentioned data from the NEB are summarised fuel consumption data. To get technical details which are needed for calculating emissions, additional statistical data are used.

All the data is filled in to the calculation model "Balance of Emission Sources" which is part of the central database (CSE). The aim of this database is to produce more detailed fuel consumption data which are adjusted to the special technical characteristics of electricity and heat production. As a result, fuel-specific and technology-specific emission factors may be applied to the relevant activity rates. As a result, 153 time series were implemented in the database CSE. The years 1990-1994 required a different structure within the database with 153 additional time series, since 1990 was the year of the re-unification in Germany with two different statistical offices and two data systems.

When the calculations for the submission were done, the Energy Balance for the inventory year was not yet available in its final version. Therefore, for the year 2024 data from the preliminary Energy Balance are used, provided by the Working Group on Energy Balances. Typically, finalization of the energy balance data leads to recalculations for the previous year. Additionally, every 2 years the energy balance goes through updates for the years starting from 2003, which also leads to recalculations. (For more information please see the recalculations section).

For waste incineration plants, both energy and waste statistics are used to ensure completeness and to avoid double counting.

#### Biomass

The database for the calculation model consists of the National Energy Balance. Line 14 ("Hydro, wind, photovoltaic and other power stations") comprises all systems/ plants that generate electricity from biogas, landfill gas, sewage-treatment gas or solid biomass and feed the electricity into the public grid. Since no cut-off limit applies for such systems, this category includes very small systems, too. German statistics provide only electricity generation data of those biomass plants, who feed into the public grid. But the Renewable Energy Act (EEG) does allow a full registration of electricity generation from renewable energies. However, the calculation of fuel data is connected with high uncertainties, since an average generation efficiency is necessary for the conversion.

## Waste

Activity data from waste incineration plants are given by the waste statistics of the Federal Statistical Office <sup>2)</sup>.

Waste quantities are available at a very detailed level for different economic sectors. Municipal and industrial waste were classified in keeping with the Ordinance on the European Waste Catalogue (AVV), with industrial waste including all waste with waste-classification numbers beginning with the numbers 01 through 19.

## Emission factors

### Large and medium combustion plants

The underlying data for the emission factors used is provided by the report on the research project “Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010” (Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010”; RENTZ et al, 2002)<sup>3)</sup>.

The values for the intermediate years 1996-1999 and 2001-2008 are obtained via linear interpolation.

The project, along with the linear interpolation for the intermediate years, has also provided the underlying data for the source categories 1.A.1.b, 1.A.1.c and 1.A.2.f i, where the factors include power plants, gas turbines or boilers for production of steam and hot/warm water. The research project was carried out by the Franco-German Institute for Environmental research (Deutsch-Französisches Institut für Umweltforschung - DFIU) at the University of Karlsruhe and was completed in late 2002. The project's aim was to determine and evaluate representative emission factors for the years 1995, 2000 and 2010 for the main air pollutants produced by combustion plants and gas turbine plants in Germany that are subject to licensing requirements. This process consists primarily of analysing and characterising the relevant emitter structures, and the pertinent emission factors, for the year 1995, and then of updating the data for the years 2000 and 2010. This procedure systematically determines emission factors for the substances SO<sub>x</sub>, NO<sub>x</sub>, CO, NMVOC, dust, and N<sub>2</sub>O. The process differentiates between 12 coal fuels, 4 liquid fuels, 7 gaseous fuels and firewood. In addition, the available data relative to emission factors of other substances are also compiled; these other substances include PAH, PCDD/F, As, and Cd for combustion systems subject to licensing requirements.

As part of another research project, completed in February 2007, for updating the National Programme in the framework of directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants (“NEC Directive”), individual emission factors for the components SO<sub>2</sub>, NO<sub>x</sub> and dust were revised in keeping with recent findings.

In 2018 and 2019 SO<sub>2</sub>, NO<sub>x</sub>, TSP, PM, CO, NH<sub>3</sub> and Hg emission factors were revised for all large combustion plants.<sup>4)</sup> completed in 2011. Since the data set was not complete that time, in some cases a revision until 2004 was necessary.

Heavy metal emission factors are mainly the result of a comprehensive study of PRTR data, which provide information about emissions and the quality (measurement/estimated/calculated data) of large combustion plants. The combination of emission from PRTR and the relevant fuel data, which contains additional data of large combustion plants (EU legislative), allows the determination of plant-specific emission factors. Due to the fact, that only some plants do really measure heavy metals, the determined emission factors were used for the whole sector (1.A.1.a).

HCB emission factors of hard coal were taken from the EMEP/EEA Guidebook 2009. Black carbon emission factors for all fuels are given by the EMEP/EEA Guidebook 2019.

Regarding natural gas and light fuel oil, SO<sub>2</sub> emission factors were calculated by using data on the sulfur content. In terms of natural gas, sulfur content has been measured during a project. Data on all important regions is available. The sulfur of the odorization is also considered, which is a slightly conservative, since not all plants use natural gas with odorization. Concerning light fuel oil, the limit value is used for emission reporting. It can be assumed that large combustion plants mainly use light fuel oil with a sulfur content of 1000 mg/kg while low-sulfur fuel oil is mainly used in small combustion plants.

## Engines

Emission factors for gas engines were determined by the project: “Processing of data in emissions declarations pursuant to the 11th Ordinance on the Execution of the Federal Immission Control Act”. Additional data were provided by the local

authorities (results of emission monitoring). All emission factors used for reporting are derived from plants which are subject of licensing and reviewed by the competent authorities.

However, a large number of the 7,500 biogas plants in Germany does not require a license. Due to the small size of the plants the total fuel consumption of small biogas plants is lower than fuel consumption of those plants who need a permit. Since emission behaviour of small and medium sized plants is completely different, it's necessary to use specific emission factors for each plant type. The calculation of activity data of small and medium sized plants is based on data from the Federal Network Agency. Emission factors are a result of different regional measurement campaigns in Saxony and Bavaria and the project: "Analysis of the emissions from biogas plants, and quantification of material flows through such plants, for ecological assessment of agricultural-sector biogas production and for inventories of the German agricultural sector" (DBFZ 2014). Emission factors for liquid fuels are given by the project: "Determination of the state-of-the-art of emission control techniques for stationary internal combustion engines", carried out by (Müller-BBM, 2010).

## Waste incineration plants

Data source for emission factors of waste incineration plants is the project: "Review of the emission factors for waste incineration", carried out by Daschner et al. (2010)<sup>51</sup>. The aim of the study was to determine emission factors for municipal waste, industrial waste, hazardous waste, waste wood and sewage sludge incineration. Emission factors for 25 pollutants are available. The different fuel categories are consistent with the waste statistic. The fuel category "industrial waste" has different meanings: substitute fuel originate from municipal or industrial waste or untreated production waste. This kind of fuels were basically incinerated in so called waste-to-energy-plants (in German EBS-Kraftwerke). Compared to conventional municipal waste incineration plants, "EBS-Kraftwerke" are mostly smaller and more efficient. There are also some technical differences. All these plants have to comply with the same limit values. Nevertheless emission factors are different due to different abatement technology and operating conditions. HCB emission factors of municipal waste are derived from a measurement project initiated by the industrial association. The 1990 value for waste incineration plants is an expert judgement derived from the development of legislative regulation.

Furthermore it was necessary to develop a method to calculate emissions from co-incineration systems. In Germany there is a large number of coal fired power plants, which also use a relevant amount of different waste fuels like sewage sludge, industrial waste (for example from paper industry), conditioned municipal waste etc. Since plant-specific data cannot be used, it's necessary to calculate emissions at a more aggregated level. Fuel data are available from ETS. Furthermore the information about the coal qualities is available. Therefore it's possible to calculate specific emission factors for co-incinerated waste fuels.

Table 1: Implied emission factors for public electricity and heat production for 2024

|                                  | SO <sub>x</sub> | NO <sub>x</sub> | TSP | CO    | Pb     | Hg   | Cd   |
|----------------------------------|-----------------|-----------------|-----|-------|--------|------|------|
|                                  | [kg/TJ]         |                 |     |       | [g/TJ] |      |      |
| <b>Hard Coal</b>                 | 37.9            | 48.8            | 1.5 | 6.6   | 3.67   | 1.03 | 0.50 |
| <b>Lignite</b>                   | 42.9            | 70.1            | 1.6 | 32.6  | 2.73   | 2.49 | 0.37 |
| <b>Natural gas</b>               | 0.1             | 40.7            | 0.3 | 12.3  | NA     | 0.01 | NA   |
| <b>Liquid fuels</b>              | 38.6            | 105.5           | 3.9 | 27.2  | 2.17   | 0.41 | 0.08 |
| <b>Biomass (excluding waste)</b> | 54.0            | 164.6           | 4.3 | 133.7 | 4.13   | 0.12 | 0.09 |
| <b>Waste fuels</b>               | 6.3             | 60.0            | 0.4 | 6.1   | 2.10   | 0.85 | 0.28 |

The table gives an overview of the implied emission factors. In reality, the German inventory compiling process is very complex and includes the use of a considerable number of emission factors, which cannot be published completely in the IIR. There are different emission factors available for diverse fuel types, various techniques and licensing requirements. However, the implied emission factor may give an impression about the order of magnitude.

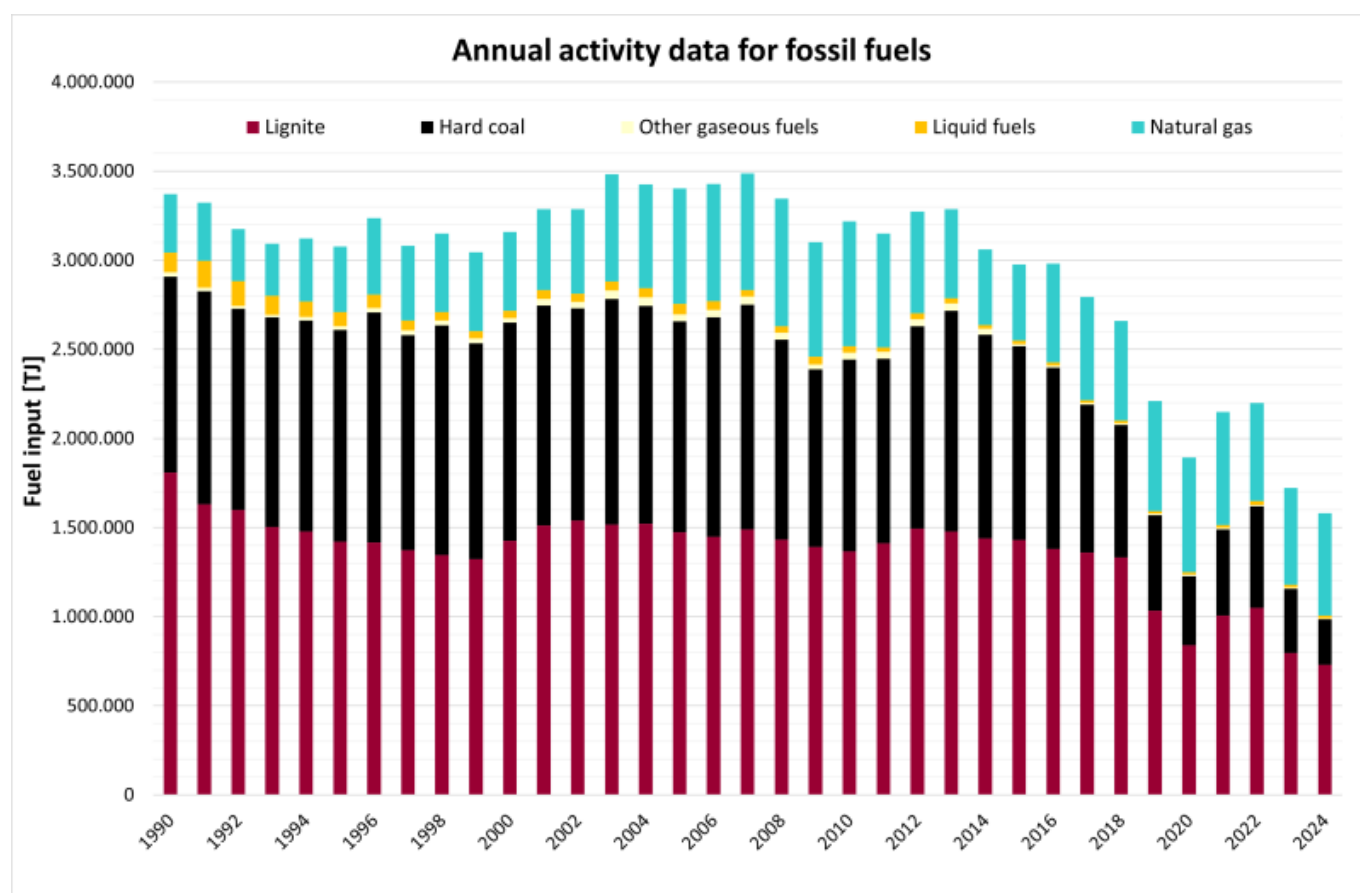
PM<sub>10</sub> and PM<sub>2.5</sub> emission factors are calculated as a fraction of TSP. Regarding all solid fuels the share of PM<sub>10</sub> is 90 % and the share of PM<sub>2.5</sub> is 80 %. This is a simple but also conservative approach, knowing that, in reality, PM emissions depend on fuel, combustion and abatement technologies. In terms of natural gas and biogas PM<sub>10</sub> and PM<sub>2.5</sub> fractions are considered as 100 % of TSP. Regarding wood a share of 100% PM<sub>10</sub> and 90% PM<sub>2.5</sub> is used. For liquid fuels the default share of 100% PM<sub>10</sub> and PM<sub>2.5</sub> is used. In the cases of co-incineration, where liquid fuels are only used for ignition in coal fired plants, the share of coal fired plants is used. PM emission reporting starts in 1995, since no sufficient information about the dust composition of the early 1990s is available.

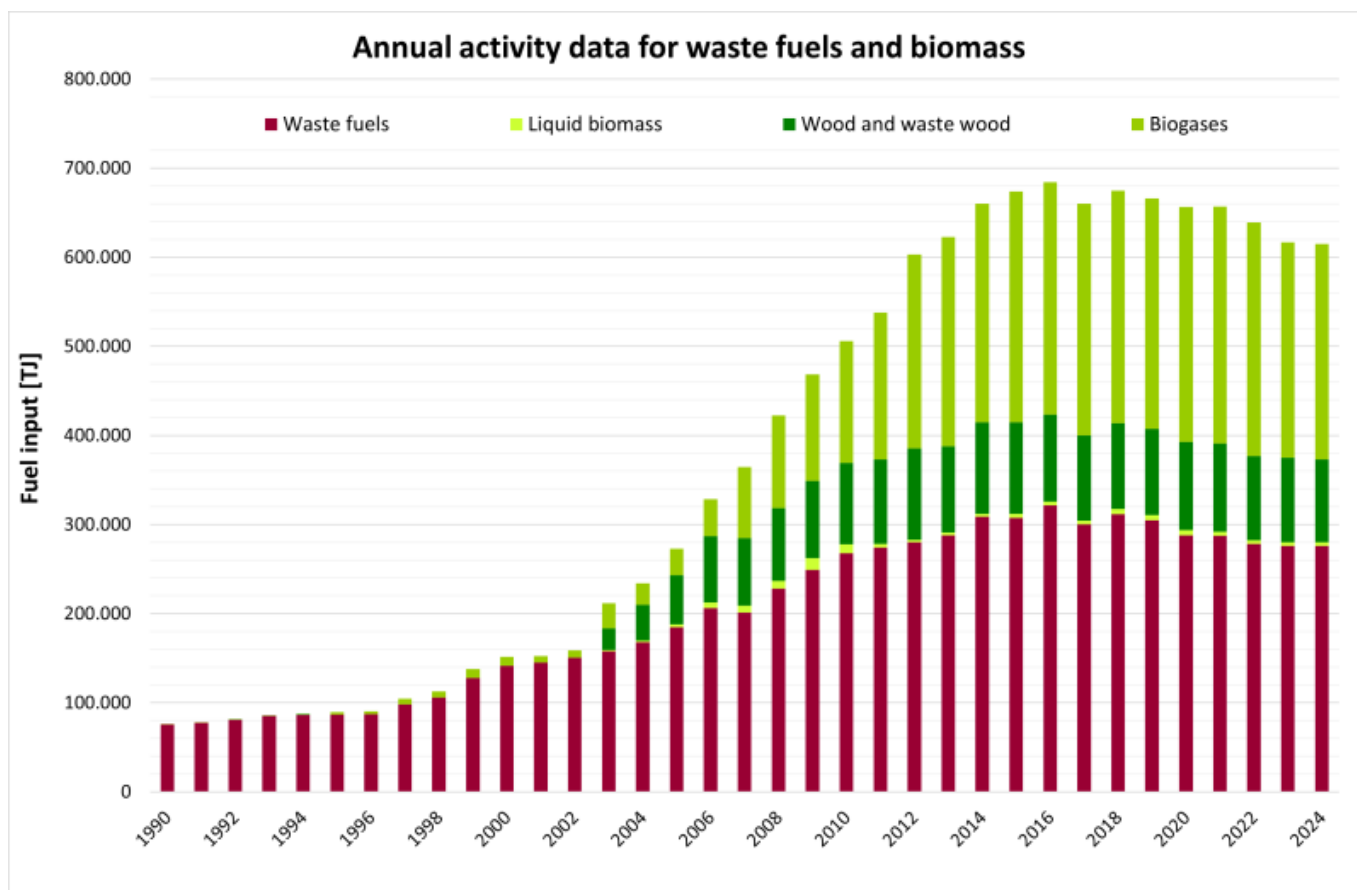
## Trend discussion for Key Sources

The following diagrams give an overview of the dominant emission trends of selected pollutants.

### Fuel Consumption

The first graph shows that the total energy consumption of fossil fuels for public electricity and heat consumption didn't change very much since 1990. The main reasons are the rising electricity demand and a great number of industrial power plants whose emissions are now reported in source category 1.A.1.a. From 1990 to the present time, a slight fuel switch from coal to natural gas was observed. In 2009 fuel consumption of all fossil fuels decreased remarkably as a result of the economic crisis. The economic recovery in 2010 led to an increasing fuel consumption because of the increasing electricity demand. 2021 and 2022 saw an increase of coal consumption, due to the difficulties with natural gas availability during that period. In recent years the consumption is decreasing, getting back to the previous trend. Biomass consumption rises considerably from 2003 onwards, due to the legislative aid of renewable energies.

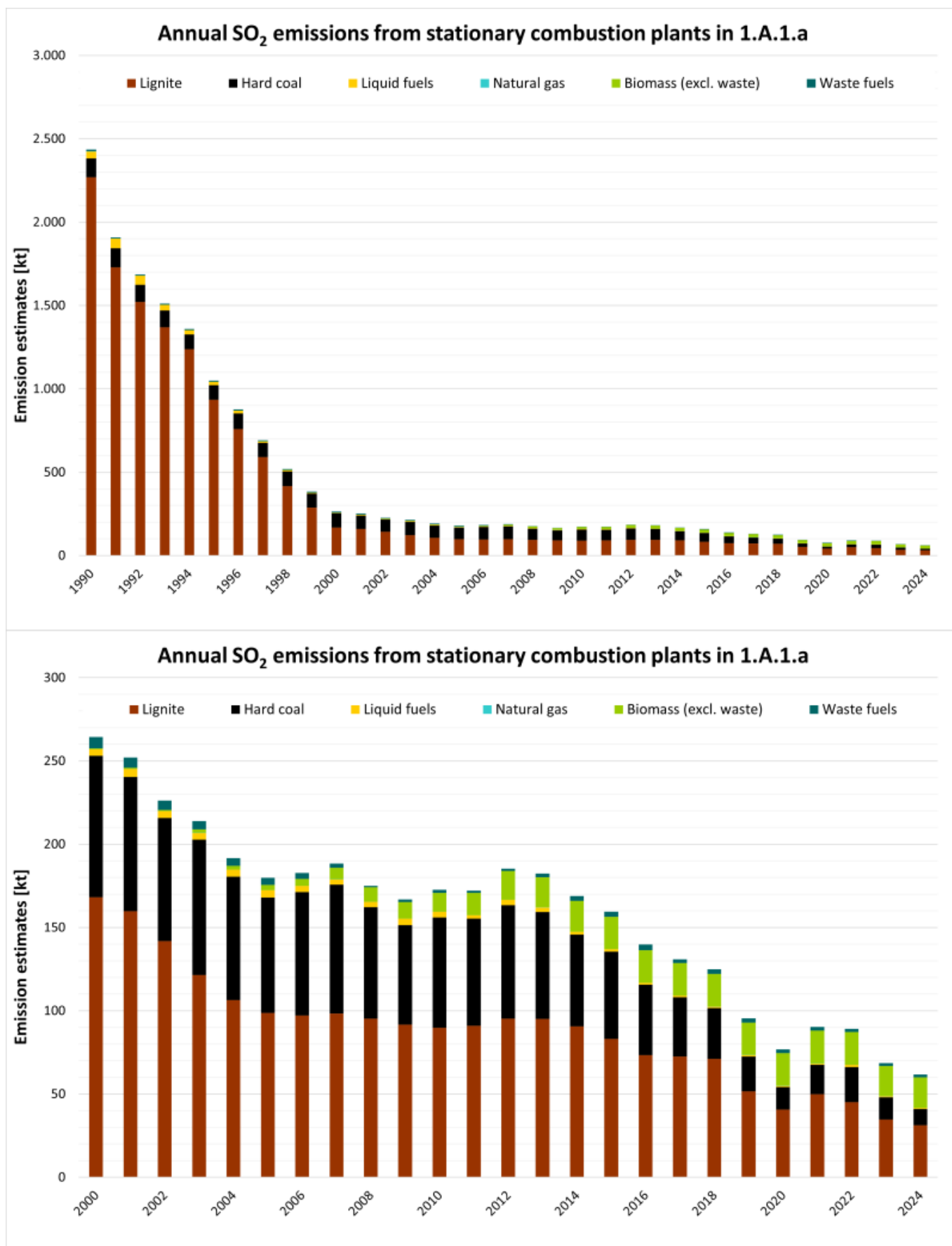




## Sulfur Oxides - SO<sub>x</sub>

SO<sub>x</sub> emission trend shows the big dominance of lignite due to high Sulphur content of lignite fuels. However SO<sub>x</sub> emissions decrease more than lignite consumption does. Before the German Reunification in 1990, lignite fired public power plants in Eastern Germany didn't use flue gas desulphurisation plants. The implementation of stricter regulations in the New German Länder resulted in considerably decreasing emissions. In recent years the development of SO<sub>2</sub> emissions is mainly influenced by coal consumption. From 2005 onwards biogas which has a considerable sulphur content gained in importance. In 2016 emissions from coal fired plants decreased considerably due to a stricter regulation related to the limit values and the reduction efficiency of desulfurization plants. The emission reduction in 2019 and 2020 is a result of the decreasing coal consumption.

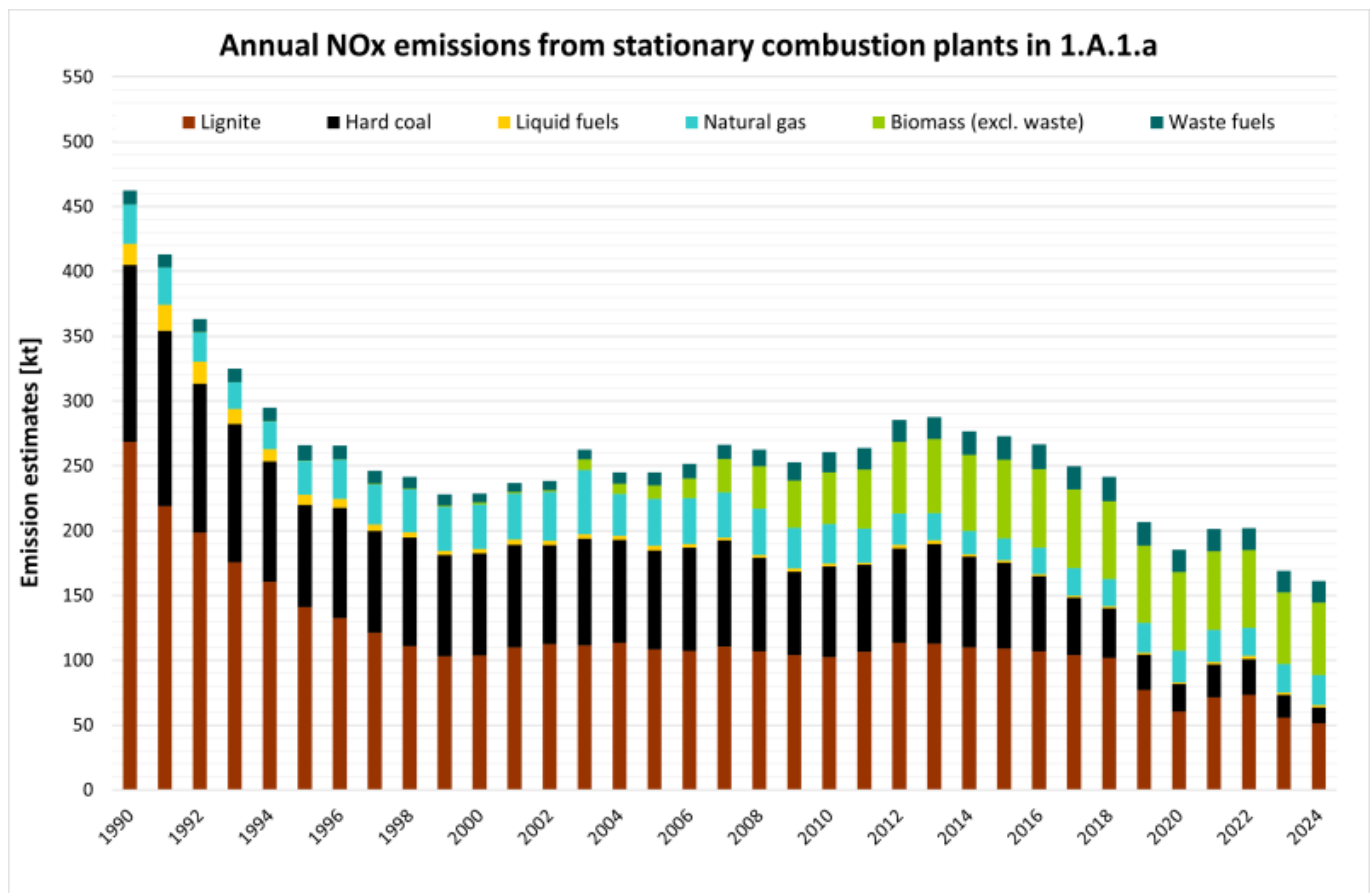




## Nitrogen Oxides - NO<sub>x</sub>

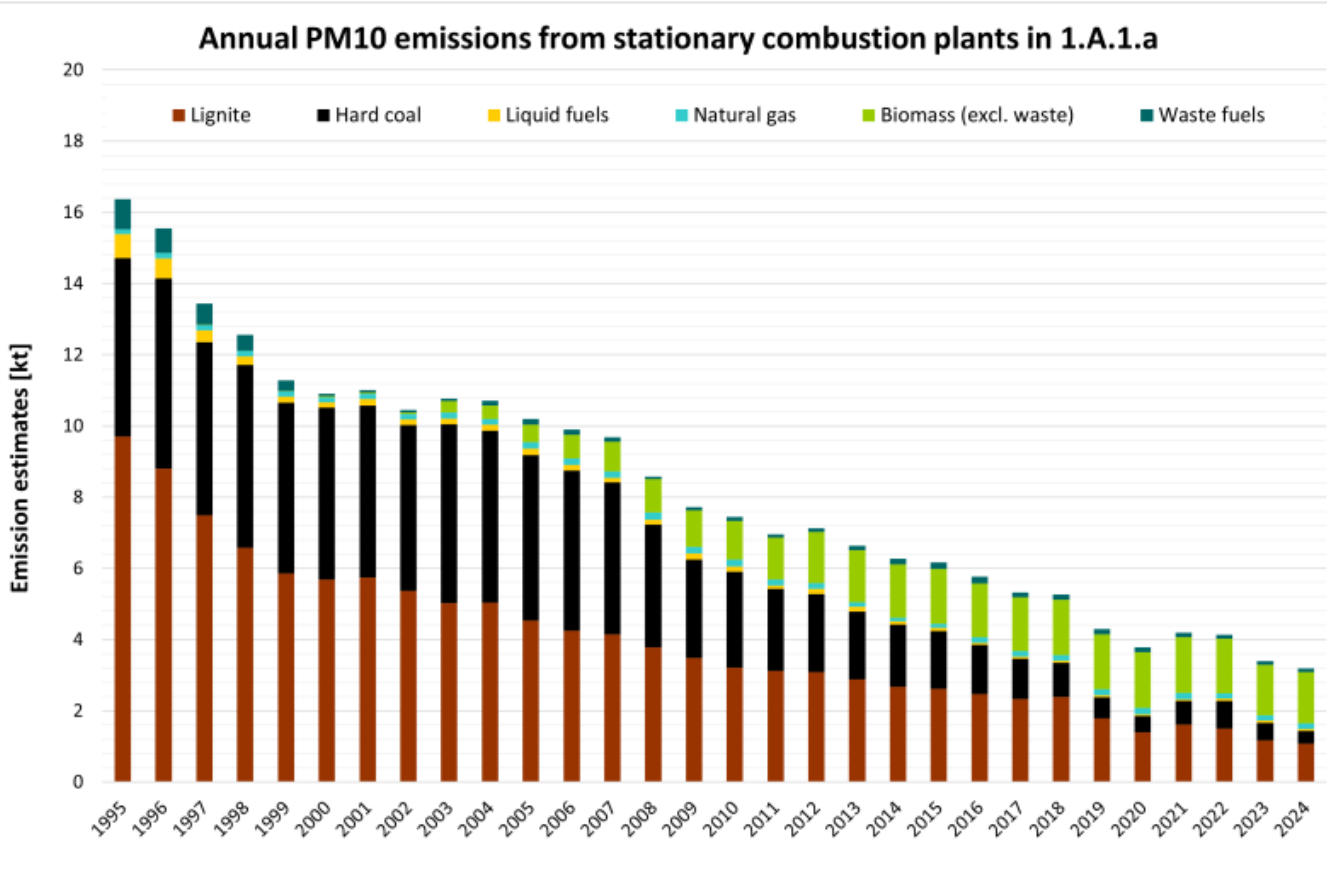
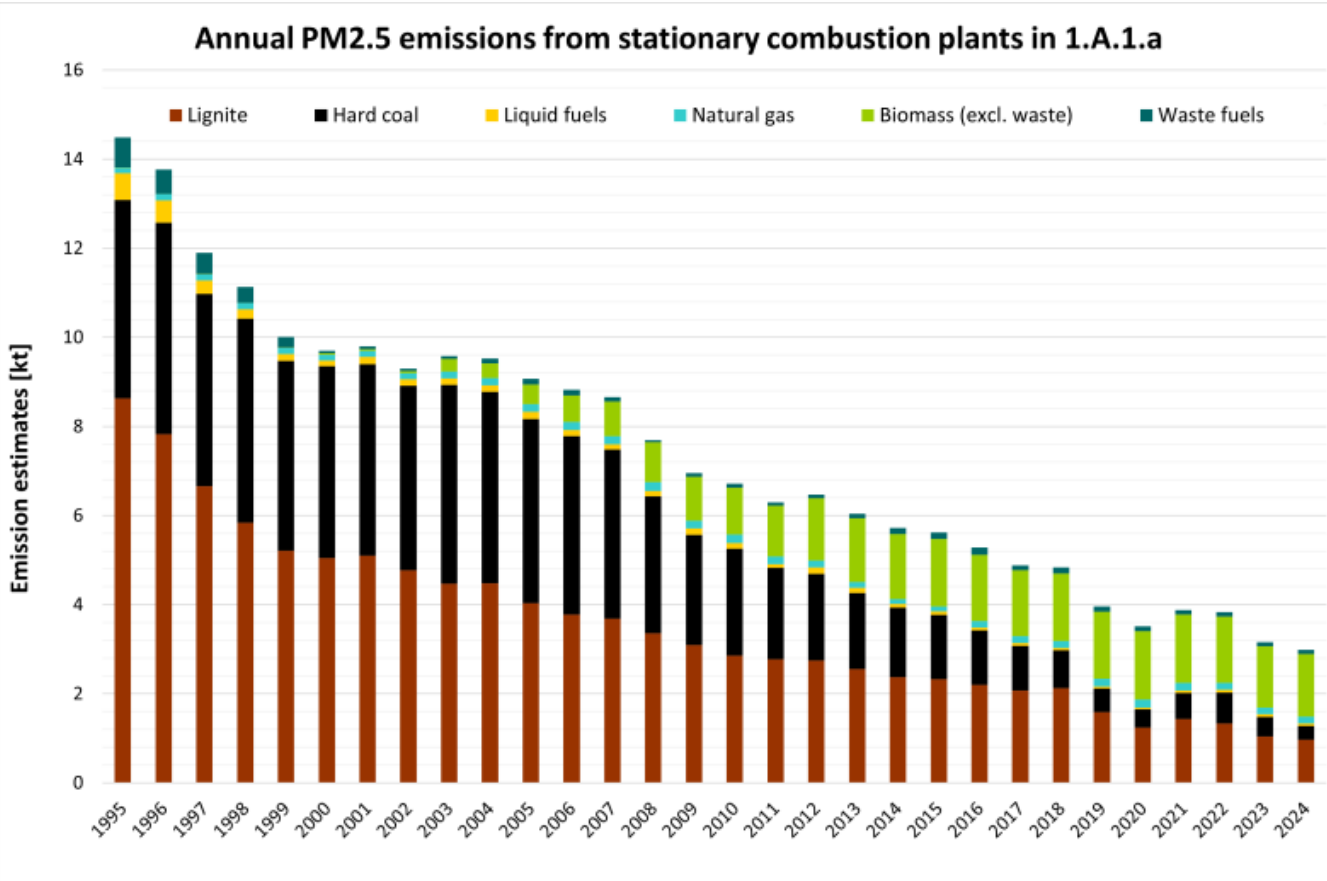
Nitrogen oxides emissions decreases due to declining lignite consumption in the early 1990s and due to NO<sub>x</sub> emission reduction measurements in the New German Länder. After 2002 the increasing consumption of natural gas biogas, wood and other biomass in the public sector gain influence and increases NO<sub>x</sub> emissions. The upward trend was only interrupted by the

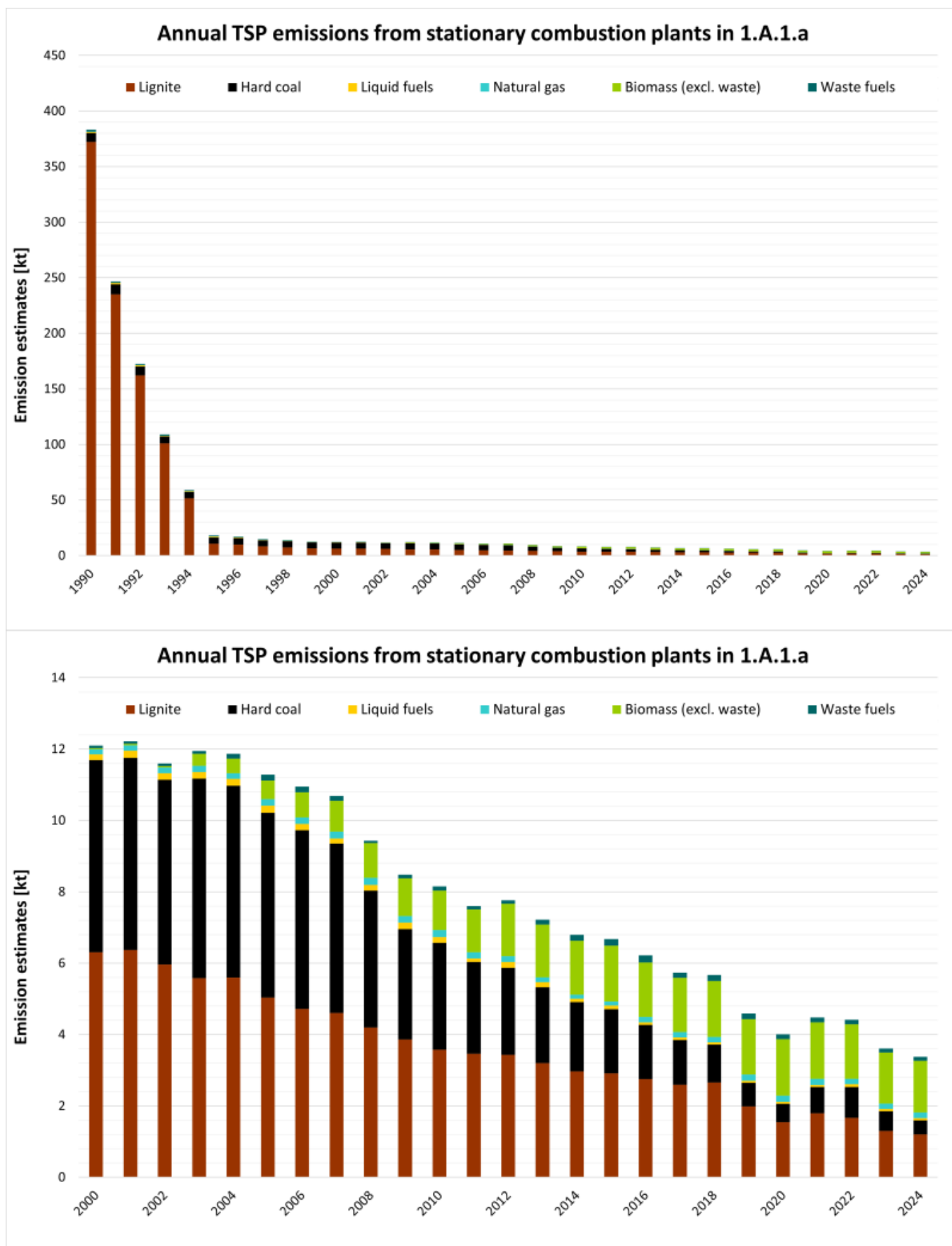
economic crises in 2009. From 2014 onwards NO<sub>x</sub> emissions decreases mainly caused by the decreasing hard coal consumption.



### Particulate Matter - PM<sub>2.5</sub> & PM<sub>10</sub> & TSP

Similar to SO<sub>x</sub> emissions, Particulate Matter emissions decreases considerably since 1990 due to stricter regulations in eastern Germany. After 2002 PM<sub>10</sub> and PM<sub>2.5</sub> emission trends were influenced by the increasing use of biomass for public electricity and heat production. TSP and PM emissions from coal fired plants show a decreasing trend from 2005 onwards due to improvements of abatement systems. The remarkable emission reduction in 2019 and 2020 is a result of the decreasing coal consumption.

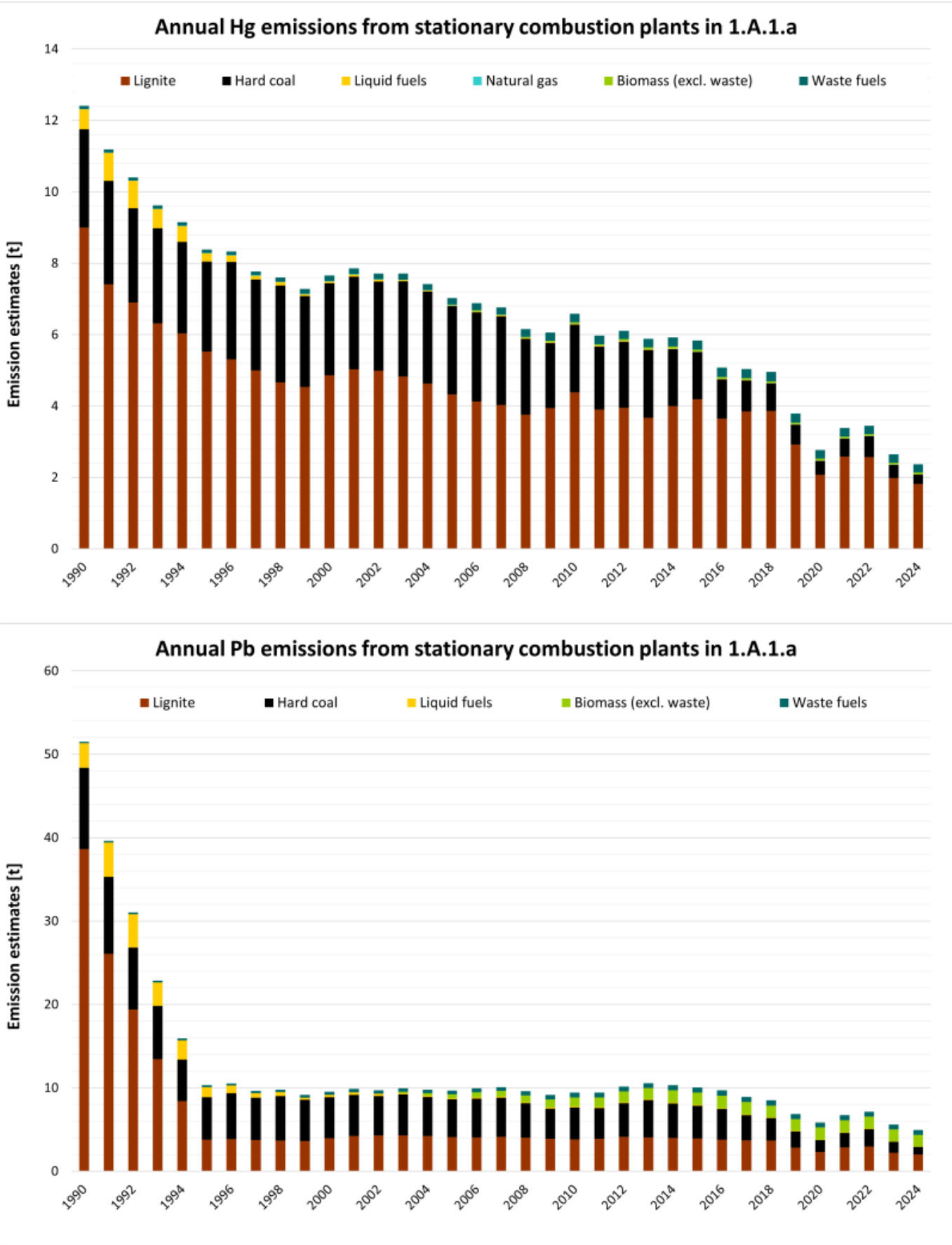


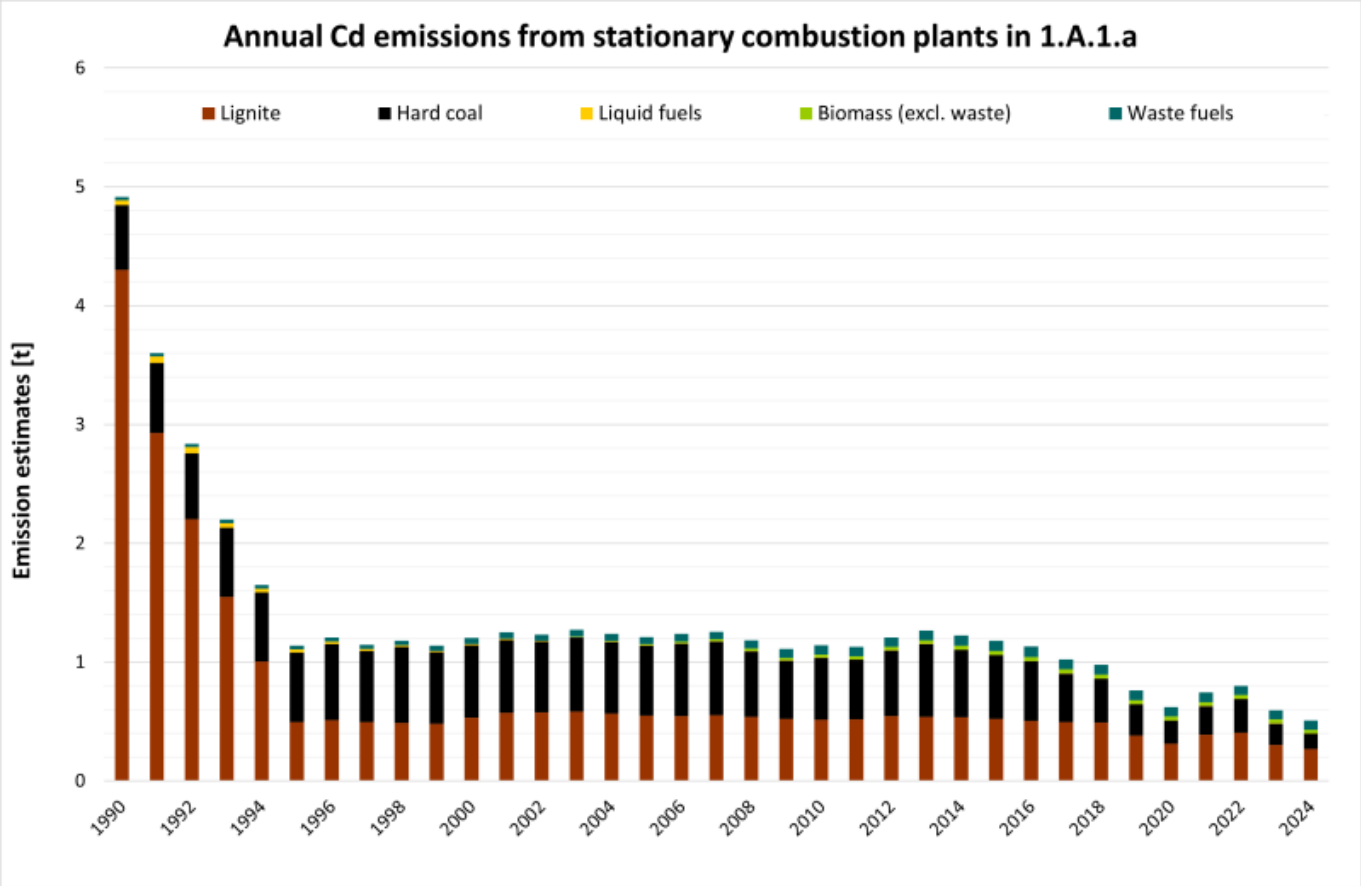


### Priority Heavy metal - Hg, Pb & Cd

Emission trends of all priority heavy metals are mostly influenced by the emissions from lignite use. The reasons of the declining emissions are on the one hand the decreasing lignite consumption and on the other hand the implementation of stricter regulations in eastern Germany. Due to the fact, that heavy metal emission factors for waste incineration plants are

constant, emission trends solely depend on coal consumption. In reality emission trends of all heavy metals would be more influenced by the emissions from waste fuels, since the emission factors for waste incineration plants in 1990 are expected to be high. In recent years emissions from Biomass combustion gain more and more influence on the trend.

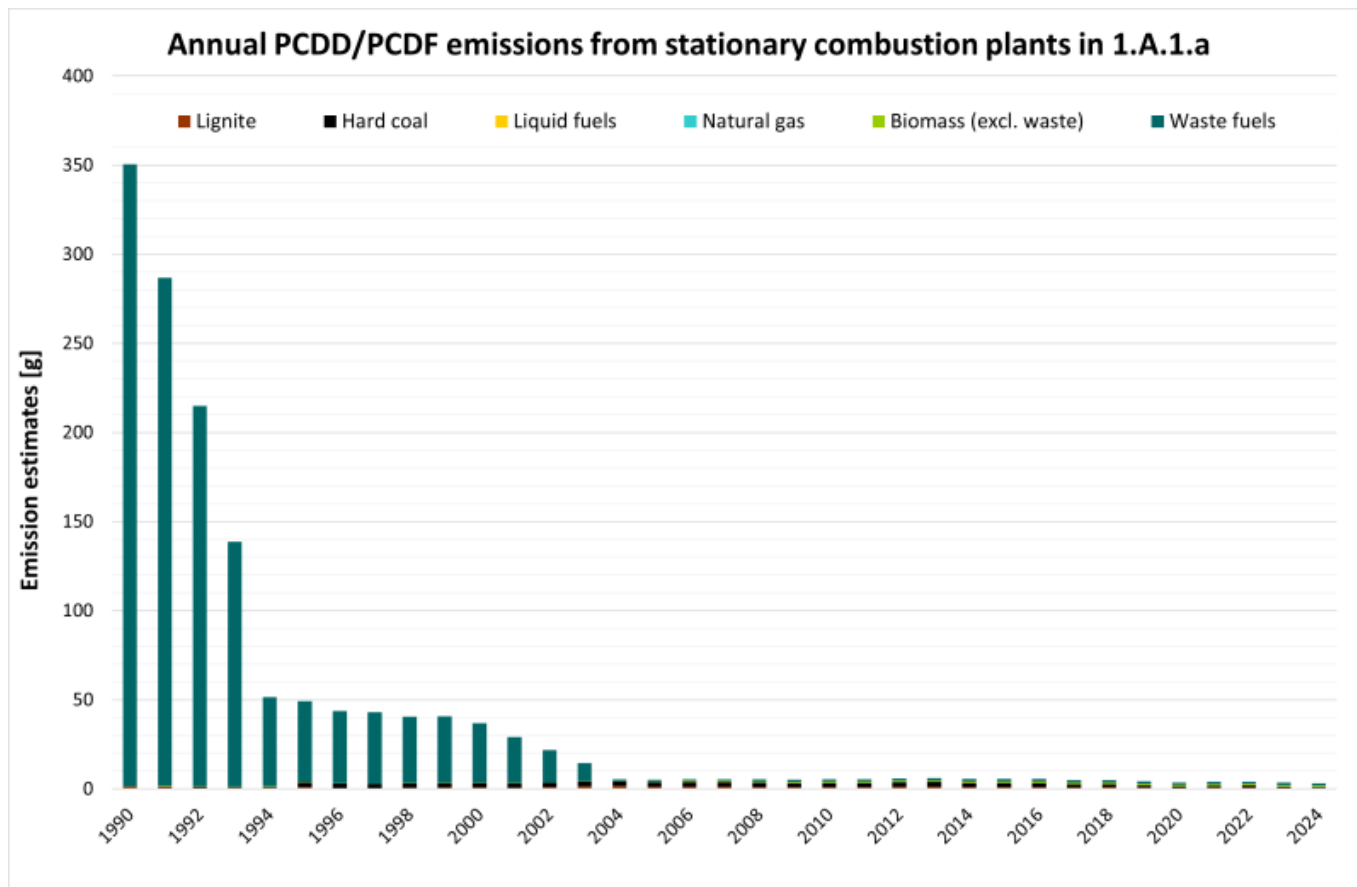




Persistent Organic Pollutants

Main driver of the dioxin emission trend is by far waste incineration with high specific emissions in the early 90s and considerably decreasing emissions due to stricter regulations in Germany. In recent years emissions remain stable at a very low level.





## Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the energy balance for 2023 led to recalculations. Moreover, for the purpose of improving data quality, national energy balances go under revisions every two years (for the years starting from 2003) through fine-tuning of the computational models, consideration of new statistics or re-allocation of activity data. Due to the revisions on the input data for submission 2026, recalculations took place <sup>6)</sup>.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

Although there are new POPs emission factors available for waste incineration plants for 2015, their implementation can only take place after a trend discussion with the experts and after a clear consensus is achieved.

The new PCB emission factors cannot be currently used since it would impair the current inventory structure and impede a thorough and correct key source analyses. The PCB emission factors were measured according to the WHO-TEQ. The values which are currently used in the inventory are based on measurements according to German standards (Ballschmiter, LAGA) with a factor of 100,000 between both EF sources. The implementation of the new PCB emission factors will only be possible when new PCB emission factors are available for iron and steel production and cement industry, too.

<sup>1)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> Destatis (2024): Federal Statistical Office (Statistisches Bundesamt): Fachserie 19, Reihe 1: Abfallentsorgung -

[https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Wasserwirtschaft/\\_inhalt.html#sprg238684](https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Wasserwirtschaft/_inhalt.html#sprg238684), Wiesbaden, 2024.

<sup>3)</sup> Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); <https://publikationen.bibliothek.kit.edu/21412002>; Karlsruhe / Dessau-Roßlau, 2002.

<sup>4)</sup> UBA2019]) For the reporting year 2016 a complete data set is available. In former times data were not complete. There was no reporting obligation of co-incineration plants. The large combustion data base was also the data basis of the research project (Fichtner et al. 2011)[(FICHTNER2011

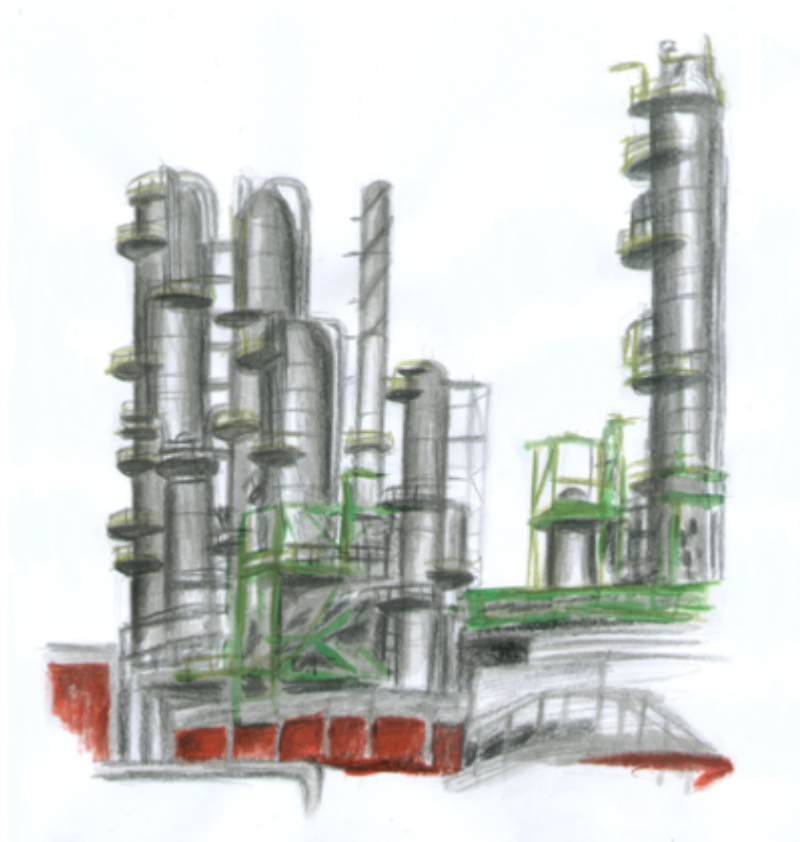
<sup>5)</sup> Daschner et al. (2010): Daschner, R., Faulstich, Prof. Dr. M. , Quicker, Prof. Dr. P., Binder, S.: Waste incineration: "Überprüfung der Emissionsfaktoren für die Abfallverbrennung"; UFOPlan FKZ 3708 49 1075, ATZ Entwicklungszentrum, on behalf of the Umweltbundesamt, Dessau-Roßlau, not published

<sup>6)</sup> AGEb (2025a): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland;

[https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?\\_jahresbereich-bilanz=2021-2030](https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?_jahresbereich-bilanz=2021-2030), (Aufruf: 04.12.2025), Köln & Berlin, September 2025

## 1.A.1.b - Petroleum Refining

### Short description



Source category *Petroleum Refining (1.A.1.b)* comprises both refinery heating plants and electricity and heat production of refinery power plants.

| NFR Code | Method | AD | EF |
|----------|--------|----|----|
| 1.A.1.b  | T2     | NS | CS |

| NFR Code                                                                                  | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|---------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|
| -/-             | -/-    | L/-             | -/-             | -/-               | -/-                                                                             | -/- | -/- | -/- | -/- | L/- | L/- | L/- | -/- | -/- | L/- | L/T | -/- | -/-    | -/-   | IE    | IE    | IE    | -/-    | -/- | -/-  |
|                 |        |                 |                 |                   | L/- key source by Level only                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | -/-T key source by Trend only                                                   |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | L/T key source by both Level and Trend                                          |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | -/- no key source for this pollutant                                            |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | IE emission of specific pollutant Included Elsewhere (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | NE emission of specific pollutant Not Estimated (yet)                           |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | NA specific pollutant not emitted from this source or activity = Not Applicable |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | * no analysis done                                                              |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |

## Methodology

Refinery processes are very complex. Therefore the development of an adequate calculation method is demanding. Since plant specific data are not complete and partly contradictory, a plant specific reporting is not possible. Data is used to determine fuel specific emission factors as general basis of the calculation model. However, in reality, a large number of fuels and waste fuels with different fuel characteristics is used for combustion processes. Insofar the calculation model is limited. Only some refinery power plants use wet desulfurisation in order to decrease sulfur emissions. Usually the fuels mix ensures the compliance with the limit values.

### Activity data

Fuel inputs for electricity production in refinery power stations are included in Energy Balance line 12 ("Industrial power stations (only for electricity)"). Energy Balance line 38 ("Refineries") shows the energy consumption (for heat production) of refineries. <sup>1)</sup>

Fuel inputs for heat production in refinery power plants and for bottom heating in refinery processes are derived from these figures.

Fuel inputs for electricity and heat production in petroleum refining are determined by combining the national statistics of the Federal statistical Office (DESTATIS) and the Federal Office of Economics and Export Control (BAFA) <sup>2)</sup>.

Energy inputs in facilities for used-oil processing are reported under [1.A.1.c - Manufacture Of Solid Fuels And Other Energy Industries](#) sector.

## Emission factors

The emission factors for refinery power plants have been taken from the research project "Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010" (Rentz et al., 2002) <sup>3)</sup>.

A detailed description of the procedure is presented in Chapter: [1.A.1.a - Public Electricity And Heat Production](#).

Emission factors are available for different fuel types and combustion technologies. The distinction between refinery power plants and bottom heating in refinery processes is necessary since bottom heating systems have considerably higher specific emissions.

The first results of a research project to evaluate data from emission declarations for the years 2004, 2008, 2012 and 2016 for all refineries for refinery gas provides the following emission factor range:

Table 1: Range of emission factors, in kg/TJ

|                       | Range         |
|-----------------------|---------------|
| <b>SO<sub>2</sub></b> | 4.79 - 16.09  |
| <b>CO</b>             | 1.02 - 1.85   |
| <b>NO<sub>x</sub></b> | 36.71 - 45.60 |
| <b>NMVOC</b>          | 0.843 - 1.170 |
| <b>TSP</b>            | 0.24 - 0.37   |

Before these emission factors can be applied, their representativeness have be ensured. Further quality checks are necessary in order to reproduce the trend correctly.

## Trend discussion for Key Sources

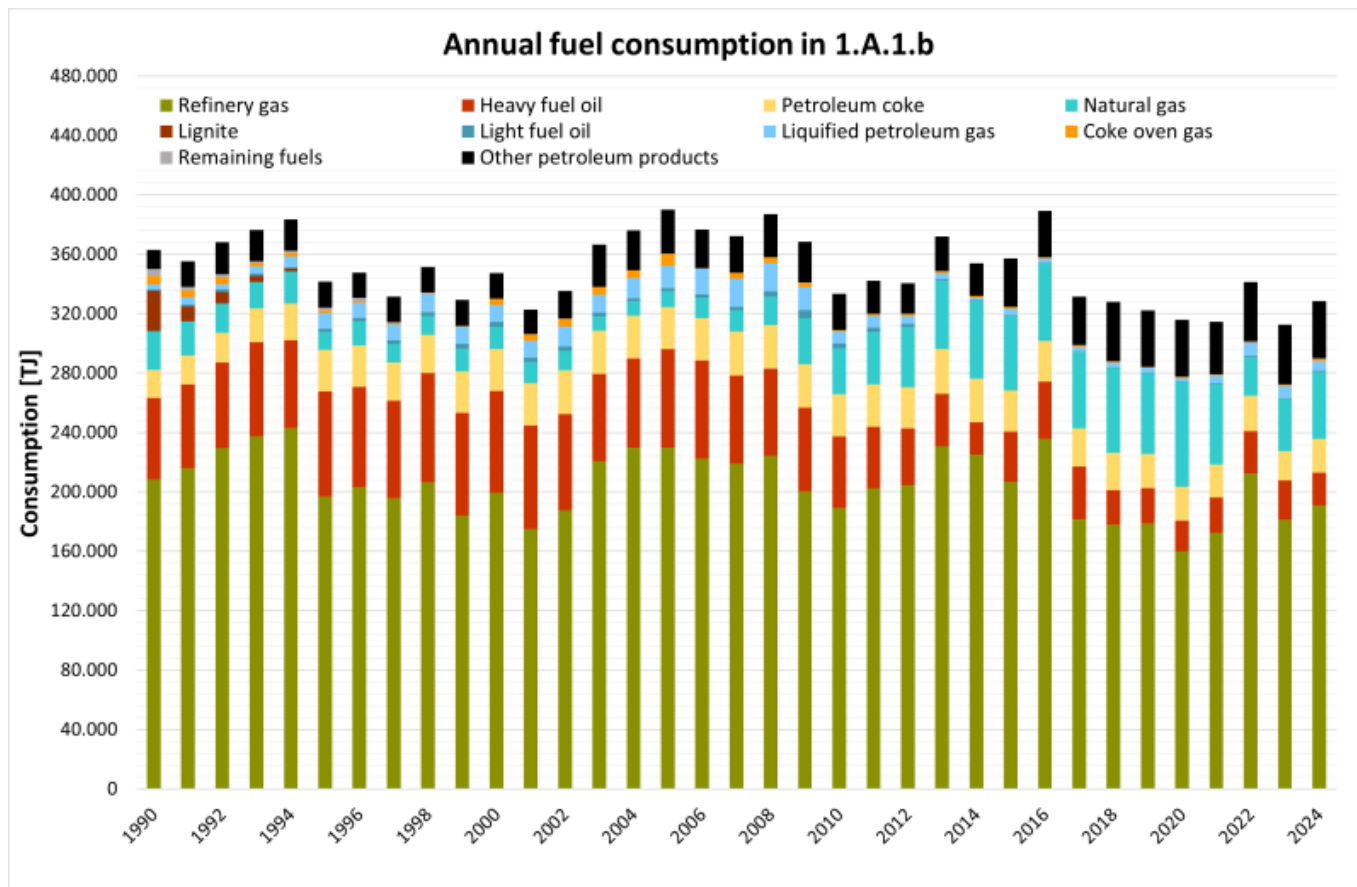
Since 1990, fuel consumption has shown a slightly increasing overall trend. While some relevant installations have been decommissioned since 1990 - especially in the territory of the former GDR - production increased nevertheless. And while installation efficiencies were improved, increased production of lighter petroleum products and intensified hydrosulphurisation, which led to increases in specific fuel consumptions.

Annual fluctuations of all fuel types can be explained as the result of differences in production quantities.

A substantial production of petroleum products occurred in 2005, as a result of a shortfall in capacity in the USA, which led to an increase in imports. Thereafter, production decreased by reducing excess capacities all over Europe.

The increasing use of natural gas in recent years led to decreasing emissions of all pollutants (except NO<sub>x</sub> ).

The following chart gives an overview of the fuel consumption in the refinery sector:



## Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the energy balance for 2023 led to recalculations. Moreover, for the purpose of improving data quality, national energy balances go under revisions every two years (for the years starting from 2003) through fine-tuning of the computational models, consideration of new statistics or re-allocation of activity data. Due to the revisions on the input data for submission 2026, recalculations took place <sup>4)</sup>.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

It is planned to revise emission factors for all pollutants on the basis of the above-mentioned project.

<sup>1)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl-daten für die Bundesrepublik Deutschland; [https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>3)</sup> Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); <https://publikationen.bibliothek.kit.edu/21412002>; Karlsruhe / Dessau-Roßlau, 2002.



<sup>4)</sup> AGEB (2025a): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland;  
[https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?\\_jahresbereich-bilanz=2021-2030](https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?_jahresbereich-bilanz=2021-2030), (Aufruf: 04.12.2025), Köln & Berlin, September 2025

# 1.A.1.c - Manufacture Of Solid Fuels And Other Energy Industries

## Short description



Source category 1.A.1.c - Manufacture Of Solid Fuels And Other Energy Industries includes hard-coal and lignite mining, coking and briquetting plants and extraction of crude oil and natural gas. Used-oil processing plants are also included. Here, CO emissions from coking plants are reported in NFR sub-category 1.B.1.b.

| NFR Code                                                                                  | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 1.A.1.c                                                                                   | T2                                   | NS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP                                                                                 | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|
| L/T             | -/-    | L/T             | -/-             | -/T               | -/-              | L/T                                                                                 | -/- | -/- | -/- | L/T | L/T | L/T | L/T | L/T | L/T | -/- | L/T | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | -/-  |
|                 |        |                 |                 |                   | L/-              | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | -/T              | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | L/T              | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | -/-              | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | IE               | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | NE               | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | NA               | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | *                | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |

## Method

### Activity data

Fuel inputs for electricity production in power plants of the hard-coal and lignite mining sector are listed in Energy Balance line 12 "Industrial power stations". Fuel inputs for heat production in the transformation sector are listed in Energy Balance lines 33-39 <sup>1) 2)</sup>.

Fuel inputs for electricity production in power stations of the hard-coal mining sector are determined with the help of figures of the Federal Statistical Office (DESTATIS). The activity rates for heat production in power stations of the hard-coal mining sector correspond to Energy Balance line 34 "Energy input in pit and briquette plants of the hard-coal mining sector". The listed fuel input for electricity and heat production in pit power plants is based on association information from DEBRIV (the federal German association of all lignite producing companies and their affiliated organisations). Inputs for heat production, especially for lignite drying for production of lignite products, are not shown in the Energy Balance. Those are calculated from figures for production of lignite products (STATISTIK DER KOHLENWIRTSCHAFT)<sup>3)</sup> and from the specific fuel inputs required for drying from DEBRIV.

Energy consumption data for hard-coal coke production are provided by the Energy Balance line 33<sup>4) 5)</sup>.

The fuel input for heat production in the remaining transformation sector is obtained by combining the energy consumption figures in Energy Balance lines 33 to 39 (total energy consumption in the transformation sector). These figures include the pits' own consumption, facilities for petroleum and natural gas production and for processing of old oil; plants that produce coal products; plants for production and processing of fissile and fertile materials; and wastewater-treatment facilities.

### Emission factors

The emission factors for power stations and other boiler combustion for production of steam and hot water, in source category 1.A.1.c, have been taken from the research project "Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010" (Rentz et al., 2002)<sup>6)</sup>. A detailed description of the procedure is presented in Chapter: [1.A.1.a - Public Electricity And Heat Production](#). In 2018 all emission factors for large combustion plants were revised (UBA, 2019)<sup>7)</sup>.

The German inventory compiling process is very complex and includes the use of a considerable number of emission factors, which cannot be published completely in the IIR. The emission factors are available for diverse fuel types, various techniques and licensing requirements.

PM<sub>10</sub> and PM<sub>2.5</sub> emission factors are calculated as a fraction of TSP. The share of PM<sub>10</sub> is 90 % and the share of PM<sub>2.5</sub> is 80 %. This is a simple but also conservative approach, knowing that, in reality, PM emissions depend on fuel, combustion and abatement technologies. PM emission reporting starts in 1995, since no sufficient information about the dust composition of the early 1990th is available.

Emission factors of sewage sludge refer to mono-incineration, using fluidized-bed combustion. Emission factors of coke oven gas do not include underfiring systems of coking plants. The determination of emission factors of coking plants is described in the study: "Emissionsfaktoren zur Eisen und Stahlindustrie für die Emissionsberichterstattung" carried out by Hensmann et al.(2011)<sup>8)</sup>. Emission factors refer to the produced amount of coke, distinction is drawn between diffuse and channelled sources. The following graph gives an overview of the methodology:

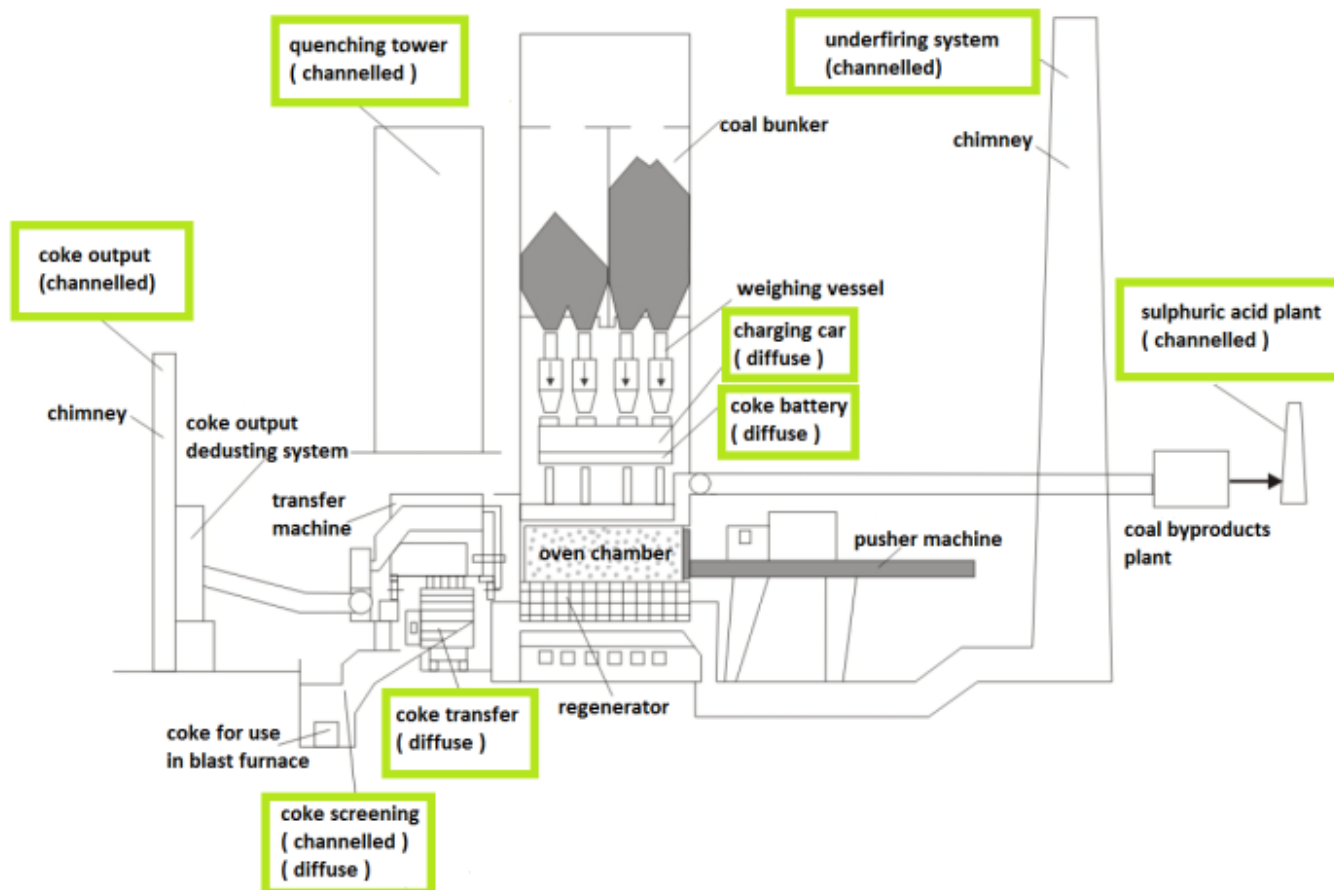


Table 2: emission factors for coking plants (solely channelled sources)

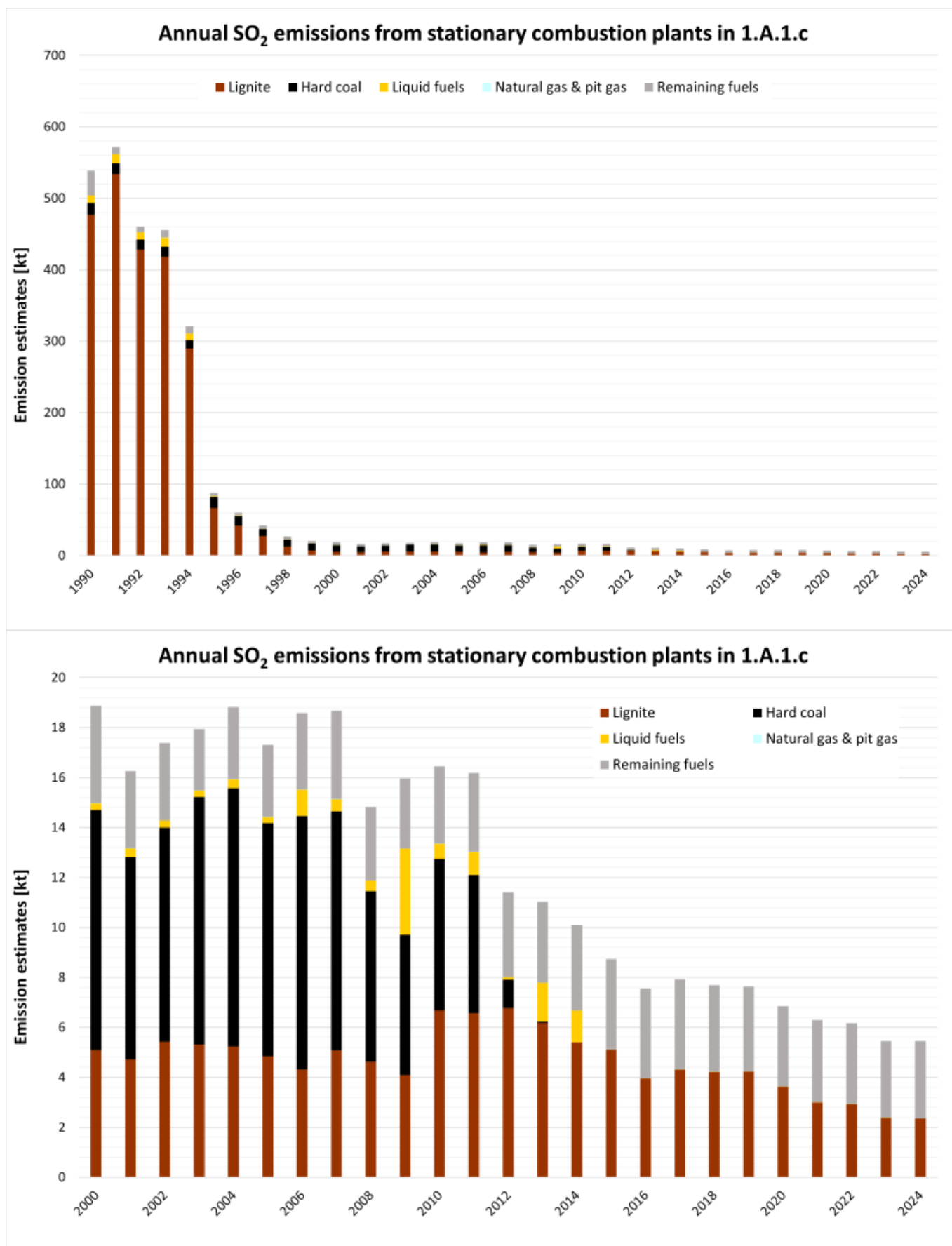
| SO <sub>x</sub> | NO <sub>x</sub> | CO    | TSP  | PM <sub>10</sub> | NH <sub>3</sub> | B[a]P          | Benzene |
|-----------------|-----------------|-------|------|------------------|-----------------|----------------|---------|
| [g/t product]   |                 |       |      |                  |                 | [mg/t product] | Unit    |
| 220.5           | 529.9           | 828.2 | 25.9 | 12.1             | 1.9             | 7.2            | 36.2    |

## Trend Discussion for Key Sources

The following diagrams give an overview and assistance for explaining the dominant emission trends of selected pollutants.

### Sulfur Oxides - SO<sub>x</sub>

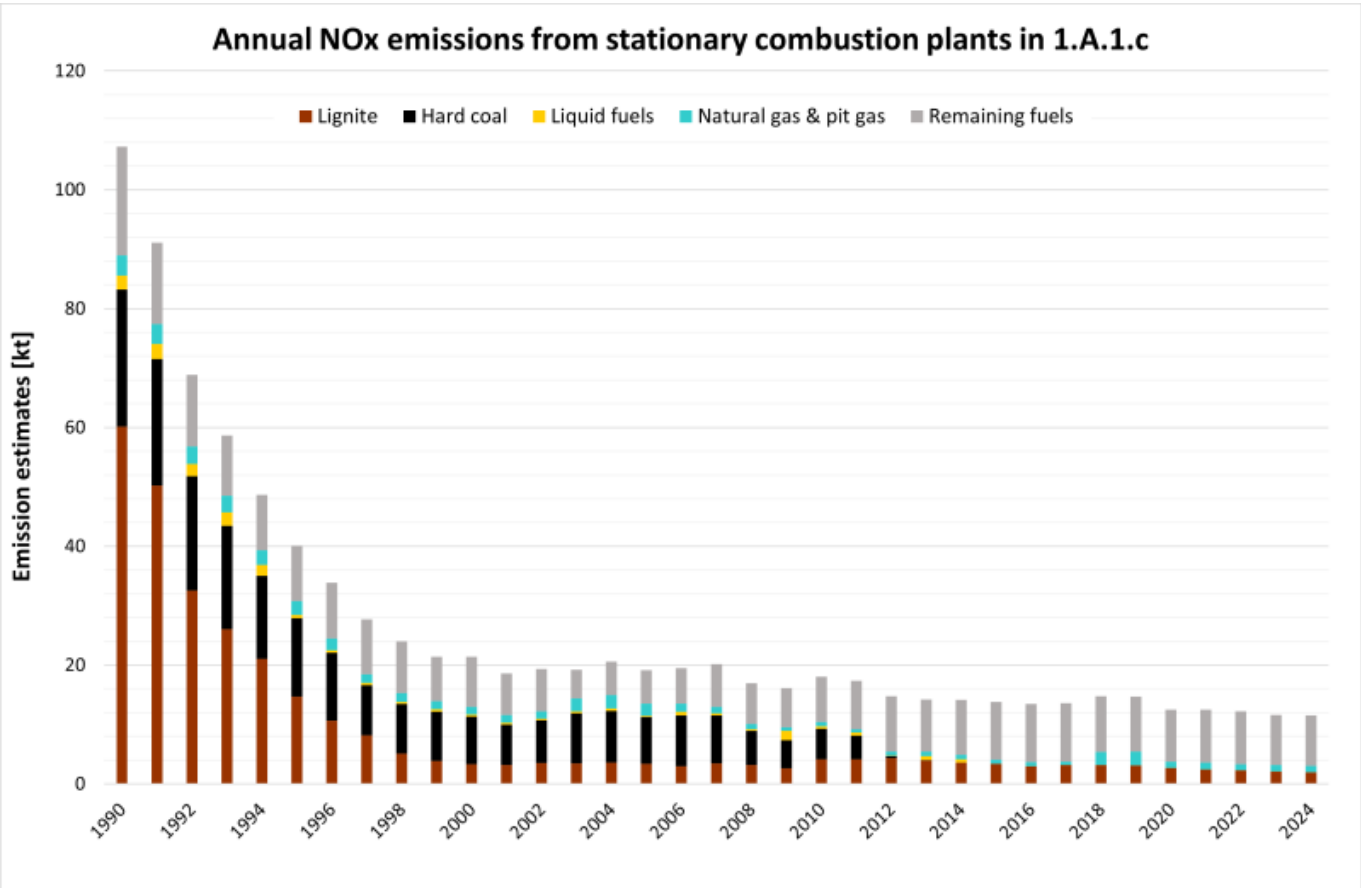
The graph shows sharp declining SO<sub>x</sub> emissions between 1990 and 1995 due to decreasing lignite consumption as well as the implementation of stricter regulations in eastern Germany. In the former GDR lignite industry was of prime importance for the economy. After the reunification, lignite briquette production in eastern Germany collapsed. The remaining factories had to install flue gas desulphurisation plants. The strong decline of SO<sub>2</sub> emissions in 2012 can be explained by the change of some power plants from the industrial to the public sector as a result of the closure of hard coal mines. A further reduction of SO<sub>2</sub> emission factors followed in 2016 when the reduction efficiency of desulfurization plants increased from 95 to 96%. However, this effect is counterbalanced by the increased use of lignite.



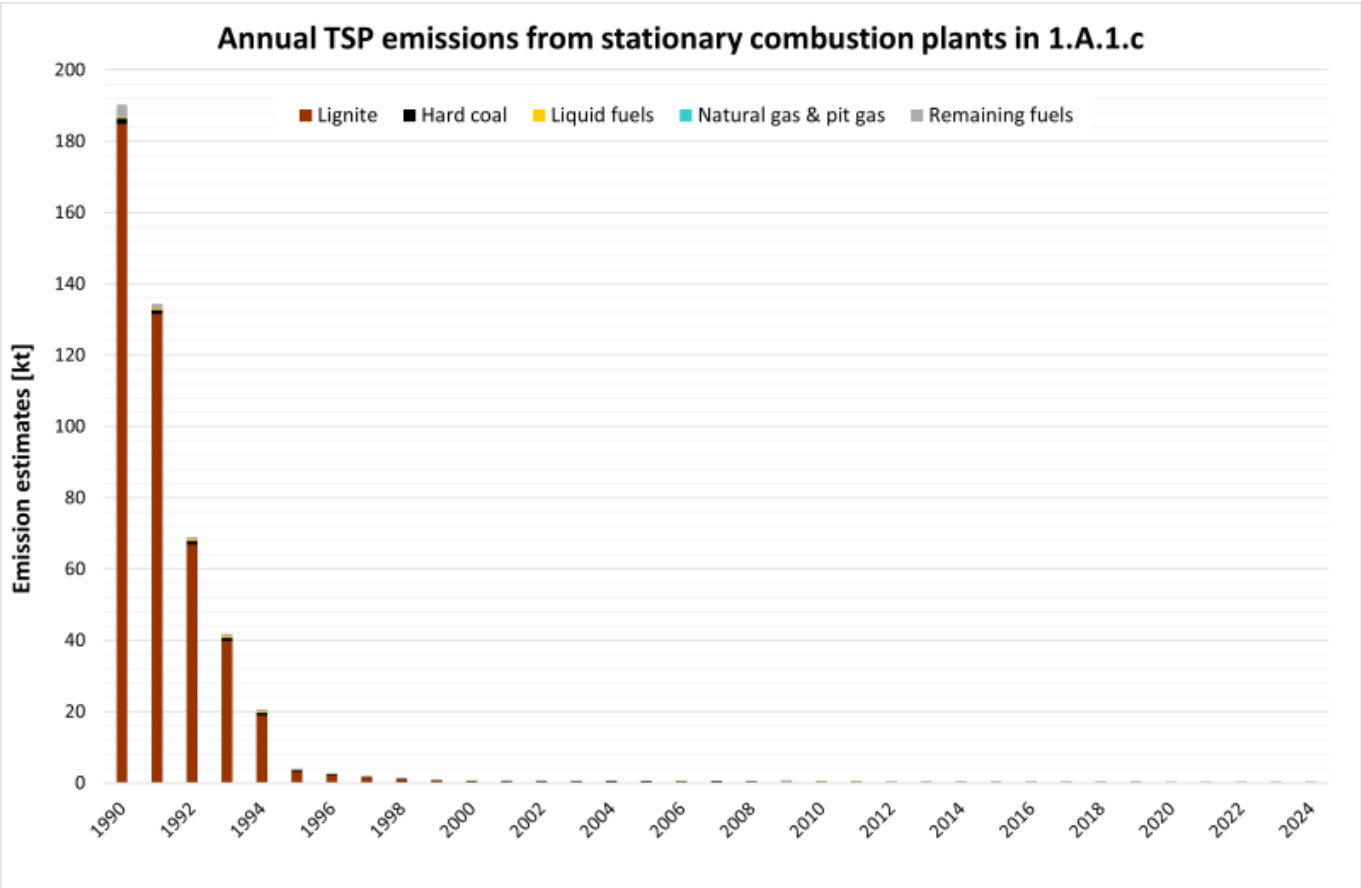
## Nitrogen Oxides - NO<sub>x</sub>

NO<sub>x</sub> emissions decrease gradually from 1990 to 2001. The main reasons are the minor fuel use of lignite and of hard coal in this sector and the adaptation of regulations in eastern Germany to the western standard. Besides German hard coal production decreased considerably since 1990. Therefore some hard coal fired industrial power plants changed from sector

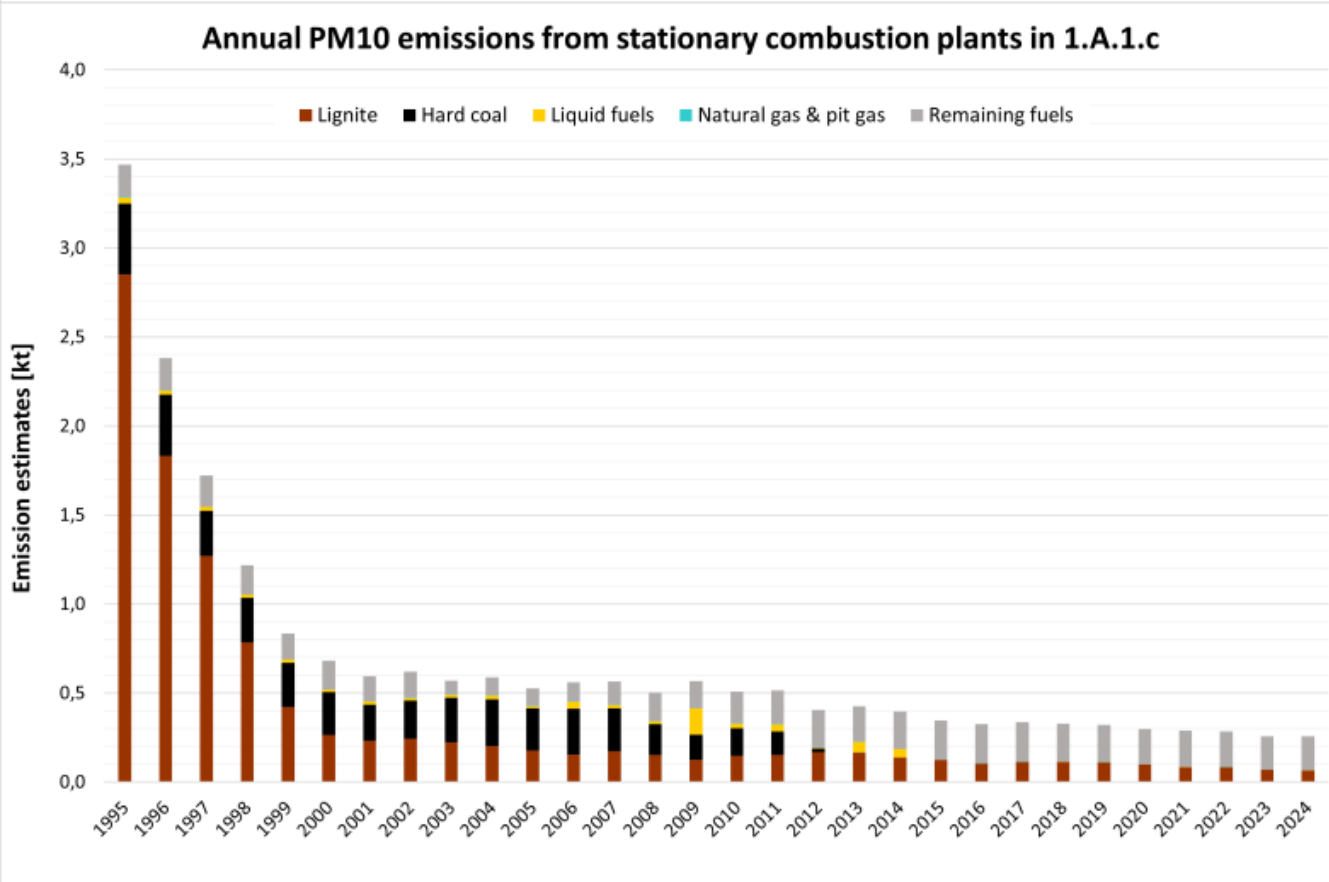
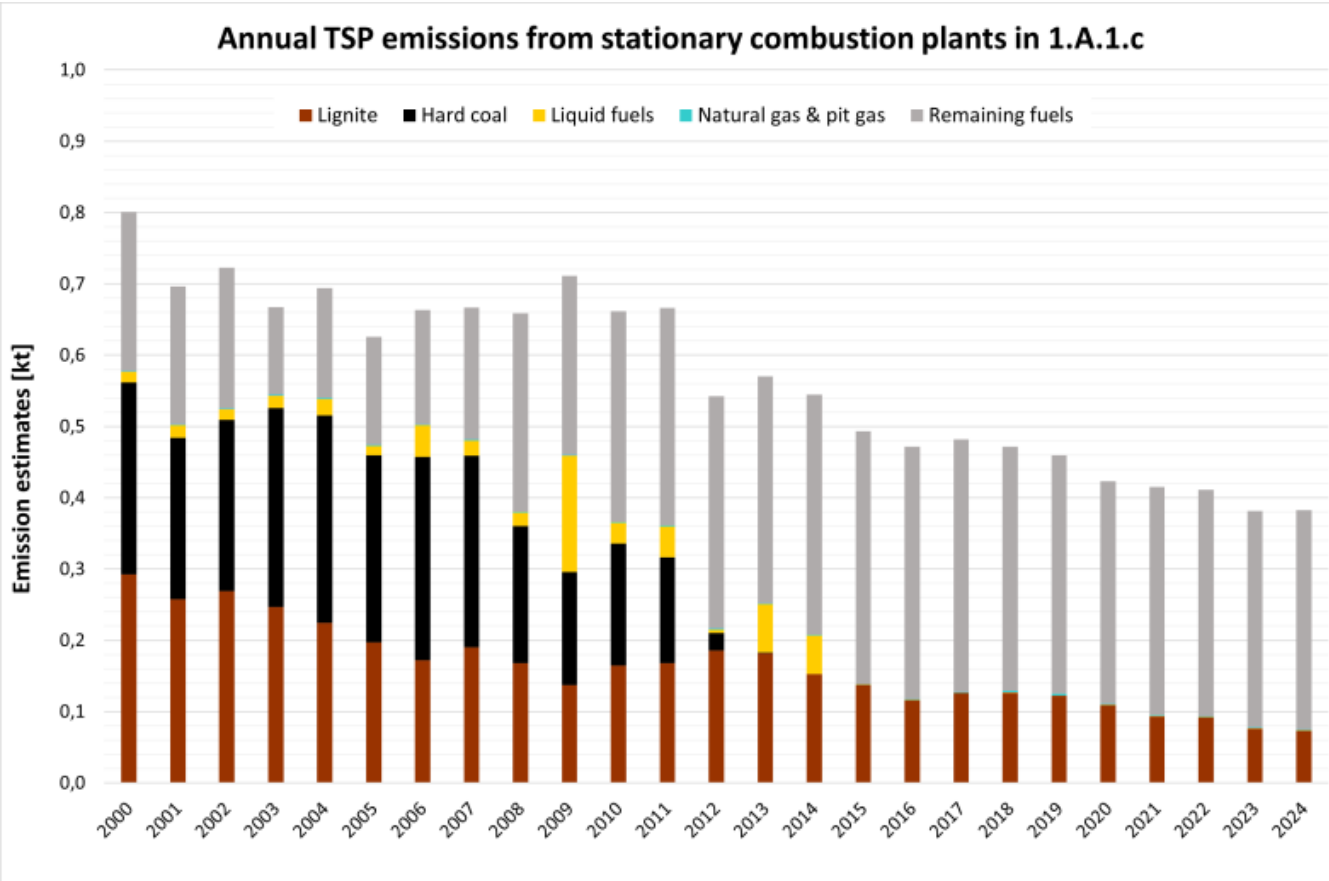
1.A.1.c to the public sector. This is also the reason for the significant emission reduction in 2012.

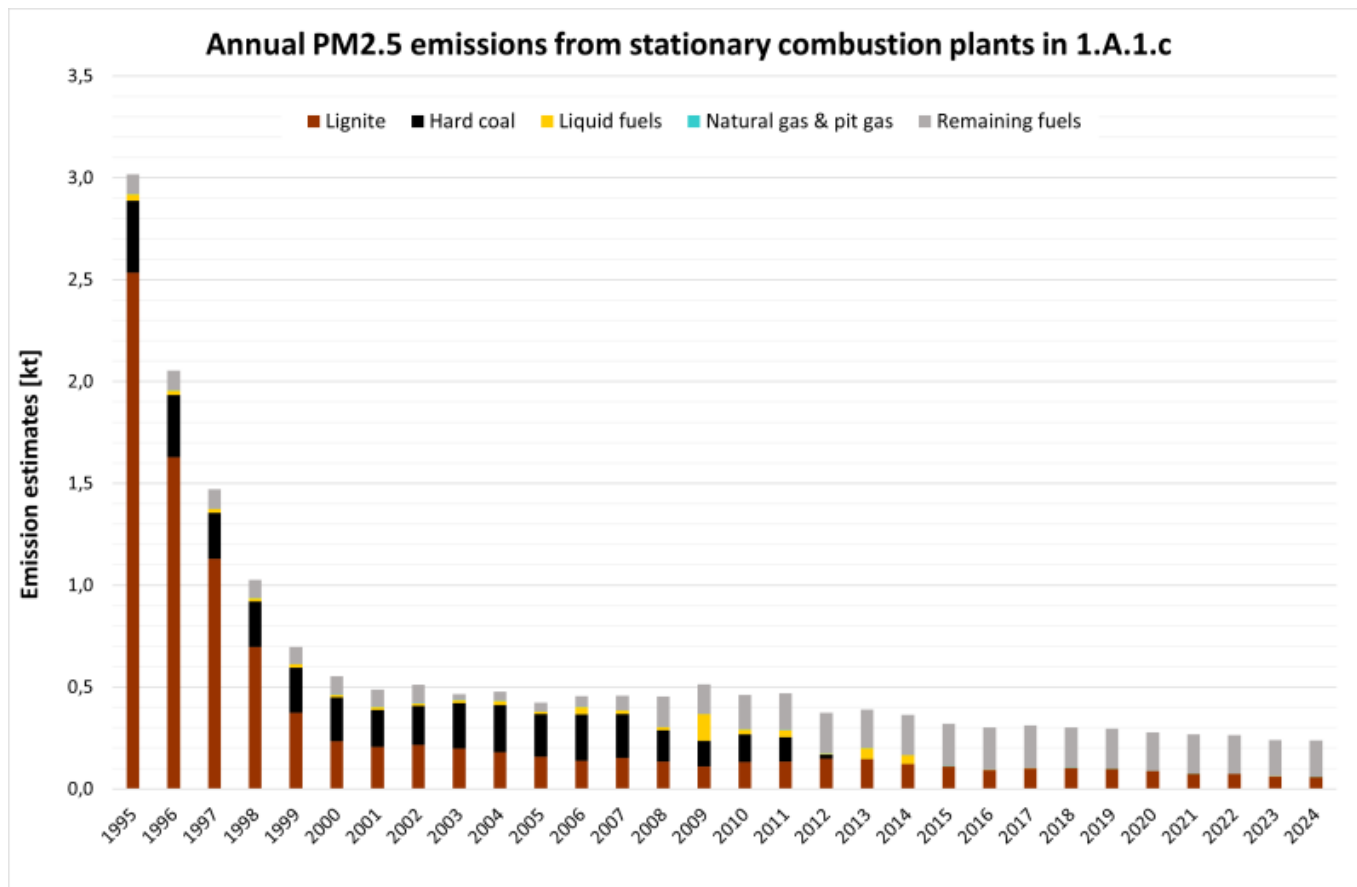


Total Suspended Matter - TSP, PM10 & PM2.5



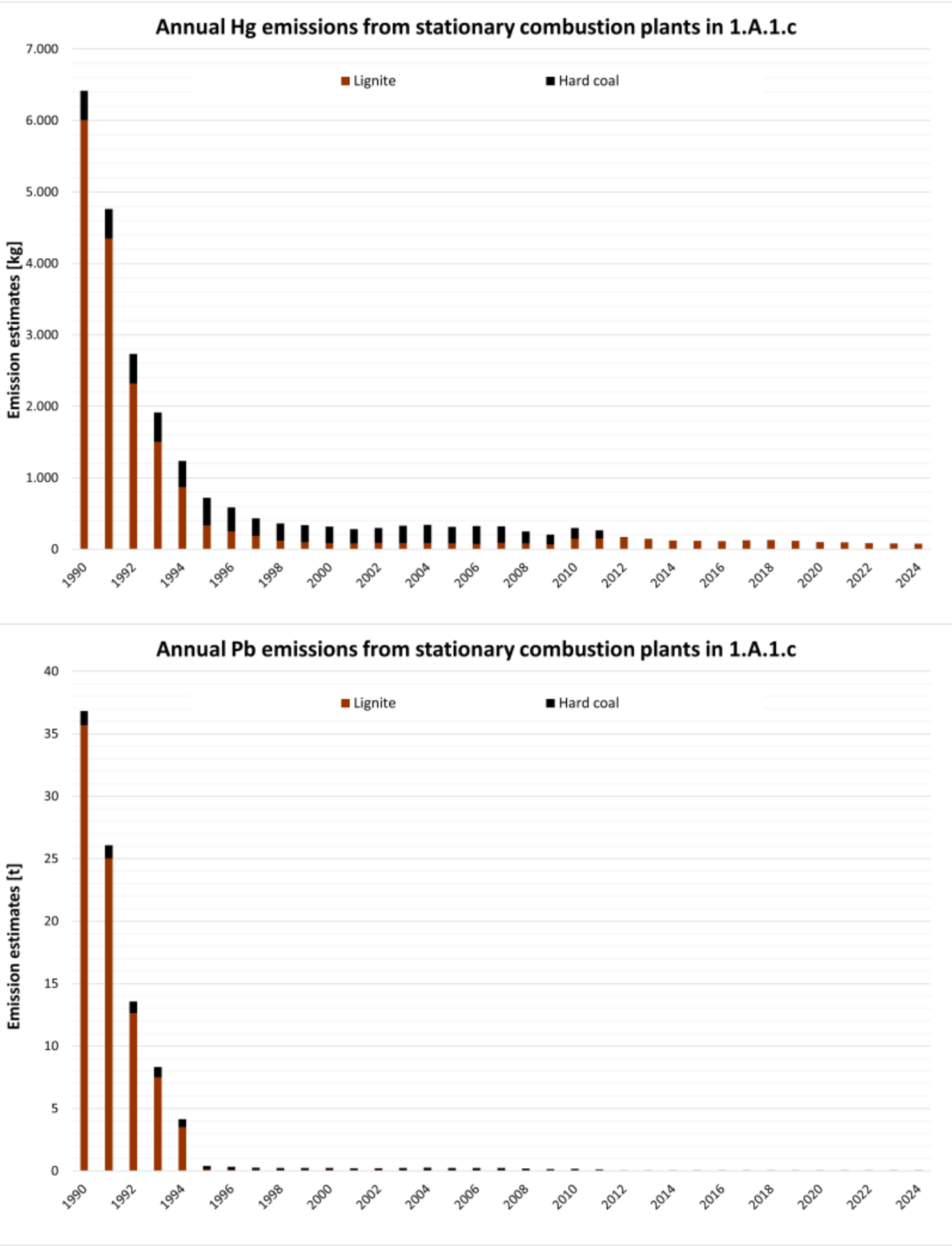


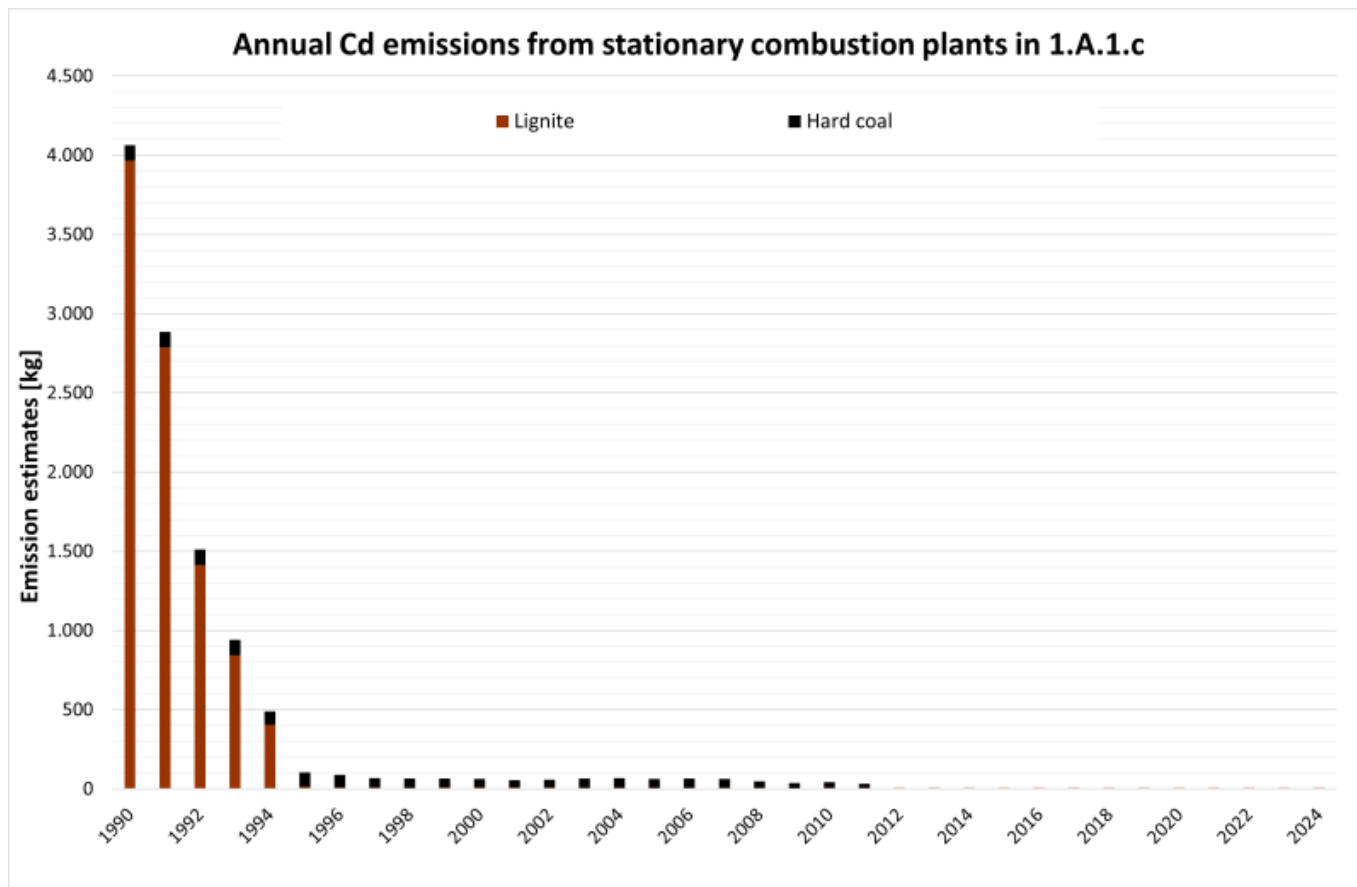




### Priority Heavy Metal - Hg, Pb & Cd

Similar to SO<sub>x</sub> emissions, TSP and Priority Heavy Metal emission trends show a high dominance of emissions from lignite combustion. Like already discussed for other pollutants, the main reason for sharp declining emissions in this sector is the complete restructuring of the east German lignite industry. The low standard of dust abatement in eastern Germany in the early 1990s involved high heavy metal emissions too. The closing of briquette factories and the implementation of stricter regulations resulted in a considerable improvement of the air quality especially in the New German Länder.





## Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the energy balance for 2023 led to recalculations. Moreover, for the purpose of improving data quality, national energy balances go under revisions every two years (for the years starting from 2003) through fine-tuning of the computational models, consideration of new statistics or re-allocation of activity data. Due to the revisions on the input data for submission 2026, recalculations took place <sup>9)</sup>.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1), 4)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2), 5), 9)</sup> AGEb (2025a): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; [https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?\\_jahresbereich-bilanz=2021-2030](https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?_jahresbereich-bilanz=2021-2030), (Aufruf: 04.12.2025), Köln & Berlin, September 2025

- <sup>3)</sup> Statistik der Kohlenwirtschaft, 2021 - URL: <https://www.kohlenstatistik.de>
- <sup>6)</sup> Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); <https://publikationen.bibliothek.kit.edu/21412002>; Karlsruhe / Dessau-Roßlau, 2002.
- <sup>7)</sup> UBA (2019): Juhlich, K. and Beckers, R.: "Updating the Emission Factors for Large Combustion Plants", <https://www.umweltbundesamt.de/publikationen/updating-emission-factors-large-combustion-plants>, Dessau-Roßlau, 2019
- <sup>8)</sup> Hensmann et al. (2011): Hensmann, M., Haardt, S., Ebert, D.: Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichterstattung (FKZ 3707 42 301); <https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/4362.pdf>, on behalf of the Umweltbundesamt, Dessau-Roßlau, October 2012

## 1.A.2 - Fuel Combustion Activities in Industries and Construction (OVERVIEW)

### Short description

In sub-sector **1.A.2 - Fuel Combustion Activities in Industries and Construction** emissions from both stationary and mobile fuel combustion activities in industries and construction are reported within the following sub-categories:

| NFR-Code                                                                  | Name of Category                                                                 |
|---------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| <b>Stationary Combustion in Manufacturing Industries and Construction</b> |                                                                                  |
| 1.A.2.a                                                                   | <a href="#">Iron and Steel</a>                                                   |
| 1.A.2.b                                                                   | <a href="#">Non-ferrous Metals</a>                                               |
| 1.A.2.c                                                                   | <a href="#">Chemicals</a>                                                        |
| 1.A.2.d                                                                   | <a href="#">Pulp, Paper and Print</a>                                            |
| 1.A.2.e                                                                   | <a href="#">Food Processing, Beverages and Tobacco</a>                           |
| 1.A.2.f                                                                   | <a href="#">Non-Metallic Minerals</a>                                            |
| 1.A.2.g viii                                                              | <a href="#">Other</a>                                                            |
| <b>Mobile Combustion in Manufacturing Industries and Construction</b>     |                                                                                  |
| 1.A.2.g vii                                                               | <a href="#">Mobile Combustion in Manufacturing Industries &amp; Construction</a> |

The German emission inventory is generally based on the emission behaviour of the plants. Therefore it's necessary to distinguish between process-combustion on the one hand and industrial power plants and boiler systems on the other hand.

The emission behaviour of power plants and boiler systems of the various industrial sectors is similar. That's why all the emissions from these type of plants were reported under source category 1.A.2.g.viii other. Whereas the emission behaviour of the different process-combustion systems is individual. A distinction between fuel and process related emissions is usually not possible. Therefore all emissions from process-combustion systems are reported in the corresponding source category of the industry sector NFR 2.



# 1.A.2.a - Stationary Combustion in Manufacturing Industries and Construction: Iron and Steel



## Short description

| Category Code | Method | AD | EF |
|---------------|--------|----|----|
| 1.A.2.a       | T2     | NS | ?  |

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP                                                                                    | BC | CO  | Pb | Cd | Hg  | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|----------------------------------------------------------------------------------------|----|-----|----|----|-----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|------|
| -/T             | -/-    | -/-             | -/-             | -/-               | -/-              | -/-                                                                                    | NE | -/- | IE | IE | -/- | NE | NE | NE | NE | NE | NE | -/-    | -/-   | NE    | NE    | NE    | -/-    | NA  | NA   |
|                 |        |                 |                 |                   |                  | L/- key source by <b>Level</b> only                                                    |    |     |    |    |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   |                  | -/T key source by <b>Trend</b> only                                                    |    |     |    |    |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   |                  | L/T key source by both <b>Level</b> and <b>Trend</b>                                   |    |     |    |    |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   |                  | -/- no key source for this pollutant                                                   |    |     |    |    |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   |                  | IE emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |    |     |    |    |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   |                  | NE emission of specific pollutant <b>Not Estimated</b> (yet)                           |    |     |    |    |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   |                  | NA specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |    |     |    |    |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   |                  | * no analysis done                                                                     |    |     |    |    |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   |                  |                                                                                        |    |     |    |    |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |

In 2024, a total of 26.5 million tonnes of raw steel were produced in six integrated steelworks. Electrical steel production amounted to another 10.8 million tonnes.

The structural elements of this category are the production of pig iron (blast furnaces), sponge iron (direct reduction), sinter, rolled steel, iron and steel casting, Siemens-Martin steel (in the new German Länder only until shortly after 1990), electric steel and the power stations and boilers of the entire steel production.

In category 1.A.2.a Iron and Steel only emissions of

- CO (for all years except 2008-2010, where only CO emissions from ferrous metal foundries are reported),
- NH<sub>3</sub> (until 1999 and then for the years 2010 and later; from 2000 to 2009 only NH<sub>3</sub> emissions from use of coal and coke in electric steelworks are reported),
- NMVOC and NO<sub>x</sub> (until 1999),
- PM<sub>2.5</sub>, PM<sub>10</sub> and TSP (until 2007 and then for the years 2010 and later; for 2008 and 2009 only emissions from the use of fuel gases sinter plants (ignition hoods) are reported) and
- SO<sub>2</sub> (until 1999; SO<sub>2</sub> emissions from the use of coal and coke in electric steelworks until 2000 and in 2004)

are reported. The emissions of these pollutants in other years as well as emissions of other pollutants are reported under Category 2.C.1 (see explanation below).

## Methods

### Activity data

Data source of the fuel consumption for iron and steel casting is the statistic for the manufacturing sector; Statistik 060 - Energieverwendung des produzierenden Gewerbes (Energy use in the manufacturing sector; DESTATIS), reporting-numbers 27.21, 27.51 and 27.52. Fuel consumption data for the hot metal production as well as the production of sinter and hot rolling are collected by the steel trade association (WV Stahl) in continuation of the former National Statistic: Fachserie 4, Reihe 8.1.

### Emission factors

The emission factors used for the years 1990 - 1994 were taken from the report on the research project "Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010" (Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010"; RENTZ et al, 2002)<sup>1)</sup>. Starting from 1995 new emission factors for iron and steel were determined, based on real emission data from the installations concerned. (1995-2001: own calculations by UBA; EF for 2008 by a research project by the steel industry's research institut BSI.

In category 1.A.2.a - Iron and Steel only emissions from power plants and steam boiler of the steel industry are reported. Basically, all industrial power plants and steam boiler are reported in source category 1.A.2.gviii - Other since the emission behaviour is comparable. The reason for the different structure of 1.A.2.a are the requirements of the UNFCCC Guidelines and the resulting review proceedings. Insofar it is more sensible to report all emissions from blast furnace fired power plants and steam boiler in Source category 1.A.2.a to avoid notes regarding CO<sub>2</sub> IEFs.

Whereever emission factors were determined from real emission data of the installations concerned, both process and energy related emissions from the production of sinter, pig iron (blast furnace including the cowpers), steel (both BOF and EAF steel production), rolled steel as well as from cast iron and steel are reported under Category 2.C.1, since it is not possible to separate combustion from process emissions within the same stack. Insofar in later years the emissions of the most pollutants are reported under 2.C.1.

## Trend discussion for Key Sources

Category 1.A.2.a Iron and Steel is a trend key category for NO<sub>x</sub> (mainly because the NO<sub>x</sub> emissions reported here until 1999 are then reported under Category [2.C.1](#)).

## Recalculations

Recalculations were necessary for 2023 due to the implementation of the now finalised National Energy Balance.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

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<sup>1)</sup> Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); <https://publikationen.bibliothek.kit.edu/21412002>; Karlsruhe / Dessau-Roßlau, 2002.

### Short description

In Germany, aluminium is produced at four foundries, in electrolytic furnaces with pre-burnt anodes. The principal emission sources are resulting from fuel provided in the energy related processes.

| <b>NFR Code</b>                                                                           | <b>Method</b>                        | <b>AD</b> | <b>EF</b> |
|-------------------------------------------------------------------------------------------|--------------------------------------|-----------|-----------|
| 1.A.2.b                                                                                   | T2                                   | NS        | CS        |
| <b>Method(s) applied</b>                                                                  |                                      |           |           |
| <b>D</b>                                                                                  | Default                              |           |           |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |           |           |
| <b>T2</b>                                                                                 | Tier 2*                              |           |           |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |           |           |
| <b>C</b>                                                                                  | CORINAIR                             |           |           |
| <b>CS</b>                                                                                 | Country Specific                     |           |           |
| <b>M</b>                                                                                  | Model                                |           |           |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |           |           |
| <b>(source for) Activity Data</b>                                                         |                                      |           |           |
| <b>NS</b>                                                                                 | National Statistics                  |           |           |
| <b>RS</b>                                                                                 | Regional Statistics                  |           |           |
| <b>IS</b>                                                                                 | International Statistics             |           |           |
| <b>PS</b>                                                                                 | Plant Specific                       |           |           |
| <b>As</b>                                                                                 | Associations, business organisations |           |           |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |           |           |
| <b>M</b>                                                                                  | Model / Modelled                     |           |           |
| <b>C</b>                                                                                  | Confidential                         |           |           |
| <b>(source for) Emission Factors</b>                                                      |                                      |           |           |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |           |           |
| <b>CS</b>                                                                                 | Country Specific                     |           |           |
| <b>PS</b>                                                                                 | Plant Specific                       |           |           |
| <b>M</b>                                                                                  | Model / Modelled                     |           |           |
| <b>C</b>                                                                                  | Confidential                         |           |           |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                    | TSP | BC | CO  | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |
|-----------------|--------|-----------------|-----------------|-------------------|-------------------------------------------------------------------------------------|-----|----|-----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|------|--|
| -/-             | -/-    | -/-             | -/-             | IE                | IE                                                                                  | IE  | IE | -/- | IE | IE | IE | IE | IE | IE | IE | IE | IE | IE     | IE    | IE    | IE    | IE    | IE     | IE  | IE   |  |
|                 |        |                 |                 | L/-               | key source by <b>Level</b> only                                                     |     |    |     |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | -/T               | key source by <b>Trend</b> only                                                     |     |    |     |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | L/T               | key source by both <b>Level</b> and <b>Trend</b>                                    |     |    |     |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                    |     |    |     |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | IE                | emission of specific pollutant Included <b>Elsewhere</b> (i.e. in another category) |     |    |     |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |    |     |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |    |     |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | *                 | no analysis done                                                                    |     |    |     |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |

## Method

### Activity data

The source of the fuel inputs consists of the statistics for the manufacturing sector (Statistik 060 - Energieverwendung des produzierenden Gewerbes / energy use in the manufacturing sector), DESTATIS, reporting number 27.43 and 27.44, production and initial processing of lead, zinc and tin, production and initial processing of copper - and, for differentiations relative to heat and electricity production, Statistik 067 (DESTATIS).

Data for fuel consumption for production and initial processing of precious metals are also provided by these statistics.

### Emission factors

Reported pollutants are NO<sub>x</sub>, NMVOC, SO<sub>2</sub>, NH<sub>3</sub> and CO. Instead, all particulate matter emissions are reported as process emissions in the associated categories in 2.C. Germany carefully checked all possible additional sources for HCB in this sector. This includes the BREF documents as well as other literature. There was no indication for any missing emission found. The emission factors for HCB in the Guidebook are only applicable to processes not occurring in Germany.

The underlying data for the emission factors used is provided by the report on the research project "Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010" (Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010"; RENTZ et al, 2002)<sup>1)</sup>. The values for the intermediate years 1996 - 1999 and 2001 - 2010 are obtained via linear interpolation; adjusted values for the following years.

## Recalculations



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); <https://publikationen.bibliothek.kit.edu/21412002>; Karlsruhe / Dessau-Roßlau, 2002.



## 1.A.2.c - Fuel Combustion Activities in Industries and Construction: Chemicals

Energy related emissions from power plants and boiler systems are reported in [NFR 1.A.2.g viii: Other](#) whereas process related emissions are reported in NFR 2.B - Chemical Industry.

## **1.A.2.d - Pulp, Paper and Print**

All emissions from fossil fired power plants and boiler systems are reported in [NFR 1.A.2.g viii: Other](#) whereas all process related emissions as well as emissions from black liquor incineration are reported in [NFR 2.H.1 - Pulp and Paper](#) .

It is not possible to report combustion related emissions under the category 1.A.2.d for purposes of comparison as the emission estimates are based on a complete report of branches with EF for all occurring emissions in sum.

## Short description

| <b>NFR Code</b>                                                                          | <b>Method</b>                        | <b>AD</b> | <b>EF</b> |
|------------------------------------------------------------------------------------------|--------------------------------------|-----------|-----------|
| 1.A.2.e                                                                                  | T2                                   | NS        | CS        |
| <b>Method(s) applied</b>                                                                 |                                      |           |           |
| <b>D</b>                                                                                 | Default                              |           |           |
| <b>T1</b>                                                                                | Tier 1 / Simple Methodology *        |           |           |
| <b>T2</b>                                                                                | Tier 2*                              |           |           |
| <b>T3</b>                                                                                | Tier 3 / Detailed Methodology *      |           |           |
| <b>C</b>                                                                                 | CORINAIR                             |           |           |
| <b>CS</b>                                                                                | Country Specific                     |           |           |
| <b>M</b>                                                                                 | Model                                |           |           |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters |                                      |           |           |
| <b>(source for) Activity Data</b>                                                        |                                      |           |           |
| <b>NS</b>                                                                                | National Statistics                  |           |           |
| <b>RS</b>                                                                                | Regional Statistics                  |           |           |
| <b>IS</b>                                                                                | International Statistics             |           |           |
| <b>PS</b>                                                                                | Plant Specific                       |           |           |
| <b>As</b>                                                                                | Associations, business organisations |           |           |
| <b>Q</b>                                                                                 | specific Questionnaires (or surveys) |           |           |
| <b>M</b>                                                                                 | Model / Modelled                     |           |           |
| <b>C</b>                                                                                 | Confidential                         |           |           |
| <b>(source for) Emission Factors</b>                                                     |                                      |           |           |
| <b>D</b>                                                                                 | Default (EMEP Guidebook)             |           |           |
| <b>CS</b>                                                                                | Country Specific                     |           |           |
| <b>PS</b>                                                                                | Plant Specific                       |           |           |
| <b>M</b>                                                                                 | Model / Modelled                     |           |           |
| <b>C</b>                                                                                 | Confidential                         |           |           |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                             | TSP | BC  | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |  |
|-----------------|--------|-----------------|-----------------|-------------------|----------------------------------------------------------------------------------------------|-----|-----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|------|--|--|
| -/-             | -/-    | -/-             | -/-             | IE                | IE                                                                                           | IE  | -/- | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE     | NE    | NE    | NE    | NE    | NE     | NA  | NA   |  |  |
|                 |        |                 |                 | L/-               | key source by <b>Level</b> only                                                              |     |     |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | -/T               | key source by <b>Trend</b> only                                                              |     |     |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | L/T               | key source by both <b>Level</b> and <b>Trend</b>                                             |     |     |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                             |     |     |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | IE                | emission of specific pollutant Included <b>E</b> lsewhere (i.e. in another category)         |     |     |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |     |     |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |     |     |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | *                 | no analysis done                                                                             |     |     |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 |                   |                                                                                              |     |     |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |  |

## Method

### Activity data

The source of the fuel inputs consists of the statistics for the manufacturing sector (Statistik 060 - Energieverwendung des produzierenden Gewerbes / energy use in the manufacturing sector), DESTATIS, reporting number 10.81, sugar production - and, for differentiations relative to heat and electricity production, Statistik 067 (DESTATIS).

### Emission factors

Reported pollutants are NO<sub>x</sub>, NMVOC, SO<sub>2</sub>, NH<sub>3</sub> and CO.

All particulate matter emissions are reported as process emissions under 2.H.2. But the allocable part of BC emissions is included in 1.A.2.g viii (emissions from CHP plants and steam boilers).

The underlying data used for the emission factors is provided by the report on the research project "Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010" (Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010"; RENTZ et al, 2002)<sup>1)</sup>.

The values for the intermediate years 1996-1999 and 2001-2010 are obtained via linear interpolation; adjusted values for the following years.

## Recalculations

Recalculations were necessary for most recently year due to the implementation of the now finalised National Energy Balance.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); <https://publikationen.bibliothek.kit.edu/21412002>; Karlsruhe / Dessau-Roßlau, 2002.

### Short Description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 1.A.2.f                                                                                   | T1                                   | NS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC                                                                              | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO  | Heavy Metals | POPs |
|-----------------|-------------------------------------------------------------------------------------|-----------------|-----------------|-------------------|------------------|-----|----|-----|--------------|------|
| -/-             | -/-                                                                                 | -/-             | -/-             | IE                | IE               | IE  | IE | -/- | NA           | NA   |
| L/-             | key source by <b>Level</b> only                                                     |                 |                 |                   |                  |     |    |     |              |      |
| -/T             | key source by <b>Trend</b> only                                                     |                 |                 |                   |                  |     |    |     |              |      |
| L/T             | key source by both <b>Level</b> and <b>Trend</b>                                    |                 |                 |                   |                  |     |    |     |              |      |
| -/-             | no key source for this pollutant                                                    |                 |                 |                   |                  |     |    |     |              |      |
| IE              | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |                 |                 |                   |                  |     |    |     |              |      |
| NE              | emission of specific pollutant <b>Not Estimated</b> (yet)                           |                 |                 |                   |                  |     |    |     |              |      |
| NA              | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |                 |                 |                   |                  |     |    |     |              |      |
| *               | no analysis done                                                                    |                 |                 |                   |                  |     |    |     |              |      |



In order of significance relating energy use and emissions, the covered industries are:

- burning of cement clinker,
- burning of quicklime,
- melting of glass,
- burning of ceramics.

## Method

Regarding the burning processes emissions can be allocated to the use of fuels or to the production process. Current allocation is regarding the main importance of the production process.

## Activity data

The key source of all conventional fuel data is the national energy balance. Moreover the use of additional statistical data is necessary in order to disaggregate data. Data source for fuel inputs for energy-related process combustion in cement industry are manufacturing-sector statistics (Statistik des produzierenden Gewerbes); reporting number (Melde-Nr.) 23.51, Cement production. Furthermore the cement industry uses significant amounts of substitute fuels that do not appear in national statistics and in the Energy Balance. Relevant production figures and fuel-use amounts have been taken from statistics of the VDZ cement-industry association. The fuel-input data for ceramics production has also been taken from manufacturing industry statistics (Statistik des produzierenden Gewerbes); reporting no. (Melde-Nr.) 23.32, brickworks (Ziegelei), production of other construction ceramics. The same statistic is also used as source for fuel input of glass (reporting number: 23.1, Production of glass and glassware) and lime production (reporting number: 23.52, Lime).

## Emissions

Due to allocating emissions to process part we have removed most of time series inconsistencies. The current situation is the following:

Table 1: relevance of emission sources regarding the fuel use due to burning processes in 1.A.2.f

|                 | SO <sub>x</sub> | NO <sub>x</sub> | CO              | NM VOC          | NH <sub>3</sub> | TSP             | BC |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----|
| <b>cement</b>   | IE <sup>1</sup> | IE <sup>1</sup> | medium          | IE <sup>1</sup> | IE <sup>1</sup> | IE <sup>2</sup> | NE |
| <b>lime</b>     | IE <sup>1</sup> | IE <sup>1</sup> | IE <sup>1</sup> | IE <sup>1</sup> | low             | IE <sup>2</sup> | NE |
| <b>glass</b>    | IE <sup>2</sup> | IE <sup>1</sup> | IE <sup>1</sup> | IE <sup>1</sup> | IE <sup>1</sup> | IE <sup>2</sup> | NE |
| <b>ceramics</b> | IE <sup>3</sup> | IE <sup>3</sup> | low             | IE <sup>1</sup> | IE <sup>1</sup> | IE <sup>1</sup> | NE |

<sup>1</sup> Included in process related emissions, in all cases it is the link to complementary source category.

<sup>2</sup> Some artifacts occur for 1990 emissions that cannot be shifted.

<sup>3</sup> Inclusion in process related emissions occurs from different time points onwards.



The entire appraisal of the emissions situation succeeds only in connection with the process related emissions. Especially further relevant pollutants as heavy metals or persistent organics are shown as process related generally.

## Recalculations

Recalculations were necessary for most recently year due to the implementation of the now finalised National Energy Balance.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

# 1.A.2.g viii - Stationary Combustion in Manufacturing Industries and Construction: Other

## Short description

Source category 1.A.2.g viii - *Stationary Combustion in Manufacturing Industries and Construction: Other* comprises stationary combustion systems for heat and power production of industrial power plants and industrial boiler systems.

| NFR Code                                                                                  | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 1.A.2.g viii                                                                              | T2                                   | NS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|
| L/T             | -/-    | L/T             | -/-             | L/-               | -/-              | L/T | -/- | -/- | -/- | L/- | L/T | L/T | -/T | -/- | L/T | -/- | L/T | L/T    | -/T   | IE    | IE    | IE    | -/T    | -/- | L/-  |

| NO <sub>x</sub>                                                                           | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |
|-------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|------|--|
| <b>Method(s) applied</b>                                                                  |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>D</b> Default                                                                          |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>T1</b> Tier 1 / Simple Methodology *                                                   |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>T2</b> Tier 2*                                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>T3</b> Tier 3 / Detailed Methodology *                                                 |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>C</b> CORINAIR                                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>CS</b> Country Specific                                                                |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>M</b> Model                                                                            |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>(source for) Activity Data</b>                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>NS</b> National Statistics                                                             |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>RS</b> Regional Statistics                                                             |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>IS</b> International Statistics                                                        |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>PS</b> Plant Specific                                                                  |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>As</b> Associations, business organisations                                            |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>Q</b> specific Questionnaires (or surveys)                                             |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>M</b> Model / Modelled                                                                 |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>C</b> Confidential                                                                     |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>(source for) Emission Factors</b>                                                      |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>D</b> Default (EMEP Guidebook)                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>CS</b> Country Specific                                                                |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>PS</b> Plant Specific                                                                  |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>M</b> Model / Modelled                                                                 |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>C</b> Confidential                                                                     |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |



## Method

Generally, the calculation method is based on a Tier 2 approach. This means the use of country-specific data at a more detailed level.

Emission factors and activity data are available for different fuel types, different technologies, plant size, etc. The use of plant-specific data for a bottom-up approach is not possible. Emissions from industrial power plants cannot be allocated clearly to source category 1.A.2, since reality does not follow the definition of the Guidebook. In real life an industrial power plant generates electricity and heat for the industry but also electricity for the public network. Therefore the borderline between these two categories is not fixed.

The market is not static. Frequent changes in the cooperate structure of industrial enterprises including the separation of the energy supply via spin-off from the parent company lead to frequent changes between sector 1.A.1.a, 1.A.1.c and 1.A.2. Therefore it was necessary to develop a flexible calculation system, based on robust emission factors, which can be used for all sectors.

Source category 1.A.2.g.viii only include emissions from industrial power plants and boiler systems.

## Activity data

### Conventional fuels

The key source of all conventional fuel data are the national energy balances published by the Working Group on Energy Balances (AGEB, 2025)<sup>1)</sup>.

Moreover, the use of additional statistical data is necessary in order to disaggregate data. Data source for fuel inputs for electricity generation in industrial power stations are shown in Energy Balance line 12. The difference resulting after deduction of the fuel inputs for refinery power stations, pit power stations, power stations in the hard-coal-mining sector and, for the period until 1999, for the power stations of German Railways (Deutsche Bahn) consists of the activity data for other industrial power stations. These data cannot be further differentiated. Additional data from the Federal Statistical Office are needed for allocation of fuel inputs to heat production in industrial power stations and boiler systems. For both electricity production and heat production, gas turbines, gas and steam systems and gas engines are differentiated. These detailed information is provided by the national statistic 067 (industrial power stations). The definition of industrial and public power plants follows the national statistics.

### Biomass

Along with the main Energy Balance, a Satellite Balance of renewable Energies (Satellitenbilanz Erneuerbarer Energieträger) is also published. This balance describes the growth and use of renewable energies in detail. This is the database for all biomass fuels excluding waste.

### Waste

With regard to determination of activity data from waste incineration and co-combustion of waste in combustion system in source category 1.A.2 Energy Balance and energy statistics show smaller waste quantities than the waste statistics of the Federal Statistical Office (Statistisches Bundesamt, Fachserie 19, Reihe 1)<sup>2)</sup>. For that reason activity data were taken from waste statistics.

## Emission factors

The emission factors for power stations and other boiler combustion for production of steam and hot water, in source category 1.A.2.g.viii, have been taken from the research project "Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010" (RENTZ et al., 2002)<sup>3)</sup>.

In 2018 and 2019 SO<sub>2</sub>, NO<sub>x</sub>, TSP, PM, CO, NH<sub>3</sub> and Hg emission factors were revised for all large combustion plants by using data from the large combustion plant reporting (UBA 2019)<sup>4)</sup>. A detailed description of the procedure is presented in Chapter: 1.A.1.a - Public Electricity And Heat Production. This chapter contains also information about emission factors of engines and waste incineration plants. For black carbon, default emission factors for the EMEP EEA Guidebook 2019 are used.

Table 1: Implied emission factors for industrial electricity and heat generation for 2024

|  | SO <sub>x</sub> | NO <sub>x</sub> | TSP | CO | Pb | Hg | Cd |
|--|-----------------|-----------------|-----|----|----|----|----|
|--|-----------------|-----------------|-----|----|----|----|----|

|                        | SO <sub>x</sub> | NO <sub>x</sub> | TSP  | CO   | Pb     | Hg   | Cd   |
|------------------------|-----------------|-----------------|------|------|--------|------|------|
|                        | [kg/TJ]         |                 |      |      | [g/TJ] |      |      |
| <b>Hard Coal</b>       | 150.8           | 101.3           | 3.4  | 26.2 | 4.85   | 2.36 | 0.36 |
| <b>Lignite</b>         | 196.7           | 90.7            | 4.1  | 45.4 | 1.52   | 2.47 | 0.20 |
| <b>Natural gas</b>     | 0.1             | 41.4            | 0.2  | 10.9 | NA     | 0.01 | NA   |
| <b>Liquid fuels</b>    | 28.8            | 53.5            | 1.4  | 4.8  | 0.79   | 0.24 | 0.06 |
| <b>Biomass</b>         | 9.4             | 127.1           | 14.4 | 44.5 | 0.32   | 0.25 | 0.39 |
| <b>Hazardous waste</b> | 0.5             | 69.2            | 0.2  | 7.8  | 4.90   | 0.34 | 1.10 |

The table gives an overview of the implied emission factors. The German inventory compiling process is very complex and includes the use of a considerable number of emission factors, which cannot be completely published in the IIR.

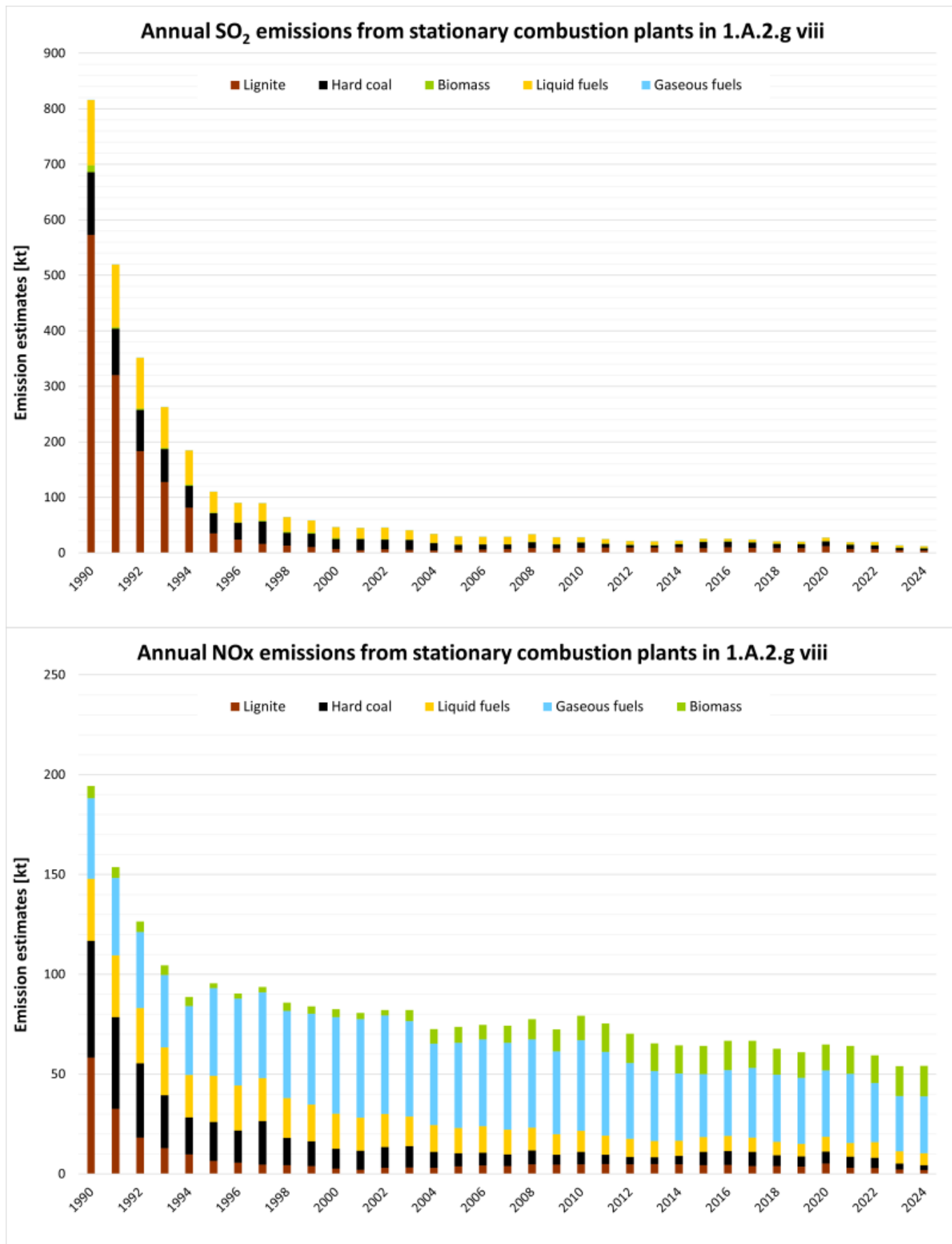
There are different emission factors available depending on fuel types, firing techniques and the permissions. However, the implied emission factors may give an impression about the order of magnitude. PM<sub>10</sub> and PM<sub>2.5</sub> emission factors are calculated as a fraction of TSP. The share of PM<sub>10</sub> is 90 % and the share of PM<sub>2.5</sub> is 80 % for solid fuels. This is a simple but also conservative approach, knowing that, in reality, PM emissions depend on fuel, combustion and abatement technologies. In terms of natural gas and biogas PM<sub>10</sub> and PM<sub>2.5</sub> fractions are considered as 100 % of TSP. Regarding wood a share of 100% PM<sub>10</sub> and 90% PM<sub>2.5</sub> is used. For liquid fuels the default share of 100% PM<sub>10</sub> and PM<sub>2.5</sub> is used. In the cases of co-incineration, where liquid fuels are only used for ignition in coal fired plants, the share of coal fired plants is used. PM emission reporting starts in 1995, since no sufficient information about the dust composition of the early 1990s is available.

## Trend Discussion for Key Sources

The following diagrams give an overview of the dominant emission trends of selected pollutants.

### Sulfur Oxides & Nitrogen Oxides - SO<sub>x</sub> & NO<sub>x</sub>

As already discussed in source category 1.A.1.c, SO<sub>x</sub> emission trend is very much influenced by emissions from lignite fired plants. The strong decline of lignite use in the East German industry and the installation of flue gas desulfurisation plants in the remaining heat and power stations are the main reasons for decreasing SO<sub>x</sub> emissions.

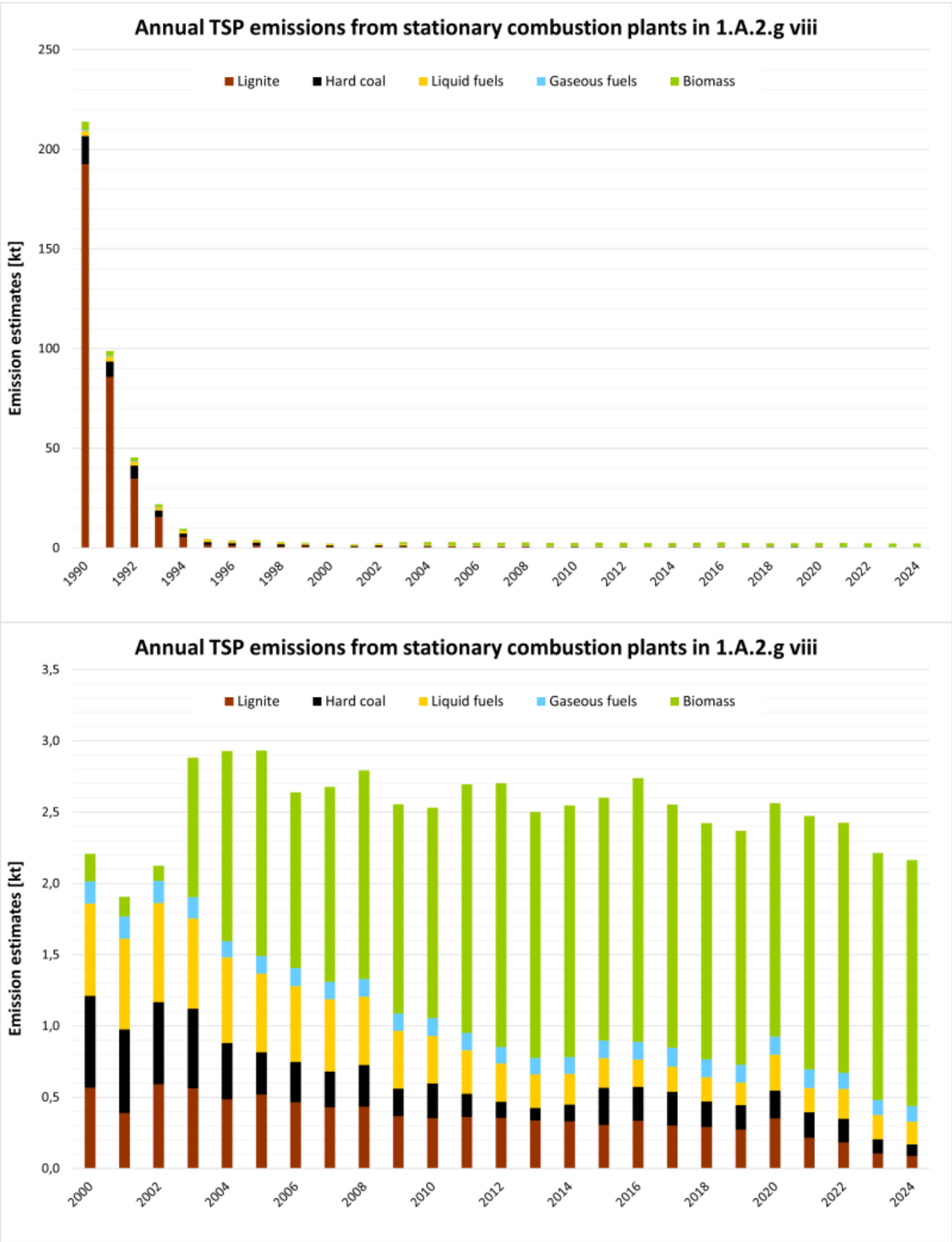


### Particulate Matter (TSP, PM<sub>10</sub>) and Priority Heavy Metals (Hg & Cd)

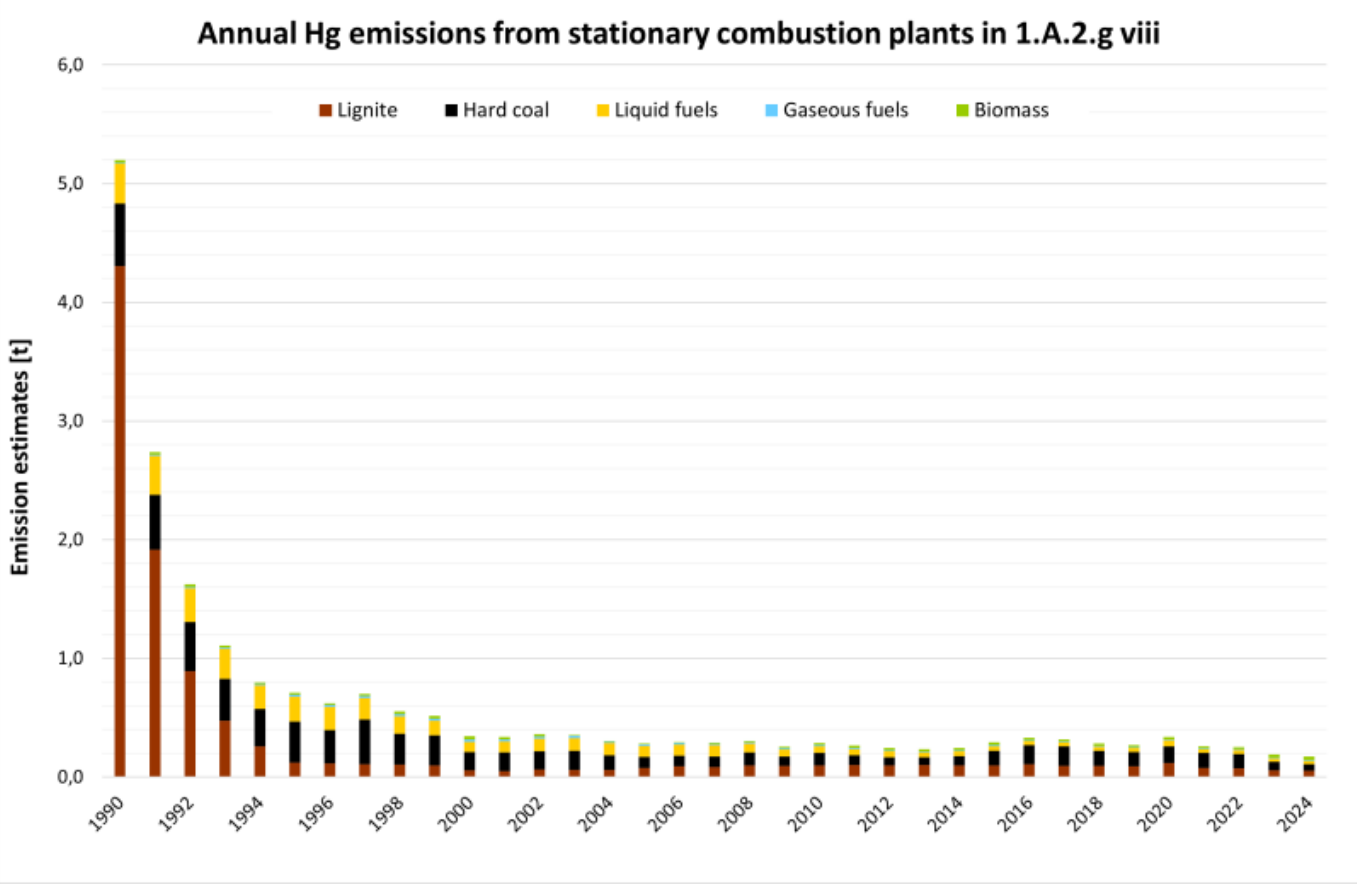
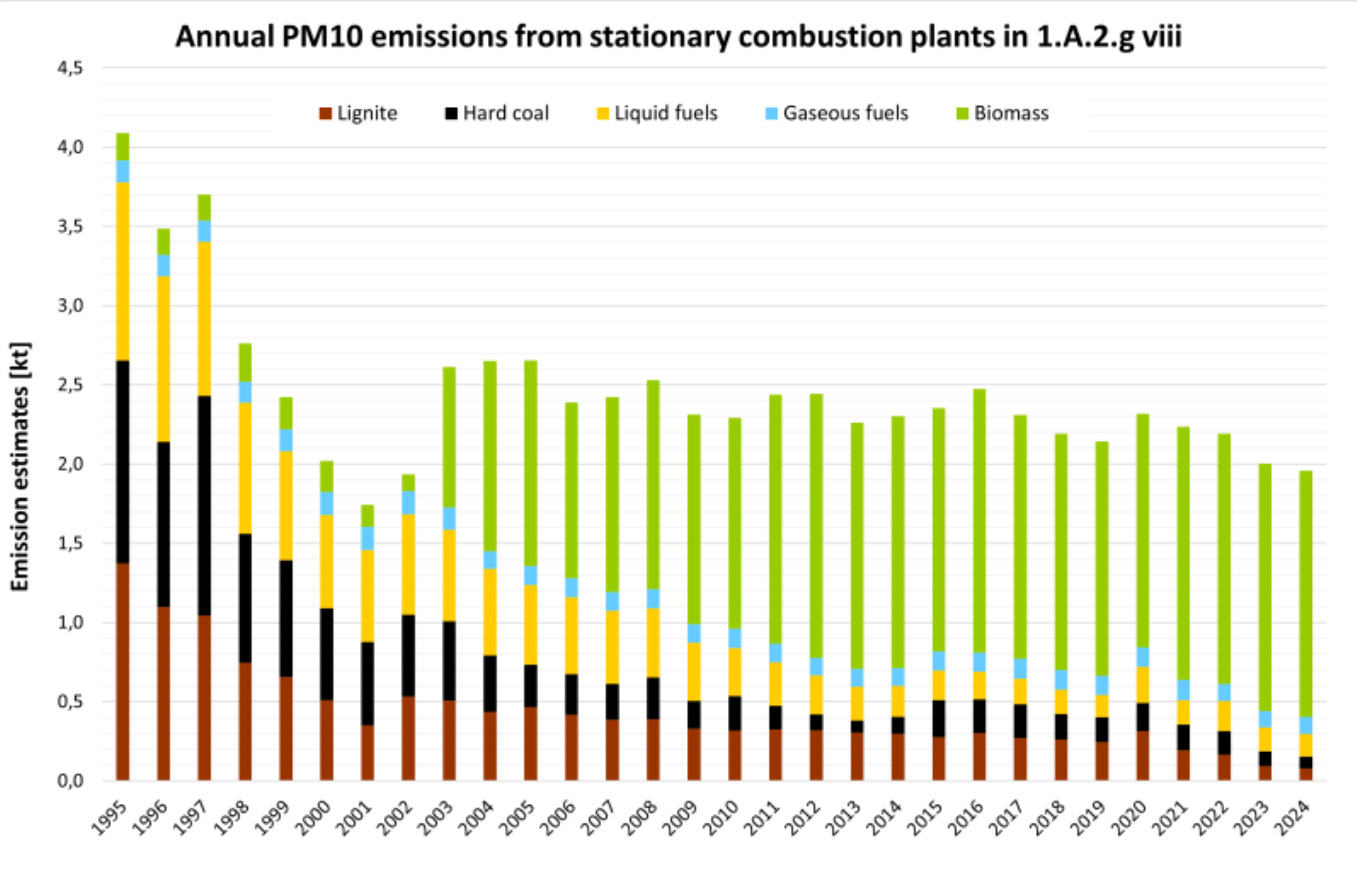
The main driver of TSP and heavy metal emission trends is the declining lignite combustion due to the closure of industrial plants in the East German industry especially from 1990 to 1994. Furthermore, the noticeable improvement of dust extraction installations and the optimisation of the combustion process resulted in considerably decreasing TSP and heavy

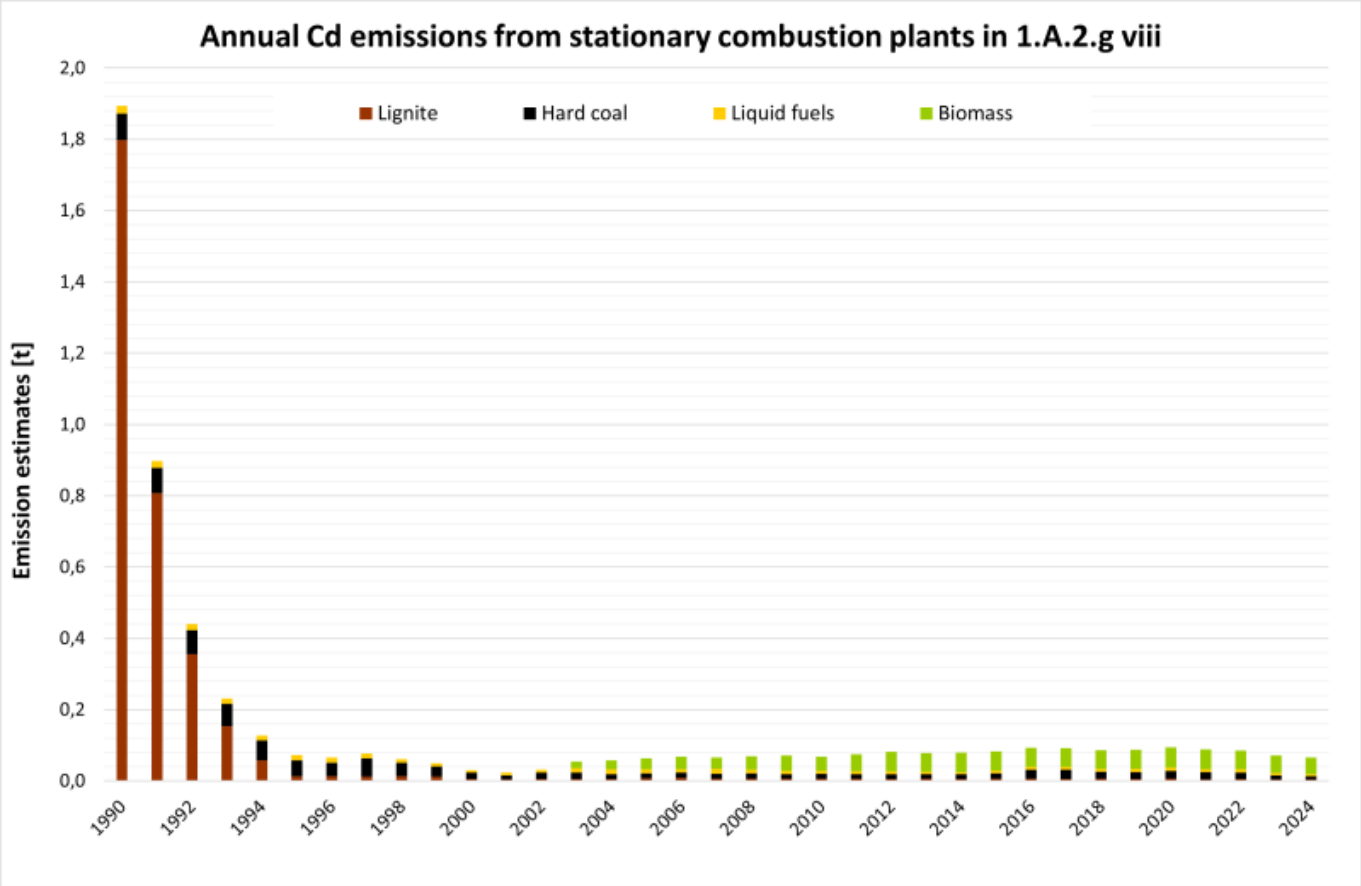
metal emissions.

In recent years the use of biomass gains influence.



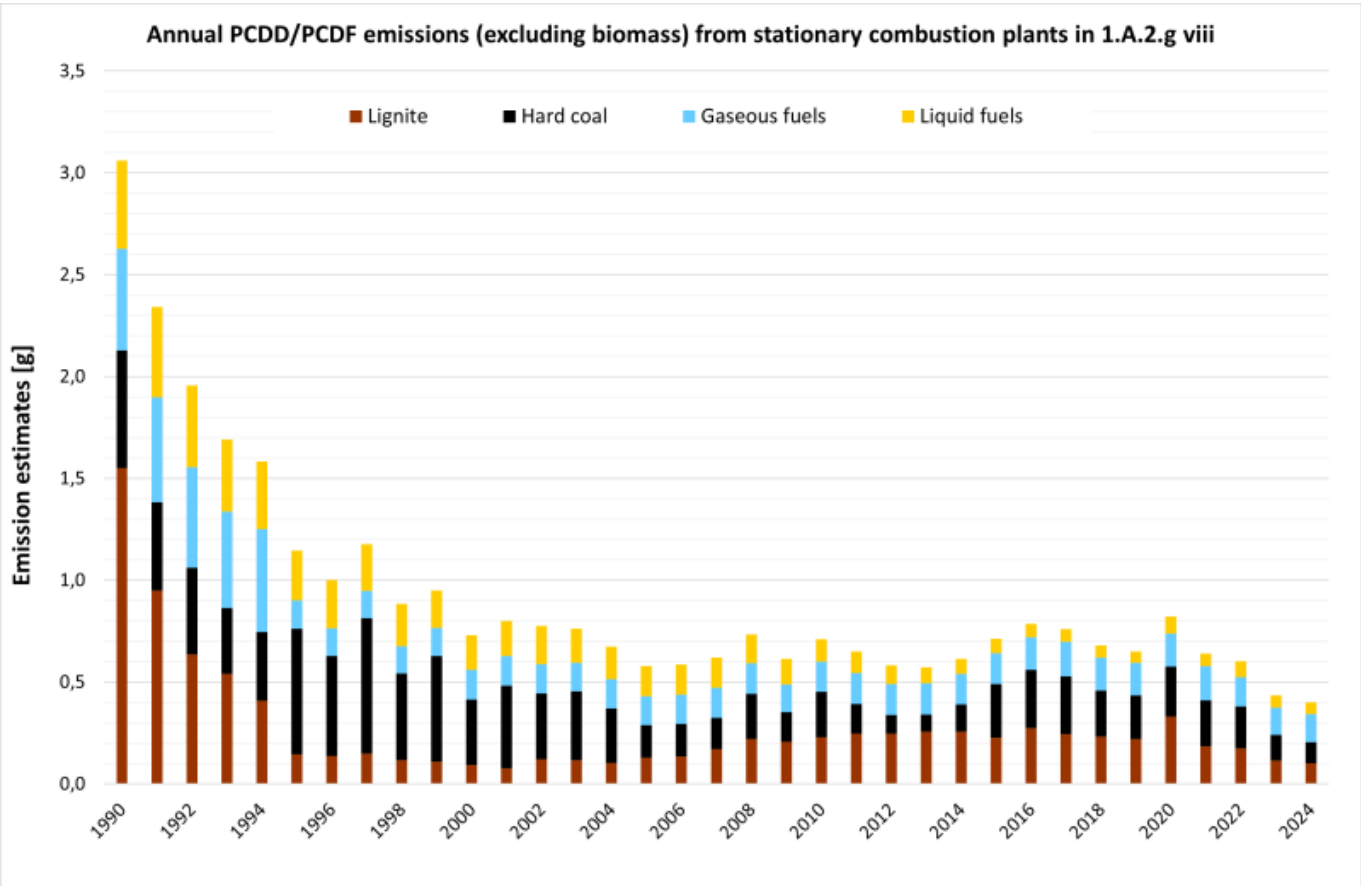






**Persistent Organic Pollutants**

Overall a decrease in PCDD and PCDF emissions is observed since the 90s, mainly based on the fuel consumption in the industry sector. The decreasing trend is more pronounced in the recent years.



## Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the energy balance for 2023 led to recalculations. Moreover, for the purpose of improving data quality, national energy balances go under revisions every two years (for the years starting from 2003) through fine-tuning of the computational models, consideration of new statistics or re-allocation of activity data. Due to the revisions on the input data for submission 2026, recalculations took place <sup>5)</sup>.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> Destatis (2024a): Federal Statistical Office (Statistisches Bundesamt - Destatis): Fachserie 19, Reihe 1: Abfallentsorgung (now data on waste management are available from the GENESIS-Online database) - URL: [http://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Abfallwirtschaft/\\_inhalt.html#sprg238672](http://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Abfallwirtschaft/_inhalt.html#sprg238672), Wiesbaden, 2024.

<sup>3)</sup> Rentz et al. (2002): Rentz, O., Karl, U., Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010: Forschungsbericht 299 43 142; on behalf of the Umweltbundesamt; final report; Deutsch-Französisches Inst. f. Umweltforschung, Univ. (TH); <https://publikationen.bibliothek.kit.edu/21412002>; Karlsruhe / Dessau-Roßlau, 2002.

<sup>4)</sup> Umweltbundesamt (2019): Juhlich, K., Beckers, R.: "Updating the Emission Factors for Large Combustion Plants": <https://www.umweltbundesamt.de/publikationen/updating-emission-factors-large-combustion-plants>; Dessau-Roßlau, 2002.

<sup>5)</sup> AGEb (2025a): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; [https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?\\_jahresbereich-bilanz=2021-2030](https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?_jahresbereich-bilanz=2021-2030), (Aufruf: 04.12.2025), Köln & Berlin, September 2025

# 1.A.2.g vii - Mobile Combustion in Manufacturing Industries and Construction

## Short description

Under NFR 1.A.2.g vii - *Mobile Combustion in Manufacturing Industries and Construction*, emissions from Off-Road Construction Vehicles and Construction Machinery are reported in the German inventory.

| NFR Code                                                                                  | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.2.g vii                                                                               | T1,T2                                | NS, M | CS, D, M |
| Method(s) applied                                                                         |                                      |       |          |
| D                                                                                         | Default                              |       |          |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |          |
| T2                                                                                        | Tier 2*                              |       |          |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |          |
| C                                                                                         | CORINAIR                             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| M                                                                                         | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| (source for) Activity Data                                                                |                                      |       |          |
| NS                                                                                        | National Statistics                  |       |          |
| RS                                                                                        | Regional Statistics                  |       |          |
| IS                                                                                        | International Statistics             |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| As                                                                                        | Associations, business organisations |       |          |
| Q                                                                                         | specific Questionnaires (or surveys) |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |
| (source for) Emission Factors                                                             |                                      |       |          |
| D                                                                                         | Default (EMEP Guidebook)             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP                                                                                 | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |    |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|----|
| -/-             | -/-    | -/-             | -/-             | -/-               | -/-              | -/-                                                                                 | -/- | L/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NE   | NE |
|                 |        |                 |                 |                   | L/-              | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 |                   | -/T              | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 |                   | L/T              | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 |                   | -/-              | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 |                   | IE               | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 |                   | NE               | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 |                   | NA               | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 |                   | *                | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |

## Methodology

### Activity data

Sector-specific consumption data is included in the primary fuel-delivery data are available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2025) <sup>1)</sup>

Table 1: Sources for primary fuel-delivery data

|              |                                                                                                           |
|--------------|-----------------------------------------------------------------------------------------------------------|
| through 1994 | <b>AGEB</b> - National Energy Balance, line 79: 'Haushalte und Kleinverbraucher insgesamt'                |
| as of 1995   | <b>AGEB</b> - National Energy Balance, line 67: 'Gewerbe, Handel, Dienstleistungen u. übrige Verbraucher' |

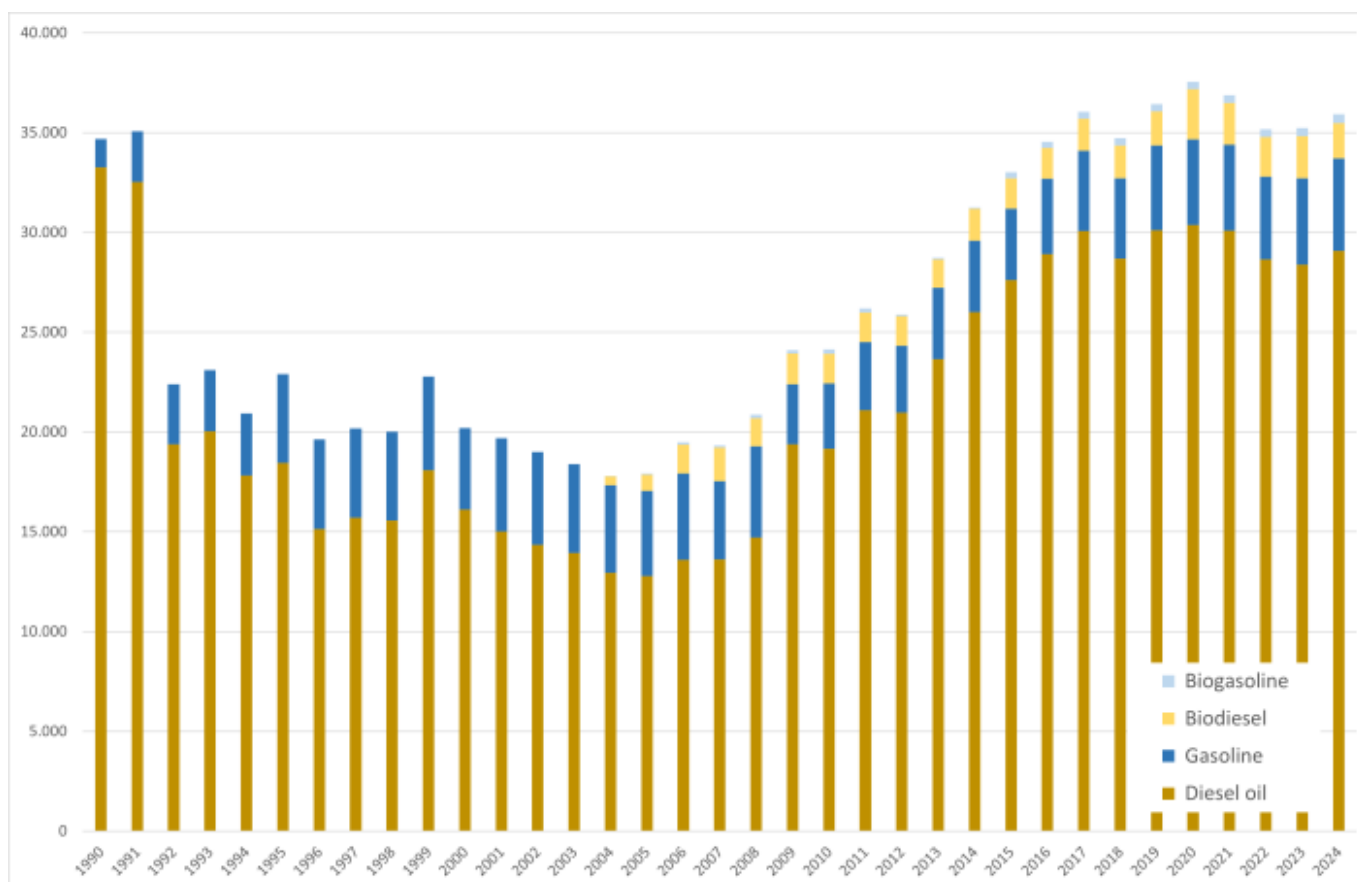
Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2025) <sup>2)</sup>, the remaining amounts of gasoline and diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and off-road vehicles in commercial/institutional use (1.A.4. ii) as well as agriculture and forestry (NFR 1.A.4.c ii) based upon annual shares derived from TREMOD-MM (Knörr et al. (2025b)) <sup>3)</sup> (cf. NFR 1.A.4 - mobile).

Table 2: Percentual annual contribution of 1.A.2.g vii to fuel-specific over-all delivery data provided in NEB line 67

|                       | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|-----------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>Diesel Fuels</b>   | 29.7% | 18.9% | 17.0% | 15.6% | 21.6% | 26.7% | 27.5% | 28.2% | 27.8% | 28.5% | 28.8% | 28.4% | 28.1% | 28.2% | 28.6% |
| <b>Gasoline Fuels</b> | 31.5% | 59.7% | 55.1% | 58.6% | 64.5% | 68.0% | 70.9% | 71.1% | 67.9% | 67.1% | 63.5% | 63.4% | 63.8% | 66.2% | 70.9% |

Table 3: Annual fuel consumption in construction vehicles and mobile machinery, in terajoules

|                      | 1990          | 1995          | 2000          | 2005          | 2010          | 2015          | 2016          | 2017          | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
|----------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>Diesel Oil</b>    | 33,264        | 18,448        | 16,123        | 12,784        | 19,158        | 27,623        | 28,923        | 30,072        | 28,694        | 30,110        | 30,387        | 30,104        | 28,649        | 28,384        | 29,084        |
| <b>Gasoline</b>      | 1,420         | 4,453         | 4,079         | 4,271         | 3,276         | 3,572         | 3,764         | 4,032         | 4,017         | 4,249         | 4,274         | 4,290         | 4,158         | 4,333         | 4,622         |
| <b>Biodiesel</b>     |               |               |               | 815           | 1,483         | 1,515         | 1,547         | 1,605         | 1,657         | 1,711         | 2,515         | 2,090         | 1,982         | 2,112         | 1,781         |
| <b>Biogasoline</b>   |               |               |               | 58.0          | 220           | 300           | 317           | 335           | 350           | 356           | 378           | 396           | 384           | 412           | 433           |
| <b>Σ 1.A.2.g vii</b> | <b>34,684</b> | <b>22,901</b> | <b>20,202</b> | <b>17,928</b> | <b>24,137</b> | <b>33,010</b> | <b>34,551</b> | <b>36,044</b> | <b>34,718</b> | <b>36,425</b> | <b>37,554</b> | <b>36,881</b> | <b>35,173</b> | <b>35,240</b> | <b>35,919</b> |



## Emission factors

The emission factors used here are of rather different quality: Basically, for all **main pollutants, carbon monoxide** and **particulate matter**, annual IEF modelled within TREMOD MM (Knörr et al. (2025b)) <sup>4)</sup> are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

Table 4: Annual country-specific emission factors<sup>1</sup>, in kg/TJ

|                                                                                                                                                                                                        | 1990   | 1995   | 2000                               | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Gasoline fuels                                                                                                                                                                                         |        |        |                                    |        |        |        |        |        |        |        |        |        |        |        |        |
| NH <sub>3</sub>                                                                                                                                                                                        | 0.089  | 0.092  | 0.093                              | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  | 0.094  |
| NMVOC <sup>2</sup>                                                                                                                                                                                     | 678    | 623    | 571                                | 562    | 561    | 561    | 561    | 561    | 561    | 559    | 550    | 538    | 526    | 514    | 501    |
| NMVOC <sup>3</sup>                                                                                                                                                                                     | 77.8   | 74.8   | 82.3                               | 100.8  | 105.8  | 99.7   | 93.8   | 92.1   | 89.9   | 88.4   | 89.8   | 88.8   | 93.5   | 95.7   | 91.2   |
| NO <sub>x</sub>                                                                                                                                                                                        | 54.1   | 68.3   | 75.9                               | 76.8   | 76.9   | 76.9   | 76.9   | 76.9   | 76.9   | 75.1   | 70.4   | 64.9   | 60.2   | 56.2   | 52.7   |
| SO <sub>x</sub>                                                                                                                                                                                        | 10.1   | 8.27   | 3.22                               | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   |
| BC <sup>5</sup>                                                                                                                                                                                        | 0.30   | 0.27   | 0.24                               | 0.24   | 0.24   | 0.24   | 0.24   | 0.24   | 0.24   | 0.24   | 0.24   | 0.24   | 0.24   | 0.24   | 0.24   |
| PM <sup>4</sup>                                                                                                                                                                                        | 6.03   | 5.43   | 4.82                               | 4.72   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   | 4.71   |
| TSP <sup>6</sup>                                                                                                                                                                                       | 2.35   | 0.82   | led gasoline out of use since 1997 |        |        |        |        |        |        |        |        |        |        |        |        |
| CO                                                                                                                                                                                                     | 38,510 | 35,310 | 32,415                             | 32,095 | 34,666 | 36,825 | 36,903 | 36,958 | 36,994 | 36,685 | 35,450 | 33,555 | 31,563 | 29,552 | 27,580 |
| Pb                                                                                                                                                                                                     | 1.47   | 0.52   | led gasoline out of use since 1997 |        |        |        |        |        |        |        |        |        |        |        |        |
| Diesel fuels                                                                                                                                                                                           |        |        |                                    |        |        |        |        |        |        |        |        |        |        |        |        |
| NH <sub>3</sub>                                                                                                                                                                                        | 0.162  | 0.165  | 0.168                              | 0.169  | 0.170  | 0.169  | 0.169  | 0.169  | 0.169  | 0.169  | 0.169  | 0.169  | 0.169  | 0.169  | 0.170  |
| NMVOC                                                                                                                                                                                                  | 183    | 154    | 129                                | 85.8   | 56.0   | 38.9   | 35.4   | 31.9   | 28.8   | 25.9   | 23.0   | 20.2   | 17.5   | 15.1   | 13.1   |
| NO <sub>x</sub>                                                                                                                                                                                        | 1,040  | 1,012  | 971                                | 755    | 518    | 384    | 362    | 340    | 321    | 303    | 283    | 262    | 240    | 219    | 200    |
| SO <sub>x</sub>                                                                                                                                                                                        | 79.6   | 60.5   | 14.0                               | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   |
| BC <sup>5</sup>                                                                                                                                                                                        | 78.2   | 63.6   | 50.3                               | 35.6   | 26.7   | 20.3   | 18.8   | 17.4   | 16.0   | 14.6   | 13.0   | 11.3   | 9.58   | 7.93   | 6.50   |
| PM <sup>4</sup>                                                                                                                                                                                        | 148    | 120    | 92.8                               | 58.8   | 37.7   | 26.7   | 24.7   | 22.7   | 20.9   | 19.1   | 17.1   | 15.1   | 13.0   | 11.1   | 9.51   |
| CO                                                                                                                                                                                                     | 580    | 570    | 536                                | 405    | 310    | 251    | 233    | 214    | 195    | 177    | 159    | 142    | 125    | 109    | 95.9   |
| <sup>1</sup> due to lack of better information: similar EF are applied for fossil and biofuels                                                                                                         |        |        |                                    |        |        |        |        |        |        |        |        |        |        |        |        |
| <sup>2</sup> from fuel combustion                                                                                                                                                                      |        |        |                                    |        |        |        |        |        |        |        |        |        |        |        |        |
| <sup>3</sup> from gasoline evaporation                                                                                                                                                                 |        |        |                                    |        |        |        |        |        |        |        |        |        |        |        |        |
| <sup>4</sup> EF(PM <sub>2.5</sub> ) also applied for PM <sub>10</sub> and TSP (assumption: > 99% of TSP consists of PM <sub>2.5</sub> )                                                                |        |        |                                    |        |        |        |        |        |        |        |        |        |        |        |        |
| <sup>5</sup> estimated via a f-BCs as provided in <sup>5)</sup> , Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery |        |        |                                    |        |        |        |        |        |        |        |        |        |        |        |        |
| <sup>6</sup> from leaded gasoline (until 1997)                                                                                                                                                         |        |        |                                    |        |        |        |        |        |        |        |        |        |        |        |        |



With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>1)</sup>

For lead (Pb) from leaded gasoline and corresponding TSP emissions, additional emissions are calculated from 1990 to 1997 based upon country-specific emission factors from <sup>6)</sup>.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

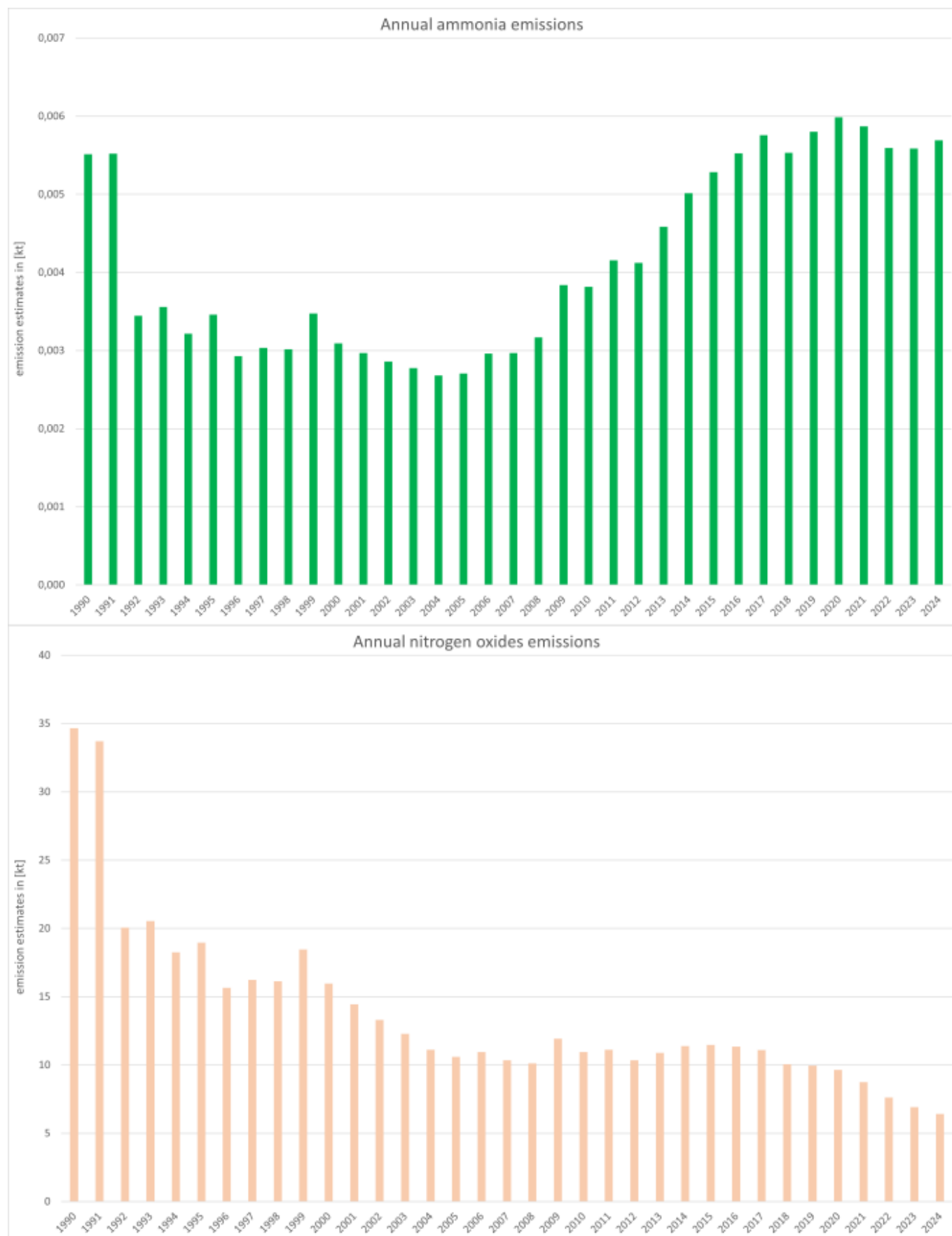
## Discussion of emission trends

Table 5: Outcome of Key Category Analysis

|                 |                    |
|-----------------|--------------------|
| key source for: | <b>CO</b>          |
| by:             | Level of emissions |

For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.

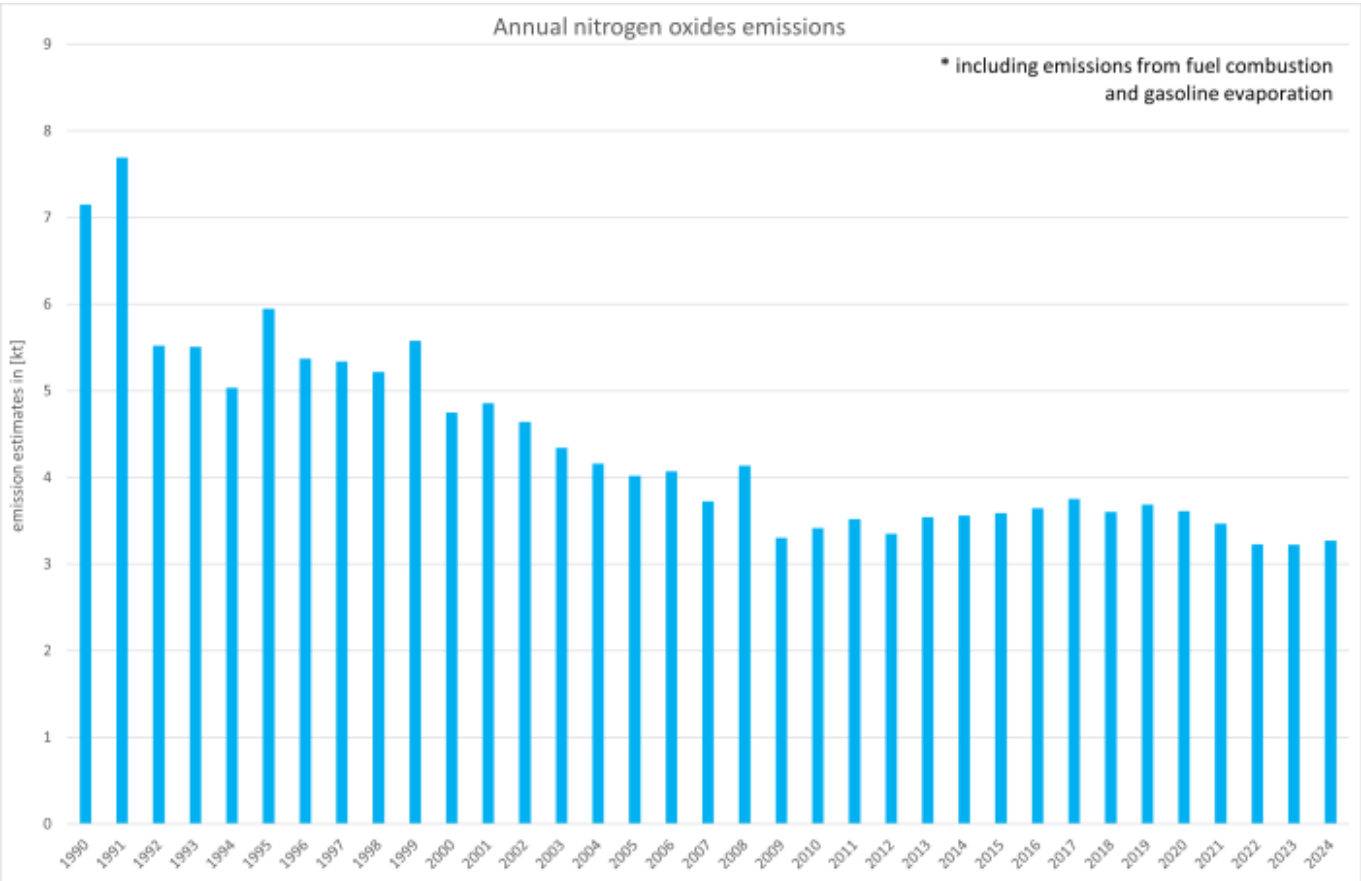
In contrast, for all regulated pollutants (such as NO<sub>x</sub>, SO<sub>x</sub>, NMVOC and particles), emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation.



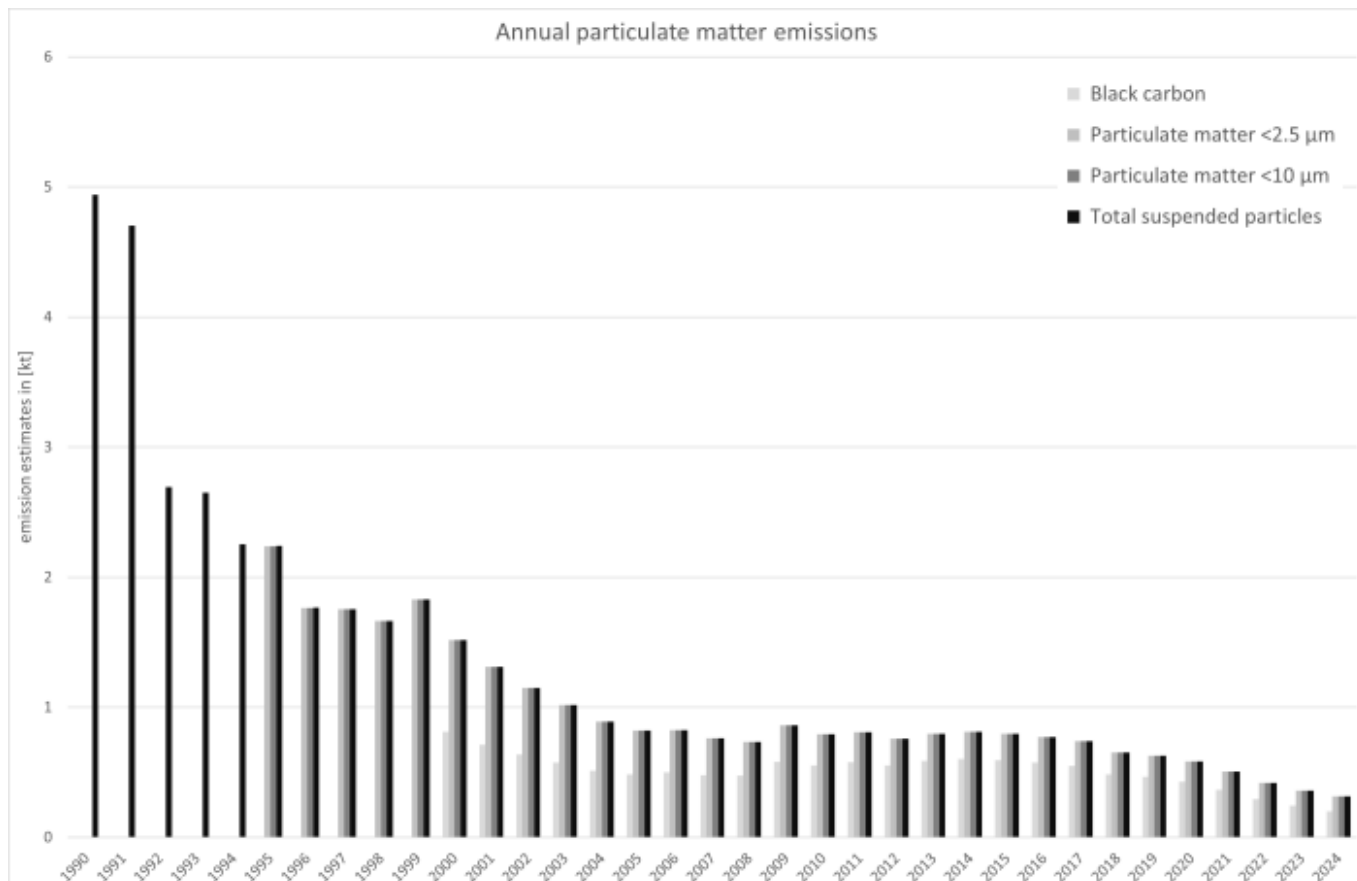
Here, as NMVOC emissions are dominated by gasoline fuels, the trend shows the same strong decline after 2011 as the underlying activity data (see above and NFR 1.A.4 - mobile, Table 1.) The remarkable increase after 2014 relates to the strongly increased gasoline inland deliveries reported in NEB line 67. (see table 3 above). This noticeable increase will be



checked by the compiler of the National Energy Balance.



Over-all PM emissions are by far dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption between 2000 and 2005. Nonetheless, the decrease of the over-all emission trend was and still is amplified by the expanding use of particle filters especially to eliminate soot emissions.



Additional contributors such as the impact of TSP emissions from the use of leaded gasoline (until 1997) have no significant effect onto over-all emission estimates.

## Recalculations

Revisions in activity data result from a revision of the underlying National Energy Balances 2003 to 2022 <sup>7)</sup> and finalization of the NEB 2023 <sup>8)</sup> as well as revised consumption data for agricultural mobile sources. Here, as the over-all amounts of fuels to be distributed onto the different non-road mobile machinery (NRMM) is provided in NEB line 67, the strongly increased AD applied for agricultural mobile sources results in increased amounts of diesel oil allocated to construction/demolition (see also: chapter on NFR 1.A.4.c ii (ii)). In contrast, percental shares remain unaltered for gasoline fuels. However, as the over-all inland deliveries of gasoline fuels as provided in Energy Balance line 67 have been revised strongly, amounts allocated to this NFR sub-category have been revised accordingly.

Table 6: Revised annual shares of NEB line 67, in %

|                            | 1990  | 1995  | 2000  | 2005   | 2010   | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  |
|----------------------------|-------|-------|-------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>DIESEL FUELS</b>        |       |       |       |        |        |       |       |       |       |       |       |       |       |       |
| <b>current submission</b>  | 0.297 | 0.189 | 0.170 | 0.156  | 0.216  | 0.267 | 0.275 | 0.282 | 0.278 | 0.285 | 0.288 | 0.284 | 0.281 | 0.282 |
| <b>previous submission</b> | 0.297 | 0.189 | 0.170 | 0.156  | 0.216  | 0.255 | 0.262 | 0.264 | 0.242 | 0.251 | 0.251 | 0.238 | 0.219 | 0.203 |
| <b>absolute change</b>     | 0.000 | 0.000 | 0.000 | -0.001 | 0.000  | 0.012 | 0.013 | 0.018 | 0.036 | 0.033 | 0.037 | 0.046 | 0.062 | 0.078 |
| <b>relative change</b>     | 0.01% | 0.01% | 0.00% | -0.36% | -0.16% | 4.79% | 5.10% | 7.00% | 14.7% | 13.3% | 14.9% | 19.4% | 28.2% | 38.5% |
| <b>GASOLINE</b>            |       |       |       |        |        |       |       |       |       |       |       |       |       |       |
| <b>current submission</b>  | 0.315 | 0.597 | 0.551 | 0.586  | 0.645  | 0.680 | 0.709 | 0.711 | 0.679 | 0.671 | 0.635 | 0.634 | 0.638 | 0.662 |
| <b>previous submission</b> | 0.315 | 0.597 | 0.551 | 0.586  | 0.645  | 0.680 | 0.709 | 0.711 | 0.679 | 0.671 | 0.635 | 0.634 | 0.638 | 0.662 |
| <b>absolute change</b>     | 0.000 | 0.000 | 0.000 | 0.000  | 0.000  | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| <b>relative change</b>     | 0.02% | 0.01% | 0.00% | 0.00%  | 0.00%  | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

Table 7: Revised activity data, in terajoules

|  | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|

|                                  | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>DIESEL FUELS</b>              |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>        | 33,264 | 18,448 | 16,123 | 13,599 | 20,641 | 29,138 | 30,470 | 31,678 | 30,351 | 31,821 | 32,903 | 32,194 | 30,631 | 30,495 |
| <b>previous submission</b>       | 33,262 | 18,447 | 16,122 | 13,685 | 20,689 | 27,824 | 29,009 | 29,637 | 26,419 | 28,073 | 28,299 | 27,061 | 23,972 | 22,014 |
| <b>absolute change</b>           | 2,34   | 1,00   | 0,58   | -85,7  | -47,8  | 1,314  | 1,461  | 2,041  | 3,932  | 3,748  | 4,604  | 5,133  | 6,659  | 8,481  |
| <b>relative change</b>           | 0.01%  | 0.01%  | 0.00%  | -0.63% | -0.23% | 4.72%  | 5.04%  | 6.89%  | 14.9%  | 13.4%  | 16.3%  | 19.0%  | 27.8%  | 38.5%  |
| <b>GASOLINE FUELS</b>            |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>        | 1,420  | 4,453  | 4,079  | 4,329  | 3,496  | 3,872  | 4,081  | 4,366  | 4,367  | 4,605  | 4,652  | 4,686  | 4,542  | 4,745  |
| <b>previous submission</b>       | 1,420  | 4,453  | 4,079  | 4,343  | 6,753  | 6,564  | 6,612  | 6,476  | 6,268  | 6,366  | 6,034  | 6,177  | 6,126  | 6,300  |
| <b>absolute change</b>           | 0.22   | 0.28   | 0.18   | -14.2  | -3,258 | -2,692 | -2,531 | -2,110 | -1,901 | -1,761 | -1,382 | -1,491 | -1,584 | -1,555 |
| <b>relative change</b>           | 0.02%  | 0.01%  | 0.00%  | -0.33% | -48.2% | -41.0% | -38.3% | -32.6% | -30.3% | -27.7% | -22.9% | -24.1% | -25.9% | -24.7% |
| <b>OVER-ALL FUEL CONSUMPTION</b> |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>        | 36,104 | 27,354 | 24,281 | 22,199 | 27,413 | 36,582 | 38,315 | 40,075 | 38,734 | 40,674 | 41,828 | 41,171 | 39,331 | 39,573 |
| <b>previous submission</b>       | 36,101 | 27,353 | 24,281 | 22,312 | 33,974 | 40,459 | 41,733 | 42,105 | 38,456 | 40,320 | 39,870 | 38,884 | 35,705 | 34,069 |
| <b>absolute change</b>           | 2.77   | 1.56   | 0.95   | -113   | -6,562 | -3,877 | -3,418 | -2,029 | 278    | 355    | 1,958  | 2,287  | 3,626  | 5,504  |
| <b>relative change</b>           | 0.01%  | 0.01%  | 0.00%  | -0.51% | -19.3% | -9.58% | -8.19% | -4.82% | 0.72%  | 0.88%  | 4.91%  | 5.88%  | 10.2%  | 16.2%  |

As, in contrast, all **emission factors** remain unrevised compared to last year's submission, emission estimates change in accordance with the underlying activity data.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following [chapter 9.1 - Recalculations](#).

## Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: "Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland" by (Knörr et al. (2009)) <sup>9)</sup>.

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

## Planned improvements

Besides a **routine revision** of the **TREMOD MM** model, no specific improvements are planned.

## FAQs

### **Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?**

The EF provided in <sup>10)</sup> represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained in the biofuels. But since the specific shares of (i), (ii) and (iii)

cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to diesel and biodiesel.

<sup>1), 8)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl-daten für die Bundesrepublik Deutschland;

[https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>3), 4), 6)</sup> Knörr et al. (2025b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2025, Heidelberg, 2025.

<sup>5), 10)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook – 2023, <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023>, Copenhagen, 2023.

<sup>7)</sup> AGEb (2025a): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland;

[https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?\\_jahresbereich-bilanz=2021-2030](https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?_jahresbereich-bilanz=2021-2030), (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>9)</sup> Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland;

<https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf>, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

<sup>1)</sup>  
During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

## 1.A.3 - Transport (OVERVIEW)

### Short description

Sub-sector **1.A.3 - Transport** includes emissions from fuel combustion activities as well as abrasive emission and fugitive emissions within the following sub-categories:

| NFR-Code | Name of Category |
|----------|------------------|
| 1.A.3.a  | Civil Aviation   |
| 1.A.3.b  | Road Transport   |
| 1.A.3.c  | Railways         |
| 1.A.3.d  | Navigation       |
| 1.A.3.e  | Other Transport  |

## 1.A.3.a - Transport: Civil Aviation



NFR-specific inventory data

### Short description

| NFR-Code                                             | Name of Category                                      | Method | AD | EF | Key Category Analysis           |
|------------------------------------------------------|-------------------------------------------------------|--------|----|----|---------------------------------|
| 1.A.3.a                                              | Civil Aviation                                        |        |    |    | <i>see sub-category details</i> |
| <i>consisting of / including source categories</i>   |                                                       |        |    |    |                                 |
| <b>LTO-range: Included in National Totals</b>        |                                                       |        |    |    |                                 |
| 1.A.3.a i (i)                                        | <a href="#">International Civil Aviation - LTO</a>    |        |    |    | <i>see sub-category details</i> |
| 1.A.3.a ii (i)                                       | <a href="#">Domestic Civil Aviation - LTO</a>         |        |    |    | <i>see sub-category details</i> |
| <b>Cruise phase: Not included in National Totals</b> |                                                       |        |    |    |                                 |
| 1.A.3.a i (ii)                                       | <a href="#">International Civil Aviation - Cruise</a> |        |    |    | <i>see sub-category details</i> |
| 1.A.3.a ii (ii)                                      | <a href="#">Domestic Civil Aviation - Cruise</a>      |        |    |    | <i>see sub-category details</i> |

Air transports differ significantly from land and water transports with respect to emissions production. In air transports, fuels are burned under atmospheric conditions that a) differ markedly from those prevailing at ground level and b) can vary widely.



The main factors that influence the combustion process in this sector include atmospheric pressure, environmental temperature and humidity – all of which are factors that vary considerably with altitude.

In category 1.A.3.a - Civil Aviation the emissions from both national (domestic) and international civil aviation are reported with separate acquisition of flight phases LTO (Landing/Take-off: 0-3,000 feet) and Cruise (above 3,000 feet) where only emissions from LTO from both national and international flights have to be included in the national totals.

Emissions from military aircraft are not included in this category but are reported under military airborne combustion in NFR sub-category 1.A.5.b ii.

Country specifics: The use of aviation gasoline is assumed to take place within the LTO-range of domestic flights only (below 3,000 feet). This assumption is a compromise due to a lack of further information and data.

### Methodology

NOTE: Data available from Eurocontrol via the European Environment Agency (EEA) is not being used for inventory

compilation. Nonetheless, depending on its timeliness, it is taken into account for verification purposes.

Estimation of aircraft emissions has been carried out using a tier 3a approach, i.e. under consideration of the annual distances flown by different types of aircraft, deviated into domestic and international flights, also considering the different flight stages L/TO cycle (Landing/Take-off cycle, i.e. aircraft movements below 3,000 feet or about 915 meters of altitude) and cruise.

Essential for emissions reporting is the separation of domestic and international air traffic. This happens using a so-called split factor representing the ratio of fuel consumption for national flights and the over-all consumption.

For determination of this ratio, results from TREMOD AV (TRansport Emissions MODel AViation) have been used, based on the great circle distances flown by the different types of aircraft (Allekotte et al. (2025) <sup>1)</sup>. Here, the ratio is calculated on the basis of statistics on numbers of national and international flights departing from German airports provided by the Federal Statistical Office (Statistisches Bundesamt).

For further dividing kerosene consumption onto flight stages LTO and cruise, again results calculated within the TREMOD AV data base based on data provided by the Federal Statistical Office have been used.

Emissions are being estimated by multiplying the kerosene consumption of the flight stage with specific emission factors (EF). Here, emissions of SO<sub>2</sub> are independent from the method used, depending only on the quantity and qualities of the fuel used. In contrast, emissions of NO<sub>x</sub>, NMVOC, and CO strongly depend on the types of engines, flight elevations, flight stage, etc. and can be estimated more precisely with higher tiers. The emission factors for NO<sub>x</sub>, CO, and NMVOC are therefore computed within TREMOD AV.

The aviation gasoline (avgas) used is not added to the annual kerosene consumptions but reported separately. As proposed in (IPCC, 2006a) <sup>2)</sup>, emissions caused by the incineration of avgas are calculated using adapted EF and calorific values following a tier1 approach.

For further information on AD (entire time series), EF, key sources, and recalculations see sub-chapters linked above.

## Activity Data

Emissions estimation is mainly based on consumption data for jet kerosene and aviation gasoline as provided in the national Energy Balances (AGEB, 2025) <sup>3)</sup>. For very recent years with no AGEB data available (Normally the last year of the period reported.) data provided by the Federal Office of Economics and Export Control (BAFA) <sup>4)</sup> is being used.

Table 1: Sources for 1.A.3.a activity data

|                                                                                                                                                                                                       |                                                                                             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| through 1994                                                                                                                                                                                          | <b>AGEB</b> - National Energy Balance, line 76: 'Luftverkehr'                               |
| from 1995                                                                                                                                                                                             | <b>AGEB</b> - National Energy Balance, line 63: 'Luftverkehr'                               |
| recent years / comparison                                                                                                                                                                             | <b>BAFA</b> - Official oil data, table 7j: 'An die Luftfahrt' + 'An Sonstige' <sup>1)</sup> |
| <sup>1)</sup> to achieve consistency with AGEB data, amounts given for deliveries 'to Aviation' ('An die Luftfahrt') and 'to Others' ('An Sonstige') have to be added (see FAQs for more information) |                                                                                             |

Table 2: Total inland fuel deliveries to civil aviation, in terajoules

|                                                                                                      | 1990    | 1995    | 2000    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    | 2024    |
|------------------------------------------------------------------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>Kerosene</b>                                                                                      | 193,329 | 233,437 | 297,258 | 343,828 | 361,751 | 361,651 | 389,024 | 425,140 | 437,203 | 434,490 | 199,931 | 257,520 | 384,975 | 401,833 | 385,857 |
| <b>Avgas</b>                                                                                         | 2,438   | 1,142   | 1,120   | 697     | 567     | 569     | 418     | 415     | 400     | 328     | 214     | 159     | 175     | 133     | 169     |
| <b>1.A.3.a</b>                                                                                       | 195,767 | 234,579 | 298,378 | 344,525 | 362,319 | 362,220 | 389,443 | 425,555 | 437,604 | 434,818 | 200,145 | 257,679 | 385,151 | 401,965 | 386,027 |
| source: Working Group on Energy Balances (AGEB): National Energy Balances (AGEB, 2025) <sup>5)</sup> |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |

For the present purposes, kerosene-consumption figures from NEB and BAFA statistics have to be broken down by national (= domestic) and international flights: Here, the split has been calculated on the basis of statistics on numbers of national and international flights departing from German airports provided by the Federal Statistical Office (Statistisches Bundesamt) within TREMOD AV <sup>6)</sup>.

Table 3: Ratios for calculating the shares of fuels used in 1.A.3.a ii - Domestic and 1.A.3.a i - International Civil Aviation, in %

|  | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|



|                                                 | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>1.A.3.a ii - Civil domestic aviation</b>     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>Kerosene</b>                                 | 15.3 | 12.8 | 11.0 | 8.80 | 8.35 | 7.63 | 7.14 | 6.34 | 6.14 | 6.38 | 6.18 | 3.70 | 3.61 | 3.65 | 3.81 |
| <b>Avgas</b>                                    | 86.0 | 85.9 | 86.1 | 86.2 | 86.3 | 86.2 | 97.3 | 97.0 | 96.5 | 96.2 | 97.5 | 92.8 | 92.8 | 79.2 | 80.5 |
| <b>1.A.3.a i - Civil international aviation</b> |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>Kerosene</b>                                 | 84.7 | 87.2 | 89.0 | 91.2 | 91.6 | 92.4 | 92.9 | 93.7 | 93.9 | 93.6 | 93.8 | 96.3 | 96.4 | 96.3 | 96.2 |
| <b>Avgas</b>                                    | 14.0 | 14.1 | 13.9 | 13.8 | 13.7 | 13.8 | 2.66 | 3.00 | 3.53 | 3.80 | 2.54 | 7.22 | 7.20 | 20.8 | 19.5 |

Table 4: Resulting annual shares of jet kerosene and avgas used in 1.A.3.a ii - Domestic and 1.A.3.a i - International Civil Aviation, in [T]

|                                          | 1990    | 1995    | 2000    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    | 2024    |
|------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1.A.3.a ii - Civil domestic aviation     |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>Kerosene</b>                          | 29,501  | 29,989  | 32,746  | 30,260  | 30,210  | 27,605  | 27,783  | 26,935  | 26,843  | 27,739  | 12,354  | 9,541   | 13,914  | 14,676  | 14,710  |
| <b>Avgas</b>                             | 2,098   | 981     | 964     | 601     | 489     | 491     | 407     | 403     | 386     | 316     | 208     | 147     | 163     | 105     | 136     |
| 1.A.3.a i - Civil international aviation |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>Kerosene</b>                          | 163,828 | 203,448 | 264,512 | 313,568 | 331,542 | 334,046 | 361,241 | 398,205 | 410,360 | 406,750 | 187,577 | 247,979 | 371,062 | 387,156 | 371,147 |
| <b>Avgas</b>                             | 340     | 161     | 156     | 96      | 78      | 78.6    | 11.1    | 12.5    | 14.1    | 12.5    | 5.43    | 11.5    | 12.6    | 27.6    | 33.1    |
| 1.A.3.a - OVER-ALL                       |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>Kerosene</b>                          | 193,329 | 233,437 | 297,258 | 343,828 | 361,751 | 361,651 | 389,024 | 425,140 | 437,203 | 434,490 | 199,931 | 257,520 | 384,975 | 401,833 | 385,857 |
| <b>Avgas</b>                             | 2,438   | 1,142   | 1,120   | 697     | 567     | 569     | 418     | 415     | 400     | 328     | 214     | 159     | 175     | 133     | 169     |

The deviation of the kerosene consumed onto the two flight stages L/TO and cruise again has been carried based on TREMOD AV estimations allowing the export of kerosene consumption during L/TO for both domestic and international flights.

Table 5: Annual shares of L/TO stage in domestic and international civil aviation, in %

|                   | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>1.A.3.a i</b>  | 7.55 | 8.25 | 7.42 | 7.13 | 7.59 | 8.37 | 8.01 | 7.44 | 7.43 | 7.71 | 7.25 | 6.08 | 6.14 | 6.53 | 6.14 |
| <b>1.A.3.a ii</b> | 30.0 | 29.3 | 27.8 | 27.5 | 27.5 | 27.6 | 28.0 | 28.1 | 28.3 | 28.1 | 27.5 | 32.9 | 31.8 | 28.5 | 31.8 |

source: number of domestic and international flights as provided by the Federal Statistical Office (Destatis, 2025) <sup>7)</sup>, compiled and computed within <sup>8)</sup>

a assumption: all aircraft using aviation gasoline are operated within the L/TO-range below 3,000 feet and only for domestic flights

Cruise consumption is then calculated as Total inland deliveries minus consumption during L/TO.

## Emission factors

### Kerosene

Emissions have been calculated for each flight phase, based on the respective emission factors. Therefore, the EF used have been taken from a wide range of different sources. In contrast to earlier submissions, the emissions of NO<sub>x</sub>, CO und HC are based on aircraft-specific EF deposited within TREMOD AV. With this very detailed estimations average EF are being formed which are than used for emissions reporting.

The EF provided with the current submission represent annual average EF for the entire fleet, calculated as implied EF from the emissions computed within TREMOD AV and therefore differ from the values used in the past.

**Sulphur dioxide (SO<sub>2</sub>)** emissions depend directly on the kerosene's sulphur content which varies regionally as well as seasonally. The EF used by Eurocontrol of 0.84 kg SO<sub>2</sub>/t kerosene lies between the values used for German inventory for 1990 to 1994 (1.08 to 1.03 kg SO<sub>2</sub>/t) and from 1995 (0.4 kg SO<sub>2</sub>/t). In IPCC 2006b <sup>9)</sup> with 1 kg SO<sub>2</sub>/t kerosene value comes very close to the old inventory values provided, based on a sulfur content of 0.05 % of weight. Following current information of the expert committee for the standardization of mineral oil and fuels (Fachausschuss für Mineralöl-und Brennstoffnormung, FAM), the common value for sulphur content of kerosene in Germany is about 0.01% of weight, i.e. one fifth of the IPCC data. In IIR 2009, a sulfur content of 0.021 weight% have been used, based on measurements from 1998

(Döpelheuer (2002))<sup>10)</sup>.

As an EF decreasing due to improved production procedures and stricter critical levels seems plausible, for this report a constant decline between the annual values of 1.08 g SO<sub>2</sub>/kg for 1990, 0.4 g for 1998 and 0.2 g for 2009 has been assumed. Thereby, an exhaustive conversion of the sulfur into sulfur dioxide is expected. - Due to the EF depending directly on the S content of the kerosene, one annual EF is used for both flight stages.

**Nitrogen oxide (NO<sub>x</sub>), carbon monoxide (CO) and hydrocarbons (HC)** emissions were estimated using IEF calculated within TREMOD AV, based upon more specific (depending on type of aircraft, flight stage) EF mostly taken from the EMEP-EEA data base. For 2009, 40 % of over-all starts (about 70 % of total kilometres flown) had to be linked with adapted EF as it was not possible to directly or even indirectly (via similar types of aircraft) allocate the aircraft used here. Therefore, regression analysis had to be carried out, estimating EF via emission functions that calculate an EF for the respective type of engine depending on the particular take-off weight.

As a basis for these functions the EF of types of aircraft with given EF have been used (see: Allekotte et al. (2024))<sup>11)</sup>. From the trend of the emissions calculated within TREMOD AV, annual average EF for the entire fleet have been formed, which have then been used for reporting. Hence, the EF differ widely from those used in earlier submissions.

**Ammonia (NH<sub>3</sub>)** emissions were estimated using an EF of 0.173 g/kg kerosene for both flight stages (UBA, 2009)<sup>12)</sup>.

The EFs for **non-methane volatile organic compounds (NMVOC)** were calculated as the difference between the EF for over-all hydrocarbons (HC) and the EF for methane (CH<sub>4</sub>).

**Particulate Matter** Within the IPCC EF data base, there are no default data provided for emissions of particulate matter (TSP, PM<sub>10</sub>, and PM<sub>2.5</sub>). Therefore, the EF for dust (**Total Suspended Particulate Matter – TSP**) are taken over from Corinair (2006)<sup>13)</sup>, giving specific values for an average fleet and for the two flight stages in table 8.2: For national flights 0.7 kg TSP/LTO and 0.2 kg TSP/t kerosene and 0.15 kg TSP/LTO and 0.2 kg TSP/t kerosene for international flights. Following this table, a kerosene consumption per LTO cycle of 825 kg for national and 1,617 kg for international flights have been assumed and the EF for the LTO stage have been estimated.

Regarding **Black Carbon**, f-BC fractions from EMEP/EEA guidebook 2023, Chapter 1.A.3.a, 1.A.5 - Aviation, Annex 3, Table A3.2 and Conclusion have been applied for both jet kerosene and aviation gasoline. (EMEP/EEA, 2023)<sup>14)</sup>

As for **polycyclic aromatic hydrocarbons (PAH)**, tier1 EF from (EMEP/EEA, 2019)<sup>15)</sup> have been applied here. As the EMEP guidebook does not provide original EF for jet kerosene, values provided for gasoline in road transport have been used here as a proxy and will be replaced by more appropriate data as soon as this is available.

The conversion of EF representing emissions per kilo fuel combusted [kg pollutant/kg kerosene] into energy related EF [kg pollutant/TJ energy] has been carried out using a net calorific value of 43,000 kJ/kg.

## Aviation gasoline

For aviation gasoline (avgas) a deviation onto LTO and cruise is assumed to be unnecessary. Therefore, there are no such specific EF used here. As for kerosene, the EF for **NO<sub>x</sub>, CO and HC** have been taken from the calculations carried out within TREMOD AV. Here, for calculating aircraft specific NO<sub>x</sub>, CO, and HC emissions corresponding EF from the EMEP-EEA data base have been used that have then been divided by the annual avgas consumption to form annual average EF for emission reporting.

With respect to fuel characteristics, there are no big differences between avgas and gasoline used in passenger cars (PC). Therefore, specific **sulphur dioxide (SO<sub>2</sub>)** emissions from PC gasoline can be carried forward to avgas. - Following the expert committee for the standardization of mineral oil and fuels (FAM), the critical value of sulfur content for gasoline sold at gas stations is 10 mg/kg, i.e. 0,001 % of weight - or one tenth of the kerosene value. Therefore, the EF used for avgas equals the EF used for kerosene reduced by 90 %.

There are different sorts of avgas sold with different **lead (Pb)** contents. As an exact annual ration of the sorts sold is not available, the most common type of avgas (AvGas 100 LL (Low Lead)) with a lead content of 0.56 g/l is set as an approximation. (see EMEP/EEA (2023), Chapter 1.A.3.a, 1.A.5.b Aviation, Annex 2, page 44, Table A2.1)<sup>16)</sup>

The **EF(TSP)** were calculated from the lead content of AvGas 100 LL by multiplication with a factor 1.6 as used for leaded gasoline in road transport in the TREMOD system.

For **NMVOC**, an emission factor from the Revised IPCC Guidelines 1996 (pages I 42 and 40)<sup>17), 18)</sup> is used.

All other emission factors are not available specifically for small aircraft and therefore have been equalized with the EF used for kerosene, national, cruise.

The conversion of the emission factors from [kg emission/kg avgas consumed] into [kg emission/T] energy converted] has been carried out using a net calorific value of 44,300 kJ/kg.

**NOTE:** For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Recalculations

Total jet kerosene inland deliveries remaining unchanged for all years but 2023 within the National Energy Balances. On the other hand, avgas inland deliveries were revised for all years as of 2003 within the same National Energy Balances.

Table 7: Revised total annual inland deliveries of jet kerosene and avgas as provided in NEB line 63, in terajoules [TJ]

|                            | 2003    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    |
|----------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>JET KEROSENE</b>        |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  | 290,470 | 343,828 | 361,751 | 361,651 | 389,024 | 425,140 | 437,203 | 434,490 | 199,931 | 257,520 | 384,975 | 401,833 |
| <b>previous submission</b> | 290,470 | 343,828 | 361,751 | 361,651 | 389,024 | 425,140 | 437,203 | 434,490 | 199,931 | 257,520 | 384,975 | 402,121 |
| <b>absolute change</b>     | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | -289    |
| <b>relative change</b>     | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | -0.07%  |
| <b>AVGAS</b>               |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  | 765     | 697     | 567     | 569     | 418     | 415     | 400     | 328     | 214     | 159     | 175     | 133     |
| <b>previous submission</b> | 766     | 698     | 568     | 570     | 419     | 415     | 401     | 328     | 214     | 159     | 175     | 130     |
| <b>absolute change</b>     | -0.48   | -0.43   | -0.35   | -0.35   | -0.26   | -0.26   | -0.25   | -0.20   | -0.13   | -0.10   | -0.11   | 3.05    |
| <b>relative change</b>     | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | 2.34%   |

Furthermore, the domestic share of total kerosene consumption was revised for 2023 and based on slightly revised background data for this specific year computed within the underlying model, TREMOD Aviation:

Table 8: Revised percental share of kerosene used for domestic flights in 2023, in %

|                            |        |
|----------------------------|--------|
| <b>current submission</b>  | 3.6523 |
| <b>previous submission</b> | 3.6497 |
| <b>absolute change</b>     | 0.0026 |
| <b>relative change</b>     | 0.07%  |

As a result, the amounts of jet kerosene allocated to NFR sub-categories 1.A.3.a i and 1.A.3.a ii and for 2023 had to be revised accordingly. Here, the activity data allocated to NFR 1.A.3.a i was reduced by the same amount by which the activity data allocated to NFR 1.A.3.a ii was increased:

Table 9: Revised amounts of fuel allocated to international (1.A.3.a i) and domestic (1.A.3.a ii) flights, in [TJ]

|                                          | 2003    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    |
|------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1.A.3.a i - Civil international aviation |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>JET KEROSENE</b>                      |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>                | 260,237 | 313,568 | 331,542 | 334,046 | 361,241 | 398,205 | 410,360 | 406,750 | 187,577 | 247,979 | 371,062 | 387,156 |

|                                      | 2003    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    |
|--------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>previous submission</b>           | 260,237 | 313,568 | 331,542 | 334,046 | 361,241 | 398,205 | 410,360 | 406,750 | 187,577 | 247,979 | 371,062 | 387,445 |
| <b>absolute change</b>               | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | -289    |
| <b>relative change</b>               | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | -0.07%  |
| <b>AVGAS</b>                         |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>            | 106     | 96.2    | 77.9    | 78.6    | 11.1    | 12.5    | 14.1    | 12.5    | 5.43    | 11.5    | 12.6    | 27.6    |
| <b>previous submission</b>           | 106     | 96.3    | 78.0    | 78.6    | 11.1    | 12.5    | 14.1    | 12.5    | 5.43    | 11.5    | 12.6    | 27.0    |
| <b>absolute change</b>               | -0.066  | -0.060  | -0.048  | -0.049  | -0.007  | -0.008  | -0.009  | -0.008  | -0.003  | -0.007  | -0.008  | 0.633   |
| <b>relative change</b>               | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | 2.34%   |
| 1.A.3.a ii - Civil domestic aviation |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>JET KEROSENE</b>                  |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>            | 30,233  | 30,260  | 30,210  | 27,605  | 27,783  | 26,935  | 26,843  | 27,739  | 12,354  | 9,541   | 13,914  | 14,676  |
| <b>previous submission</b>           | 30,233  | 30,260  | 30,210  | 27,605  | 27,783  | 26,935  | 26,843  | 27,739  | 12,354  | 9,541   | 13,914  | 14,676  |
| <b>absolute change</b>               | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    |
| <b>relative change</b>               | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   |
| <b>AVGAS</b>                         |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>            | 660     | 601     | 489     | 491     | 407     | 403     | 386     | 316     | 208     | 147     | 163     | 105     |
| <b>previous submission</b>           | 660     | 601     | 490     | 491     | 407     | 403     | 386     | 316     | 209     | 147     | 163     | 103     |
| <b>absolute change</b>               | -0.41   | -0.37   | -0.30   | -0.31   | -0.25   | -0.25   | -0.24   | -0.20   | -0.13   | -0.09   | -0.10   | 2.41    |
| <b>relative change</b>               | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | 2.34%   |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

Besides the routine revision of the underlying model, no specific improvements are planned.

## Uncertainties

Information on uncertainties is provided here with most data representing expert judgement from the research project mentioned above.

For estimating uncertainties, the partial uncertainties ( $U_1$  to  $U_n$ ) of the components incorporated in emission calculations have to be quantified. By additive linking of the squared partial uncertainties the overall uncertainty ( $U_{\text{total}}$ ) can then be estimated (IPCC, 2000) <sup>19)</sup>.

The uncertainties given here have been evaluated for all time series and flight stages as average values. Estimating the overall uncertainty has been carried out as shown in the table below. In the very left column the components of the uncertainty estimations are listed with their partial uncertainties given in the next column. The next columns show the data linked to estimate the different overall uncertainties which themselves represent partial uncertainties for higher aggregated data and so on.

As an example, the uncertainty of the kerosene consumptions for domestic flights divided by flight stages (LTO and cruise)

has been calculated from the partial uncertainty of the over-all kerosene consumption for domestic flights and the partial uncertainty of the LTO-cruise-split. Here, the split is based on the number of flights provided by the Federal Statistical Office and assumptions on the composition of the fleet. The overall uncertainties of both fuel consumption during LTO and cruise itself then represent a partial uncertainty within the estimation of the uncertainties of emissions.

Several partial uncertainties are based on assumptions. For example, the uncertainty given for the entire time series of the split factor domestic:international flights is an average value: For the years 1990 to 2002 data is based upon estimations carried out within TREMOD AV which themselves are based on data from the Federal Statistical Office and EF from the EMEP-EEA data base. For 2003 to 2011 data from Eurocontrol are being used, that are calculated within ANCAT. Comparing results from the ANCAT model with actual consumption data show aberrations of  $\pm 12\%$ . Here, data calculated with AEM 3 model would have an uncertainty of only 3 to 5 % (EUROCONTROL 2006) <sup>20)</sup>.

As no uncertainty estimates were carried out for ammonia and particulate matter within the above-mentioned project, values from the PAREST research project mentioned for most over mobile sources were used. Here, the final report has not yet been published.

## FAQs

### Whereby does the party justify the adding-up of the two amounts provided by BAFA as deliveries 'An die Luftfahrt' and 'An Sonstige' ?

For mineral oils, German National Energy Balances (NEBs) - amongst other sources - are based on BAFA data on the amounts delivered to different sectors. A comparison with consumption data from AGEB and BAFA shows that data from NEB line 76 /63: 'Luftverkehr' equals to the amount added from both columns provided by BAFA <sup>21)</sup>.

### On which basis does the party estimate the reported lead emissions from aviation gasoline?

assumption by party: aviation gasoline = AvGas 100 LL (see EMEP/EEA (2023): Chapter 1.A.3.a, 1.A.5.b Aviation, Annex 2, page 44, Table A2.1) <sup>22)</sup> (AvGas 100 LL is the predominant sort of aviation gasoline in Western Europe) <sup>23)</sup> lead content of AvGas 100 LL: 0.56 g lead/liter (as tetra ethyl lead) <sup>24)</sup>

The applied procedure is similar to the one used for calculating lead emissions from leaded gasoline used in road transport. (There, in contrast to aviation gasoline, the lead content constantly declined resulting in a ban of leaded gasoline in 1997.)

### On which basis does the party estimate the reported TSP emissions from aviation gasoline?

The TSP emissions calculated depend directly on the reported lead emissions: The emission factor for TSP is 1.6 times the emission factor used for lead:  $EF(TSP) = 1.6 \times EF(Pb)$ . The applied procedure is similar to the one used for calculating TSP emissions from leaded gasoline used in road transport.

<sup>2)</sup> IPCC (2006b): Intergovernmental Panel on Climate Change: IPCC emission factor data base; URL:

<http://www.ipcc-nggip.iges.or.jp/EFDB/main.php>

<sup>3), 5)</sup> AGEB (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>4), 21)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl-daten für die Bundesrepublik Deutschland;

[https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>6), 8)</sup> Allekotte et al. (2025): TREMOD Aviation (TREMOD AV) - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., on behalf of the Umweltbundesamt, Heidelberg & Berlin / Dessau-Roßlau, 2025.

<sup>10)</sup> Doepelheuer, A. (2002): Anwendungsorientierte Verfahren zur Bestimmung von CO, HC und Ruß aus Luftfahrttriebwerken, Dissertationsschrift des DLR, Institut für Antriebstechnik, <https://elib.dlr.de/49148/>, ISSN: 1434-8454, Köln, 2002.

<sup>13)</sup> CORINAIR, 2006 - EMEP/CORINAIR Emission Inventory Guidebook - 2006, EEA technical report No. 11/2006; Dezember 2006, Kopenhagen, 2006 URL: <http://www.eea.europa.eu/publications/EMEPCORINAIR4>

<sup>14), 16), 22), 24)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023/view>; Copenhagen, 2023.

<sup>17)</sup> Revised 1996 IPCC Guidelines, Volume 3: Reference Manual, Chapter I: Energy; URL:

<http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref2.pdf>, p. I.40

<sup>18)</sup> Revised 1996 IPCC Guidelines, Volume 3: Reference Manual, Chapter I: Energy;

<http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ref3.pdf>, p. I.42

<sup>19)</sup> IPCC, 2000: Intergovernmental Panel on Climate Change, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC Secretariat, 16th Session, Montreal, 1-8 May 2000, URL:

<http://www.ipcc-nggip.iges.or.jp/public/gp/english/>

<sup>20)</sup> EUROCONTROL, 2006 – The Advanced Emission Model (AEM3) – Validation Report, Jelinek, F., Carlier, S., Smith, J., EEC Report EEC/SEE/2004/004, Brüssel 2004 URL:

[http://www.eurocontrol.int/eec/public/standard\\_page/DOC\\_Report\\_2004\\_016.html](http://www.eurocontrol.int/eec/public/standard_page/DOC_Report_2004_016.html)

[http://www.eurocontrol.int/eec/public/standard\\_page/DOC\\_Report\\_2006\\_030.html](http://www.eurocontrol.int/eec/public/standard_page/DOC_Report_2006_030.html)

<sup>23)</sup> <https://en.wikipedia.org/wiki/Avgas>



NFR-specific inventory data

In NFR category 1.A.3.a i (i) - *International Civil Aviation: LTO* emissions during LTO stage (Landing/Take-off: 0-3,000 feet) are reported. In the following, information on sub-category specific AD, (implied) emission factors and emission estimates are provided.

| Category Code                                                                             | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.3.a i(i)                                                                              | T1, T2, T3                           | NS, M | CS, D, M |
| Method(s) applied                                                                         |                                      |       |          |
| D                                                                                         | Default                              |       |          |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |          |
| T2                                                                                        | Tier 2*                              |       |          |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |          |
| C                                                                                         | CORINAIR                             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| M                                                                                         | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| (source for) Activity Data                                                                |                                      |       |          |
| NS                                                                                        | National Statistics                  |       |          |
| RS                                                                                        | Regional Statistics                  |       |          |
| IS                                                                                        | International Statistics             |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| As                                                                                        | Associations, business organisations |       |          |
| Q                                                                                         | specific Questionnaires (or surveys) |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |
| (source for) Emission Factors                                                             |                                      |       |          |
| D                                                                                         | Default (EMEP Guidebook)             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                    | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|
| -/-             | -/-    | -/-             | -/-             | -/-               | -/-                                                                                 | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | NE     | -/-   | -/-   | -/-   | -/-   | -/-    | NA  | NA   |
|                 |        |                 |                 | L/-               | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | -/T               | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | L/T               | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | IE                | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | *                 | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |



## Methodology

### Actitivy Data

Specific jet kerosene consumption during LTO-stage is calculated within TREMOD AV <sup>1)</sup> as described in the [main chapter](#) on civil aviation.

Table 1: Percentual annual fuel consumption during LTO-stage of international flights

|                   | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Jet Kerosene      | 7.55 | 8.25 | 7.42 | 7.13 | 7.59 | 8.37 | 8.01 | 7.44 | 7.43 | 7.71 | 7.25 | 6.08 | 6.14 | 6.53 | 7.40 |
| Aviation Gasoline | 1.89 | 1.84 | 1.82 | 1.89 | 1.87 | 1.74 | 6.80 | 6.63 | 7.44 | 7.59 | 9.09 | 20.9 | 19.9 | 1.58 | 1.77 |

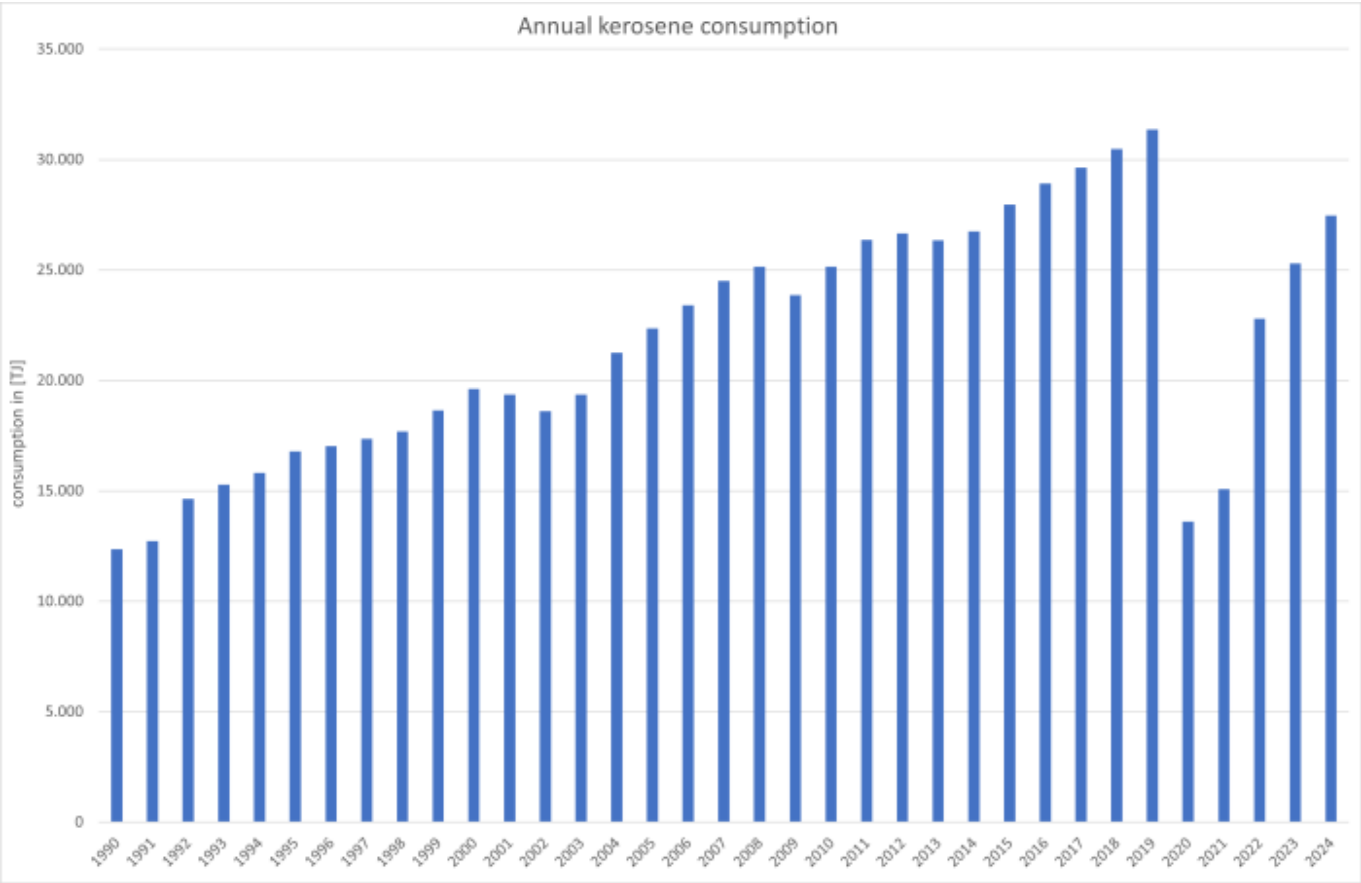
source: Allekotte et al. (2025) <sup>2)</sup>

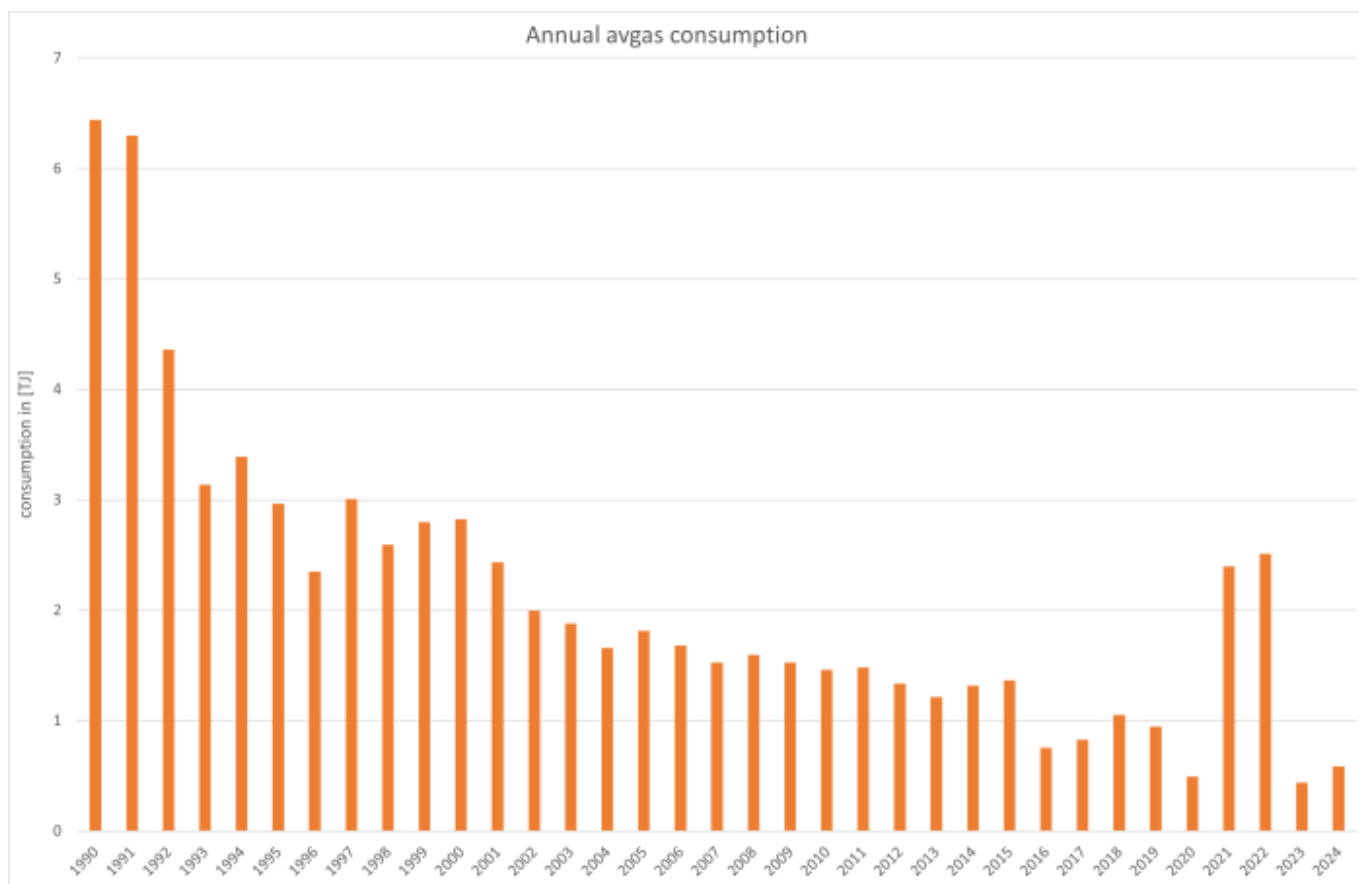
Table 2: annual LTO fuel consumption for international flights, in terajoule

|                   | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Jet Kerosene      | 12,364 | 16,785 | 19,619 | 22,351 | 25,149 | 27,961 | 28,920 | 29,629 | 30,477 | 31,355 | 13,603 | 15,084 | 22,789 | 25,293 | 27,470 |
| Aviation Gasoline | 6.44   | 2.96   | 2.82   | 1.81   | 1.46   | 1.37   | 0.76   | 0.83   | 1.05   | 0.95   | 0.49   | 2.40   | 2.51   | 0.44   | 0.59   |
| Σ                 | 12,370 | 16,788 | 19,622 | 22,353 | 25,150 | 27,963 | 28,920 | 29,630 | 30,478 | 31,356 | 13,604 | 15,087 | 22,791 | 25,294 | 27,470 |

source: Allekotte et al. (2025) <sup>3)</sup>

After a strong but temporary decline during an right after the Covid-19 pandemic, kerosene consumption shows a steady upwards trend again especially after 2021, already reaching about 80% of its pre-pandemic levels. In contrast, domestic flights show no such strong “regeneration” yet (see related sub-chapters).





## Emission factors

All country specific emission factors used for emission reporting were basically ascertained within UBA project FKZ 360 16 029 (Knörr, W., Schacht, A., & Gores, S. (2012))<sup>4)</sup> and have since then been compiled, revised and maintained in TREMOD AV<sup>5)</sup>.

For more information, please see [superordinate chapter](#) on civil aviation.

Table 2: Annual country-specific emission factors, in kg/TJ

|                                                                   | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|-------------------------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>JET KEROSENE</b>                                               |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NH<sub>3</sub></b>                                             | 3.98   | 3.95   | 3.95   | 3.97   | 3.97   | 3.97   | 3.97   | 3.97   | 3.97   | 3.97   | 3.97   | 3.97   | 3.97   | 3.97   |
| <b>NM<sub>10</sub>VOC</b>                                         | 61.7   | 37.5   | 27.0   | 23.7   | 21.9   | 21.3   | 20.9   | 21.4   | 22.2   | 20.0   | 20.7   | 19.1   | 18.9   | 17.8   |
| <b>NO<sub>x</sub></b>                                             | 296    | 306    | 302    | 323    | 342    | 352    | 357    | 357    | 355    | 358    | 368    | 367    | 365    | 365    |
| <b>SO<sub>x</sub></b>                                             | 19.7   | 19.5   | 19.5   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   |
| <b>BC<sup>1</sup></b>                                             | 1.75   | 1.61   | 1.44   | 1.36   | 1.20   | 1.13   | 1.11   | 1.10   | 1.10   | 1.06   | 1.05   | 1.06   | 1.08   | 1.09   |
| <b>PM<sub>2.5</sub>,<br/>PM<sub>10</sub>,<br/>TSP<sup>2</sup></b> | 3.65   | 3.35   | 2.99   | 2.82   | 2.49   | 2.35   | 2.32   | 2.29   | 2.29   | 2.22   | 2.19   | 2.21   | 2.24   | 2.28   |
| <b>CO</b>                                                         | 253    | 230    | 240    | 221    | 204    | 198    | 193    | 193    | 197    | 189    | 189    | 189    | 187    | 184    |
| <b>AVIATION GASOLINE</b>                                          |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NH<sub>3</sub></b>                                             | NE     |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NM<sub>10</sub>VOC</b>                                         | 619    | 636    | 659    | 678    | 665    | 668    | 653    | 644    | 651    | 642    | 634    | 667    | 667    | 663    |
| <b>NO<sub>x</sub></b>                                             | 101    | 96.1   | 92.7   | 91.9   | 91.3   | 96.7   | 97.4   | 98.2   | 80.4   | 75.8   | 72.8   | 95.7   | 97.9   | 94.2   |
| <b>SO<sub>x</sub></b>                                             | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   |
| <b>BC<sup>1</sup></b>                                             | 4.06   | 4.59   | 4.92   | 4.90   | 4.98   | 4.25   | 4.10   | 4.02   | 6.95   | 7.71   | 8.13   | 4.53   | 4.18   | 4.81   |
| <b>PM<sub>2.5</sub>,<br/>PM<sub>10</sub>,<br/>TSP<sup>3</sup></b> | 27.0   | 30.6   | 32.8   | 32.6   | 33.2   | 28.3   | 27.3   | 26.8   | 46.4   | 51.4   | 54.2   | 30.2   | 27.9   | 32.0   |
| <b>CO</b>                                                         | 42.2   | 45.8   | 48.0   | 47.8   | 48.4   | 43.5   | 42.5   | 42.0   | 61.5   | 66.6   | 69.3   | 45.4   | 43.0   | 47.2   |
| <b>CO</b>                                                         | 15,535 | 16,276 | 16,792 | 16,174 | 16,885 | 16,141 | 16,441 | 16,754 | 19,006 | 19,952 | 20,619 | 16,543 | 16,262 | 16,961 |

|                                                                                                                                                                                            | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <sup>1</sup> estimated via a f-BCs (avgas: 0.15, jet kerosene: 0.48) as provided in EMEP/EEA (2023) <sup>6)</sup> , Chapter: 1.A.3.a, 1.A.5.b Aviation, Annex 3, Table A3.2 and Conclusion |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <sup>2</sup> EF(PM <sub>2.5</sub> ) also applied for PM <sub>10</sub> and TSP (assumption: > 99% of TSP from diesel oil combustion consists of PM <sub>2.5</sub> )                         |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <sup>3</sup> also including TSP from lead: EF(TSP) = 1.6 x EF(Pb) - see road transport                                                                                                     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |



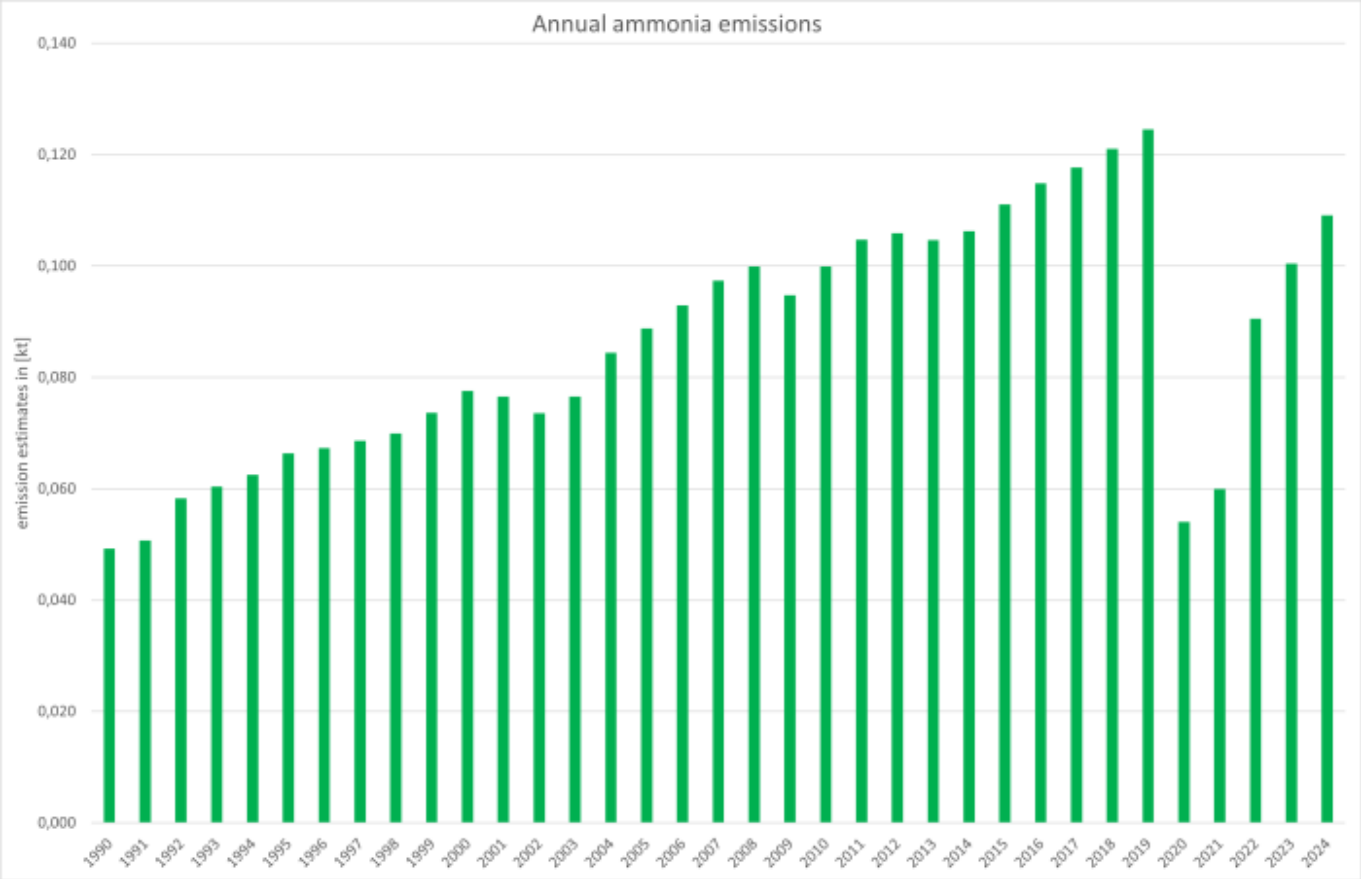
For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

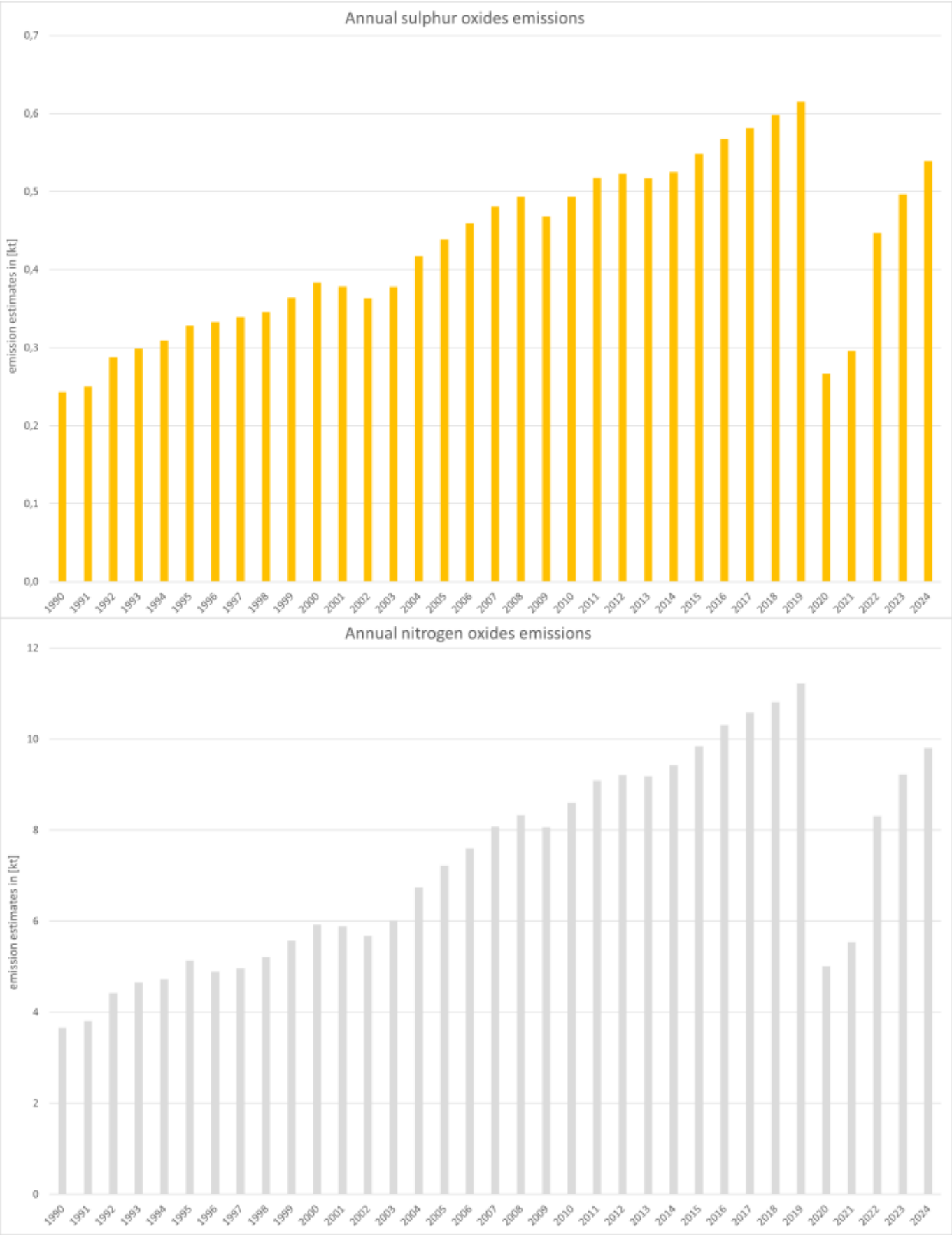
Discussion of emission trends

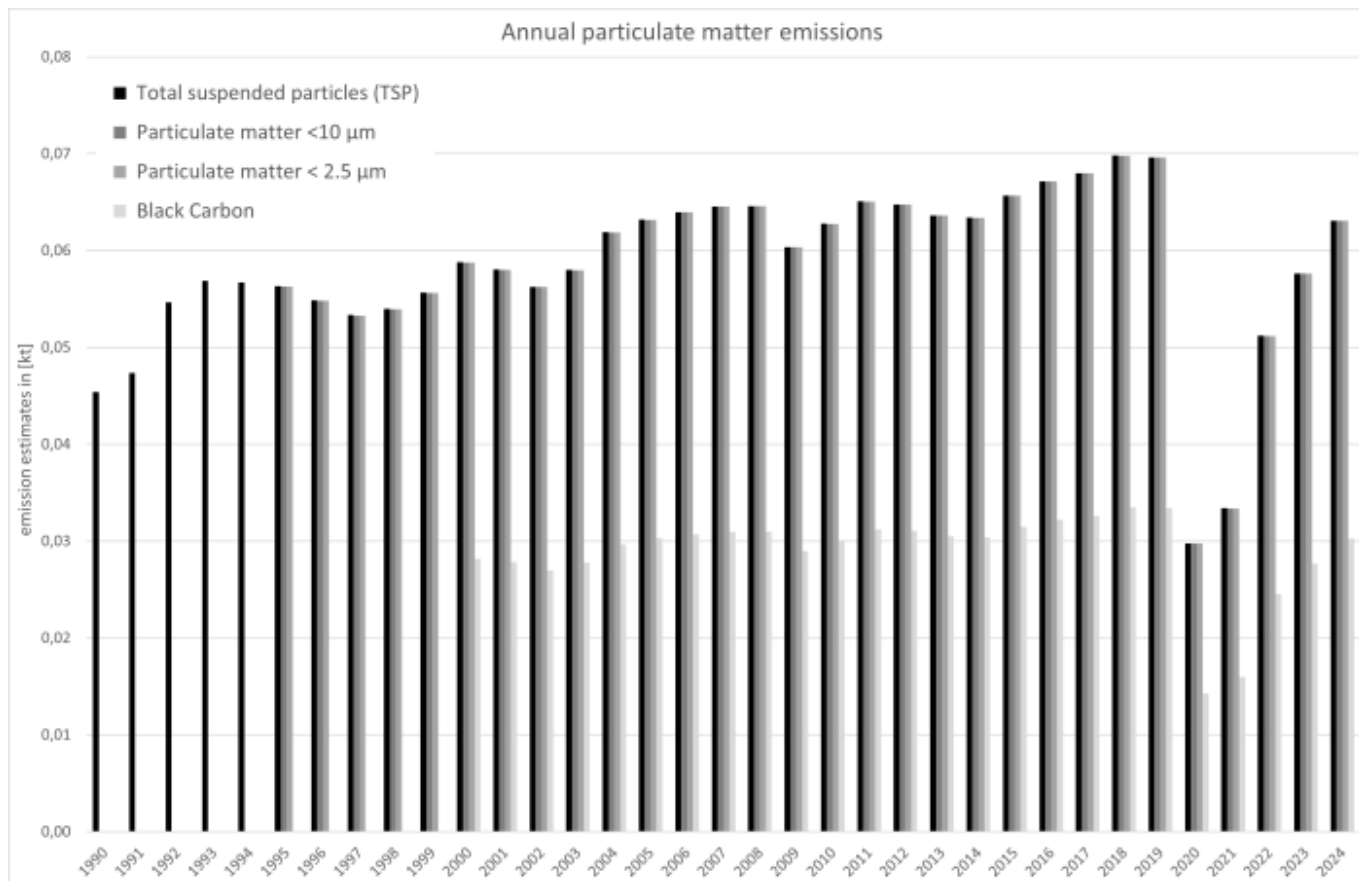


NFR sub-category 1.A.3.a i (i) is no key source for emissions.

Corresponding directly with fuel consumption, emission estimates show a steady upwards trend again especially as of 2022 for international flights, already reaching about 80% of its pre-pandemic levels. In contrast, emissions from domestic flights show no such strong “regeneration” yet (see related sub-chapters).







## Recalculations

As the **percentual shares** of kerosene and aviation gasoline consumed during L/TO remain unrevised, changes in **activity data** occur only as a result of the biennial routine revision of the National Energy Balances for all years as of 2003, and only for aviation gasoline.

Table 5: Revised fuel consumption data 2003-2023, in terajoules

|                            | 2003   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>JET KEROSENE</b>        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 19,355 | 22,351 | 25,149 | 27,961 | 28,920 | 29,629 | 30,477 | 31,355 | 13,603 | 15,084 | 22,789 | 25,293 |
| <b>previous submission</b> | 19,355 | 22,351 | 25,149 | 27,961 | 28,920 | 29,629 | 30,477 | 31,355 | 13,603 | 15,084 | 22,789 | 25,293 |
| <b>absolute change</b>     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   |
| <b>relative change</b>     | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  |
| <b>AVGAS</b>               |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 1.880  | 1.814  | 1.459  | 1.365  | 0.756  | 0.828  | 1.052  | 0.947  | 0.494  | 2.398  | 2.512  | 0.437  |
| <b>previous submission</b> | 1.882  | 1.815  | 1.460  | 1.366  | 0.757  | 0.828  | 1.053  | 0.947  | 0.494  | 2.399  | 2.514  | 0.427  |
| <b>absolute change</b>     | -0.001 | -0.001 | -0.001 | -0.001 | 0.000  | -0.001 | -0.001 | -0.001 | 0.000  | -0.001 | -0.002 | 0.010  |
| <b>relative change</b>     | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | 2.34%  |

In contrast, all country-specific **emission factors** as well as values derived from defaults remain unaltered with the current submission.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Uncertainties



For information on uncertainties, please see the [main chapter](#) on civil aviation.

## Planned improvements



For information on planned improvements, please see [main chapter](#) on civil aviation.

## FAQs

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<sup>1), 2), 3), 5)</sup> Allekotte et al. (2025): TREMOD Aviation (TREMOT AV) - Revision des Modells zur Berechnung des Flugverkehrs (TREMOT-AV). Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., on behalf of the Umweltbundesamt, Heidelberg & Berlin / Dessau-Roßlau, 2025.

<sup>4)</sup> Knörr, W., Schacht, A., & Gores, S. (2012): Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOT-AV): Endbericht. Endbericht zum F+E-Vorhaben 360 16 029, URL: <https://www.umweltbundesamt.de/publikationen/entwicklung-eines-modells-zur-berechnung>; on behalf of the Umweltbundesamt, Heidelberg & Berlin / Dessau-Roßlau, 2012.

<sup>6)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 1.A.3.a, 1.A.5.b Aviation, <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023/@download/file>; Copenhagen, 2023



NFR-specific inventory data

In NFR category 1.A.3.a ii (i) - Domestic Civil Aviation: LTO emissions from domestic flights between German airports occurring during LTO stage (Landing/Take-off: 0-3.000 feet) are reported.

| Category Code                                                                             | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.3.a ii (i)                                                                            | T1, T2, T3                           | NS, M | CS, D, M |
| Method(s) applied                                                                         |                                      |       |          |
| D                                                                                         | Default                              |       |          |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |          |
| T2                                                                                        | Tier 2*                              |       |          |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |          |
| C                                                                                         | CORINAIR                             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| M                                                                                         | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| (source for) Activity Data                                                                |                                      |       |          |
| NS                                                                                        | National Statistics                  |       |          |
| RS                                                                                        | Regional Statistics                  |       |          |
| IS                                                                                        | International Statistics             |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| As                                                                                        | Associations, business organisations |       |          |
| Q                                                                                         | specific Questionnaires (or surveys) |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |
| (source for) Emission Factors                                                             |                                      |       |          |
| D                                                                                         | Default (EMEP Guidebook)             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub>                                                                               | PM <sub>10</sub> | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |
|-----------------|--------|-----------------|-----------------|-------------------------------------------------------------------------------------------------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|--|
| -/-             | -/-    | -/-             | -/-             | -/-                                                                                             | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | NE     | -/-   | -/-   | -/-   | -/-   | -/-    | NA  | NA   |  |
|                 |        |                 |                 | L/- key source by <b>Level</b> only                                                             |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | -/T key source by <b>Trend</b> only                                                             |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | L/T key source by both <b>Level</b> and <b>Trend</b>                                            |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | -/- no key source for this pollutant                                                            |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | IE emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | NE emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | NA specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | * no analysis done                                                                              |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |

In the following, information on sub-category specific AD, (implied) emission factors and emission estimates are provided.



## Methodology

### Actitvity Data

Specific jet kerosene consumption during LTO-stage is calculated within TREMOD AV as described in the superordinate chapter.

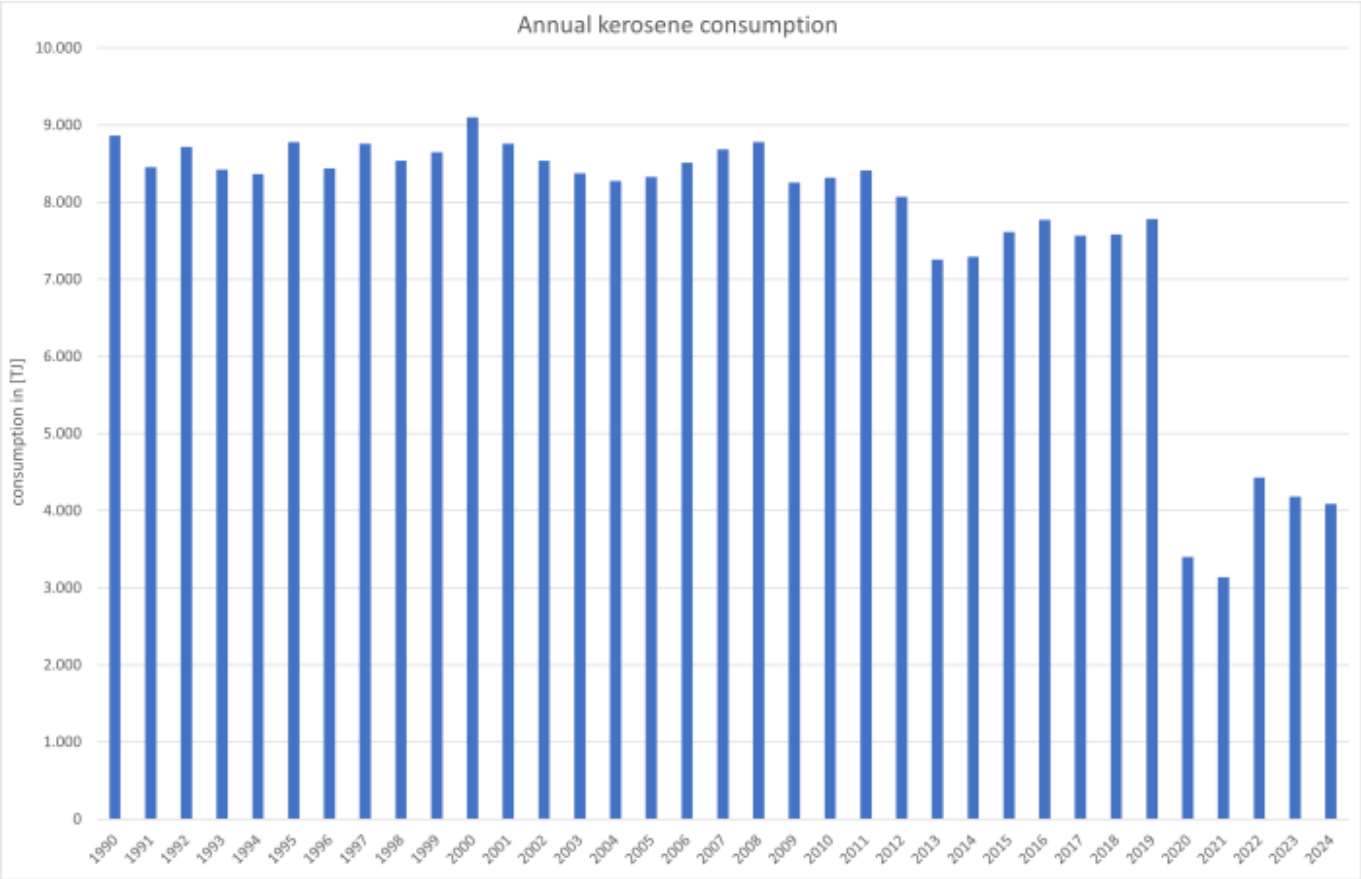
Table 1: Percentual annual fuel consumption during LTO-stage of domestic flights

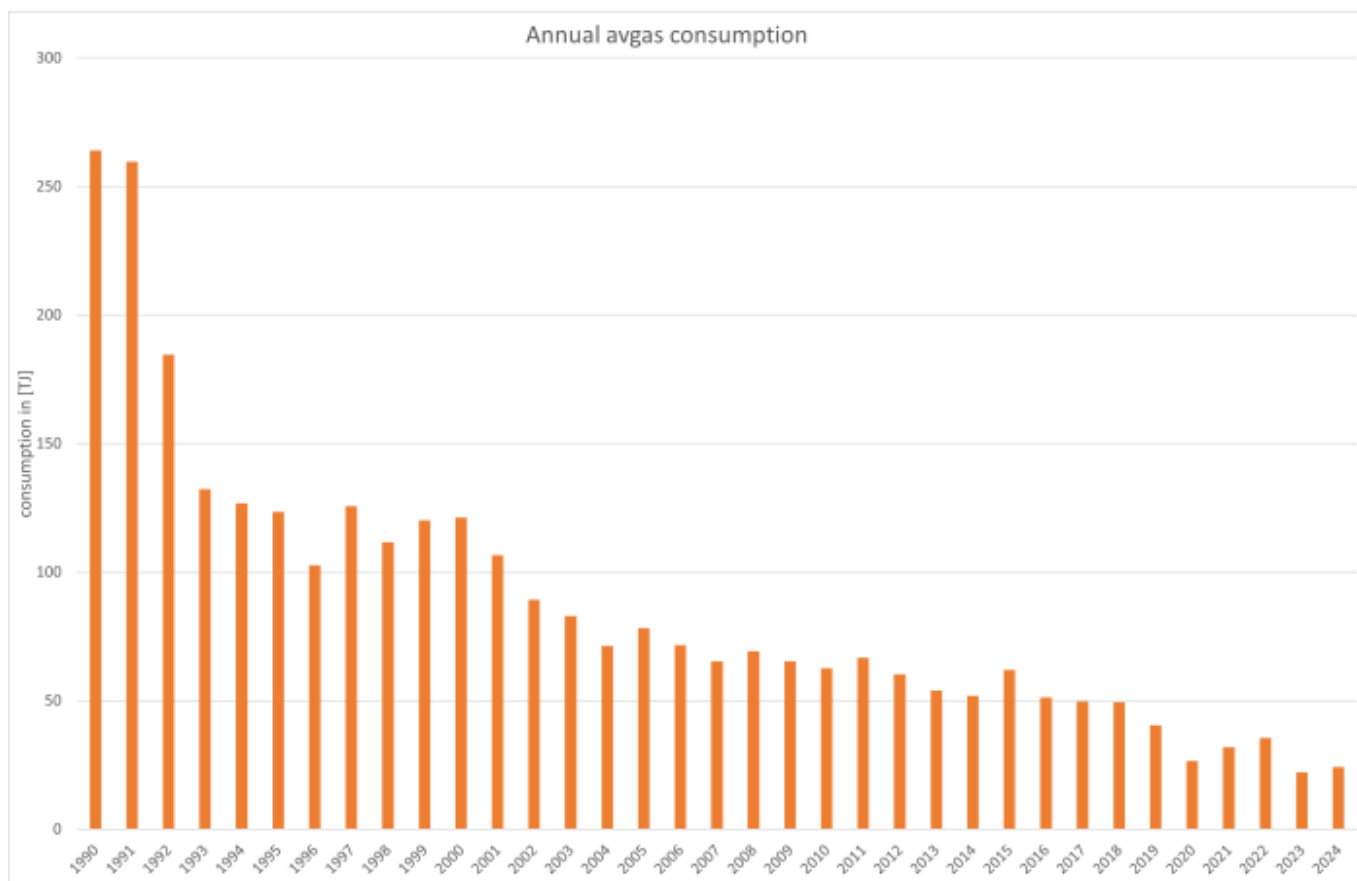
|                                               | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-----------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Jet Kerosene                                  | 30.0 | 29.3 | 27.8 | 27.5 | 27.5 | 27.6 | 28.0 | 28.1 | 28.3 | 28.1 | 27.5 | 32.9 | 31.8 | 28.5 | 27.8 |
| Aviation Gasoline                             | 12.6 | 12.6 | 12.6 | 13.0 | 12.8 | 12.6 | 12.6 | 12.3 | 12.8 | 12.8 | 12.7 | 21.7 | 21.9 | 21.0 | 17.7 |
| source: Allekotte et al. (2025) <sup>1)</sup> |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

As explained above, the use of aviation gasoline is - due to a lack of further information - assumed to entirely take place within the LTO-range.

Table 2: annual LTO fuel consumption for domestic flights, in terajoule

|                                 | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Jet Kerosene                    | 8,864 | 8,782 | 9,100 | 8,331 | 8,318 | 7,612 | 7,773 | 7,569 | 7,584 | 7,784 | 3,402 | 3,140 | 4,429 | 4,186 | 4,091 |
| Aviation Gasoline               | 264   | 123   | 121   | 78.2  | 62.6  | 62.0  | 51.3  | 49.7  | 49.4  | 40.5  | 26.5  | 31.9  | 35.6  | 22.1  | 24.1  |
| Σ                               | 9,128 | 8,906 | 9,221 | 8,409 | 8,380 | 7,674 | 7,825 | 7,619 | 7,634 | 7,824 | 3,428 | 3,172 | 4,465 | 4,208 | 4,115 |
| source: Allekotte et al. (2025) |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |





## Emission factors

All country-specific emission factors used for emission reporting were basically ascertained within UBA project FKZ 360 16 029 (Knörr, W., Schacht, A., & Gores, S. (2012))<sup>2)</sup> and have since then been compiled, revised and maintained in TREMOD AV.

Furthermore, the **newly implemented EF(BC)** have been estimated via f-BCs as provided in the 2023 EMEP/EEA Guidebook<sup>3)</sup>, Chapter 1.A.3.a, 1.A.5.b Aviation, page 49: "Conclusion".

For more details, please see the superordinate chapter on civil aviation.

Table 3: Country-specific emission factors, in kg/Tj

|                                                                   | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-------------------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>JET KEROSENE</b>                                               |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>NH<sub>3</sub></b>                                             | 3.98 | 3.95 | 3.95 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 |
| <b>NM VOC</b>                                                     | 36.1 | 36.2 | 38.8 | 39.5 | 38.6 | 44.8 | 42.3 | 44.6 | 48.0 | 50.2 | 80.4 | 92.2 | 72.8 | 48.7 | 49.4 |
| <b>NO<sub>x</sub></b>                                             | 290  | 320  | 282  | 273  | 300  | 308  | 318  | 318  | 313  | 310  | 286  | 272  | 288  | 305  | 307  |
| <b>SO<sub>x</sub></b>                                             | 19.7 | 19.5 | 19.5 | 19.6 | 19.6 | 19.6 | 19.6 | 19.6 | 19.6 | 19.6 | 19.6 | 19.6 | 19.6 | 19.6 | 19.6 |
| <b>BC<sup>1</sup></b>                                             | 1.37 | 1.51 | 1.49 | 1.55 | 1.45 | 1.44 | 1.39 | 1.37 | 1.46 | 1.32 | 1.38 | 1.44 | 1.39 | 1.25 | 1.28 |
| <b>PM<sub>2.5</sub>,<br/>PM<sub>10</sub>,<br/>TSP<sup>2</sup></b> | 2.86 | 3.15 | 3.10 | 3.23 | 3.02 | 3.01 | 2.89 | 2.85 | 3.04 | 2.75 | 2.87 | 2.99 | 2.91 | 2.61 | 2.67 |
| <b>CO</b>                                                         | 227  | 225  | 293  | 305  | 273  | 280  | 264  | 267  | 280  | 289  | 402  | 442  | 372  | 369  | 367  |
| <b>AVIATION GASOLINE</b>                                          |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>NH<sub>3</sub></b>                                             | NE   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>NM VOC</b>                                                     | 673  | 672  | 673  | 687  | 675  | 672  | 663  | 654  | 674  | 669  | 666  | 667  | 663  | 668  | 649  |
| <b>NO<sub>x</sub></b>                                             | 97.2 | 96.7 | 96.7 | 94.7 | 95.4 | 96.9 | 97.8 | 98.8 | 95.5 | 94.2 | 94.6 | 93.5 | 91.6 | 98.2 | 98.9 |
| <b>SO<sub>x</sub></b>                                             | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 | 0.46 |
| <b>BC<sup>1</sup></b>                                             | 4.26 | 4.32 | 4.31 | 4.52 | 4.47 | 4.29 | 4.19 | 4.10 | 4.50 | 4.74 | 4.69 | 4.90 | 5.22 | 4.14 | 4.10 |

|                                              | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|----------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>PM<sub>2.5</sub>,<br/>PM<sub>10</sub></b> | 28.4   | 28.8   | 28.8   | 30.2   | 29.8   | 28.6   | 27.9   | 27.3   | 30.0   | 31.6   | 31.3   | 32.7   | 34.8   | 27.6   | 27.3   |
| <b>TSP<sup>3</sup></b>                       | 43.5   | 44.0   | 43.9   | 45.3   | 45.0   | 43.8   | 43.1   | 42.5   | 45.2   | 46.8   | 46.4   | 47.8   | 50.0   | 42.8   | 42.5   |
| <b>CO</b>                                    | 16,026 | 16,098 | 16,095 | 15,647 | 16,133 | 16,131 | 16,436 | 16,740 | 16,287 | 16,667 | 16,761 | 16,948 | 17,407 | 16,236 | 16,766 |

<sup>1</sup> estimated via a f-BCs (avgas: 0.15, jet kerosene: 0.48) as provided in EMEP/EEA (2023) <sup>4)</sup>, Chapter: 1.A.3.a, 1.A.5.b Aviation, Annex 3, Table A3.2 and Conclusions

<sup>2</sup> EF(PM<sub>2.5</sub>) also applied for PM<sub>10</sub> and TSP (assumption: > 99% of TSP from diesel oil combustion consists of PM<sub>2.5</sub>)

<sup>3</sup> also including TSP from lead: EF(TSP) = 1.6 x EF(Pb) - see road transport



For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

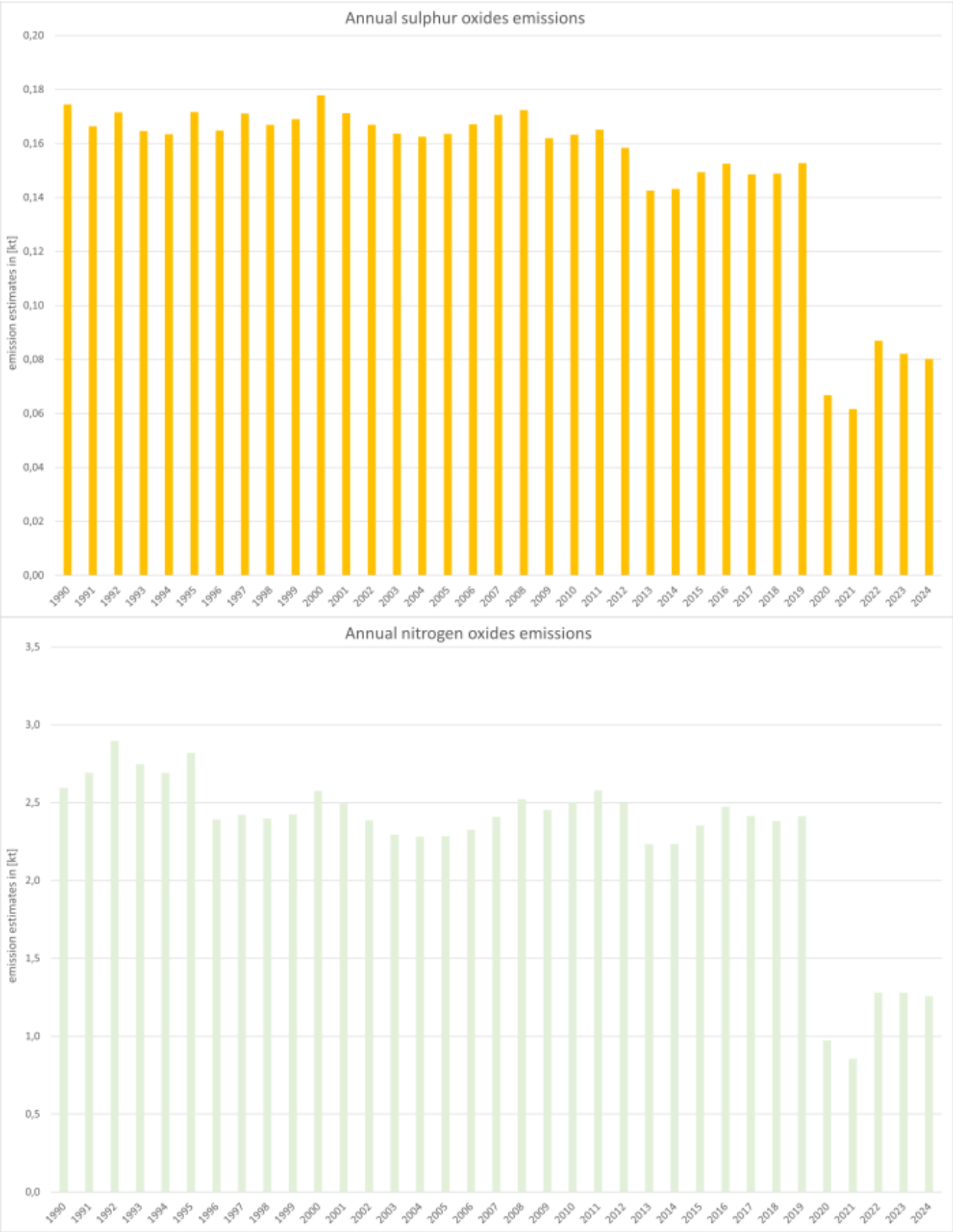
## Trend discussion for Key Sources



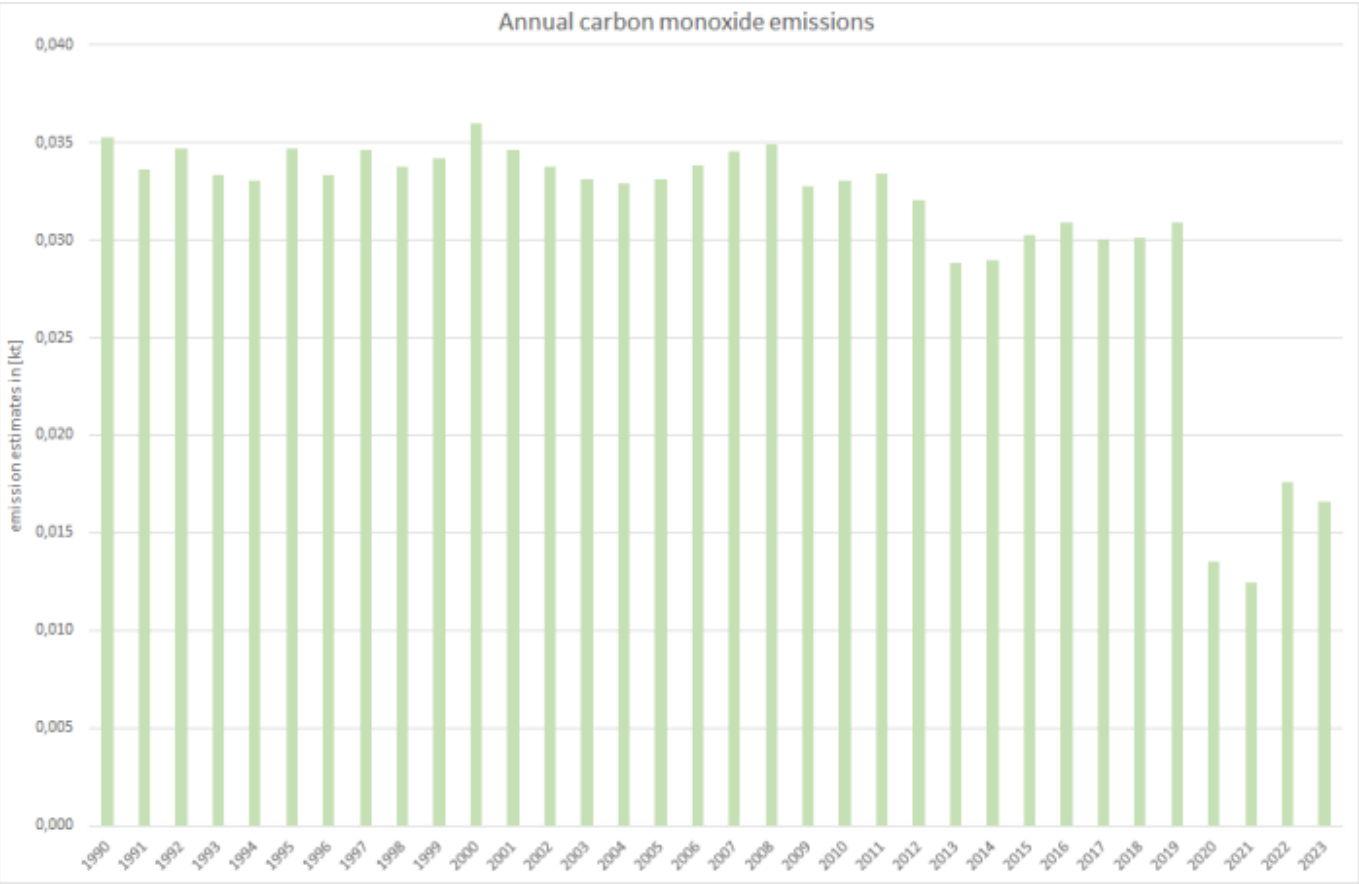
NFR sub-category 1.A.3.a ii (i) is no key source for emissions.

Basically, emission trends correspond directly with fuel consumption, resulting in a strong but temporary decline during an right after the Covid-19 pandemic. Here, with fuel consumption and emissions showing a steady upwards trend again in 2021 and 2022 for international flights, this “recovery” is much slower for domestic flights.

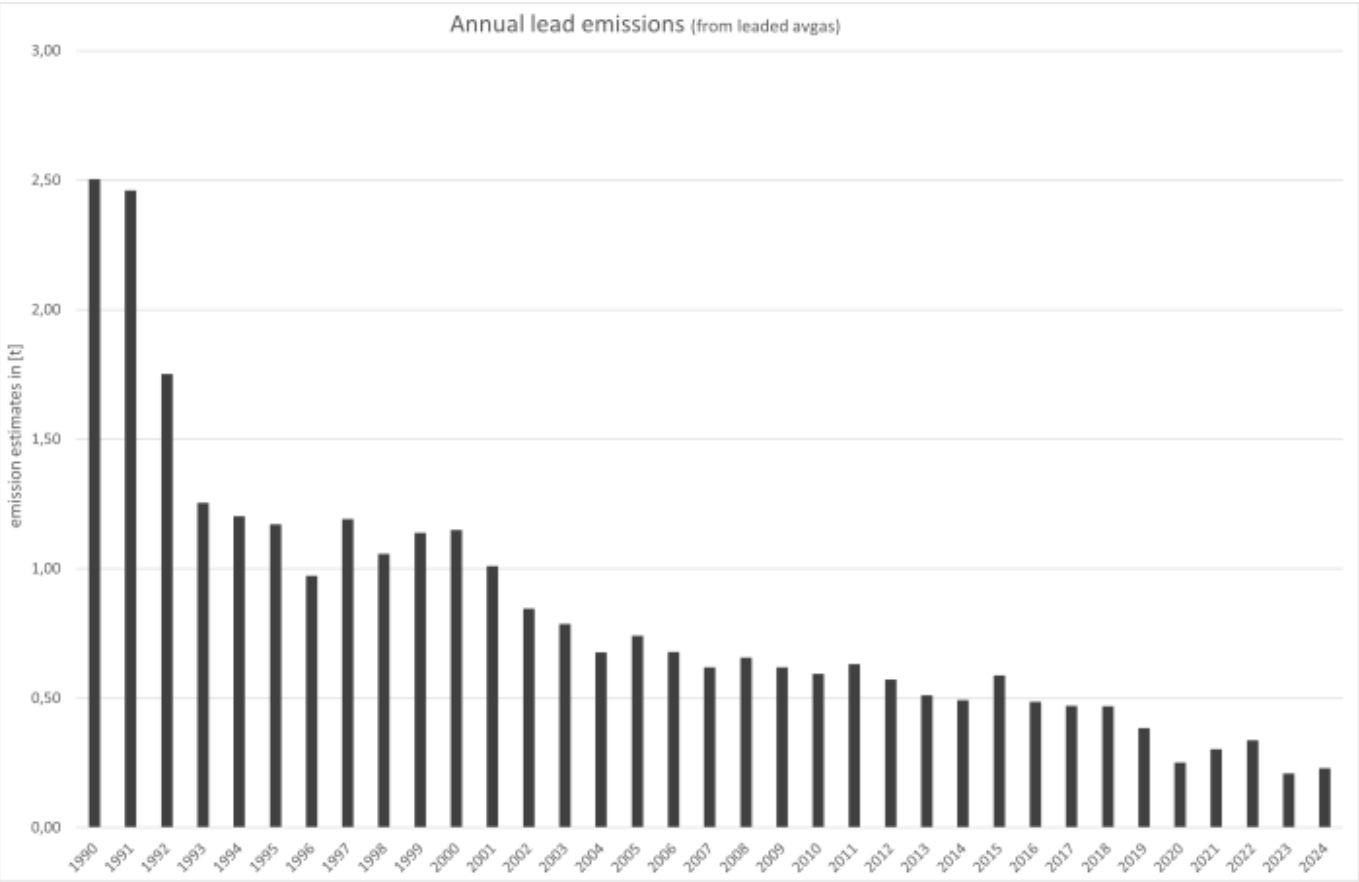
Where, for example, **nitrogen oxides** and **sulphur oxides** emissions are dominated by jet kerosene due to the amount of fuel used,...



... the majority of **carbon monoxide** stems from the consumption of avgas given the much higher emission factor applied to this fuel, with the emission trend following the trend in avgas consumption:



**Lead** emissions, on the other hand, with no emission factor available for jet kerosene, are only calculated for avgas. Based on a stable fuel lead-content, the emission trend follows the trend in avgas consumption:



## Recalculations

As the **percentual shares** of kerosene and aviation gasoline consumed during L/TO remain unrevised, changes in **activity data** occur only as a result of the biennial routine revision of the National Energy Balances for all years as of 2003, and only for aviation gasoline.

Table 4: Revised fuel consumption data 2003-2023, in terajoules

|                            | 2003   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023  |
|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| <b>JET KEROSENE</b>        |        |        |        |        |        |        |        |        |        |        |        |       |
| <b>current submission</b>  | 8,376  | 8,331  | 8,318  | 7,612  | 7,773  | 7,569  | 7,584  | 7,784  | 3,402  | 3,140  | 4,429  | 4,186 |
| <b>previous submission</b> | 8,376  | 8,331  | 8,318  | 7,612  | 7,773  | 7,569  | 7,584  | 7,784  | 3,402  | 3,140  | 4,429  | 4,186 |
| <b>absolute change</b>     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00  |
| <b>relative change</b>     | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00% |
| <b>AVGAS</b>               |        |        |        |        |        |        |        |        |        |        |        |       |
| <b>current submission</b>  | 82.9   | 78.2   | 62.6   | 62.0   | 51.3   | 49.7   | 49.4   | 40.5   | 26.5   | 31.9   | 35.6   | 22.1  |
| <b>previous submission</b> | 83.0   | 78.2   | 62.6   | 62.0   | 51.3   | 49.7   | 49.4   | 40.5   | 26.6   | 32.0   | 35.6   | 21.6  |
| <b>absolute change</b>     | -0.05  | -0.05  | -0.04  | -0.04  | -0.03  | -0.03  | -0.03  | -0.03  | -0.02  | -0.02  | -0.02  | 0.51  |
| <b>relative change</b>     | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | 2.34% |

Furthermore, all country-specific **emission factors** as well as values derived from defaults remain unaltered, too, with the current submission.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Uncertainties



For information on uncertainties, please see the [main chapter](#) on civil aviation.

## Planned improvements



For information on planned improvements, please see [main chapter](#) on civil aviation.

<sup>1)</sup> Allekotte et al. (2025): TREMOD Aviation (TREMOD AV) - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., on behalf of the Umweltbundesamt, Heidelberg & Berlin / Dessau-Roßlau, 2025.

<sup>2)</sup> Knörr, W., Schacht, A., & Gores, S. (2012): Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV): Endbericht. Endbericht zum F+E-Vorhaben 360 16 029, URL: <https://www.umweltbundesamt.de/publikationen/entwicklung-eines-modells-zur-berechnung>; on behalf of the Umweltbundesamt, Heidelberg & Berlin / Dessau-Roßlau, 2012.

<sup>3), 4)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 1.A.3.a, 1.A.5.b Aviation, <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023/@download/file>; Copenhagen, 2023





## 1.A.3.a i (ii) - Internatinal Civil Aviation: Cruise



NFR-specific inventory  
data

### Short description

| Category Code                                                                             | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.3.a i (ii)                                                                            | T1, T2, T3                           | NS, M | CS, D, M |
| Method(s) applied                                                                         |                                      |       |          |
| D                                                                                         | Default                              |       |          |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |          |
| T2                                                                                        | Tier 2*                              |       |          |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |          |
| C                                                                                         | CORINAIR                             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| M                                                                                         | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| (source for) Activity Data                                                                |                                      |       |          |
| NS                                                                                        | National Statistics                  |       |          |
| RS                                                                                        | Regional Statistics                  |       |          |
| IS                                                                                        | International Statistics             |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| As                                                                                        | Associations, business organisations |       |          |
| Q                                                                                         | specific Questionnaires (or surveys) |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |
| (source for) Emission Factors                                                             |                                      |       |          |
| D                                                                                         | Default (EMEP Guidebook)             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                    | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |
|-----------------|--------|-----------------|-----------------|-------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|--|
| -/-             | -/-    | -/-             | -/-             | -/-               | -/-                                                                                 | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | NE     | -/-   | -/-   | -/-   | -/-   | -/-    | NA  | NA   |  |
|                 |        |                 |                 | L/-               | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | -/T               | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | L/T               | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | IE                | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | *                 | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |

In NFR category 1.A.3.a i (ii) - *Internatinal Civil Aviation: Cruise* emissions from international flights from German airports during cruise stage (above 3,000 feet of altitude) are reported.

In the following, information on sub-category specific activity data, (implied) emission factors and emission estimates are provided.



|                         | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|-------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>NMVOG</b>            | 13.5   | 9.09   | 6.13   | 5.33   | 4.72   | 4.44   | 4.24   | 4.30   | 4.41   | 4.35   | 4.49   | 4.13   | 4.21   | 4.13   | 3.85   |
| <b>NO<sub>x</sub></b>   | 313    | 316    | 328    | 337    | 351    | 365    | 370    | 372    | 373    | 375    | 379    | 378    | 378    | 375    | 373    |
| <b>SO<sub>x</sub></b>   | 19.7   | 19.5   | 19.5   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   |
| <b>BC<sup>2</sup></b>   | 1.87   | 1.94   | 2.02   | 1.92   | 1.80   | 1.71   | 1.72   | 1.72   | 1.73   | 1.71   | 1.68   | 1.76   | 1.77   | 1.79   | 1.80   |
| <b>PM<sub>2.5</sub></b> |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>PM<sub>10</sub></b>  | 3.90   | 4.04   | 4.20   | 4.00   | 3.75   | 3.57   | 3.59   | 3.58   | 3.60   | 3.57   | 3.50   | 3.67   | 3.69   | 3.73   | 3.74   |
| <b>TSP<sup>1</sup></b>  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>CO</b>               | 74.4   | 62.1   | 48.5   | 42.6   | 38.1   | 36.5   | 34.5   | 34.5   | 35.0   | 34.4   | 35.1   | 34.8   | 34.6   | 37.4   | 36.7   |
| <b>AVGAS</b>            |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NH<sub>3</sub></b>   | NE     |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NMVOG</b>            | 593    | 592    | 599    | 601    | 600    | 602    | 594    | 593    | 572    | 563    | 543    | 589    | 591    | 601    | 585    |
| <b>NO<sub>x</sub></b>   | 147    | 147    | 148    | 149    | 148    | 150    | 150    | 149    | 135    | 130    | 118    | 146    | 148    | 149    | 142    |
| <b>SO<sub>x</sub></b>   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   |
| <b>BC<sup>2</sup></b>   | 0.41   | 0.41   | 0.42   | 0.42   | 0.42   | 0.42   | 0.41   | 0.42   | 0.42   | 0.42   | 0.43   | 0.42   | 0.42   | 0.42   | 0.43   |
| <b>PM<sub>2.5</sub></b> |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>PM<sub>10</sub></b>  | 2.75   | 2.75   | 2.78   | 2.77   | 2.78   | 2.77   | 2.76   | 2.77   | 2.80   | 2.82   | 2.85   | 2.79   | 2.78   | 2.78   | 2.84   |
| <b>TSP<sup>3</sup></b>  | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 18.0   | 18.0   | 18.0   | 18.0   | 18.0   | 17.9   | 18.0   |
| <b>CO</b>               | 19,837 | 20,022 | 20,502 | 20,378 | 20,563 | 20,217 | 20,287 | 20,390 | 22,290 | 22,963 | 24,691 | 20,738 | 20,533 | 20,374 | 21,247 |

<sup>1</sup> EF(TSP) also applied for PM<sub>10</sub> and PM<sub>2.5</sub> (assumption: > 99% of TSP consists of PM<sub>2.5</sub>)

<sup>2</sup> estimated via a f-BC of 0.48 as provided in the EMEP/EEA Guidebook 2023 <sup>4)</sup>, Chapter: 1.A.3.a, 1.A.5.b Aviation, Annex 3, Table A3.2 and Conclusion.

<sup>3</sup> also including TSP formed from lead: EF(TSP) = 1.6 x EF(Pb) - see road transport



For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Trend discussion for Key Sources



NFR 1.A.3.a i (ii) - International Civil Aviation - Cruise is **not included in the national emission totals** and hence **not included in the key category analysis**.

## Recalculations

As the **percentual shares** of kerosene and aviation gasoline consumed during L/TO as well as the corresponding consumptions during cruise stage remain unrevised, changes in **activity data** occur only as a result of the biennial routine revision of the National Energy Balances for all years as of 2003.

Table 5: Revised fuel consumption data 2003-2023, in terajoules

|                           | 2003    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    |
|---------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>JET KEROSENE</b>       |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b> | 240,882 | 291,217 | 306,393 | 306,085 | 332,321 | 368,575 | 379,883 | 375,395 | 173,974 | 232,895 | 348,273 | 361,863 |

|                            | 2003    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    |
|----------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>previous submission</b> | 240,882 | 291,217 | 306,393 | 306,085 | 332,321 | 368,575 | 379,883 | 375,395 | 173,974 | 232,895 | 348,273 | 362,152 |
| <b>absolute change</b>     | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | -289    |
| <b>relative change</b>     | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.00%   | -0.08%  |
| <b>AVGAS</b>               |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  | 104     | 94.4    | 76.5    | 77.2    | 10.4    | 11.6    | 13.1    | 11.5    | 4.94    | 9.07    | 10.1    | 27.2    |
| <b>previous submission</b> | 104     | 94.5    | 76.5    | 77.3    | 10.4    | 11.7    | 13.1    | 11.5    | 4.94    | 9.07    | 10.1    | 26.6    |
| <b>absolute change</b>     | -0.06   | -0.06   | -0.05   | -0.05   | -0.01   | -0.01   | -0.01   | -0.01   | 0.00    | -0.01   | -0.01   | 0.62    |
| <b>relative change</b>     | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | -0.06%  | 2.34%   |

Furthermore, all country-specific **emission factors** as well as values derived from defaults remain unaltered, too, with the current submission.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Uncertainties



For information on uncertainties, please see the [main chapter](#) on civil aviation.

## Planned improvements



For information on planned improvements, please see [main chapter](#) on civil aviation.

<sup>1), 3)</sup> Allekotte et al. (2025): TREMOD Aviation (TREMOD AV) - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., on behalf of the Umweltbundesamt, Heidelberg & Berlin / Dessau-Roßlau, 2025.

<sup>2)</sup> Knörr, W., Schacht, A., & Gores, S. (2012): Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV): Endbericht. Endbericht zum F+E-Vorhaben 360 16 029, URL: <https://www.umweltbundesamt.de/publikationen/entwicklung-eines-modells-zur-berechnung>; on behalf of the Umweltbundesamt, Heidelberg & Berlin / Dessau-Roßlau, 2012.

<sup>4)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 1.A.3.a, 1.A.5.b Aviation, Annex 3, Table A3.2 and

Conclusion <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023/@download/file>; Copenhagen, 2023)] [(EUROCONTROL2022> Eurocontrol (2022): Advanced emission model (AEM); <https://www.eurocontrol.int/model/advanced-emission-model>; 2022.

## 1.A.3.a ii (ii) - Domestic Civil Aviation: Cruise



NFR-specific inventory  
data

### Short description

| Category Code                                                                             | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.3.a ii (ii)                                                                           | T1, T2, T3                           | NS, M | CS, D, M |
| Method(s) applied                                                                         |                                      |       |          |
| D                                                                                         | Default                              |       |          |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |          |
| T2                                                                                        | Tier 2*                              |       |          |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |          |
| C                                                                                         | CORINAIR                             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| M                                                                                         | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| (source for) Activity Data                                                                |                                      |       |          |
| NS                                                                                        | National Statistics                  |       |          |
| RS                                                                                        | Regional Statistics                  |       |          |
| IS                                                                                        | International Statistics             |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| As                                                                                        | Associations, business organisations |       |          |
| Q                                                                                         | specific Questionnaires (or surveys) |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |
| (source for) Emission Factors                                                             |                                      |       |          |
| D                                                                                         | Default (EMEP Guidebook)             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                    | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |
|-----------------|--------|-----------------|-----------------|-------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|--|
| -/-             | -/-    | -/-             | -/-             | -/-               | -/-                                                                                 | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | NE     | -/-   | -/-   | -/-   | -/-   | -/-    | NA  | NA   |  |
|                 |        |                 |                 | L/-               | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | -/T               | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | L/T               | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | IE                | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | *                 | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 |                   |                                                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |

In NFR category 1.A.3.a ii (ii) - Domestic Civil Aviation: Cruise emissions from domestic flights between German airports during cruise stage (above 3,000 feet of altitude) are reported.

In the following, information on sub-category specific activity data, (implied) emission factors and emission estimates are provided.

Methodology

Actitivity Data

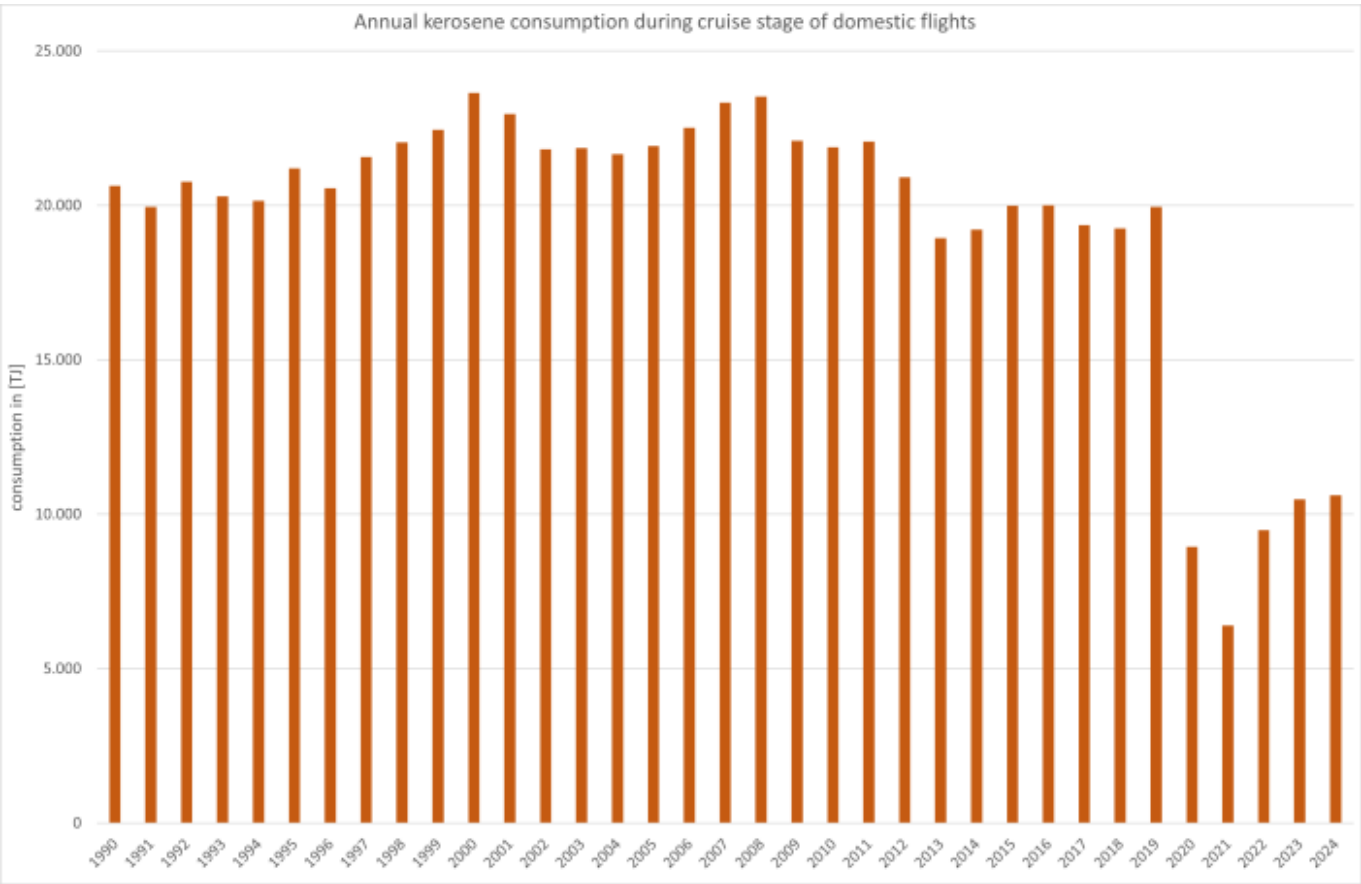
Specific fuel consumption during cruise-stage is calculated within TREMOD AV as described in the [superordinate chapter](#).

Table 1: annual jet kerosene & avgas consumption during cruise-stage, in terajoules

|          | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020  | 2021  | 2022  | 2023   | 2024   |
|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|-------|--------|--------|
| Kerosene | 20,637 | 21,207 | 23,646 | 21,929 | 21,892 | 19,993 | 20,010 | 19,366 | 19,259 | 19,956 | 8,952 | 6,401 | 9,485 | 10,490 | 10,619 |
| Avgas    | 1,833  | 858    | 843    | 523    | 427    | 429    | 356    | 353    | 337    | 275    | 182   | 115   | 127   | 83,3   | 112    |

source: Allekotte et al. (2025) <sup>1)</sup>

Here, with international flights coming close to pre-panemic levels again, fuel consumption of domestic flights shows a rather slow “recovery”, reaching only about 50% of its pre-pandemic level in 2022:



Emission factors

All country specific emission factors used for emission reporting were basically ascertained within UBA project FKZ 360 16 029 <sup>2)</sup> and have since then been compiled, revised and maintained in TREMOD AV (Allekotte et al. (2025)) <sup>3)</sup>.

For more information, please see the [superordinate chapter](#) on civil aviation.

Table 2: Annual country-specific emission factors, in kg/Tj

|                 | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-----------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| JET KEROSENE    |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| NH <sub>3</sub> | 3.98 | 3.95 | 3.95 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 | 3.97 |
| NMVOc           | 16.0 | 17.6 | 18.6 | 20.1 | 21.1 | 23.7 | 19.0 | 19.7 | 20.5 | 23.7 | 36.3 | 35.8 | 28.2 | 21.2 | 23.9 |

|                                     | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|-------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>NO<sub>x</sub></b>               | 330    | 367    | 340    | 334    | 368    | 379    | 391    | 392    | 388    | 390    | 357    | 358    | 375    | 376    | 373    |
| <b>SO<sub>x</sub></b>               | 19.7   | 19.5   | 19.5   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   | 19.6   |
| <b>BC<sup>2</sup></b>               | 1.87   | 2.15   | 2.03   | 2.21   | 2.01   | 2.01   | 1.93   | 1.96   | 2.00   | 1.73   | 1.79   | 1.86   | 1.82   | 2.08   | 2.18   |
| <b>PM<sub>2.5</sub><sup>1</sup></b> |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>PM<sub>10</sub><sup>1</sup></b>  | 3.89   | 4.49   | 4.23   | 4.60   | 4.19   | 4.18   | 4.02   | 4.08   | 4.16   | 3.61   | 3.74   | 3.88   | 3.79   | 4.33   | 4.54   |
| <b>TSP<sup>1</sup></b>              |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>CO</b>                           | 150    | 152    | 194    | 205    | 198    | 217    | 157    | 155    | 158    | 170    | 272    | 310    | 237    | 305    | 364    |
| <b>AVGAS</b>                        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NH<sub>3</sub></b>               | NE     |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NM VOC</b>                       | 594    | 593    | 594    | 593    | 592    | 594    | 592    | 591    | 591    | 589    | 588    | 587    | 582    | 595    | 590    |
| <b>NO<sub>x</sub></b>               | 150    | 149    | 149    | 150    | 149    | 150    | 149    | 149    | 149    | 147    | 147    | 147    | 146    | 150    | 148    |
| <b>SO<sub>x</sub></b>               | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   | 0.46   |
| <b>BC<sup>2</sup></b>               | 0.42   | 0.42   | 0.42   | 0.42   | 0.42   | 0.42   | 0.42   | 0.42   | 0.42   | 0.42   | 0.42   | 0.42   | 0.42   | 0.42   | 0.43   |
| <b>PM<sub>2.5</sub><sup>1</sup></b> | 2.77   | 2.78   | 2.78   | 2.77   | 2.78   | 2.77   | 2.77   | 2.77   | 2.78   | 2.78   | 2.78   | 2.78   | 2.78   | 2.78   | 2.86   |
| <b>PM<sub>10</sub><sup>1</sup></b>  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>TSP<sup>3</sup></b>              | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 17.9   | 18.0   |
| <b>CO</b>                           | 20,142 | 20,216 | 20,229 | 20,160 | 20,305 | 20,208 | 20,265 | 20,286 | 20,319 | 20,478 | 20,495 | 20,526 | 20,701 | 20,217 | 20,433 |

<sup>1</sup> EF(TSP) also applied for PM<sub>10</sub> and PM<sub>2.5</sub> (assumption: > 99% of TSP consists of PM<sub>2.5</sub>)

<sup>2</sup> estimated via a f-BC of 0.48 as provided in the EMEP/EEA Guidebook 2023 <sup>4)</sup>, Chapter: 1.A.3.a, 1.A.5.b Aviation, Annex 3, Table A3.2 and Conclusion.

<sup>3</sup> also including TSP formed from lead: EF(TSP) = 1.6 x EF(Pb) - see road transport



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Trend discussion for Key Sources



NFR 1.A.3.a ii (ii) - Domestic Civil Aviation - Cruise is **not included in the national emission totals** and hence **not included in the key category analysis**.

## Recalculations

As the **percentual shares** of kerosene and aviation gasoline consumed during L/TO as well as the corresponding consumptions during cruise stage remain unrevised, changes in **activity data** occur only as a result of the biennial routine revision of the National Energy Balances for all years as of 2003, and only for aviation gasoline.

Table 5: Revised fuel consumption data 2003-2023, in terajoules

|                            | 2003   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020  | 2021  | 2022  | 2023   |
|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|-------|--------|
| <b>JET KEROSENE</b>        |        |        |        |        |        |        |        |        |       |       |       |        |
| <b>current submission</b>  | 21,857 | 21,929 | 21,892 | 19,993 | 20,010 | 19,366 | 19,259 | 19,956 | 8,952 | 6,401 | 9,485 | 10,490 |
| <b>previous submission</b> | 21,857 | 21,929 | 21,892 | 19,993 | 20,010 | 19,366 | 19,259 | 19,956 | 8,952 | 6,401 | 9,485 | 10,490 |
| <b>absolute change</b>     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00  | 0.00  | 0.00  | 0.00   |
| <b>relative change</b>     | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00% | 0.00% | 0.00% | 0.00%  |
| <b>AVGAS</b>               |        |        |        |        |        |        |        |        |       |       |       |        |
| <b>current submission</b>  | 577    | 523    | 427    | 429    | 356    | 353    | 337    | 275    | 182   | 115   | 127   | 83.3   |
| <b>previous submission</b> | 577    | 523    | 427    | 429    | 356    | 353    | 337    | 275    | 182   | 115   | 127   | 81.4   |
| <b>absolute change</b>     | -0.36  | -0.32  | -0.26  | -0.27  | -0.22  | -0.22  | -0.21  | -0.17  | -0.11 | -0.07 | -0.08 | 1.91   |



|                        | 2003   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023  |
|------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| <b>relative change</b> | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | -0.06% | 2.34% |

Furthermore, all country-specific **emission factors** as well as values derived from defaults remain unaltered, too, with the current submission.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Uncertainties



For information on uncertainties, please see the [main chapter](#) on civil aviation.

## Planned improvements



For information on planned improvements, please see [main chapter](#) on civil aviation.

<sup>1), 3)</sup> Allekotte et al. (2025): TREMOD Aviation (TREMOD AV) - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., on behalf of the Umweltbundesamt, Heidelberg & Berlin / Dessau-Roßlau, 2025.

<sup>2)</sup> Knörr, W., Schacht, A., & Gores, S. (2012): Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV): Endbericht. Endbericht zum F+E-Vorhaben 360 16 029, URL: <https://www.umweltbundesamt.de/publikationen/entwicklung-eines-modells-zur-berechnung>; on behalf of the Umweltbundesamt, Heidelberg & Berlin / Dessau-Roßlau, 2012.

<sup>4)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 1.A.3.a, 1.A.5.b Aviation, <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023/@download/file>; Copenhagen, 2023

## 1.A.3.b - Transport: Road Transport

### Short description

In category *1.A.3.b - Road Transport* emissions from fuel combustion activities as well as abrasive and fugitive emissions are reported within the following categories:

| NFR-Code                                                      | Name of Category                  |
|---------------------------------------------------------------|-----------------------------------|
| <b>Emissions from Fuel Combustion in Road Vehicles</b>        |                                   |
| 1.A.3.b i                                                     | Passenger Cars - PCs              |
| 1.A.3.b ii                                                    | Light Duty Vehicles - LDVs        |
| 1.A.3.b iii                                                   | Heavy Duty Vehicles - HDVs        |
| 1.A.3.b iv                                                    | Mopeds & Motorcycles - MPDs & MCs |
| <b>Fugitive Emissions from Road Vehicles</b>                  |                                   |
| 1.A.3.b v                                                     | Gasoline Evaporation              |
| <b>Emissions from Tyre and Brake Wear &amp; Road Abrasion</b> |                                   |
| 1.A.3.b vi                                                    | Automobile Tyre and Brake Wear    |
| 1.A.3.b vii                                                   | Automobile Road Abrasion          |

Emissions from motorised road traffic in Germany are reported under this category. It includes traffic on public roads within Germany, except for agricultural and forestry transports and military transports. Calculations are made for the vehicle categories of passenger cars, motorcycles, light duty vehicles, heavy duty vehicles and buses. For calculation purposes, the vehicle categories are broken down into so-called vehicle layers with the same emissions behaviour. To this end, vehicle categories are also broken down by type of fuel used, vehicle size (trucks and buses by weight class; automobiles and motorcycles by engine displacement) and pollution control equipment used, as defined by EU directives for emissions control ("EURO norms"), and by regional traffic distribution (outside of cities, in cities and autobahn).

Since 1990, emissions of NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> from road transports have decreased sharply, due to catalytic-converter use and engine improvements resulting from continual tightening of emissions laws, and due to improved fuel quality.

For buses and heavy duty vehicles (over 3.5 t total permissible vehicle weight), maximum permissible levels of hydrocarbon (HC, incl. NMVOC) emissions were lowered especially sharply (-40%) via the introduction of the EURO3 standard in 2000. Since EURO3 vehicles were very quick to reach the market as of 2000, the emission factor for hydrocarbon emissions from diesel fuel - and the relevant emissions themselves - decreased considerably after 2000.

### Methodology

Emissions are calculated with the aid of the TREMOD, the "Transport Emission Estimation Model" maintained by Knörr et al.<sup>1)</sup>

This model adopts a "bottom-up" (tier3) approach whereby mileage of the individual vehicle layers is multiplied by region-specific emission factors. For passenger cars and light duty vehicles, a "cold start surplus" is also added. The total consumption calculated on the basis of fuel type is compared with the consumption according to the Energy Balance. The emissions are then corrected with the aid of factors obtained from this comparison process. For petrol-powered vehicles, the evaporation emissions of VOC are calculated in keeping with the pollution-control technology used. From the emissions and fuel consumption for the various vehicle layers, aggregated, fuelbased emission factors (kg of emissions per TJ of fuel consumption) are derived, and then the emission factors are forwarded to the CSE via a relevant interface. In keeping with the CORINAIR report structure, these factors are differentiated only by type of fuel, type of road (autobahn, rural road, city road) and, within the vehicle categories, by "without/with emissions-control equipment". The following emissions-control categories are differentiated:

For calculation with TREMOD, extensive basic data from generally accessible statistics and special surveys were used, co-ordinated, and supplemented. An overview of the principal sources and key assumptions is given below. Detailed descriptions of the databases, including information on the sources used, and the calculation methods used in TREMOD, are provided in the aforementioned IFEU report.

## Activity Data

The basis for CSE data collection for the road-transport sector consists of fuel consumption data provided by the Working Group on Energy Balances (AGEB) <sup>2)</sup>. For each year, the sum of the activity rates for the various individual structural elements must correspond to the Energy Balance data, in terajoule. The relevant basic Energy Balance data is shown in the table below.

Table 1: Energy input in German road transport, in terajoules

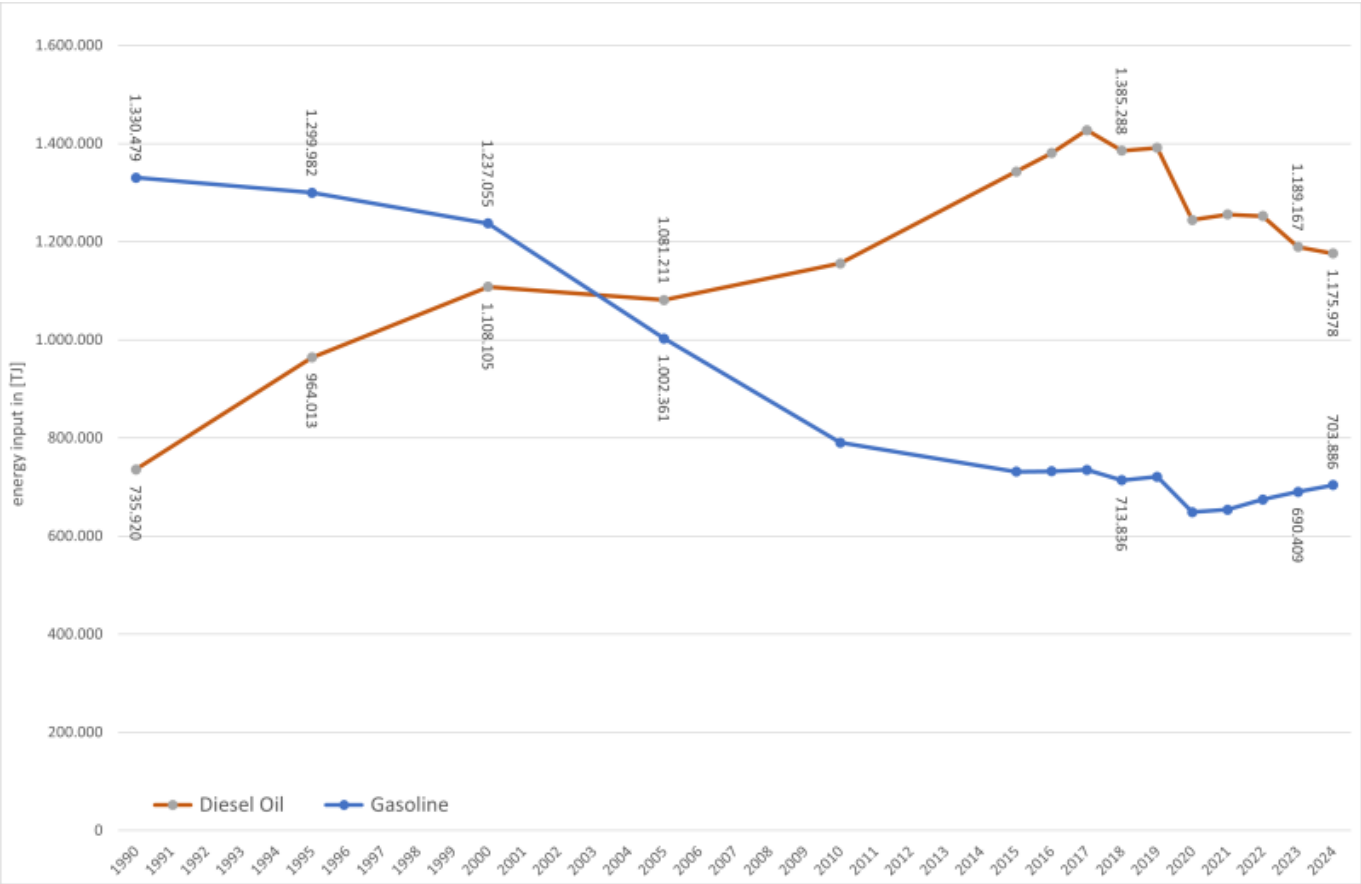
|      | Diesel oil | Gasoline  | LPG    | Natural Gas <sup>1</sup> | Petroleum <sup>2</sup> | Biodiesel | Biogasoline | Biomethane | Lubricants <sup>3</sup> | TOTAL     |
|------|------------|-----------|--------|--------------------------|------------------------|-----------|-------------|------------|-------------------------|-----------|
| 1990 | 735,920    | 1,330,479 | 138    |                          |                        |           |             |            | 2,543                   | 2,069,080 |
| 1991 | 785,174    | 1,332,285 | 137    |                          |                        |           |             |            | 1,702                   | 2,119,298 |
| 1992 | 853,502    | 1,344,129 | 229    |                          |                        |           |             |            | 1,299                   | 2,199,159 |
| 1993 | 907,787    | 1,350,617 | 184    |                          | 473                    |           |             |            | 872                     | 2,259,933 |
| 1994 | 932,060    | 1,276,637 | 184    |                          | 559                    |           |             |            | 596                     | 2,210,036 |
| 1995 | 964,013    | 1,299,982 | 138    |                          | 610                    | 1,504     |             |            | 455                     | 2,266,702 |
| 1996 | 964,580    | 1,299,879 | 115    |                          | 638                    | 2,046     |             |            | 372                     | 2,267,630 |
| 1997 | 979,586    | 1,297,487 | 106    |                          | 357                    | 3,652     |             |            | 266                     | 2,281,454 |
| 1998 | 1,022,794  | 1,300,463 | 106    |                          | 637                    | 4,081     |             |            | 206                     | 2,328,287 |
| 1999 | 1,097,036  | 1,300,602 | 100    |                          | 637                    | 5,370     |             |            | 116                     | 2,403,861 |
| 2000 | 1,108,105  | 1,237,055 | 94,0   |                          | 414                    | 12,276    |             |            | 82,7                    | 2,358,027 |
| 2001 | 1,097,416  | 1,199,318 | 98,0   |                          | 471                    | 16,740    |             |            | 74,5                    | 2,314,117 |
| 2002 | 1,105,842  | 1,166,381 | 607    |                          | 472                    | 20,460    |             |            | 77,3                    | 2,293,839 |
| 2003 | 1,069,729  | 1,107,428 | 697    | 2,488                    |                        | 29,948    |             |            | 72,8                    | 2,210,363 |
| 2004 | 1,102,318  | 1,073,174 | 1,892  | 2,774                    |                        | 38,886    | 1,143       |            | 72,4                    | 2,220,259 |
| 2005 | 1,081,211  | 1,002,361 | 2,369  | 3,127                    |                        | 72,055    | 6,809       |            | 79,3                    | 2,168,012 |
| 2006 | 1,125,137  | 967,016   | 6,399  | 4,446                    |                        | 130,539   | 13,405      |            | 79,6                    | 2,247,022 |
| 2007 | 1,065,886  | 891,408   | 10,519 | 4,089                    |                        | 143,658   | 12,041      |            | 79,7                    | 2,127,680 |
| 2008 | 1,090,704  | 852,680   | 17,732 | 4,884                    |                        | 109,785   | 16,301      | 14,0       | 83,6                    | 2,092,184 |
| 2009 | 1,113,086  | 827,600   | 23,777 | 5,302                    |                        | 90,015    | 23,689      | 47,0       | 88,7                    | 2,083,604 |
| 2010 | 1,155,828  | 790,544   | 22,987 | 5,491                    |                        | 89,471    | 30,548      | 270        | 82,5                    | 2,095,222 |
| 2011 | 1,182,061  | 787,483   | 23,337 | 5,579                    |                        | 83,302    | 32,268      | 333        | 80,1                    | 2,114,443 |
| 2012 | 1,211,695  | 739,581   | 20,860 | 5,784                    |                        | 86,067    | 32,746      | 1,200      | 75,4                    | 2,098,008 |
| 2013 | 1,267,041  | 738,174   | 22,682 | 5,874                    |                        | 75,817    | 31,613      | 1,737      | 77,7                    | 2,143,016 |
| 2014 | 1,287,335  | 741,983   | 20,247 | 5,673                    |                        | 79,339    | 32,235      | 1,617      | 74,2                    | 2,168,503 |
| 2015 | 1,342,885  | 731,258   | 18,709 | 5,837                    |                        | 73,652    | 30,770      | 1,242      | 80,4                    | 2,204,434 |
| 2016 | 1,380,618  | 732,014   | 17,767 | 5,369                    |                        | 73,826    | 30,834      | 1,363      | 82,6                    | 2,241,872 |
| 2017 | 1,427,136  | 735,005   | 15,775 | 5,161                    |                        | 76,193    | 30,344      | 1,603      | 79,5                    | 2,291,297 |
| 2018 | 1,385,288  | 713,836   | 16,966 | 5,068                    |                        | 79,978    | 31,134      | 1,399      | 78,5                    | 2,233,748 |
| 2019 | 1,391,411  | 720,708   | 14,747 | 4,840                    |                        | 79,049    | 30,156      | 2,378      | 79,6                    | 2,243,369 |
| 2020 | 1,244,496  | 649,012   | 10,205 | 4,727                    |                        | 103,010   | 28,734      | 3,181      | 82,6                    | 2,043,447 |
| 2021 | 1,255,404  | 653,665   | 9,520  | 8,047                    |                        | 87,149    | 30,160      | 3,474      | 73,0                    | 2,047,493 |
| 2022 | 1,252,038  | 674,363   | 9,054  | 7,858                    |                        | 86,632    | 31,169      | 4,796      | 78,1                    | 2,065,989 |
| 2023 | 1,189,167  | 690,409   | 7,921  | 6,943                    |                        | 88,469    | 32,793      | 7,035      | 68,9                    | 2,022,807 |
| 2024 | 1,175,978  | 703,886   | 7,661  | 2,429                    |                        | 71,995    | 32,931      | 12,775     | 68,8                    | 2,007,725 |

<sup>1)</sup> including both CNG (Compressed Natural Gas) and LNG (Liquefied Natural Gas)

<sup>2)</sup> applied only from 1993 to 2002 in a small number of buses (see chapter on NFR 1.A.3.b iii)

<sup>3)</sup> amounts of lubricants unintentionally co-incinerated in road vehicles (lubricants intentionally co-incinerated in 2-stroke road vehicles are taken into account in NFR 2.D.3.i Mobile Use of Lubricants)

The following chart illustrates the trend to diesel vehicles operated in Germany, the so-called “Dieselization” with the amounts of fossil diesel oil exceeding those of fossil gasoline fuels from 2004 onwards.



For more information on the derivation of activity data and the emission factors applied, please refer to the sub-ordinate chapters as well as Appendix 2.2.

Chart 2 illustrates the increase in annual mileage of electric road vehicles in 10<sup>6</sup> kilometers. Despite the exponential growth, only about 1.8 per cent of annual mileage was “electric” in 2022 (13 Mio km of 682 Mio km).

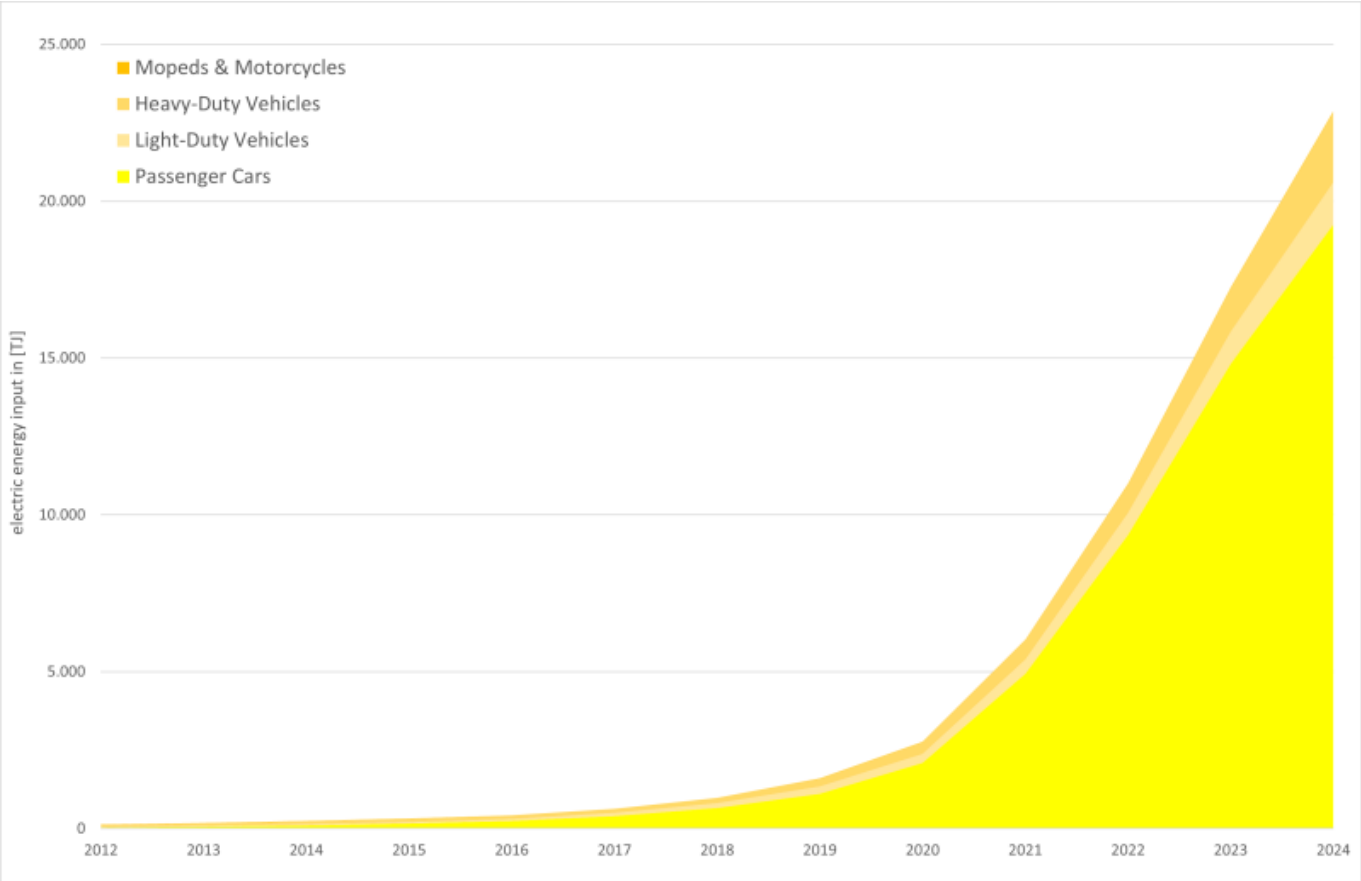


Table 2: Electric energy input as of 2012, in terajoules

|                                 | 2012       | 2013       | 2014       | 2015       | 2016       | 2017       | 2018       | 2019         | 2020         | 2021         | 2022          | 2023          | 2024          |
|---------------------------------|------------|------------|------------|------------|------------|------------|------------|--------------|--------------|--------------|---------------|---------------|---------------|
| <b>Passenger Cars</b>           | 36.0       | 60.7       | 103        | 164        | 244        | 399        | 650        | 1,109        | 2,097        | 4,943        | 9,369         | 14,806        | 19,250        |
| <b>Light-Duty Vehicles</b>      | 17.3       | 25.1       | 34.1       | 44.4       | 61.2       | 101        | 163        | 235          | 285          | 450          | 692           | 1,023         | 1,351         |
| <b>Heavy-Duty Vehicles</b>      | 83.5       | 81.7       | 93.3       | 103        | 113        | 128        | 160        | 243          | 367          | 621          | 914           | 1,389         | 2,230         |
| <b>Mopeds &amp; Motorcycles</b> | 2.84       | 3.98       | 4.80       | 5.55       | 6.35       | 7.16       | 7.86       | 8.80         | 10.0         | 10.5         | 20.5          | 27.9          | 30.7          |
|                                 | <b>140</b> | <b>171</b> | <b>236</b> | <b>316</b> | <b>425</b> | <b>635</b> | <b>981</b> | <b>1,596</b> | <b>2,759</b> | <b>6,024</b> | <b>10,995</b> | <b>17,246</b> | <b>22,862</b> |

## Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: "Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland" by (Knörr et al. (2009)) <sup>3)</sup>.

Uncertainty estimates for **emission factors** for all 1.A.3.b sub-categories were compiled during the PAREST research project. Here, the final report has not yet been published.

## Recalculations



Basically, recalculations result from a) the revision of the National Energy Balance (for most recent years) and b) routine revisions of the underlying TREMOD model (recent years or entire time series, depending on outline of revision).

For more details please refer to the related sub-chapters as linked above.

## Planned improvements

Besides the routine revision of the TREMOD model, no specific improvements are planned.

<sup>2)</sup> AGEB (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>3)</sup> Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; <https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf>, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

# 1.A.3.b i-iv - Emissions from fuel combustion in Road Vehicles (OVERVIEW)

## Short description

This overview chapter provides information on the emissions from fuel combustion activities in road transport sub-categories 1.A.3.b i, ii, iii, and iv.

| NFR-Code    | Name of Category                         |
|-------------|------------------------------------------|
| 1.A.3.b i   | <a href="#">Passenger Cars</a>           |
| 1.A.3.b ii  | <a href="#">Light Duty Vehicles</a>      |
| 1.A.3.b iii | <a href="#">Heavy Duty Vehicles</a>      |
| 1.A.3.b iv  | <a href="#">Mopeds &amp; Motorcycles</a> |

## Methodology

### Activity data

Basically, total inland fuel deliveries are available from the National Energy Balances (NEBs) (AGEB, 2025) <sup>1)</sup>, line 62: Straßenverkehr (Road Transport).

Based upon these primary activity data, specific consumption data for the different types of road vehicles are generated within TREMOD <sup>2)</sup>.



For further details see main chapter [1.A.3.b - Road Transport](#) as well as the sub-category chapters linked above.

### Emission factors

The majority of emissions factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, version 4.2) <sup>3)</sup> where they are provided on a tier3 level mostly and processed within the TREMOD software used by the party <sup>4)</sup>.



With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>2)</sup>

As it is not possible to present these tier3 values in a comprehensible way, the NFR sub-chapters linked above provide sets of fuel-specific implied emission factors instead.

For heavy-metal (other than lead from leaded gasoline) and PAH exhaust-emissions, default emission factors from (EMEP/EEA, 2023) <sup>5)</sup> have been applied. Regarding PCDD/F, tier1 EF from (Rentz et al., 2008) <sup>6)</sup> are used instead.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Trends of exhaust emissions from road transport vehicles

For **ammonia emissions**, the increasing use of catalytic converters in gasoline driven cars in the 1990s lead to a steep increase whereas both the technical development of the converters and the ongoing shift from gasoline to diesel cars resulted in decreasing emissions in the following years.

The observed trends for **NO<sub>x</sub>**, **NM VOC** and **CO emissions** represent the changes in legislative emission limits and the regarding implementation of mitigation technologies. The following table provides an overview of the implementation of Euro norms in Germany.

Table 1: Overview of Euro norms and their implementation in Germany

|                                                              | Type Approval for new vehicle types            | Type Approval for new vehicles              | Testing Cycle |
|--------------------------------------------------------------|------------------------------------------------|---------------------------------------------|---------------|
| <b>PASSENGER CARS &amp; LIGHT-DUTY VEHICLES<sup>7)</sup></b> |                                                |                                             |               |
| <b>Euro Norm 1</b>                                           | since 01. Juli 1992                            | since 01. Januar 1993                       | NEFZ          |
| <b>Euro 2</b>                                                | since 01. Januar 1996                          | since 01. Januar 1997                       | NEFZ          |
| <b>Euro 3</b>                                                | since 01. Januar 2000                          | since 01. Januar 2001                       | NEFZ          |
| <b>Euro 4</b>                                                | since 01. Januar 2005                          | since 01. Januar 2006                       | NEFZ          |
| <b>Euro 5a<sup>8)</sup></b>                                  | since 01. September 2009                       | since 01. Januar 2011                       | NEFZ          |
| <b>Euro 5b*</b>                                              | since 01. September 2011                       | since 01. Januar 2013                       | NEFZ          |
| <b>Euro 6b<sup>9)</sup></b>                                  | since 01. September 2014                       | since 01. September 2015                    | NEFZ          |
| <b>Euro 6c</b>                                               | since 01. September 2017                       | since 01. September 2018                    | WLTC          |
| <b>Euro 6d-Temp</b>                                          | since 01. September 2017                       | since 01. September 2019                    | WLTC          |
| <b>Euro 6d</b>                                               | Freiwillige Einstufung                         | Freiwillige Einstufung                      | WLTC          |
| <b>Euro 6d-ISC-FCM</b>                                       | since 01.01.2020 (36AP) / 10.01.2021 (36AQ-AR) | Ab 01.01.2021 (36AP) / 01.01.2022 (36AQ-AR) | WLTC          |
| <b>Euro 7<sup>10)</sup></b>                                  | as of 29.11.2026                               | as of 29.11.2027                            | WLTC          |
| * only for gasoline                                          |                                                |                                             |               |
| <b>BUSES &amp; TRUCKS<sup>11)</sup></b>                      |                                                |                                             |               |
| <b>Euro I</b>                                                | 01. Jan 92                                     |                                             | ESC R-49      |
| <b>Euro II</b>                                               | 01. Okt 96                                     |                                             | ESC R-49      |
| <b>Euro III</b>                                              | 01. Okt 00                                     |                                             | ESC&ELR, ETC  |
| <b>Euro IV</b>                                               | 01. Okt 05                                     |                                             | ESC&ELR, ETC  |
| <b>Euro V</b>                                                | 01. Okt 08                                     |                                             | ESC&ELR, ETC  |
| <b>Euro VI<sup>12)</sup></b>                                 | 01. Okt 13                                     |                                             | WHTC, WHSC    |
| <b>Euro VII<sup>13)</sup></b>                                | as of 29.05.2028                               | as of 29.05.2029                            |               |
| <b>MOTORCYCLES<sup>14)</sup></b>                             |                                                |                                             |               |
| <b>Euro 1</b>                                                | since 17. Juni 1999                            |                                             | ECE R47       |
| <b>Euro 2</b>                                                | since 17. Juni 2002                            |                                             | ECE R47       |
| <b>Euro 4<sup>15)</sup></b>                                  | since 01. Januar 2017                          | since 01. Januar 2018                       | ECE R47       |
| <b>Euro 5<sup>16)</sup></b>                                  | since 01. Januar 2020                          | since 01. Januar 2021                       | WMTC          |
| <b>MOPEDS</b>                                                |                                                |                                             |               |
| <b>Euro 1</b>                                                | since 17. Juni 1999                            |                                             | ECE R47       |
| <b>Euro 2</b>                                                | since 17. Juni 2002                            |                                             | ECE R47       |
| <b>Euro 4<sup>17)</sup></b>                                  | 2016                                           | 2017                                        |               |

Trends for **sulphur dioxide** show characteristics very different from those shown above. Here, the strong dependence on increasing fuel qualities leads to an cascaded downward trend of **SO<sub>2</sub> emissions**, influenced only slightly by increases in fuel consumption and mileage.

The following table provides the development of sulphur contents over the years for Old (OGL) and New German Länder (NGL) and Germany (GER).

Table 2: Development of fuel sulphur contents in Germany



| Area covered       | Year(s) covered | Gasoline | Diesel oil |
|--------------------|-----------------|----------|------------|
| EAST GERMANY (DDR) | until 1988      | 500 ppm  | 6,000 ppm  |
|                    | 1989-1990       | 500 ppm  | 6,000 ppm  |
| WEST GERMANY (BRD) | until 1984      | 250 ppm  | 2,700 ppm  |
|                    | 1985            |          | 2,500 ppm  |
|                    | 1986            |          | 2,100 ppm  |
|                    | 1987            |          |            |
|                    | 1988            |          | 1,700 ppm  |
|                    | 1989            |          |            |
|                    | 1990            | 220 ppm  |            |
| GERMANY            | 1991            | 220 ppm  | 1,300 ppm  |
|                    | 1992            |          |            |
|                    | 1993            |          |            |
|                    | 1994            |          |            |
|                    | 1995            | 180 ppm  | 600 ppm    |
|                    | 1996            |          |            |
|                    | 1997            |          |            |
|                    | 1998-2000       | 70 ppm   | 300 ppm    |
|                    | 2001            | 55 ppm   | 250 ppm    |
|                    | 2002            | 25 ppm   | 40 ppm     |
|                    | since 2003      | 8 ppm    | 8 ppm      |

For **exhaust particulate matter emissions** from diesel road vehicles, the party assumes that nearly all particles emitted are within the PM<sub>2.5</sub> range, resulting in similar emission values for PM<sub>2.5</sub>, PM<sub>10</sub>, and TSP. Excumptions can be observed for gasoline road vehicles for the years until 1997 when **additional TSP emissions** resulted **from the use of leaded gasoline** that was banned in 1997.

Furthermore, **black carbon** emissions are estimated via implied emission factors derived from fractions of PM as provided in <sup>18)</sup>.

For **Heavy Metals** tier1 default EF from the EMEP/EEA Guidebook 2023 <sup>19)</sup> are applied resulting in trends that simply reflect the annual fuel consumption. Here, the only excumption are **lead emissions from leaded gasoline** that was in use until 1996 with lead contents provided in the table below:

Table 3: Development of gasoline's lead content in Germany

| Area covered       | Year(s) covered | Lead content    | EF applied |
|--------------------|-----------------|-----------------|------------|
| EAST GERMANY (GDR) | 1989-1990       | 126 mg/l        | in [g/TJ]  |
| WEST GERMANY (BRD) | 1990            | 42 mg/l         | 1,203      |
| GERMANY            | 1991            | 29 mg/l         | 976        |
|                    | 1992            | 20 mg/l         | 778        |
|                    | 1993            | 16 mg/l         | 691        |
|                    | 1994            | 11 mg/l         | 521        |
|                    | 1995            | 8 mg/l          | 440        |
|                    | 1996            | 4 mg/l          | 278        |
|                    | since 1997      | 0 mg/l (banned) | 4.00       |
|                    | as of 1998      |                 | 0.0367*    |

\* "natural" lead content (+ engine wear); no additives

Here, for the years as of 1998, the tier1 default EFs for exhaust lead emissions from gasoline as provided in the EMEP/EEA Guidebook 2023 <sup>20)</sup> are used.

For **exhaust emissions of Benzo[a]Pyrene, Benzo[b]Fluoranthene, Benzo[k]Fluoranthene, and Indeno[1,2,3-c,d]Pyrene** the tier2 emission factors as provided in the 2023 EMEP/EEA Guidebook, Chapter 1.A.3.b i-iv(Update 2025), Tables 3-18 to 3-26 have been implemented with the current submission, upgrading the estimation to a tier2 approach.

Table 4: tier2 emission factors for exhaust PAH emissions from road vehicles, in [g/km]

| NFR                                                           | VEHICLE TYPE | FUEL                    | EURO standard  | B[a]P       | B[b]F       | B[k]F       | I[123cd]P   | PAH 1-4     |
|---------------------------------------------------------------|--------------|-------------------------|----------------|-------------|-------------|-------------|-------------|-------------|
| 1.A.3.b<br>i                                                  | PCs          | diesel fuels            | as of pre-EURO | 0.000001740 | 0.000001950 | 0.000001530 | 0.000001620 | 0.000006840 |
|                                                               |              | gasoline fuels          | pre-EURO       | 0.000000480 | 0.000000880 | 0.000000300 | 0.000001030 | 0.000002690 |
|                                                               |              |                         | as of EURO1    | 0.000000320 | 0.000000360 | 0.000000260 | 0.000000390 | 0.000001330 |
|                                                               |              | LPG                     | as of pre-EURO | 0.000000010 | 0.000000000 | 0.000000010 | 0.000000010 | 0.000000030 |
| 1.A.3.b<br>ii                                                 | LDVs         | diesel fuels            | pre-EURO       | 0.000002850 | 0.000003300 | 0.000002870 | 0.000002540 | 0.000011560 |
|                                                               |              |                         | as of EURO1    | 0.000000630 | 0.000000600 | 0.000000190 | 0.000000700 | 0.000002120 |
|                                                               |              | gasoline fuels          | pre-EURO       | 0.000000480 | 0.000000880 | 0.000000300 | 0.000001030 | 0.000002690 |
|                                                               |              |                         | as of EURO1    | 0.000000320 | 0.000000360 | 0.000000260 | 0.000000390 | 0.000001330 |
|                                                               |              | natural gas, biomethane | as of EURO4    | 0.000000320 | 0.000000360 | 0.000000260 | 0.000000390 | 0.000001330 |
| 1.A.3.b<br>iii                                                | HDVs & buses | diesel fuels            | as of pre-EURO | 0.000000900 | 0.000005450 | 0.000006090 | 0.000001400 | 0.000013840 |
|                                                               |              | natural gas, biomethane | as of EUROV    | 0.000000050 | 0.000000080 | 0.000000040 | 0.000000030 | 0.000000200 |
| 1.A.3.b<br>iv                                                 | Mopeds       | gasoline fuels          | pre-EURO       | 0.000000096 | 0.000000176 | 0.000000060 | 0.000000206 | 0.000000538 |
|                                                               |              |                         | as of EURO1    | 0.000000064 | 0.000000072 | 0.000000052 | 0.000000078 | 0.000000266 |
|                                                               | Motorcycles  |                         | as of pre-EURO | 0.000000320 | 0.000000360 | 0.000000260 | 0.000000390 | 0.000001330 |
| additional info:<br>derivation of tier2 EF<br>(MS Excel file) |              |                         |                |             |             |             |             |             |

Due to this improvement, the reported emissions especially for B[a]P and, hence, the sum for PAH 1-4 increased rather strongly, by about %and % respectively, whereas the amounts of B[b]F, B[k]F, and I[x]P increased only slightly.

Regarding PCDD/F, a tier1 EF from (Rentz et al., 2008) <sup>21)</sup> is used instead.



For more details on the default EF from the EMEP/EEA Guidebook please refer to the appendices 2.3 and 2.4 to this report.

## Recalculations



Recalculations of exhaust-emissions are mainly based on (i) the **finalisation of the most recent National Energy Balance** as well as (ii) the **routine revision the underlying TREMOD model**.

However, for the current submission, **recalculations** have been carried out also due to the biennial in-depth review of the National Energy Balances for all years as of 2023, resulting in revised activity data for the last 21 years of the time series and **affecting all fuel-combustion related emission estimates as reported as of 2003**.

For more information, please see the specific chapters linked above.

Table 5: Revised domestic fossil fuel deliveries as provided in line 62 (road transportation) of the National Energy Balances 2003-2023, in terajoules [TJ]

|                            | 1990    | 1995    | 2000      | 2005      | 2010      | 2015      | 2016      | 2017      | 2018      | 2019      | 2020      | 2021      | 2022      | 2023      |
|----------------------------|---------|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| <b>Diesel oil</b>          |         |         |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current submission</b>  | 735,920 | 964,013 | 1,108,105 | 1,081,211 | 1,155,828 | 1,342,885 | 1,380,618 | 1,427,136 | 1,385,288 | 1,391,411 | 1,244,496 | 1,255,404 | 1,252,038 | 1,189,167 |
| <b>previous submission</b> | 735,920 | 964,013 | 1,108,105 | 1,032,053 | 1,142,946 | 1,324,400 | 1,360,456 | 1,395,407 | 1,420,095 | 1,393,821 | 1,261,942 | 1,241,273 | 1,248,164 | 1,195,950 |
| <b>absolute change</b>     | 0.00    | 0.00    | 0.00      | 49,157    | 12,883    | 18,485    | 20,162    | 31,729    | -34,808   | -2,409    | -17,446   | 14,131    | 3,874     | -6,783    |

|                                    | 1990      | 1995      | 2000      | 2005      | 2010      | 2015      | 2016      | 2017      | 2018      | 2019      | 2020      | 2021      | 2022      | 2023      |
|------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| <b>relative change</b>             | 0.00%     | 0.00%     | 0.00%     | 4.76%     | 1.13%     | 1.40%     | 1.48%     | 2.27%     | -2.45%    | -0.17%    | -1.38%    | 1.14%     | 0.31%     | -0.57%    |
| <b>Biodiesel</b>                   |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current submission</b>          |           | 1,504     | 12,276    | 72,055    | 89,471    | 73,652    | 73,826    | 76,193    | 79,978    | 79,049    | 103,010   | 87,149    | 86,632    | 88,469    |
| <b>previous submission</b>         |           | 1,504     | 12,276    | 71,956    | 89,399    | 73,570    | 73,739    | 76,061    | 80,127    | 79,063    | 103,219   | 87,043    | 86,588    | 88,638    |
| <b>absolute change</b>             |           | 0.00      | 0.00      | 99.9      | 71.5      | 82.4      | 87.2      | 133       | -149      | -13.29    | -209      | 106       | 44.3      | -169      |
| <b>relative change</b>             |           | 0.00%     | 0.00%     | 0.14%     | 0.08%     | 0.11%     | 0.12%     | 0.17%     | -0.19%    | -0.02%    | -0.20%    | 0.12%     | 0.05%     | -0.19%    |
| <b>Gasoline</b>                    |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current submission</b>          | 1,330,479 | 1,299,982 | 1,237,055 | 1,002,361 | 790,544   | 731,258   | 732,014   | 735,005   | 713,836   | 720,708   | 649,012   | 653,665   | 674,363   | 690,409   |
| <b>previous submission</b>         | 1,330,479 | 1,299,982 | 1,237,055 | 982,008   | 781,262   | 759,221   | 752,476   | 740,633   | 716,959   | 729,626   | 638,820   | 637,768   | 670,246   | 691,899   |
| <b>absolute change</b>             | 0.00      | 0.00      | 0.00      | 20,353    | 9,282     | -27,963   | -20,462   | -5,628    | -3,123    | -8,918    | 10,192    | 15,897    | 4,117     | -1,490    |
| <b>relative change</b>             | 0.00%     | 0.00%     | 0.00%     | 2.07%     | 1.19%     | -3.68%    | -2.72%    | -0.76%    | -0.44%    | -1.22%    | 1.60%     | 2.49%     | 0.61%     | -0.22%    |
| <b>Biogasoline</b>                 |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current submission</b>          |           |           |           | 6,809     | 30,548    | 30,770    | 30,834    | 30,344    | 31,134    | 30,156    | 28,734    | 30,160    | 31,169    | 32,793    |
| <b>previous submission</b>         |           |           |           | 6,807     | 30,350    | 30,646    | 30,717    | 30,240    | 31,029    | 30,063    | 28,640    | 30,050    | 31,064    | 32,683    |
| <b>absolute change</b>             |           |           |           | 2.47      | 199       | 124       | 116       | 104       | 105       | 92.5      | 93.6      | 110       | 106       | 110       |
| <b>relative change</b>             |           |           |           | 0.04%     | 0.66%     | 0.40%     | 0.38%     | 0.34%     | 0.34%     | 0.31%     | 0.33%     | 0.37%     | 0.34%     | 0.34%     |
| <b>LPG</b>                         |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current submission</b>          | 138       | 138       | 94,0      | 2,369     | 22,987    | 18,709    | 17,767    | 15,775    | 16,966    | 14,747    | 10,205    | 9,520     | 9,054     | 7,921     |
| <b>previous submission</b>         | 138       | 138       | 94,0      | 2,369     | 22,982    | 18,709    | 17,767    | 15,775    | 16,922    | 14,692    | 10,213    | 10,138    | 11,761    | 7,927     |
| <b>absolute change</b>             | 0.00      | 0.00      | 0.00      | 0.00      | 4.51      | 0.00      | 0.00      | 0.00      | 43.4      | 55.1      | -7.53     | -618      | -2,706    | -5.86     |
| <b>relative change</b>             | 0.00%     | 0.00%     | 0.00%     | 0.00%     | 0.02%     | 0.00%     | 0.00%     | 0.00%     | 0.26%     | 0.37%     | -0.07%    | -6.10%    | -23.0%    | -0.07%    |
| <b>NATURAL GAS (CNG &amp; LNG)</b> |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current submission</b>          |           |           |           | 3,127     | 5,491     | 5,837     | 5,369     | 5,161     | 5,068     | 4,840     | 4,727     | 8,047     | 7,858     | 6,943     |
| <b>previous submission</b>         |           |           |           | 3,127     | 8,498     | 4,595     | 4,006     | 2,632     | 3,163     | 2,377     | 2,881     | 7,144     | 7,749     | 6,886     |
| <b>absolute change</b>             |           |           |           | 0.00      | -3,007    | 1,242     | 1,363     | 2,529     | 1,905     | 2,463     | 1,846     | 903       | 108       | 57.4      |
| <b>relative change</b>             |           |           |           | 0.00%     | -35.4%    | 27.0%     | 34.0%     | 96.1%     | 60.2%     | 104%      | 64.1%     | 12.6%     | 1.40%     | 0.83%     |
| <b>Biomethane</b>                  |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current submission</b>          |           |           |           |           | 270       | 1,242     | 1,363     | 1,603     | 1,399     | 2,378     | 3,181     | 3,474     | 4,796     | 7,035     |
| <b>previous submission</b>         |           |           |           |           | 270       | 1,242     | 1,363     | 1,603     | 1,399     | 2,378     | 3,181     | 3,474     | 3,821     | 5,218     |
| <b>absolute change</b>             |           |           |           |           | 0.00      | 0.00      | 0.00      | 0.00      | 0.00      | 0.00      | 0.00      | 0.00      | 975       | 1,817     |
| <b>relative change</b>             |           |           |           |           | 0.00%     | 0.00%     | 0.00%     | 0.00%     | 0.00%     | 0.00%     | 0.00%     | 0.00%     | 25.5%     | 34.8%     |
| <b>TOTAL 1.A.3.b i-iv</b>          |           |           |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current submission</b>          | 2,069,080 | 2,266,702 | 2,358,027 | 2,168,012 | 2,095,222 | 2,204,750 | 2,242,297 | 2,291,932 | 2,234,730 | 2,244,965 | 2,046,207 | 2,053,521 | 2,076,990 | 2,040,059 |
| <b>previous submission</b>         | 2,069,080 | 2,266,702 | 2,358,027 | 2,098,398 | 2,075,788 | 2,212,776 | 2,241,025 | 2,263,061 | 2,270,751 | 2,253,689 | 2,051,750 | 2,022,985 | 2,070,471 | 2,046,386 |
| <b>absolute change</b>             | 0,00      | 0,00      | 0,00      | 69,614    | 19,434    | -8,026    | 1,272     | 28,871    | -36,022   | -8,724    | -5,543    | 30,536    | 6,519     | -6,326    |
| <b>relative change</b>             | 0.00%     | 0.00%     | 0.00%     | 3.32%     | 0.94%     | -0.36%    | 0.06%     | 1.28%     | -1.59%    | -0.39%    | -0.27%    | 1.51%     | 0.31%     | -0.31%    |

Furthermore, affecting the entire time series as of 1990, the **default emission factors applied for exhaust heavy metal and POP emissions have been checked and updated to the most recent information available from the EMEP/EEA Guidebook 2003:**

- **Regarding exhaust heavy metals** (taking into account the heavy metal contents of the fuel used as well as engine wear), ....
- **Regarding PAHs**, tier2 emission factors from chapter 1.A.3.b (Update 2024), tables 3-18 to 3-26 of the 2023 EMEP/EEA Guidebook have been implemented with the current submission, upgrading the estimation from a tier1- to a tier2-approach. Due to this improvement, the reported emissions especially for Benzo[a]Pyrene and, hence, the sum for PAH 1-4 increased rather strongly, by about %and % respectively, whereas the amounts of B[b]F, B[k]F, and

[123cd]P increased only slightly. (for details see pollutant-specific recalculation tables provided in chapter 10.1 of this report).

<sup>1)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2), 4)</sup> Knörr et al. (2025a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, on behalf of the Umweltbundesamt, Heidelberg & Berlin / Dessau-Roßlau, 2025.

<sup>3)</sup> Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: [https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0\\_HBEFA42\\_Update\\_Documentation.pdf](https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf) - Dokumentation, Bern, 2022.

<sup>5), 18), 19), 20)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2019; <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023>; Copenhagen, 2023.

<sup>6), 21)</sup> Rentz et al. (2008): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, January 2008 - URL: <http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer>

<sup>7)</sup> UBA (2016): Themen > Verkehr > Emissionsstandards > Pkw und leichte Nutzfahrzeuge: [https://www.umweltbundesamt.de/sites/default/files/medien/376/bilder/dateien/tabelle\\_grenzwerte\\_fuer\\_schadstoffemissionen\\_von\\_pkw.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/376/bilder/dateien/tabelle_grenzwerte_fuer_schadstoffemissionen_von_pkw.pdf); Umweltbundesamt, Dessau-Roßlau, 2016

<sup>8), 9)</sup> EU (2007): REGULATION (EC) No 715/2007 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information - <https://data.europa.eu/eli/reg/2007/715/oj>

<sup>10), 13)</sup> EU (2024): Regulation (EU) 2024/1257 of the European Parliament and of the Council of 24 April 2024 on type-approval of motor vehicles and engines and of systems, components and separate technical units intended for such vehicles, with respect to their emissions and battery durability (Euro 7), amending Regulation (EU) 2018/858 of the European Parliament and of the Council and repealing Regulations (EC) No 715/2007 and (EC) No 595/2009 of the European Parliament and of the Council, Commission Regulation (EU) No 582/2011, Commission Regulation (EU) 2017/1151, Commission Regulation (EU) 2017/2400 and Commission Implementing Regulation (EU) 2022/1362; <http://data.europa.eu/eli/reg/2024/1257/oj>

<sup>11)</sup> UBA (2024): Themen > Verkehr > Emissionsstandards > Schwere Nutzfahrzeuge: [https://www.umweltbundesamt.de/sites/default/files/medien/366/bilder/dateien/2024\\_tabelle\\_grenzwerte\\_snf\\_busse.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/366/bilder/dateien/2024_tabelle_grenzwerte_snf_busse.pdf); Umweltbundesamt, Dessau-Roßlau, 2024

<sup>12)</sup> EU (2009): REGULATION (EC) No 595/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information and amending Regulation (EC) No 715/2007 and Directive 2007/46/EC and repealing Directives 80/1269/EEC, 2005/55/EC and 2005/78/EC - <https://data.europa.eu/eli/reg/2009/595/oj>

<sup>14)</sup> UBA (2015): Themen > Verkehr > Emissionsstandards > Motorisierte Zweiräder: [https://www.umweltbundesamt.de/sites/default/files/medien/376/bilder/grenzwerte\\_fuer\\_schadstoffemissionen\\_motorisierter\\_zweiraeder\\_1.png](https://www.umweltbundesamt.de/sites/default/files/medien/376/bilder/grenzwerte_fuer_schadstoffemissionen_motorisierter_zweiraeder_1.png); Umweltbundesamt, Dessau-Roßlau, 2015

<sup>15), 16), 17)</sup> EU (2013): Regulation (EU) No 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles - Consolidated text; <http://data.europa.eu/eli/reg/2013/168/2024-11-27>

<sup>2)</sup> During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.



specific inventory data  
for NFR 1.A.3.b i -  
Passenger Cars

In sub-category *1.A.3.b i - Road transport: Passenger cars* emissions from fuel combustion in passenger cars (PCs) are reported.

| Category Code                                                                             | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.3.b i                                                                                 | T1, T3                               | NS, M | CS, M, D |
| Method(s) applied                                                                         |                                      |       |          |
| D                                                                                         | Default                              |       |          |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |          |
| T2                                                                                        | Tier 2*                              |       |          |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |          |
| C                                                                                         | CORINAIR                             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| M                                                                                         | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| (source for) Activity Data                                                                |                                      |       |          |
| NS                                                                                        | National Statistics                  |       |          |
| RS                                                                                        | Regional Statistics                  |       |          |
| IS                                                                                        | International Statistics             |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| As                                                                                        | Associations, business organisations |       |          |
| Q                                                                                         | specific Questionnaires (or surveys) |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |
| (source for) Emission Factors                                                             |                                      |       |          |
| D                                                                                         | Default (EMEP Guidebook)             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |

| NO <sub>x</sub> | NMVOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP                                                                                 | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|-------|-----------------|-----------------|-------------------|------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|
| L/T             | L/T   | -/-             | -/-             | L/T               | L/T              | -/-                                                                                 | L/T | L/T | L/T | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | NE  | -/-  |
|                 |       |                 |                 |                   | L/-              | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |       |                 |                 |                   | -/T              | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |       |                 |                 |                   | L/T              | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |       |                 |                 |                   | -/-              | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |       |                 |                 |                   | IE               | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |       |                 |                 |                   | NE               | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |       |                 |                 |                   | NA               | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |       |                 |                 |                   | *                | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |

## Methodology

Detailed information on the methods applied is provided in the [superordinate chapter](#).

### Activity data

Specific consumption data for passenger cars is generated within TREMOD <sup>1)</sup>.

The following table gives an overview of annual amounts of the fuels consumed by passenger cars in Germany.

Table 1: Annual energy input allocated to passenger cars, in terajoule [TJ]

|                    | 1990             | 1995             | 2000             | 2005             | 2010             | 2015             | 2016             | 2017             | 2018             | 2019             | 2020             | 2021             | 2022             | 2023             | 2024             |
|--------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Diesel oil         | 266,175          | 321,615          | 348,554          | 469,954          | 499,195          | 622,273          | 651,012          | 664,870          | 638,874          | 636,275          | 527,503          | 541,468          | 554,473          | 531,094          | 527,138          |
| Gasoline           | 1,273,347        | 1,258,708        | 1,194,743        | 967,730          | 764,449          | 706,489          | 706,818          | 709,460          | 688,689          | 694,835          | 622,758          | 629,090          | 648,537          | 666,660          | 679,914          |
| LPG                | 138              | 138              | 94.0             | 2,369            | 22,987           | 18,709           | 17,767           | 15,775           | 16,966           | 14,747           | 10,205           | 9,520            | 9,054            | 7,921            | 7,661            |
| Natural Gas        |                  |                  |                  | 1,628            | 3,368            | 3,466            | 3,221            | 3,120            | 3,086            | 2,672            | 1,884            | 2,319            | 1,902            | 1,618            | 533              |
| Biodiesel          |                  | 502              | 3,861            | 31,319           | 38,642           | 34,129           | 34,812           | 35,497           | 36,885           | 36,148           | 43,663           | 37,588           | 38,366           | 39,511           | 32,272           |
| Biogasoline        |                  |                  |                  | 6,574            | 29,540           | 29,728           | 29,772           | 29,290           | 30,038           | 29,073           | 27,571           | 29,026           | 29,975           | 31,665           | 31,810           |
| Boimethane         |                  |                  |                  |                  | 166              | 737              | 818              | 969              | 852              | 1,313            | 1,268            | 1,001            | 1,161            | 1,640            | 2,802            |
| <b>Σ 1.A.3.b i</b> | <b>1,539,661</b> | <b>1,580,963</b> | <b>1,547,252</b> | <b>1,479,575</b> | <b>1,358,346</b> | <b>1,415,532</b> | <b>1,444,219</b> | <b>1,458,981</b> | <b>1,415,389</b> | <b>1,415,063</b> | <b>1,234,851</b> | <b>1,250,013</b> | <b>1,283,469</b> | <b>1,280,110</b> | <b>1,282,129</b> |

Here, the following charts underline the ongoing shift from gasoline to diesel-powered passenger cars, that started around 1999/2000.

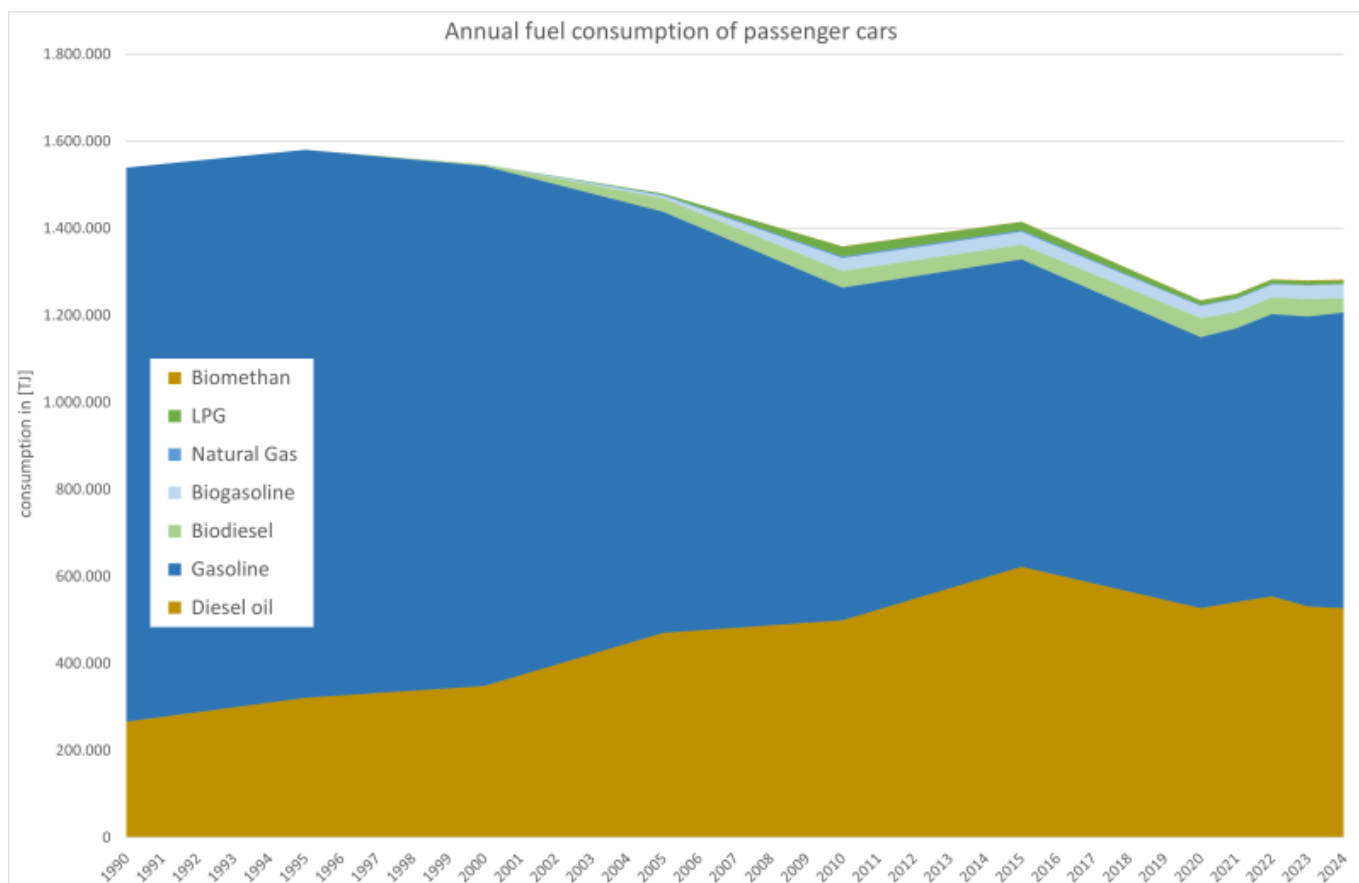
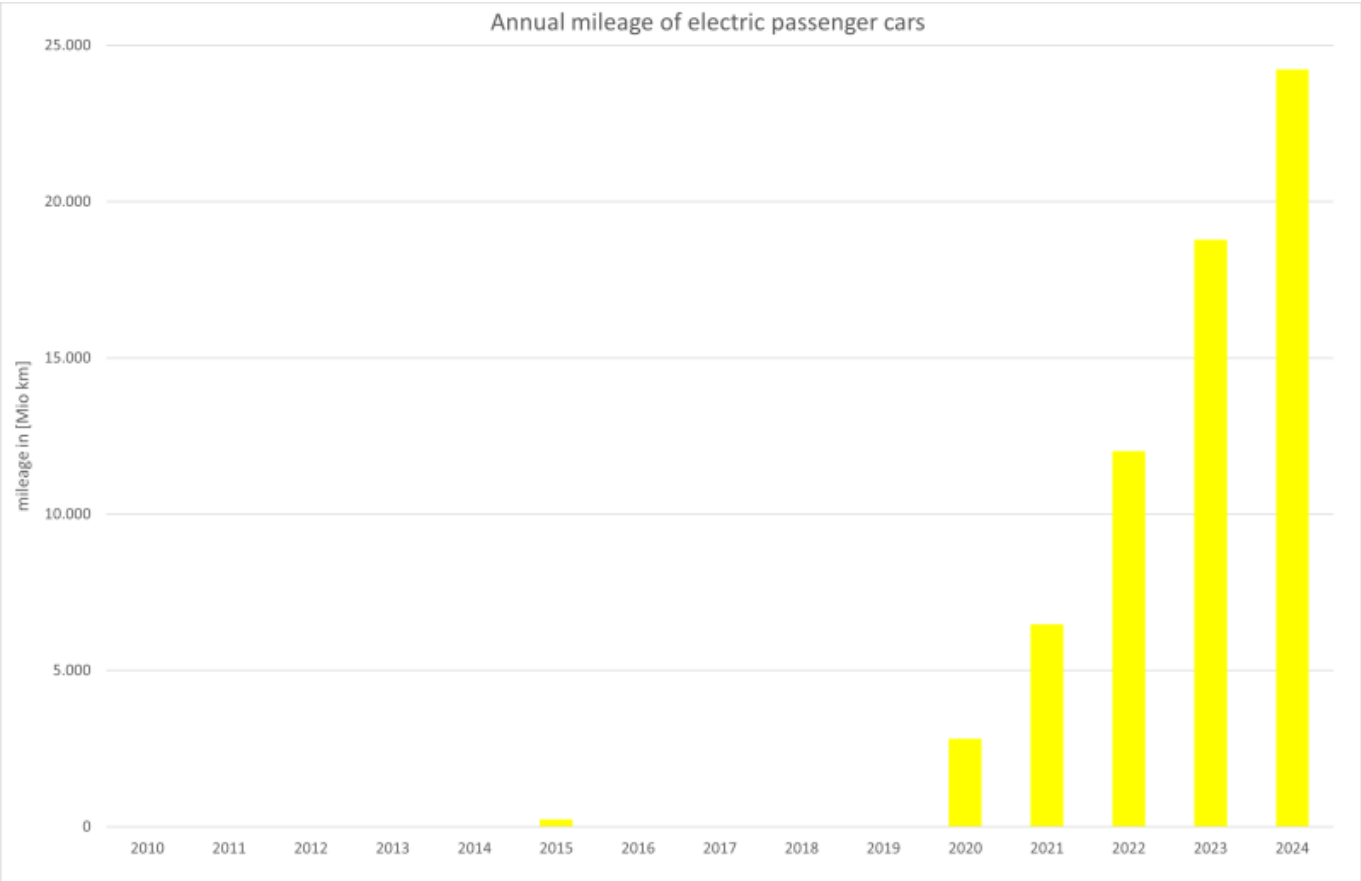


Table 2: Annual mileage of electric light-duty vehicles, as of 2012, in [Mio km]

| 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019  | 2020  | 2021  | 2022   | 2023   | 2024   |
|------|------|------|------|------|------|------|-------|-------|-------|--------|--------|--------|
| 52.7 | 88.8 | 152  | 241  | 356  | 583  | 947  | 1,534 | 2,820 | 6,481 | 12,013 | 18,777 | 24,229 |



For further information on mileage and abrasion-related emissions, please refer to sub-chapters on emissions from [tyre & brake wear and road abrasion](#).

Emission factors

The majority of emission factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, versions 4.1 and 4.2) <sup>2)</sup> <sup>3)</sup>, where they are provided on a tier3 level mostly and processed within TREMOD <sup>4)</sup>.

However, it is not possible to present these highly specific tier3 values in a comprehensible way here.



With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>3)</sup>

For **heavy-metal** (other then lead from leaded gasoline) **exhaust-emissions**, default emission factors from the 2025 Update of the 2023 EMEP/EEA Guidebook, Table 3-82: “Heavy metal emission factors for all vehicle categories in ppm/wt fuel” have been applied <sup>5)</sup> (see super-ordinate chapter [here](#) ). (see table 3 below)

In contrast, for **exhaust PAH emissions**, emission factors were derived from tier2 values as provided in EMEP/EEA guidebook 2023 (Update 2025) <sup>6)</sup>, Table 3-18: “Tier 2 exhaust emission factors for passenger cars, NFR 1.A.3.b.i”. (see table 4 below)

Regarding **PCDD/F**, tier1 EF from (Rentz et al., 2008) <sup>7)</sup> are used instead. (see table 4)

The following tables provide an overview of non-annual emission factors for exhaust emissions of heavy metals and POPs.

Table 3: Overview of tier1 EF applied for heavy metals exhaust-emissions, in [g/TJ]



|                                                                                                                                               | Pb    | Cd    | Hg    | As    | Cr    | Cu    | Ni    | Se    | Zn    |
|-----------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Diesel oil                                                                                                                                    | 0.012 | 0.001 | 0.123 | 0.002 | 0.198 | 0.133 | 0.005 | 0.002 | 0.419 |
| Biodiesel <sup>1</sup>                                                                                                                        | 0.013 | 0.001 | 0.142 | 0.003 | 0.228 | 0.153 | 0.005 | 0.003 | 0.483 |
| Gasoline fuels                                                                                                                                | 0.037 | 0.005 | 0.200 | 0.007 | 0.145 | 0.103 | 0.053 | 0.005 | 0.758 |
| CNG & Biomethane                                                                                                                              | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    |
| LPG                                                                                                                                           | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    |
| NOTE: values derived from the EMEP/EEA defaults provided Table 3-82: “Heavy metal emission factors for all vehicle categories in ppm/wt fuel” |       |       |       |       |       |       |       |       |       |
| <sup>1</sup> Biodiesel: values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel               |       |       |       |       |       |       |       |       |       |

For **exhaust emissions of Benzo[a]Pyrene, Benzo[b]Fluoranthene, Benzo[k]Fluoranthene, and Indeno[1,2,3-c,d]Pyrene** the tier2 emission factors as provided in the 2025 Update of the EMEP/EEA guidebook 2023<sup>8)</sup>, Chapter 1.A.3.b-iv; Table 3-18: Tier 2 exhaust emission factors for passenger cars, NFR 1.A.3.b.i with the current submission, upgrading the estimation to a tier2-approach.

Table 4: Overview of tier2 EF applied for PAH exhaust-emissions, in [g/km]

| FUEL                                                                                          | EURO standard  | B[a]P       | B[b]F       | B[k]F       | I[123cd]P   | PAH 1-4     |
|-----------------------------------------------------------------------------------------------|----------------|-------------|-------------|-------------|-------------|-------------|
| diesel fuels                                                                                  | as of pre-EURO | 0.000001740 | 0.000001950 | 0.000001530 | 0.000001620 | 0.000006840 |
| gasoline fuels                                                                                | pre-EURO       | 0.000000480 | 0.000000880 | 0.000000300 | 0.000001030 | 0.000002690 |
|                                                                                               | as of EURO1    | 0.000000320 | 0.000000360 | 0.000000260 | 0.000000390 | 0.000001330 |
| LPG                                                                                           | as of pre-EURO | 0.000000010 | 0.000000000 | 0.000000010 | 0.000000010 | 0.000000030 |
| natural gas, biomethane                                                                       | as of EURO4    | 0.000000320 | 0.000000360 | 0.000000260 | 0.000000390 | 0.000001330 |
| additional info:<br><a href="#">derivation of tier2 EF</a><br><a href="#">(MS Excel file)</a> |                |             |             |             |             |             |

Discussion of emission trends

Table 4: Outcome of Key Category Analysis

|                 |                            |       |                   |                  |     |     |     |
|-----------------|----------------------------|-------|-------------------|------------------|-----|-----|-----|
| key source for: | NO <sub>x</sub>            | NMVOC | PM <sub>2.5</sub> | PM <sub>10</sub> | BC  | CO  | Pb  |
| by:             | Level & Trend of emissions | L/T   | L/T               | L/T              | L/T | L/T | L/T |

Non-methane volatile organic compounds, nitrogen oxides, and carbon monoxide

Since 1990, exhaust emissions of **nitrogen oxides**, **NMVOC**, and **carbon monoxide** have decreased sharply due to catalytic-converter use and engine improvements resulting from ongoing tightening of emissions laws and improved fuel quality.

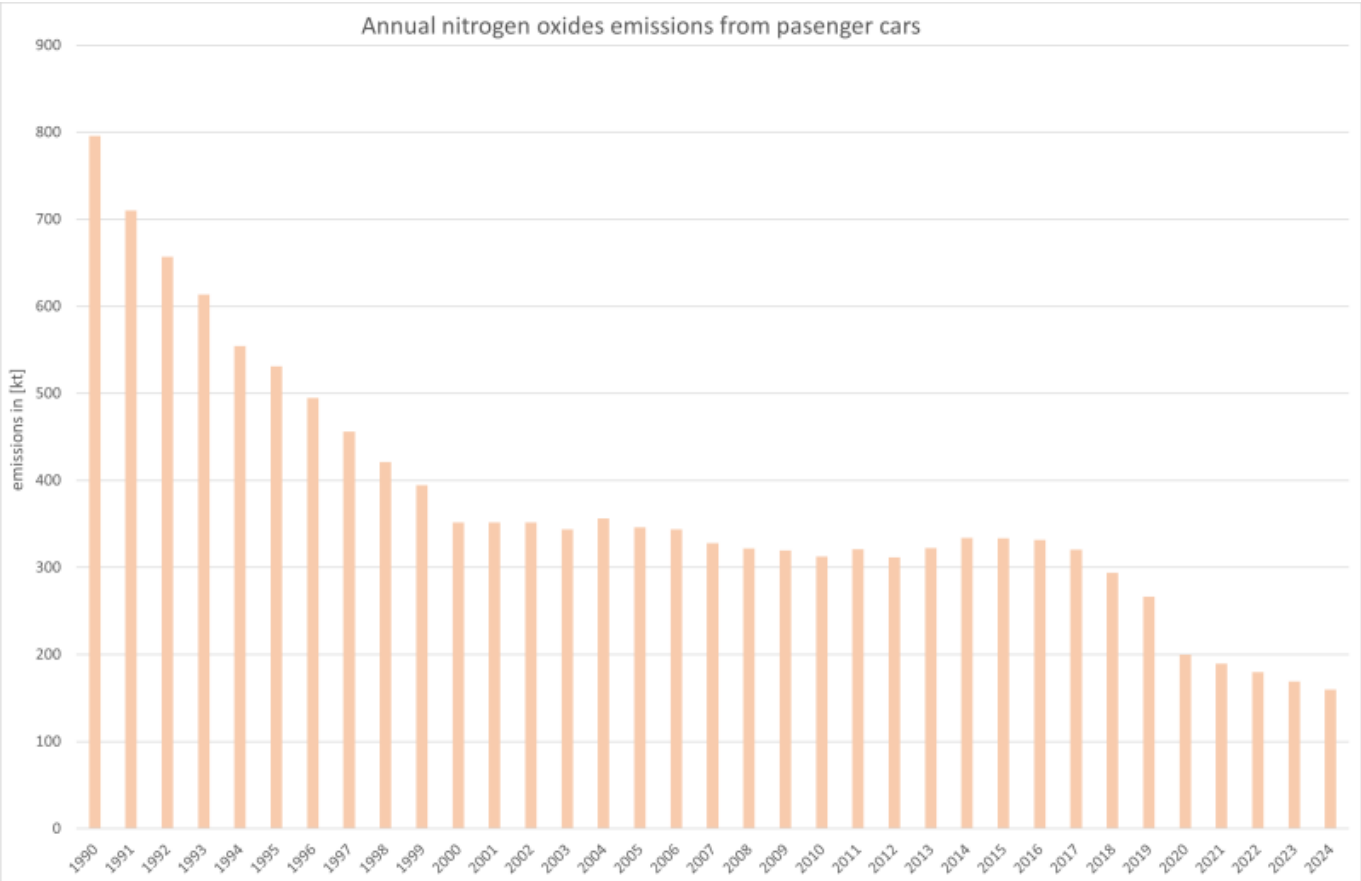


Table 5: EURO norms and their effect on limit values of NO<sub>x</sub> emissions from passenger cars, in [mg/km]

| exhaust emission standard (EURO norm) | Euro 1 | Euro 2 | Euro 3 | Euro 4 | Euro 5 | Euro 6a/b | Euro 6c | Euro 6d |
|---------------------------------------|--------|--------|--------|--------|--------|-----------|---------|---------|
| Diesel                                | -      | -      | 500    | 250    | 180    | 80        |         |         |
| Gasoline                              | -      | -      | 150    | 80     | 60     | 60        |         |         |

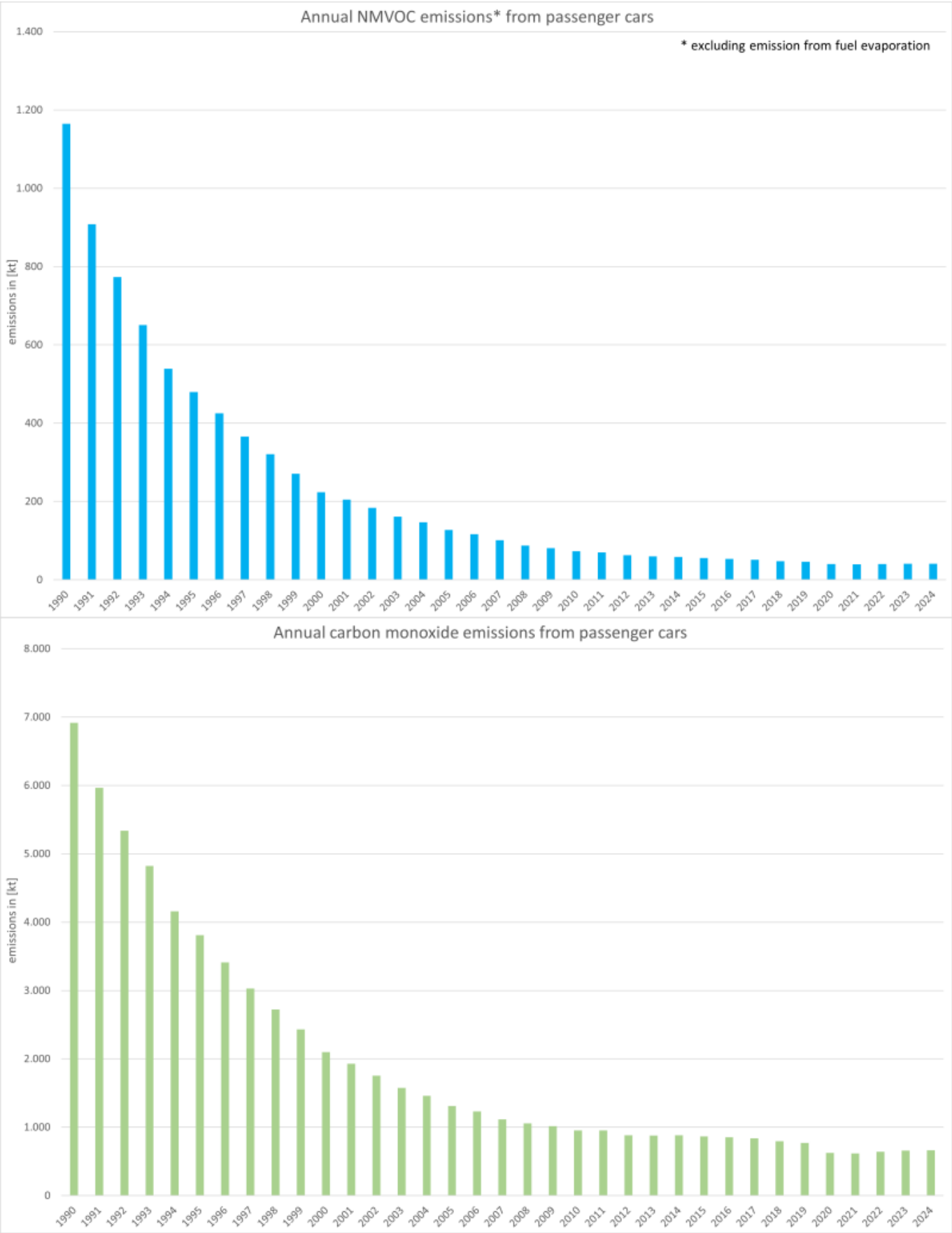


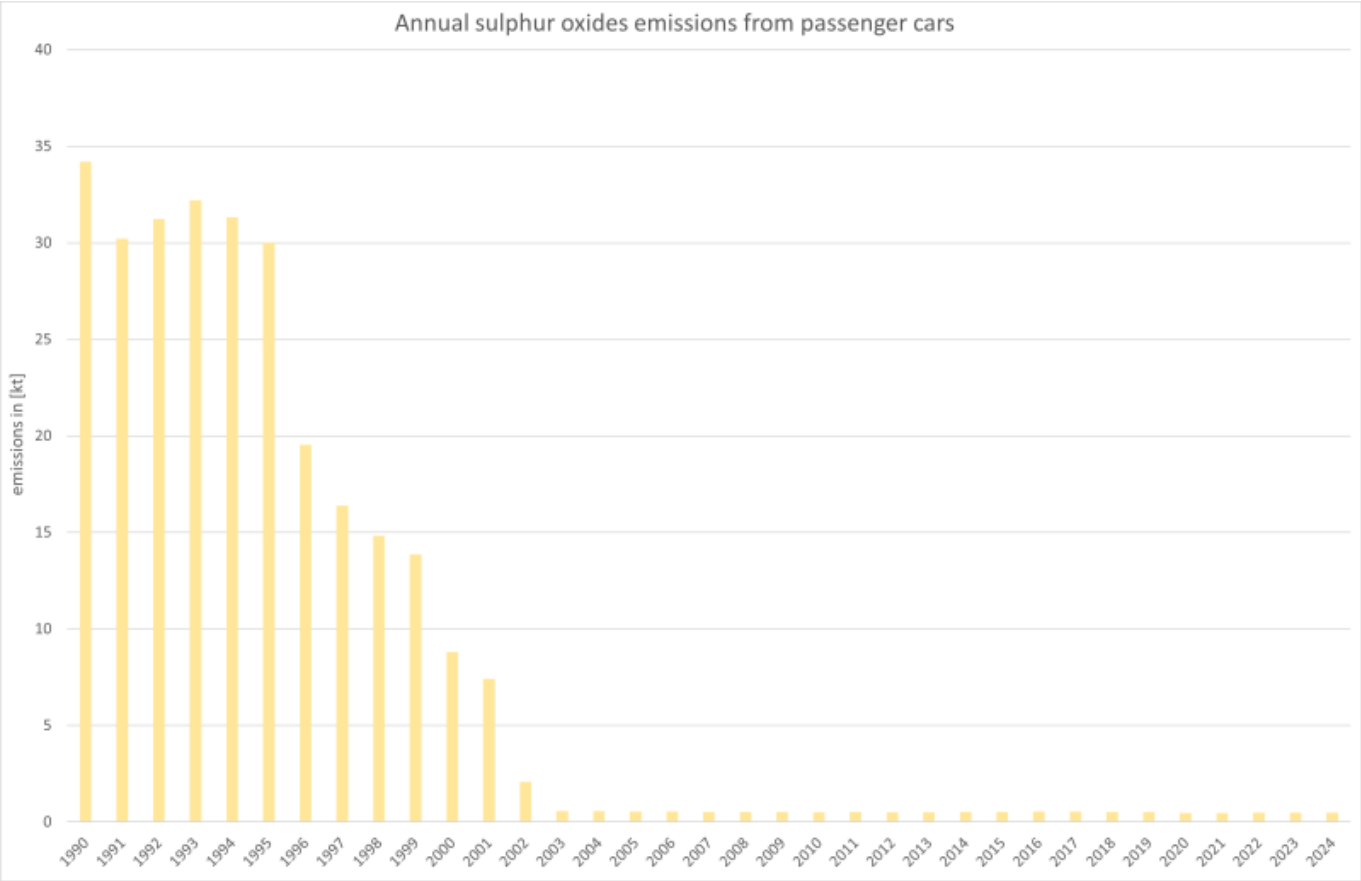
Table 6: EURO norms and their effect on limit values of CO emissions from passenger cars, in [mg/km]

| exhaust emission standard (EURO norm) | Euro 1        | Euro 2 | Euro 3 | Euro 4 | Euro 5 | Euro 6a/b | Euro 6c | Euro 6d |
|---------------------------------------|---------------|--------|--------|--------|--------|-----------|---------|---------|
| Diesel                                | 2,720 / 3,160 | 1,000  | 640    | 500    | 500    | 500       |         |         |
| Gasoline                              | 2,720 / 3,160 | 2,200  | 2,300  | 1,000  | 1,000  | 1,000     |         |         |

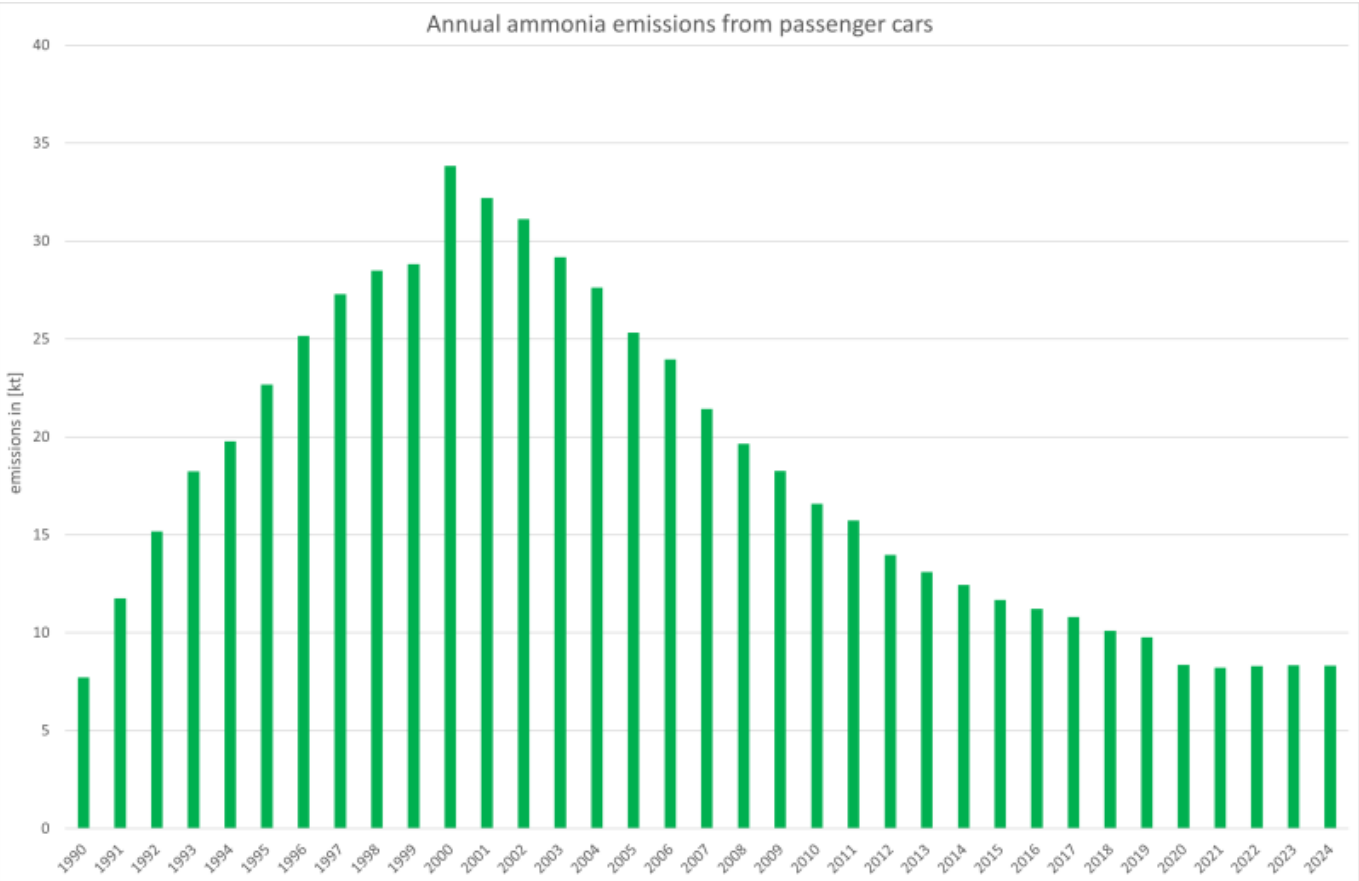
Ammonia and sulphur dioxide

As for the entire road transport sector, the trends for **sulphur dioxide** and **ammonia** exhaust emissions from passenger cars show characteristics very different from those shown above.

Here, the strong dependence on increasing fuel qualities (sulphur content) leads to an cascaded downward trend of emissions , influenced only slightly by increases in fuel consumption and mileage.



For **ammonia** emissions, the increasing use of catalytic converters in gasoline driven cars in the 1990s lead to a steep increase whereas both the technical development of the converters and the ongoing shift from gasoline to diesel cars resulted in decreasing emissions in the following years.



Particulate matter & Black carbon

(from fuel combustion only; no wear/abrasion included)

Starting in the middle of the 1990s, a so-called “diesel boom” began, leading to a switch from gasoline to diesel powered passenger cars. As the newly registered diesel cars had to meet the EURO2 standard (in force since 1996/'97) with a PM limit value less than half the EURO1 value, the growing diesel consumption was overcompensated quickly by the mitigation technologies implemented due to the new EURO norm. During the following years, new EURO norms came into force. With the still ongoing “diesel boom” those norms led to a stabilisation (EURO3, 2000/'01) of emissions and to another strong decrease of PM emissions (EURO4, 2005/'06), respectively. Over-all, the increased consumption of diesel in passenger cars was overestimated by the implemented mitigation technologies. The table below shows the evolution of the limit value for particle emissions from passenger cars with diesel engines.

With this submission, Black Carbon (BC) emissions are reported for the first time. Here, EF are estimated based on as fractions of PM as provided in <sup>9)</sup>. Due to this fuel-specific fractions, the trend of BC emissions reflects the ongoing shift from gasoline to diesel (“dieselisation”).

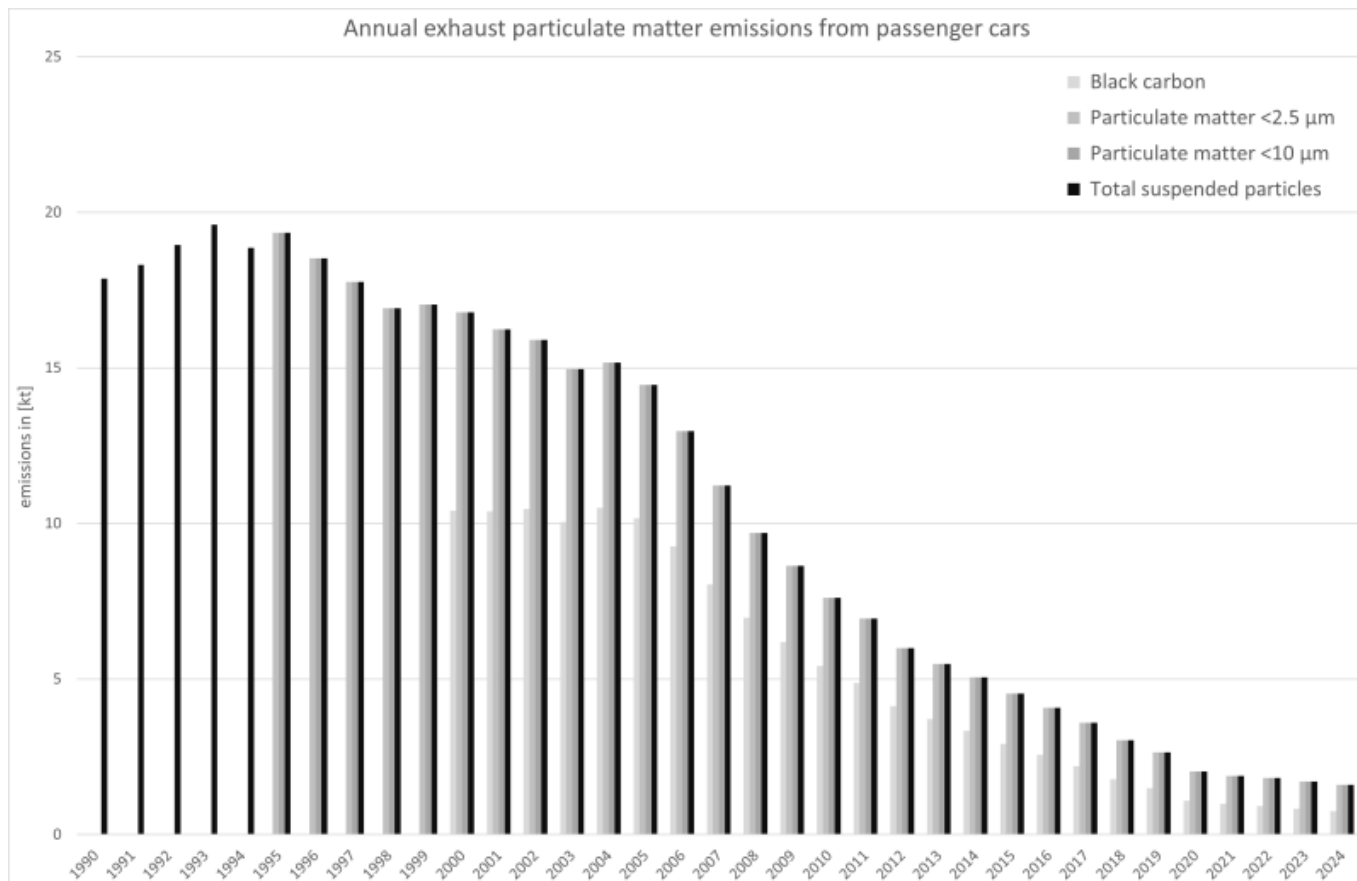


Table 7: EURO norms and their effect on limit values of PM emissions from passenger cars

| exhaust emission standard (EURO norm)     | Euro 1 | Euro 2              | Euro 3 | Euro 4 | Euro 5               | Euro 6a/b            | Euro 6c | Euro 6d |
|-------------------------------------------|--------|---------------------|--------|--------|----------------------|----------------------|---------|---------|
| limit values in [mg/km]                   |        |                     |        |        |                      |                      |         |         |
| Diesel                                    | 180    | 80/100 <sup>1</sup> | 50     | 25     | 4.5                  | 4.5                  |         |         |
| Gasoline                                  | -      | -                   | -      | -      | 4.5                  | 4.5                  |         |         |
| limit values in [number of particles]     |        |                     |        |        |                      |                      |         |         |
| Diesel                                    | -      | -                   | -      | -      | 6 x 10 <sup>11</sup> |                      |         |         |
| Gasoline                                  | -      | -                   | -      | -      | -                    | 6 x 10 <sup>11</sup> |         |         |
| <sup>1</sup> for direct injection engines |        |                     |        |        |                      |                      |         |         |

## Recalculations

Compared to submission 2025, recalculations result mainly from the biennial routine revision of the underlying National Energy Balances (NEB) for all years as of 2003 and the routine revision of the underlying TREMOD model used for distributing the inland fuel deliveries to road transport on the different vehicle types and mitigation technologies (Euro standards) as required for emission reporting .

Table 8: Revised energy input data 2003-2023, in terajoules [TJ]

|                            | <b>2003</b> | <b>2005</b> | <b>2010</b> | <b>2015</b> | <b>2016</b> | <b>2017</b> | <b>2018</b> | <b>2019</b> | <b>2020</b> | <b>2021</b> | <b>2022</b> | <b>2023</b> |
|----------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <b>DIESEL OIL</b>          |             |             |             |             |             |             |             |             |             |             |             |             |
| <b>current Submission</b>  | 418,448     | 469,954     | 499,195     | 622,273     | 651,012     | 664,870     | 638,874     | 636,275     | 527,503     | 541,468     | 554,473     | 531,094     |
| <b>previous Submission</b> | 419,746     | 459,150     | 493,060     | 644,577     | 667,913     | 668,958     | 642,258     | 643,791     | 520,027     | 528,230     | 550,835     | 532,067     |
| <b>absolute change</b>     | -1,299      | 10,804      | 6,135       | -22,304     | -16,901     | -4,088      | -3,384      | -7,516      | 7,476       | 13,238      | 3,638       | -973        |
| <b>relative change</b>     | -0.31%      | 2.35%       | 1.24%       | -3.46%      | -2.53%      | -0.61%      | -0.53%      | -1.17%      | 1.44%       | 2.51%       | 0.66%       | -0.18%      |
| <b>BIODIESEL</b>           |             |             |             |             |             |             |             |             |             |             |             |             |
| <b>current Submission</b>  | 11,715      | 31,319      | 38,642      | 34,129      | 34,812      | 35,497      | 36,885      | 36,148      | 43,663      | 37,588      | 38,366      | 39,511      |

|                                                         | 2003      | 2005      | 2010      | 2015      | 2016      | 2017      | 2018      | 2019      | 2020      | 2021      | 2022      | 2023      |
|---------------------------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| <b>previous Submission</b>                              | 12,143    | 32,012    | 38,566    | 35,806    | 36,202    | 36,464    | 36,239    | 36,518    | 42,535    | 37,042    | 38,213    | 39,434    |
| <b>absolute change</b>                                  | -428      | -693      | 75,5      | -1.677    | -1.390    | -967      | 646       | -370      | 1.128     | 546       | 153       | 77,1      |
| <b>relative change</b>                                  | -3,52%    | -2,16%    | 0,20%     | -4,68%    | -3,84%    | -2,65%    | 1,78%     | -1,01%    | 2,65%     | 1,48%     | 0,40%     | 0,20%     |
| <b>GASOLINE</b>                                         |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current Submission</b>                               | 1,070,489 | 967,730   | 764,449   | 706,489   | 706,818   | 709,460   | 688,689   | 694,835   | 622,758   | 629,090   | 648,537   | 666,660   |
| <b>previous Submission</b>                              | 1,074,786 | 948,080   | 755,474   | 733,505   | 726,576   | 714,892   | 691,702   | 703,555   | 613,047   | 613,541   | 644,312   | 667,928   |
| <b>absolute change</b>                                  | -4,297    | 19,650    | 8,976     | -27,016   | -19,758   | -5,433    | -3,013    | -8,720    | 9,710     | 15,549    | 4,225     | -1,268    |
| <b>relative change</b>                                  | -0.40%    | 2.07%     | 1.19%     | -3.68%    | -2.72%    | -0.76%    | -0.44%    | -1.24%    | 1.58%     | 2.53%     | 0.66%     | -0.19%    |
| <b>BIOGASOLINE</b>                                      |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>Submission 2023</b>                                  |           | 6,574     | 29,540    | 29,728    | 29,772    | 29,290    | 30,038    | 29,073    | 27,571    | 29,026    | 29,975    | 31,665    |
| <b>Submission 2022</b>                                  |           | 6,572     | 29,348    | 29,608    | 29,660    | 29,189    | 29,936    | 28,989    | 27,485    | 28,909    | 29,862    | 31,551    |
| <b>absolute change</b>                                  |           | 2.39      | 192       | 119.8     | 112.4     | 100.6     | 101       | 84        | 86.7      | 118       | 113.9     | 114       |
| <b>relative change</b>                                  |           | 0.04%     | 0.66%     | 0.40%     | 0.38%     | 0.34%     | 0.34%     | 0.29%     | 0.32%     | 0.41%     | 0.38%     | 0.36%     |
| <b>LPG (LIQUEFIED PETROLEUM GAS)</b>                    |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current Submission</b>                               | 697       | 2,369     | 22,987    | 18,709    | 17,767    | 15,775    | 16,966    | 14,747    | 10,205    | 9,520     | 9,054     | 7,921     |
| <b>previous Submission</b>                              | 697       | 2,369     | 22,982    | 18,709    | 17,767    | 15,775    | 16,922    | 14,692    | 10,213    | 10,138    | 11,761    | 7,927     |
| <b>absolute change</b>                                  | 0.00      | 0.00      | 4.51      | 0.00      | 0.00      | 0.00      | 43.4      | 55.1      | -7.53     | -618      | -2,706    | -5.86     |
| <b>relative change</b>                                  | 0.00%     | 0.00%     | 0.02%     | 0.00%     | 0.00%     | 0.00%     | 0.26%     | 0.37%     | -0.07%    | -6.10%    | -23.0%    | -0.07%    |
| <b>NATURAL GAS</b>                                      |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current Submission</b>                               | 1,296     | 1,628     | 3,368     | 3,466     | 3,221     | 3,120     | 3,086     | 2,672     | 1,884     | 2,319     | 1,902     | 1,618     |
| <b>previous Submission</b>                              | 1,296     | 1,628     | 5,213     | 2,729     | 2,403     | 1,591     | 1,926     | 1,314     | 1,151     | 2,045     | 1,855     | 1,573     |
| <b>absolute change</b>                                  | 0.00      | 0.00      | -1,844    | 737       | 818       | 1,529     | 1,160     | 1,358     | 733       | 275       | 47.5      | 45.6      |
| <b>relative change</b>                                  | 0.00%     | 0.0%      | -35.4%    | 27.0%     | 34.0%     | 96.1%     | 60.3%     | 103.4%    | 63.7%     | 13.4%     | 2.56%     | 2.90%     |
| <b>BIOMETHANE</b>                                       |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current Submission</b>                               |           |           | 166       | 737       | 818       | 969       | 852       | 1,313     | 1,268     | 1,001     | 1,161     | 1,640     |
| <b>previous Submission</b>                              |           |           | 166       | 738       | 818       | 969       | 852       | 1,314     | 1,271     | 994       | 914       | 1,192     |
| <b>absolute change</b>                                  |           |           | 0.00      | -0.09     | -0.05     | 0.01      | 0.10      | -1.20     | -3.36     | 6.98      | 247       | 448       |
| <b>relative change</b>                                  |           |           | 0.00%     | -0.01%    | -0.01%    | 0.00%     | 0.01%     | -0.09%    | -0.26%    | 0.70%     | 27.0%     | 37.6%     |
| <b>TOTAL ENERGY INPUT as allocated to NFR 1.A.3.b i</b> |           |           |           |           |           |           |           |           |           |           |           |           |
| <b>current Submission</b>                               | 1,502,644 | 1,479,575 | 1,358,346 | 1,415,696 | 1,444,463 | 1,459,379 | 1,416,039 | 1,416,172 | 1,236,947 | 1,254,956 | 1,292,837 | 1,294,916 |
| <b>previous Submission</b>                              | 1,508,668 | 1,449,811 | 1,344,808 | 1,465,835 | 1,481,583 | 1,468,237 | 1,420,485 | 1,431,283 | 1,217,847 | 1,225,841 | 1,287,120 | 1,296,344 |
| <b>absolute change</b>                                  | -6,024    | 29,763    | 13,539    | -50,140   | -37,120   | -8,858    | -4,446    | -15,112   | 19,100    | 29,115    | 5,718     | -1,428    |
| <b>relative change</b>                                  | -0.40%    | 2.05%     | 1.01%     | -3.42%    | -2.51%    | -0.60%    | -0.31%    | -1.06%    | 1.57%     | 2.38%     | 0.44%     | -0.11%    |



Due to the variety of tier3 **emission factors** applied, it is not possible to display any changes in these data sets in a comprehensible way.





For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

<sup>1), 4)</sup> Knörr et al. (2025a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2025.

<sup>2)</sup> Keller et al. (2019): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: [https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8\\_HBEFA41\\_Development\\_Report.pdf](https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8_HBEFA41_Development_Report.pdf) - Dokumentation, Bern, 2019.

<sup>3)</sup> Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: [https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0\\_HBEFA42\\_Update\\_Documentation.pdf](https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf) - Dokumentation, Bern, 2022.

<sup>5), 6), 8), 9)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i>; Copenhagen, 2025.

<sup>7)</sup> Rentz et al. (2008): Otto Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung, Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte 01/2008, <http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer>; Dessau-Roßlau, 2008

<sup>3)</sup> During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.



specific inventory data  
for NFR 1.A.3.b ii - Light-  
duty vehicles

In sub-category 1.A.3.b ii - Road Transport: Light Duty Vehicles emissions from fuel combustion in Light Duty Vehicles (LDVs) are reported.

| Category Code                                                                             | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.3.b ii                                                                                | T1, T3                               | NS, M | CS, M, D |
| Method(s) applied                                                                         |                                      |       |          |
| D                                                                                         | Default                              |       |          |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |          |
| T2                                                                                        | Tier 2*                              |       |          |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |          |
| C                                                                                         | CORINAIR                             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| M                                                                                         | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| (source for) Activity Data                                                                |                                      |       |          |
| NS                                                                                        | National Statistics                  |       |          |
| RS                                                                                        | Regional Statistics                  |       |          |
| IS                                                                                        | International Statistics             |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| As                                                                                        | Associations, business organisations |       |          |
| Q                                                                                         | specific Questionnaires (or surveys) |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |
| (source for) Emission Factors                                                             |                                      |       |          |
| D                                                                                         | Default (EMEP Guidebook)             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub>                                                                               | PM <sub>10</sub> | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |
|-----------------|--------|-----------------|-----------------|-------------------------------------------------------------------------------------------------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|--|
| L/-             | -/-    | -/-             | -/-             | L/T                                                                                             | L/T              | -/- | L/T | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | NE  | -/-  |  |
|                 |        |                 |                 | L/- key source by <b>Level</b> only                                                             |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | -/T key source by <b>Trend</b> only                                                             |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | L/T key source by both <b>Level</b> and <b>Trend</b>                                            |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | -/- no key source for this pollutant                                                            |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | IE emission of specific pollutant Included <b>E</b> lsewhere (i.e. in another category)         |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | NE emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | NA specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 | * no analysis done                                                                              |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |

## Methodology

### Activity data

Specific consumption data for light-duty vehicles (LDV) are generated within TREMOD <sup>1)</sup>. - The following table provides an overview of annual amounts of fuels consumed by LDV in Germany.

Table 1: Annual energy input allocated to light duty vehicles, in terajoules

|                     | 1990          | 1995           | 2000           | 2005           | 2010           | 2015           | 2016           | 2017           | 2018           | 2019           | 2020           | 2021           | 2022           | 2023           | 2024           |
|---------------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| <b>Diesel oil</b>   | 32,966        | 88,993         | 123,189        | 121,992        | 113,851        | 135,747        | 143,949        | 150,252        | 150,076        | 153,960        | 145,892        | 156,311        | 159,575        | 155,894        | 158,596        |
| <b>Gasoline</b>     | 34,782        | 21,433         | 18,095         | 11,196         | 6,892          | 6,304          | 6,447          | 6,677          | 6,903          | 7,397          | 7,339          | 7,844          | 8,087          | 8,041          | 8,216          |
| <b>Natural Gas</b>  |               |                |                | 355            | 792            | 894            | 831            | 801            | 761            | 621            | 453            | 554            | 435            | 346            | 109            |
| <b>Biodiesel</b>    |               | 139            | 1,365          | 8,130          | 8,813          | 7,445          | 7,697          | 8,022          | 8,664          | 8,747          | 12,076         | 10,851         | 11,042         | 11,598         | 9,709          |
| <b>Biogasoline</b>  |               |                |                | 76             | 266            | 265            | 272            | 276            | 301            | 309            | 325            | 362            | 374            | 382            | 384            |
| <b>Biomethane</b>   |               |                |                |                | 39             | 190            | 211            | 249            | 210            | 305            | 305            | 239            | 265            | 351            | 573            |
| <b>Σ 1.A.3.b ii</b> | <b>67,748</b> | <b>110,566</b> | <b>142,649</b> | <b>141,750</b> | <b>130,652</b> | <b>150,846</b> | <b>159,407</b> | <b>166,277</b> | <b>166,915</b> | <b>171,338</b> | <b>166,390</b> | <b>176,161</b> | <b>179,777</b> | <b>176,611</b> | <b>177,588</b> |

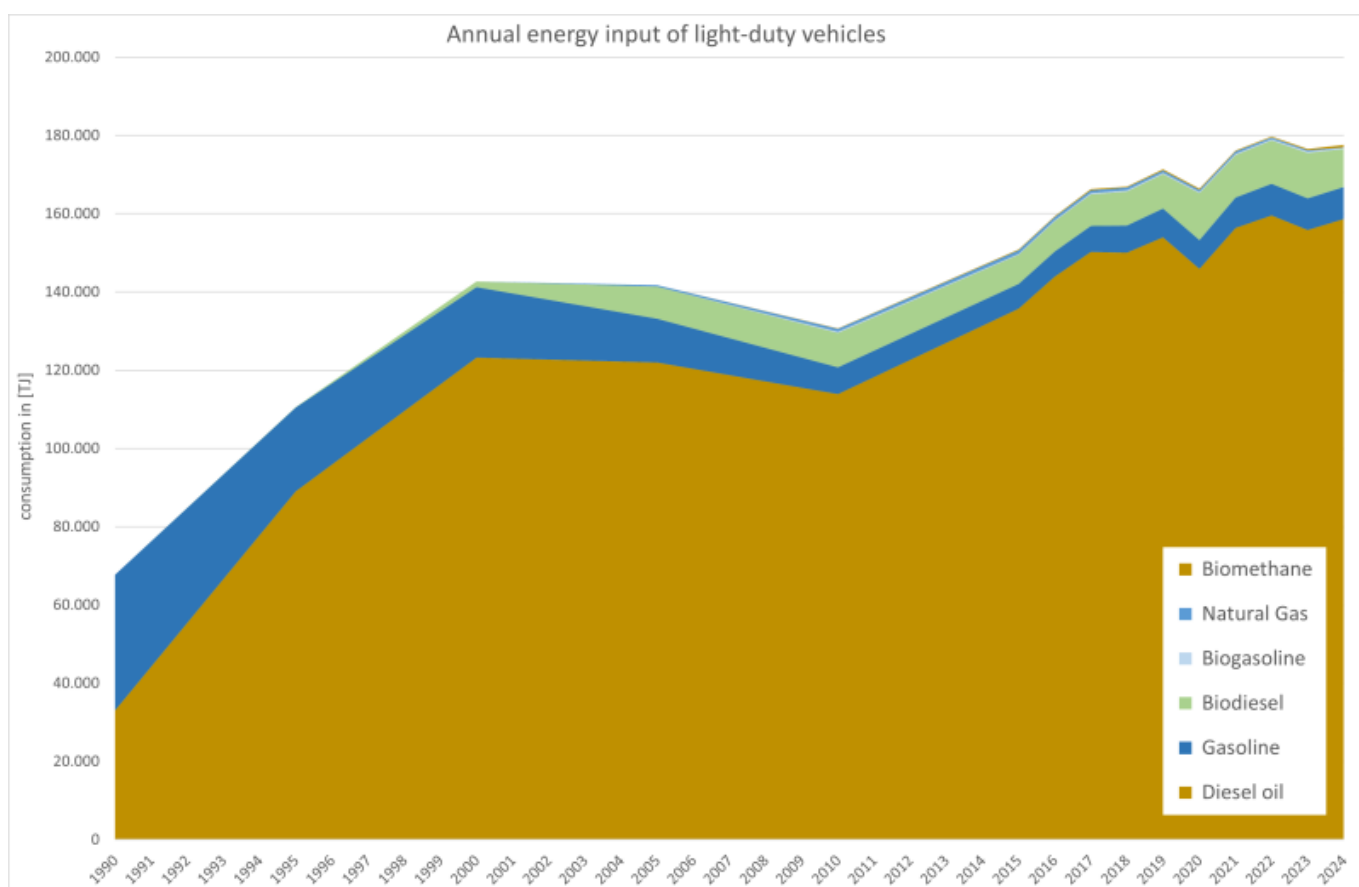
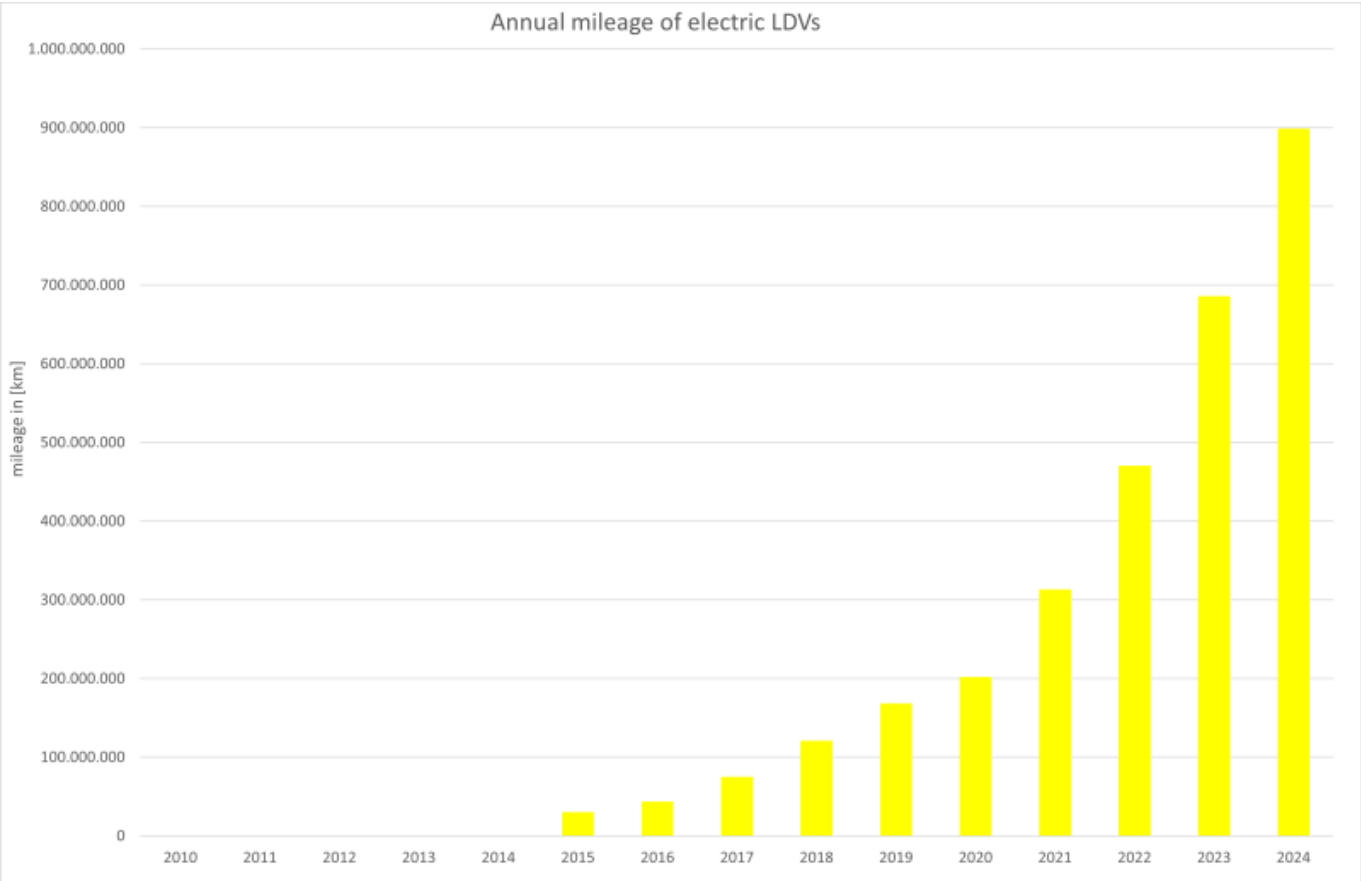


Table 2: Annual mileage of electric light-duty vehicles, as of 2012, in [km]

| 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 0.00 | 0.00 | 13.1 | 19.1 | 24.5 | 30.6 | 43.6 | 75.4 | 121  | 169  | 202  | 313  | 471  | 686  | 899  |



For further information on mileage and abrasion-related emissions, please refer to sub-chapters on emissions from [tyre & brake wear and road abrasion](#).

Emission factors

The majority of emission factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, versions 4.1 and 4.2) <sup>2)</sup> <sup>3)</sup>, where they are provided on a tier3 level mostly and processed within TREMOD <sup>4)</sup>.

However, it is not possible to present these highly specific tier3 values here in a comprehensible way .



With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>3)</sup>

For **heavy-metal** (other then lead from leaded gasoline) **exhaust-emissions**, default emission factors from the 2025 Update of the 2023 EMEP/EEA Guidebook, Table 3-82: “Heavy metal emission factors for all vehicle categories in ppm/wt fuel” have been applied <sup>5)</sup> (see super-ordinate chapter [here](#) ). (see table 3 below)

In contrast, for **exhaust PAH emissions**, emission factors were derived from tier2 values as provided in EMEP/EEA guidebook 2023 (Update 2025) <sup>6)</sup>, Table 3-18: “Tier 2 exhaust emission factors for passenger cars, NFR 1.A.3.b.i”. (see table 4 below)

Regarding **PCDD/F**, tier1 EF from (Rentz et al., 2008) <sup>7)</sup> are used instead. (see table 4)

The following tables provide an overview of non-annual emission factors for exhaust emissions of heavy metals and POPs.

Table 3: Overview of tier1 EF applied for heavy metals exhaust-emissions, in [g/TJ]

|                                                                                                                                               | Pb    | Cd    | Hg    | As    | Cr    | Cu    | Ni    | Se    | Zn    |
|-----------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Diesel oil                                                                                                                                    | 0.012 | 0.001 | 0.123 | 0.002 | 0.198 | 0.133 | 0.005 | 0.002 | 0.419 |
| Biodiesel <sup>1</sup>                                                                                                                        | 0.013 | 0.001 | 0.142 | 0.003 | 0.228 | 0.153 | 0.005 | 0.003 | 0.483 |
| Gasoline fuels                                                                                                                                | 0.037 | 0.005 | 0.200 | 0.007 | 0.145 | 0.103 | 0.053 | 0.005 | 0.758 |
| CNG & Biomethane                                                                                                                              | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    |
| LPG                                                                                                                                           | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    |
| NOTE: values derived from the EMEP/EEA defaults provided Table 3-82: “Heavy metal emission factors for all vehicle categories in ppm/wt fuel” |       |       |       |       |       |       |       |       |       |
| <sup>1</sup> Biodiesel: values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel               |       |       |       |       |       |       |       |       |       |

For **exhaust emissions of Benzo[a]Pyrene, Benzo[b]Fluoranthene, Benzo[k]Fluoranthene, and Indeno[1,2,3-c,d]Pyrene** the tier2 emission factors provided in the 2025 Update of the EMEP/EEA guidebook 2023 <sup>8)</sup>, Chapter 1.A.3.bi-iv; Table 3-18: “Tier 2 exhaust emission factors for passenger cars, NFR 1.A.3.b.i” are implemented with the current submission, upgrading the estimation to a tier2-approach.

Table: tier2 emission factors for exhaust PAH emissions from road vehicles, in [g/km]

| FUEL                                                                                          | EURO standard | B[a]P       | B[b]F       | B[k]F       | I[123cd]P   | PAH 1-4     |
|-----------------------------------------------------------------------------------------------|---------------|-------------|-------------|-------------|-------------|-------------|
| diesel fuels                                                                                  | pre-EURO      | 0.000002850 | 0.000003300 | 0.000002870 | 0.000002540 | 0.000011560 |
|                                                                                               | as of EURO1   | 0.000000630 | 0.000000600 | 0.000000190 | 0.000000700 | 0.000002120 |
| gasoline fuels                                                                                | pre-EURO      | 0.000000480 | 0.000000880 | 0.000000300 | 0.000001030 | 0.000002690 |
|                                                                                               | as of EURO1   | 0.000000320 | 0.000000360 | 0.000000260 | 0.000000390 | 0.000001330 |
| natural gas, biomethane                                                                       | as of EURO4   | 0.000000320 | 0.000000360 | 0.000000260 | 0.000000390 | 0.000001330 |
| additional info:<br><a href="#">derivation of tier2 EF</a><br><a href="#">(MS Excel file)</a> |               |             |             |             |             |             |

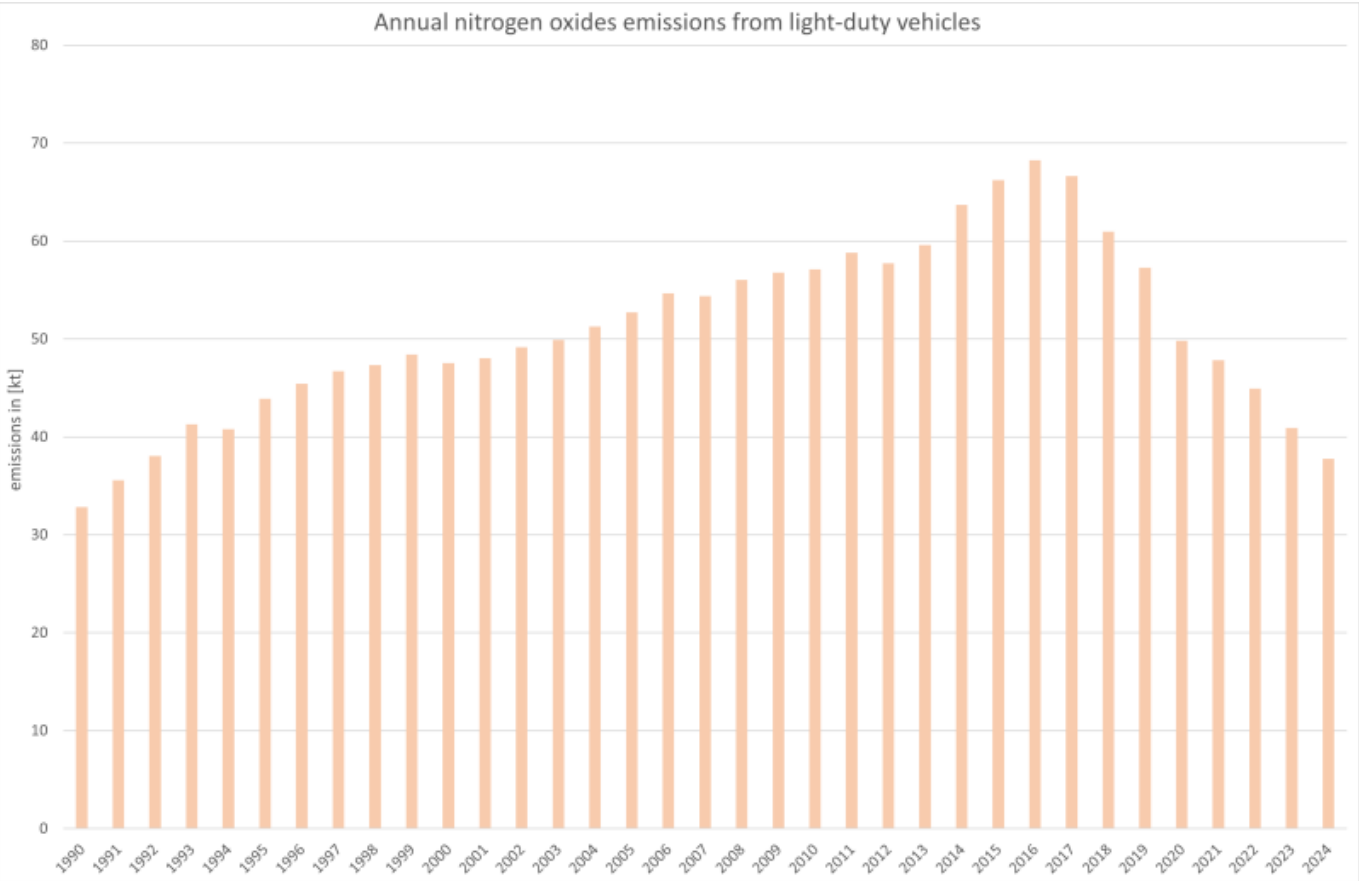
Discussion of emission trends

Table 4: Outcome of Key Category Analysis

|                 |                    |                   |                  |     |
|-----------------|--------------------|-------------------|------------------|-----|
| key source for: | NO <sub>x</sub>    | PM <sub>2.5</sub> | PM <sub>10</sub> | BC  |
| by:             | Level of emissions | Level & Trend     | L/T              | L/T |

Nitrogen oxides

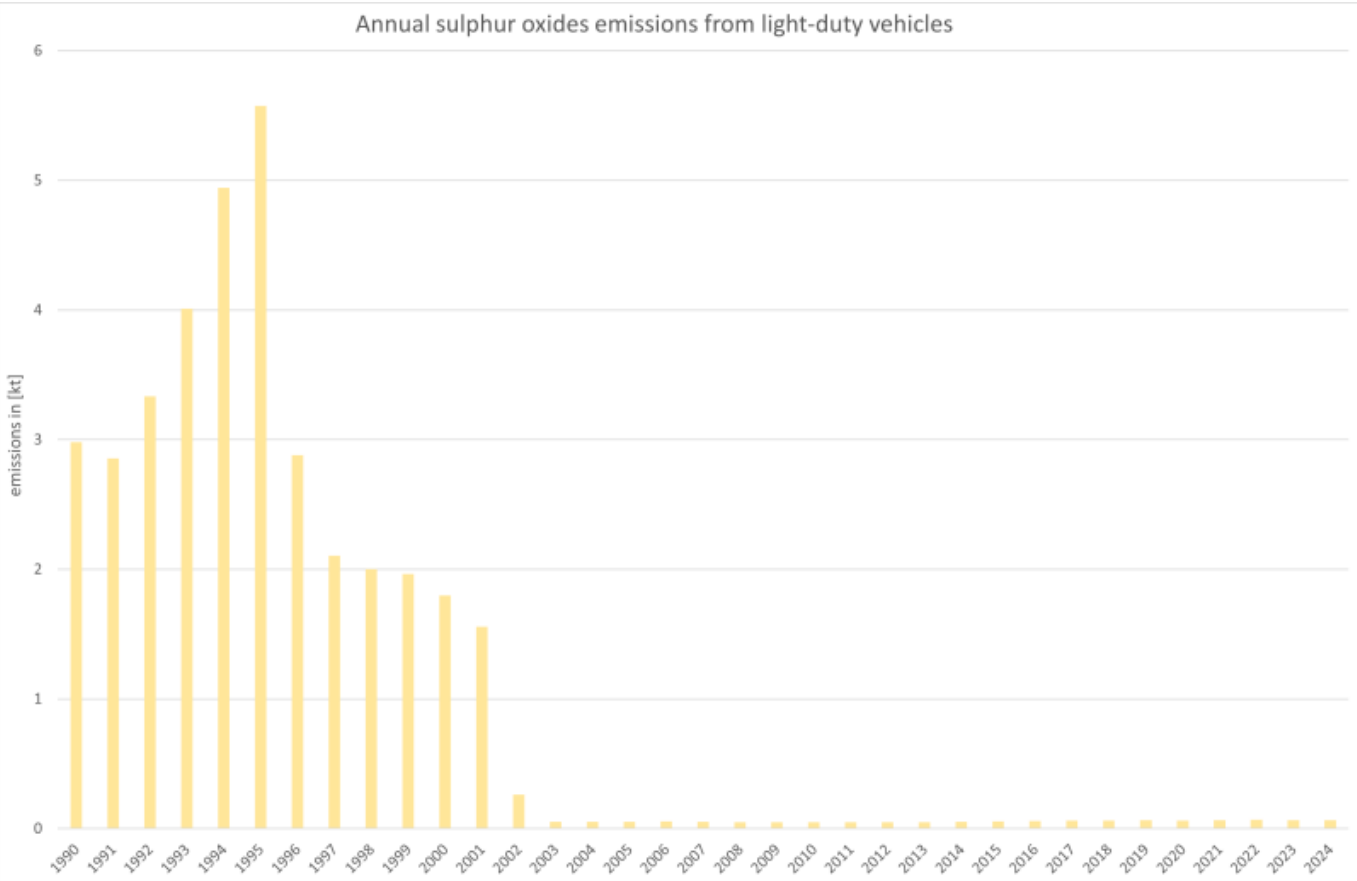
NO<sub>x</sub> emissions increased steadily until 2002 following the shift to diesel engines. During the last ten years, emissions decline steadily due to catalytic-converter use and engine improvements resulting from ongoing tightening of emissions laws and improved fuel quality.



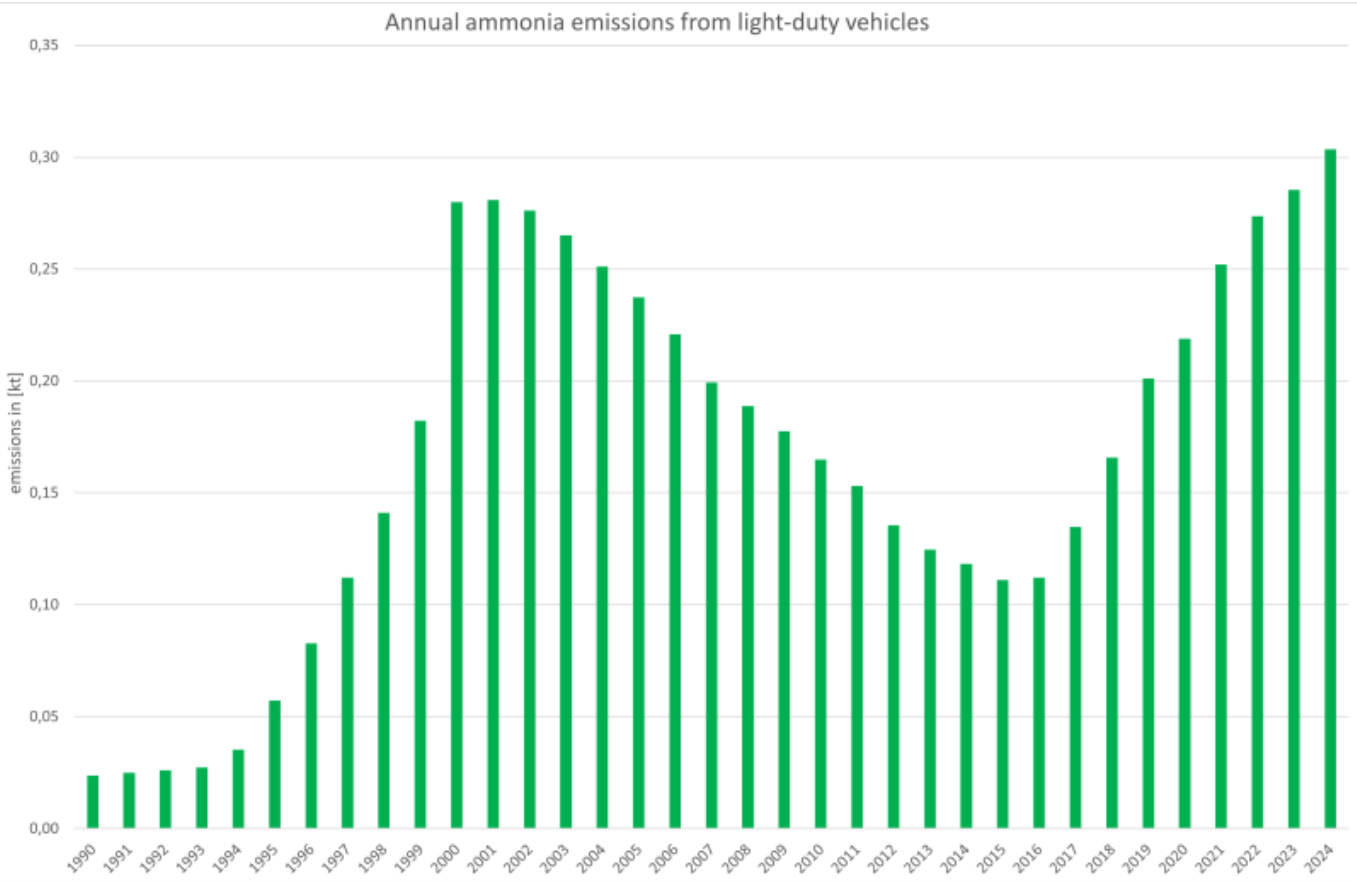
Ammonia and sulphur dioxide

As for the entire road transport sector, the trends for **sulphur dioxide** and **ammonia** exhaust emissions from passenger cars show characteristics very different from those shown above.

Here, the strong dependence on increasing fuel qualities (sulphur content) leads to an cascaded downward trend of emissions, influenced only slightly by increases in fuel consumption and mileage.



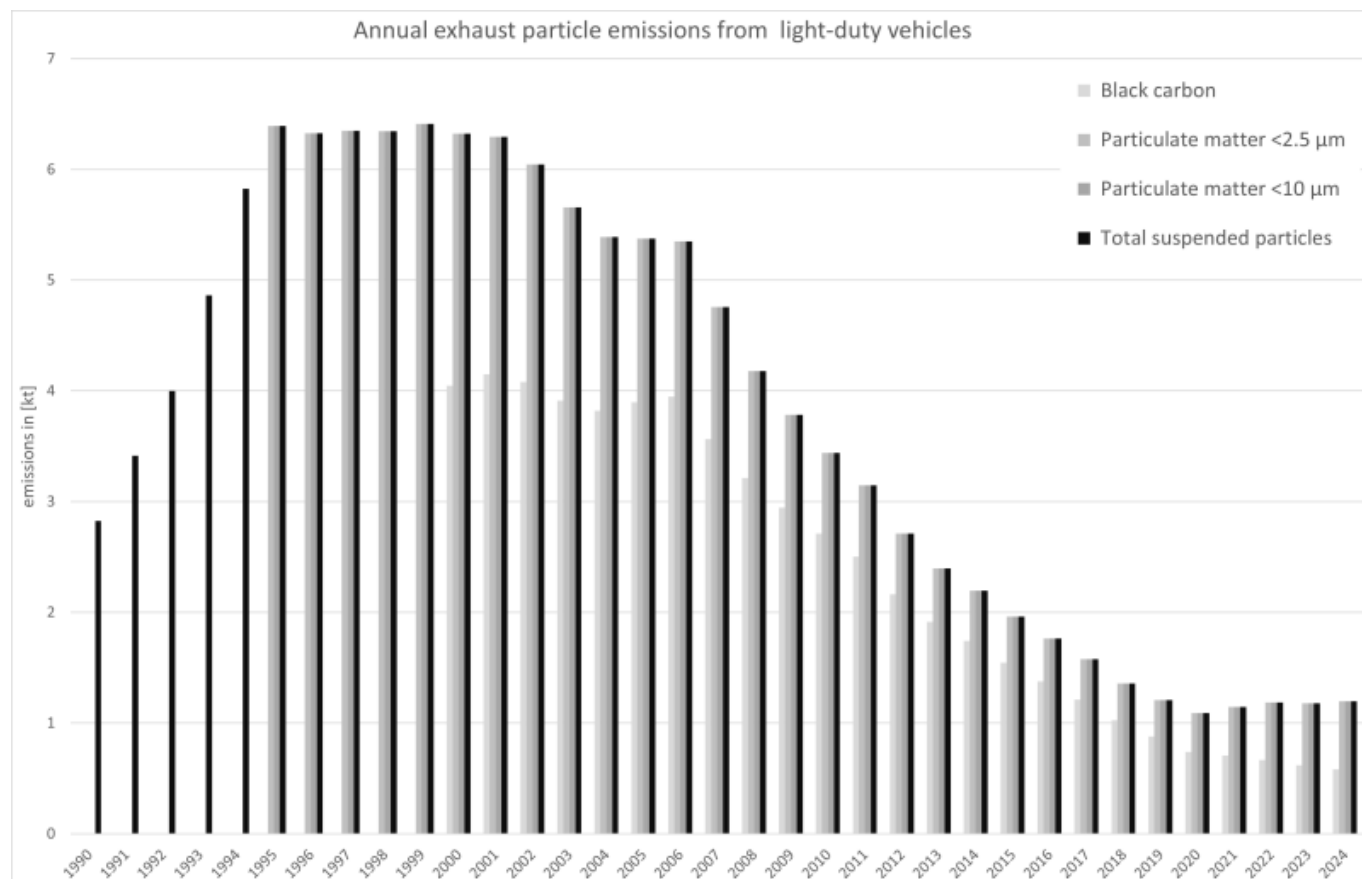
For **ammonia** emissions the increasing use of catalytic converters in gasoline driven cars in the 1990s lead to a steep increase whereas both the technical development of the converters and the ongoing shift from gasoline to diesel cars resulted in decreasing emissions in the following years.



## Particulate matter & Black carbon

Starting in the middle of the 1990s, a so-called “diesel boom” began, leading to a switch from gasoline to diesel powered passenger cars. As the newly registered diesel cars had to meet the EURO2 standard (in force since 1996/'97) with a PM limit value less than half the EURO1 value, the growing diesel consumption was overcompensated quickly by the mitigation technologies implemented due to the new EURO norm. During the following years, new EURO norms came into force.

With the still ongoing “diesel boom” those norms led to a stabilisation (EURO3, 2000/'01) of emissions and to another strong decrease of PM emissions (EURO4, 2005/'06), respectively. Over-all, the increased consumption of diesel in passenger cars was over-estimated by the implemented mitigation technologies.



## Recalculations

As already described, compared to submission 2024, recalculations result mainly from the biennial routine revision of the National Energy Balances for all years as of 2003:

Table 4: Revised energy input data 2003-2023, in terajoules [TJ]

|                            | 2003    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    |
|----------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>Diesel oil</b>          |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  | 125,118 | 121,992 | 113,851 | 135,747 | 143,949 | 150,252 | 150,076 | 153,960 | 145,892 | 156,311 | 159,575 | 155,894 |
| <b>previous submission</b> | 125,506 | 119,188 | 112,451 | 140,613 | 147,686 | 151,176 | 150,871 | 154,885 | 142,818 | 153,829 | 159,891 | 157,548 |
| <b>absolute change</b>     | -388    | 2,805   | 1,399   | -4,866  | -3,737  | -924    | -795    | -925    | 3,074   | 2,482   | -315    | -1,654  |
| <b>relative change</b>     | -0.31%  | 2.35%   | 1.24%   | -3.46%  | -2.53%  | -0.61%  | -0.53%  | -0.60%  | 2.15%   | 1.61%   | -0.20%  | -1.05%  |
| <b>Biodiesel</b>           |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  | 3,503   | 8,130   | 8,813   | 7,445   | 7,697   | 8,022   | 8,664   | 8,747   | 12,076  | 10,851  | 11,042  | 11,598  |



|                                                       | 2003    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    |
|-------------------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>previous submission</b>                            | 3,631   | 8,310   | 8,796   | 7,811   | 8,005   | 8,240   | 8,513   | 8,786   | 11,682  | 10,787  | 11,092  | 11,677  |
| <b>absolute change</b>                                | -128    | -180    | 17.2    | -366    | -307    | -218    | 152     | -38.8   | 394     | 63.8    | -50.5   | -78.8   |
| <b>relative change</b>                                | -3.52%  | -2.16%  | 0.20%   | -4.68%  | -3.84%  | -2.65%  | 1.78%   | -0.44%  | 3.37%   | 0.59%   | -0.45%  | -0.67%  |
| <b>Gasoline</b>                                       |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>                             | 13,330  | 11,196  | 6,892   | 6,304   | 6,447   | 6,677   | 6,903   | 7,397   | 7,339   | 7,844   | 8,087   | 8,041   |
| <b>previous submission</b>                            | 13,384  | 10,969  | 6,811   | 6,545   | 6,627   | 6,729   | 6,934   | 7,465   | 7,194   | 7,718   | 8,104   | 8,126   |
| <b>absolute change</b>                                | -53.5   | 227     | 80.9    | -241    | -180    | -51.1   | -30.2   | -67.9   | 145     | 126     | -17.2   | -85.2   |
| <b>relative change</b>                                | -0.40%  | 2.07%   | 1.19%   | -3.68%  | -2.72%  | -0.76%  | -0.44%  | -0.91%  | 2.01%   | 1.63%   | -0.21%  | -1.05%  |
| <b>Biogasoline</b>                                    |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>                             |         | 76.1    | 266     | 265     | 272     | 276     | 301     | 309     | 325     | 362     | 374     | 382     |
| <b>previous submission</b>                            |         | 76.0    | 265     | 264     | 271     | 275     | 300     | 308     | 323     | 364     | 376     | 384     |
| <b>absolute change</b>                                |         | 0.03    | 1.73    | 1.07    | 1.03    | 0.95    | 1.01    | 1.92    | 2.38    | -1.74   | -1.82   | -1.93   |
| <b>relative change</b>                                |         | 0.04%   | 0.66%   | 0.40%   | 0.38%   | 0.34%   | 0.34%   | 0.63%   | 0.74%   | -0.48%  | -0.48%  | -0.50%  |
| <b>Natural Gas</b>                                    |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>                             | 283     | 355     | 792     | 894     | 831     | 801     | 761     | 621     | 453     | 554     | 435     | 346     |
| <b>previous submission</b>                            | 283     | 355     | 1,225   | 704     | 620     | 409     | 475     | 304     | 276     | 493     | 427     | 339     |
| <b>absolute change</b>                                | 0.00    | 0.00    | -434    | 190     | 211     | 393     | 286     | 317     | 178     | 61.3    | 7.18    | 6.81    |
| <b>relative change</b>                                | 0.00%   | 0.0%    | -35.4%  | 27.0%   | 34.0%   | 96.1%   | 60.3%   | 104%    | 64.4%   | 12.4%   | 1.68%   | 2.01%   |
| <b>Biomethane</b>                                     |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>                             |         |         | 38,9    | 190     | 211     | 249     | 210     | 305     | 305     | 239     | 265     | 351     |
| <b>previous submission</b>                            |         |         | 38,9    | 190     | 211     | 249     | 210     | 304     | 304     | 240     | 211     | 257     |
| <b>absolute change</b>                                |         |         | 0.00    | -0.02   | -0.01   | 0.00    | 0.02    | 0.86    | 0.61    | -0.44   | 54.5    | 93.5    |
| <b>relative change</b>                                |         |         | 0.00%   | -0.01%  | -0.01%  | 0.00%   | 0.01%   | 0.28%   | 0.20%   | -0.18%  | 25.9%   | 36.4%   |
| <b>TOTAL ENERGY INPUT allocated to NFR 1.A.3.b ii</b> |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>                             | 142,234 | 141,750 | 130,652 | 150,846 | 159,407 | 166,277 | 166,915 | 171,338 | 166,390 | 176,161 | 179,777 | 176,611 |
| <b>previous submission</b>                            | 142,804 | 138,898 | 129,587 | 156,127 | 163,420 | 167,077 | 167,302 | 172,050 | 162,596 | 173,431 | 180,100 | 178,330 |
| <b>absolute change</b>                                | -570    | 2,852   | 1,065   | -5,281  | -4,013  | -800    | -386    | -712    | 3,794   | 2,731   | -323    | -1,720  |
| <b>relative change</b>                                | -0.40%  | 2.05%   | 0.82%   | -3.38%  | -2.46%  | -0.48%  | -0.23%  | -0.41%  | 2.33%   | 1.57%   | -0.18%  | -0.96%  |



Due to the variety of tier3 **emission factors** applied, it is not possible to display any changes in these data sets in a comprehensible way.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

<sup>1), 4)</sup> Knörr et al. (2025a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2025.

<sup>2)</sup> Keller et al. (2019): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: [https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8\\_HBEFA41\\_Development\\_Report.pdf](https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8_HBEFA41_Development_Report.pdf) - Dokumentation, Bern, 2019.

<sup>3)</sup> Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: [https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0\\_HBEFA42\\_Update\\_Documentation.pdf](https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf) - Dokumentation, Bern, 2022.

<sup>5), 6), 8)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i-@@download/file>; Table 3-82: Heavy metal emission factors for all vehicle categories in ppm/wt fuel; Copenhagen, 2023.

<sup>7)</sup> Rentz et al. (2008): Otto Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung, Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte 01/2008, <http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer>; Dessau-Roßlau, 2008

<sup>3)</sup> During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

specific inventory data  
for 1.A.3.b iii - Heavy-  
duty Vehicles and Buses

[illegible]

| NO <sub>x</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|------|
| <div> <div>L/-</div> <div>key source by Level only</div> </div> <div> <div>-/T</div> <div>key source by Trend only</div> </div> <div> <div>L/T</div> <div>key source by both Level and Trend</div> </div> <div> <div>-/-</div> <div>no key source for this pollutant</div> </div> <div> <div>IE</div> <div>emission of specific pollutant Included Elsewhere (i.e. in another category)</div> </div> <div> <div>NE</div> <div>emission of specific pollutant Not Estimated (yet)</div> </div> <div> <div>NA</div> <div>specific pollutant not emitted from this source or activity = Not Applicable</div> </div> <div> <div>*</div> <div>no analysis done</div> </div> |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |

## Methodology

### Activity data

Specific consumption data for heavy-duty vehicles (trucks and lorries) and buses are generated within TREMOD <sup>1)</sup>. - The following tables provide an overview of annual amounts of fuels consumed by these vehicles in Germany.

Table 1: Annual energy input allocated to trucks and lorries, in terajoules

|                                      | 1990           | 1995           | 2000           | 2005           | 2010           | 2015           | 2016           | 2017           | 2018           | 2019           | 2020           | 2021           | 2022           | 2023           | 2024           |
|--------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| <b>thereof: Buses</b>                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |
| Diesel oil                           | 54,436         | 46,012         | 45,864         | 37,361         | 43,243         | 46,964         | 47,664         | 47,999         | 45,863         | 47,228         | 31,292         | 31,780         | 35,906         | 36,590         | 35,973         |
| Biodiesel                            |                | 71.8           | 508            | 2,490          | 3,347          | 2,576          | 2,549          | 2,563          | 2,648          | 2,683          | 2,590          | 2,206          | 2,484          | 2,722          | 2,202          |
| Natural Gas (CNG & LNG)              |                |                |                | 1,144          | 1,331          | 1,209          | 1,079          | 975            | 874            | 690            | 482            | 544            | 416            | 316            | 103            |
| Biomethane                           |                |                |                |                | 65.4           | 257            | 274            | 303            | 241            | 339            | 324            | 235            | 254            | 320            | 539            |
| Petroleum                            |                | 610            | 414            |                |                |                |                |                |                |                |                |                |                |                |                |
| <b>Σ Buses</b>                       | <b>54,436</b>  | <b>46,694</b>  | <b>46,786</b>  | <b>40,995</b>  | <b>47,987</b>  | <b>51,007</b>  | <b>51,567</b>  | <b>51,840</b>  | <b>49,626</b>  | <b>50,940</b>  | <b>34,688</b>  | <b>34,765</b>  | <b>39,060</b>  | <b>39,948</b>  | <b>38,817</b>  |
| <b>thereof: Trucks &amp; Lorries</b> |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |
| Diesel oil                           | 382,343        | 507,393        | 590,498        | 451,903        | 499,541        | 537,900        | 537,993        | 564,015        | 550,475        | 553,949        | 539,809        | 525,845        | 502,084        | 465,589        | 454,272        |
| Biodiesel                            |                | 792            | 6,542          | 30,116         | 38,669         | 29,502         | 28,768         | 30,112         | 31,781         | 31,471         | 44,681         | 36,504         | 34,741         | 34,638         | 27,811         |
| Natural Gas (CNG & LNG)              |                |                |                |                |                | 268            | 237            | 264            | 348            | 857            | 1,908          | 4,629          | 5,105          | 4,663          | 1,685          |
| Biomethane                           |                |                |                |                |                | 56.9           | 60.2           | 82.0           | 96.0           | 421            | 1,284          | 1,999          | 3,116          | 4,725          | 8,861          |
| <b>Σ Trucks &amp; Lorries</b>        | <b>382,343</b> | <b>508,185</b> | <b>597,040</b> | <b>482,019</b> | <b>538,209</b> | <b>567,727</b> | <b>567,059</b> | <b>594,473</b> | <b>582,700</b> | <b>586,699</b> | <b>587,682</b> | <b>568,977</b> | <b>545,045</b> | <b>509,615</b> | <b>492,628</b> |
| <b>HDVs over-all</b>                 |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |
| Diesel oil                           | 436,779        | 553,405        | 636,362        | 489,264        | 542,783        | 584,864        | 585,657        | 612,014        | 596,338        | 601,177        | 571,101        | 557,625        | 537,989        | 502,179        | 490,245        |
| Biodiesel                            |                | 863            | 7,050          | 32,606         | 42,016         | 32,078         | 31,317         | 32,675         | 34,429         | 34,154         | 47,271         | 38,710         | 37,225         | 37,360         | 30,013         |
| Natural Gas (CNG & LNG)              |                |                |                | 1,144          | 1,331          | 1,477          | 1,317          | 1,240          | 1,221          | 1,548          | 2,390          | 5,174          | 5,521          | 4,979          | 1,788          |
| Biomethane                           |                |                |                |                | 65.4           | 314            | 334            | 385            | 337            | 760            | 1,608          | 2,233          | 3,370          | 5,045          | 9,400          |
| Petroleum                            |                | 610            | 414            |                |                |                |                |                |                |                |                |                |                |                |                |
| <b>Σ 1.A.3.b iii</b>                 | <b>436,779</b> | <b>554,878</b> | <b>643,825</b> | <b>523,014</b> | <b>586,196</b> | <b>618,733</b> | <b>618,625</b> | <b>646,313</b> | <b>632,326</b> | <b>637,639</b> | <b>622,370</b> | <b>603,742</b> | <b>584,105</b> | <b>549,563</b> | <b>531,446</b> |

source: TREMOD 2025 <sup>2)</sup>

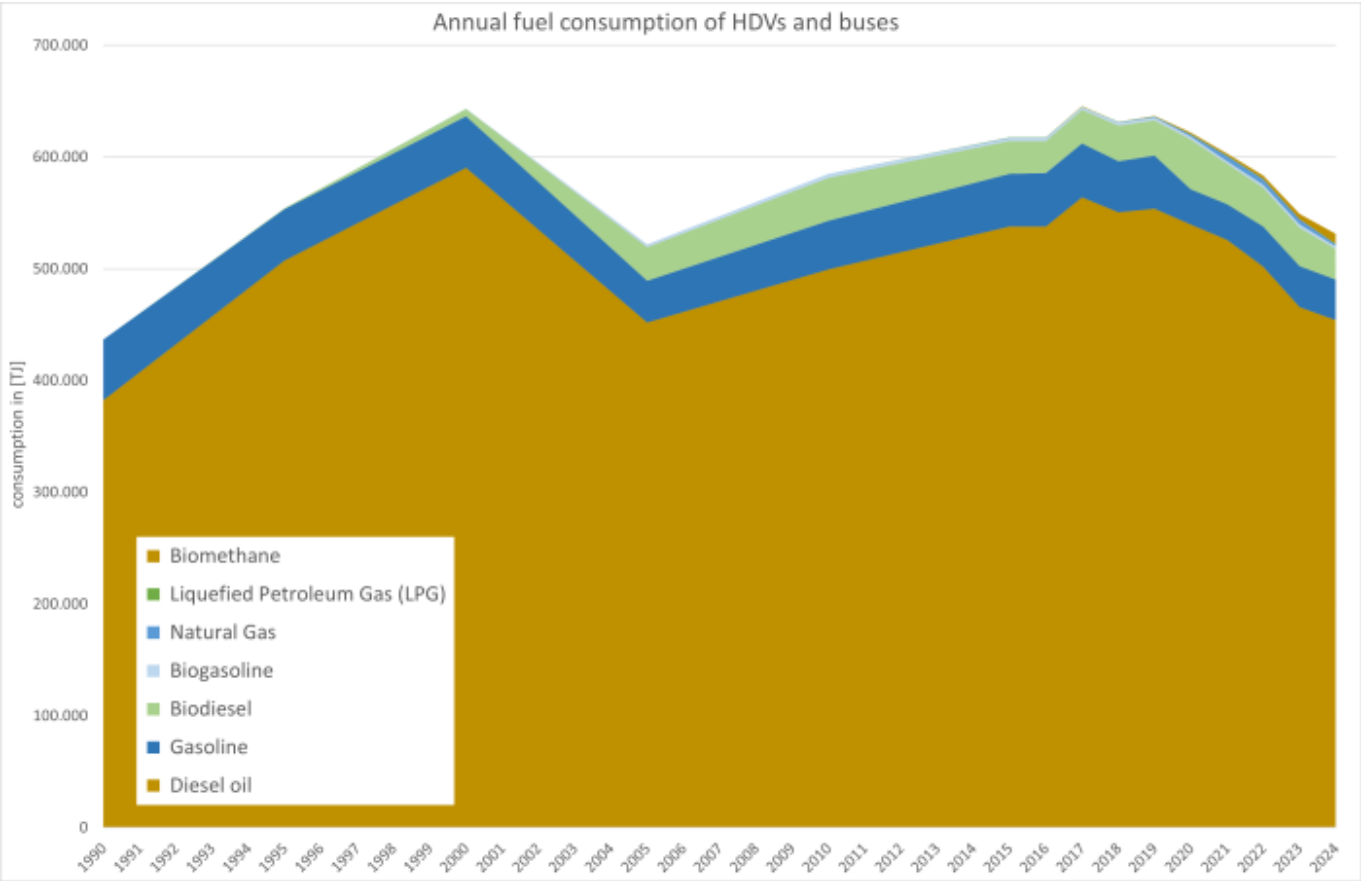
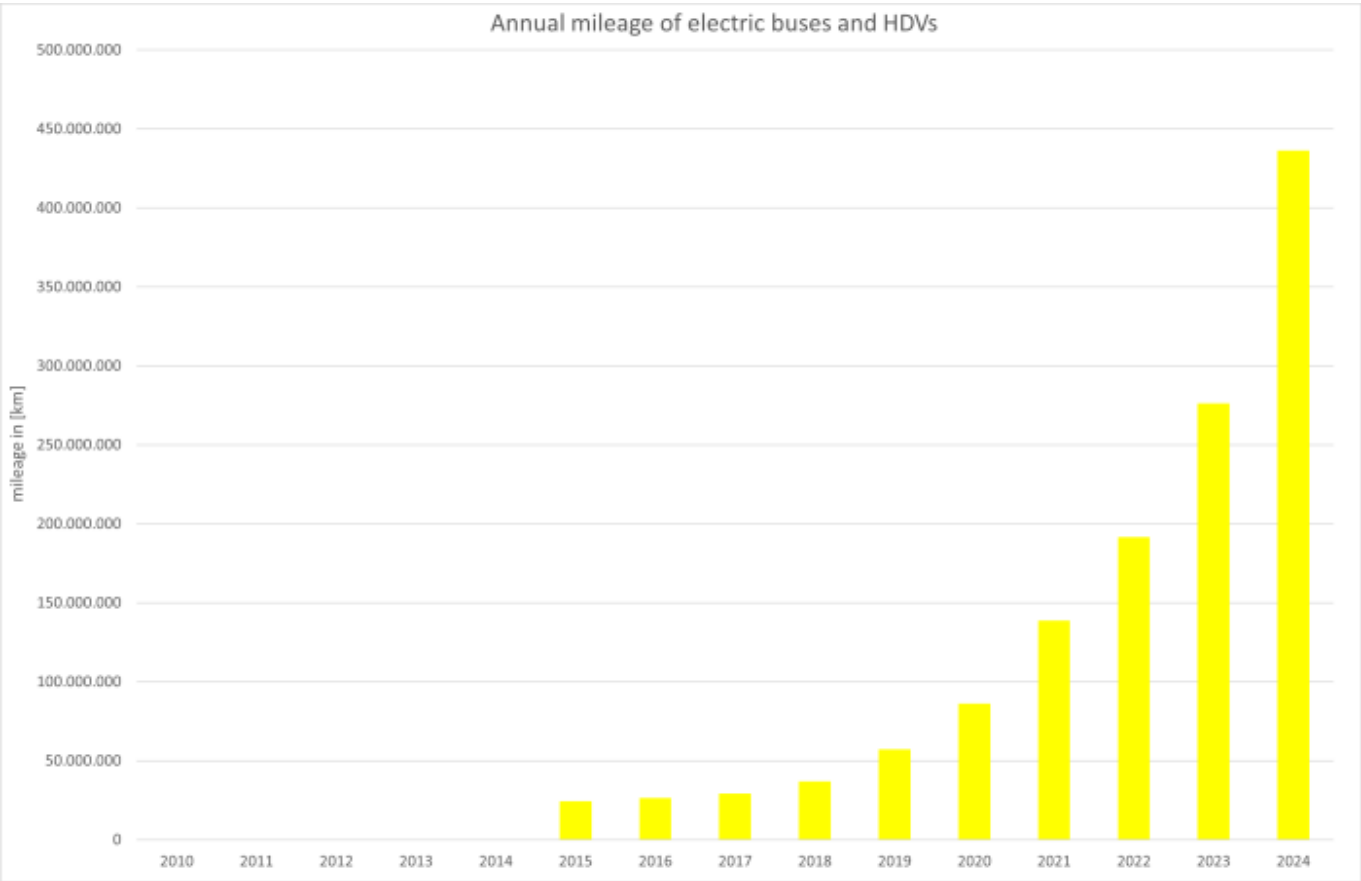


Table 2: Annual mileage of electric buses and trucks, as of 2012, in [km]

|          | 2012       | 2013       | 2014       | 2015       | 2016       | 2017       | 2018        | 2019        | 2020       | 2021       | 2022       |
|----------|------------|------------|------------|------------|------------|------------|-------------|-------------|------------|------------|------------|
| e-buses  | 8,487,329  | 9,845,760  | 10,876,484 | 12,152,006 | 16,751,955 | 22,652,366 | 44,265,774  | 73,852,059  | 17,202,225 | 18,705,389 | 46,436,326 |
| e-trucks | 16,622,028 | 17,425,009 | 19,612,927 | 26,890,851 | 44,461,550 | 70,219,861 | 103,916,921 | 132,048,817 | 53,621,255 | 53,399,717 | 78,383,254 |





For more information on mileage and abrasion-related emissions, please refer to sub-chapters on emissions from [tyre & brake wear and road abrasion](#).

## Emission factors

The majority of emission factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, versions 4.1 and 4.2) <sup>3)</sup>, <sup>4)</sup> where they are provided on a tier3 level mostly and processed within the TREMOD software used by the party <sup>5)</sup>.

However, it is not possible to present these tier3 values in a comprehensible way here.



With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>4)</sup>

For **heavy-metal** (other than lead from leaded gasoline) **exhaust-emissions**, default emission factors from the 2025 Update of the 2023 EMEP/EEA Guidebook, Table 3-82: "Heavy metal emission factors for all vehicle categories in ppm/wt fuel" have been applied <sup>6)</sup> (see super-ordinate chapter [here](#) ). (see table 3 below)

In contrast, for **exhaust PAH emissions**, emission factors were derived from tier2 values as provided in EMEP/EEA guidebook 2023 (Update 2025) <sup>7)</sup>, Table 3-18: "Tier 2 exhaust emission factors for passenger cars, NFR 1.A.3.b.i". (see table 4 below)

Regarding PCDD/F, tier1 EF from (Rentz et al., 2008) <sup>8)</sup> are used instead.

The following table provides an overview of the EF. Please note, that the values for heavy-metal (in [g/TJ]) and PAH (in [mg/TJ]) exhaust-emissions have been estimated from the EMEP/EEA defaults provided in [ppm/wt].

Table 3: Overview of tier1 EF applied for heavy metals and POPs exhaust-emissions

|                                                                                                                                               | Pb     | Cd    | Hg    | As    | Cr    | Cu    | Ni    | Se    | Zn    | PCDD/F   |
|-----------------------------------------------------------------------------------------------------------------------------------------------|--------|-------|-------|-------|-------|-------|-------|-------|-------|----------|
|                                                                                                                                               | [g/TJ] |       |       |       |       |       |       |       |       | [µg/km]  |
| Diesel oil                                                                                                                                    | 0.012  | 0.001 | 0.123 | 0.002 | 0.198 | 0.133 | 0.005 | 0.002 | 0.419 |          |
| Biodiesel                                                                                                                                     | 0.013  | 0.001 | 0.142 | 0.003 | 0.228 | 0.153 | 0.005 | 0.003 | 0.483 |          |
| CNG & Biomethane                                                                                                                              | NE     | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    |          |
| Petroleum                                                                                                                                     | NE     | NE    | NE    | NE    | NE    | NE    | NE    | NE    | NE    |          |
| all fuels: buses                                                                                                                              |        |       |       |       |       |       |       |       |       | 0.000019 |
| all fuels: trucks & lorries                                                                                                                   |        |       |       |       |       |       |       |       |       | 0.000016 |
| NOTE: values derived from the EMEP/EEA defaults provided Table 3-82: “Heavy metal emission factors for all vehicle categories in ppm/wt fuel” |        |       |       |       |       |       |       |       |       |          |
| <sup>1</sup> Biodiesel: values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel               |        |       |       |       |       |       |       |       |       |          |



For **exhaust emissions of Benzo[a]Pyrene, Benzo[b]Fluoranthene, Benzo[k]Fluoranthene, and Indeno[1,2,3-c,d]Pyrene** the tier2 emission factors as provided in the 2023 EMEP/EEA Guidebook, Chapter 1.A.3.b i-iv (Update 2025),

Table 3-18 have been implemented with the current submission, upgrading the estimation to a tier2 approach.

Table 4: Tier2 emission factors for exhaust PAH emissions from road vehicles, in [g/km]

| FUEL                                                                                          | EURO standard  | B[a]P       | B[b]F       | B[k]F       | I[123cd]P   | PAH 1-4     |
|-----------------------------------------------------------------------------------------------|----------------|-------------|-------------|-------------|-------------|-------------|
| diesel fuels                                                                                  | as of pre-EURO | 0.000000900 | 0.000005450 | 0.000006090 | 0.000001400 | 0.000013840 |
| natural gas, biomethane                                                                       | as of EUROV    | 0.000000050 | 0.000000080 | 0.000000040 | 0.000000030 | 0.000000200 |
| additional info:<br><a href="#">derivation of tier2 EF</a><br><a href="#">(MS Excel file)</a> |                |             |             |             |             |             |

Discussion of emission trends

Table 5: Outcome of Key Category Analysis

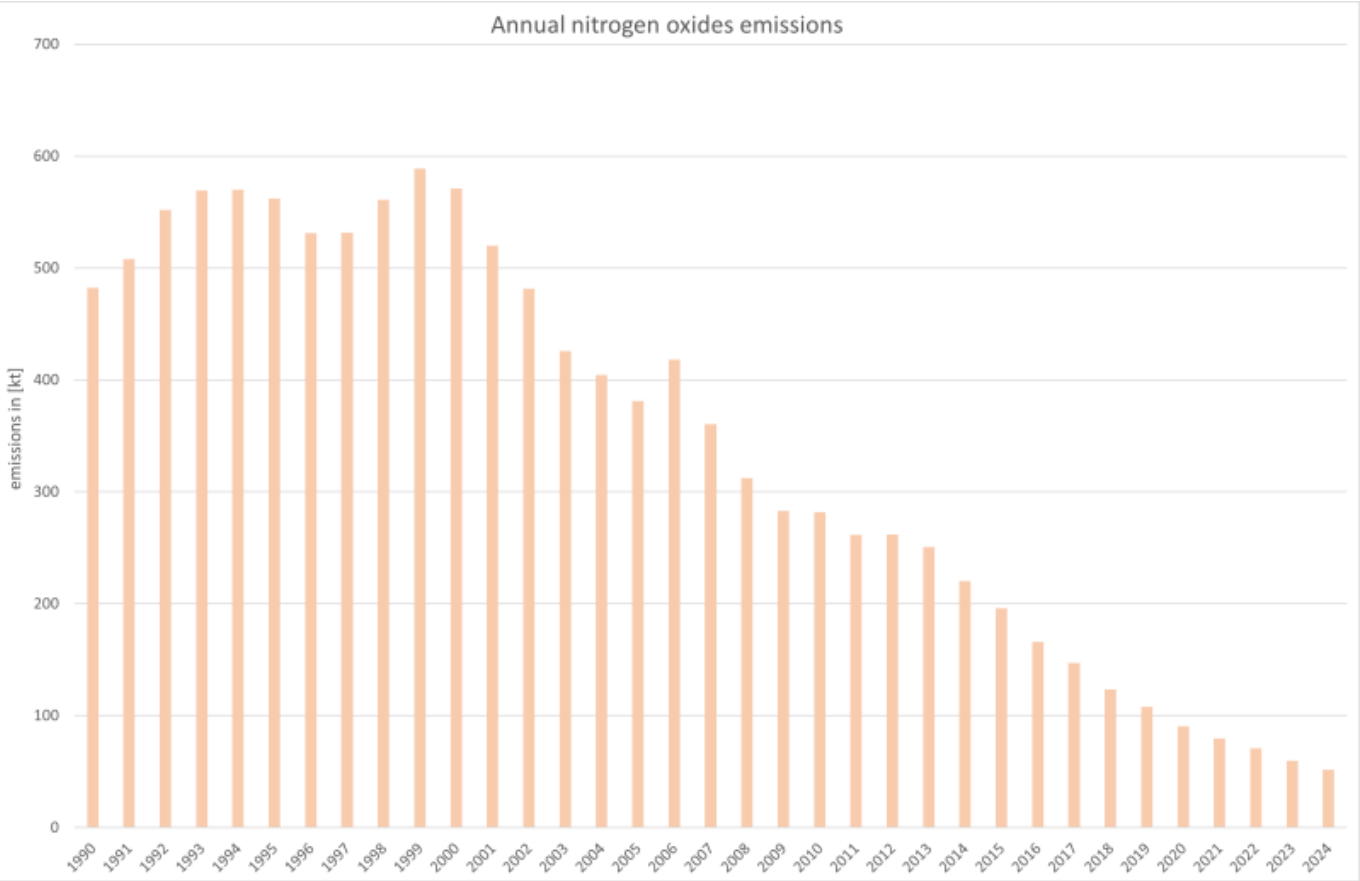
|                 |                            |                   |                  |     |
|-----------------|----------------------------|-------------------|------------------|-----|
| key source for: | NO <sub>x</sub>            | PM <sub>2.5</sub> | PM <sub>10</sub> | BC  |
| by:             | Level & Trend of emissions | L/T               | L/T              | L/T |

Nitrogen oxides

Until 2005, NO<sub>x</sub> emissions followed mileage and fuel consumption. Since 2006, in contrast to nearly unchanged fuel consumption, emissions have decreased due to controlled catalytic-converter use and engine improvements resulting from continual tightening of emissions laws.

Table 6: EURO norms and their effect on limit values of NO<sub>x</sub> emissions from diesel heavy-duty vehicles, in [g/kWh]

| pre-Euro | Euro I | Euro II | Euro III | Euro IV | Euro V | Euro VI <sup>9)10)</sup> |
|----------|--------|---------|----------|---------|--------|--------------------------|
| 14.4     | 8 / 9  | 7       | 5        | 3.5     | 2      | 0.4 / 0.46               |

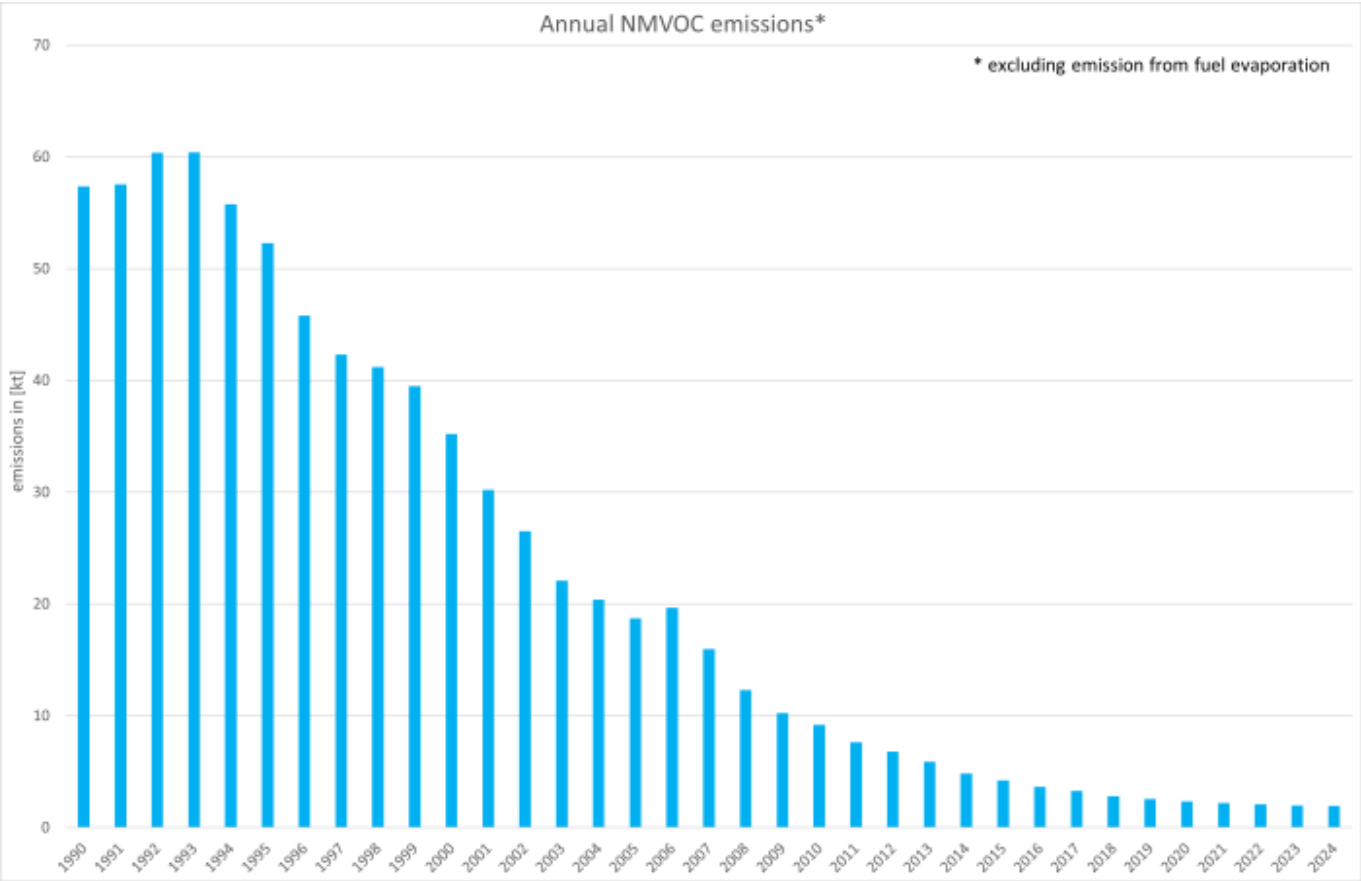


Non-methane volatile organic compounds (NMVOC) and carbon monoxide

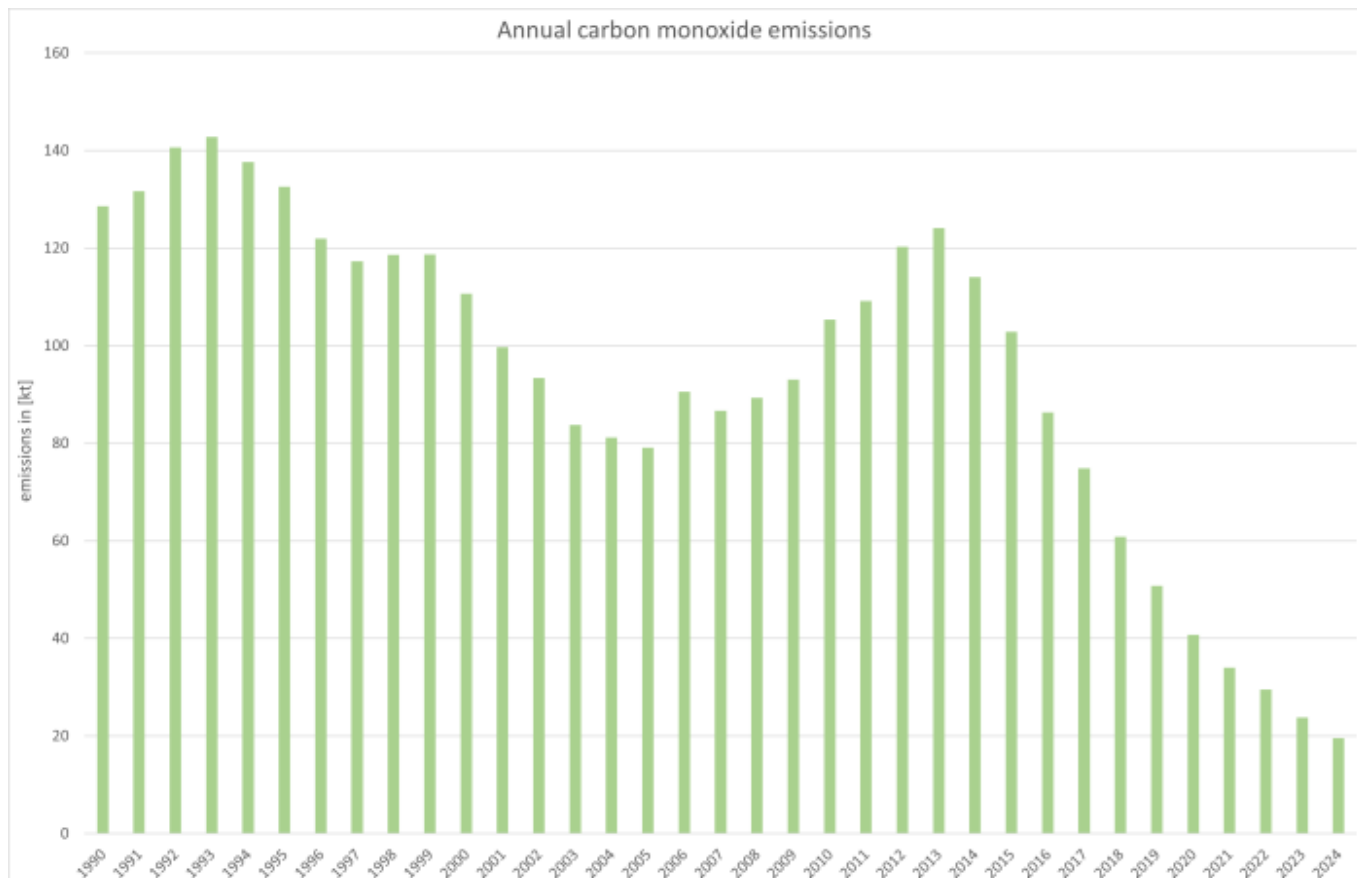
Since 1990, exhaust emissions of **NMVOC** and **carbon monoxide** have decreased sharply due to catalytic-converter use and engine improvements resulting from ongoing tightening of emissions laws and improved fuel quality.

Table 7: EURO norms and their effect on limit values of CO emissions from diesel heavy-duty vehicles, in [g/kWh]

| pre-Euro | Euro I    | Euro II | Euro III | Euro IV | Euro V | Euro VI <sup>1)</sup> |
|----------|-----------|---------|----------|---------|--------|-----------------------|
| 11.2     | 4.5 / 4.9 | 4       | 2.1      | 1.5     | 1.5    | 1.5                   |

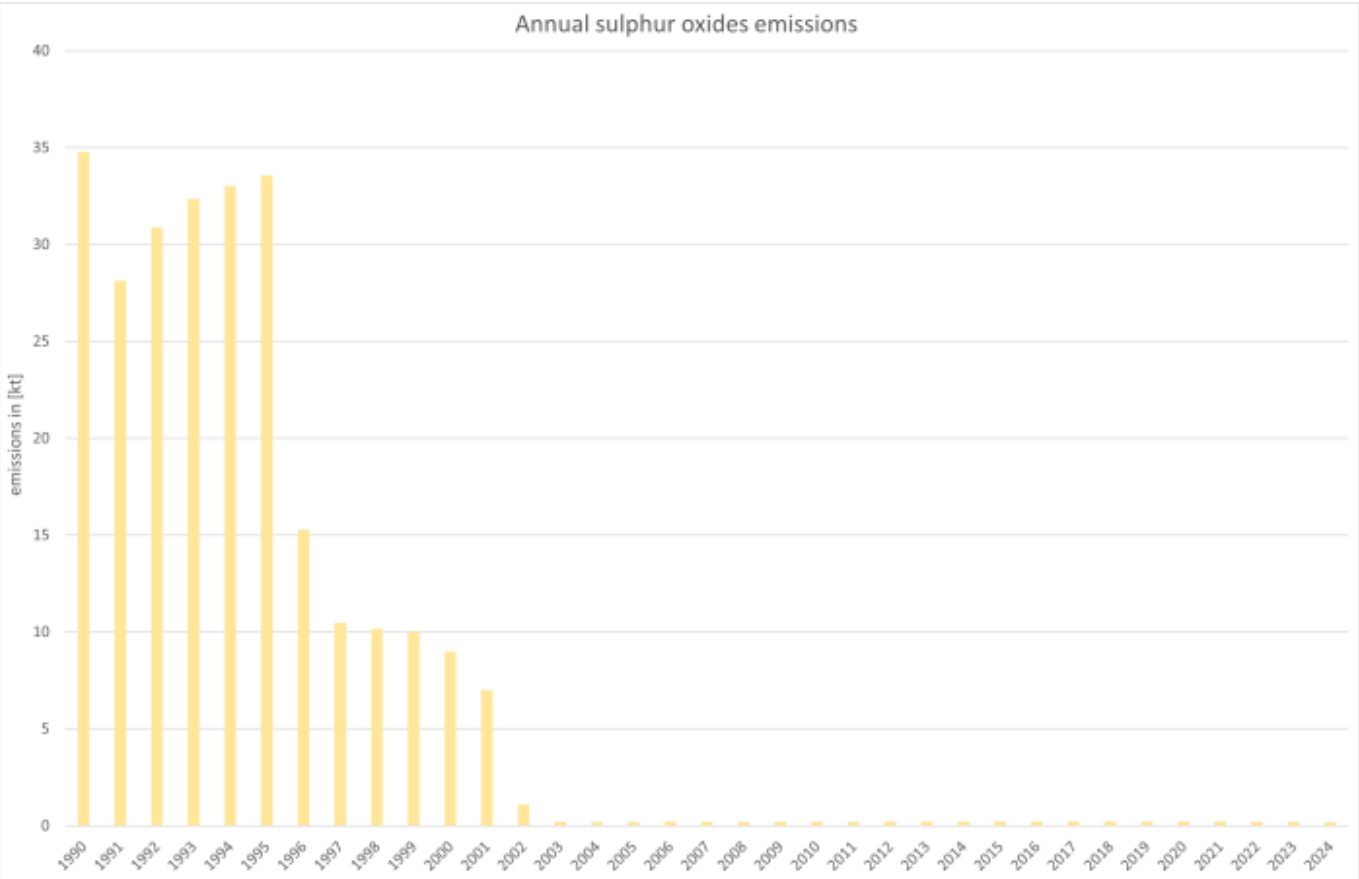






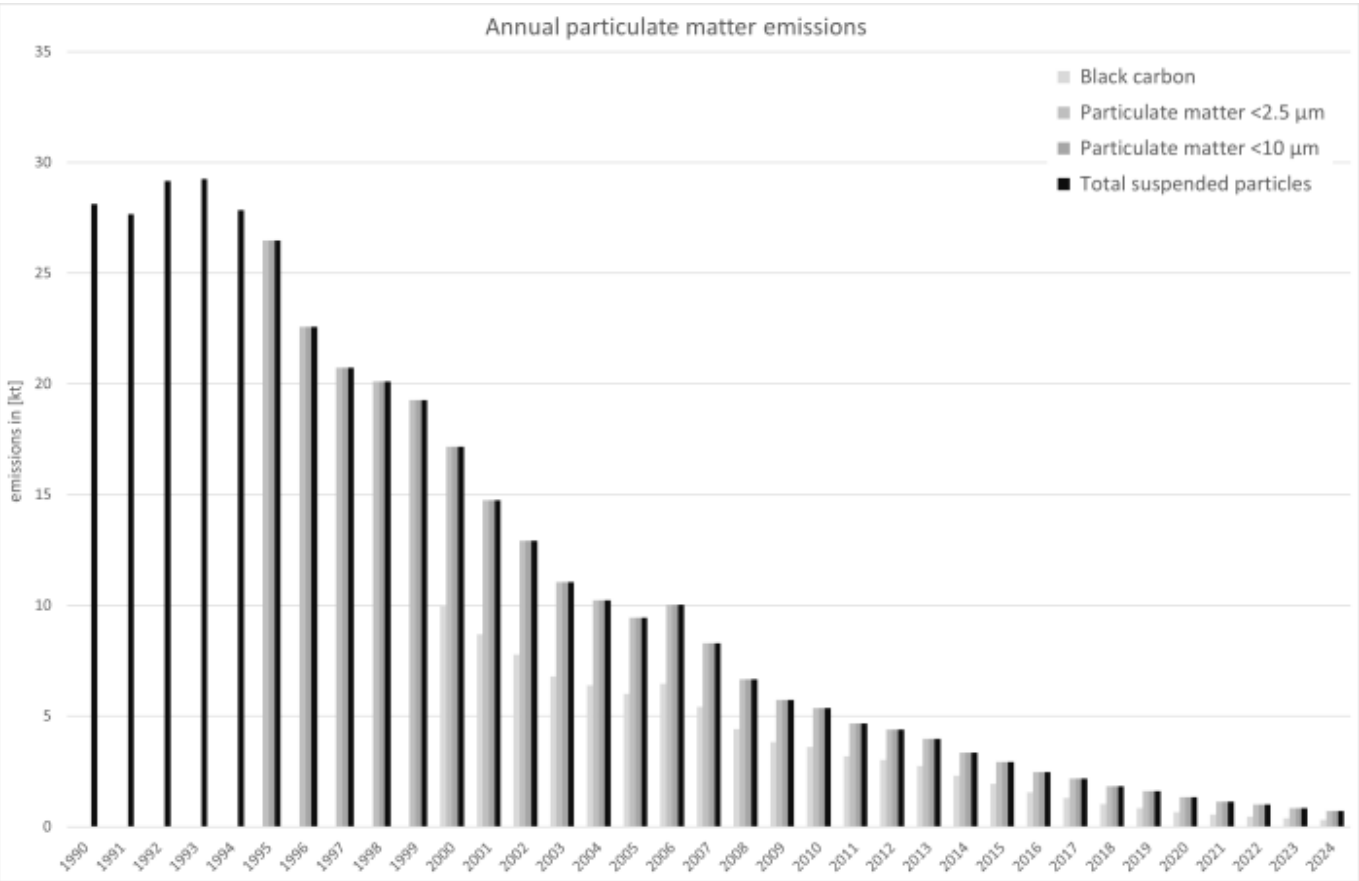
### Ammonia and sulphur dioxide

As for the entire road transport sector, the trends for **sulphur dioxide** (SO<sub>2</sub>) and **ammonia** (NH<sub>3</sub>) exhaust emissions from heavy duty vehicles show characteristics different from those shown above: Here, the strong dependence on increasing fuel qualities (sulphur content) leads to an cascaded downward trend of SO<sub>2</sub> emissions , influenced only slightly by increases in fuel consumption and mileage. For **ammonia** emissions the increasing use of catalytic converters in gasoline driven cars in the 1990s lead to a steep increase whereas both the technical development of the converters and the ongoing shift from gasoline to diesel cars resulted in decreasing emissions in the following years.



Particulate matter & Black carbon

As for all reported exhaust PM emissions from mobile diesel vehicles the Party assumes that nearly all particles emitted are within the PM<sub>2.5</sub> range, resulting in similar emission values for PM<sub>2.5</sub>, PM<sub>10</sub>, and TSP.



## Recalculations

Compared to submission 2025, recalculations in **activity data** result mainly from the biennial routine revision of the National Energy Balances (NEB) as of 2003, the finalization of the NEB for 2023 and the annual routine revision of the underlying model (TREMOT).

Table 8: Revised energy input data 2003-2023, in terajoules [TJ]

|                            | 2003    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    |
|----------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>Diesel oil</b>          |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  | 526,164 | 489,264 | 542,783 | 584,864 | 585,657 | 612,014 | 596,338 | 601,177 | 571,101 | 557,625 | 537,989 | 502,179 |
| <b>previous submission</b> | 489,987 | 453,716 | 537,434 | 539,210 | 544,857 | 575,273 | 626,967 | 595,144 | 599,097 | 559,214 | 537,439 | 506,335 |
| <b>absolute change</b>     | 36,177  | 35,549  | 5,349   | 45,654  | 40,800  | 36,741  | -30,629 | 6,032   | -27,996 | -1,589  | 550     | -4,156  |
| <b>relative change</b>     | 7.38%   | 7.84%   | 1.00%   | 8.47%   | 7.49%   | 6.39%   | -4.89%  | 1.01%   | -4.67%  | -0.28%  | 0.10%   | -0.82%  |
| <b>Biodiesel</b>           |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  | 14,730  | 32,606  | 42,016  | 32,078  | 31,317  | 32,675  | 34,429  | 34,154  | 47,271  | 38,710  | 37,225  | 37,360  |
| <b>previous submission</b> | 14,175  | 31,633  | 42,037  | 29,953  | 29,532  | 31,357  | 35,376  | 33,759  | 49,002  | 39,215  | 37,283  | 37,527  |
| <b>absolute change</b>     | 556     | 973     | -21.2   | 2,125   | 1,785   | 1,318   | -947    | 395     | -1,731  | -505    | -58.2   | -167    |
| <b>relative change</b>     | 3.92%   | 3.08%   | -0.05%  | 7.09%   | 6.04%   | 4.20%   | -2.68%  | 1.17%   | -3.53%  | -1.29%  | -0.16%  | -0.44%  |
| <b>Natural Gas</b>         |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  | 910     | 1,144   | 1,331   | 1,477   | 1,317   | 1,240   | 1,221   | 1,548   | 2,390   | 5,174   | 5,521   | 4,979   |
| <b>previous submission</b> | 910     | 1,144   | 2,060   | 1,162   | 982     | 632     | 763     | 760     | 1,454   | 4,607   | 5,468   | 4,974   |
| <b>absolute change</b>     | 0.00    | 0.00    | -729    | 315     | 334     | 607     | 459     | 788     | 936     | 567     | 53.7    | 4.96    |
| <b>relative change</b>     | 0.00%   | 0.00%   | -35.4%  | 27.1%   | 34.1%   | 96.1%   | 60.2%   | 103.7%  | 64.4%   | 12.3%   | 1.0%    | 0.10%   |
| <b>Biomethane</b>          |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  |         |         | 65.4    | 314     | 334     | 385     | 337     | 760     | 1,608   | 2,233   | 3,370   | 5,045   |
| <b>previous submission</b> |         |         | 65.4    | 314     | 334     | 385     | 337     | 760     | 1,606   | 2,240   | 2,696   | 3,769   |
| <b>absolute change</b>     |         |         | 0.00    | 0.11    | 0.06    | -0.02   | -0.12   | 0.34    | 2.75    | -6.54   | 674     | 1,276   |
| <b>relative change</b>     |         |         | 0.00%   | 0.03%   | 0.02%   | 0.00%   | -0.04%  | 0.05%   | 0.17%   | -0.29%  | 25.0%   | 33.8%   |
| <b>Σ 1.A.3.b iii</b>       |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  | 541,804 | 523,014 | 586,196 | 618,733 | 618,625 | 646,313 | 632,326 | 637,639 | 622,370 | 603,742 | 584,105 | 549,563 |
| <b>previous submission</b> | 505,072 | 486,493 | 581,597 | 570,639 | 575,706 | 607,647 | 663,443 | 630,423 | 651,159 | 605,275 | 582,886 | 552,605 |
| <b>absolute change</b>     | 36,733  | 36,522  | 4,599   | 48,094  | 42,920  | 38,666  | -31,117 | 7,216   | -28,789 | -1,533  | 1,220   | -3,042  |
| <b>relative change</b>     | 7.27%   | 7.51%   | 0.79%   | 8.43%   | 7.46%   | 6.36%   | -4.69%  | 1.14%   | -4.42%  | -0.25%  | 0.21%   | -0.55%  |



Due to the variety of tier3 **emission factors** applied, it is not possible to display any changes in these data sets in a comprehensible way.



For **pollutant-specific information on recalculated emission estimates**



for Base Year and 2023, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

<sup>1), 2), 5)</sup> Knörr et al. (2025a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2025.

<sup>3)</sup> Keller et al. (2019): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: [https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8\\_HBEFA41\\_Development\\_Report.pdf](https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8_HBEFA41_Development_Report.pdf) - Dokumentation, Bern, 2019.

<sup>4)</sup> Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: [https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0\\_HBEFA42\\_Update\\_Documentation.pdf](https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf) - Dokumentation, Bern, 2022.

<sup>6), 7)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i-@@download/file>; Table 3-82: Heavy metal emission factors for all vehicle categories in ppm/wt fuel; Copenhagen, 2023.

<sup>8)</sup> Rentz et al. (2008): Otto Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung, Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte 01/2008, <http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer>; Dessau-Roßlau, 2008

<sup>9)</sup> EU (2009): REGULATION (EC) No 595/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information and amending Regulation (EC) No 715/2007 and Directive 2007/46/EC and repealing Directives 80/1269/EEC, 2005/55/EC and 2005/78/EC - <https://data.europa.eu/eli/reg/2009/595/oj>; Brussels, 18 June 2009.

<sup>10)</sup> EU (2011): REGULATIONS COMMISSION REGULATION (EU) No 582/2011 implementing and amending Regulation (EC) No 595/2009 of the European Parliament and of the Council with respect to emissions from heavy duty vehicles (Euro VI) and amending Annexes I and III to Directive 2007/46/EC of the European Parliament and of the Council; <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0582&qid=1744032326229>; <http://data.europa.eu/eli/reg/2011/582/oj>; Brussels, 25 May 2011

<sup>4)</sup> During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

## 1.A.3.b iv - Road Transport: Mopeds & Motorcycles



specific inventory data  
for NFR 1.A.3.b iv -  
Mopeds & Motorcycles

### Short description

In sub-categories *1.A.3.b iv - Road Transport: Mopeds & Motorcycles* emissions from fuel combustion in motorised two-wheelers are reported.



| Category Code                                                                             | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.3.b iv                                                                                | T1, T3                               | NS, M | CS, M, D |
| Method(s) applied                                                                         |                                      |       |          |
| D                                                                                         | Default                              |       |          |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |          |
| T2                                                                                        | Tier 2*                              |       |          |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |          |
| C                                                                                         | CORINAIR                             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| M                                                                                         | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| (source for) Activity Data                                                                |                                      |       |          |
| NS                                                                                        | National Statistics                  |       |          |
| RS                                                                                        | Regional Statistics                  |       |          |
| IS                                                                                        | International Statistics             |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| As                                                                                        | Associations, business organisations |       |          |
| Q                                                                                         | specific Questionnaires (or surveys) |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |
| (source for) Emission Factors                                                             |                                      |       |          |
| D                                                                                         | Default (EMEP Guidebook)             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP                                                                                 | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|
| -/-             | -/-    | -/-             | -/-             | -/-               | -/-              | -/-                                                                                 | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | NE  | -/-  |
|                 |        |                 |                 |                   | L/-              | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | -/T              | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | L/T              | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | -/-              | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | IE               | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | NE               | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | NA               | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 |                   | *                | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |

## Methodology

### Activity data

Specific consumption data for mopeds and motorcycles is generated within the TREMOD model (Knörr, 2025a) <sup>1)</sup>.

The following table provides an overview of annual amounts of gasoline fuels consumed by motorized two-wheelers in Germany.

Table 1: Annual fuel consumption of mopeds and motorcycles, in terajoules

|                                                       | 1990          | 1995          | 2000          | 2005          | 2010          | 2015          | 2016          | 2017          | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
|-------------------------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>MOPEDS</b>                                         |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| <b>Gasoline</b>                                       | 5,143         | 3,206         | 3,223         | 3,156         | 3,344         | 3,311         | 3,320         | 3,260         | 3,230         | 3,272         | 3,432         | 3,029         | 3,240         | 2,857         | 2,860         |
| <b>Biogasoline</b>                                    |               |               |               | 21.4          | 129           | 139           | 140           | 135           | 141           | 137           | 152           | 140           | 150           | 136           | 134           |
| <b>Σ Mopeds</b>                                       | <b>5,143</b>  | <b>3,206</b>  | <b>3,223</b>  | <b>3,177</b>  | <b>3,474</b>  | <b>3,450</b>  | <b>3,460</b>  | <b>3,394</b>  | <b>3,371</b>  | <b>3,408</b>  | <b>3,584</b>  | <b>3,168</b>  | <b>3,390</b>  | <b>2,993</b>  | <b>2,994</b>  |
| <b>MOTORCYCLES</b>                                    |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| <b>Gasoline</b>                                       | 17,206        | 16,634        | 20,995        | 20,280        | 15,859        | 15,154        | 15,429        | 15,608        | 15,013        | 15,205        | 15,484        | 13,702        | 14,499        | 12,851        | 12,895        |
| <b>Biogasoline</b>                                    |               |               |               | 138           | 613           | 638           | 650           | 644           | 655           | 636           | 686           | 632           | 670           | 610           | 603           |
| <b>Σ Motorcycles</b>                                  | <b>17,206</b> | <b>16,634</b> | <b>20,995</b> | <b>20,418</b> | <b>16,472</b> | <b>15,792</b> | <b>16,079</b> | <b>16,252</b> | <b>15,668</b> | <b>15,841</b> | <b>16,169</b> | <b>14,335</b> | <b>15,169</b> | <b>13,461</b> | <b>13,499</b> |
| <b>MOTORIZED 2-WHEELERS: Mopeds &amp; Motorcycles</b> |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| <b>Gasoline</b>                                       | 22,350        | 19,840        | 24,218        | 23,436        | 19,203        | 18,465        | 18,749        | 18,867        | 18,244        | 18,476        | 18,916        | 16,731        | 17,739        | 15,708        | 15,755        |
| <b>Biogasoline</b>                                    |               |               |               | 159           | 742           | 777           | 790           | 779           | 796           | 773           | 837           | 772           | 820           | 746           | 737           |
| <b>Σ 1.A.3.b iv</b>                                   | <b>22,350</b> | <b>19,840</b> | <b>24,218</b> | <b>23,595</b> | <b>19,945</b> | <b>19,242</b> | <b>19,539</b> | <b>19,646</b> | <b>19,040</b> | <b>19,250</b> | <b>19,753</b> | <b>17,503</b> | <b>18,559</b> | <b>16,454</b> | <b>16,492</b> |

source: TREMOD <sup>2)</sup>

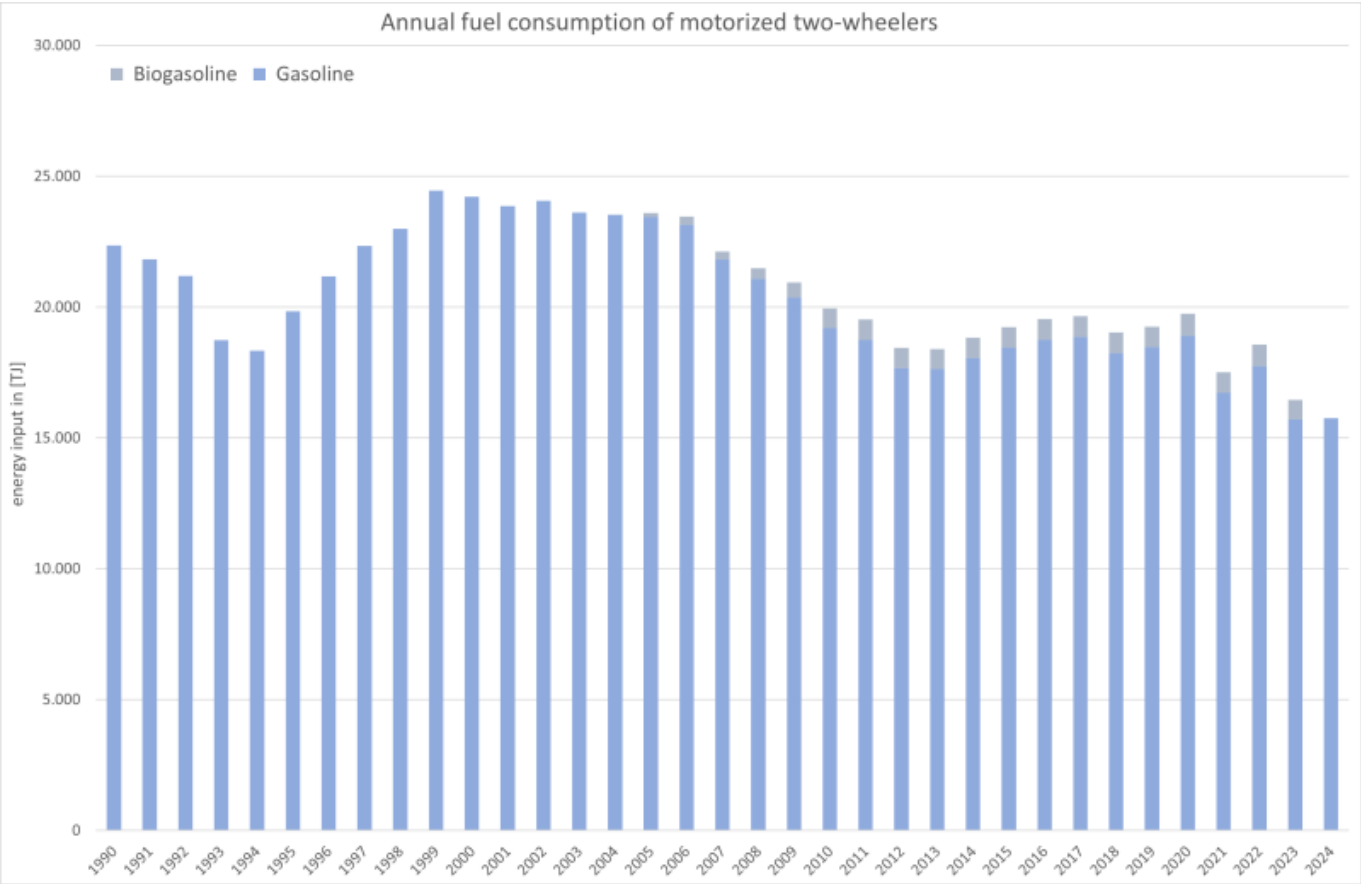
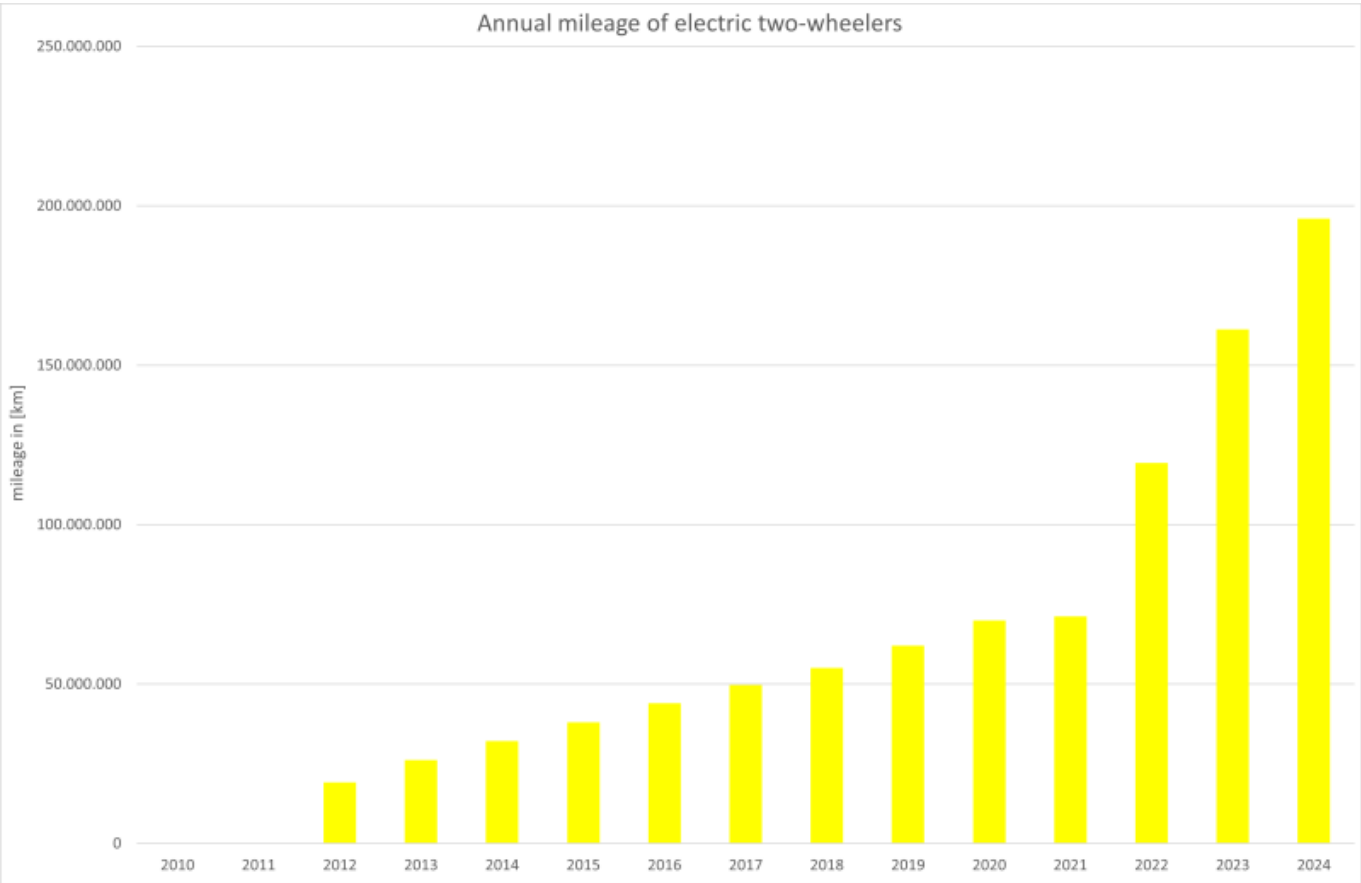


Table 2: Annual mileage of electric mopeds and motorcycles, as of 2012, in [km]

|               | 2012       | 2013       | 2014       | 2015       | 2016       | 2017       | 2018       | 2019       | 2020       | 2021       | 2022       |
|---------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| e-mopeds      | 4,893,858  | 7,081,254  | 8,286,339  | 9,349,275  | 10,473,058 | 11,684,376 | 12,603,833 | 14,405,436 | 17,202,225 | 18,705,389 | 46,436,326 |
| e-motorcycles | 14,288,683 | 19,091,180 | 23,913,479 | 28,696,175 | 33,478,875 | 38,107,442 | 42,529,340 | 47,620,933 | 53,621,255 | 53,399,717 | 78,383,254 |





For further information on mileage as well as abrasion-related emissions, please refer to sub-chapters on emissions from [tyre & brake wear and road abrasion](#).

## Emission factors

The majority of emission factors for exhaust emissions from road transport are taken from the 'Handbook Emission Factors for Road Transport' (HBEFA, versions 4.1 and 4.2) <sup>3)</sup> <sup>4)</sup> where they are provided on a tier3 level mostly and processed within TREMOD <sup>5)</sup>.

However, it is not possible to present these highly specific tier3 values in a comprehensible way here.



With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>5)</sup>

For heavy-metal (other than lead from leaded gasoline) and PAH exhaust-emissions, default emission factors from the 2023 EMEP/EEA Guidebook (EMEP/EEA, 2023), Table 3-86 have been applied <sup>6)</sup> (see super-ordinate chapter [here](#) ).

Regarding PCDD/F, tier1 EF from (Rentz et al., 2008) <sup>7)</sup> are used instead.

The following table provides an overview of the EF. Please note, that the values for heavy-metal (in [g/TJ]) and PAH (in [mg/TJ]) exhaust-emissions have been estimated from the EMEP/EEA defaults provided in [ppm/wt].

Table 3: Overview of tier1 EF applied for heavy metals and POPs exhaust-emissions

| As     | Cd    | Cr    | Cu    | Hg    | Ni    | Pb    | Se    | Zn    | PCDD/F    |
|--------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|
| [g/TJ] |       |       |       |       |       |       |       |       | [µg/km]   |
| 0.007  | 0.005 | 0.145 | 0.103 | 0.200 | 0.053 | 0.037 | 0.005 | 0.758 | 0.0000027 |

For **exhaust emissions of Benzo[a]Pyrene, Benzo[b]Fluoranthene, Benzo[k]Fluoranthene, and Indeno[1,2,3-c,d]Pyrene** the tier2 emission factors as provided in the 2023 EMEP/EEA Guidebook, Chapter 1.A.3.b i-iv (Update 2025), Tables 3-18 have been implemented with the current submission, upgrading the estimation to a tier2 approach.

Table: tier2 emission factors for exhaust PAH emissions from road vehicles, in [g/km]

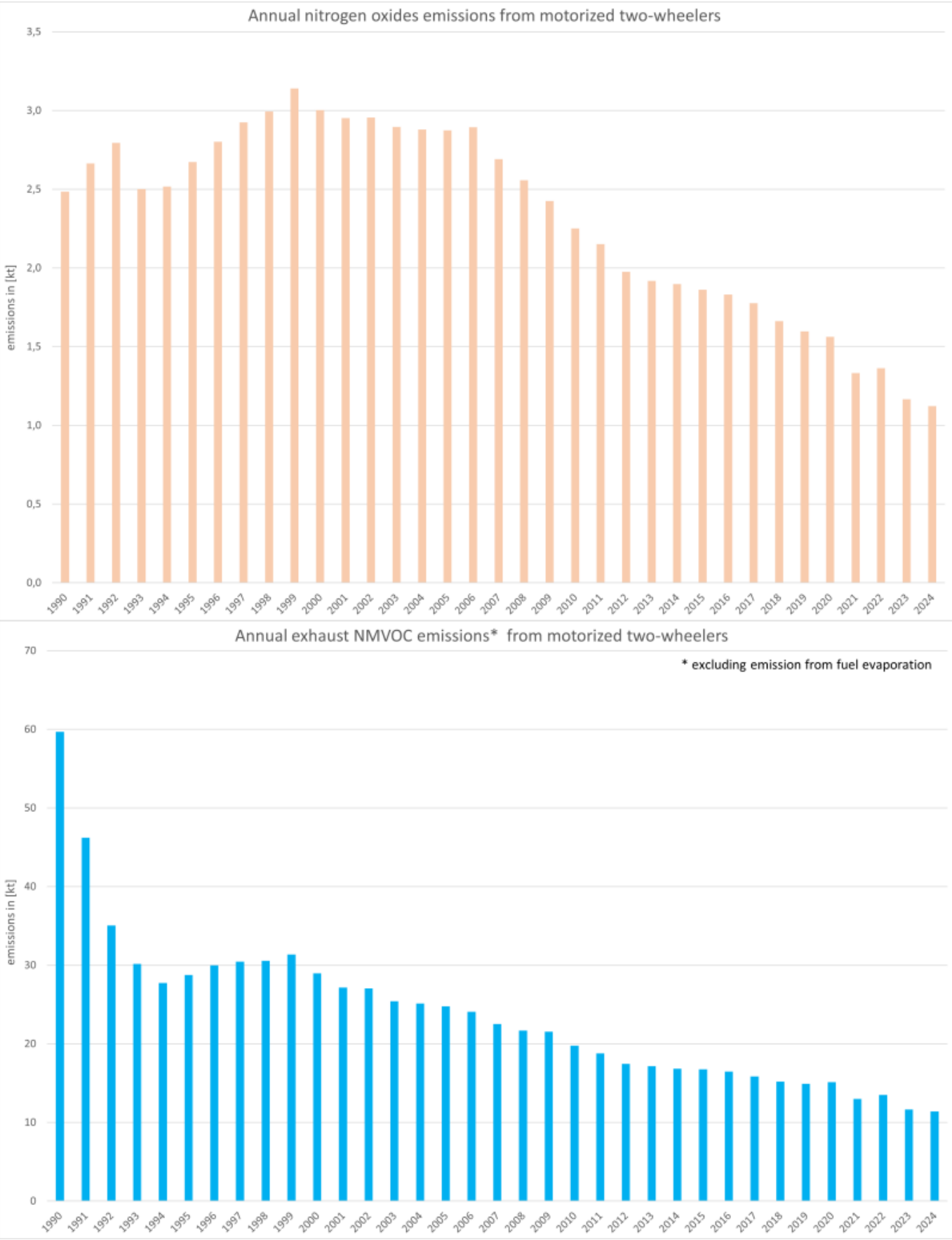
| FUEL                                                                          | EURO standard  | B[a]P       | B[b]F       | B[k]F       | I[123cd]P   | PAH 1-4     |
|-------------------------------------------------------------------------------|----------------|-------------|-------------|-------------|-------------|-------------|
| Mopeds                                                                        | pre-EURO       | 0.000000096 | 0.000000176 | 0.000000060 | 0.000000206 | 0.000000538 |
|                                                                               | as of EURO1    | 0.000000064 | 0.000000072 | 0.000000052 | 0.000000078 | 0.000000266 |
| Motorcycles                                                                   | as of pre-EURO | 0.000000320 | 0.000000360 | 0.000000260 | 0.000000390 | 0.000001330 |
| additional info:<br><a href="#">derivation of tier2 EF</a><br>(MS Excel file) |                |             |             |             |             |             |

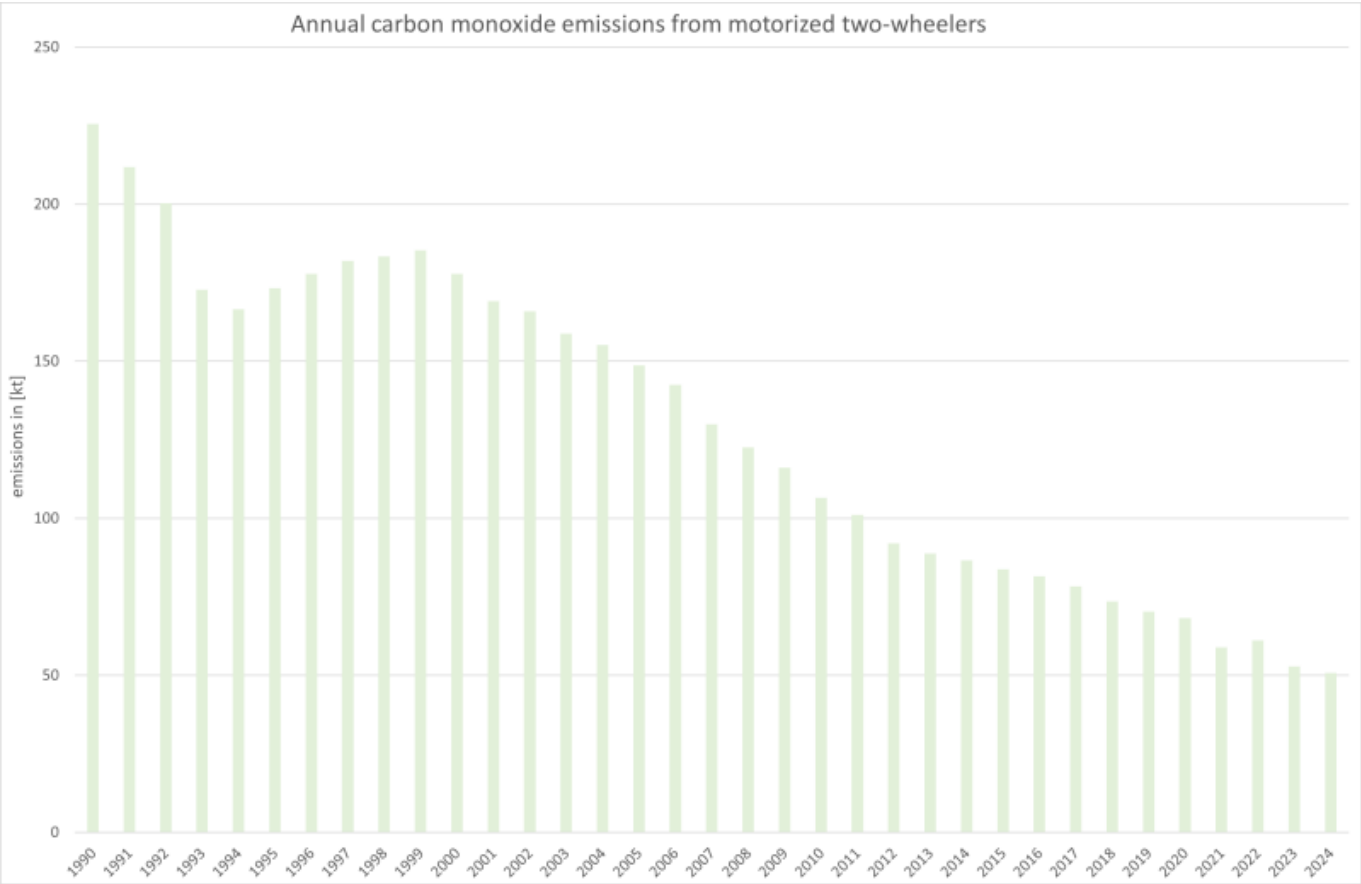
## Discussion of emission trends

**NFR 1.A.3.b iv** is no key category.

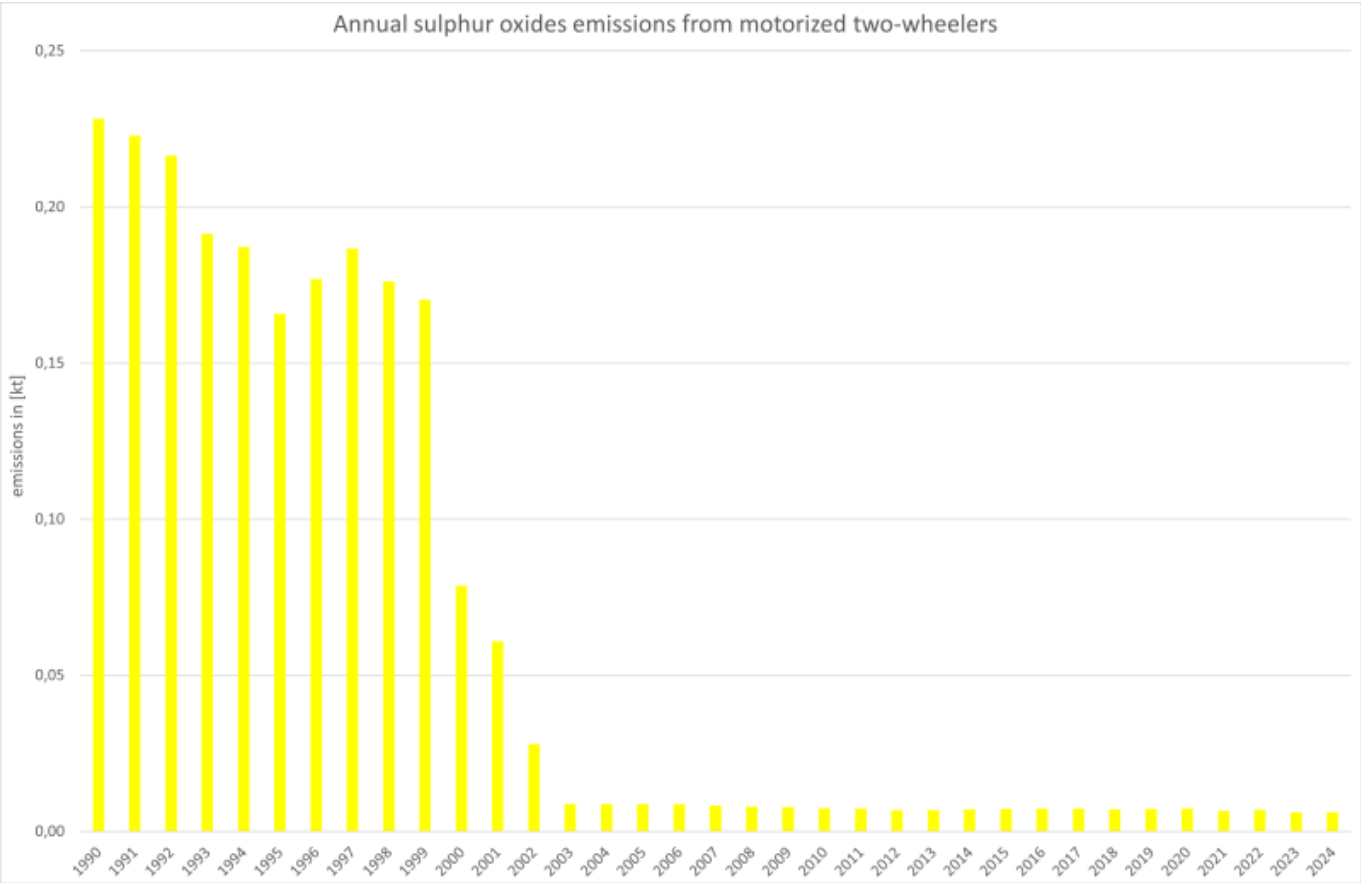
Since 1990, exhaust emissions of NO<sub>x</sub>, NMVOC, and CO have decreased due to technical improvements.



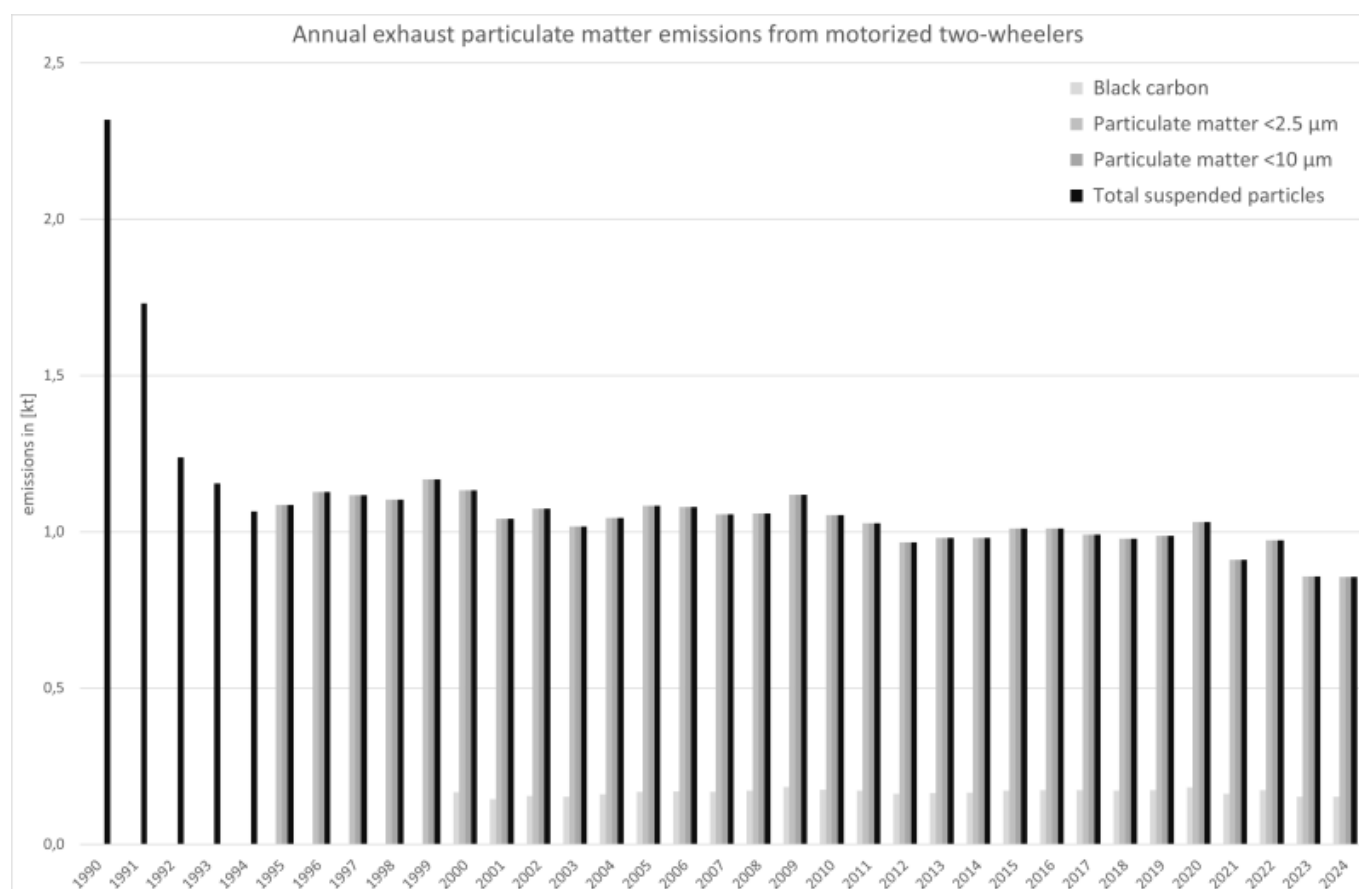




As for the entire road transport sector, the trends for **sulphur dioxide** exhaust emissions from two-wheelers shows characteristics very different from those shown above: Here, the strong dependence on increasing fuel qualities (sulphur content) leads to an cascaded downward trend of emissions , influenced only slightly by increases in fuel consumption and mileage.



**Particle emissions** result from the combustion of gasoline and bioethanol. Here, due to the assumption that nearly all TSP emitted is formed by particles in the PM<sub>2.5</sub> range, similar estimates are provided for all three fractions. (Exception: Until 1997, additional TSP emissions from use of leaded gasoline are included.)



## Recalculations

As described earlier, compared to the previous submission, recalculations result mainly from the biennial routine revision of the National Energy Balances for all years as of 2003:

Table 4: Revised energy input data 2003-2023, in terajoules [TJ]

|                                                       | 2003   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|-------------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>GASOLINE</b>                                       |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission                                    | 23,608 | 23,436 | 19,203 | 18,465 | 18,749 | 18,867 | 18,244 | 18,476 | 18,916 | 16,731 | 17,739 | 15,708 |
| previous submission                                   | 23,703 | 22,960 | 18,978 | 19,171 | 19,273 | 19,012 | 18,324 | 18,606 | 18,579 | 16,509 | 17,831 | 15,845 |
| absolute change                                       | -94.8  | 476    | 225    | -706   | -524   | -144   | -79.8  | -130   | 337    | 222    | -91.2  | -137   |
| relative change                                       | -0.40% | 2.07%  | 1.19%  | -3.68% | -2.72% | -0.76% | -0.44% | -0.70% | 1.81%  | 1.34%  | -0.51% | -0.87% |
| <b>BIOGASOLINE</b>                                    |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission                                    |        | 159    | 742    | 777    | 790    | 779    | 796    | 773    | 837    | 772    | 820    | 746    |
| previous submission                                   |        | 159    | 737    | 774    | 787    | 776    | 793    | 767    | 833    | 778    | 826    | 748    |
| absolute change                                       |        | 0.06   | 4.83   | 3.13   | 2.98   | 2.68   | 2.68   | 6.44   | 4.51   | -5.91  | -6.47  | -2.39  |
| relative change                                       |        | 0.04%  | 0.66%  | 0.40%  | 0.38%  | 0.34%  | 0.34%  | 0.84%  | 0.54%  | -0.76% | -0.78% | -0.32% |
| <b>TOTAL ENERGY INPUT allocated to NFR 1.A.3.b iv</b> |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission                                    | 23,608 | 23,595 | 19,945 | 19,242 | 19,539 | 19,646 | 19,040 | 19,250 | 19,753 | 17,503 | 18,559 | 16,454 |
| previous submission                                   | 23,703 | 23,119 | 19,715 | 19,945 | 20,060 | 19,788 | 19,117 | 19,373 | 19,412 | 17,287 | 18,657 | 16,594 |
| absolute change                                       | -94.8  | 476    | 230    | -703   | -521   | -142   | -77.1  | -124   | 341    | 216    | -97.7  | -140   |
| relative change                                       | -0.40% | 2.06%  | 1.17%  | -3.52% | -2.60% | -0.72% | -0.40% | -0.64% | 1.76%  | 1.25%  | -0.52% | -0.84% |





Due to the variety of tier3 **emission factors** applied, it is not possible to display any changes in these data sets in a comprehensible way.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

<sup>1), 2), 5)</sup> Knörr et al. (2025a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2025.

<sup>3)</sup> Keller et al. (2019): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: [https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8\\_HBEFA41\\_Development\\_Report.pdf](https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8_HBEFA41_Development_Report.pdf) - Dokumentation, Bern, 2019.

<sup>4)</sup> Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: [https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0\\_HBEFA42\\_Update\\_Documentation.pdf](https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf) - Dokumentation, Bern, 2022.

<sup>6)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/@download/file>; Table 3-82: Heavy metal emission factors for all vehicle categories in ppm/wt fuel; Copenhagen, 2023.

<sup>7)</sup> Rentz et al. (2008): Otto Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung, Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte 01/2008, <http://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer>; Dessau-Roßlau, 200 [(EU2013> EU (2013): Verordnung (EU) Nr. 168/2013 des Europäischen Parlaments und des Rates vom 15. Januar 2013 über die Genehmigung und Marktüberwachung von zwei- oder dreirädrigen und vierrädrigen Fahrzeugen; <http://data.europa.eu/eli/reg/2013/168/oj>; 15. Januar 2013, Straßburg

<sup>5)</sup>

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.



NFR-specific inventory data

In category 1.A.3.b v - Road Transport: Gasoline evaporation fugitive emissions from the evaporation of gasoline from road vehicles are reported.

| <b>NFR Code</b>                                                                           | <b>Method</b>                        | <b>AD</b> | <b>EF</b> |
|-------------------------------------------------------------------------------------------|--------------------------------------|-----------|-----------|
| 1.A.3.b v                                                                                 | T2                                   | NS, M     | CS, M     |
| <b>Method(s) applied</b>                                                                  |                                      |           |           |
| <b>D</b>                                                                                  | Default                              |           |           |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |           |           |
| <b>T2</b>                                                                                 | Tier 2*                              |           |           |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |           |           |
| <b>C</b>                                                                                  | CORINAIR                             |           |           |
| <b>CS</b>                                                                                 | Country Specific                     |           |           |
| <b>M</b>                                                                                  | Model                                |           |           |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |           |           |
| <b>(source for) Activity Data</b>                                                         |                                      |           |           |
| <b>NS</b>                                                                                 | National Statistics                  |           |           |
| <b>RS</b>                                                                                 | Regional Statistics                  |           |           |
| <b>IS</b>                                                                                 | International Statistics             |           |           |
| <b>PS</b>                                                                                 | Plant Specific                       |           |           |
| <b>As</b>                                                                                 | Associations, business organisations |           |           |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |           |           |
| <b>M</b>                                                                                  | Model / Modelled                     |           |           |
| <b>C</b>                                                                                  | Confidential                         |           |           |
| <b>(source for) Emission Factors</b>                                                      |                                      |           |           |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |           |           |
| <b>CS</b>                                                                                 | Country Specific                     |           |           |
| <b>PS</b>                                                                                 | Plant Specific                       |           |           |
| <b>M</b>                                                                                  | Model / Modelled                     |           |           |
| <b>C</b>                                                                                  | Confidential                         |           |           |

| NO <sub>x</sub> | NMVOC                                                                                        | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|-----------------|----------------------------------------------------------------------------------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA              | L/T                                                                                          | NA              | NA              | NA                | NA               | NA  | NA | NA | NA           | NA   |
| L/-             | key source by <b>L</b> evel only                                                             |                 |                 |                   |                  |     |    |    |              |      |
| -/T             | key source by <b>T</b> rend only                                                             |                 |                 |                   |                  |     |    |    |              |      |
| L/T             | key source by both <b>L</b> evel and <b>T</b> rend                                           |                 |                 |                   |                  |     |    |    |              |      |
| -/-             | no key source for this pollutant                                                             |                 |                 |                   |                  |     |    |    |              |      |
| IE              | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                 |                 |                   |                  |     |    |    |              |      |
| NE              | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                 |                 |                   |                  |     |    |    |              |      |
| NA              | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                 |                 |                   |                  |     |    |    |              |      |
| *               | no analysis done                                                                             |                 |                 |                   |                  |     |    |    |              |      |

Methodology

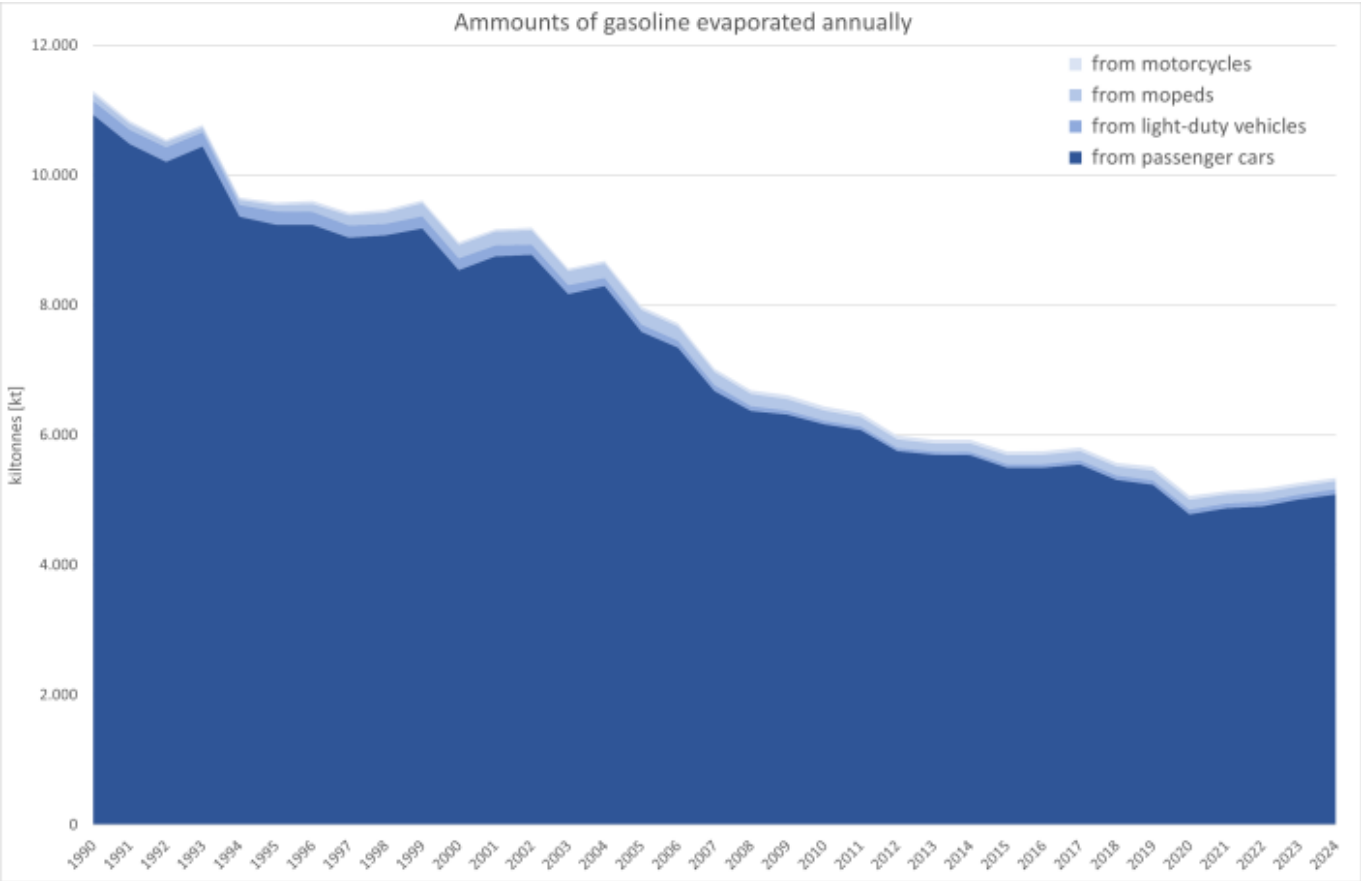
Activity data

Specific data for gasoline evaporation from road vehicles are generated within TREMOD <sup>1)</sup>. - The following table provides an overview of annual amounts of gasoline evaporated from road vehicles in Germany.

Table 1: Annual amount of gasoline evaporated from road vehicles, in kilotonnes

|             | 1990   | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|-------------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| PCs         | 10,926 | 9,239 | 8,537 | 7,587 | 6,162 | 5,499 | 5,497 | 5,548 | 5,309 | 5,236 | 4,782 | 4,874 | 4,902 | 5,013 | 5,088 |
| LDVs        | 213    | 203   | 182   | 115   | 61.9  | 53.1  | 57.6  | 63.5  | 69.3  | 69.2  | 69.3  | 73.8  | 74.6  | 74.5  | 76.1  |
| Mopeds      | 105    | 97.0  | 204   | 222   | 156   | 137   | 140   | 142   | 136   | 148   | 154   | 134   | 141   | 124   | 125   |
| Motorcycles | 50.2   | 42.2  | 43.9  | 48.4  | 59.0  | 59.6  | 59.6  | 58.1  | 58.1  | 59.2  | 62.3  | 55.1  | 58.9  | 52.0  | 52.0  |
| Σ 1.A.3.b v | 11,283 | 9,581 | 8,967 | 7,973 | 6,439 | 5,749 | 5,753 | 5,811 | 5,573 | 5,513 | 5,067 | 5,137 | 5,176 | 5,263 | 5,340 |

source: TREMOD <sup>2)</sup>



(Implied) Emission factors

Tier3 emission factors representing the effect of mitigation technologies are derived from TREMOD.

Table 2: Overview of implied emission factors per vehcile type, in kg/t

|                    | Mitigation      | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|--------------------|-----------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>PCs</b>         | Euro_1_I        | 0.18 | 1.25 | 1.82 | 2.30 | 2.85 | 3.39 | 3.45 | 3.48 | 3.61 | 3.76 | 4.11 | 4.30 | 4.41 | 4.27 | 4.22 |
|                    | Euro_2_II       |      | 1.47 | 1.95 | 2.42 | 2.99 | 4.02 | 4.23 | 4.42 | 4.73 | 5.07 | 5.64 | 5.91 | 6.23 | 6.17 | 6.18 |
|                    | Euro_3_III      |      |      | 1.93 | 2.41 | 2.85 | 3.64 | 3.80 | 3.94 | 4.19 | 4.47 | 5.01 | 5.27 | 5.59 | 5.61 | 5.70 |
|                    | Euro_4_IV       |      |      | 1.67 | 1.91 | 2.11 | 2.77 | 2.89 | 2.99 | 3.17 | 3.37 | 3.78 | 4.00 | 4.22 | 4.24 | 4.34 |
|                    | Euro_5_V        |      |      |      |      | 1.81 | 2.25 | 2.38 | 2.50 | 2.69 | 2.88 | 3.29 | 3.50 | 3.70 | 3.72 | 3.81 |
|                    | Euro_6ab_VI     |      |      |      |      |      |      |      |      | 3.22 | 1.60 | 2.03 | 2.21 | 2.36 | 2.35 | 2.34 |
|                    | Euro_6c_VI      |      |      |      |      |      |      |      | 1.58 | 1.59 | 1.66 | 1.94 | 2.15 | 2.30 | 2.35 | 2.44 |
|                    | Euro_6d_temp_VI |      |      |      |      | 1.99 | 1.79 | 1.84 | 1.88 | 1.98 | 2.14 | 2.51 | 2.73 | 2.92 | 2.95 | 3.03 |
|                    | Euro_6d_VI      |      |      |      |      |      | 1.91 | 1.88 | 1.86 | 1.65 | 1.74 | 2.04 | 2.25 | 2.41 | 2.45 | 2.54 |
|                    | pre-Euro        | 23.6 | 30.5 | 33.9 | 33.5 | 34.9 | 36.8 | 36.9 | 36.8 | 37.4 | 38.2 | 39.8 | 32.2 | 32.9 | 32.8 | 32.9 |
| <b>LDVs</b>        | Euro_1_I        |      |      |      |      |      | 0.14 | 0.13 | 0.13 | 0.57 | 0.68 | 0.75 | 0.82 | 0.95 | 1.06 | 1.19 |
|                    | Euro_2_II       |      |      |      |      |      | 0.75 | 0.73 | 0.71 | 0.69 | 0.78 | 0.90 | 1.00 | 1.13 | 1.23 | 1.32 |
|                    | Euro_3_III      |      |      |      |      |      |      |      |      | 0.50 | 0.58 | 0.67 | 0.75 | 0.85 | 0.95 | 1.06 |
|                    | Euro_4_IV       |      |      |      |      |      | 13.8 | 14.0 | 13.8 | 13.4 | 14.3 | 3.04 | 1.45 | 1.29 | 1.27 | 1.29 |
|                    | Euro_5_V        |      |      |      |      | 0.97 | 1.09 | 1.11 | 1.16 | 1.23 | 1.46 | 1.69 | 1.84 | 2.07 | 2.27 | 2.48 |
|                    | Euro_6ab_VI     |      |      | 0.75 | 1.13 | 1.96 | 2.72 | 2.67 | 2.60 | 2.55 | 2.83 | 3.04 | 3.05 | 3.20 | 3.27 | 3.33 |
|                    | Euro_6c_VI      |      | 0.68 | 0.96 | 1.42 | 2.26 | 2.88 | 2.78 | 2.66 | 2.56 | 2.78 | 2.91 | 2.85 | 2.90 | 2.86 | 2.86 |
|                    | Euro_6d_temp_VI |      |      |      | 0.69 | 1.17 | 1.93 | 1.96 | 2.00 | 2.05 | 2.37 | 2.66 | 2.84 | 3.16 | 3.42 | 3.68 |
|                    | Euro_6d_VI      |      |      |      | 0.87 | 1.62 | 2.32 | 2.31 | 2.30 | 2.31 | 2.62 | 2.90 | 2.99 | 3.23 | 3.39 | 3.57 |
|                    | pre-Euro        | 20.5 | 17.1 | 17.1 | 17.6 | 20.3 | 21.7 | 20.4 | 19.3 | 18.5 | 19.7 | 20.1 | 17.0 | 17.2 | 17.2 | 17.3 |
| <b>Mopeds</b>      | Euro_1_I        |      |      | 0    | 11.0 | 15.3 | 21.3 | 22.2 | 22.7 | 23.7 | 22.5 | 23.5 | 27.6 | 28.4 | 32.6 | 33.0 |
|                    | Euro_2_II       |      |      | 14.2 | 14.0 | 18.8 | 25.7 | 26.7 | 27.2 | 28.3 | 26.7 | 27.6 | 31.9 | 31.9 | 36.0 | 37.0 |
|                    | Euro_4_IV       |      |      |      | 10.7 | 11.0 | 14.3 | 14.6 | 14.8 | 15.6 | 14.8 | 15.5 | 18.3 | 18.7 | 21.7 | 22.2 |
|                    | Euro_5_V        |      |      |      |      |      |      |      |      |      |      |      | 17.8 | 17.5 | 19.8 | 20.3 |
|                    | pre-Euro        |      |      |      |      |      | 14.0 | 14.6 | 15.2 | 15.8 | 14.8 | 15.4 | 18.0 | 18.2 | 21.0 | 22.1 |
| <b>Motorcycles</b> | Euro_1_I        | 23.3 | 24.8 | 16.6 | 17.6 | 23.4 | 31.0 | 31.9 | 32.1 | 33.0 | 30.7 | 31.3 | 35.7 | 35.0 | 39.0 | 39.7 |
|                    | Euro_2_II       |      |      |      | 13.2 | 11.6 | 11.3 | 11.3 | 11.5 | 11.5 | 11.7 | 11.9 | 13.5 | 13.3 | 14.9 | 15.2 |
|                    | Euro_3_III      |      |      | 16.6 | 15.0 | 14.6 | 16.0 | 16.4 | 17.0 | 17.1 | 17.3 | 17.4 | 19.7 | 19.2 | 21.2 | 21.2 |
|                    | Euro_4_IV       |      |      |      |      |      |      |      |      |      |      |      | 9.79 | 9.47 | 10.3 | 10.4 |
|                    | Euro_5_V        |      |      |      |      |      |      |      |      | 9.34 | 9.24 | 9.24 | 10.3 | 10.2 | 11.3 | 11.5 |
|                    | pre-Euro        | 37.4 | 19.2 | 19.9 | 18.0 | 17.4 | 18.1 | 18.3 | 18.8 | 18.8 | 18.8 | 18.8 | 21.1 | 20.3 | 22.3 | 22.0 |

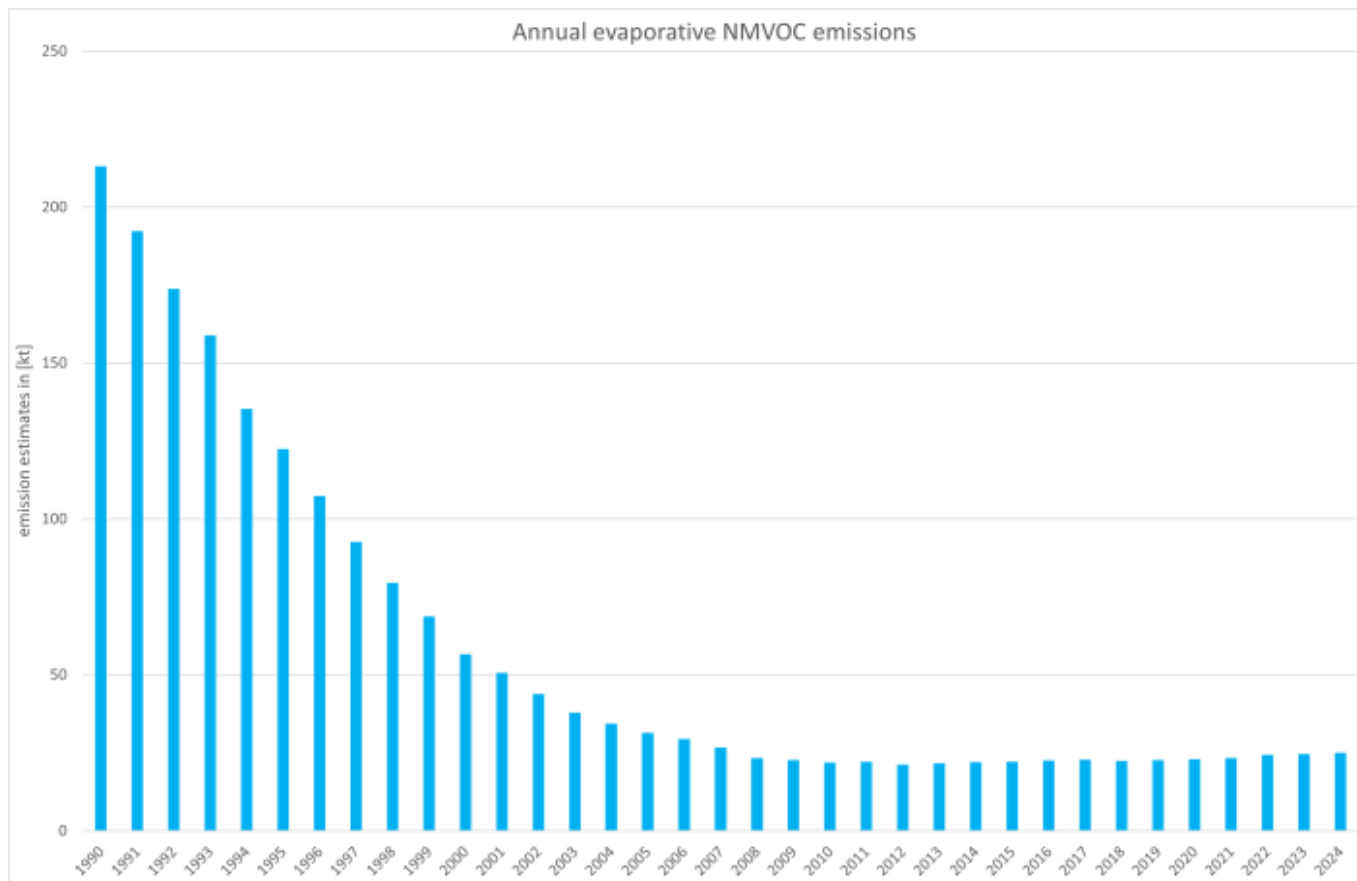
## Discussion of emission trends

Table 3: Outcome of Key Category Analysis

|                 |                            |
|-----------------|----------------------------|
| key source for: | <b>NMVOC</b>               |
| by:             | Level & Trend of emissions |

NFR 1.A.3.b v is key source for emissions of Non-Methane Volatile Organic Compounds - NMVOC.

*(fugitive emissions only; no NMVOC emissions from fuel combustion included)*



Since its maximum level of over 11,000 kilotonnes in 1990, the amount of evaporated gasoline is decreasing - and so are the related NMVOC emissions. The amounts of evaporated gasoline are connected directly with those of gasoline consumed. Here, the decrease becomes sharper from 2000 onwards following a growing switch from gasoline to diesel oil especially in passenger cars. Here, the annual amounts of NMVOC emissions from evaporation not only depend directly on the amount of evaporated gasoline but also on the number of vehicles equipped with mitigation technologies. Thus, the decrease is sharpest straight after 1990 and since then slowing down.

## Recalculations

**Activity data** have been revised for all years as of 2003 following the revision of the underlying National Energy Balances.

Table 4: Revised annual amounts of evaporated gasoline, in kilotonnes [kt]

|                            | 2003   | 2005  | 2010  | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021  | 2022  | 2023  |
|----------------------------|--------|-------|-------|--------|--------|--------|--------|--------|--------|-------|-------|-------|
| <b>current submission</b>  | 8,565  | 7,973 | 6,439 | 5,749  | 5,753  | 5,811  | 5,573  | 5,513  | 5,067  | 5,137 | 5,176 | 5,263 |
| <b>previous submission</b> | 8,599  | 7,812 | 6,364 | 5,959  | 5,907  | 5,853  | 5,595  | 5,661  | 5,107  | 5,018 | 5,147 | 5,253 |
| <b>absolute change</b>     | -34.4  | 161   | 74.3  | -210   | -153   | -41.9  | -22.6  | -148   | -39.4  | 119   | 29.5  | 10.2  |
| <b>relative change</b>     | -0.40% | 2.06% | 1.17% | -3.52% | -2.60% | -0.72% | -0.40% | -2.62% | -0.77% | 2.37% | 0.57% | 0.19% |

In addition, the NMVOC **emission factors** applied were revised for recent years.

Table 5: Revised implied emission factors 2019-2023, in [kg/kt]

|                            | 2019  | 2020  | 2021   | 2022   | 2023   |
|----------------------------|-------|-------|--------|--------|--------|
| <b>Passenger Cars</b>      |       |       |        |        |        |
| <b>current submission</b>  | 0.161 | 0.185 | 0.178  | 0.183  | 0.174  |
| <b>previous submission</b> | 0.158 | 0.179 | 0.179  | 0.184  | 0.176  |
| <b>absolute change</b>     | 0.003 | 0.006 | 0.000  | 0.000  | -0.002 |
| <b>relative change</b>     | 1.82% | 3.39% | -0.19% | -0.20% | -1.25% |
| <b>Light-duty vehicles</b> |       |       |        |        |        |



|                            | 2019   | 2020   | 2021  | 2022  | 2023   |
|----------------------------|--------|--------|-------|-------|--------|
| <b>current submission</b>  | 267    | 265    | 255   | 264   | 269    |
| <b>previous submission</b> | 241    | 235    | 252   | 261   | 268    |
| <b>absolute change</b>     | 25.9   | 29.8   | 3.26  | 3.38  | 0.48   |
| <b>relative change</b>     | 10.8%  | 12.6%  | 1.30% | 1.29% | 0.18%  |
| <b>Mopeds</b>              |        |        |       |       |        |
| <b>current submission</b>  | 1.96   | 1.91   | 2.08  | 2.05  | 2.34   |
| <b>previous submission</b> | 2.11   | 2.05   | 2.06  | 2.04  | 2.35   |
| <b>absolute change</b>     | -0.15  | -0.14  | 0.01  | 0.01  | 0.00   |
| <b>relative change</b>     | -7.21% | -6.63% | 0.70% | 0.72% | -0.20% |
| <b>Motorcycles</b>         |        |        |       |       |        |
| <b>current submission</b>  | 53.5   | 53.8   | 60.7  | 59.2  | 66.0   |
| <b>previous submission</b> | 53.5   | 53.2   | 60.0  | 58.5  | 66.2   |
| <b>absolute change</b>     | -0.06  | 0.55   | 0.70  | 0.68  | -0.12  |
| <b>relative change</b>     | -0.11% | 1.03%  | 1.17% | 1.17% | -0.18% |

As a result, NMVOC emissions from gasoline evaporation were re-estimated for all years as of 2003 as follows:

Table 6: Re-estimated NMVOC emissions 2003ff, in kilotonnes [kt]

|                            | 2003   | 2005  | 2010  | 2015   | 2016   | 2017   | 2018   | 2019   | 2020  | 2021  | 2022  | 2023   |
|----------------------------|--------|-------|-------|--------|--------|--------|--------|--------|-------|-------|-------|--------|
| <b>current submission</b>  | 38.0   | 31.4  | 22.0  | 22.2   | 22.5   | 22.8   | 22.5   | 22.7   | 22.9  | 23.3  | 24.4  | 24.6   |
| <b>previous submission</b> | 38.1   | 30.8  | 21.7  | 23.0   | 23.1   | 23.0   | 22.5   | 23.0   | 22.4  | 22.8  | 24.3  | 24.8   |
| <b>absolute change</b>     | -0.15  | 0.63  | 0.25  | -0.81  | -0.60  | -0.16  | -0.09  | -0.23  | 0.54  | 0.55  | 0.15  | -0.22  |
| <b>relative change</b>     | -0.40% | 2.06% | 1.17% | -3.52% | -2.60% | -0.72% | -0.40% | -1.00% | 2.42% | 2.40% | 0.61% | -0.88% |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

<sup>1), 2)</sup> Knörr et al. (2025a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, on behalf of Umweltbundesamt; Heidelberg & Berlin, 2025.

## 1.A.3.b vi-vii - Road Transport: Automobile Tyre and Brake Wear and Road Abrasion

This overview chapter provides information on emissions from automobile tyre and brake wear & road abrasion are reported reported in NFR sub-categories 1.A.3.b vi and 1.A.3.b vii. These sub-categories are important sources for a) particle emissions and b) emissions of heavy metals, POPs etc. included in these particles.



specific inventory  
activity data for NFRs  
1.A.3.b vi and vii

| NFR-Code    | Name of Category                               |
|-------------|------------------------------------------------|
| 1.A.3.b vi  | <a href="#">Automobile Tyre and Brake Wear</a> |
| 1.A.3.b vii | <a href="#">Automobile Road Abrasion</a>       |

### Methodology

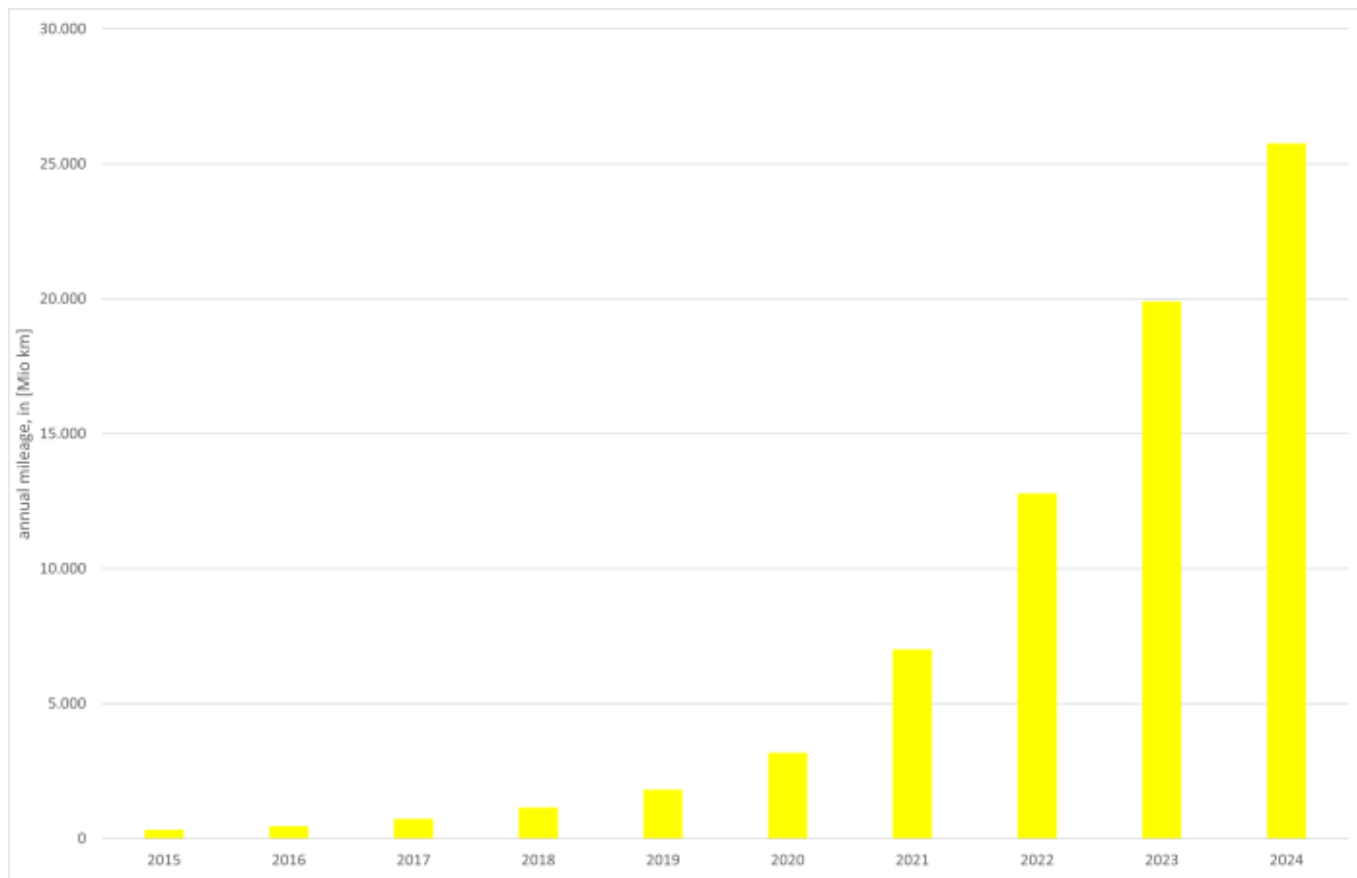
#### Activity data

Specific mileage data for all different types of road vehicles are generated within TREMOD (Knörr et al., 2025a)<sup>1)</sup>. The following table provides an overview of annual mileages.

Table 1: Mileage data for road vehicles 1990-2022, in 10<sup>6</sup> kilometers

|                                      | 1990           | 1995           | 2000           | 2005           | 2010           | 2015           | 2016           | 2017           | 2018           | 2019           | 2020           | 2021           | 2022           | 2023           | 2024           |
|--------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| <b>Passenger Cars</b>                | 492,280        | 535,524        | 565,345        | 580,076        | 596,532        | 630,791        | 637,873        | 643,278        | 642,503        | 644,675        | 541,777        | 552,281        | 554,077        | 563,381        | 564,355        |
| <b>Light Duty Vehicles</b>           | 14,259         | 23,294         | 31,541         | 35,938         | 39,226         | 45,299         | 47,413         | 49,623         | 51,797         | 53,489         | 50,288         | 53,735         | 53,823         | 54,344         | 55,089         |
| <b>Heavy Duty Vehicles</b>           | 40,827         | 54,025         | 62,478         | 60,932         | 61,970         | 66,439         | 68,433         | 69,234         | 70,613         | 69,995         | 66,454         | 68,389         | 67,484         | 64,674         | 65,031         |
| <i>thereof: Lorries &amp; Trucks</i> | 36,657         | 50,109         | 58,440         | 56,788         | 57,728         | 61,532         | 63,044         | 64,685         | 66,059         | 65,395         | 63,530         | 65,263         | 63,838         | 60,889         | 61,219         |
| <i>thereof: Buses</i>                | 4,170          | 3,916          | 4,038          | 4,144          | 4,243          | 4,907          | 5,389          | 4,549          | 4,553          | 4,601          | 2,924          | 3,126          | 3,647          | 3,784          | 3,812          |
| <b>Two-wheelers</b>                  | 15,734         | 12,303         | 15,161         | 15,621         | 15,298         | 14,470         | 14,475         | 14,454         | 14,570         | 14,780         | 14,733         | 13,175         | 13,765         | 12,414         | 12,417         |
| <i>thereof: Mopeds</i>               | 5,917          | 3,830          | 4,047          | 4,191          | 4,990          | 4,841          | 4,798          | 4,692          | 4,806          | 4,874          | 4,920          | 4,368          | 4,557          | 4,079          | 4,068          |
| <i>thereof: Motorcycles</i>          | 9,817          | 8,473          | 11,113         | 11,429         | 10,308         | 9,629          | 9,677          | 9,762          | 9,764          | 9,906          | 9,813          | 8,807          | 9,208          | 8,335          | 8,349          |
| <b>TOTAL MILEAGE</b>                 | <b>563,099</b> | <b>625,145</b> | <b>674,524</b> | <b>692,567</b> | <b>713,026</b> | <b>756,999</b> | <b>768,195</b> | <b>776,589</b> | <b>779,483</b> | <b>782,938</b> | <b>673,252</b> | <b>687,580</b> | <b>689,149</b> | <b>694,812</b> | <b>696,891</b> |

The following chart illustrates the increase in annual mileage of electric road vehicles in 10<sup>6</sup> kilometers:



## Discussion of emission trends



Please see sub-category chapters [1.A.3.b vi - Automobile Tyre and Brake Wear](#) and [1.A.3.b vii - Automobile Road Abrasion](#).

## Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

<sup>1)</sup> Knörr et al. (2025a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg & Berlin, 2025.

# 1.A.3.b vi - Road Transport: Automobile Tyre and Brake Wear



specific inventory data  
for NFR 1.A.3.b vi

## Short description

In sub-categories 1.A.3.b vi - Road transport: Automobile tyre and brake wear emissions from automobile tyre and brake wear in RT are reported. Therefore, these sub-category is an important source for a) particle emissions and b) emissions of heavy metals, POPs etc. included in these particles.

| Category Code                                                                             | Method                               | AD    | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----|
| 1.A.3.b vi                                                                                | T1, T3                               | NS, M | CS |
| <b>Method(s) applied</b>                                                                  |                                      |       |    |
| <b>D</b>                                                                                  | Default                              |       |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |       |    |
| <b>T2</b>                                                                                 | Tier 2*                              |       |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |       |    |
| <b>C</b>                                                                                  | CORINAIR                             |       |    |
| <b>CS</b>                                                                                 | Country Specific                     |       |    |
| <b>M</b>                                                                                  | Model                                |       |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |    |
| <b>(source for) Activity Data</b>                                                         |                                      |       |    |
| <b>NS</b>                                                                                 | National Statistics                  |       |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |       |    |
| <b>IS</b>                                                                                 | International Statistics             |       |    |
| <b>PS</b>                                                                                 | Plant Specific                       |       |    |
| <b>As</b>                                                                                 | Associations, business organisations |       |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |       |    |
| <b>M</b>                                                                                  | Model / Modelled                     |       |    |
| <b>C</b>                                                                                  | Confidential                         |       |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |       |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |       |    |
| <b>CS</b>                                                                                 | Country Specific                     |       |    |
| <b>PS</b>                                                                                 | Plant Specific                       |       |    |
| <b>M</b>                                                                                  | Model / Modelled                     |       |    |
| <b>C</b>                                                                                  | Confidential                         |       |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                             | TSP | BC  | CO | Pb  | Cd  | Hg | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|------------------------------------------------------------------------------|-----|-----|----|-----|-----|----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|
| NA              | NA     | NA              | NA              | L/-               | L/-                                                                          | L/- | L/- | NA | L/- | -/- | NA | L/- | L/- | L/T | -/- | L/- | L/T | NA     | -/-   | -/-   | -/-   | NE    | -/-    | NA  | NA   |
|                 |        |                 |                 | L/-               | key source by Level only                                                     |     |     |    |     |     |    |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | -/T               | key source by Trend only                                                     |     |     |    |     |     |    |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | L/T               | key source by both Level and Trend                                           |     |     |    |     |     |    |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                             |     |     |    |     |     |    |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | IE                | emission of specific pollutant Included Elsewhere (i.e. in another category) |     |     |    |     |     |    |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | NE                | emission of specific pollutant Not Estimated (yet)                           |     |     |    |     |     |    |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = Not Applicable |     |     |    |     |     |    |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | *                 | no analysis done                                                             |     |     |    |     |     |    |     |     |     |     |     |     |        |       |       |       |       |        |     |      |

## Methodology

### Activity data

Abrasive emissions from tyre and brake wear are estimated based on vehicle-type specific mileage data.

For detailed mileage data, please see [superordinate chapter](#) on abrasive emissions from road vehicles.

### Emission factors

Table 1: Emission factors applied

|                                          | Tyre Wear |          |          |          |          |                      | Brake Wear |          |          |          |                      |
|------------------------------------------|-----------|----------|----------|----------|----------|----------------------|------------|----------|----------|----------|----------------------|
|                                          | PCs       |          | LDVs     | HDVs     | Buses    | Mopeds & Motorcycles | PCs        |          | LDVs     | HDVs     | Mopeds & Motorcycles |
| Particulate Matter, in [mg/km]           | comb.     | elec.    |          |          |          |                      | comb.      | elec.    |          |          |                      |
| <b>BC</b>                                | 1.64      | 1.77     | 2.59     | 6.83     | 5.12     | 0.70                 | 0.37       | 0.08     | 0.45     | 1.01     | 0.10                 |
| <b>PM<sub>2.5</sub></b>                  | 4.49      | 4.87     | 7.10     | 18.8     | 14.1     | 1.93                 | 5.54       | 1.17     | 6.77     | 15.0     | 1.44                 |
| <b>PM<sub>10</sub></b>                   | 6.42      | 6.96     | 10.1     | 26.8     | 20.1     | 2.76                 | 13.9       | 2.94     | 17.0     | 37.8     | 3.63                 |
| <b>TSP</b>                               | 10.7      | 11.6     | 16.9     | 44.6     | 33.5     | 4.60                 | 14.2       | 3.00     | 17.4     | 38.5     | 3.70                 |
| <b>Priority Heavy Metals, in [µg/km]</b> |           |          |          |          |          |                      |            |          |          |          |                      |
| <b>Pb</b>                                | 0.002     | 0.002    | 0.003    | 0.008    | 0.006    | 0.001                | 0.09       | 0.000    | 0.11     | 0.23     | 0.02                 |
| <b>Hg</b>                                | NA        | NA       | NA       | NA       | NA       | NA                   | NA         | NA       | NA       | NA       | NA                   |
| <b>Cd</b>                                | 0.0001    | 0.0001   | 0.0001   | 0.0002   | 0.0002   | 0.0000               | 0.0003     | 0.0001   | 0.0004   | 0.0009   | 0.0001               |
| <b>Other Heavy Metals, in [µg/km]</b>    |           |          |          |          |          |                      |            |          |          |          |                      |
| <b>As</b>                                | 0.00004   | 0.00004  | 0.00006  | 0.00017  | 0.00013  | 0.00002              | 0.0010     | 0.00020  | 0.0012   | 0.0026   | 0.0002               |
| <b>Cr</b>                                | 0.00025   | 0.00028  | 0.00040  | 0.00106  | 0.00080  | 0.00011              | 0.0328     | 0.00693  | 0.0401   | 0.0890   | 0.0086               |
| <b>Cu</b>                                | 0.00186   | 0.00202  | 0.00294  | 0.00777  | 0.00583  | 0.00080              | 0.7258     | 0.15334  | 0.8878   | 1.9692   | 0.1891               |
| <b>Ni</b>                                | 0.00032   | 0.00035  | 0.00051  | 0.00133  | 0.00100  | 0.00014              | 0.0046     | 0.00098  | 0.0057   | 0.0126   | 0.0012               |
| <b>Se</b>                                | 0.00021   | 0.00023  | 0.00034  | 0.00089  | 0.00067  | 0.00009              | 0.0003     | 0.00006  | 0.0003   | 0.0008   | 0.0001               |
| <b>Zn</b>                                | 0.07954   | 0.08623  | 0.12563  | 0.33189  | 0.24892  | 0.03420              | 0.1232     | 0.02603  | 0.1507   | 0.3343   | 0.0321               |
| <b>PAHs, in [µg/km]</b>                  |           |          |          |          |          |                      |            |          |          |          |                      |
| <b>B[a]P</b>                             | 0.000042  | 0.000045 | 0.000066 | 0.000174 | 0.000131 | 0.000018             | 0.000011   | 0.000002 | 0.000013 | 0.000029 | 0.000003             |
| <b>B[b]F</b>                             | NE        | NE       | NE       | NE       | NE       | NE                   | 0.000006   | 0.000001 | 0.000007 | 0.000016 | 0.000002             |
| <b>B[k]F</b>                             | NE        | NE       | NE       | NE       | NE       | NE                   | 0.000009   | 0.000002 | 0.000011 | 0.000024 | 0.000002             |
| <b>I[...]<b>P</b></b>                    | NE        | NE       | NE       | NE       | NE       | NE                   | NE         | NE       | NE       | NE       | NE                   |
| <b>Σ PAHs 1-4</b>                        | 0.000042  | 0.000045 | 0.000066 | 0.000174 | 0.000131 | 0.000018             | 0.000025   | 0.000005 | 0.000031 | 0.000069 | 0.000007             |

The emission factors for heavy metals of interest are calculated from the emission factor for TSP and a specific mass ratio for either brake or tyre wear. In contrast to the other heavy metals reported from 1.A.3.b vi, Copper (Cu) and chromium (Cr) emissions are dominated from wear of (disc) brakes. Thus, the doubling of the emission factor for brake wear particle emission heavily effects the traffic-related copper and chromium emissions, whereas for the other heavy metals only a moderate increase can be observed.

## Discussion of emission trends

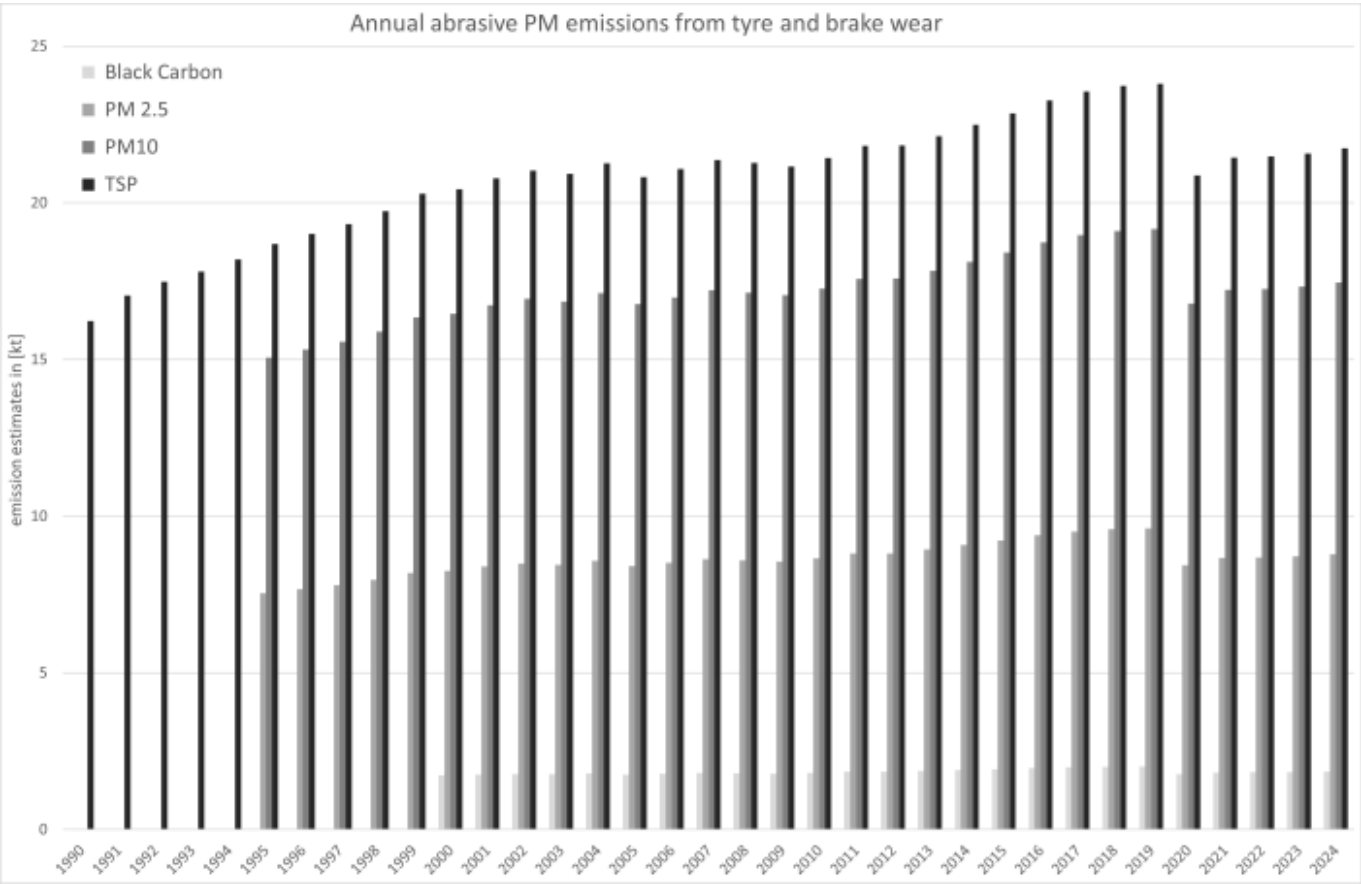
*(emissions from wear/abrasion only; no fuel combustion included)*

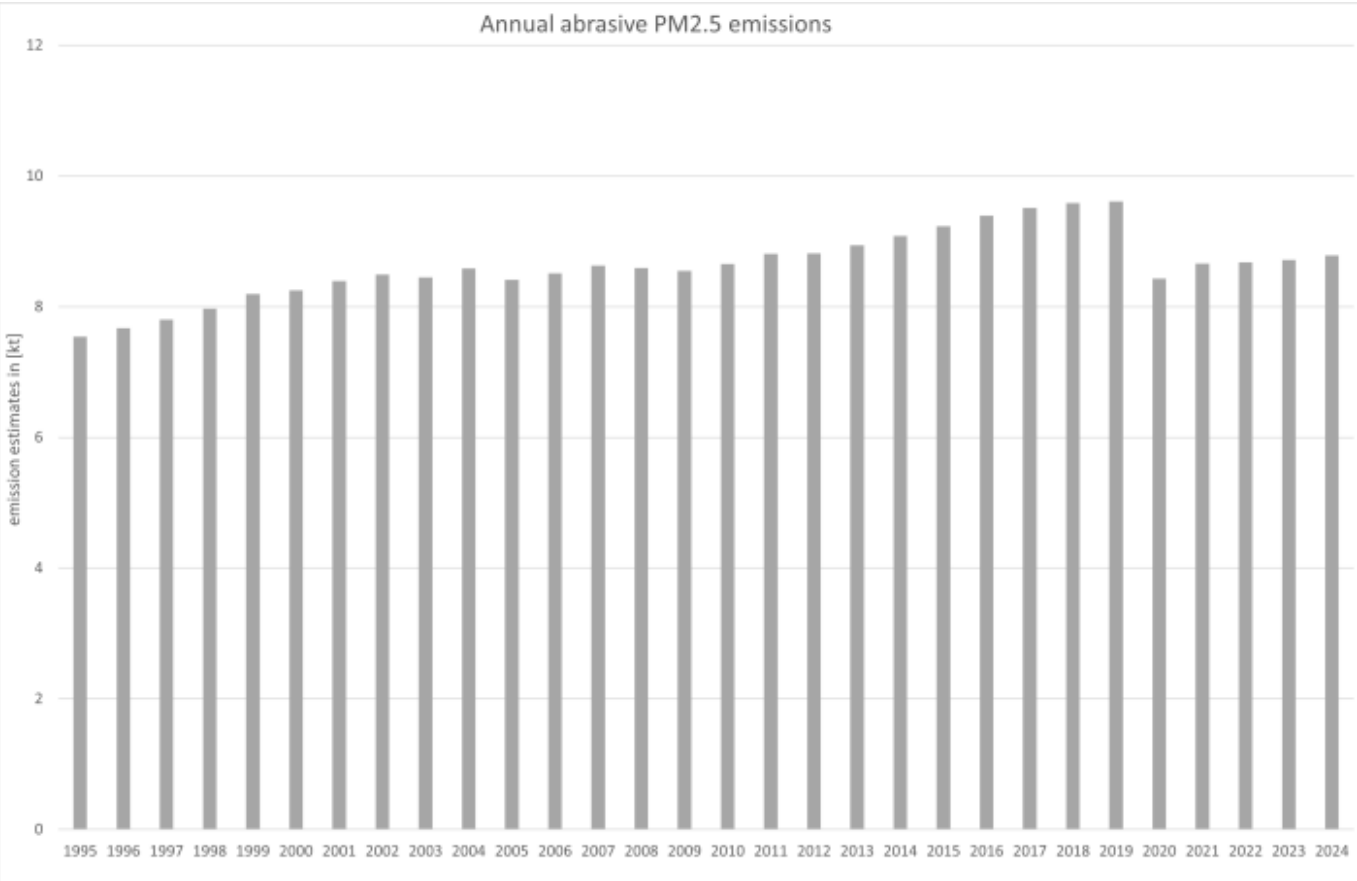
Table 2: Outcome of Key Category Analysis

| key source for: | PM <sub>2.5</sub>                                                                            | PM <sub>10</sub> | TSP | BC  | Pb  | As  | Cr  | Cu  | Se  | Zn  |
|-----------------|----------------------------------------------------------------------------------------------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| by:             | L/-                                                                                          | L/-              | L/- | L/- | L/- | L/- | L/- | L/T | L/- | L/T |
| L/-             | key source by <b>L</b> evel only                                                             |                  |     |     |     |     |     |     |     |     |
| -/T             | key source by <b>T</b> rend only                                                             |                  |     |     |     |     |     |     |     |     |
| L/T             | key source by both <b>L</b> evel and <b>T</b> rend                                           |                  |     |     |     |     |     |     |     |     |
| -/-             | no key source for this pollutant                                                             |                  |     |     |     |     |     |     |     |     |
| IE              | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                  |     |     |     |     |     |     |     |     |
| NE              | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                  |     |     |     |     |     |     |     |     |
| NA              | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                  |     |     |     |     |     |     |     |     |
| *               | no analysis done                                                                             |                  |     |     |     |     |     |     |     |     |

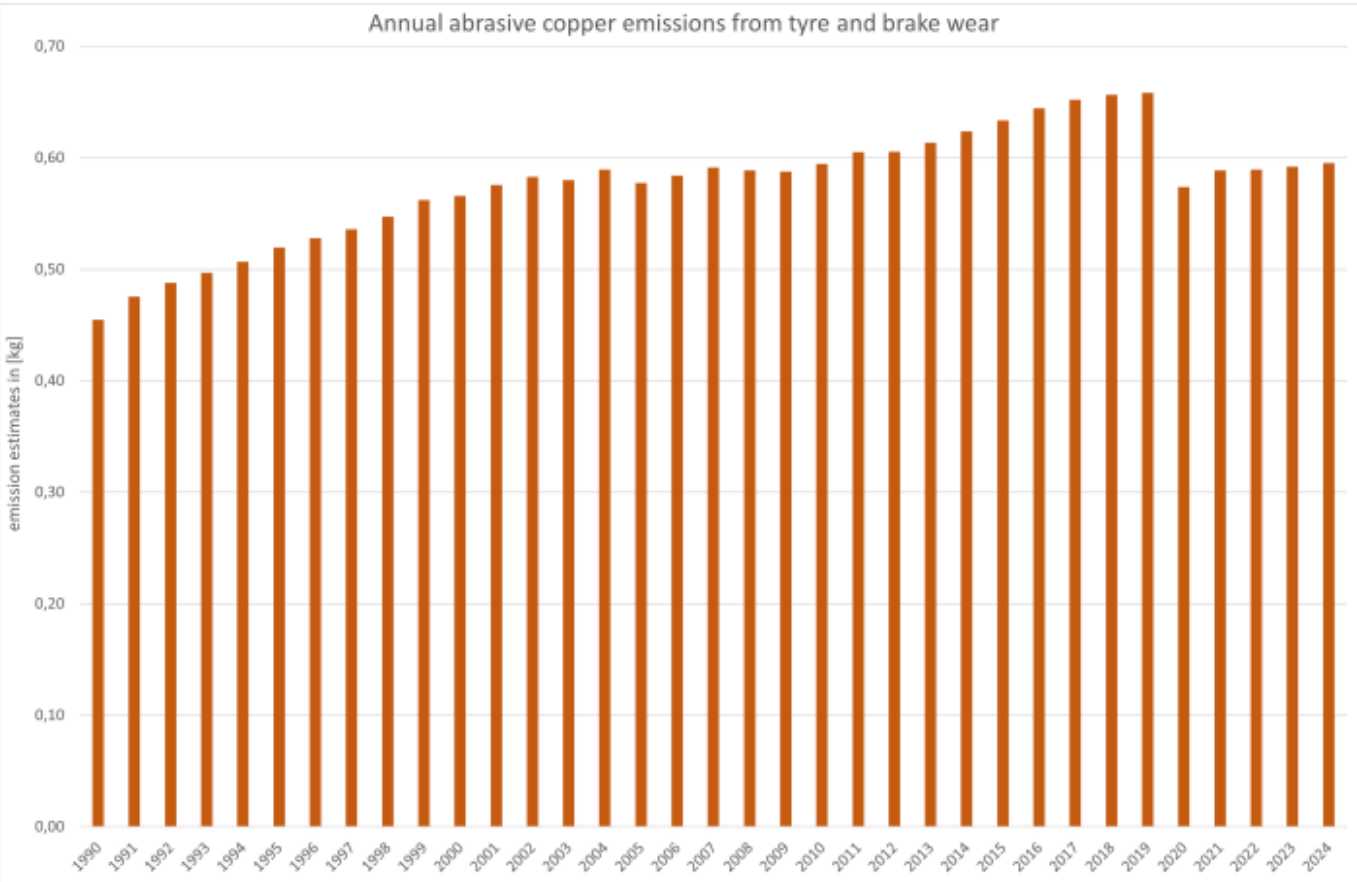
All reported emissions from tyre and brake wear are linked directly to the mileage driven by the road vehicles covered.

Here, after a moderate decrease during the Covid-19 pandemic, mileage related abrasive emissions show a slow recovery not yet reaching pre-pandemic levels again.

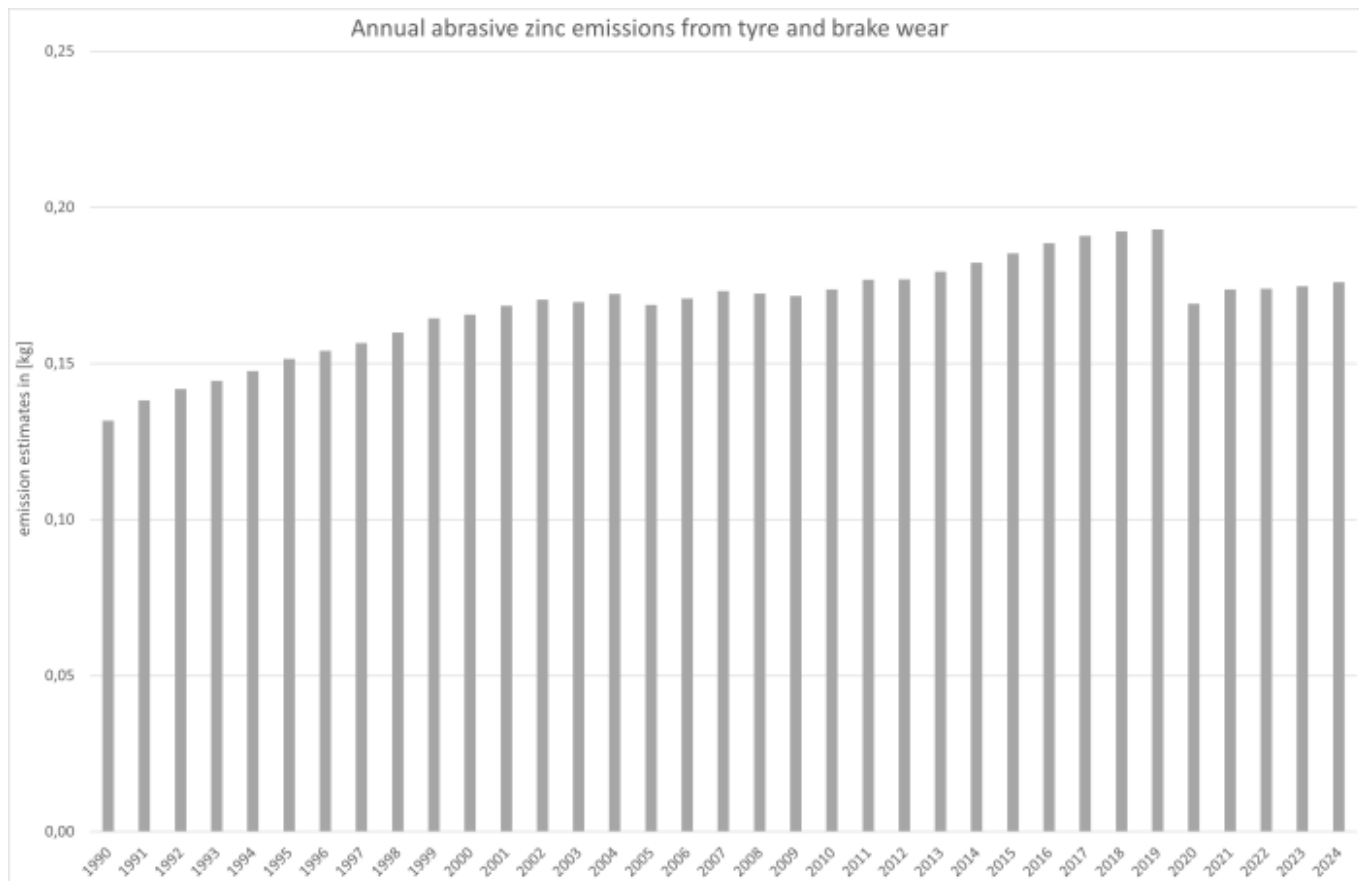




Whereas annual copper emissions result almost entirely from the wear of (disc) brakes...



...zinc emissions result from both tyre and brake wear with high amounts of zinc used in tyre rubber and drum brakes applied in trucks (heavy loads) and buses (stop-and-go).



## Recalculations

With the current submission, TSP emission factors are replaced by values derived from the tier2 values provided with latest version (published in 2025) of the 2023 EMEP/EEA emissions inventories guidebook<sup>1)</sup>:

Table 3: Revised TSP emission factors, in [mg/km]

|                            | from tyre wear |       |        |        |                      | from brake wear |       |       |                      |
|----------------------------|----------------|-------|--------|--------|----------------------|-----------------|-------|-------|----------------------|
|                            | PCs            | LDVs  | HDVs   | Buses  | Mopeds & Motorcycles | PCs             | LDVs  | HDVs  | Mopeds & Motorcycles |
| <b>current submission</b>  | 10.7           | 16.9  | 44.6   | 33.5   | 4.60                 | 14.2            | 17.37 | 38.5  | 3.70                 |
| <b>previous submission</b> | 10.7           | 16.9  | 45.0   | 45.0   | 4.60                 | 7.50            | 11.7  | 32.7  | 3.70                 |
| <b>absolute change</b>     | 0.00           | 0.00  | -0.36  | -11.5  | 0.00                 | 6.70            | 5.67  | 5.88  | 0.00                 |
| <b>relative change</b>     | 0.00%          | 0.00% | -0.79% | -25.6% | 0.00%                | 89.3%           | 48.5% | 18.0% | 0.00%                |

Due to this implemetation of tier2 default emission factors, emissions from tyre and brake wear are revised rather strongly with significant increases for all pollutants.

Table 4: Revised emission estimates

|                            | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023   |
|----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| <b>BC</b>                  |       |       |       |       |       |       |       |       |       |       |       |       |       |        |
| <b>current submission</b>  | 1.36  | 1.57  | 1.73  | 1.76  | 1.81  | 1.93  | 1.96  | 1.99  | 2.01  | 2.01  | 1.77  | 1.82  | 1.83  | 1.84   |
| <b>previous submission</b> | 1.27  | 1.47  | 1.62  | 1.65  | 1.69  | 1.81  | 1.84  | 1.87  | 1.88  | 1.89  | 1.68  | 1.70  | 1.73  | 1.85   |
| <b>absolute change</b>     | 0.09  | 0.10  | 0.11  | 0.11  | 0.11  | 0.12  | 0.12  | 0.12  | 0.12  | 0.12  | 0.09  | 0.12  | 0.09  | -0.01  |
| <b>relative change</b>     | 6.91% | 6.76% | 6.57% | 6.65% | 6.68% | 6.64% | 6.57% | 6.65% | 6.61% | 6.62% | 5.51% | 7.31% | 5.45% | -0.73% |
| <b>PM<sub>2.5</sub></b>    |       |       |       |       |       |       |       |       |       |       |       |       |       |        |
| <b>current submission</b>  | 6.55  | 7.54  | 8.25  | 8.41  | 8.65  | 9.23  | 9.40  | 9.51  | 9.58  | 9.61  | 8.43  | 8.66  | 8.68  | 8.71   |
| <b>previous submission</b> | 5.16  | 6.00  | 6.59  | 6.70  | 6.90  | 7.36  | 7.50  | 7.60  | 7.66  | 7.68  | 6.84  | 6.92  | 7.06  | 7.53   |
| <b>absolute change</b>     | 1.39  | 1.55  | 1.66  | 1.71  | 1.76  | 1.87  | 1.89  | 1.92  | 1.92  | 1.93  | 1.59  | 1.74  | 1.62  | 1.19   |



|                            | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  |
|----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>relative change</b>     | 26.8% | 25.8% | 25.2% | 25.5% | 25.5% | 25.4% | 25.2% | 25.2% | 25.1% | 25.1% | 23.3% | 25.2% | 23.0% | 15.8% |
| <b>PM<sub>10</sub></b>     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>current submission</b>  | 13.1  | 15.1  | 16.5  | 16.8  | 17.3  | 18.4  | 18.7  | 19.0  | 19.1  | 19.2  | 16.8  | 17.2  | 17.3  | 17.3  |
| <b>previous submission</b> | 9.56  | 11.1  | 12.2  | 12.4  | 12.8  | 13.6  | 13.9  | 14.1  | 14.2  | 14.2  | 12.7  | 12.8  | 13.1  | 13.9  |
| <b>absolute change</b>     | 3.54  | 3.95  | 4.24  | 4.36  | 4.49  | 4.77  | 4.84  | 4.89  | 4.91  | 4.93  | 4.10  | 4.40  | 4.18  | 3.38  |
| <b>relative change</b>     | 37.1% | 35.6% | 34.7% | 35.1% | 35.1% | 35.0% | 34.8% | 34.8% | 34.6% | 34.6% | 32.3% | 34.3% | 31.9% | 24.2% |
| <b>TSP</b>                 |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>current submission</b>  | 16.2  | 18.7  | 20.4  | 20.8  | 21.4  | 22.9  | 23.3  | 23.6  | 23.7  | 23.8  | 20.9  | 21.4  | 21.5  | 21.6  |
| <b>previous submission</b> | 12.7  | 14.7  | 16.2  | 16.4  | 16.9  | 18.1  | 18.4  | 18.6  | 18.8  | 18.9  | 16.8  | 17.0  | 17.3  | 18.5  |
| <b>absolute change</b>     | 3.56  | 3.97  | 4.27  | 4.38  | 4.51  | 4.79  | 4.86  | 4.92  | 4.94  | 4.95  | 4.09  | 4.47  | 4.17  | 3.10  |
| <b>relative change</b>     | 28.1% | 27.0% | 26.4% | 26.6% | 26.7% | 26.5% | 26.4% | 26.4% | 26.3% | 26.3% | 24.4% | 26.3% | 24.1% | 16.8% |
| <b>Copper</b>              |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>current submission</b>  | 0.45  | 0.52  | 0.57  | 0.58  | 0.59  | 0.63  | 0.64  | 0.65  | 0.66  | 0.66  | 0.57  | 0.59  | 0.59  | 0.59  |
| <b>previous submission</b> | 0.27  | 0.31  | 0.34  | 0.35  | 0.36  | 0.38  | 0.39  | 0.40  | 0.40  | 0.40  | 0.36  | 0.36  | 0.37  | 0.39  |
| <b>absolute change</b>     | 0.18  | 0.21  | 0.22  | 0.23  | 0.23  | 0.25  | 0.25  | 0.26  | 0.26  | 0.26  | 0.22  | 0.23  | 0.22  | 0.20  |
| <b>relative change</b>     | 68.6% | 65.9% | 64.3% | 64.9% | 65.0% | 64.7% | 64.4% | 64.3% | 64.0% | 64.0% | 60.5% | 62.8% | 59.8% | 50.6% |
| <b>Zinc</b>                |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>current submission</b>  | 0.13  | 0.15  | 0.17  | 0.17  | 0.17  | 0.19  | 0.19  | 0.19  | 0.19  | 0.19  | 0.17  | 0.17  | 0.17  | 0.17  |
| <b>previous submission</b> | 0.09  | 0.11  | 0.12  | 0.12  | 0.12  | 0.13  | 0.14  | 0.14  | 0.14  | 0.14  | 0.12  | 0.12  | 0.13  | 0.14  |
| <b>absolute change</b>     | 0.04  | 0.04  | 0.05  | 0.05  | 0.05  | 0.05  | 0.05  | 0.05  | 0.05  | 0.05  | 0.05  | 0.05  | 0.05  | 0.04  |
| <b>relative change</b>     | 39.7% | 39.7% | 39.5% | 39.3% | 39.3% | 39.2% | 39.2% | 39.1% | 39.0% | 39.0% | 37.5% | 39.9% | 37.1% | 27.9% |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

<sup>1)</sup> EMEP/EEA (2025): EMEP/EEA air pollutant emission inventory guidebook 2023 - Update 2025; Chapter 1.A.3.b.vi Road transport: Automobile tyre and brake wear & 1.A.3.b.vii Road transport: Automobile road abrasion; <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-vi/@download/file>, Copenhagen, 2025

## 1.A.3.b vii - Road Transport: Automobile Road Abrasion

### Short description

In sub-category 1.A.3.b vii - Road Transport: Automobile Road Abrasion emissions from road abrasion in Road Transport are reported. Therefore, this sub-category is an important source for a) particle emissions and b) emissions of heavy metals, POPs etc. included in these particles.

| Category Code                                                                             | Method                               | AD    | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----|
| 1.A.3.b vii                                                                               | T1, T3                               | NS, M | CS |
| <b>Method(s) applied</b>                                                                  |                                      |       |    |
| <b>D</b>                                                                                  | Default                              |       |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |       |    |
| <b>T2</b>                                                                                 | Tier 2*                              |       |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |       |    |
| <b>C</b>                                                                                  | CORINAIR                             |       |    |
| <b>CS</b>                                                                                 | Country Specific                     |       |    |
| <b>M</b>                                                                                  | Model                                |       |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |    |
| <b>(source for) Activity Data</b>                                                         |                                      |       |    |
| <b>NS</b>                                                                                 | National Statistics                  |       |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |       |    |
| <b>IS</b>                                                                                 | International Statistics             |       |    |
| <b>PS</b>                                                                                 | Plant Specific                       |       |    |
| <b>As</b>                                                                                 | Associations, business organisations |       |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |       |    |
| <b>M</b>                                                                                  | Model / Modelled                     |       |    |
| <b>C</b>                                                                                  | Confidential                         |       |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |       |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |       |    |
| <b>CS</b>                                                                                 | Country Specific                     |       |    |
| <b>PS</b>                                                                                 | Plant Specific                       |       |    |
| <b>M</b>                                                                                  | Model / Modelled                     |       |    |
| <b>C</b>                                                                                  | Confidential                         |       |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub>                                                                      | PM <sub>10</sub> | TSP | BC  | CO  | Pb  | Cd  | Hg | As  | Cr  | Cu  | Ni  | Se | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|----------------------------------------------------------------------------------------|------------------|-----|-----|-----|-----|-----|----|-----|-----|-----|-----|----|-----|--------|-------|-------|-------|-------|--------|-----|------|
| NA              | NA     | NA              | NA              | L/-                                                                                    | L/-              | L/- | -/- | -/- | -/- | -/- | NA | -/- | -/- | -/- | -/- | NE | -/- | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |
|                 |        |                 |                 | L/- key source by <b>Level</b> only                                                    |                  |     |     |     |     |     |    |     |     |     |     |    |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | -/- key source by <b>Trend</b> only                                                    |                  |     |     |     |     |     |    |     |     |     |     |    |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | L/T key source by both <b>Level</b> and <b>Trend</b>                                   |                  |     |     |     |     |     |    |     |     |     |     |    |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | -/- no key source for this pollutant                                                   |                  |     |     |     |     |     |    |     |     |     |     |    |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | IE emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |                  |     |     |     |     |     |    |     |     |     |     |    |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | NE emission of specific pollutant <b>Not Estimated</b> (yet)                           |                  |     |     |     |     |     |    |     |     |     |     |    |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | NA specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |                  |     |     |     |     |     |    |     |     |     |     |    |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | * no analysis done                                                                     |                  |     |     |     |     |     |    |     |     |     |     |    |     |        |       |       |       |       |        |     |      |

### Methodology

## Activity data

Abrasive emissions from tyre and brake wear are estimated based on vehicle-type specific mileage data. For detailed mileage data, please see [superordinate chapter](#) on abrasive emissions from road vehicles.

## Emission factors

Emission factors for particulate matter (TSP, PM<sub>10</sub>, PM<sub>2.5</sub>) are derived from tier2 values provided in Chapter 1.A.3.b vi & vii of the 2025 update of the EMEP/EEA Guidebook 2023 <sup>1)</sup>. Here, black carbon emissions are calculated based on the f-BC value of 0.0106 as provided in table 3-11: BC and OC ratios to be used for road abrasion:

In terms of BC, and the absence of better information, EC values quoted in Table 3-12 can be used as proxies for BC as well. For road abrasion, the values of Table 3-11, originating from Kupiainen and Klimont (2004) can be used.

**Table 3-11 BC and OC ratios to be used for road abrasion.**

| Category      | f-BC   | f-OC  | +/- uncertainty (%) |
|---------------|--------|-------|---------------------|
| Road abrasion | 0.0106 | 0.135 | 50                  |

In addition, country-specific emission factors for heavy metals are estimated via percental shares of TSP as derived from related scientific literature.

Table 1: Emission factors applied

|                         | Passenger Cars |          | Light-Duty Vehicles | Heavy-Duty Vehicles (incl. Buses) | Mopeds & Motorcycles |
|-------------------------|----------------|----------|---------------------|-----------------------------------|----------------------|
|                         | combustion     | electric | c&e                 | c&e                               | c&e                  |
| particulate matter:     |                |          |                     |                                   |                      |
| <b>TSP</b>              | 15.0           | 16.9     | 21.0                | 76.0                              | 6.00                 |
| <b>PM<sub>10</sub></b>  | 7.50           | 8.45     | 10.5                | 38.0                              | 3.00                 |
| <b>PM<sub>2.5</sub></b> | 4.05           | 4.56     | 5.67                | 20.5                              | 1.62                 |
| <b>BC</b>               | 0.16           | 0.18     | 0.22                | 0.81                              | 0.06                 |
| heavy metals:           |                |          |                     |                                   |                      |
| <b>Hg</b>               | NE             |          |                     |                                   |                      |
| <b>Pb</b>               | 0.000062       | 0.000069 | 0.000062            | 0.000312                          | 0.000025             |
| <b>Cd</b>               | 0.000003       | 0.000004 | 0.000003            | 0.000016                          | 0.000001             |
| <b>As</b>               | 0.000039       | 0.000044 | 0.000039            | 0.000198                          | 0.000016             |
| <b>Cr</b>               | 0.001080       | 0.001217 | 0.001080            | 0.005472                          | 0.000432             |
| <b>Cu</b>               | 0.000037       | 0.000041 | 0.000037            | 0.000186                          | 0.000015             |
| <b>Ni</b>               | 0.000570       | 0.000642 | 0.000570            | 0.002888                          | 0.000228             |
| <b>Se</b>               | NA             |          |                     |                                   |                      |
| <b>Zn</b>               | 0.001290       | 0.001453 | 0.001290            | 0.006536                          | 0.000516             |

The additional *distinction between combustion and electric traction* is made only for passenger cars, taking into account the (significantly) higher weight and power of electric (sports-utility) vehicles.

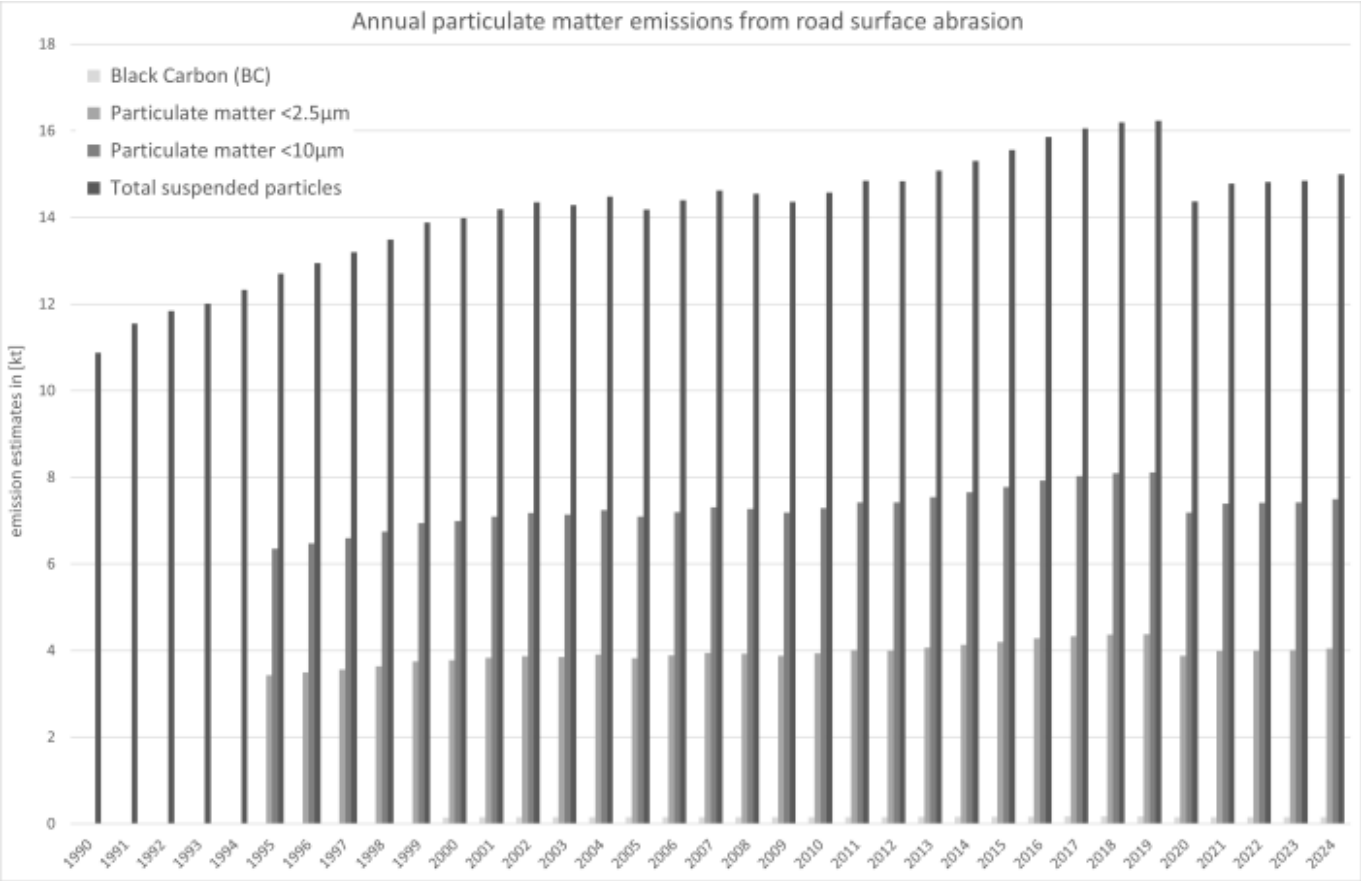
## Discussion of emission trends

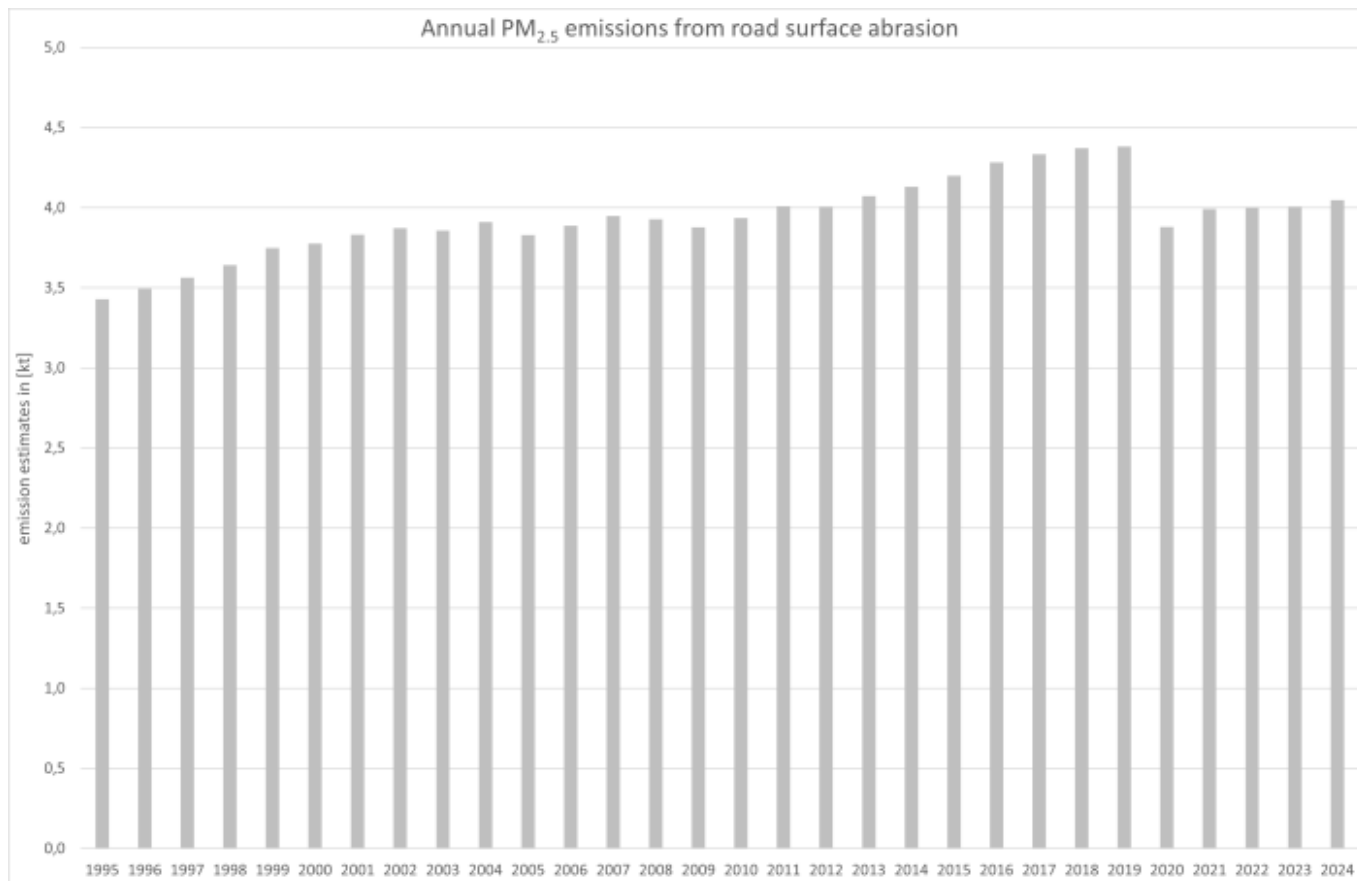
Table 2: Outcome of Key Category Analysis

|      |            |                        |                         |
|------|------------|------------------------|-------------------------|
| for: | <b>TSP</b> | <b>PM<sub>10</sub></b> | <b>PM<sub>2.5</sub></b> |
| by:  | Level      | Level                  | Level                   |

Emissions from road abrasion are directly linked to driven mileage. Thus, the overall trend of emissions from road abrasion is similar to the trend for total driven mileage.

Here, as described for tyre and brake wear, after a moderate decrease during the Covid-19 pandemic, mileage related abrasive emissions show a steady recovery not yet reaching pre-pandemic levels.





## Recalculations

Recalculations result from both changes in the underlying activity data (mileage) and emission factors.

Here, regarding **emission factors**, tier2 values from the 2025 update of the EMEP/EEA Guidebook 2023 <sup>2)</sup> have been implemented. Due to this revision, black carbon emissions are calculated and reported for the first time with the current submission (see also: information on emission factors provided above)



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

Besides a routine revision of the underlying model, no specific improvements are planned.

<sup>1), 2)</sup> EMEP/EEA (2025): EMEP/EEA air pollutant emission inventory guidebook 2023 - Update 2025; Chapter 1.A.3.b.vi Road transport: Automobile tyre and brake wear & 1.A.3.b.vii Road transport: Automobile road abrasion; <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-vi/@download/file>, Copenhagen, 2025

## 1.A.3.c - Transport: Railways



NFR-specific inventory  
data

### Short description

In category 1.A.3.c - Railways, emissions from fuel combustion in German railways and from the related abrasion and wear of contact line, braking systems and tyres on rails are reported.

| Category Code                                                                             | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.3.c                                                                                   | T1, T2                               | NS, M | CS, D, M |
| Method(s) applied                                                                         |                                      |       |          |
| D                                                                                         | Default                              |       |          |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |          |
| T2                                                                                        | Tier 2*                              |       |          |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |          |
| C                                                                                         | CORINAIR                             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| M                                                                                         | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| (source for) Activity Data                                                                |                                      |       |          |
| NS                                                                                        | National Statistics                  |       |          |
| RS                                                                                        | Regional Statistics                  |       |          |
| IS                                                                                        | International Statistics             |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| As                                                                                        | Associations, business organisations |       |          |
| Q                                                                                         | specific Questionnaires (or surveys) |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |
| (source for) Emission Factors                                                             |                                      |       |          |
| D                                                                                         | Default (EMEP Guidebook)             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |

| NO <sub>x</sub> | NMVOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub>                                                                      | PM <sub>10</sub> | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |
|-----------------|-------|-----------------|-----------------|----------------------------------------------------------------------------------------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|--|
| -/T             | -/-   | -/-             | -/-             | L/-                                                                                    | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | L/- | L/- | L/T | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | -/-  |  |
|                 |       |                 |                 | L/- key source by <b>Level</b> only                                                    |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |       |                 |                 | -/T key source by <b>Trend</b> only                                                    |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |       |                 |                 | L/T key source by both <b>Level</b> and <b>Trend</b>                                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |       |                 |                 | -/- no key source for this pollutant                                                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |       |                 |                 | IE emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |       |                 |                 | NE emission of specific pollutant <b>Not Estimated</b> (yet)                           |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |       |                 |                 | NA specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |
|                 |       |                 |                 | * no analysis done                                                                     |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |

Germany's railway sector is undergoing a long-term modernisation process aimed at making electricity the main energy source for rail transports. Use of electricity, instead of diesel fuel, to power locomotives has been continually increased, and electricity now provides over 80% of all railway traction power. Railways' power stations for generation of traction current

are allocated to the stationary component of the energy sector (1.A.1.a) and are not included in the following. In energy input for trains of German railways, diesel fuel is the only energy source that plays a significant role apart from electric power.

## Methodology

### Activity Data

Generally, total inland deliveries of *diesel oil* are available from the National Energy Balances (NEBs) (AGEB, 2025) <sup>1)</sup>. This data is based upon sales data of the Association of the German Petroleum Industry (MWV) <sup>2)</sup>. As a revision of this MWV data for the years 2005 to 2009 was not adopted to the respective National Energy Balances, the original MWV data are applied for this five years.

Data on the consumption of biodiesel in railways is provided in the NEBs as well, from 2004 onward. However, the data applied in the emissions inventory are based on the average annual shares of biodiesel added to the fossil diesel oil.

In addition, rather small quantities of *solid fuels* are used for historical steam engines vehicles operated mostly for tourism and exhibition purposes. Official fuel delivery data are available for lignite, through 2002, and for hard coal, through 2000 only. Therefore, in order to complete these time series, operator surveys were carried out in 2012 <sup>3)</sup>, 2016 <sup>4)</sup> and 2021 <sup>5)</sup>. During these surveys, questionnaires were provided to any known operator of historical steam engines in Germany. Here, due to limited data archiving, nearly complete data could only be gained for years as of 2005 and for the main operators only. For earlier years and a variety of smaller operators, conservative gap filling was applied.

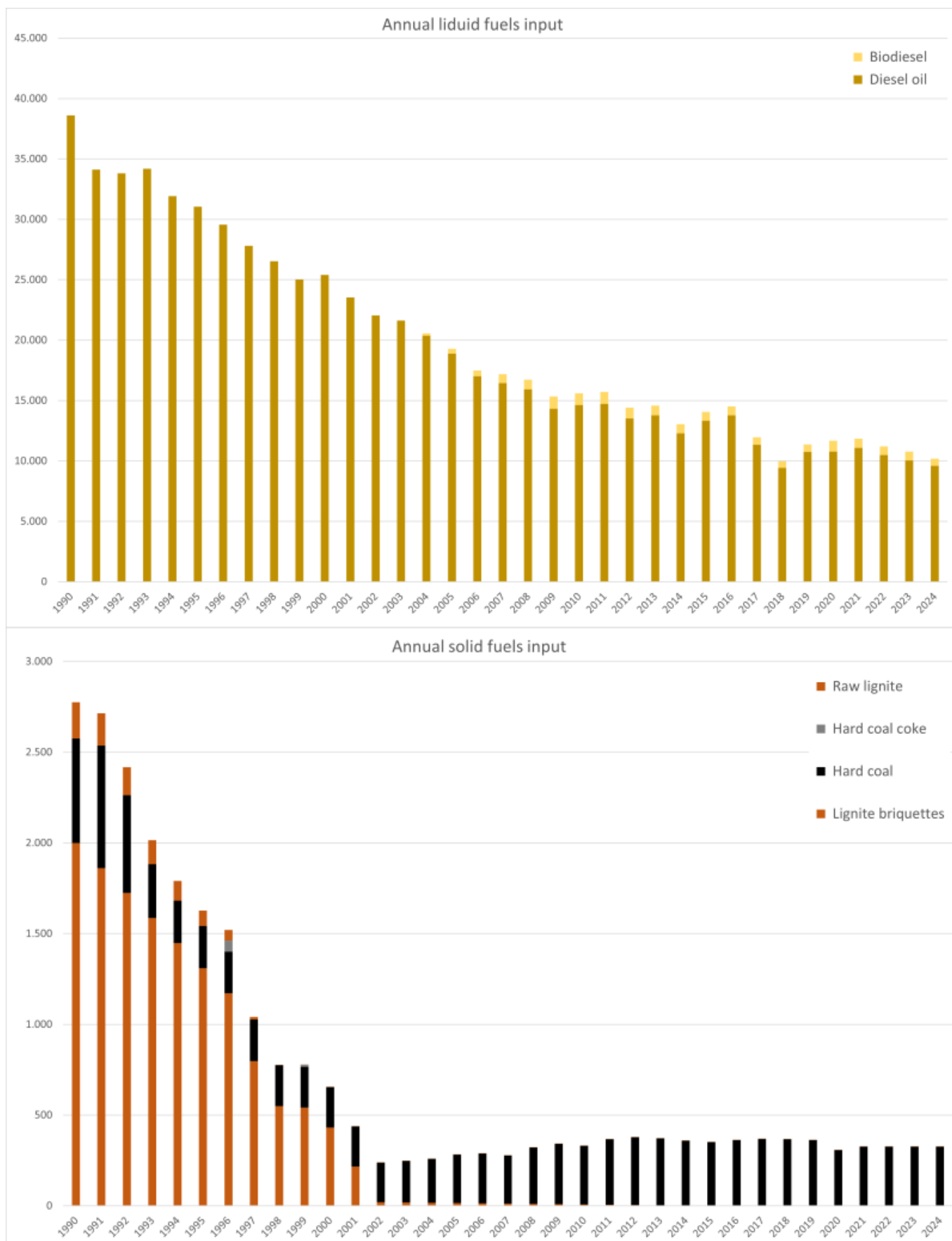
Table 1: Overview of activity-data sources for domestic fuel sales to railway operators

| Activity                                                                      | data source / quality of activity data                                                                                                                   |
|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| combustion of:                                                                |                                                                                                                                                          |
| Diesel oil                                                                    | 1990-2004: NEB lines 74 & 61: 'Schienenverkehr' / 2005-2009: MWV annual report, table: 'Sektoraler Verbrauch von Dieselmotoren' / from 2010: NEB line 61 |
| Biodiesel                                                                     | calculated from official blending rates                                                                                                                  |
| Hard coal                                                                     | 1990-1994: NEB line 74; 1995-2004: interpolation; 2005, 2010, 2015, 2019 and 2020: survey data; as of 2021: extrapolation                                |
| Hard coal coke                                                                | 1990-1997: NEB lines 74 & 61; 1998-2004: interpolation; 2005, 2010, 2015, 2019 and 2020: survey data; as of 2021: extrapolation                          |
| Raw lignite                                                                   | from 1990: NEB lines 74 & 61                                                                                                                             |
| Lignite briquettes                                                            | from 1990: NEB lines 74 & 61                                                                                                                             |
| <b>abrasion and wear of contact line, braking systems and tyres on rails:</b> |                                                                                                                                                          |
| transport performance data                                                    | in Mio ptkm (performance-ton-kilometers) derived from the TREMOD model                                                                                   |

Table 2: Annual fuel consumption in German railways, in [TJ]

|                           | 1990          | 1995          | 2000          | 2005          | 2010          | 2015          | 2016          | 2017          | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
|---------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>Diesel Oil</b>         | 38,605        | 31,054        | 25,410        | 18,877        | 14,626        | 13,321        | 13,775        | 11,344        | 9,425         | 10,747        | 10,782        | 11,072        | 10,482        | 10,035        | 9,589         |
| <b>Biodiesel</b>          |               |               |               | 416           | 966           | 729           | 735           | 606           | 544           | 611           | 892           | 769           | 725           | 747           | 587           |
| <b>Liquids TOTAL</b>      | <b>38,605</b> | <b>31,054</b> | <b>25,410</b> | <b>19,293</b> | <b>15,592</b> | <b>14,050</b> | <b>14,510</b> | <b>11,950</b> | <b>9,969</b>  | <b>11,358</b> | <b>11,674</b> | <b>11,841</b> | <b>11,208</b> | <b>10,782</b> | <b>10,177</b> |
| <b>Lignite Briquettes</b> | 200           | 86.0          | 1.33          | 0.79          | 0.79          | 0.66          | 0.63          | 0.46          | 0.46          | 0.43          | 0.22          | 0.35          | 0.35          | 0.35          | 0.35          |
| <b>Hard Coal</b>          | 576           | 232           | 223           | 267           | 324           | 351           | 361           | 367           | 365           | 362           | 306           | 325           | 325           | 325           | 325           |
| <b>Hard Coal Coke</b>     | 2,000         | 1,309         | 431           | 14.6          | 7.32          | 0.02          | 1.19          | 1.21          | 1.20          | 1.20          | 1.12          | 1.15          | 1.15          | 1.15          | 1.15          |
| <b>Solids TOTAL</b>       | <b>2,776</b>  | <b>1,627</b>  | <b>655</b>    | <b>283</b>    | <b>332</b>    | <b>352</b>    | <b>363</b>    | <b>368</b>    | <b>367</b>    | <b>363</b>    | <b>308</b>    | <b>327</b>    | <b>327</b>    | <b>327</b>    | <b>327</b>    |
| <b>Σ 1.A.3.c</b>          | <b>41,381</b> | <b>32,681</b> | <b>26,065</b> | <b>19,576</b> | <b>15,924</b> | <b>14,401</b> | <b>14,873</b> | <b>12,318</b> | <b>10,336</b> | <b>11,721</b> | <b>11,982</b> | <b>12,167</b> | <b>11,534</b> | <b>11,108</b> | <b>10,503</b> |

The use of other fuels – such as vegetable oils or gas – in private narrow-gauge railway vehicles has not been included to date and may still be considered negligible.

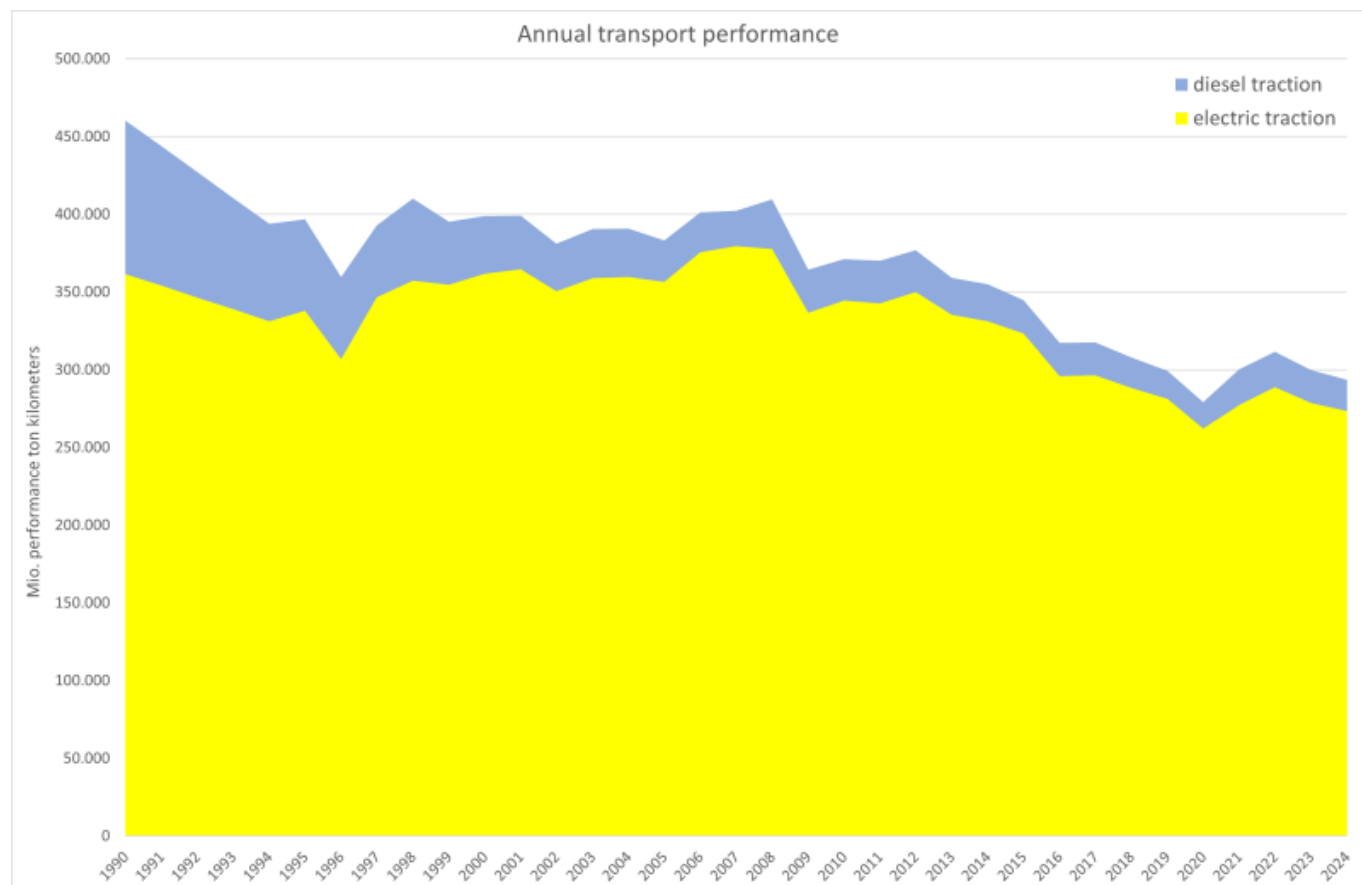


For estimating abrasive emissions of PM and heavy metals from wheel on track, brakes and contact line (electric traction only), annual transport performance data is applied, representing the trains gross weight (locomotive + waggons + freight) times the mileage driven and provide by the Deutsche Bahn in performance ton-kilometers [Ptkm].



Table 3: Annual transport performance by mode of traction, in Mio Ptkm (performance ton-kilometers)

|                 | 1990           | 1995           | 2000           | 2005           | 2010           | 2015           | 2016           | 2017           | 2018           | 2019           | 2020           | 2021           | 2022           | 2023           | 2024           |
|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| <b>Diesel</b>   | 98,812         | 58,805         | 37,237         | 26,540         | 26,702         | 21,397         | 21,484         | 21,365         | 19,580         | 18,058         | 16,917         | 23,028         | 22,733         | 21,028         | 20,019         |
| <b>Electric</b> | 361,515        | 337,853        | 361,633        | 356,605        | 344,546        | 323,387        | 295,798        | 296,280        | 288,336        | 281,130        | 262,268        | 277,395        | 288,761        | 278,660        | 273,407        |
| <b>Σ</b>        | <b>460,326</b> | <b>396,658</b> | <b>398,870</b> | <b>383,145</b> | <b>371,248</b> | <b>344,785</b> | <b>317,282</b> | <b>317,645</b> | <b>307,916</b> | <b>299,188</b> | <b>279,184</b> | <b>300,423</b> | <b>311,494</b> | <b>299,688</b> | <b>293,426</b> |
| <b>1.A.3.c</b>  |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |



Transport performance showed only a moderate pandemic-related decrease in 2020 and has fully recovered in 2021 and 2022.

Regarding particulate-matter and heavy-metal emissions from **abrasion and wear of contact line, braking systems, tyres on rails**, annual transport performances of railway vehicles with electrical and Diesel traction derived from Knörr et al. (2025a) <sup>6)</sup> are applied as activity data.

## Emission factors

The (implied) emission factors used here for estimating **emissions from diesel fuel combustion** are of very different quality:

For the main pollutants, CO and PM, annual tier2 IEF computed within the TREMOD model are used, representing the development of German railway fleet, fuel quality and mitigation technologies <sup>7)</sup>. (see next table).



With respect to the emission factors applied for exhaust particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>7)</sup>

Table 3: Annual country-specific emission factors for diesel fuels<sup>1</sup>, in kg/TJ

|  | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|

|                       | 1990  | 1995  | 2000  | 2005  | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-----------------------|-------|-------|-------|-------|------|------|------|------|------|------|------|------|------|------|------|
| <b>NH<sub>3</sub></b> | 0.54  | 0.54  | 0.54  | 0.54  | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 |
| <b>NM VOC</b>         | 109   | 100   | 90.2  | 64.8  | 52.0 | 39.2 | 39.3 | 38.0 | 37.0 | 36.6 | 38.1 | 37.3 | 34.9 | 33.5 | 33.7 |
| <b>NO<sub>x</sub></b> | 1,170 | 1,207 | 1,225 | 1,111 | 970  | 826  | 803  | 776  | 750  | 708  | 742  | 745  | 697  | 679  | 641  |
| <b>SO<sub>x</sub></b> | 196   | 60.5  | 14.1  | 0.32  | 0.32 | 0.32 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 |
| <b>PM<sup>2</sup></b> | 28.8  | 28.3  | 23.8  | 15.2  | 11.5 | 8.67 | 8.54 | 8.05 | 7.71 | 7.44 | 7.95 | 7.97 | 7.30 | 6.95 | 6.40 |
| <b>BC<sup>3</sup></b> | 44.4  | 43.6  | 36.6  | 23.4  | 17.7 | 13.3 | 13.1 | 12.4 | 11.9 | 11.4 | 12.2 | 12.3 | 11.2 | 10.7 | 9.84 |
| <b>CO</b>             | 287   | 292   | 255   | 162   | 121  | 95.8 | 95.1 | 94.0 | 91.4 | 90.3 | 90.9 | 90.5 | 87.7 | 86.5 | 85.5 |

<sup>1</sup> due to lack of better information: similar EF are applied for fossil diesel oil and biodiesel

<sup>2</sup> EF(PM<sub>2.5</sub>) also applied for PM<sub>10</sub> and TSP (assumption: >99% of TSP consists of PM<sub>2.5</sub>)

<sup>3</sup> EFs calculated via f-BCs as provided in <sup>8)</sup>, Chapter: 1.A.3.c - Railways, Appendix A: tier1: diesel fuels: f-BC=0.56

Regarding **emissions from solid fuels** used in historic steam engines, all emission factors displayed below have been adopted from small-scale stationary combustion.

Table 4: Emission factors applied for solid fuels, in kg/TJ

|                       | <b>NH<sub>3</sub></b> | <b>NM VOC</b> | <b>NO<sub>x</sub></b> | <b>SO<sub>x</sub></b> | <b>PM<sub>2.5</sub></b> | <b>PM<sub>10</sub></b> | <b>TSP</b> | <b>BC<sup>1</sup></b> | <b>CO</b> |
|-----------------------|-----------------------|---------------|-----------------------|-----------------------|-------------------------|------------------------|------------|-----------------------|-----------|
| <b>Hard coal</b>      | 4.00                  | 15.0          | 120                   | 650                   | 222                     | 250                    | 278        | 14.2                  | 500       |
| <b>Hard coal coke</b> | 4.00                  | 0.50          | 120                   | 500                   | 15.0                    | 15.0                   | 15.0       | 0.96                  | 1,000     |

<sup>1</sup> EFs calculated via f-BCs as provided in EMEP/EEA 2019, Chapter: 1.A.4 - Small Combustion: Residential combustion (1.A.4.b): Table 3-3, Zhang et al., 2012): f-BC=0.064

Table 5: Tier1 emission factors applied to railway vehicles, in [g/TJ]

|                              | <b>Pb</b>          | <b>Cd</b>          | <b>Hg</b>          | <b>As</b>          | <b>Cr</b>         | <b>Cu</b>          | <b>Ni</b>         | <b>Se</b>         | <b>Zn</b>          |
|------------------------------|--------------------|--------------------|--------------------|--------------------|-------------------|--------------------|-------------------|-------------------|--------------------|
| <b>Diesel oil</b>            | 0.012 <sup>1</sup> | 0.233 <sup>2</sup> | 0.123 <sup>1</sup> | 0.002 <sup>1</sup> | 1.16 <sup>2</sup> | 39.57 <sup>2</sup> | 1.63 <sup>2</sup> | 0.23 <sup>2</sup> | 23.28 <sup>2</sup> |
| <b>Biodiesel<sup>3</sup></b> | 0.013              | 0.269              | 0.142              | 0.003              | 1.34              | 0.15               | 0.01              | 0.003             | 0.48               |
| <b>Lignite Briquettes</b>    | NE                 |                    |                    |                    |                   |                    |                   |                   |                    |
| <b>Raw Lignite</b>           | NE                 |                    |                    |                    |                   |                    |                   |                   |                    |
| <b>Hard Coal</b>             | NE                 |                    |                    |                    |                   |                    |                   |                   |                    |
| <b>Hard Coal Coke</b>        | NE                 |                    |                    |                    |                   |                    |                   |                   |                    |

<sup>1</sup> tier1 default from <sup>9)</sup>, chapter: 1.A.3.b i-iv - Road transport: exhaust emissions: tier1 value for diesel vehicles

<sup>2</sup> tier1 default from <sup>10)</sup>, chapter: 1.A.3.c - Railways

<sup>3</sup> values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel

(NOTE: Assuming that biodiesel contains far less HMs than fossil diesel oil, similar values are applied to all mobile sources using this biogenic fuel.)

Here, as the EMEP/EEA Guidebook 2023 does not provide specific defaults for **Pb, Hg and As**, the EF applied here has been derived from chapter: 1.A.3.b i-iv, tier1 value for heavy-duty diesel vehicles.

Regarding the **POPs to be reported**, tier1 emission factors have been derived from different sources. For B[a]P, B[b]F, B[k]F, and I[123cd]P from diesel railway engines, tier1 values as provided in the EMEP/EEA Guidebook 2023 in chapters 1.A.3.c and 1.A.3.b (Update 2024) are used. Here, as no tier1 defaults specific to railways are provided for B[k]F and I[1,2,3-cd]P, the values provided for road heavy-duty vehicles are applied instead, as proposed in Table 3-9 in chapter 1.A.3.c of the EMEP/EEA Guidebook 2023 <sup>11)</sup>.

For dioxins and furans (PCDD/F), as the EMEP/EEA Guidebook 2023 <sup>12)</sup>, chapter 1.A.3.c Railways, Table 3-1: Tier 1 emission factors for diesel railways does not provide a tier1 value, the EF has been derived from a study carried out by Rentz et al. (2008) <sup>13)</sup> for the German Federal Environment Agency. Furthermore, both **HCB** and **PCBs** emissions are stated as *not applicable* in the EMEP/EEA Guidebook 2023 <sup>14)</sup>. Therefore, these emissions are only calculated for firewood (HCB) and fossil solid fuels (PCBs), respectively, with EF adopted from stationary combustion.

Table 6: Tier1 emission factors applied to railway vehicles

|  | <b>B[a]P</b> | <b>B[b]F</b> | <b>B[k]F</b> | <b>I[...]<sub>p</sub></b> | <b>PAH 1-4<sup>3</sup></b> | <b>PCDD/F</b> |
|--|--------------|--------------|--------------|---------------------------|----------------------------|---------------|
|  | [mg/TJ]      |              |              |                           |                            | [µg/TJ]       |

|                                                                                                                                                         |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <sup>1</sup> tier1 default from <sup>15)</sup> , chapter: 1.A.3.b i-iv - Road transport: exhaust emissions: tier1 values for diesel heavy-duty vehicles |  |
| <sup>2</sup> tier1 default from <sup>16)</sup> , chapter: 1.A.3.c - Railways                                                                            |  |
| <sup>3</sup> sum of tier1 default value applied for B[a]P, B[b]F, B[k]F, and I[...]P                                                                    |  |
| additional info:<br>derivation of tier1 EF for PAHs from diesel railway engines<br>(MS Excel file)                                                      |  |



<sup>3</sup> assumption contact line: 100 per cent copper; current collector: typically aluminium alloy + coal contacts; no particulate matter emissions calculated yet

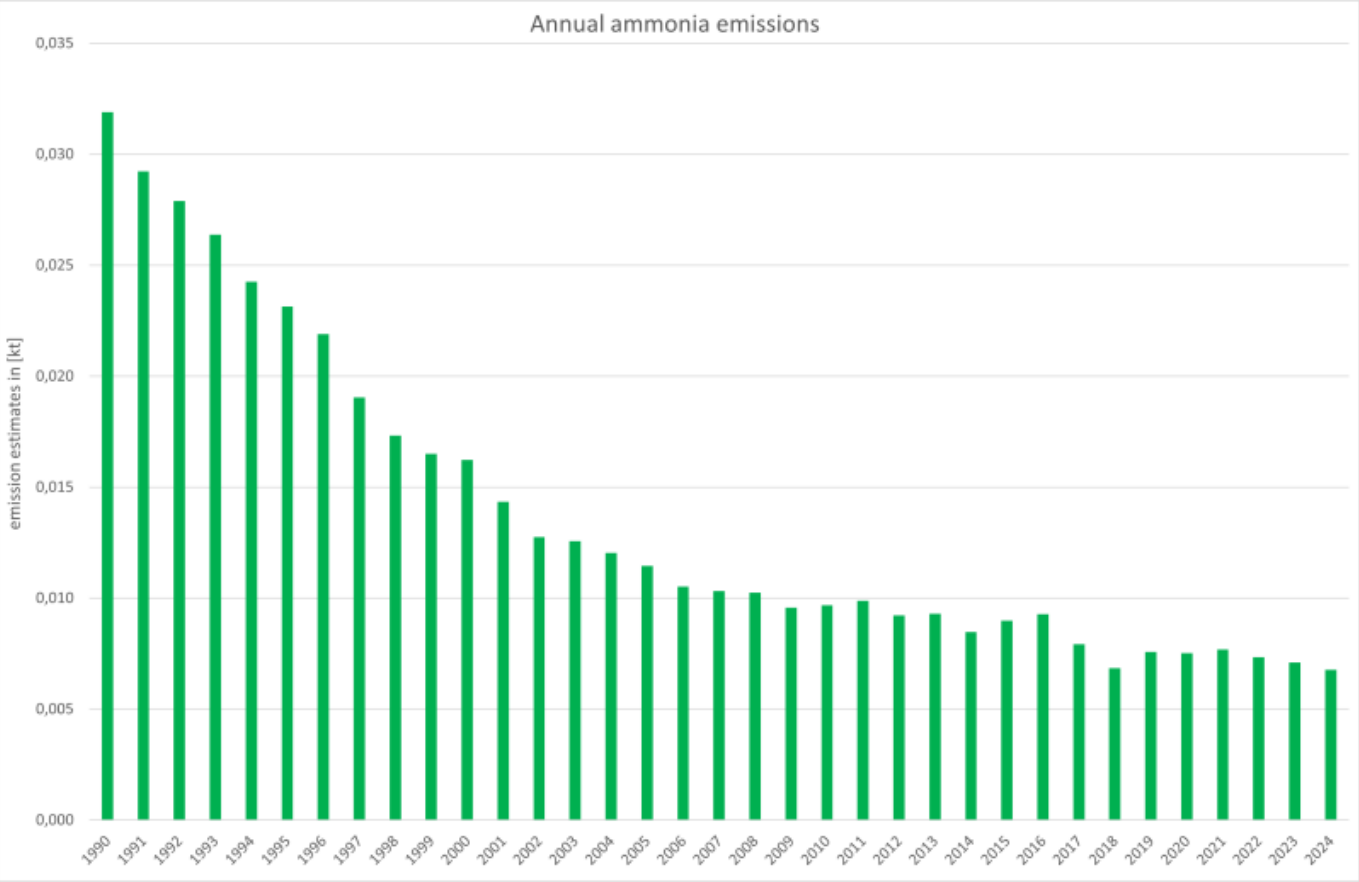
## Discussion of emission trends

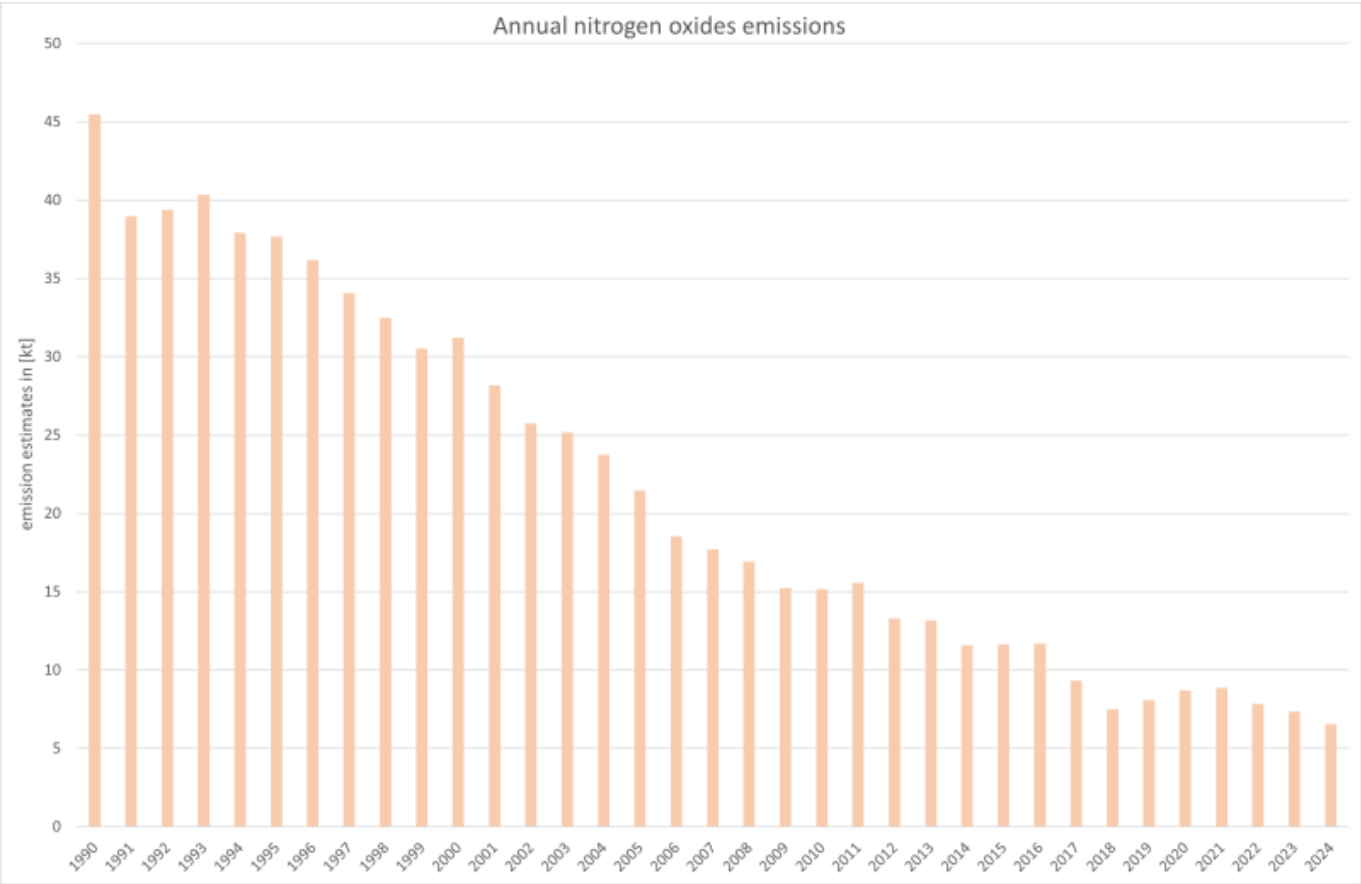
Table 6: Outcome of Key Category Analysis

|      |                       |                         |                        |            |            |            |
|------|-----------------------|-------------------------|------------------------|------------|------------|------------|
| for: | <b>NO<sub>x</sub></b> | <b>PM<sub>2.5</sub></b> | <b>PM<sub>10</sub></b> | <b>Cr</b>  | <b>Cu</b>  | <b>Ni</b>  |
| by:  | <b>-/T</b>            | <b>L/T</b>              | <b>L/-</b>             | <b>L/-</b> | <b>L/-</b> | <b>L/T</b> |

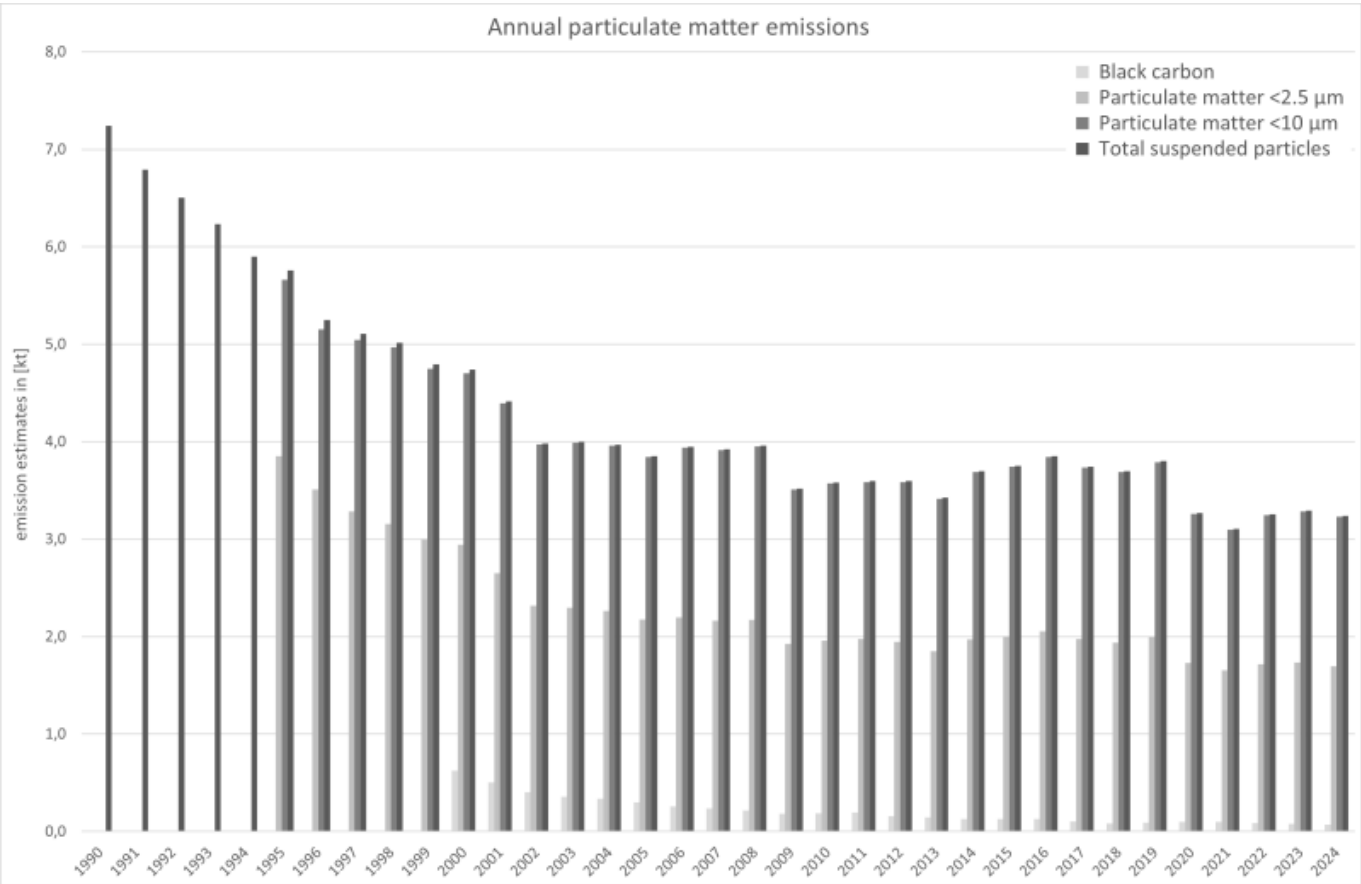
Basically, for all unregulated pollutants, emission trends directly follow the trend in over-all fuel consumption.

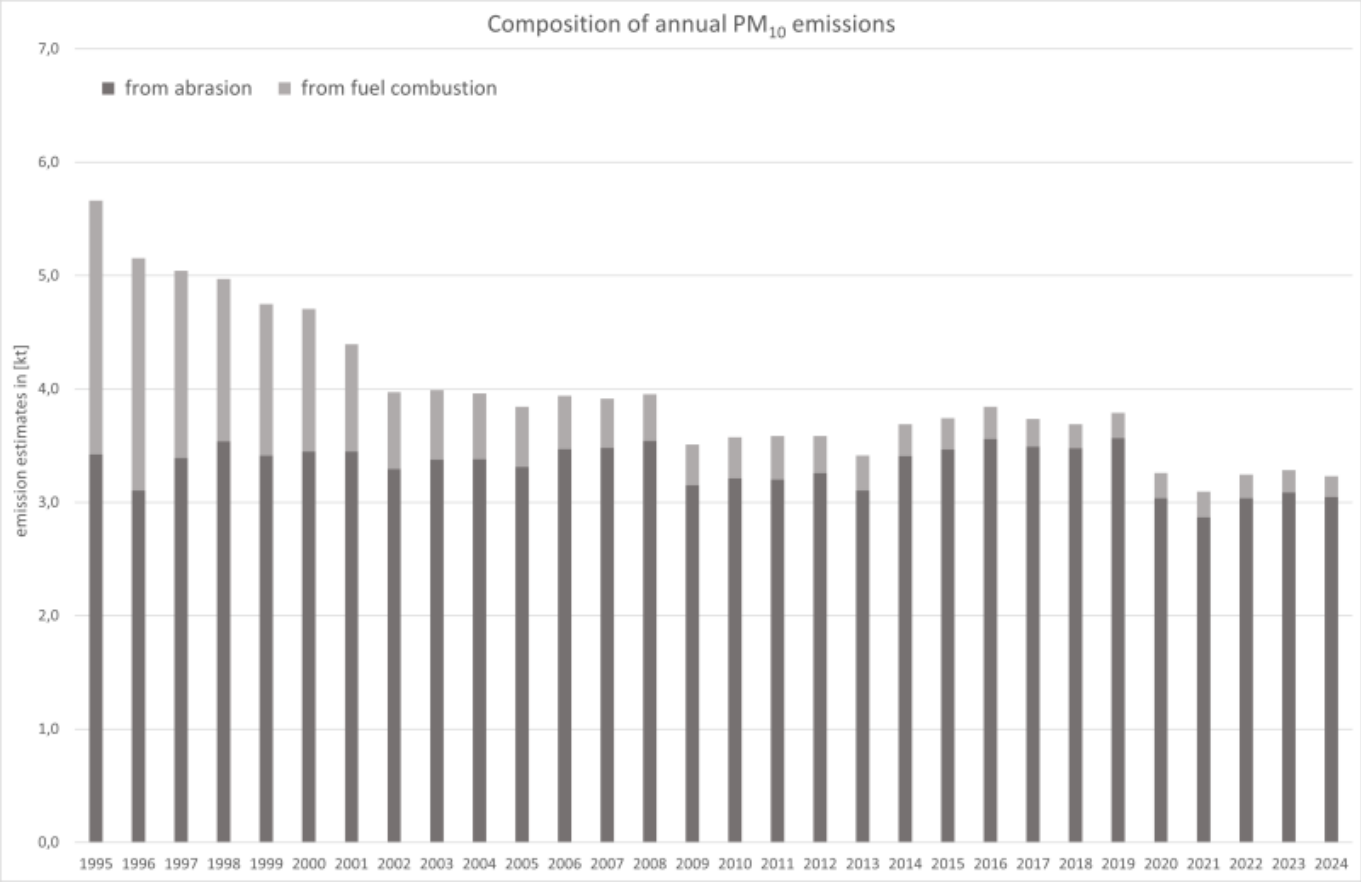
Here, as emission factors for solid fuels tend to be much higher than those for diesel oil, emission trends are disproportionately effected by the amount of solid fuels used. Therefore, for the **main pollutants, carbon monoxide, particulate matter** and **PAHs**, emission trends show remarkable jumps especially after 1995 that result from the significantly higher amounts of solid fuels used.



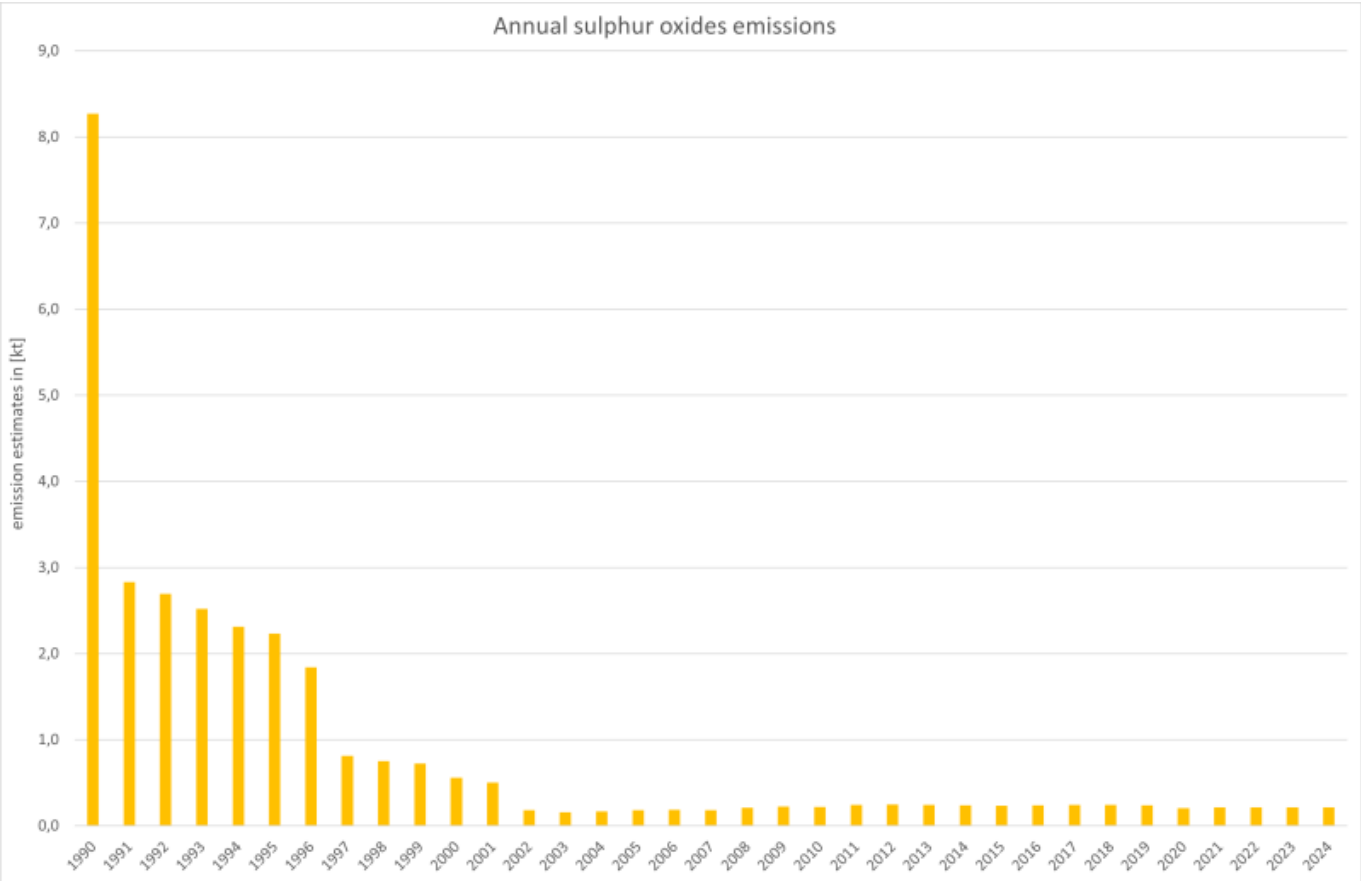


For all fractions of **particulate matter**, the majority of emissions generally result from abrasion and wear and the combustion of diesel fuels. Additional jumps in the over-all trend result from the use of lignite briquettes (1996-2001). Here, as the EF(BC) for fuel combustion are estimated via fractions provided in <sup>18)</sup>, black carbon emissions follow the corresponding emissions of PM<sub>2.5</sub>.





Due to fuel-sulphur legislation, the trend of **sulphur dioxide** emissions follows not only the trend in fuel consumption but also reflects the impact of regulated fuel-qualities. For the years as of 2005, sulphur emissions from diesel combustion have decreased so strongly, that the over-all trend shows a slight increase again due to the now dominating contribution of sulphur from the use of solid fuels.



Composition of annual copper emissions

from abrasion

from fuel combustion & engine wear

emission estimates in [kt]

| Year | from abrasion [kt] | from fuel combustion & engine wear [kt] | Total [kt] |
|------|--------------------|-----------------------------------------|------------|
| 1980 | 0.095              | 0.095                                   | 0.190      |
| 1981 | 0.093              | 0.093                                   | 0.186      |
| 1982 | 0.091              | 0.091                                   | 0.182      |
| 1983 | 0.089              | 0.089                                   | 0.178      |
| 1984 | 0.087              | 0.087                                   | 0.174      |
| 1985 | 0.089              | 0.089                                   | 0.178      |
| 1986 | 0.081              | 0.081                                   | 0.162      |
| 1987 | 0.091              | 0.091                                   | 0.182      |
| 1988 | 0.093              | 0.093                                   | 0.186      |
| 1989 | 0.092              | 0.092                                   | 0.184      |
| 1990 | 0.094              | 0.094                                   | 0.188      |
| 1991 | 0.095              | 0.095                                   | 0.190      |
| 1992 | 0.092              | 0.092                                   | 0.184      |
| 1993 | 0.093              | 0.093                                   | 0.186      |
| 1994 | 0.093              | 0.093                                   | 0.186      |
| 1995 | 0.091              | 0.091                                   | 0.182      |
| 1996 | 0.081              | 0.081                                   | 0.162      |
| 1997 | 0.091              | 0.091                                   | 0.182      |
| 1998 | 0.093              | 0.093                                   | 0.186      |
| 1999 | 0.092              | 0.092                                   | 0.184      |
| 2000 | 0.094              | 0.094                                   | 0.188      |
| 2001 | 0.095              | 0.095                                   | 0.190      |
| 2002 | 0.092              | 0.092                                   | 0.184      |
| 2003 | 0.093              | 0.093                                   | 0.186      |
| 2004 | 0.093              | 0.093                                   | 0.186      |
| 2005 | 0.091              | 0.091                                   | 0.182      |
| 2006 | 0.097              | 0.097                                   | 0.194      |
| 2007 | 0.098              | 0.098                                   | 0.196      |
| 2008 | 0.097              | 0.097                                   | 0.194      |
| 2009 | 0.087              | 0.087                                   | 0.174      |
| 2010 | 0.090              | 0.090                                   | 0.180      |
| 2011 | 0.089              | 0.089                                   | 0.178      |
| 2012 | 0.091              | 0.091                                   | 0.182      |
| 2013 | 0.087              | 0.087                                   | 0.174      |
| 2014 | 0.093              | 0.093                                   | 0.186      |
| 2015 | 0.096              | 0.096                                   | 0.192      |
| 2016 | 0.097              | 0.097                                   | 0.194      |
| 2017 | 0.095              | 0.095                                   | 0.190      |
| 2018 | 0.097              | 0.097                                   | 0.194      |
| 2019 | 0.100              | 0.100                                   | 0.200      |
| 2020 | 0.104              | 0.104                                   | 0.208      |
| 2021 | 0.109              | 0.109                                   | 0.218      |
| 2022 | 0.106              | 0.106                                   | 0.214      |
| 2023 | 0.107              | 0.107                                   | 0.214      |
| 2024 | 0.106              | 0.106                                   | 0.214      |

**Activity data** have been recalculated due to the finalization of the National Energy Balances 2023 <sup>19)</sup>. In addition, the shares of blende biodiesel have been revised for all years as of 2004.

|                        | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018  | 2019   | 2020   | 2021   | 2022   | 2023   |
|------------------------|--------|--------|--------|--------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|
| DIESEL OIL             |        |        |        |        |        |        |        |        |       |        |        |        |        |        |
| current submission     | 38,605 | 31,054 | 25,410 | 18,877 | 14,626 | 13,321 | 13,775 | 11,344 | 9,425 | 10,747 | 10,782 | 11,072 | 10,482 | 10,035 |
| previous submission    | 38,605 | 31,054 | 25,410 | 18,877 | 14,626 | 13,321 | 13,775 | 11,344 | 9,425 | 10,747 | 10,782 | 11,072 | 10,482 | 10,039 |
| absolute change        | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | -3.75  |
| relative change        | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00% | 0.00%  | 0.00%  | 0.00%  | 0.00%  | -0.04% |
| BIODIESEL (as of 2004) |        |        |        |        |        |        |        |        |       |        |        |        |        |        |
| current submission     |        |        |        | 416    | 966    | 729    | 735    | 606    | 544   | 611    | 892    | 769    | 725    | 747    |
| previous submission    |        |        |        | 434    | 976    | 738    | 745    | 618    | 532   | 610    | 882    | 776    | 727    | 744    |
| absolute change        |        |        |        | -18.0  | -9.97  | -9.34  | -10.0  | -12.7  | 12.3  | 0.95   | 10.6   | -7.81  | -1.88  | 2.54   |
| relative change        |        |        |        | -4.14% | -1.02% | -1.27% | -1.34% | -2.05% | 2.32% | 0.16%  | 1.20%  | -1.01% | -0.26% | 0.34%  |
| SOLID FUELS            |        |        |        |        |        |        |        |        |       |        |        |        |        |        |

|                              | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>current submission</b>    | 2,776  | 1,627  | 655    | 283    | 332    | 352    | 363    | 368    | 367    | 363    | 308    | 327    | 327    | 327    |
| <b>previous submission</b>   | 2.776  | 1.627  | 655    | 283    | 332    | 352    | 363    | 368    | 367    | 363    | 308    | 327    | 327    | 327    |
| <b>absolute change</b>       | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   |
| <b>relative change</b>       | 0%     | 0%     | 0.00%  | 0.0%   | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  |
| <b>OVER-ALL ENERGY INPUT</b> |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>    | 41,381 | 32,681 | 26,065 | 19,576 | 15,924 | 14,401 | 14,873 | 12,318 | 10,336 | 11,721 | 11,982 | 12,167 | 11,534 | 11,108 |
| <b>previous submission</b>   | 41,381 | 32,681 | 26,065 | 19,594 | 15,934 | 14,411 | 14,883 | 12,331 | 10,324 | 11,720 | 11,972 | 12,175 | 11,536 | 11,110 |
| <b>absolute change</b>       | 0.00   | 0.00   | 0.00   | -18.0  | -10.0  | -9.34  | -10.0  | -12.7  | 12.3   | 0.95   | 10.6   | -7.81  | -1.88  | -1.21  |
| <b>relative change</b>       | 0.00%  | 0.00%  | 0.00%  | -0.09% | -0.06% | -0.06% | -0.07% | -0.10% | 0.12%  | 0.01%  | 0.09%  | -0.06% | -0.02% | -0.01% |

Furthermore, due to the routine revision of the TREMOD model <sup>20)</sup>, tier2 **emission factors** changed slightly for recent years.

In contrast, transport performance data as well as the corresponding emission factors applied for the estimation of **abrasive** particulate matter and heavy metals (Cu, Ni, Cr) **emissions remain unaltered**.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023 (title: "Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland") carried out by Knörr et al. (2009) <sup>21)</sup>.

## Planned improvements

Besides the scheduled **routine revision** of TREMOD, no further improvements are planned for the next annual submission.

## FAQs

### **Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?**

The EF provided in the 2023 EMEP/EEA Guidebook <sup>22)</sup> represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metals contained in the biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel.

<sup>1), 19)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> MWV (2021): Association of the German Petroleum Industry (Mineralölwirtschaftsverband, MWV): Annual Report 2018, page 65, Table 'Sektoraler Verbrauch von Dieselmotoren 2012-2019'; [https://www.mwv.de/wp-content/uploads/2020/09/MWV\\_Mineraloelwirtschaftsverband-e.V.-Jahresbericht-2020-Webversion.p](https://www.mwv.de/wp-content/uploads/2020/09/MWV_Mineraloelwirtschaftsverband-e.V.-Jahresbericht-2020-Webversion.p)



df, Berlin, 2021.

<sup>3)</sup> Hedel & Kunze (2012): Hedel, R., Kunze, J.: Recherche des jährlichen Kohleeinsatzes in historischen Schienenfahrzeugen seit 1990. Probst & Consorten Marketing-Beratung. Dresden, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2012.

<sup>4)</sup> Illichmann, S. (2016): Illichmann, S.: Recherche des Festbrennstoffeinsatzes historischer Schienenfahrzeuge in Deutschland 2015, Probst & Consorten Marketing-Beratung, on behalf of the Umweltbundesamt, Dessau-Roßlau, unpublished, 2016.

<sup>5)</sup> Hasenbalg (2021): Recherche des Festbrennstoffeinsatzes historischer Schienenfahrzeuge in Deutschland 2019 & 2020, Probst & Consorten Marketing-Beratung, FKZ 363 01 392; un published; Dresden, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2021.

<sup>6), 7), 20)</sup> Knörr et al. (2025a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2025.

<sup>8)</sup> (bibcite 6)

<sup>9), 10), 11), 12), 14), 15), 16), 22)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023>, Copenhagen, 2023.

<sup>13)</sup> Rentz et al. (2008): Otto Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung, Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), FKZ 205 67 444, UBA Texte 01/2008, <https://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer>; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008

<sup>17)</sup> DZSF (2025): Deutsches Zentrum für Schienenverkehrsforschung / German Centre for Rail Traffic Research) research project on “Size-specific and spatial distribution of traffic-related abrasion and particulate emissions” (Größenspezifische und räumliche Verteilung von verkehrsbedingten Abrieben und partikulären Emissionen); [https://www.dzsf.bund.de/SharedDocs/Standardartikel/DZSF/Projekte/Projekt\\_44\\_Abriebe\\_Emissionen.html](https://www.dzsf.bund.de/SharedDocs/Standardartikel/DZSF/Projekte/Projekt_44_Abriebe_Emissionen.html), 2025

<sup>18)</sup> EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, <https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-c-railways/view>; Copenhagen, 2019.

<sup>21)</sup> Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; <https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf>, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

<sup>7)</sup>

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

## 1.A.3.d - Navigation

### Short description

Category 1.A.3.d - Navigation includes emissions from national and international inland and maritime navigation.

| NFR-Code                                    | Name of Category                  | Method                                                    | AD | EF | Key Category Analysis |
|---------------------------------------------|-----------------------------------|-----------------------------------------------------------|----|----|-----------------------|
| 1.A.3.d                                     | Navigation                        | see sub-category details                                  |    |    |                       |
| consisting of / including source categories |                                   |                                                           |    |    |                       |
| 1.A.3.d i (ii)                              | International Inland Waterways    | Germany does not report emissions from this sub-category. |    |    |                       |
| 1.A.3.d ii                                  | National Navigation (Shipping)    | see sub-category details                                  |    |    |                       |
| 1.A.3.d i (i)                               | International Maritime Navigation | see sub-category details                                  |    |    |                       |

### Methodology

#### Activity Data

Primary fuel deliveries data for the entire navigation sector (maritime and inland waterways) is included in lines 6 ('International Maritime Bunkers') and 64 ('Coastal and Inland Navigation') of the National Energy Balance (NEB) (AGEB, 2025) <sup>1)</sup>. (For comparison, official mineral-oil data of the Federal Office of Economics and Export Control (BAFA, 2025) <sup>2)</sup> are applied, too.)

Data on the consumption of *biodiesel* is provided in NEB line 64 from 2004 onward. However, as this data appears to be rather inconsistent, the consumption of biofuels is calculated within TREMOD via the official annual blending rates.

Table 1: Primary fuel deliveries as listed in the National Energy Balance, in terajoules

|                                                                                                                                                                                | 1990    | 1995    | 2000    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|--------|--------|--------|--------|--------|--------|--------|
| NEB line 6 - Maritime Bunkers ('Hochseebunkeringen')                                                                                                                           |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |
| Diesel                                                                                                                                                                         | 23,336  | 20,426  | 21,542  | 18,342  | 22,340  | 43,254  | 42,198  | 9,822   |        |        |        |        |        |        |        |
| Light fuel oil (Heating oil)                                                                                                                                                   | NO      |         |         |         |         |         |         | 26,958  | 31,267 | 30,086 | 22,683 | 30,116 | 31,488 | 27,802 | 26,569 |
| Heavy fuel oil                                                                                                                                                                 | 80,230  | 64,382  | 69,578  | 86,272  | 93,886  | 57,386  | 75,445  | 58,277  | 39,248 | 26,813 | 32,431 | 28,106 | 29,652 | 26,794 | 27,221 |
| LNG <sup>1</sup>                                                                                                                                                               | NO      |         |         |         |         | 22.0    | 64.4    | 58.8    | 197    | 153    | 276    | 293    | 513    | 382    | 504    |
| NEB line 64 - Coastal and Inland Navigation ('Küsten- und Binnenschifffahrt')                                                                                                  |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |
| Diesel oil                                                                                                                                                                     | 27,716  | 23,562  | 11,864  | 19,715  | 18,230  | 15,730  | 14,368  | 14,738  | 14,652 | 14,535 | 13,761 | 11,785 | 8,786  | 9,473  | 9,747  |
| LPG                                                                                                                                                                            | 7.00    | 7.00    | 7.00    | 7.02    | 7.08    | 7.10    | 7.25    | 7.06    | 7.14   | 7.20   | 7.36   | 7.49   | 7.23   | 7.53   | 7.34   |
| Gasoline                                                                                                                                                                       | 272     | 272     | 272     | 274     | 261     | 265     | 265     | 266     | 262    | 265    | 269    | 273    | 275    | 273    | 274    |
| Biogasoline <sup>2</sup>                                                                                                                                                       | NO      |         |         | 1.86    | 10.1    | 11.1    | 11.2    | 11.0    | 11.4   | 11.1   | 11.9   | 12.6   | 12.7   | 13.0   | 12.8   |
| TOTAL inland fuel deliveries                                                                                                                                                   | 131,561 | 108,649 | 103,263 | 124,739 | 134,875 | 116,838 | 132,520 | 110,138 | 85,645 | 71,870 | 69,439 | 70,593 | 70,734 | 64,745 | 64,335 |
| data sources: fossil liquid fuels: NEB <sup>3)</sup> ; <sup>1</sup> LNG (as not yet included in NEB): BSH model <sup>4)</sup> ; <sup>2</sup> biogasoline: TREMOD <sup>5)</sup> |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |
| <i>italic numbers: extrapolated backwards as data provided in NEB only as of 2003</i>                                                                                          |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |

As the statistical allocation of fuels delivered to the navigation (shipping) sector follows tax aspects, NEB line 6 ('International Maritime Bunkers') includes all fuel deliveries to IMO-registered ship involved in both national and international maritime activities. On the other hand, NEB line 64 ('Coastal and Inland Navigation') includes all fuel deliveries to ship involved in inland and non-IMO maritime navigation.

Table 2: Allocation of for subsector-specific fuel deliveries data in the NEB

| NEB line                             | including fuel deliveries to navigation sub-sectors...                                                                              |
|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| 6 - 'International Maritime Bunkers' | ...international maritime navigation / national maritime navigation (IMO) / national fishing (IMO) / military navigation (IMO)      |
| 64 - 'Coastal and Inland Navigation' | ...national inland navigation / national maritime navigation (non-IMO) / national fishing (non-IMO) / military navigation (non-IMO) |

Therefore, the amounts of fuels listed in NEB lines 6 and 64 are broken down on several sub-sectors.

Regarding all national maritime activities, taking place in National Maritime Navigation, national fishing, and military navigation, a country-specific approach allows for estimating tier3 fuel consumption data based on ship movement information (AIS signal) for IMO- and non-IMO ships.

In contrast to this bottom-up approach, fuel consumption in both *international maritime navigation* and *national inland navigation* are calculated as tier1 estimates. The following equations and charts try to illustrate the way of deducing these tier1 activity data:

#### Estimating the tier1 activity data for International maritime navigation:

|                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $AD_{1.A.3.d\ i} = PAD_{NEB\ line\ 6} - AD_{1.A.3.d\ ii\ (a) - IMO} - AD_{1.A.4.c\ iii - IMO} - AD_{1.A.5.b\ iii - IMO}$ | with<br>* $AD_{1.A.3.d\ i}$ - tier1 activity data for International maritime navigation<br>* $PAD_{NEB\ line\ 6}$ - primary over-all fuel deliveries data from NEB line 6 - 'International Maritime Bunkers'<br>* $AD_{1.A.3.d\ ii\ (a) - IMO}$ - tier3 activity data for IMO-registered ships involved in national maritime navigation<br>* $AD_{1.A.4.c\ iii - IMO}$ - tier3 activity data for IMO-registered ships involved in national fishing<br>* $AD_{1.A.5.b\ iii - IMO}$ - tier3 activity data for IMO-registered ships involved in military navigation |
|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

#### Estimating the tier1 activity data for National inland navigation:

|                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $AD_{1.A.3.d\ ii\ (b)} = PAD_{NEB\ line\ 64} - AD_{1.A.3.d\ ii\ (a) - non-IMO} - AD_{1.A.4.c\ iii - non-IMO} - AD_{1.A.5.b\ iii - non-IMO}$ | with<br>* $AD_{1.A.3.d\ ii\ (b)}$ - tier1 activity data for National inland navigation<br>* $PAD_{NEB\ line\ 64}$ - primary over-all fuel deliveries data from NEB line 64 - 'Coastal and Inland Navigation'<br>* $AD_{1.A.3.d\ ii\ (a) - non-IMO}$ - tier3 activity data for non-IMO ships involved in national maritime navigation<br>* $AD_{1.A.4.c\ iii - non-IMO}$ - tier3 activity data for for non-IMO ships involved in national fishing<br>* $AD_{1.A.5.b\ iii - non-IMO}$ - tier3 activity data for for non-IMO ships involved in military navigation |
|---------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Table 3: Resulting breakdown of primary fuel deliveries onto the different navigation sub-sectors, in terajoules

|                                               | 1990    | 1995    | 2000    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|-----------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|--------|--------|--------|--------|--------|--------|--------|
| TOTAL                                         | 131,561 | 108,649 | 103,263 | 124,739 | 134,875 | 116,838 | 132,520 | 110,138 | 85,645 | 71,870 | 69,439 | 70,593 | 70,734 | 64,745 | 64,335 |
| 1.A.3.d i - International maritime navigation |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |
| Diesel oil                                    | 13,162  | 13,096  | 13,709  | 11,546  | 16,273  | 33,836  | 32,424  | 27,370  | 16,000 |        |        |        |        |        |        |
| Light fuel oil                                | NO      |         |         |         |         |         |         |         | 5,333  | 20,103 | 13,606 | 21,258 | 23,257 | 19,519 | 17,832 |
| Heavy fuel oil                                | 76,942  | 62,066  | 67,080  | 84,127  | 91,992  | 57,278  | 75,408  | 58,196  | 38,986 | 26,418 | 32,053 | 27,713 | 29,416 | 26,591 | 26,990 |
| 1.A.3.d ii (a) - National maritime navigation |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |
| Diesel oil                                    | 9,484   | 6,828   | 7,367   | 6,399   | 5,690   | 8,980   | 9,335   | 8,960   | 7,084  | NO     |        |        |        |        |        |
| Light fuel oil                                | NO      |         |         |         |         |         |         |         | 2,361  | 9,497  | 8,329  | 8,475  | 7,879  | 7,922  | 8,407  |
| Heavy fuel oil                                | 3,103   | 2,186   | 2,382   | 2,054   | 1,810   | 108     | 37,0    | 81,1    | 262    | 394    | 378    | 392    | 235    | 203    | 231    |
| LNG                                           | NO      |         |         |         |         | 22.0    | 64.4    | 58.8    | 197    | 153    | 276    | 293    | 513    | 382    | 504    |
| 1.A.3.d ii (b) - National inland navigation   |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |
| Diesel oil                                    | 27,716  | 23,562  | 11,864  | 19,715  | 18,230  | 15,730  | 14,368  | 14,738  | 14,652 | 14,535 | 13,761 | 11,785 | 8,786  | 9,473  | 9,747  |
| Gasoline                                      | 272     | 272     | 272     | 274     | 261     | 265     | 265     | 266     | 262    | 265    | 269    | 273    | 275    | 273    | 274    |
| Biogasoline                                   |         |         |         | 1.86    | 10.1    | 11.1    | 11.2    | 11.0    | 11.4   | 11.1   | 11.9   | 12.6   | 12.7   | 13.0   | 12.8   |
| LPG                                           | 7.00    | 7.00    | 7.00    | 7.02    | 7.08    | 7.10    | 7.25    | 7.06    | 7.14   | 7.20   | 7.36   | 7.49   | 7.23   | 7.53   | 7.34   |
| 1.A.4.c iii - National Fishing                |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |
| Diesel oil                                    | 305     | 240     | 238     | 226     | 227     | 284     | 298     | 293     | 267    | NO     |        |        |        |        |        |
| Light fuel oil                                | NO      |         |         |         |         |         |         |         | 88.9   | 322    | 359    | 265    | 221    | 225    | 232    |
| Heavy fuel oil                                | 33.3    | 26.0    | 26.0    | 24.4    | 24.5    | NO      |         |         |        |        |        |        |        |        |        |
| 1.A.5.b iii - Military Navigation             |         |         |         |         |         |         |         |         |        |        |        |        |        |        |        |
| Diesel oil                                    | 380     | 263     | 228     | 171     | 150     | 154     | 141     | 156     | 99.5   | NO     |        |        |        |        |        |

|                       | 1990           | 1995           | 2000           | 2005           | 2010           | 2015           | 2016           | 2017           | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
|-----------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>TOTAL</b>          | <b>131,561</b> | <b>108,649</b> | <b>103,263</b> | <b>124,739</b> | <b>134,875</b> | <b>116,838</b> | <b>132,520</b> | <b>110,138</b> | <b>85,645</b> | <b>71,870</b> | <b>69,439</b> | <b>70,593</b> | <b>70,734</b> | <b>64,745</b> | <b>64,335</b> |
| <b>Light fuel oil</b> | NO             |                |                |                |                |                |                |                | 33.2          | 164           | 390           | 118           | 131           | 135           | 97.6          |
| <b>Heavy fuel oil</b> | 152            | 104            | 90.4           | 67.4           | 59.0           | NO             |                |                |               |               |               |               |               |               |               |

## Emission factors

Annual country-specific emission factors have been developed within the underlying models maintained at the ifeu Institute for Energy and Environmental Research (Knörr et al. (2025a): TREMOD)<sup>6)</sup> and the Federal Maritime and Hydrographic Agency (Deichnik (2025): BSH model)<sup>7)</sup>.

For information on these country-specific emission factors, please refer to the sub-chapters linked above.

## Impact of fuel-sulphur regulation on sulphur dioxide

Table 4: Development of fuel-sulfur limits for maritime fuels in SECAs, in [% m/m]

|                                                                                  |      |                     |
|----------------------------------------------------------------------------------|------|---------------------|
| mid-2006 to mid-2010                                                             | 1.50 |                     |
| mid-2010 to 2015                                                                 | 1.00 | LSFO <sup>2)</sup>  |
| as of 2015                                                                       | 0.10 | ULSFO <sup>3)</sup> |
| <sup>1)</sup> SECA = Sulphur Emission Control Area <sup>8)</sup> , <sup>9)</sup> |      |                     |
| <sup>2)</sup> Low sulphur Fuel Oil                                               |      |                     |
| <sup>3)</sup> Ultra low sulphur Fuel Oil                                         |      |                     |

These fuel-sulfur limits listed are used for the derivation of emission factors especially for heavy fuel oil used in the German inventory. Here, until 2006, a global average of 2.70 % m/m is applied.

Table 5: Development of global fuel-sulfur limits for maritime fuels, in [% m/m]

|              |      |
|--------------|------|
| until 2012   | 4.50 |
| 2012 to 2020 | 3.50 |
| as of 2020   | 0.50 |

## Heavy metals and POPs

For heavy metal and POP emissions, tier1 EF have been derived from the EMEP/EEA Guidebook 2019 mainly <sup>10)</sup>.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

Table 4 shows the tier1 emission factors for exhaust emissions of **heavy-metals** and **POPs** as applied to all navigation sub-categories in 1.A.3.d as well as NFRs 1.A.4.c iii and 1.A.5.b iii. The listed values have been derived from default values provided in the EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2019) <sup>11)</sup> and (Rentz et al., 2008) <sup>12)</sup>.

Here, as the 2019 EMEP/EEA Guidebook does not provide source-specific values for **PAHs**, respective values provided for diesel in railways and heavy duty road vehicles have been applied as a gap-filling proxy. As an improvement, the specific tier1 default emission factors available from the latest (2023) version of the EMEP/EEA Guidebook have not yet been implemented in the inventory but will be applied with the next annual submission.

Table 6: Tier1 emission factors for heavy-metal and POP exhaust emissions

|                                                                                                                                                    | Pb                | Cd                 | Hg                 | As                | Cr                | Cu                | Ni                | Se                | Zn                | B[a]P            | B[b]F              | B[k]F            | I[...] <sub>p</sub> | PAH<br>1-4         | PCBs               | HCb               | PCDD/F            |
|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|------------------|--------------------|------------------|---------------------|--------------------|--------------------|-------------------|-------------------|
|                                                                                                                                                    | [g/T]             |                    |                    |                   |                   |                   |                   |                   |                   | [mg/T]           |                    |                  |                     |                    |                    |                   |                   |
| <b>Diesel oil &amp; Light fuel oil</b>                                                                                                             | 3.03 <sub>2</sub> | 0.233 <sub>2</sub> | 0.698 <sub>2</sub> | 0.93 <sub>2</sub> | 1.16 <sub>2</sub> | 20.5 <sub>2</sub> | 23.3 <sub>2</sub> | 2.33 <sub>2</sub> | 27.9 <sub>2</sub> | 698 <sup>5</sup> | 1,164 <sup>5</sup> | 801 <sup>6</sup> | 184 <sup>6</sup>    | 2,847 <sup>4</sup> | 0.885 <sub>2</sub> | 1.86 <sub>2</sub> | 93.0 <sup>7</sup> |
| <b>Heavy fuel oil</b>                                                                                                                              | 4.46 <sub>3</sub> | 0.496 <sub>3</sub> | 0.496 <sub>3</sub> | 16.9 <sub>3</sub> | 17.8 <sub>3</sub> | 31.0 <sub>3</sub> | 793 <sub>3</sub>  | 5.20 <sub>3</sub> | 29.7 <sub>3</sub> | 741 <sup>5</sup> | 1,235 <sup>5</sup> | 849 <sup>6</sup> | 195 <sup>6</sup>    | 3,020 <sup>4</sup> | 14.1 <sub>3</sub>  | 3.46 <sub>3</sub> | 98.7 <sup>7</sup> |
| <sup>3</sup> tier1 defaults from <sup>13)</sup> , Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Table 3-1                                |                   |                    |                    |                   |                   |                   |                   |                   |                   |                  |                    |                  |                     |                    |                    |                   |                   |
| <sup>2</sup> tier1 defaults from <sup>14)</sup> , Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Table 3-2                                |                   |                    |                    |                   |                   |                   |                   |                   |                   |                  |                    |                  |                     |                    |                    |                   |                   |
| <sup>4</sup> sum of tier1 default values applied for B[a]P, B[b]F, B[k]F, and I[1,2,3-c,d]P                                                        |                   |                    |                    |                   |                   |                   |                   |                   |                   |                  |                    |                  |                     |                    |                    |                   |                   |
| <sup>5</sup> tier1 defaults from <sup>15)</sup> , Chapter: 1.A.3.c Railways: Diesel, Table 3-1                                                     |                   |                    |                    |                   |                   |                   |                   |                   |                   |                  |                    |                  |                     |                    |                    |                   |                   |
| <sup>6</sup> tier1 defaults from <sup>16)</sup> , Chapter: 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv - Road transport, Table 3-8: HDV, Diesel |                   |                    |                    |                   |                   |                   |                   |                   |                   |                  |                    |                  |                     |                    |                    |                   |                   |
| <sup>7</sup> tier1 value derived from Rentz et al. (2008) <sup>17)</sup>                                                                           |                   |                    |                    |                   |                   |                   |                   |                   |                   |                  |                    |                  |                     |                    |                    |                   |                   |

<sup>1), 3)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl-daten für die Bundesrepublik Deutschland; [https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>5), 6)</sup> Knörr et al. (2024a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2025.

<sup>7)</sup> Deichnik (2025): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs. from Federal Maritime and Hydrographic Agency (BSH - Bundesamts für Seeschifffahrt und Hydrographie); on behalf of the Umweltbundesamt, Hamburg / Dessau-Roßlau, 2025.

<sup>8)</sup> Wikipedia, 2023: [https://en.wikipedia.org/wiki/Emission\\_control\\_area](https://en.wikipedia.org/wiki/Emission_control_area)

<sup>9)</sup> IMO, 2014:

[https://arquivo.pt/wayback/20141223211746/http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-\(SOx\)-%e2%80%93Regulation-14.aspx](https://arquivo.pt/wayback/20141223211746/http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-(SOx)-%e2%80%93Regulation-14.aspx)

<sup>12), 17)</sup> Rentz et al., 2008: Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, <https://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer>, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008.

<sup>13), 14), 15), 16)</sup> EMEP/EEA, 2023: EMEP/EEA air pollutant emission inventory guidebook – 2023, Chapter 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii; <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-d-navigation/@@download/file>; Copenhagen, 2023.

## 1.A.3.d ii - National Navigation

### Short description

Under category 1.A.3.d ii - *National Navigation* emissions from national navigation (both inland and maritime) are reported.

| Category Code                                                                             | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.3.d ii                                                                                | T1, T2, T3                           | NS, M | CS, D, M |
| covering emissions in:                                                                    |                                      |       |          |
| Domestic maritime navigation                                                              | T1, T2, T3                           | NS, M | CS, D, M |
| Domestic inland navigation                                                                | T1, T2, T3                           | NS, M | CS, D, M |
| Method(s) applied                                                                         |                                      |       |          |
| D                                                                                         | Default                              |       |          |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |          |
| T2                                                                                        | Tier 2*                              |       |          |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |          |
| C                                                                                         | CORINAIR                             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| M                                                                                         | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| (source for) Activity Data                                                                |                                      |       |          |
| NS                                                                                        | National Statistics                  |       |          |
| RS                                                                                        | Regional Statistics                  |       |          |
| IS                                                                                        | International Statistics             |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| As                                                                                        | Associations, business organisations |       |          |
| Q                                                                                         | specific Questionnaires (or surveys) |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |
| (source for) Emission Factors                                                             |                                      |       |          |
| D                                                                                         | Default (EMEP Guidebook)             |       |          |
| CS                                                                                        | Country Specific                     |       |          |
| PS                                                                                        | Plant Specific                       |       |          |
| M                                                                                         | Model / Modelled                     |       |          |
| C                                                                                         | Confidential                         |       |          |

| NO <sub>x</sub>                                                                        | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|----------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|
| L/-                                                                                    | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | -/-  |
| L/- key source by <b>Level</b> only                                                    |        |                 |                 |                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
| -/T key source by <b>Trend</b> only                                                    |        |                 |                 |                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
| L/T key source by both <b>Level</b> and <b>Trend</b>                                   |        |                 |                 |                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
| -/- no key source for this pollutant                                                   |        |                 |                 |                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
| IE emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |        |                 |                 |                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
| NE emission of specific pollutant <b>Not Estimated</b> (yet)                           |        |                 |                 |                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
| NA specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |        |                 |                 |                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
| * no analysis done                                                                     |        |                 |                 |                   |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |

### Methodology

#### Activity data

As described for the over-all sector 1.A.3.d and all other navigational activities in the superordinate chapter, specific fuel consumption data for NFR 1.A.3.d ii is included in the primary fuel deliveries data provided in NEB lines 6 ('International

Maritime Bunkers') and 64 ('Coastal and Inland Navigation') <sup>1)</sup>.

Here, the annual fuel consumption for domestic *maritime* navigation are modelled within <sup>2)</sup> based on AIS data and deduced from NEB lines 6 and 64 respectively, depending on whether or not a certain ship is registered by the International Maritime Organization (IMO). Here, fuels consumed by large, IMO-registered and sea-going ships and vessels are included in NEB line 6 whereas fuels consumed by smaller ships without IMO-registration are included in NEB line 64. After these deductions, the amounts of fuels remaining in NEB 64 are allocated to domestic *inland* navigation.

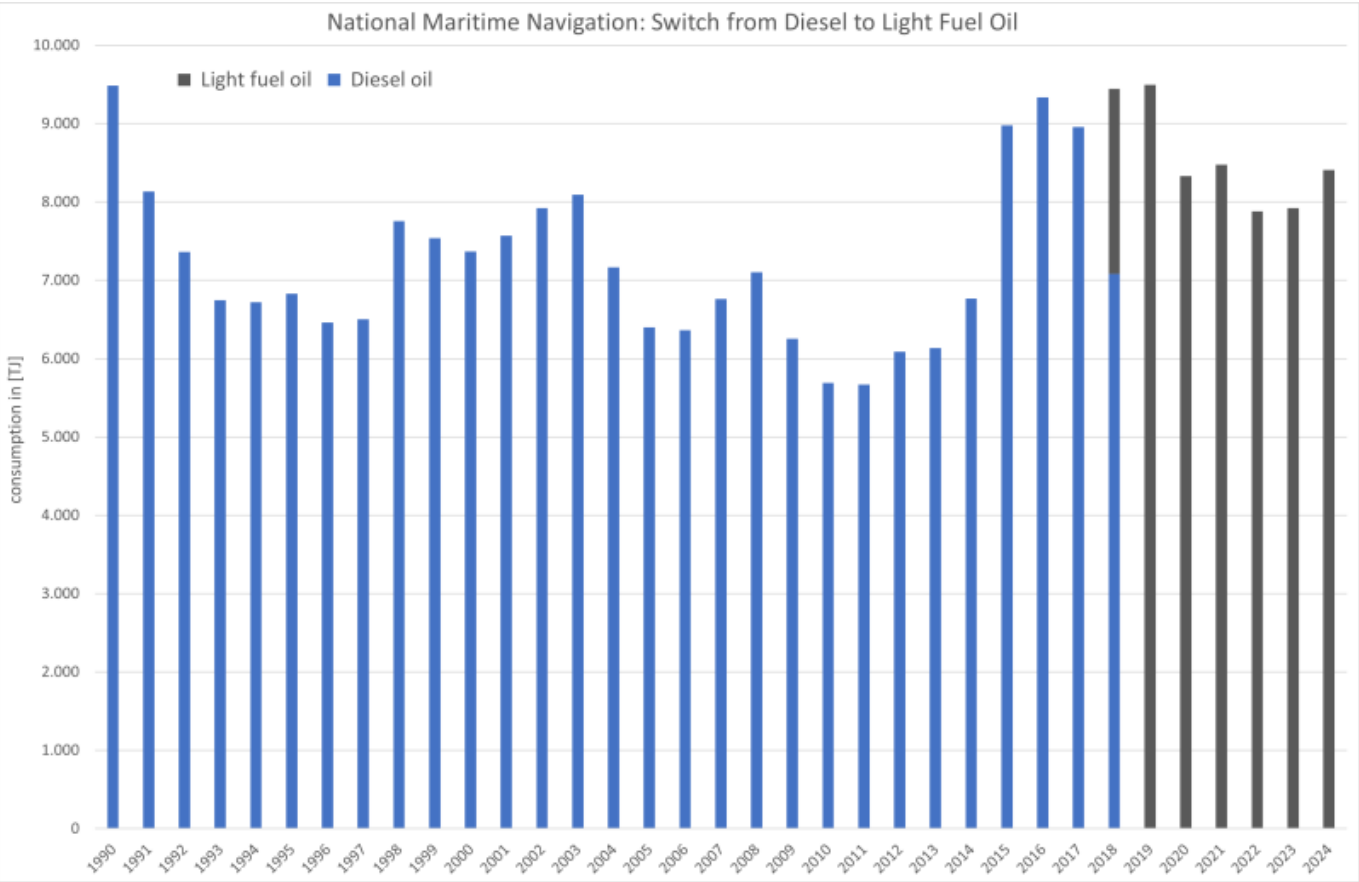
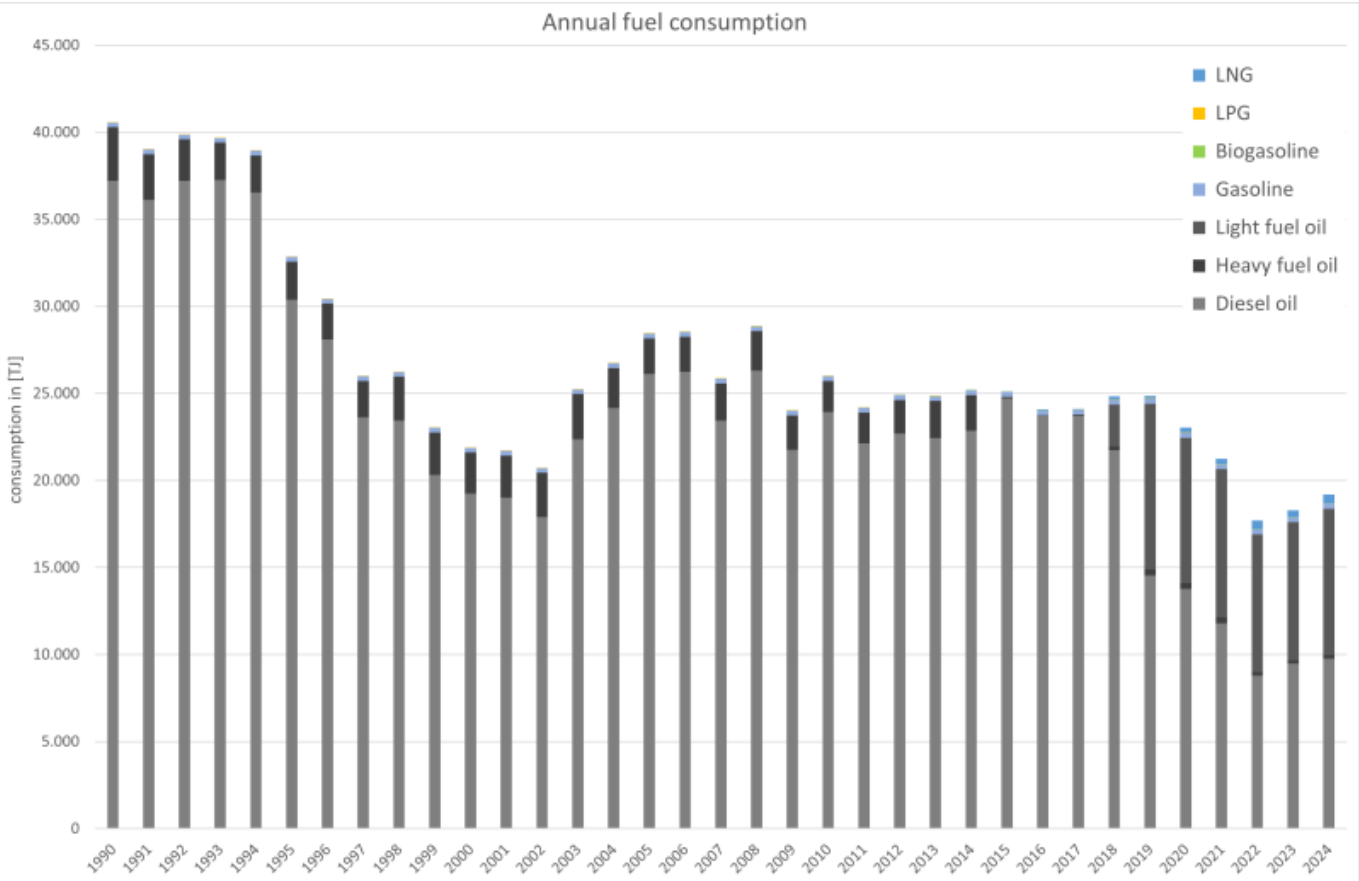
The small amounts of LNG used almost entirely in ferries are not yet included in the NEB but are estimated directly in the BSH model.

Table 1: Annual over-all fuel consumption for domestic navigation, in terajoule

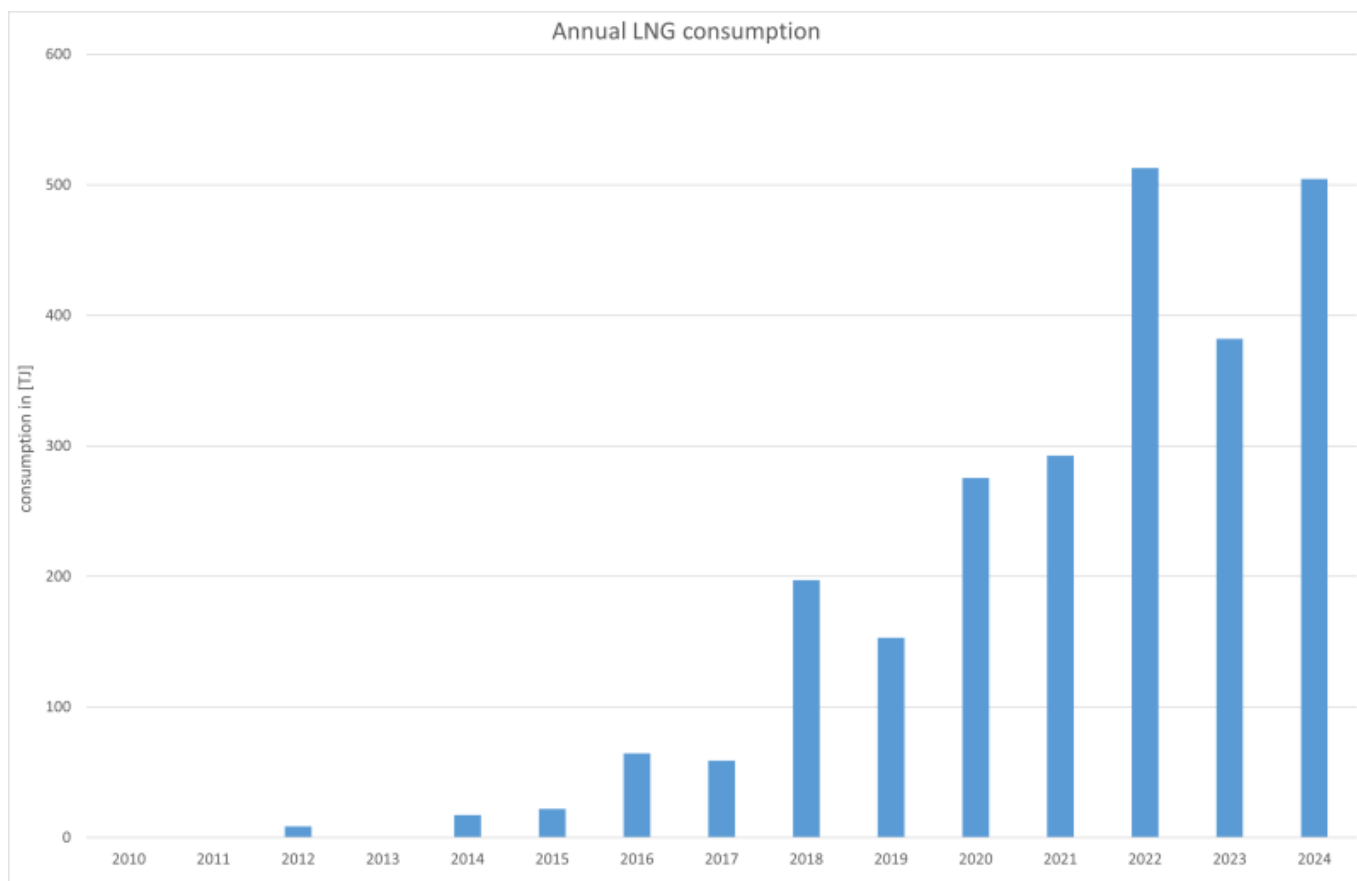
|                       | 1990          | 1995          | 2000          | 2005          | 2010          | 2015          | 2016          | 2017          | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
|-----------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>Diesel Oil</b>     | 37,199        | 30,389        | 19,231        | 26,114        | 23,920        | 24,710        | 23,703        | 23,698        | 21,736        | 14,535        | 13,761        | 11,785        | 8,786         | 9,473         | 9,747         |
| <b>Light Fuel Oil</b> |               |               |               |               |               |               |               |               | 2,361         | 9,497         | 8,329         | 8,475         | 7,879         | 7,922         | 8,407         |
| <b>Heavy fuel oil</b> | 3,103         | 2,186         | 2,382         | 2,054         | 1,810         | 108           | 37.0          | 81.1          | 262           | 394           | 378           | 392           | 235           | 203           | 231           |
| <b>LNG</b>            |               |               |               |               |               | 22.0          | 64.4          | 58.8          | 197           | 153           | 276           | 293           | 513           | 382           | 504           |
| <b>Gasoline</b>       | 272           | 272           | 272           | 274           | 261           | 265           | 265           | 266           | 262           | 265           | 269           | 273           | 275           | 273           | 274           |
| <b>Biogasoline</b>    |               |               |               | 1.86          | 10.1          | 11.1          | 11.2          | 11.0          | 11.4          | 11.1          | 11.9          | 12.6          | 12.7          | 13.0          | 12.8          |
| <b>LPG</b>            | 7.00          | 7.00          | 7.00          | 7.02          | 7.08          | 7.10          | 7.25          | 7.06          | 7.14          | 7.20          | 7.36          | 7.49          | 7.23          | 7.53          | 7.34          |
| <b>Σ 1.A.3.d ii</b>   | <b>40,582</b> | <b>32,854</b> | <b>21,892</b> | <b>28,450</b> | <b>26,009</b> | <b>25,123</b> | <b>24,088</b> | <b>24,121</b> | <b>24,837</b> | <b>24,862</b> | <b>23,031</b> | <b>21,237</b> | <b>17,708</b> | <b>18,274</b> | <b>19,184</b> |

Table 2: Specific fuel consumption data for domestic maritime and inland navigation, in terajoule

|                                     | 1990          | 1995          | 2000          | 2005          | 2010          | 2015          | 2016          | 2017          | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
|-------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>NATIONAL MARITIME NAVIGATION</b> |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| <b>Diesel Oil</b>                   | 9,484         | 6,828         | 7,367         | 6,399         | 5,690         | 8,980         | 9,335         | 8,960         | 7,084         |               |               |               |               |               |               |
| <b>Light Fuel Oil</b>               |               |               |               |               |               |               |               |               | 2,361         | 9,497         | 8,329         | 8,475         | 7,879         | 7,922         | 8,407         |
| <b>Heavy fuel oil</b>               | 3,103         | 2,186         | 2,382         | 2,054         | 1,810         | 108           | 37.0          | 81.1          | 262           | 394           | 378           | 392           | 235           | 203           | 231           |
| <b>LNG</b>                          |               |               |               |               |               | 22.0          | 64.4          | 58.8          | 197           | 153           | 276           | 293           | 513           | 382           | 504           |
| <b>NATIONAL INLAND NAVIGATION</b>   |               |               |               |               |               |               |               |               |               |               |               |               |               |               |               |
| <b>Diesel Oil</b>                   | 27,716        | 23,562        | 11,864        | 19,715        | 18,230        | 15,730        | 14,368        | 14,738        | 14,652        | 14,535        | 13,761        | 11,785        | 8,786         | 9,473         | 9,747         |
| <b>Gasoline</b>                     | 272           | 272           | 272           | 274           | 261           | 265           | 265           | 266           | 262           | 265           | 269           | 273           | 275           | 273           | 274           |
| <b>Biogasoline</b>                  |               |               |               | 1.86          | 10.1          | 11.1          | 11.2          | 11.0          | 11.4          | 11.1          | 11.9          | 12.6          | 12.7          | 13.0          | 12.8          |
| <b>LPG</b>                          | 7.00          | 7.00          | 7.00          | 7.02          | 7.08          | 7.10          | 7.25          | 7.06          | 7.14          | 7.20          | 7.36          | 7.49          | 7.23          | 7.53          | 7.34          |
| <b>Σ 1.A.3.d ii</b>                 | <b>40,582</b> | <b>32,854</b> | <b>21,892</b> | <b>28,450</b> | <b>26,009</b> | <b>25,123</b> | <b>24,088</b> | <b>24,121</b> | <b>24,837</b> | <b>24,862</b> | <b>23,031</b> | <b>21,237</b> | <b>17,708</b> | <b>18,274</b> | <b>19,184</b> |







## Emission factors

The emission factors applied for **national maritime navigation** are derived from different sources and therefore are of very different quality.

For the main pollutants, country-specific implied values are used, that are based on tier3 EF included in the BSH model <sup>3)</sup> which mainly relate on values from the EMEP/EEA guidebook 2023 <sup>4)</sup>. These modelled IEFs take into account the ship specific information derived from AIS data as well as the mix of fuel-qualities applied depending on the type of ship and the current state of activity.

Here, for **sulphur dioxide** and **particulate matter**, annual values are available representing the impact of fuel sulphur legislation. In addition, regarding <sub>2</sub>, the increasing operation of so-called scrubbers in order to fulfil emission limits especially within SECA areas is reflected for heavy fuel oil.

Table 3: Country-specific emission factors applied for fuels used in domestic maritime navigation, in [kg/Tj]

|                                                    | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  |
|----------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>DIESEL OIL &amp; LIGHT FUEL OIL<sup>1</sup></b> |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>NH<sub>3</sub></b>                              | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  |
| <b>NMVOC</b>                                       | 71.9  | 72.1  | 72.0  | 72.0  | 72.1  | 81.5  | 82.7  | 83.2  | 75.0  | 80.3  | 78.2  | 81.4  | 79.8  | 77.4  |
| <b>NO<sub>x</sub></b>                              | 1,199 | 1,198 | 1,199 | 1,199 | 1,198 | 1,115 | 1,111 | 1,115 | 1,095 | 1,106 | 1,090 | 1,098 | 1,098 | 1,095 |
| <b>SO<sub>2</sub></b>                              | 466   | 419   | 233   | 186   | 69.8  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  |
| <b>BC<sup>2</sup></b>                              | 110   | 99.1  | 55.0  | 44.0  | 16.5  | 17.4  | 17.7  | 17.7  | 17.3  | 17.5  | 16.8  | 16.9  | 17.1  | 16.9  |
| <b>PM<sub>2.5</sub></b>                            | 354   | 320   | 177   | 142   | 53.3  | 56.2  | 57.1  | 57.1  | 55.9  | 56.5  | 54.2  | 54.6  | 55.2  | 54.6  |
| <b>PM<sub>10</sub></b>                             | 378   | 342   | 190   | 152   | 57.1  | 60.1  | 61.1  | 61.1  | 59.8  | 60.4  | 58.0  | 58.5  | 59.0  | 58.4  |
| <b>TSP<sup>3</sup></b>                             | 378   | 342   | 190   | 152   | 57.1  | 60.1  | 61.1  | 61.1  | 59.8  | 60.4  | 58.0  | 58.5  | 59.0  | 58.4  |
| <b>CO</b>                                          | 128   | 128   | 128   | 128   | 128   | 140   | 142   | 141   | 139   | 140   | 138   | 140   | 140   | 142   |
| <b>HEAVY FUEL OIL</b>                              |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>NH<sub>3</sub></b>                              | 0.33  | 0.33  | 0.33  | 0.33  | 0.33  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  | 0.35  | 0.34  |
| <b>NMVOC</b>                                       | 96.6  | 96.5  | 96.5  | 96.5  | 96.5  | 104   | 117   | 131   | 156   | 172   | 168   | 156   | 165   | 166   |
| <b>NO<sub>x</sub></b>                              | 1,604 | 1,602 | 1,603 | 1,603 | 1,602 | 1,216 | 1,572 | 1,300 | 1,332 | 1,242 | 1,368 | 1,385 | 1,439 | 1,408 |

|                                                                                                                                                                                                                      | 1990  | 1995  | 2000  | 2005  | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|------|------|------|------|------|------|------|------|------|------|
| SO <sub>x</sub>                                                                                                                                                                                                      | 1,319 | 1,332 | 1,323 | 1,336 | 496  | 48.6 | 49.2 | 48.1 | 45.9 | 46.5 | 48.1 | 47.0 | 47.6 | 47.2 |
| BC <sup>2</sup>                                                                                                                                                                                                      | 70.8  | 71.2  | 70.8  | 71.6  | 26.5 | 14.2 | 18.0 | 20.1 | 19.1 | 18.9 | 21.4 | 21.3 | 23.2 | 23.4 |
| PM <sub>2.5</sub>                                                                                                                                                                                                    | 590   | 594   | 590   | 596   | 221  | 118  | 150  | 168  | 159  | 158  | 179  | 178  | 194  | 195  |
| PM <sub>10</sub>                                                                                                                                                                                                     | 649   | 653   | 649   | 656   | 243  | 130  | 165  | 184  | 175  | 173  | 197  | 195  | 213  | 214  |
| TSP <sup>3</sup>                                                                                                                                                                                                     | 649   | 653   | 649   | 656   | 243  | 130  | 165  | 184  | 175  | 173  | 197  | 195  | 213  | 214  |
| CO                                                                                                                                                                                                                   | 179   | 179   | 179   | 179   | 179  | 144  | 162  | 157  | 156  | 150  | 151  | 147  | 144  | 142  |
| LIQUEFIED NATURAL GAS (LNG)                                                                                                                                                                                          |       |       |       |       |      |      |      |      |      |      |      |      |      |      |
| NH <sub>3</sub>                                                                                                                                                                                                      | NA    |       |       |       |      | NE   |      |      |      |      |      |      |      |      |
| NMVOC                                                                                                                                                                                                                | NA    |       |       |       |      | 49.3 | 48.5 | 44.4 | 43.3 | 58.5 | 53.7 | 48.9 | 56.2 | 53.2 |
| NO <sub>x</sub>                                                                                                                                                                                                      | NA    |       |       |       |      | 112  | 112  | 112  | 112  | 112  | 112  | 112  | 112  | 112  |
| SO <sub>x</sub>                                                                                                                                                                                                      | NA    |       |       |       |      | NE   |      |      |      |      |      |      |      |      |
| BC <sup>2</sup>                                                                                                                                                                                                      | NA    |       |       |       |      |      |      |      |      |      |      |      |      |      |
| PM <sub>2.5</sub> , PM <sub>10</sub> , TSP                                                                                                                                                                           | NA    |       |       |       |      | 2.41 | 2.41 | 2.41 | 2.41 | 2.41 | 1.51 | 1.51 | 1.51 | 1.48 |
| CO                                                                                                                                                                                                                   | NA    |       |       |       |      | 157  | 157  | 157  | 157  | 157  | 156  | 154  | 154  | 145  |
| <sup>1</sup> identical EF applied for diesel oil and light fuel oil                                                                                                                                                  |       |       |       |       |      |      |      |      |      |      |      |      |      |      |
| <sup>2</sup> estimated from a BC-fraction derived from <sup>5)</sup> , chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Table 3-1 (0.017 for heavy fuel oil) and 3-2 (0.045 for diesel oil) and 3-3 (for LNG) |       |       |       |       |      |      |      |      |      |      |      |      |      |      |
| <sup>3</sup> ratios PM <sub>2.5</sub> : PM <sub>10</sub> : TSP derived from the tier1 default EF as provided in <sup>6)</sup> , chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Tables 3-1 & 3-2             |       |       |       |       |      |      |      |      |      |      |      |      |      |      |

For main pollutants and particulate matter from **national inland navigation**, modelled emission factors are available from TREMOD (Knörr et al. (2024a)) <sup>7)</sup>. Here, for SO<sub>2</sub>, and PM, annual values reflect the impact of fuel-sulphur legislation.

Table 4: Country-specific emission factors for diesel fuels used in domestic inland navigation, in [kg/TJ]

|                       | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|-----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>DIESEL OIL</b>     |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NH<sub>3</sub></b> | 0.23   | 0.23   | 0.23   | 0.23   | 0.23   | 0.23   | 0.23   | 0.23   | 0.23   | 0.23   | 0.23   | 0.23   | 0.23   | 0.23   |
| <b>NM VOC</b>         | 96.4   | 87.9   | 77.7   | 72.3   | 66.6   | 61.2   | 60.3   | 59.4   | 58.5   | 58.0   | 57.1   | 56.4   | 55.4   | 54.5   |
| <b>NO<sub>x</sub></b> | 1,327  | 1,331  | 1,336  | 1,289  | 1,231  | 1,175  | 1,164  | 1,152  | 1,141  | 1,135  | 1,124  | 1,115  | 1,093  | 1,070  |
| <b>SO<sub>x</sub></b> | 85.2   | 60.5   | 60.5   | 60.5   | 60.5   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   |
| <b>BC<sup>1</sup></b> | 17.5   | 16.0   | 14.1   | 11.8   | 9.17   | 8.14   | 7.99   | 7.83   | 7.67   | 7.58   | 7.44   | 7.31   | 7.12   | 6.95   |
| <b>PM<sup>2</sup></b> | 56.5   | 51.7   | 45.6   | 38.1   | 29.6   | 26.3   | 25.8   | 25.2   | 24.7   | 24.4   | 24.0   | 23.6   | 23.0   | 22.4   |
| <b>CO</b>             | 417    | 387    | 337    | 299    | 256    | 229    | 225    | 221    | 216    | 213    | 209    | 206    | 203    | 200    |
| <b>GASOLINE</b>       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NH<sub>3</sub></b> | 0.11   | 0.11   | 0.11   | 0.11   | 0.11   | 0.11   | 0.11   | 0.11   | 0.11   | 0.11   | 0.11   | 0.11   | 0.11   | 0.11   |
| <b>NM VOC (exh.)</b>  | 952    | 1036   | 1269   | 1373   | 1196   | 897    | 853    | 813    | 779    | 753    | 734    | 722    | 714    | 710    |
| <b>NM VOC (evap.)</b> | 28.8   | 55.3   | 131    | 164    | 196    | 186    | 185    | 185    | 184    | 184    | 184    | 185    | 187    | 188    |
| <b>NO<sub>x</sub></b> | 383    | 375    | 353    | 345    | 338    | 341    | 325    | 299    | 276    | 256    | 238    | 223    | 210    | 199    |
| <b>SO<sub>x</sub></b> | 10.1   | 8.27   | 3.22   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   |
| <b>BC<sup>1</sup></b> | 2.33   | 2.33   | 2.33   | 2.33   | 2.32   | 2.32   | 2.32   | 2.32   | 2.32   | 2.32   | 2.32   | 2.32   | 2.32   | 2.32   |
| <b>PM<sup>2</sup></b> | 7.50   | 7.50   | 7.50   | 7.50   | 7.50   | 7.49   | 7.49   | 7.49   | 7.49   | 7.49   | 7.49   | 7.49   | 7.49   | 7.49   |
| <b>CO</b>             | 30,204 | 30,817 | 32,595 | 33,248 | 26,105 | 18,536 | 17,387 | 16,286 | 15,336 | 14,583 | 13,995 | 13,565 | 13,241 | 12,996 |
| <b>LPG</b>            |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NH<sub>3</sub></b> | 0.21   | 0.21   | 0.21   | 0.21   | 0.21   | 0.21   | 0.21   | 0.21   | 0.21   | 0.21   | 0.21   | 0.21   | 0.21   | 0.21   |
| <b>NM VOC</b>         | 147    | 147    | 145    | 145    | 145    | 145    | 145    | 145    | 145    | 144    | 141    | 134    | 126    | 116    |
| <b>NO<sub>x</sub></b> | 1,346  | 1,342  | 1,325  | 1,325  | 1,325  | 1,325  | 1,325  | 1,325  | 1,325  | 1,316  | 1,284  | 1,225  | 1,144  | 1,056  |
| <b>SO<sub>x</sub></b> | 0.42   | 0.42   | 0.41   | 0.41   | 0.41   | 0.41   | 0.41   | 0.41   | 0.41   | 0.41   | 0.41   | 0.41   | 0.41   | 0.41   |
| <b>BC<sup>1</sup></b> | 0.26   | 0.26   | 0.26   | 0.26   | 0.26   | 0.26   | 0.26   | 0.26   | 0.26   | 0.26   | 0.26   | 0.26   | 0.26   | 0.26   |
| <b>PM<sup>2</sup></b> | 0.85   | 0.85   | 0.84   | 0.84   | 0.84   | 0.84   | 0.84   | 0.84   | 0.84   | 0.84   | 0.84   | 0.84   | 0.84   | 0.84   |
| <b>CO</b>             | 114    | 114    | 112    | 112    | 112    | 112    | 112    | 112    | 112    | 112    | 112    | 112    | 112    | 112    |

<sup>1</sup> calculated from f-BC as provided in <sup>8)</sup>, Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii, Table 3-2: f-BC (MDO/MGO) = 0.31

<sup>2</sup> EF(PM<sub>2.5</sub>) also applied for PM<sub>10</sub> and TSP (assumption: > 99% of TSP from diesel oil combustion consists of PM<sub>2.5</sub>)



With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>8)</sup>



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Discussion of emission trends

Table 5: Outcome of Key Category Analysis

|      |                       |                        |                         |
|------|-----------------------|------------------------|-------------------------|
| for: | <b>NO<sub>x</sub></b> | <b>PM<sub>10</sub></b> | <b>PM<sub>2.5</sub></b> |
| by:  | L/-                   | -/T                    | L/T                     |

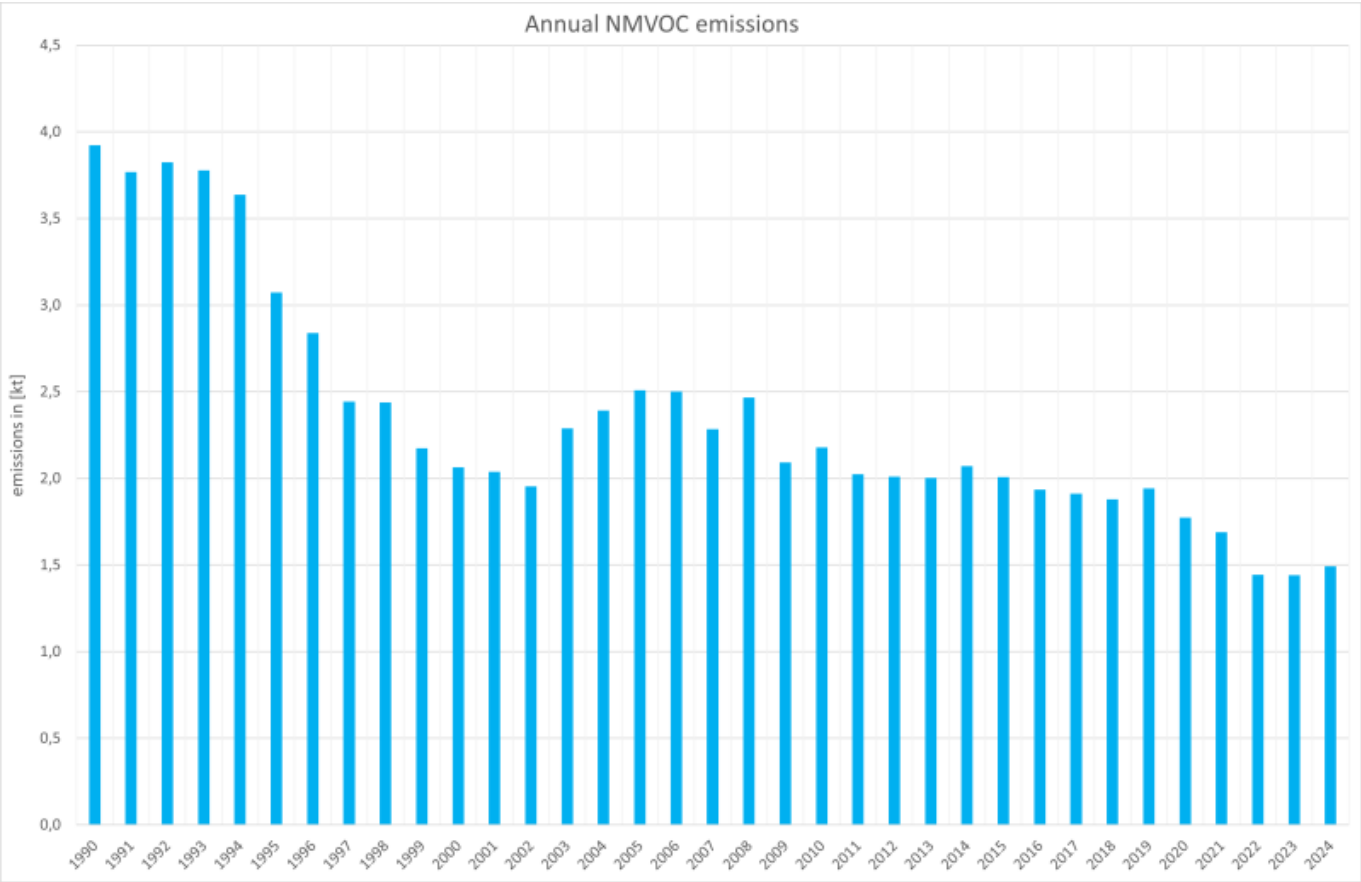
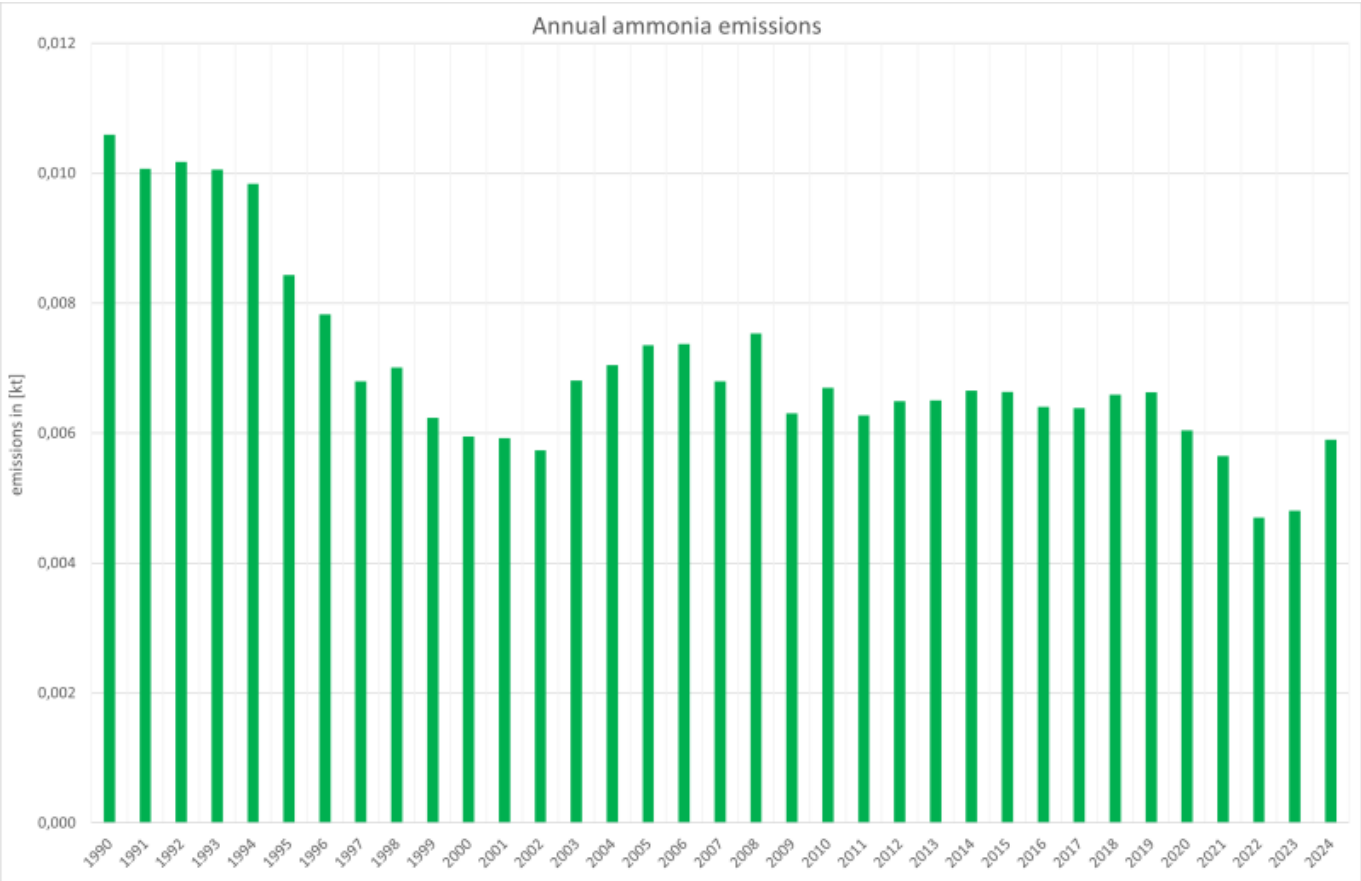
The following table includes emission limits according to Directive 2004/26/EC <sup>9)</sup> for inland vessels.

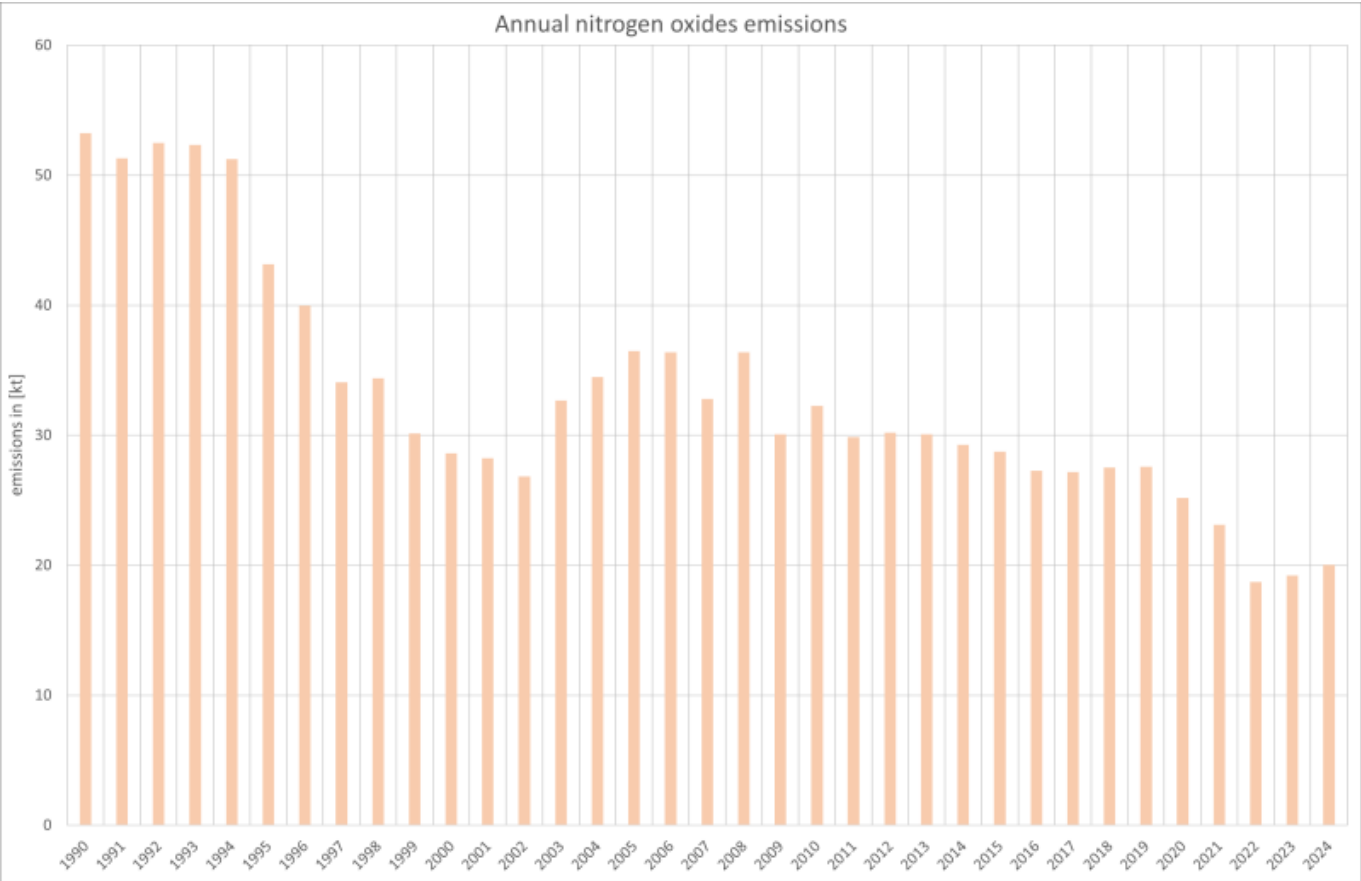
Table 6: Overview of emission limits, in [g/kWh]

| <b>Category: swept volume/net power (SV/P)</b><br><b>(litres per cylinder/kW)</b> | <b>Carbon monoxide</b><br>(CO) | <b>Σ Hydrocarbons + Nitrogen oxides</b><br>(HC+NO <sub>x</sub> ) | <b>Particulates</b><br>(PT) |
|-----------------------------------------------------------------------------------|--------------------------------|------------------------------------------------------------------|-----------------------------|
| V1:1; SV < 0,9; P ≥ 37 kW                                                         | 5.0                            | 7.5                                                              | 0.40                        |
| V1:2; 0.9 ≤ SV < 1.2                                                              | 5.0                            | 7.2                                                              | 0.30                        |
| V1:3 1.2 ≤ SV < 2.5                                                               | 5.0                            | 7.2                                                              | 0.20                        |
| V1:4; 2.5 ≤ SV < 5                                                                | 5.0                            | 7.2                                                              | 0.20                        |
| V2:1; 5 ≤ SV < 15                                                                 | 5.0                            | 7.8                                                              | 0.27                        |
| V2:2; 15 ≤ SV < 20; P < 3300 kW                                                   | 5.0                            | 8.7                                                              | 0.50                        |
| V2:3; 15 ≤ SV < 20; P ≥ 3300 kW                                                   | 5.0                            | 9.8                                                              | 0.50                        |
| V2:4; 20 ≤ SV < 25                                                                | 5.0                            | 9.8                                                              | 0.50                        |
| V2:5; 25 ≤ SV < 30                                                                | 5.0                            | 11.0                                                             | 0.50                        |

However, Directive 2004/26/EC has been replaced by Regulation (EU) 2016/1628 in 2016 <sup>10)</sup>.

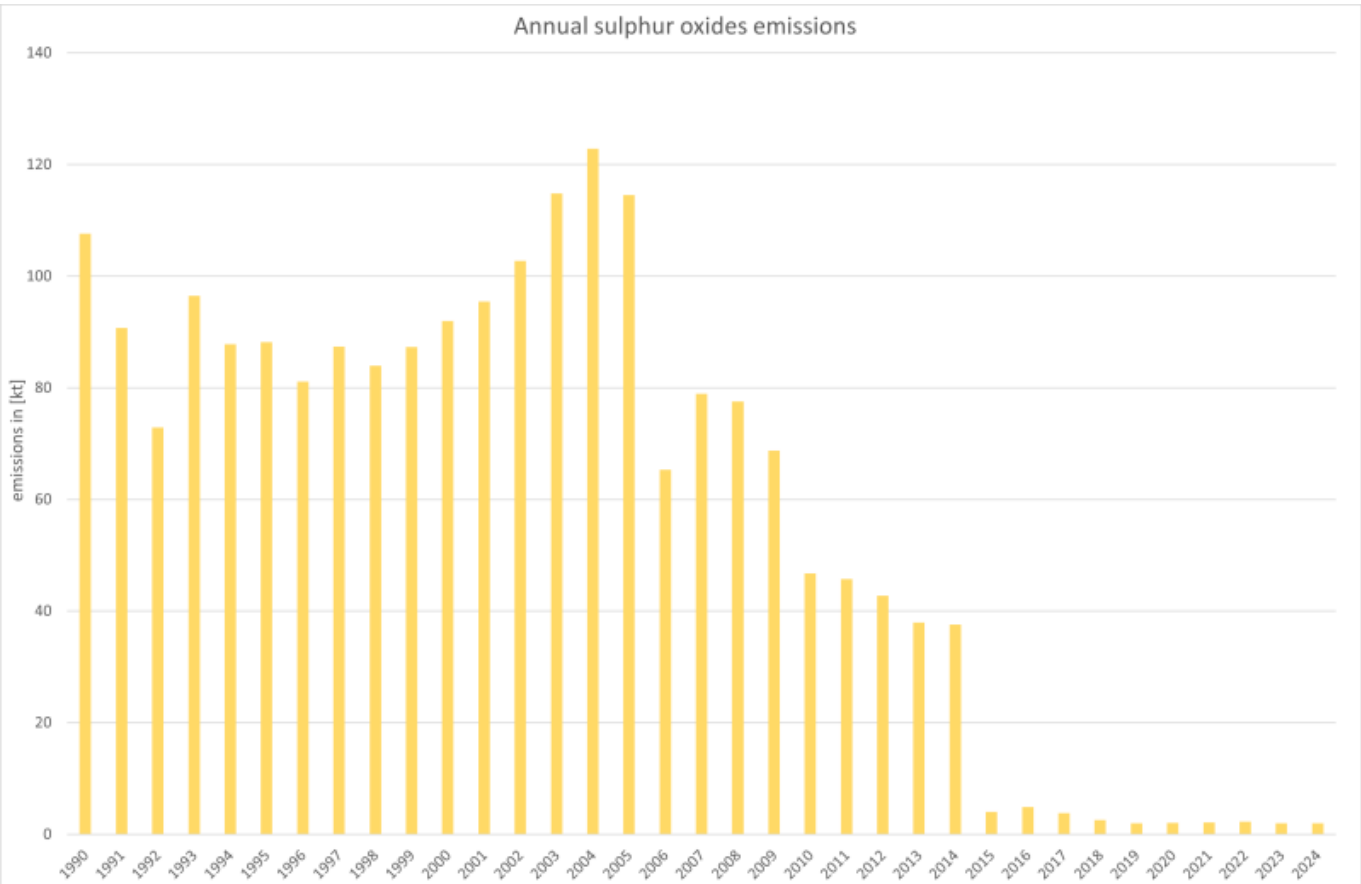
For **ammonia**, **NM VOC**, and **nitrogen oxides** as well as **carbon monoxide**, emission trends more or less represent the trend in over-all fuel consumption.

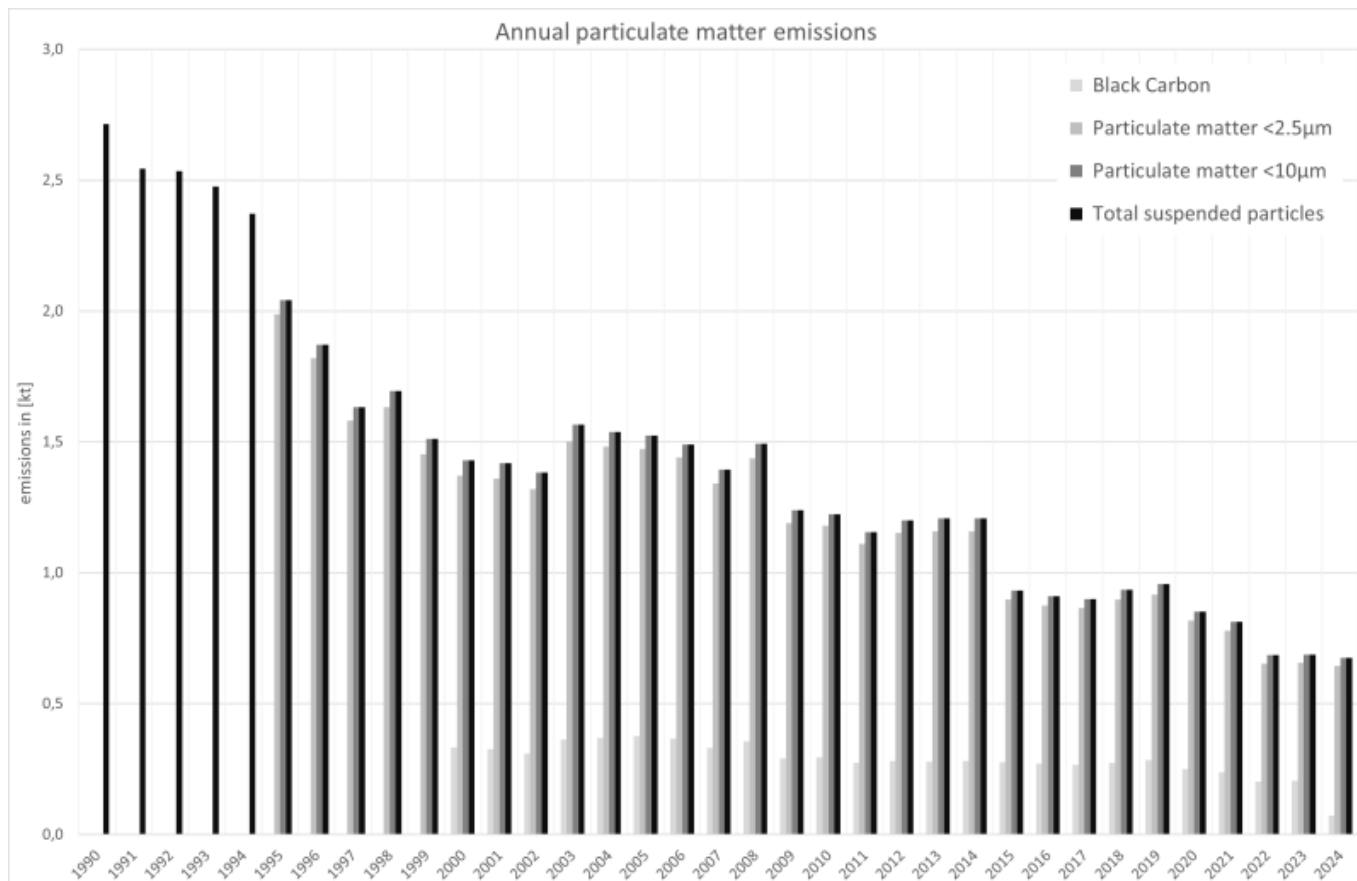




Nonetheless, for these pollutants, annual emission factors from BSH <sup>11)</sup> and TREMOD <sup>12)</sup> have been applied for national *maritime* and *inland* navigation, respectively, reflecting the technical development of the German inland navigation fleet.

Here, the trends in **sulphur dioxide** and **particulate matter** emissions reflect the impact of ongoing fuel-sulphur legislation especially in maritime navigation.





## Recalculations

Compared to the previous submission, **activity data** remain unaltered for **national maritime navigation**, whereas fuel consumption data allocated to **inland navigation** has been revised within TREMOD taking into account the finalisation of the National Energy Balance for 2024 as well as the routine revision of the National Energy Balances as of 2003 <sup>13)</sup>.

Table 7: Revised fuel consumption data for national navigation, as of 20023, in [T1]

|                                                      | 2003   | 2004   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|------------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Diesel oil (national inland and maritime navigation) |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission                                   | 22,362 | 24,170 | 26,114 | 23,920 | 24,710 | 23,703 | 23,698 | 21,736 | 14,535 | 13,761 | 11,785 | 8,786  | 9,473  |
| previous submission                                  | 22,451 | 24,282 | 26,241 | 24,060 | 24,874 | 23,863 | 23,866 | 21,897 | 14,660 | 14,029 | 12,003 | 9,275  | 9,887  |
| absolute change                                      | -89.4  | -112   | -127   | -140   | -163   | -161   | -169   | -161   | -126   | -268   | -218   | -489   | -414   |
| relative change                                      | -0.40% | -0.46% | -0.48% | -0.58% | -0.66% | -0.67% | -0.71% | -0.74% | -0.86% | -1.91% | -1.82% | -5.27% | -4.18% |
| Light fuel oil (natioponal maritime navigation only) |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission                                   |        |        |        |        |        |        |        | 2,361  | 9,497  | 8,329  | 8,475  | 7,879  | 7,922  |
| previous submission                                  |        |        |        |        |        |        |        | 2,361  | 9,497  | 8,329  | 8,475  | 7,879  | 7,922  |
| absolute change                                      |        |        |        |        |        |        |        | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   |
| relative change                                      |        |        |        |        |        |        |        | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  |
| Heavy fuel oil (national maritime navigation only)   |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission                                   | 2,607  | 2,298  | 2,054  | 1,810  | 108    | 37.0   | 81.1   | 262    | 394    | 378    | 392    | 235    | 203    |
| previous submission                                  | 2,607  | 2,298  | 2,054  | 1,810  | 108    | 37.0   | 81.1   | 262    | 394    | 378    | 392    | 237    | 237    |
| absolute change                                      | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | -1.72  | -33.8  |
| relative change                                      | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | -0.73% | -14.3% |
| LPG (national inland navigation only)                |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission                                   | 7.03   | 7.02   | 7.02   | 7.08   | 7.10   | 7.25   | 7.06   | 7.14   | 7.20   | 7.36   | 7.49   | 7.23   | 7.53   |
| previous submission                                  | 7.03   | 7.02   | 7.02   | 7.08   | 7.10   | 7.25   | 7.06   | 7.13   | 7.16   | 7.40   | 7.51   | 7.55   | 7.61   |
| absolute change                                      | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.01   | 0.04   | -0.04  | -0.02  | -0.33  | -0.08  |
| relative change                                      | 0.00%  | 0.00%  | 0.00%  | 0.01%  | 0.00%  | 0.00%  | 0.00%  | 0.17%  | 0.54%  | -0.54% | -0.24% | -4.30% | -1.00% |
| LNG (national maritime navigation only)              |        |        |        |        |        |        |        |        |        |        |        |        |        |

|                                  | 2003   | 2004   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>current submission</b>        |        |        |        |        | 22.0   | 64.4   | 58.8   | 197    | 153    | 276    | 293    | 513    | 382    |
| <b>previous submission</b>       |        |        |        |        | 22.0   | 64.4   | 58.8   | 197    | 153    | 276    | 293    | 513    | 382    |
| <b>absolute change</b>           |        |        |        |        | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   |
| <b>relative change</b>           |        |        |        |        | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  |
| <b>Over-all fuel consumption</b> |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>        | 25,248 | 26,747 | 28,450 | 26,009 | 25,123 | 24,088 | 24,121 | 24,837 | 24,862 | 23,031 | 21,237 | 17,708 | 18,274 |
| <b>previous submission</b>       | 25,337 | 26,859 | 28,577 | 26,149 | 25,286 | 24,248 | 24,290 | 24,997 | 24,988 | 23,299 | 21,456 | 18,199 | 18,724 |
| <b>absolute change</b>           | -89.4  | -112   | -127   | -140   | -163   | -161   | -169   | -161   | -125   | -268   | -218   | -492   | -450   |
| <b>relative change</b>           | -0.35% | -0.42% | -0.44% | -0.54% | -0.64% | -0.66% | -0.69% | -0.64% | -0.50% | -1.15% | -1.02% | -2.70% | -2.40% |

In addition, several emission factors have been revised within E.M.M.A. and for diesel oil/light fuel oil used in national maritime navigation:

Table 8: Revised emission factors, in kg/TJ

|                            | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>BC</b>                  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 14.3   | 14.4   | 14.4   | 14.4   | 14.4   | 16.3   | 16.5   | 16.5   | 16.2   | 16.4   | 15.7   | 15.8   | 16.0   | 15.8   |
| <b>previous submission</b> | 110    | 99.1   | 55.0   | 44.0   | 16.5   | 17.4   | 17.7   | 17.7   | 17.3   | 17.5   | 16.8   | 16.9   | 17.1   | 16.9   |
| <b>absolute change</b>     | -95.3  | -84.7  | -40.6  | -29.6  | -2.11  | -1.14  | -1.16  | -1.16  | -1.13  | -1.15  | -1.10  | -1.11  | -1.12  | -1.11  |
| <b>relative change</b>     | -86.9% | -85.5% | -73.8% | -67.3% | -12.8% | -6.54% | -6.54% | -6.54% | -6.54% | -6.54% | -6.54% | -6.54% | -6.54% | -6.54% |
| <b>PM</b>                  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 49.5   | 49.7   | 49.7   | 49.6   | 49.8   | 56.2   | 57.1   | 57.1   | 55.9   | 56.5   | 54.2   | 54.6   | 55.2   | 54.6   |
| <b>previous submission</b> | 378    | 342    | 190    | 152    | 57.1   | 60.1   | 61.1   | 61.1   | 59.8   | 60.4   | 58.0   | 58.5   | 59.0   | 58.4   |
| <b>absolute change</b>     | -329   | -292   | -140   | -102   | -7.29  | -3.93  | -3.99  | -4.00  | -3.91  | -3.95  | -3.79  | -3.83  | -3.86  | -3.82  |
| <b>relative change</b>     | -86.9% | -85.5% | -73.8% | -67.3% | -12.8% | -6.54% | -6.54% | -6.54% | -6.54% | -6.54% | -6.54% | -6.54% | -6.54% | -6.54% |
| <b>CO</b>                  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 44.9   | 44.9   | 44.9   | 44.9   | 44.9   | 41.6   | 41.1   | 40.1   | 42.1   | 43.3   | 44.2   | 42.8   | 44.9   | 45.3   |
| <b>previous submission</b> | 128    | 128    | 128    | 128    | 128    | 140    | 142    | 141    | 139    | 140    | 138    | 140    | 140    | 142    |
| <b>absolute change</b>     | -82.9  | -83.4  | -83.3  | -83.2  | -83.5  | -98.4  | -101   | -101   | -97.2  | -97.1  | -93.6  | -96.7  | -95.5  | -97.1  |
| <b>relative change</b>     | -64.9% | -65.0% | -65.0% | -65.0% | -65.1% | -70.3% | -71.1% | -71.6% | -69.8% | -69.2% | -67.9% | -69.3% | -68.0% | -68.2% |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: "Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland" by Knörr et al. (2009) <sup>14)</sup>.

## Planned improvements

Besides the **routine revisions of the models** used for maritime and inland navigation, the percental BC-fractions (f-BC) applied for maritime navigation will be updated in accordance with the information provided in Chapter 1.A.3.d Navigation (shipping) 2023 of the EMEP/EEA Guidebook 2023.

Furthermore, the proxy emission factors applied for PAH emissions from vessels/ships derived from tier1 defaults provided for railways and heavy-duty vehicles in the EMEP/EEA Guidebook 2019 will be replaced by values derived from Chapter 1.A.3.d Navigation (shipping) 2023 of the EMEP/EEA GB 2023 (see also:

[https://iir.umweltbundesamt.de/2026/general/planned\\_improvements/start](https://iir.umweltbundesamt.de/2026/general/planned_improvements/start) and

[https://iir.umweltbundesamt.de/2026/appendices/appendix2.4\\_pops\\_from\\_mobile\\_sources](https://iir.umweltbundesamt.de/2026/appendices/appendix2.4_pops_from_mobile_sources))

<sup>1)</sup> AGEB (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> Deichnik (2025): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs; Federal Maritime and Hydrographic Agency (BSH - Bundesamt für Seeschifffahrt und Hydrographie Hamburg); on behalf of the Umweltbundesamt, Hamburg / Dessau-Roßlau, 2025.

<sup>4), 5), 8)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook – 2023; Chapter 1.A.3.d Navigation (shipping) 2023;

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-d-navigation/@download/file>; Copenhagen, 2023.

<sup>9)</sup> EU (2004): Directive 2004/ 26/EC of the European Parliament and of the Council of 21 April 2004 amending Directive 97/68/EC on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery;

<http://data.europa.eu/eli/dir/2004/26/oj>; Strasbourg, 2004

<sup>10)</sup> EU (2016): Regulation (EU) 2016/1628 of the European Parliament and of the Council of 14 September 2016 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery, amending Regulations (EU) No 1024/2012 and (EU) No 167/2013, and amending and repealing Directive 97/68/EC; <http://data.europa.eu/eli/reg/2016/1628/oj>; Strasbourg, 14 September 2016

<sup>13)</sup> AGEB (2025a): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; [https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?\\_jahresbereich-bilanz=2021-2030](https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?_jahresbereich-bilanz=2021-2030), (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>14)</sup> Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; URL: <https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf>, FKZ 360 16 023, Heidelberg & Zürich, 2009.

<sup>8)</sup>

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.



## 1.A.3.d i (i) - International maritime navigation



NFR-specific inventory  
data

### Short description

Under NFR category **1.A.3.d i (i)**, emissions from international maritime navigation fuelling in and starting from German harbours are reported.

| Category Code                                                                             | Method                               | AD    | EF    |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|-------|
| 1.A.3.d i (i)                                                                             | T1, T2, T3                           | NS, M | CS, M |
| <b>Method(s) applied</b>                                                                  |                                      |       |       |
| <b>D</b>                                                                                  | Default                              |       |       |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |       |       |
| <b>T2</b>                                                                                 | Tier 2*                              |       |       |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |       |       |
| <b>C</b>                                                                                  | CORINAIR                             |       |       |
| <b>CS</b>                                                                                 | Country Specific                     |       |       |
| <b>M</b>                                                                                  | Model                                |       |       |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |       |
| <b>(source for) Activity Data</b>                                                         |                                      |       |       |
| <b>NS</b>                                                                                 | National Statistics                  |       |       |
| <b>RS</b>                                                                                 | Regional Statistics                  |       |       |
| <b>IS</b>                                                                                 | International Statistics             |       |       |
| <b>PS</b>                                                                                 | Plant Specific                       |       |       |
| <b>As</b>                                                                                 | Associations, business organisations |       |       |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |       |       |
| <b>M</b>                                                                                  | Model / Modelled                     |       |       |
| <b>C</b>                                                                                  | Confidential                         |       |       |
| <b>(source for) Emission Factors</b>                                                      |                                      |       |       |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |       |       |
| <b>CS</b>                                                                                 | Country Specific                     |       |       |
| <b>PS</b>                                                                                 | Plant Specific                       |       |       |
| <b>M</b>                                                                                  | Model / Modelled                     |       |       |
| <b>C</b>                                                                                  | Confidential                         |       |       |

|                                       |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|---------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|------|
| NO <sub>x</sub>                       | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
| not included in key category analysis |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |

### Methodology

#### Activity data

Primary fuel delivery data (primary activity data, PAD) for *international maritime navigation* is included in line 6 - 'International Deep-Sea Bunkers' of the National Energy Balances (NEB) (AGEB, 2025) <sup>1)</sup> together with respective data for IMO-registered ships used in *national maritime transport* (see 1.A.3.d ii (a)), *fishing* (see NFR 1.A.4.c iii) and *military navigation* (see NFR 1.A.5.b iii).

The AD applied for *international maritime navigation* therefore represents the remains of primary fuel delivery data from NEB line 6 minus the modelled consumption data estimated for non-IMO ships in 1.A.3.d ii (a), 1.A.4.c iii and 1.A.5.b iii:

|                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $AD_{1.A.3.d\ i} = PAD_{NEB\ line\ 6} - AD_{1.A.3.d\ ii\ (a) - IMO} - AD_{1.A.4.c\ iii - IMO} - AD_{1.A.5.b\ iii - IMO}$ | with<br>* $AD_{1.A.3.d\ i}$ - tier1 activity data for International maritime navigation<br>* $PAD_{NEB\ line\ 6}$ - primary over-all fuel deliveries data from NEB line 6 - 'International Maritime Bunkers'<br>* $AD_{1.A.3.d\ ii\ (a) - IMO}$ - tier3 activity data for IMO-registered ships involved in national maritime navigation<br>* $AD_{1.A.4.c\ iii - IMO}$ - tier3 activity data for IMO-registered ships involved in national fishing<br>* $AD_{1.A.5.b\ iii - IMO}$ - tier3 activity data for IMO-registered ships involved in military navigation |
|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

As a result, activity data can fluctuate strongly from year to year.

However, this effect can be explained with the fact that large ocean-going ships do not need to bunker fuels on every single harbour but can go on for weeks without any additional fuel uptake.

This can be further increased with increasing differences in fuel prices.

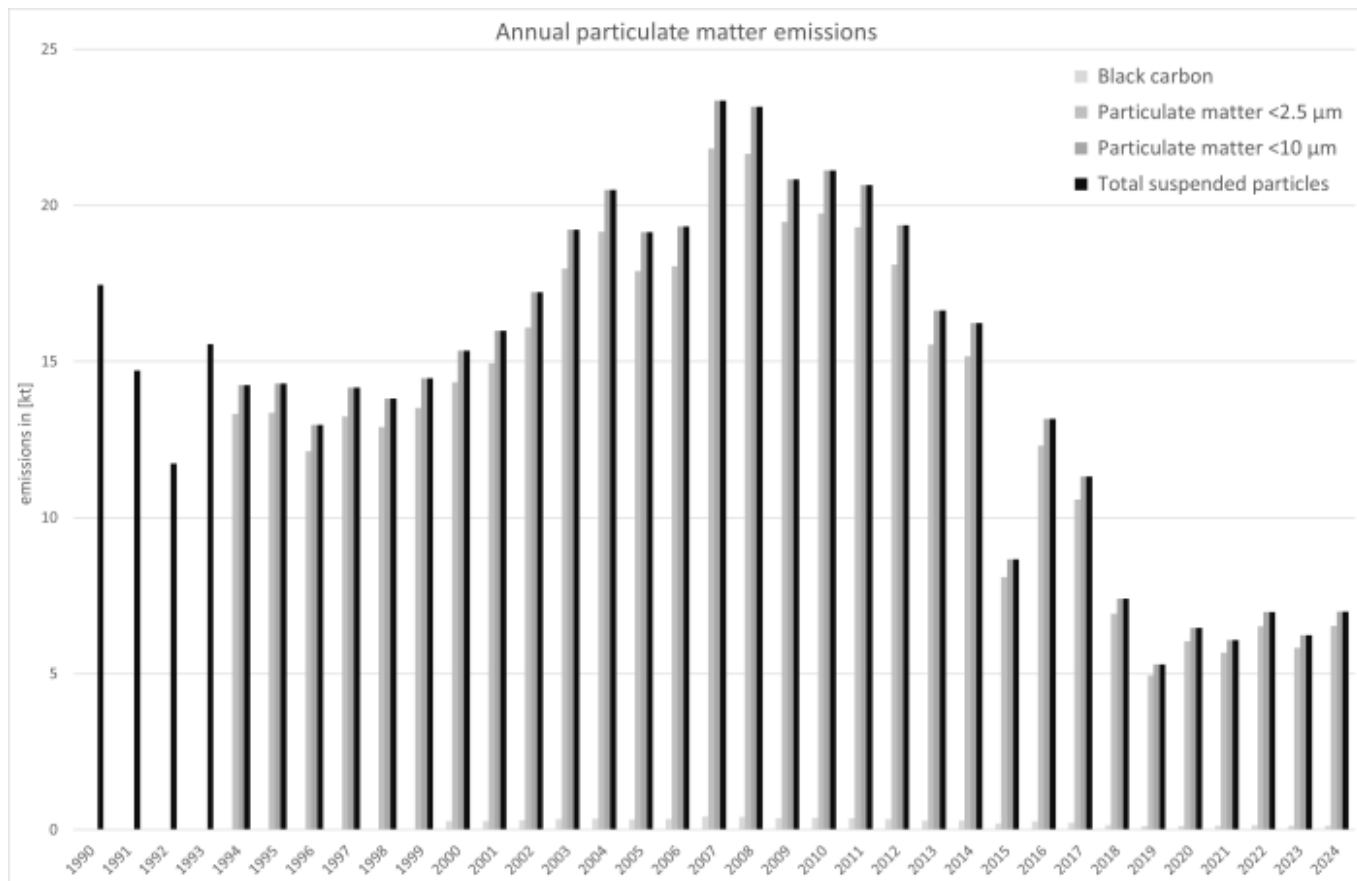
Table 1: Annual fuel deliveries to international maritime navigation departing from Germany, in terajoules

|                          | 1990          | 1995          | 2000          | 2005          | 2010           | 2015          | 2016           | 2017          | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
|--------------------------|---------------|---------------|---------------|---------------|----------------|---------------|----------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>Diesel Oil</b>        | 13,162        | 13,096        | 13,709        | 11,546        | 16,273         | 33,836        | 32,424         | 27,370        | 16,000        |               |               |               |               |               |               |
| <b>Light Heating Oil</b> |               |               |               |               |                |               |                |               | 5,333         | 20,103        | 13,606        | 21,258        | 23,257        | 19,519        | 17,832        |
| <b>Heavy fuel oil</b>    | 76,942        | 62,066        | 67,080        | 84,127        | 91,992         | 57,278        | 75,408         | 58,196        | 38,986        | 26,418        | 32,053        | 27,713        | 29,416        | 26,591        | 26,990        |
| <b>Σ 1.A.3.d i</b>       | <b>90,104</b> | <b>75,162</b> | <b>80,789</b> | <b>95,672</b> | <b>108,266</b> | <b>91,114</b> | <b>107,832</b> | <b>85,566</b> | <b>60,320</b> | <b>46,521</b> | <b>45,659</b> | <b>48,971</b> | <b>52,673</b> | <b>46,110</b> | <b>44,822</b> |

source: own estimates based on underlying BSH model (Deichnik, K. (2025)) <sup>2)</sup>

Consumption of heavy oil has been increasing since 1984 as a result of high petroleum prices, global increases in transports and increasing maritime use of diesel engines that can run on heavy oil. The emissions fluctuations that occurred in the navigation sector in 1992 and 1996 were caused by trade and oil crises.

Furthermore, after 2014, with ever stricter legislation especially regarding fuel sulphur content, an ongoing shift from heavy fuel oil to maritime diesel oil can be observed.



## Emission factors

For **main pollutants** and **particulate matter**, modelled emission factors are available from (Deichnik, K. (2025)).

Here, for **sulphur dioxide** and **particulate matter**, annual values are available representing the impact of fuel sulphur legislation. In addition, regarding SO<sub>2</sub>, the increasing operation of so-called scrubbers in order to fulfil emission limits especially within SECA areas is reflected for heavy fuel oil.

Table 2: Annual country-specific emission factors, in kg/TJ

|                                        | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|----------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>DIESEL OIL &amp; LIGHT FUEL OIL</b> |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>NH<sub>3</sub></b>                  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.42  |
| <b>NM VOC</b>                          | 71.9  | 72.1  | 72.0  | 72.0  | 72.1  | 81.5  | 82.7  | 83.2  | 75.0  | 80.3  | 78.2  | 81.4  | 79.8  | 77.4  | 77.0  |
| <b>NO<sub>x</sub></b>                  | 1,199 | 1,198 | 1,199 | 1,199 | 1,198 | 1,115 | 1,111 | 1,115 | 1,095 | 1,106 | 1,090 | 1,098 | 1,098 | 1,095 | 1,114 |
| <b>SO<sub>x</sub></b>                  | 466   | 419   | 233   | 186   | 69.8  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  |
| <b>BC<sup>1</sup></b>                  | 2.23  | 2.24  | 2.24  | 2.23  | 2.24  | 2.53  | 2.57  | 2.57  | 2.52  | 2.54  | 2.44  | 2.46  | 2.48  | 2.46  | 2.17  |
| <b>PM<sub>2.5</sub></b>                | 46.3  | 46.5  | 46.4  | 46.4  | 46.5  | 52.5  | 53.3  | 53.4  | 52.3  | 52.8  | 50.6  | 51.1  | 51.6  | 51.0  | 45.1  |
| <b>PM<sub>10</sub></b>                 | 49.5  | 49.7  | 49.7  | 49.6  | 49.8  | 56.2  | 57.1  | 57.1  | 55.9  | 56.5  | 54.2  | 54.6  | 55.2  | 54.6  | 48.3  |
| <b>TSP<sup>2</sup></b>                 | 49.5  | 49.7  | 49.7  | 49.6  | 49.8  | 56.2  | 57.1  | 57.1  | 55.9  | 56.5  | 54.2  | 54.6  | 55.2  | 54.6  | 48.3  |
| <b>CO</b>                              | 44.9  | 44.9  | 44.9  | 44.9  | 44.9  | 41.6  | 41.1  | 40.1  | 42.1  | 43.3  | 44.2  | 42.8  | 44.9  | 45.3  | 45.9  |
| <b>HEAVY FUEL OIL</b>                  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>NH<sub>3</sub></b>                  | 0.33  | 0.33  | 0.33  | 0.33  | 0.33  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  | 0.35  | 0.34  | 0.31  |
| <b>NM VOC</b>                          | 96.6  | 96.5  | 96.5  | 96.5  | 96.5  | 104   | 117   | 131   | 156   | 172   | 168   | 156   | 165   | 166   | 174   |
| <b>NO<sub>x</sub></b>                  | 1,604 | 1,602 | 1,603 | 1,603 | 1,602 | 1,216 | 1,572 | 1,300 | 1,332 | 1,242 | 1,368 | 1,385 | 1,439 | 1,408 | 1,477 |
| <b>SO<sub>x</sub></b>                  | 1,319 | 1,332 | 1,323 | 1,336 | 496   | 48.6  | 49.2  | 48.1  | 45.9  | 46.5  | 48.1  | 47.0  | 47.6  | 47.2  | 48.2  |
| <b>BC<sup>1</sup></b>                  | 3.71  | 3.74  | 3.72  | 3.75  | 3.75  | 2.01  | 2.55  | 2.85  | 2.71  | 2.68  | 3.04  | 3.02  | 3.29  | 3.31  | 3.86  |
| <b>PM<sub>2.5</sub></b>                | 204   | 205   | 204   | 206   | 206   | 110   | 140   | 157   | 149   | 147   | 167   | 166   | 181   | 182   | 212   |
| <b>PM<sub>10</sub></b>                 | 218   | 220   | 219   | 221   | 221   | 118   | 150   | 168   | 159   | 158   | 179   | 178   | 194   | 195   | 227   |
| <b>TSP<sup>2</sup></b>                 | 218   | 220   | 219   | 221   | 221   | 118   | 150   | 168   | 159   | 158   | 179   | 178   | 194   | 195   | 227   |

|           | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016  | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-----------|------|------|------|------|------|------|-------|------|------|------|------|------|------|------|------|
| <b>CO</b> | 63.2 | 63.1 | 63.1 | 63.2 | 63.1 | 63.5 | 157.7 | 62.4 | 63.9 | 64.7 | 71.7 | 69.0 | 69.3 | 65.2 | 65.8 |

<sup>1</sup> estimated from a BC-fraction derived from the EMEP/EEA Guidebook 2023 <sup>3)</sup>, chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Table 3-1 (0.017 for heavy fuel oil) and 3-2 (0.045 for diesel oil)

<sup>2</sup> ratios PM<sub>2.5</sub> : PM<sub>10</sub> : TSP derived from the tier1 default EF as provided in the EMEP/EEA Guidebook 2023 <sup>4)</sup>, chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Tables 3-1 & 3-2



For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

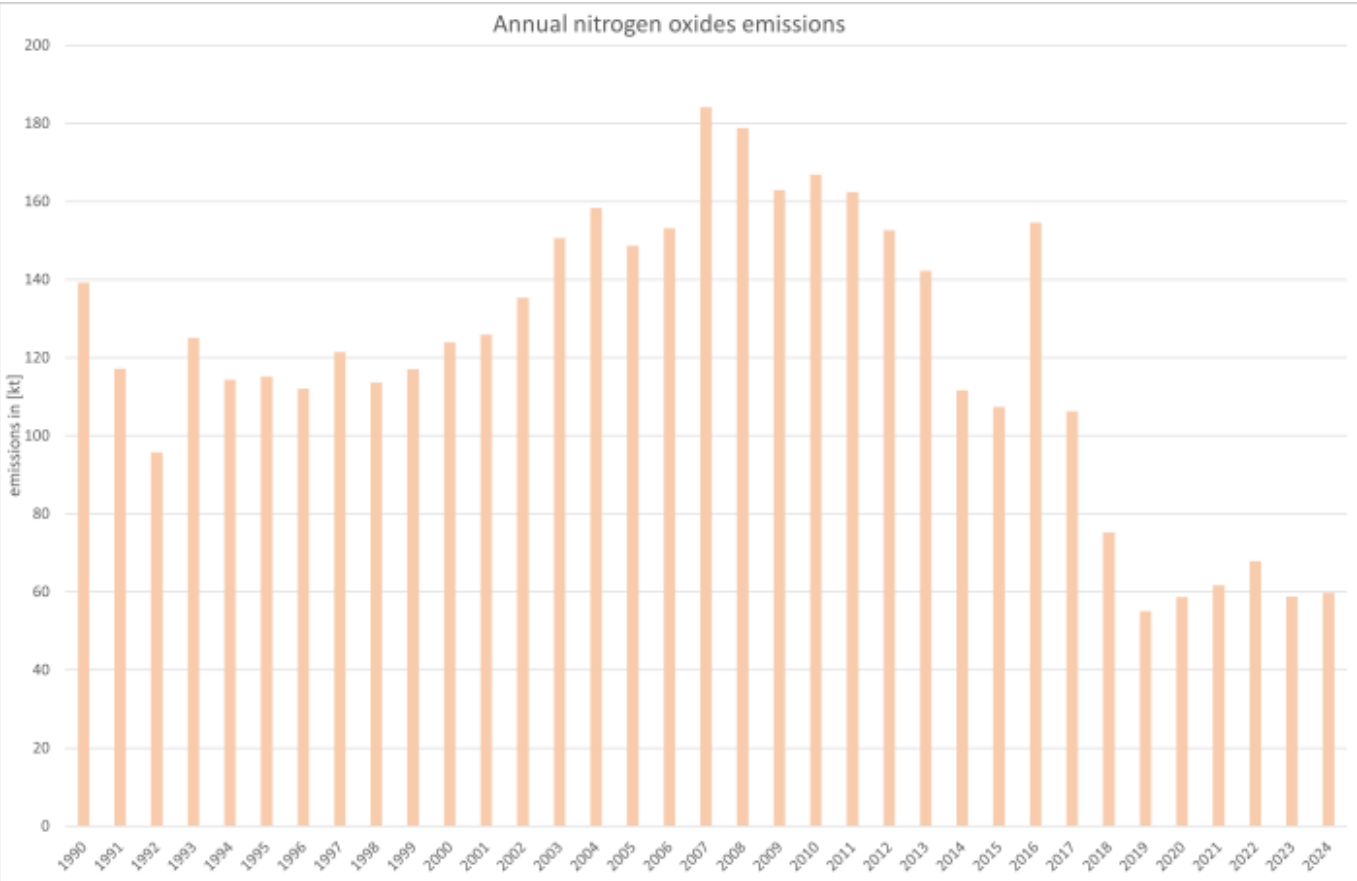
## Discussion of emission trends

### NFR 1.A.3.d i is not considered in the key category analysis.

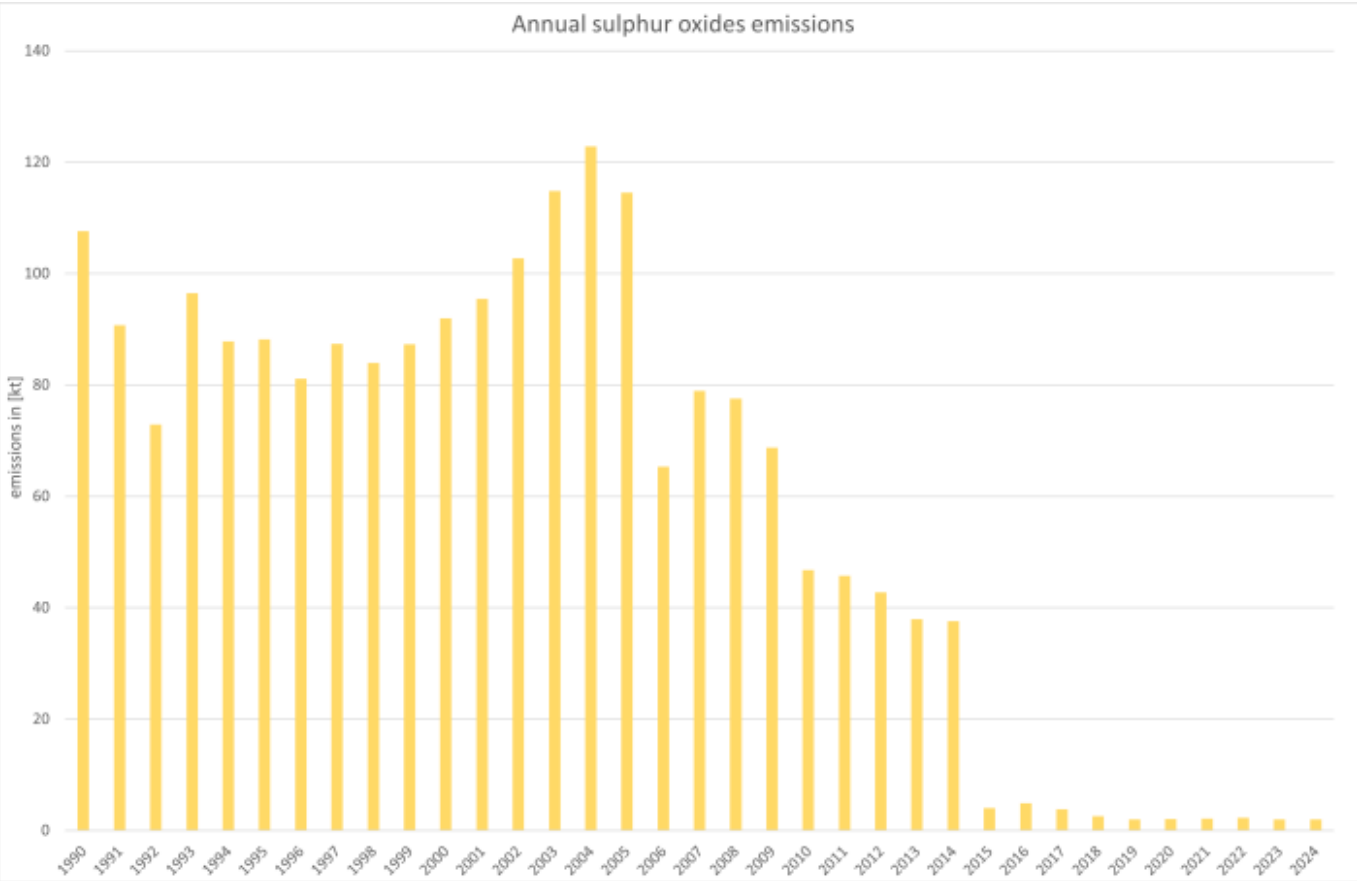
Basically, with no significant technical improvements with respect to mitigation technologies, trends in emissions depend more or less directly the amounts of fuels bunkered in German harbours and the contributions of diesel oil/light heating oil and heavy fuel oil to the over-all fuel input.

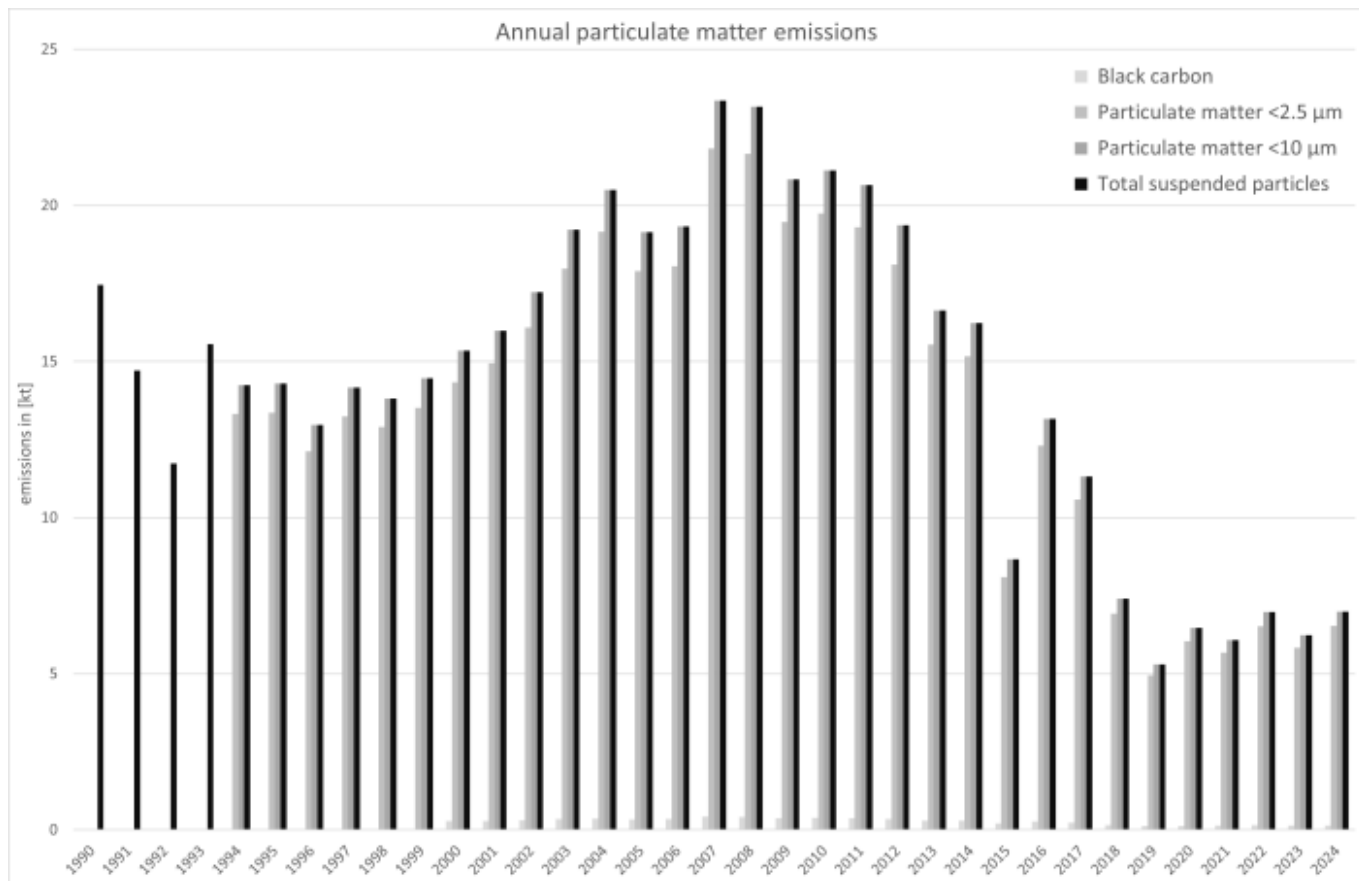
Here, as the amounts of fuels allocated to international maritime navigation represent the remains of annual over-all inland fuel deliveries minus fuel consumption in domestic shipping, activity data and, hence, emissions, fluctuate strongly from year to year (see also information on activity data as stated above).

Therefore, especially emission trends for unregulated pollutants (such as **NH<sub>3</sub>**, **NO<sub>x</sub>**, **NMVOC** and **CO**, all **HM** and **POPs**) with only slight changes in the annual over-all IEFs applied, follow the trends in fuel consumption and the shares of diesel and heavy fuel oil:



In contrast, emission trends for **SO<sub>x</sub>** and **PM**, both depending on the fuel's sulphur content, follow not only the trends in fuel consumption but do also reflect fuel-sulphur legislation:





## Recalculations

**Activity data** have been recalculated slightly due to the revision of the National Energy Balances (NEB) 2022 and 2023.

Table 3: Revised activity data for international maritime navigation departing from Germany, in terajoules

|                     | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| DIESEL OIL          |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission  | 13,162 | 13,096 | 13,709 | 11,546 | 16,273 | 33,836 | 32,424 | 27,370 | 16,000 | NO     |        |        |        |        |
| previous submission | 13,162 | 13,096 | 13,709 | 11,546 | 16,273 | 33,836 | 32,424 | 27,370 | 16,000 | NO     |        |        |        |        |
| absolute change     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | NA     |        |        |        |        |
| relative change     | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | NA     |        |        |        |        |
| LIGHT FUEL OIL      |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission  | NO     |        |        |        |        |        |        |        | 5.333  | 20.103 | 13.606 | 21.258 | 23.257 | 19.519 |
| previous submission | NO     |        |        |        |        |        |        |        | 5.333  | 20.104 | 13.606 | 21.260 | 23.267 | 18.657 |
| absolute change     | NA     |        |        |        |        |        |        |        | 0.18   | -0.71  | -0.53  | -2.12  | -10.4  | 862    |
| relative change     | NA     |        |        |        |        |        |        |        | 0.00%  | 0.00%  | 0.00%  | -0.01% | -0.04% | 4.62%  |
| HEAVY FUEL OIL      |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission  | 76,942 | 62,066 | 67,080 | 84,127 | 91,992 | 57,278 | 75,408 | 58,196 | 38,986 | 26,418 | 32,053 | 27,713 | 29,416 | 26,591 |
| previous submission | 76,942 | 62,066 | 67,080 | 84,127 | 91,992 | 57,278 | 75,408 | 58,196 | 38,986 | 26,418 | 32,053 | 27,713 | 29,414 | 26,633 |
| absolute change     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | -0.01  | 0.00   | 2.46   | -42.2  |

|                         | 1990   | 1995   | 2000   | 2005   | 2010    | 2015   | 2016    | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|-------------------------|--------|--------|--------|--------|---------|--------|---------|--------|--------|--------|--------|--------|--------|--------|
| relative change         | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%   | 0.00%  | 0.00%   | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.01%  | -0.16% |
| NFR 1.A.3.d i (i) TOTAL |        |        |        |        |         |        |         |        |        |        |        |        |        |        |
| current submission      | 90,104 | 75,162 | 80,789 | 95,672 | 108,266 | 91,114 | 107,832 | 85,566 | 60,320 | 46,521 | 45,659 | 48,971 | 52,673 | 46,110 |
| previous submission     | 90,104 | 75,162 | 80,789 | 95,672 | 108,266 | 91,114 | 107,832 | 85,566 | 60,319 | 46,522 | 45,660 | 48,973 | 52,681 | 45,290 |
| absolute change         | 0.00   | 0.00   | 0.00   | 0.00   | 0.00    | 0.00   | 0.00    | 0.00   | 0.73   | -0.71  | -0.54  | -2.12  | -7.92  | 820    |
| relative change         | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%   | 0.00%  | 0.00%   | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | -0.02% | 1.81%  |

In addition, several implied **emission factors** derived from the underlying BSH model <sup>5)</sup> have been revised.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland” by Knörr et al. (2009) <sup>6)</sup>.

Planned improvements

Besides routine maintenance and further development of the BSH model, the proxy emission factors applied for PAH emissions from vessels/ships derived from tier1 defaults provided for railways and heavy-duty vehilces in the EMEP/EEA Guidebook 2019 will be replaced by values derived from Chapter 1.A.3.d Navigation (shipping) 2023 of the EMEP/EEA Guidebook 2023 (see also: [https://iir.umweltbundesamt.de/2026/general/planned\\_improvements/start](https://iir.umweltbundesamt.de/2026/general/planned_improvements/start) and [https://iir.umweltbundesamt.de/2026/appendices/appendix2.4\\_pops\\_from\\_mobile\\_sources](https://iir.umweltbundesamt.de/2026/appendices/appendix2.4_pops_from_mobile_sources))

FAQs

<sup>1)</sup> AGEB (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2), 5)</sup> Deichnik (2025): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs; Federal Maritime and Hydrographic Agency (BSH - Bundesamt für Seeschifffahrt und Hydrographie Hamburg); on behalf of the Umweltbundesamt, Hamburg / Dessau-Roßlau, 2025.

<sup>3), 4)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, URL: <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-d-navigation>; Copenhagen, 2023.

<sup>6)</sup> Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; URL: <https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf>, FKZ 360 16 023, Heidelberg & Zürich, 2009.



At the moment, Germany does not report any emissions from this sub-category.

Primary fuel deliveries data available from the National Energy Balance (NEB), from the BAFA Official Mineral Oil Data or other statistics does not allow a differentiation into national and international inland navigation on German inland waterways. Therefore, for the time being, all activity data is allocated to [1.A.3.d ii - National Navigation](#) and here to the sub-sector of *1.A.3.d ii (b) - National Inland Navigation*.



## 1.A.3.e - Other Transport

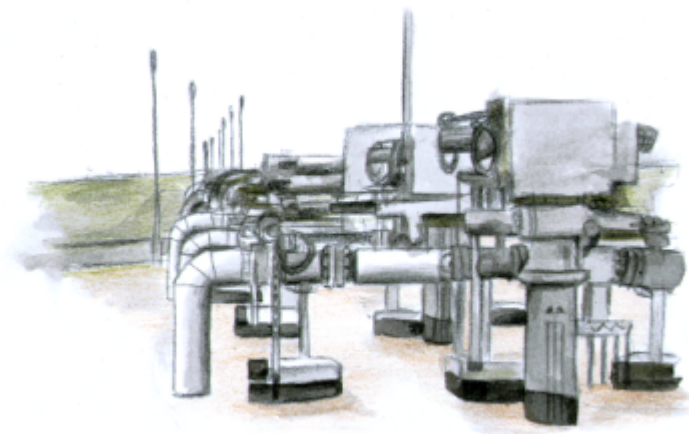
NFR category 1.A.3.e - *Other Transportation* comprises of the two sub-categories 1.A.3.e i - *Pipeline Transport* and 1.A.3.e ii - *Other Transport: Other*.

At the moment, only emissions from compressors in pipeline transport of natural gas are reported, whereas no further emission sources are allocated in NFR 1.A.3.e ii.

| NFR-Code                                    | Name of Category                    | Method                                       | AD | EF | Key Category Analysis |
|---------------------------------------------|-------------------------------------|----------------------------------------------|----|----|-----------------------|
| 1.A.3.e                                     | Other Transportation                | see sub-category details                     |    |    |                       |
| consisting of / including source categories |                                     |                                              |    |    |                       |
| 1.A.3.e i                                   | Other Transport: Pipeline Transport | see sub-category details                     |    |    |                       |
| 1.A.3.e ii                                  | Other Transport: Other              | no activities reported in this sub-catgeory. |    |    |                       |

## 1.A.3.e i - Other Transport: Pipeline Transport

### Short description



Under category 1.A.3.e i - Pipeline Compressors emissions from compressors in pipeline transport of natural gas are reported.

| NFR Code                                                                                  | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 1.A.3.e i                                                                                 | T2                                   | NS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO  | Pb | Cd | Hg  | Other HM | POPs |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|-----|----|----|-----|----------|------|
| -/-             | -/-    | -/-             | NA              | -/-               | -/-              | -/- | NE | -/- | NA | NA | -/- | NA       | NA   |

|            |                                                                                              |
|------------|----------------------------------------------------------------------------------------------|
| <b>L/-</b> | key source by <b>L</b> evel only                                                             |
| <b>-/T</b> | key source by <b>T</b> rend only                                                             |
| <b>L/T</b> | key source by both <b>L</b> evel and <b>T</b> rend                                           |
| <b>-/-</b> | no key source for this pollutant                                                             |
| <b>IE</b>  | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |
| <b>NE</b>  | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |
| <b>NA</b>  | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |
| <b>*</b>   | no analysis done                                                                             |

## Methodology

### Activity data

In past years, statistical fuel consumption data from the National Energy Balances for Germany was used (AGEB, 2025)<sup>1)</sup>. But a comparison with data from German ETS (available as of 2005) exposed several inconsistencies within these statistics.

Therefore, as the fuel consumption of a compressor station depends strongly on the amount of transferred natural gas, a conversion factor was derived reflecting the relation between the fuel consumption of all compressor stations and the primary energy consumption of natural gas within Germany. Using this conversion factor, the insufficient statistical data could be replaced by much more solid estimates for the years 1990 to 2004 whereas from 2005 on the abovementioned ETS data is used.

Table 1: Consumption of natural gas in compressor stations, in [t]

| 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 19,449 | 23,740 | 25,324 | 26,501 | 21,021 | 22,026 | 18,737 | 22,422 | 23,856 | 21,417 | 13,748 | 14,990 | 23,623 | 16,620 | 11,979 |

### Emission factors

The emission factors for pipeline compressors have been taken from the research project “Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010” (Rentz et al., 2002)<sup>2)</sup>. A detailed description of the procedure is presented in Chapter: 1.A.1.a - Public Electricity And Heat Production. In 2018 and 2019 emission factors were revised by using emission data from large combustion plants (UBA, 2019)<sup>3)</sup>.

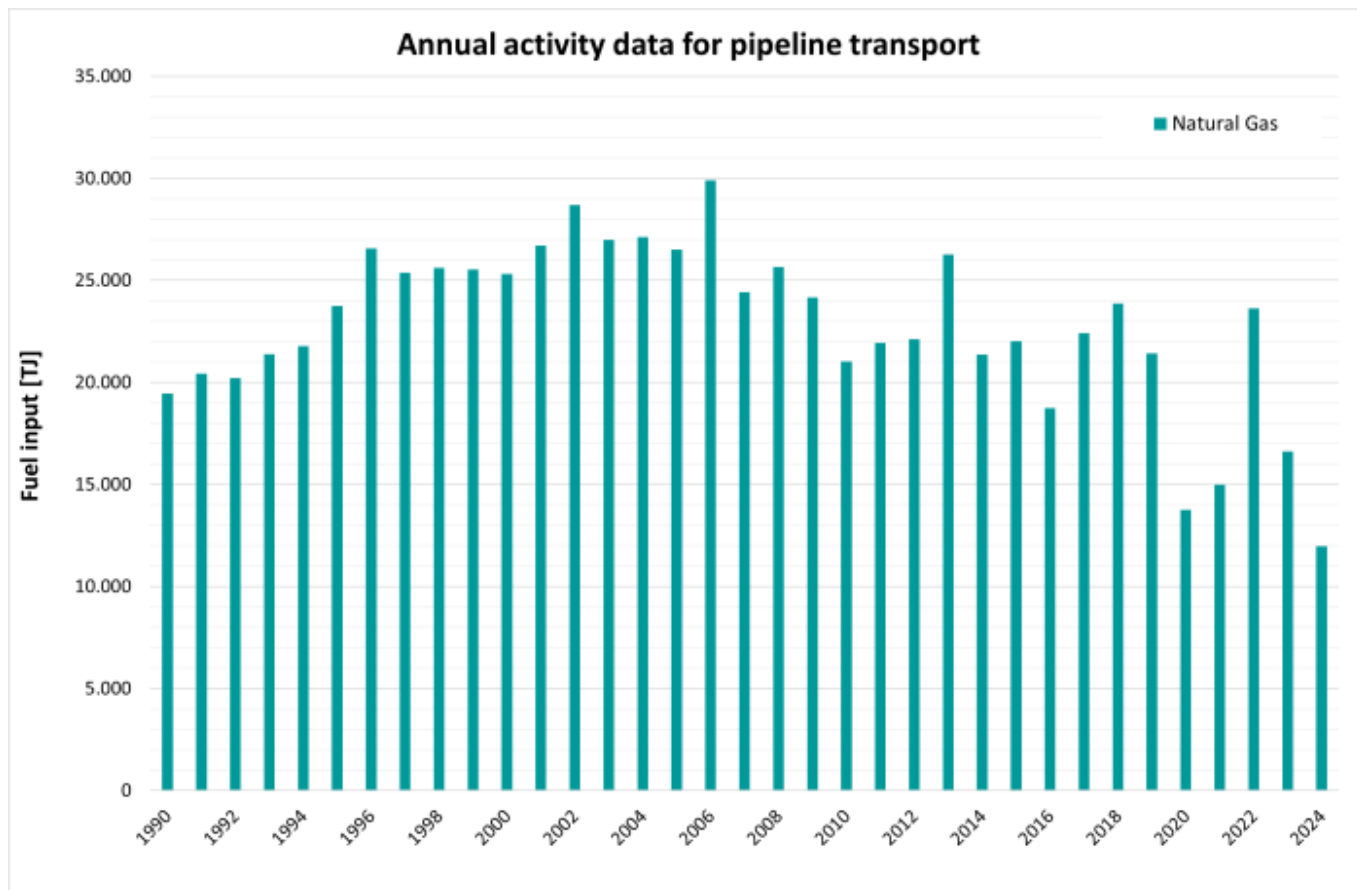
Compressor stations, in Germany mostly gas turbines, are responsible for maintaining a constant pressure in the pipeline. Basically they work discontinuously which causes relatively high specific emissions. In order to reflect this point the German law allows exemptions for installations with a low level of utilization.

Table 2: Implied emission factors applied for pipeline transport

| Pollutant               | Unit         | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-------------------------|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>NM VOC</b>           | <b>kg/TJ</b> | 0.30 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| <b>NO<sub>x</sub></b>   |              | 205  | 161  | 156  | 160  | 156  | 63.4 | 62.9 | 62.9 | 63.0 | 63.0 | 62.9 | 62.9 | 62.9 | 62.9 | 62.9 |
| <b>PM<sub>2.5</sub></b> |              | 0.00 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| <b>PM<sub>10</sub></b>  |              | 0.00 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| <b>TSP</b>              |              | 0.10 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 |
| <b>SO<sub>2</sub></b>   |              | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 |
| <b>Hg</b>               | <b>g/TJ</b>  | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.05 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |

## Trend discussion for Key Sources

The following diagram gives an overview of the fuel consumption in NFR 1.A.3.e



Since 1990 natural gas consumption has shown an increasing overall trend. Annual fluctuations are due to the varying primary energy consumption. The maximum fuel consumption occurred in 2006, the year with the so far highest German total primary energy consumption of natural gas. Thereafter, natural gas consumption decreases considerably.

## Recalculations



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no further improvements are planned.

<sup>1)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> Rentz et al. (2002) Rentz, O., Karl, U., Peter, H.: "Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010"; Forschungsbericht 299 43 142, on behalf of the Umweltbundesamt; Karlsruhe / Dessau-Roßlau, December 2002.

<sup>3)</sup> UBA (2019): Juhlich, K., Beckers, R.: "Updating the Emission Factors for Large Combustion Plants"; <https://www.umweltbundesamt.de/publikationen/updating-emission-factors-large-combustion-plants>; Dessau-Roßlau, 2019

## 1.A.4 - Small Combustion (OVERVIEW)

### Short description

NFR 1.A.4 - *Small Combustion* comprises combustion systems in the areas Commercial and Institutional (NFR 1.A.4.a), Residential (NFR 1.A.4.b), and Agriculture (NFR 1.A.4.c), along with various mobile sources.

| NFR-Code                                         | Name of Category                                 |
|--------------------------------------------------|--------------------------------------------------|
| 1.A.4                                            | Small Combustion                                 |
| <i>including / consisting of sub-categories:</i> |                                                  |
| 1.A.4.a i, b i, c i                              | <a href="#">Stationary Small Combustion</a>      |
| 1.A.4.a ii, b ii, c ii, c iii                    | <a href="#">Small Combustion: Mobile Sources</a> |

The group of stationary combustion systems in the residential and commercial/institutional sectors is very diverse with regard to installation design and size. It covers a spectrum that includes individual room furnaces for solid fuels with a rated thermal output of approximately 4 kW (e.g. fireplaces, ovens), oil and gas furnaces used to generate room heat and hot water (e.g. central heating boilers), hand-fed and automatically fed wood-burning furnaces in the commercial sector.

Besides stationary combustion, mobile sources are covered, too: From fork lifters in NFR 1.A.4.a ii -Commercial / Institutional: Mobile via lawn mowers in NFR 1.A.4.b ii - Residential: Household and Gardening: Mobile to vehicles and other mobile machinery used in NFR 1.A.4.c ii - Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery and the emissions of the German deep sea fishing fleet under NFR 1.A.4.c iii - Agriculture/Forestry/Fishing: National Fishing.

# 1.A.4 - Small Combustion: Stationary Sources (OVERVIEW)

## Short description

Source category 1.A.4 comprises stationary combustion systems in the sectors *Commercial and Institutional (1.A.4.a)*, *Residential (1.A.4.b)*, and *Agriculture (1.A.4.c)*.

| NFR-Code                                 | Name of Category                                                       |
|------------------------------------------|------------------------------------------------------------------------|
| <b>1.A.4</b>                             | <b>Small Combustion</b>                                                |
| including / consisting of sub-categories |                                                                        |
| 1.A.4.a i                                | <a href="#">Commercial and Institutional - Stationary Combustion</a>   |
| 1.A.4.b i                                | <a href="#">Residential - Stationary Combustion</a>                    |
| 1.A.4.c i                                | <a href="#">Agriculture, Forestry, Fishing - Stationary Combustion</a> |

## Method

### Activity data

Activity data in source category 1.A.4 are based on the Energy Balance for the Federal Republic of Germany prepared by the Working Group on Energy Balances (AGEB)<sup>1)</sup>. For the period prior to 1995, separate Energy Balances are used for the new and old German Länder. Lines 66 (residential) and 67 (commercial, trade, services and other consumers) of the Energy Balance are of primary importance.

Since large quantities of wood fuels, used in households and in commerce and trade, are purchased privately or obtained from system owners' own forest parcels, data are outside official statistics. For this reason, additional studies are used by the Working Group on Renewable Energy Statistics (AGEE-Stat). The results for the residential sector are based on surveys of wood consumption carried out in the framework of the "Rohstoffmonitoring Holz" ("Monitoring of raw materials - wood") project<sup>2)</sup>. That project collected data both on firewood purchased via commercial sellers and wood gathered in forests. For interim years, a regression model is applied that takes account of numbers of degree days, the price indexes for conventional fuels, and the heating systems, broken down by types, used in residential buildings. Conversions of volume units into energy units are carried out in conformance with the accepted conversion conventions of AGE-Stat. Wood consumption in heat-generation-only systems of the commercial and institutional sector is derived via a remainder calculation. In the process, the data on total wood consumption (outside of private households), as determined via the "Rohstoffmonitoring Holz" surveys and via regression models, are blended with the relevant wood-quantity data from official energy statistics and the applicable wood-quantity data given by other relevant models. The wood consumption data derived via this approach, which relate to data on heat generation by CHP systems, are also part of the data on total wood consumption in the commercial and institutional sector.

Energy data and emissions from small engines using biomass as fuel are reported in source category 1.A.1.a, since all the plants feed electricity into the local network. However a small amount of biogas and liquid biofuel, used for heat production, is reported in source category 1.A.4.

The determination of these fuel activities is a result of a comprehensive evaluation of invoicing data of the EEG (Renewable Energy Law), provided by the Federal Network Agency. The EEG-accounting system contains primarily electricity generation data, but also additional information, since a bonus is paid for heat extraction. For the calculation a typical power to heat ratio is necessary according to manufacturers specification.

### Emission factors

The database for the emission factors used for NO<sub>x</sub>, SO<sub>2</sub>, NMVOC, CO, TSP, PM<sub>10</sub>, PM<sub>2.5</sub>, heavy metals, PCDD/PCDF and PAH is the research report "Efficient provision of current emissions data for purposes of air quality control" ("Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung"; Struschka et al., 2008)<sup>3)</sup>. Within the context of that project, appliance-related and source-category-specific emission factors for the combustion systems in the residential and commercial/ institutional sectors were calculated, with a high level of detail, for all important emission components for the

reference year 2005.

In 2016 the revision of the emission factors for the main pollutants was necessary due to changes in legislation. Data source for emission factors of several pollutants from 2010 onwards is the research report “Ermittlung und Aktualisierung von Emissionsfaktoren für das nationale Emissionsinventar bezüglich kleiner und mittlerer Feuerungsanlagen der Haushalte und Kleinverbraucher”; Tebert et al., 2016)<sup>4)</sup>.

The determination of emission factors is based on a source-category-specific “bottom-up” approach that, in addition, to differentiating (sub-) source categories and fuels, also differentiates appliance technologies in detail. In the process, several technology-specific emission factors are aggregated in order to obtain mean emission factors for all systems within the source categories in question. Use of system-specific / category-specific emission factors ensures that all significant combustion-related characteristics of typical systems for the various categories are taken into account. The procedure is in keeping with the Tier-2 and Tier-3 methods, respectively.

The emission factors are structured in accordance with the relevant fuels involved in final energy consumption in Germany:

- Light Heating Oil,
- Natural gas,
- Lignite (briquettes from Rhine and Lausitz areas, and imported briquettes),
- Hard coal (coke, briquettes, anthracite) and
- Wood (unprocessed wood, wood pellets, residual wood).

In addition, emission factors for combustion systems are determined in accordance with device design, age level, output category and typical mode of operation. The emissions behaviour of the combustion systems in question were determined via a comprehensive review of the literature, in an approach that distinguished between results from test-bench studies and field measurements. Transfer factors were used to take account of the fact that emissions in a test-bench environment tend to be considerably lower than those of corresponding installed systems.

The description of the structure for installed combustion systems was prepared using statistics from the chimney-sweeping trade. These data were used to estimate the energy inputs for various system types, to make it possible to determine sectoral emission factors weighted by energy inputs.

The SO<sub>2</sub> emission factors for natural gas and lignite briquettes is calculated by the sulfur content of the fuel which is determined by measurements. In terms of light fuel oil the limit values were used. Since 2008 there are two qualities of light fuel oil available: fuel oil with a sulfur content of 1,000 mg/kg and fuel oil with a sulfur content of 50 mg/kg. In small combustion plants nowadays almost exclusively low-sulfur fuel oil is used. the share of the different light fuel oil qualities is annually available from the oil statistic. Regarding lignite briquettes can be assumed that 10 % of the sulfur were stored in the ash while 90 % were emitted as SO<sub>2</sub>. Since the sulfur content of lignite briquettes depends on the region, a weighted average emission factor has been calculated.

Black carbon emission factors are given by the EMEP/EEA Guidebook 2019.



For more detailed information on specific activity data, emission factors, emissions trends, recalculations and planned improvements, please refer to the sub-chapters linked above.

<sup>1)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> Mantau et al. (2018): Mantau, Prof. Dr. U., Döring, P. (INFRO e. K.) and Weimar, Dr. H., Glasenapp, S. (Thünen-Institut): ROHSTOFFMONITORING HOLZ - Mengenmäßige Erfassung und Bilanzierung der Holzverwendung in Deutschland; Schriftenreihe Nachwachsende Rohstoffe Band 38, publisher: Fachagentur Nachwachsende Rohstoffe e. V. (FNR), [https://www.charta-fuer-holz.de/fileadmin/charta-fuer-holz/dateien/service/mediathek/Rohstoffmonitoring\\_SR38\\_Final\\_Web\\_20180612.pdf](https://www.charta-fuer-holz.de/fileadmin/charta-fuer-holz/dateien/service/mediathek/Rohstoffmonitoring_SR38_Final_Web_20180612.pdf), ISBN 978-3-942147-37-8, Gülzow-Prüzen, 2018.

<sup>3)</sup> Struschka et al. (2008): Struschka, Dr. M., Kilgus, D., Springmann, M.; Baumbach, Prof. Dr. Günter: Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung; UBA Forschungsbericht 205 42 322; <https://www.umweltbundesamt.de/en/publikationen/effiziente-bereitstellung-aktueller-emissionsdaten>, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008.

<sup>4)</sup> Tebert et al. (2016): Tebert, Chr., Volz, S., Töfge, K., Friedrich, Chr.: Ermittlung und Aktualisierung von Emissionsfaktoren für das nationale Emissionsinventar bezüglich kleiner und mittlerer Feuerungsanlagen der Haushalte und Kleinverbraucher

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(unpublished), 2016.



## 1.A.4.a i - Commercial and Institutional: Stationary Combustion

### Short description



The source category *1.A.4.a.i - Commercial and Institutional: Stationary Combustion* emissions from commercial and institutional combustion installations are reported.

| NFR Code  | Method | AD | EF    |
|-----------|--------|----|-------|
| 1.A.4.a.i | T2, T3 | NS | CS, D |

| NFR Code                                                                                  | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                    | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCb | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|--------|-------|-------|-------|-------|------|-----|------|
| -/-             | L/T    | -/-             | -/-             | L/T               | L/T                                                                                 | L/T | L/- | L/T | L/- | -/- | -/- | L/- | -/- | -/- | -/- | NE | L/T | L/-    | L/-   | L/-   | L/-   | L/-   | L/-  | -/- | -/-  |
|                 |        |                 |                 | L/-               | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | -/T               | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | L/T               | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | IE                | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | *                 | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |

## Methodology

### Activity data

For information on activity data please refer to the [superordinate chapter](#) on small stationary combustion.

### Emission factors

For further information on the emission factors applied please refer to the [superordinate chapter](#) on small stationary combustion.

Table 1: Emission factors for commercial and institutional combustion installations

|                      | NO <sub>x</sub> | SO <sub>x</sub> | CO    | NM VOC | TSP  | PM <sub>10</sub> | PM <sub>2.5</sub> | PCDD/F  |
|----------------------|-----------------|-----------------|-------|--------|------|------------------|-------------------|---------|
|                      | [kg/TJ]         |                 |       |        |      |                  |                   | [kg/TJ] |
| <b>Hard Coal</b>     | 89.8            | 331.7           | 2,162 | 30.3   | 18.5 | 17.6             | 15.7              | 16.3    |
| <b>Residual Wood</b> | 92.7            | 8.2             | 675.7 | 49.0   | 34.8 | 33.5             | 30.0              | 355.3   |

|                   | NO <sub>x</sub> | SO <sub>x</sub> | CO   | NMVOC | TSP  | PM <sub>10</sub> | PM <sub>2.5</sub> | PCDD/F |
|-------------------|-----------------|-----------------|------|-------|------|------------------|-------------------|--------|
| Light Heating Oil | 43.6            | 2.4             | 11.9 | 2.3   | 1.0  | 1.0              | 1.0               | 2.7    |
| Natural Gas       | 22.0            | 0.1             | 12.0 | 0.4   | 0.03 | 0.03             | 0.03              | 1.6    |

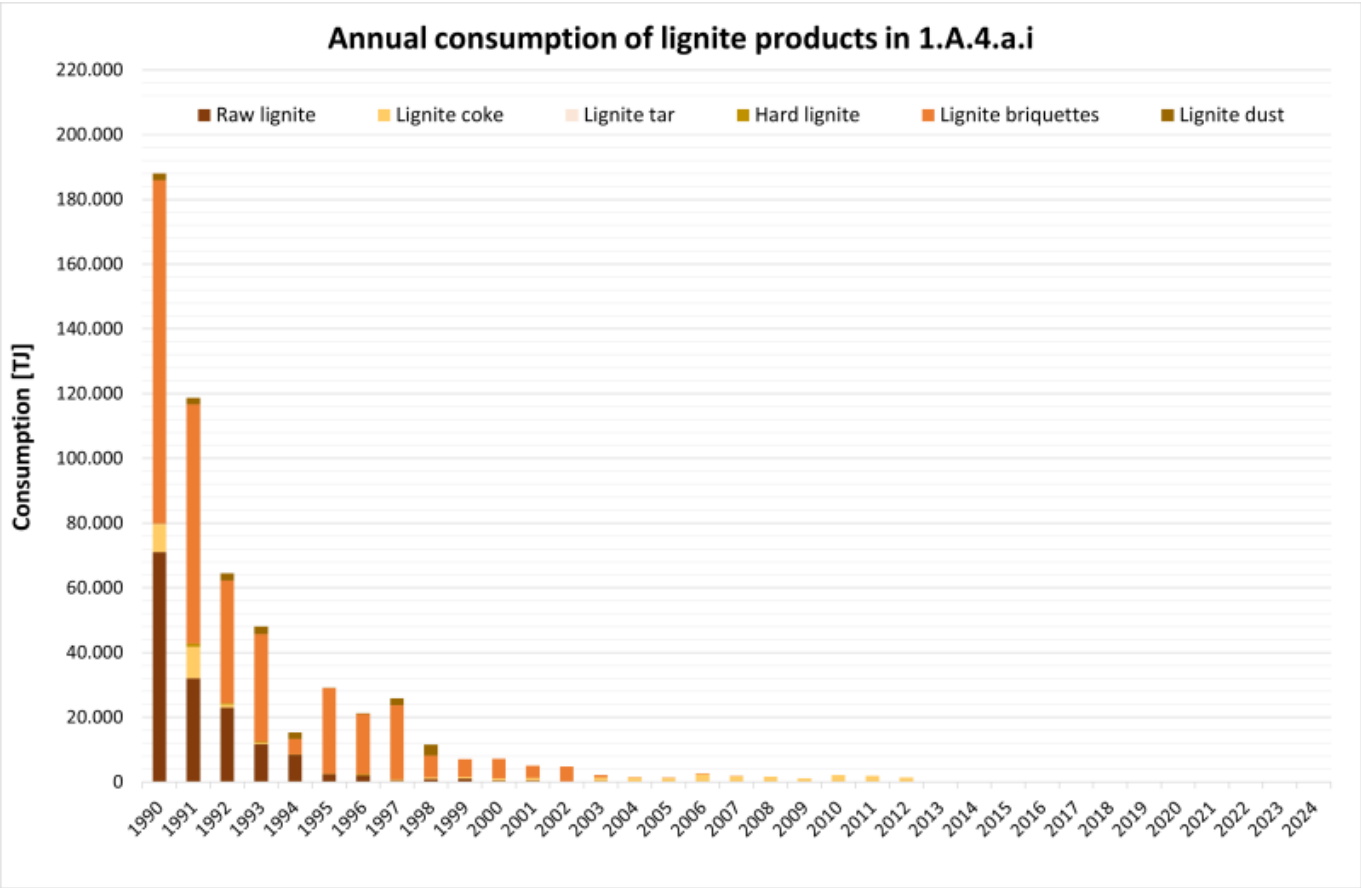
The TSP and PM emission factors are to a large extend based on measurements excluding condensed compounds, according to CEN-TS 15883, annex I. PAH measurement data contain the following individual substances:

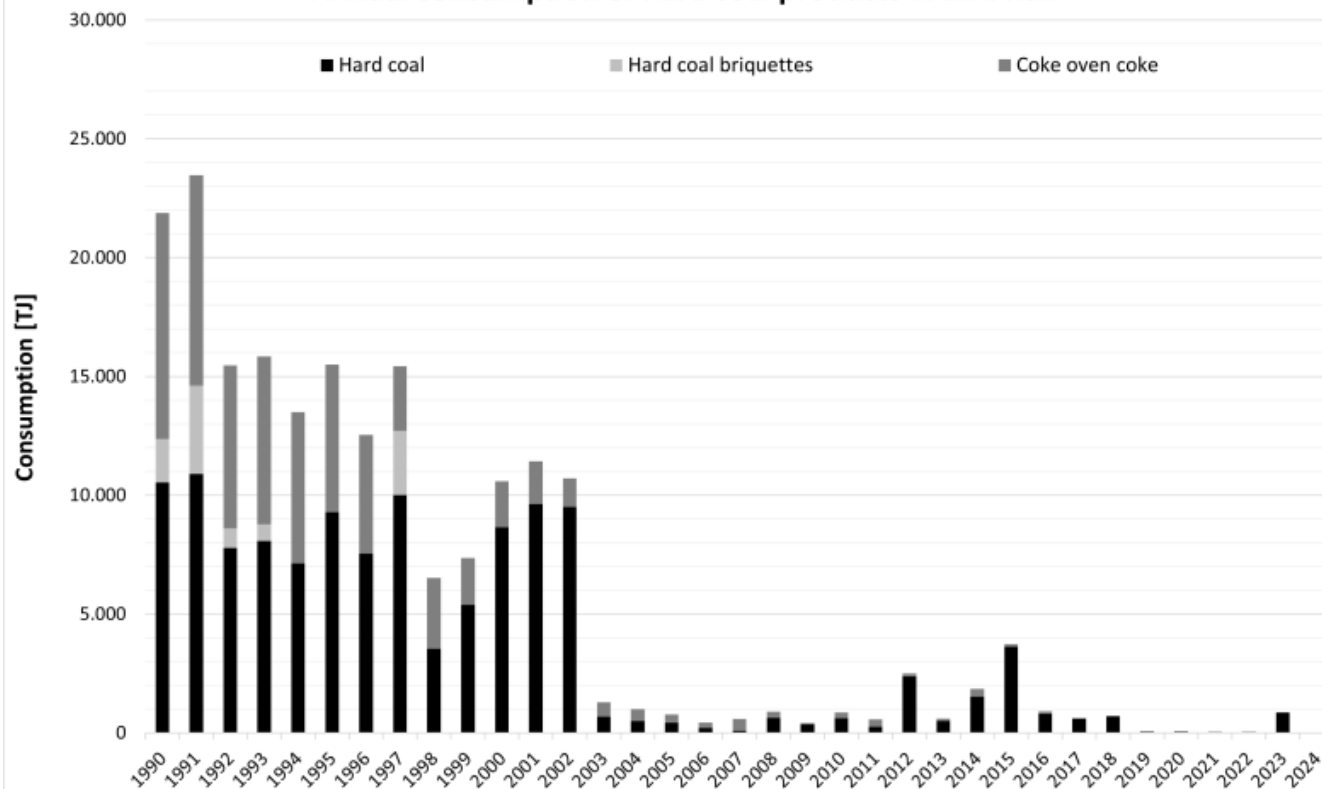
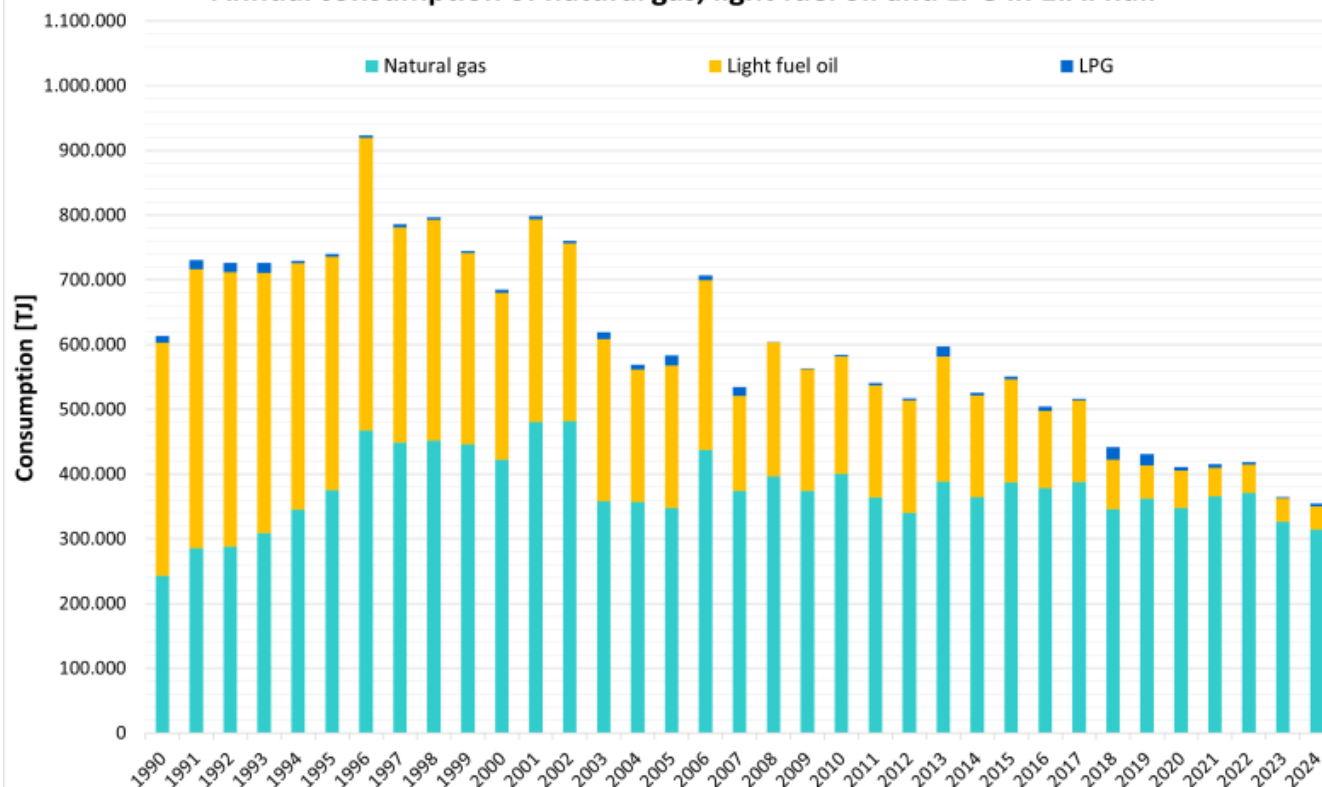
- Benzo(a)pyrene,
  - Benzo(k)fluoranthene,
  - Indeno(1,2,3-cd)pyrene,
  - Benzo(b)fluoranthene,
  - Benzo(j)fluoranthene,
  - Benzo(ghi)perylene,
  - Anthracene,
  - Benzo(a)anthracene,
  - Chrysene(+Trihenylene),
- and
- Dibenz(a,h)anthracene
- as a specific part of US EPA.

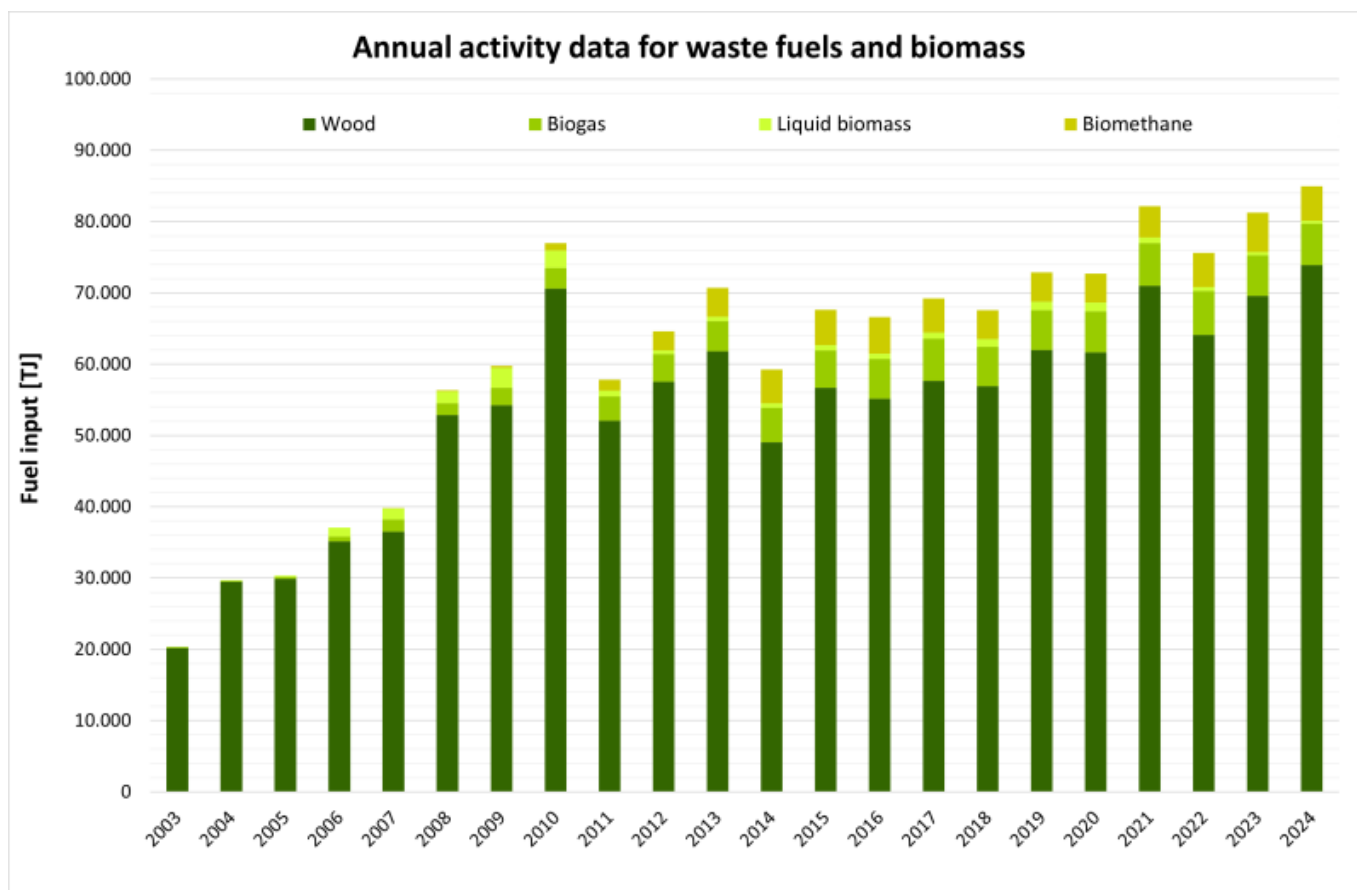
## Trend Discussion for Key Sources

The following charts give an overview and assistance for explaining dominant emission trends of selected pollutants.

### Fuel Consumption



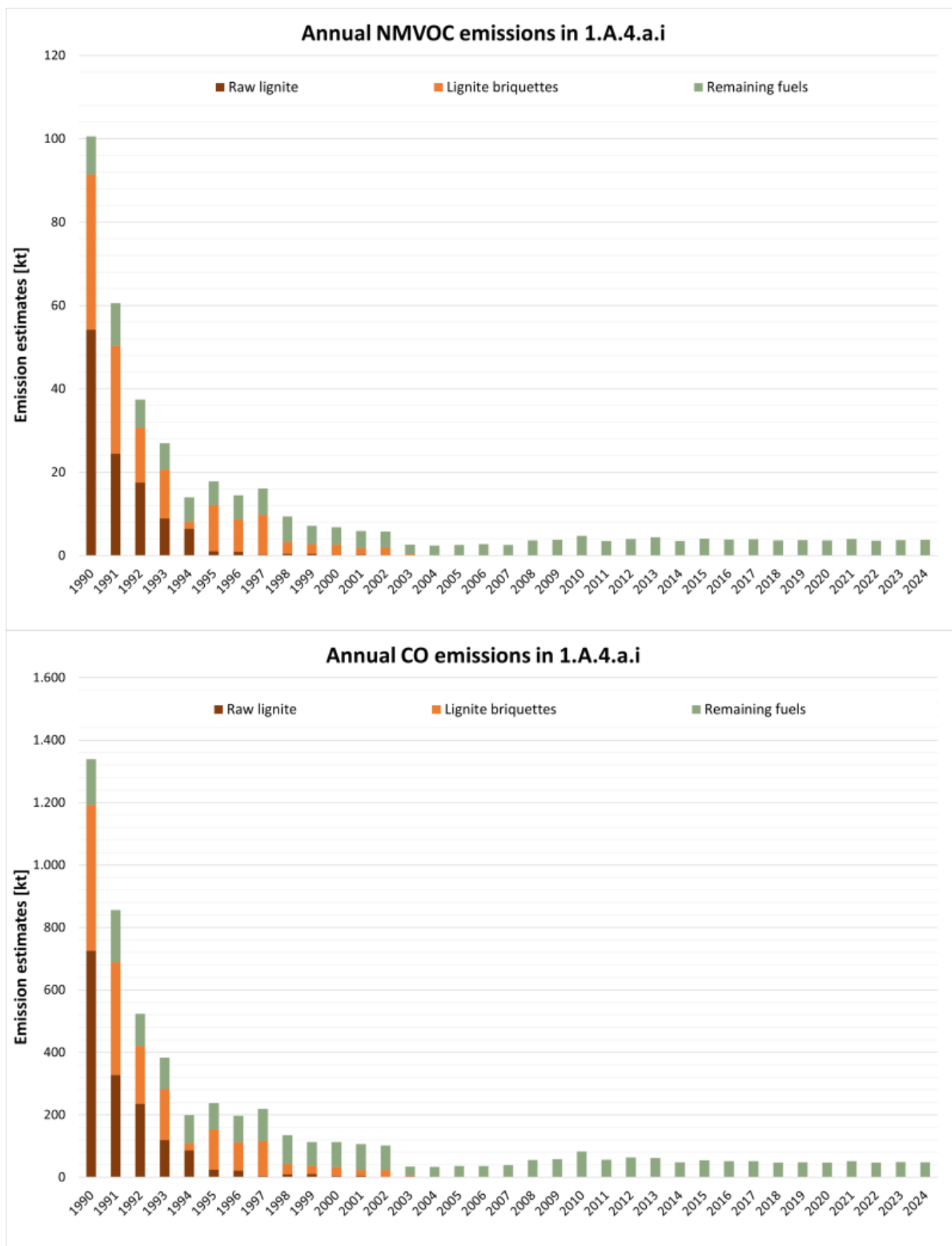
**Annual consumption of hard coal products in 1.A.4.a.i****Annual consumption of natural gas, light fuel oil and LPG in 1.A.4.a.i**



Annual fluctuations of all fuel types in source category 1.A.4 depend on heat demand subject to winter temperatures. From 1990 to the present time, fuel use changed considerably from coal & lignite to natural gas. The consumption of light heating oil decreased as well. As the activity data for light heating oil is based on the sold amount, it fluctuates due to fuel prices and changing storage amounts. The decrease of hard coal consumption in 2003 is caused by a change in statistics (data source).

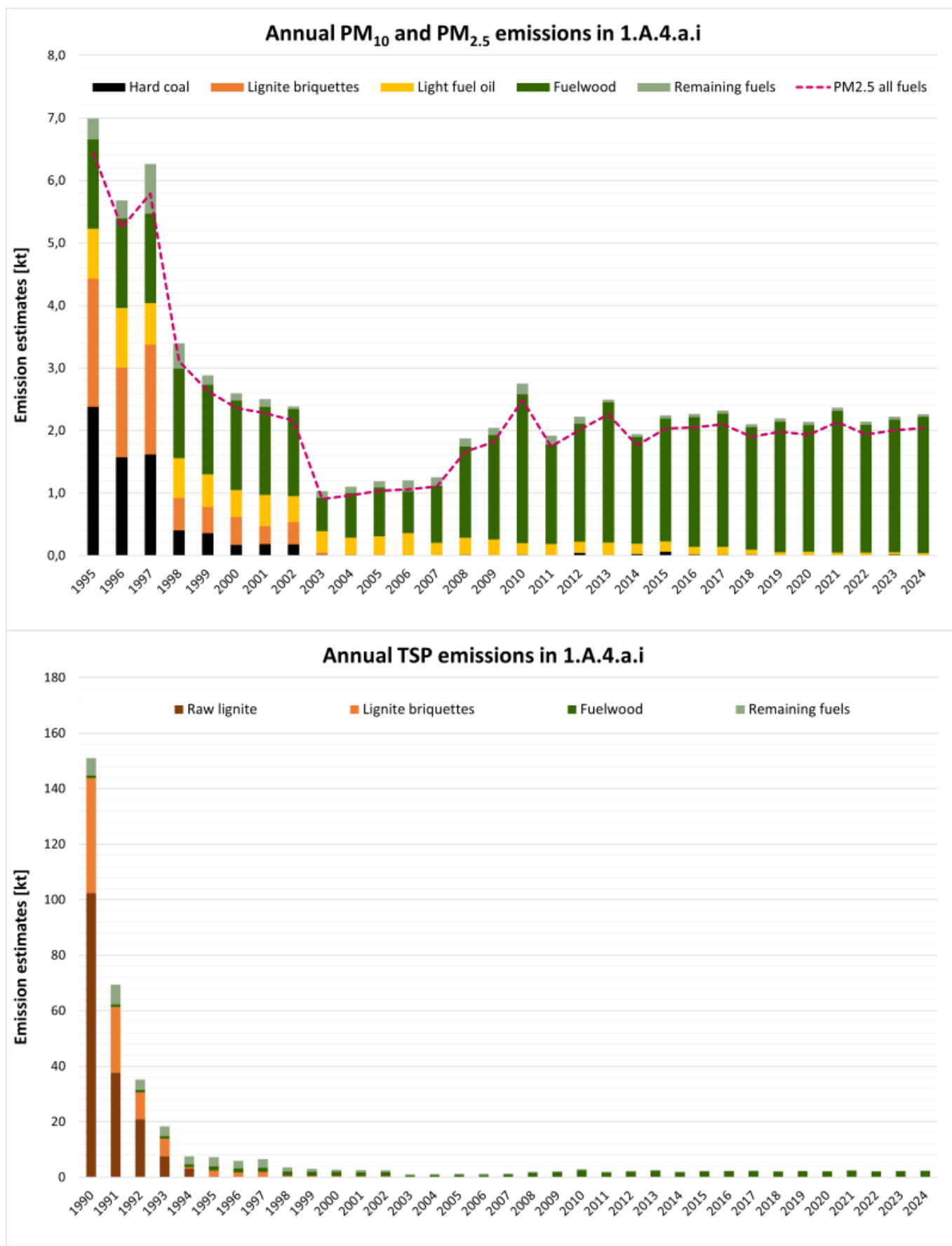
### Non-Methane Volatile Organic Compounds - NMVOC and Carbon monoxide - CO

Main driver of the NMVOC and CO emission trends is the decreasing lignite consumption: Since 1990 the fuel use changed from solid fuels causing high NMVOC and CO emissions to gaseous fuels producing much lower emissions.



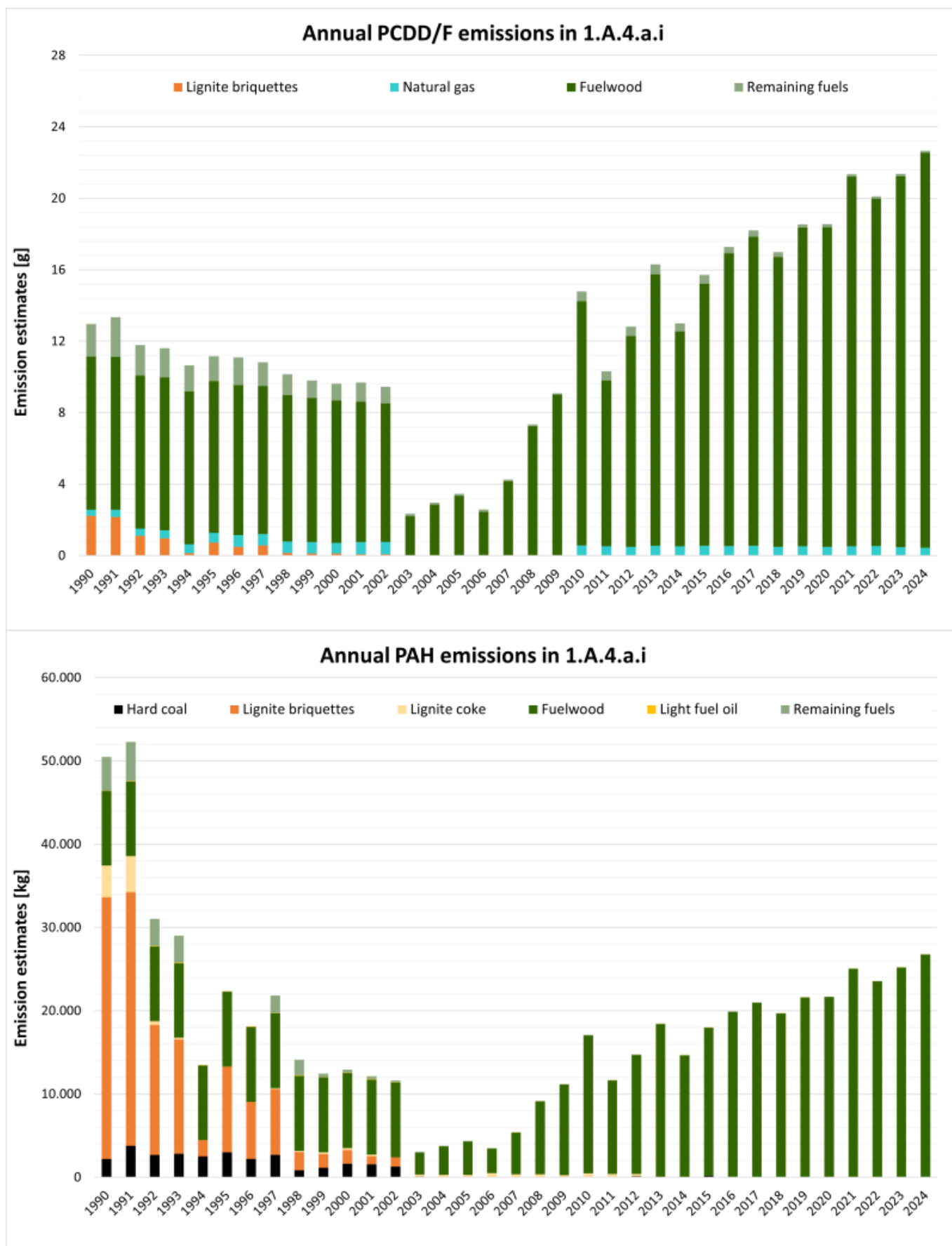
## Particulate Matter - PM<sub>2.5</sub> & PM<sub>10</sub> & TSP

The emission trends for PM<sub>2.5</sub>, PM<sub>10</sub>, and TSP are also influenced severely by decreasing coal consumption in small combustion plants, particularly in the period from 1990 to 1994. Since 1995 the emission trend hardly changed. Increasing emissions in the last years are caused by the rising wood combustion.



## Persistent Organic Pollutants

The main driver of the POPs emission trend are coal and fuelwood. PCDD/F emissions decrease from 1990 to 2003 due to decreasing lignite consumption. The use of firewood and therefore PCDD/F emissions from wood combustion show a constant development.



## Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the energy balance for 2023 led to recalculations. Moreover, for the purpose of improving data quality, national energy balances go under revisions every two years (for the years starting from 2003) through fine-tuning of the computational



models, consideration of new statistics or re-allocation of activity data. Due to the revisions on the input data for submission 2026, recalculations took place <sup>1)</sup>.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

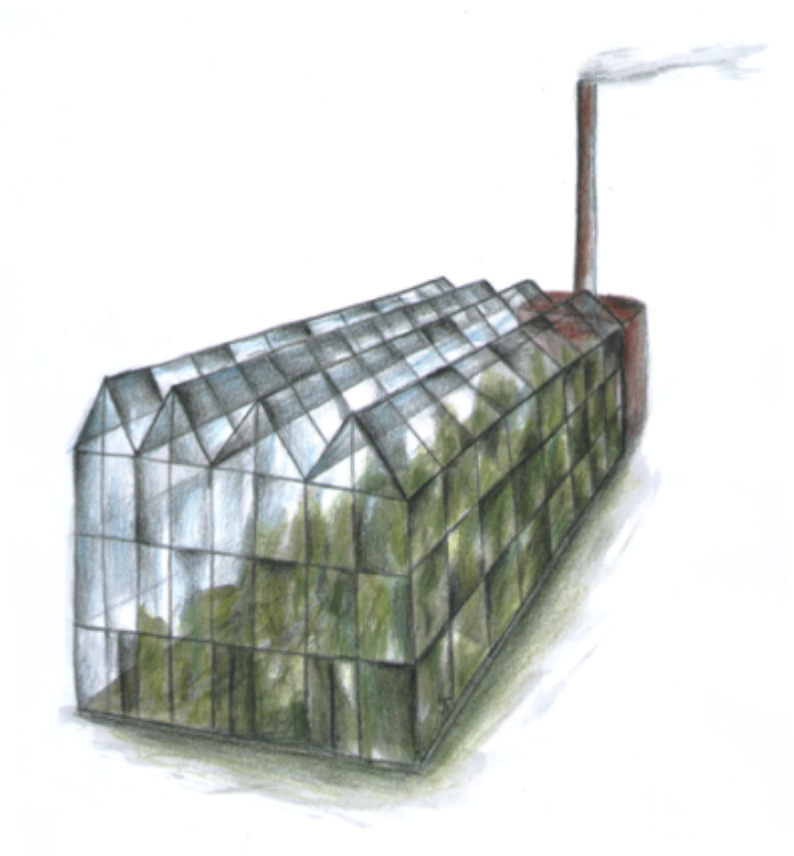
There is an ongoing research project on new emission factors for small combustion plants using updated data from the chimney sweepers and new measurement data. The project is on its last phase and when the results become available, implementation into the emission inventory will be assessed.

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<sup>1)</sup> AGEB (2025a): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland;  
[https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?\\_jahresbereich-bilanz=2021-2030](https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?_jahresbereich-bilanz=2021-2030), (Aufruf: 04.12.2025), Köln & Berlin, September 2025

# 1.A.4.c.i - Agriculture/Forestry/Fishing: Stationary

## Short description



In source category *1.A.4.c.i - Agriculture/Forestry/Fishing: Stationary* emissions from smaller combustion plants in agricultural facilities and greenhouses are reported.

| NFR Code  | Method | AD | EF    |  |
|-----------|--------|----|-------|--|
| 1.A.4.c.i | T2, T3 | NS | CS, D |  |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP                                                                                 | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |  |  |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|--------|-------|-------|-------|-------|--------|-----|------|--|--|--|
| -/-             | -/-    | -/-             | -/-             | -/-               | -/-              | -/-                                                                                 | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | NE | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | -/-  |  |  |  |
|                 |        |                 |                 |                   | L/-              | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |        |     |      |  |  |  |
|                 |        |                 |                 |                   | -/T              | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |        |     |      |  |  |  |
|                 |        |                 |                 |                   | L/T              | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |        |     |      |  |  |  |
|                 |        |                 |                 |                   | -/-              | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |        |     |      |  |  |  |
|                 |        |                 |                 |                   | IE               | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |        |     |      |  |  |  |
|                 |        |                 |                 |                   | NE               | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |        |     |      |  |  |  |
|                 |        |                 |                 |                   | NA               | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |        |     |      |  |  |  |
|                 |        |                 |                 |                   | *                | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |        |     |      |  |  |  |

## Activity data

## Emission factors

Table 1: Emission factors for commercial and institutional combustion installations

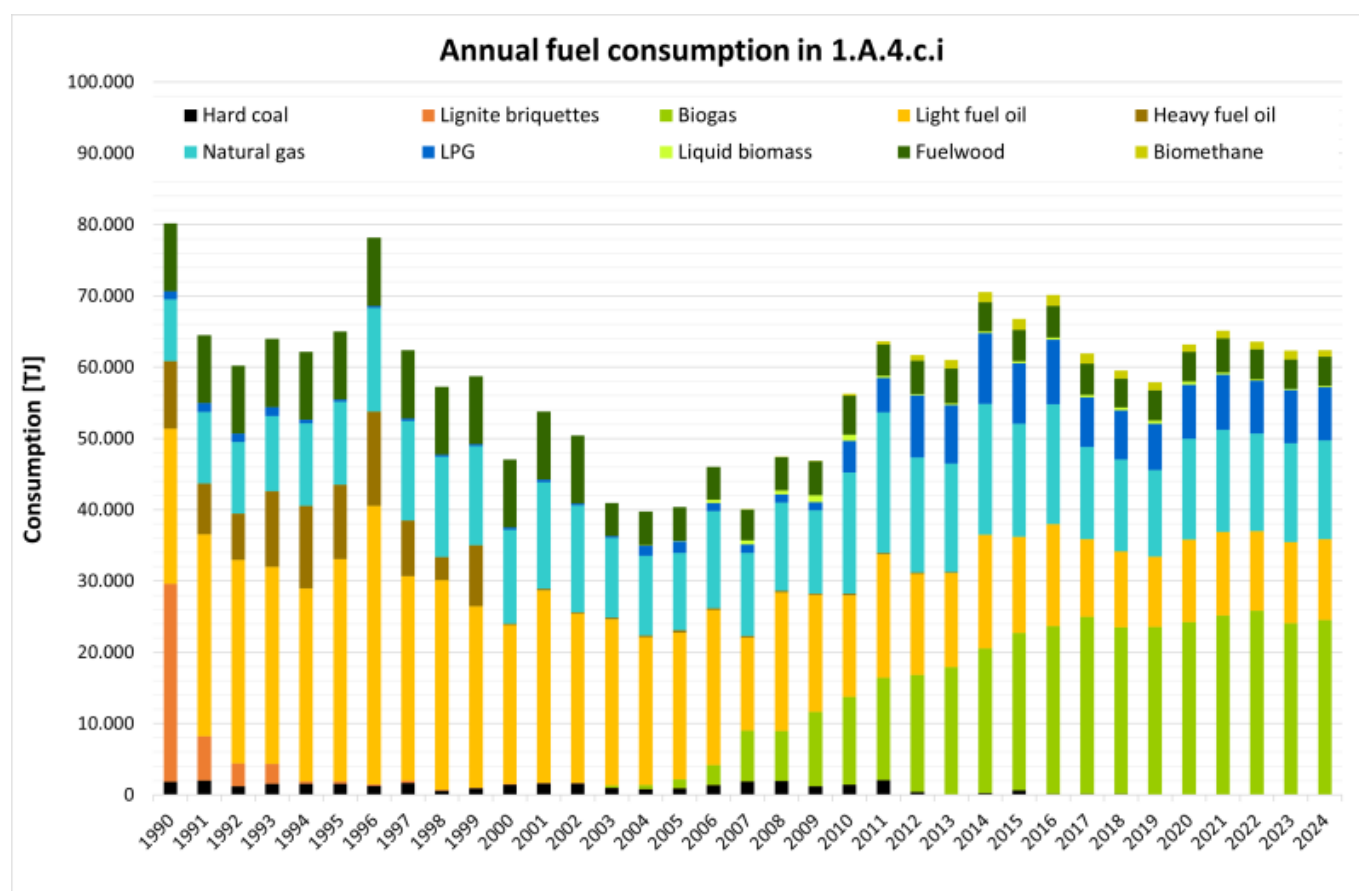
|  |                 |                 |    |        |     |                  |                   |        |
|--|-----------------|-----------------|----|--------|-----|------------------|-------------------|--------|
|  | NO <sub>x</sub> | SO <sub>x</sub> | CO | NM VOC | TSP | PM <sub>10</sub> | PM <sub>2.5</sub> | PCDD/F |
|  | [kg/T]          |                 |    |        |     |                  |                   | [kg/T] |

|                       | NO <sub>x</sub> | SO <sub>x</sub> | CO    | NM VOC | TSP  | PM <sub>10</sub> | PM <sub>2.5</sub> | PCDD/F |
|-----------------------|-----------------|-----------------|-------|--------|------|------------------|-------------------|--------|
| <b>Hard Coal</b>      | 76.2            | 331.7           | 2,709 | 48.4   | 18.5 | 17.6             | 15.7              | 16.3   |
| <b>Firewood</b>       | 79.2            | 6.5             | 2,285 | 122.1  | 84.2 | 81.6             | 76.9              | 355.3  |
| <b>Light Fuel Oil</b> | 43.7            | 2.4             | 11.9  | 2.3    | 1.0  | 1.0              | 1.0               | 2.7    |
| <b>Natural Gas</b>    | 27.2            | 0.1             | 11.1  | 0.4    | 0.03 | 0.03             | 0.03              | 1.6    |

The TSP and PM emission factors are to a large extent based on measurements excluding condensed compounds, according to CEN-TS 15883, annex I.

## Trend Discussion for Key Sources

The following charts give an overview and assistance for explaining dominant emission trends of selected pollutants.



Annual fluctuations of all fuel types in source category 1.A.4 depend on heat demand subject to winter temperatures. Between 1990 and 2014 the fuel use changed considerably from coal & lignite to natural gas & biogas. The consumption of light heating oil decreased as well. As the activity data for light heating oil is based on the sold amount, it fluctuates due to fuel prices and changing storage amounts. Biomass use has increased since the early 2000s.

## Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the energy balance for 2023 led to recalculations. Moreover, for the purpose of improving data quality, national energy balances go under revisions every two years (for the years starting from 2003) through fine-tuning of the computational models, consideration of new statistics or re-allocation of activity data. Due to the revisions on the input data for submission 2026, recalculations took place.





For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

An ongoing research project on new emission factors for small combustion plants using updated data from the chimney sweepers and new measurement data is in its final phase. As soon as the results become available, implementation into the emission inventory will be assessed.

1.A.4.b i - Residential: Stationary Combustion

Short description



In source category 1.A.4.b.i. - Other: Residential emissions from small residential combustion installations are reported.

| NFR Code  | Method | AD | EF    |
|-----------|--------|----|-------|
| 1.A.4.b.i | T2, T3 | NS | CS, D |

| NFR Code                                                                                  | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                             | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCb | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|----------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|--------|-------|-------|-------|-------|------|-----|------|
| L/-             | L/T    | L/T             | -/-             | L/T               | L/T                                                                                          | L/T | L/- | L/T | -/- | L/- | L/- | -/- | -/- | -/- | -/- | NE | L/T | L/-    | L/T   | L/T   | L/T   | L/T   | L/T  | L/- | -/-  |
|                 |        |                 |                 | L/-               | key source by <b>L</b> evel only                                                             |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | -/T               | key source by <b>T</b> rend only                                                             |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | L/T               | key source by both <b>L</b> evel and <b>T</b> rend                                           |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                             |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | IE                | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |
|                 |        |                 |                 | *                 | no analysis done                                                                             |     |     |     |     |     |     |     |     |     |     |    |     |        |       |       |       |       |      |     |      |

## Methodology

### Activity data

For information on activity data please refer to the [superordinate chapter](#) on small stationary combustion.

### Emission factors

For further information on the emission factors applied please refer to the [superordinate chapter](#) on small stationary combustion.

Table 1: Emission factors for domestic combustion installations

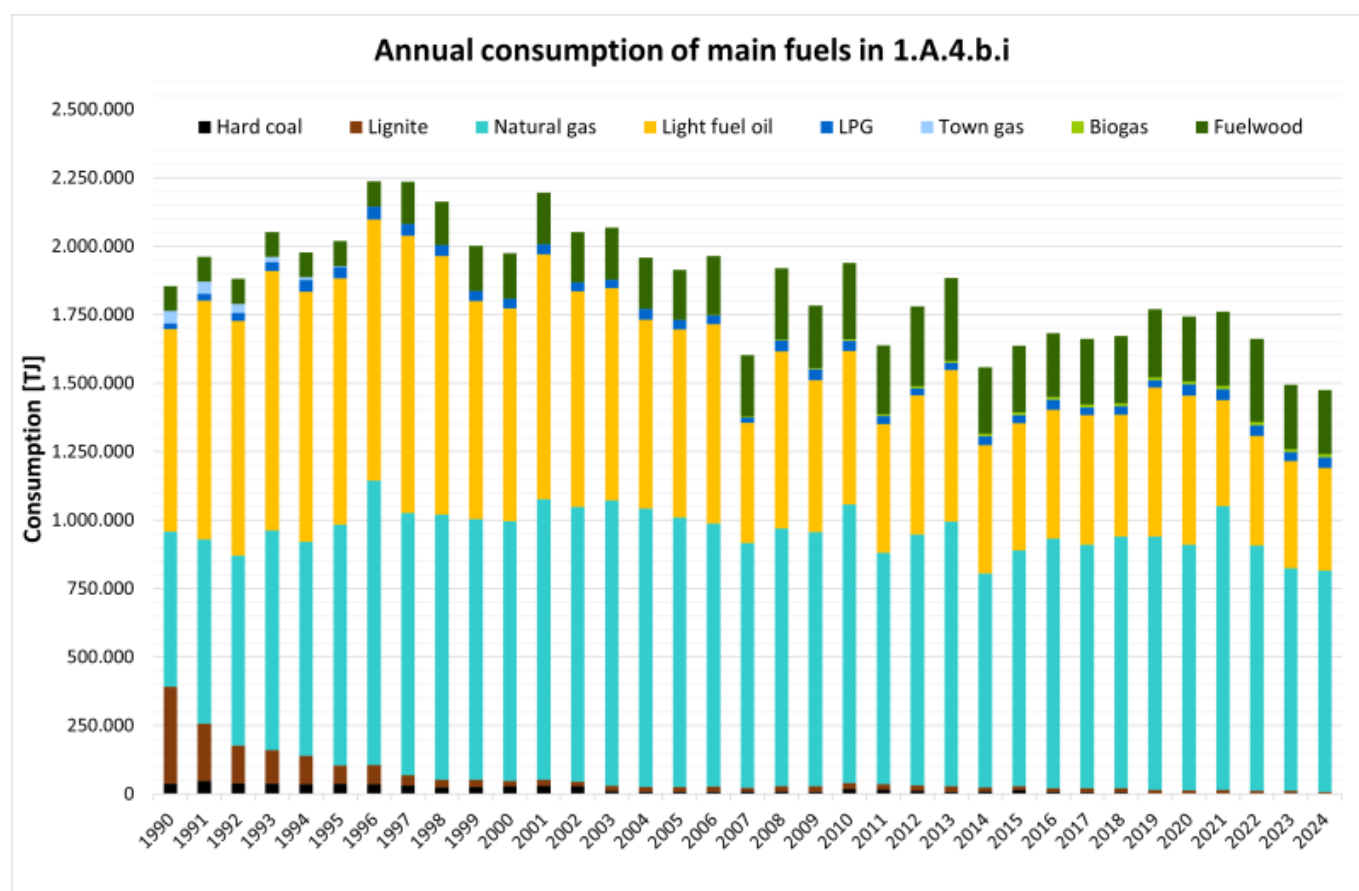
|                       | NO <sub>x</sub> | SO <sub>x</sub> | CO    | NM VOC | TSP  | PM <sub>10</sub> | PM <sub>2.5</sub> | PCDD/F |
|-----------------------|-----------------|-----------------|-------|--------|------|------------------|-------------------|--------|
|                       | [kg/T]          |                 |       |        |      |                  |                   | [µg/T] |
| <b>Hard Coal</b>      | 61.1            | 385.5           | 3,422 | 67.0   | 18.5 | 17.6             | 15.7              | 20.8   |
| <b>Hard Coal Coke</b> | 40.0            | 458.6           | 5,448 | 11.5   | 16.6 | 15.8             | 14.2              | 45.7   |

|                             | NO <sub>x</sub> | SO <sub>x</sub> | CO    | NMVOC | TSP   | PM <sub>10</sub> | PM <sub>2.5</sub> | PCDD/F |
|-----------------------------|-----------------|-----------------|-------|-------|-------|------------------|-------------------|--------|
| <b>Hard Coal Briquettes</b> | 50.4            | 563.5           | 4,875 | 184.1 | 265.4 | 252.8            | 227.3             | 20.2   |
| <b>Lignite Briquettes</b>   | 87.0            | 450.7           | 2,349 | 158.0 | 79.5  | 76.5             | 68.2              | 24.8   |
| <b>Natural Wood</b>         | 69.9            | 8.1             | 1,263 | 122.9 | 54.8  | 53.7             | 51.3              | 45.2   |
| <b>Light Fuel Oil</b>       | 41.8            | 2.4             | 11.8  | 1.5   | 0.9   | 0.9              | 0.9               | 2.2    |
| <b>Natural Gas</b>          | 20.5            | 0.1             | 13.2  | 0.6   | 0.03  | 0.03             | 0.03              | 2.1    |

TSP and PM emission factors are to a large extent based on measurements without condensed compounds, according to CEN-TS 15883, annex I.

## Trend Discussion for Key Sources

The following charts give an overview of the fuel use and the dominant emission trends of selected pollutants.



Annual fluctuations of all fuel types in source category 1.A.4.b.i depend on heat demand subject to winter temperatures. Between 1990 and 2002 the fuel use changed considerably from coal & lignite to natural gas. The consumption of light heating oil decreased as well. As the activity data for light heating oil is based on the sold amount, it fluctuates due to fuel prices and changing storage amounts.

In 2010 and 2013, fuel consumption was particularly high due to the cold winters. The higher fuel consumption between 2014 and 2017 is a result of lower temperatures during the heating period. In 2019 and 2020, the fuel demand increased due to decreasing oil prices. Coal use decreased substantially throughout the years. Since 2021, a decrease in the fuel input is observed, with natural gas being the dominant fuel.

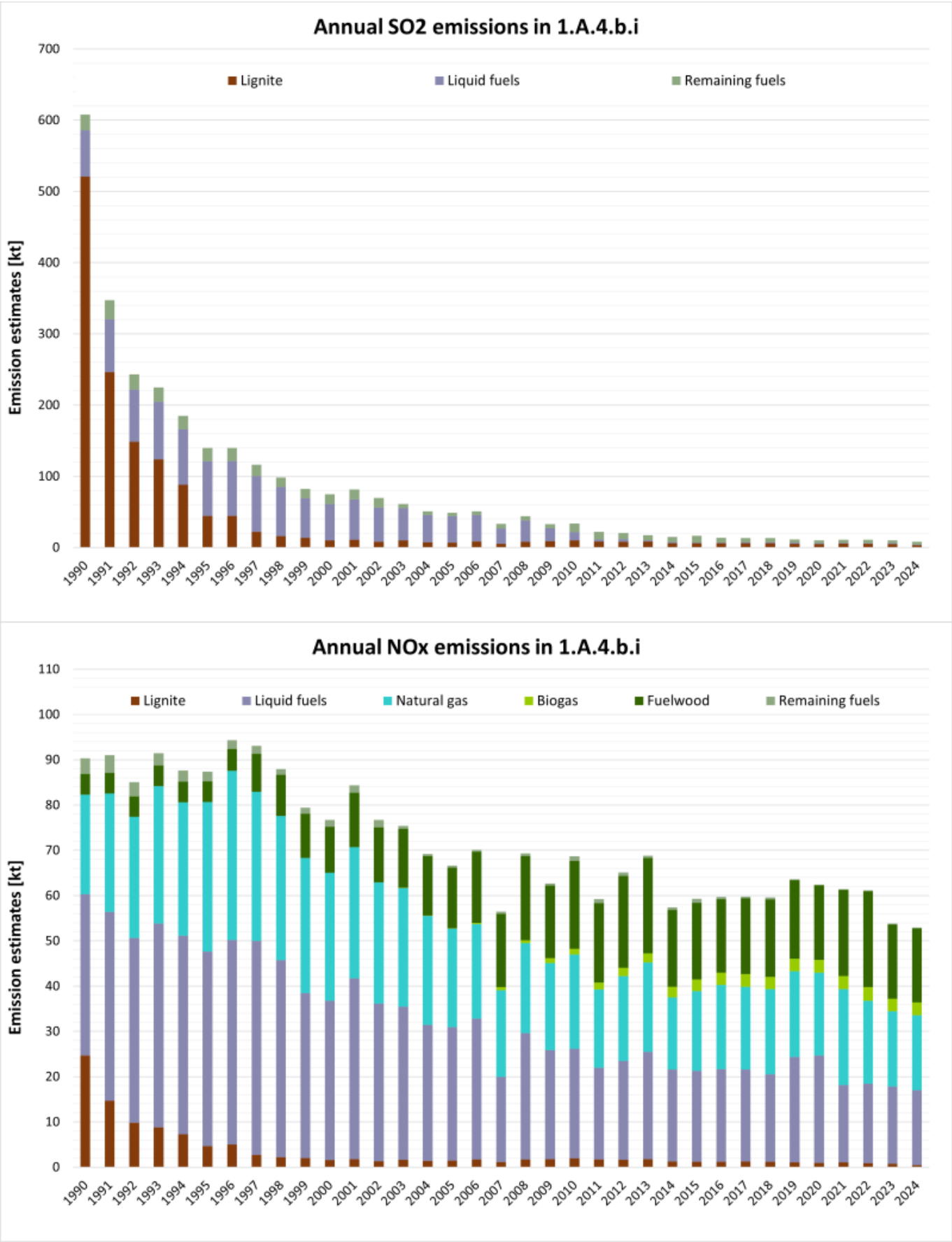
## Sulfur Oxides & Nitrogen Oxides - SO<sub>x</sub> & NO<sub>x</sub>

SO<sub>2</sub> emissions decrease due to the fuel switch from coal (especially lignite with a high emission factor) to natural gas with a lower emission factor. A further SO<sub>2</sub> reduction from 2008 onwards can be explained by the increasing use of low-sulfur fuel



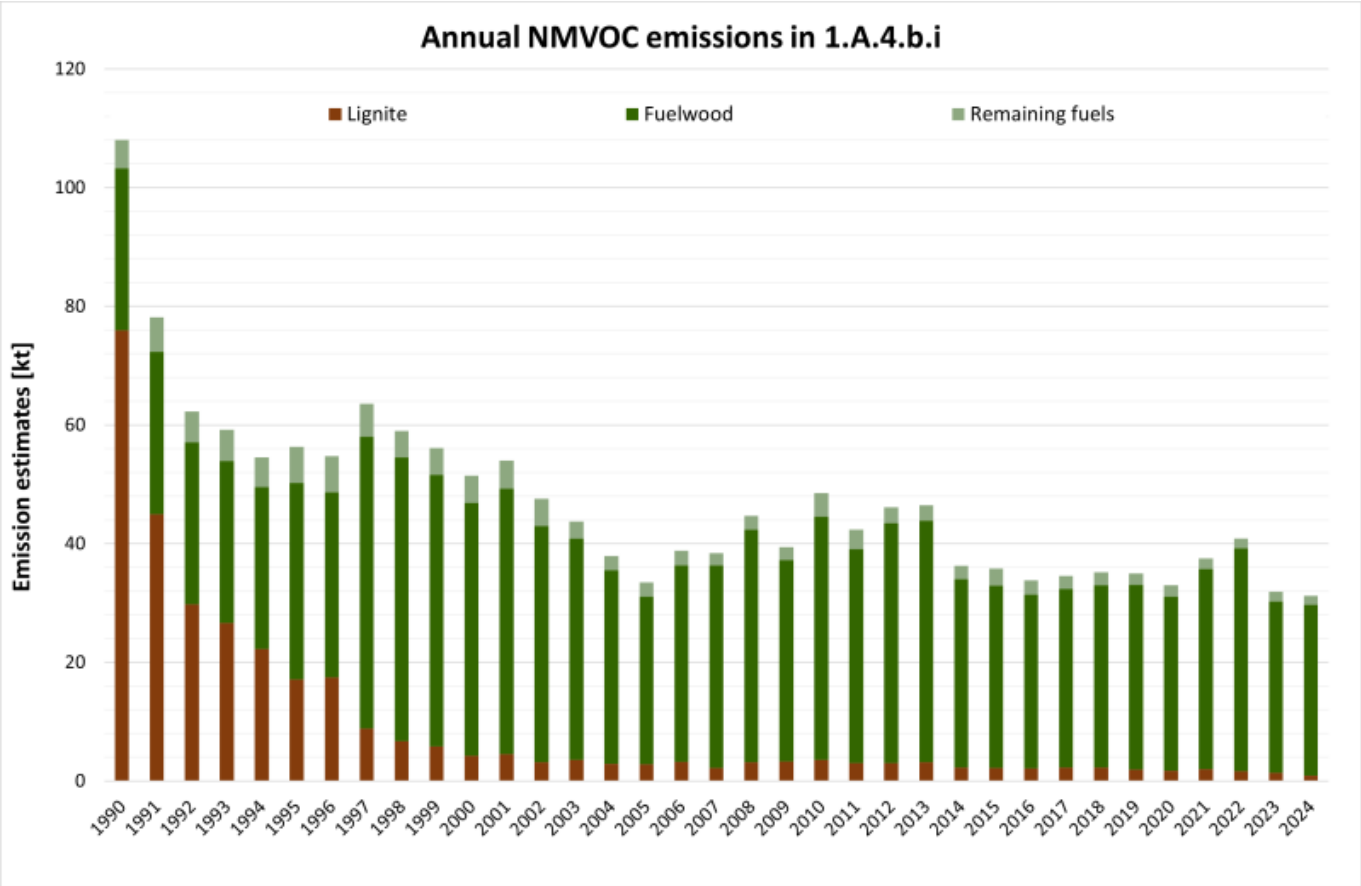
oil. Nowadays almost exclusively low-sulfur fuel oil is used.

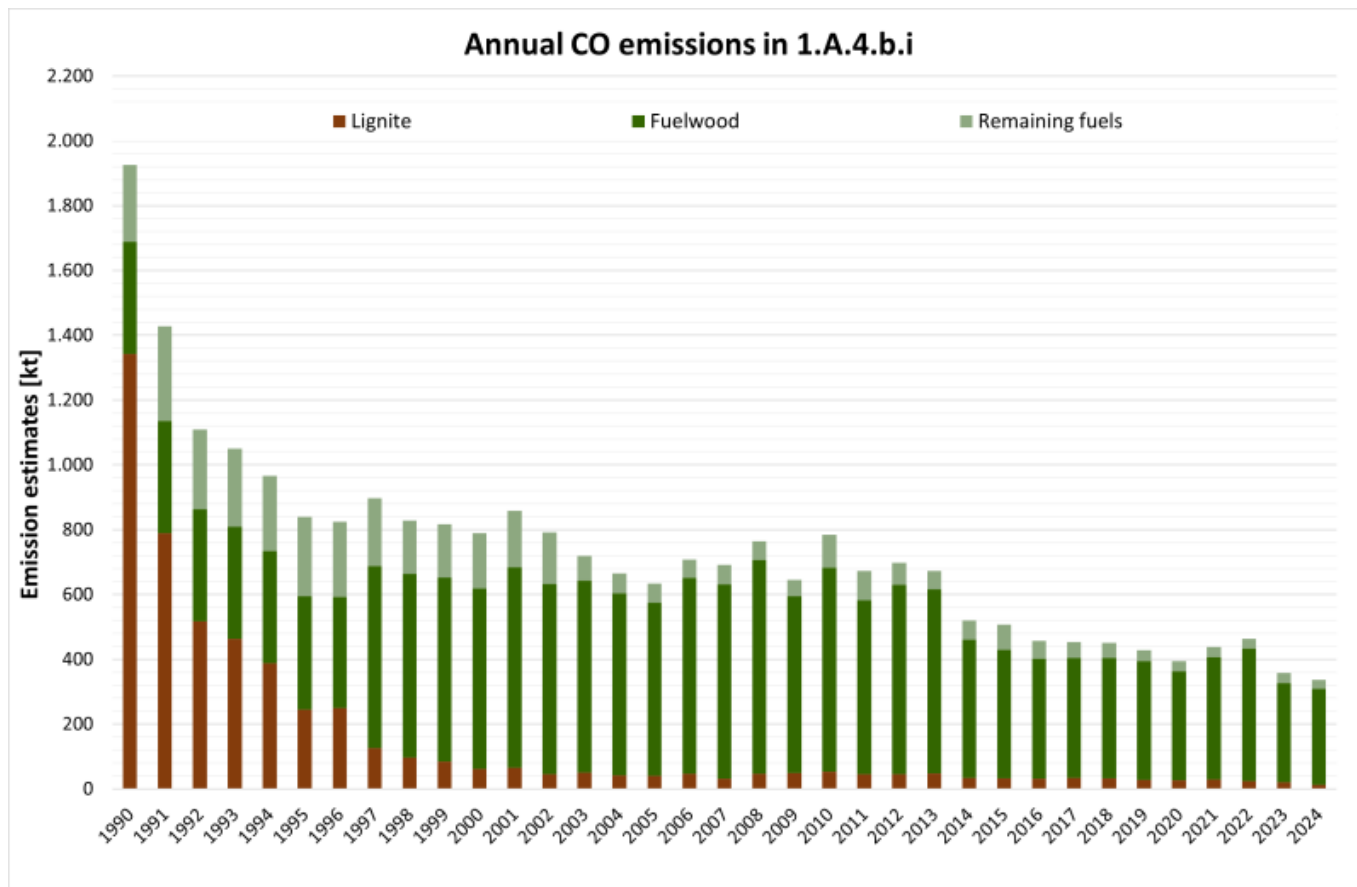
In contrast to SO<sub>2</sub> emissions NO<sub>x</sub> emission trend is less influenced by fuel characteristics but more by combustion conditions. Therefore NO<sub>x</sub> emission values shows lower reduction. During the last years the use of fuelwood gain influence.



Non-Methane Volatile Organic Compounds & Carbon Monoxide - NMVOC & CO

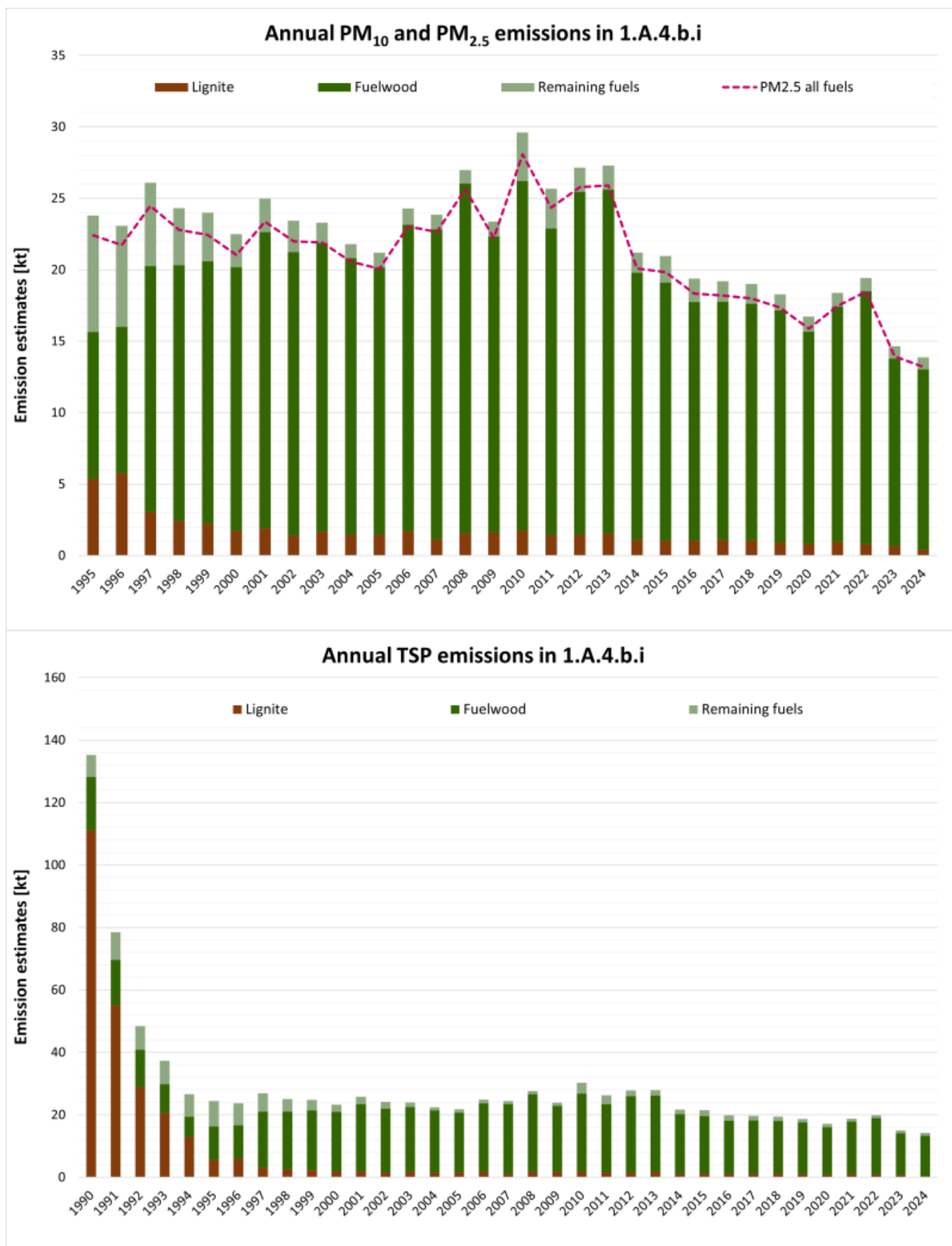
Main driver of the NMVOC emission trend is the decreasing lignite consumption. In the residential sector the emission trend is also affected by the increasing use of fuelwood with high emission factors which levels off the emission reduction. The explanation for decreasing carbon monoxide emissions is similar to the trend discussion for SO<sub>2</sub> and NMVOC. Since 1990 the fuel use changed from solid fuels, which causes high CO-emissions, to gaseous fuels, which produce less CO emissions.





### Particulate Matter - PM<sub>2.5</sub> & PM<sub>10</sub> & TSP

The emission trend for PM<sub>2.5</sub>, PM<sub>10</sub>, and TSP are also influenced strongly by decreasing coal consumption in small combustion plants, particularly in the period from 1990 to 1994. Since 1995 the emission trend did not change substantially. Slight increases in emissions in 2021/2022 are caused by the rising wood combustion in residential fire places and stoves.

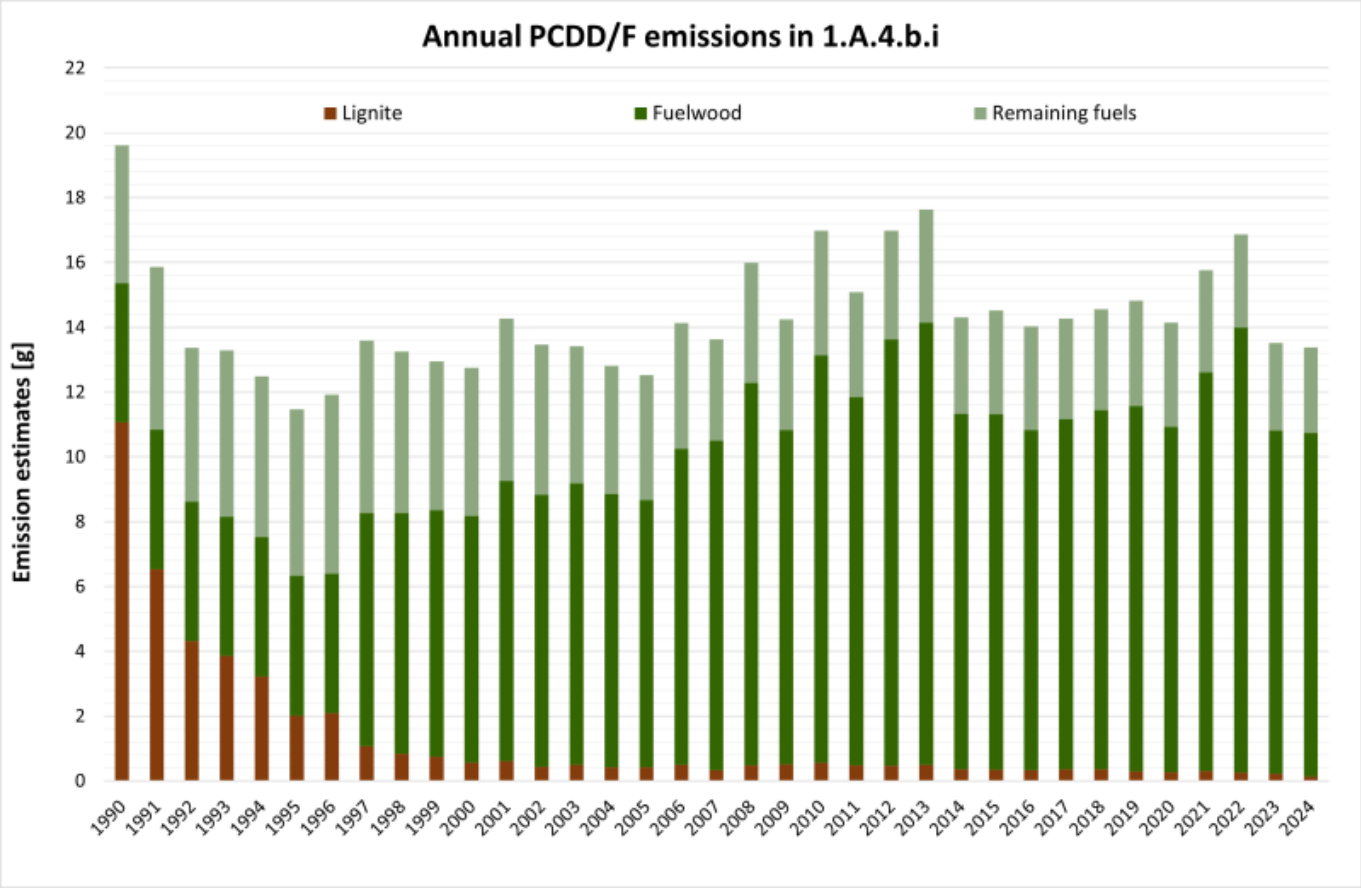


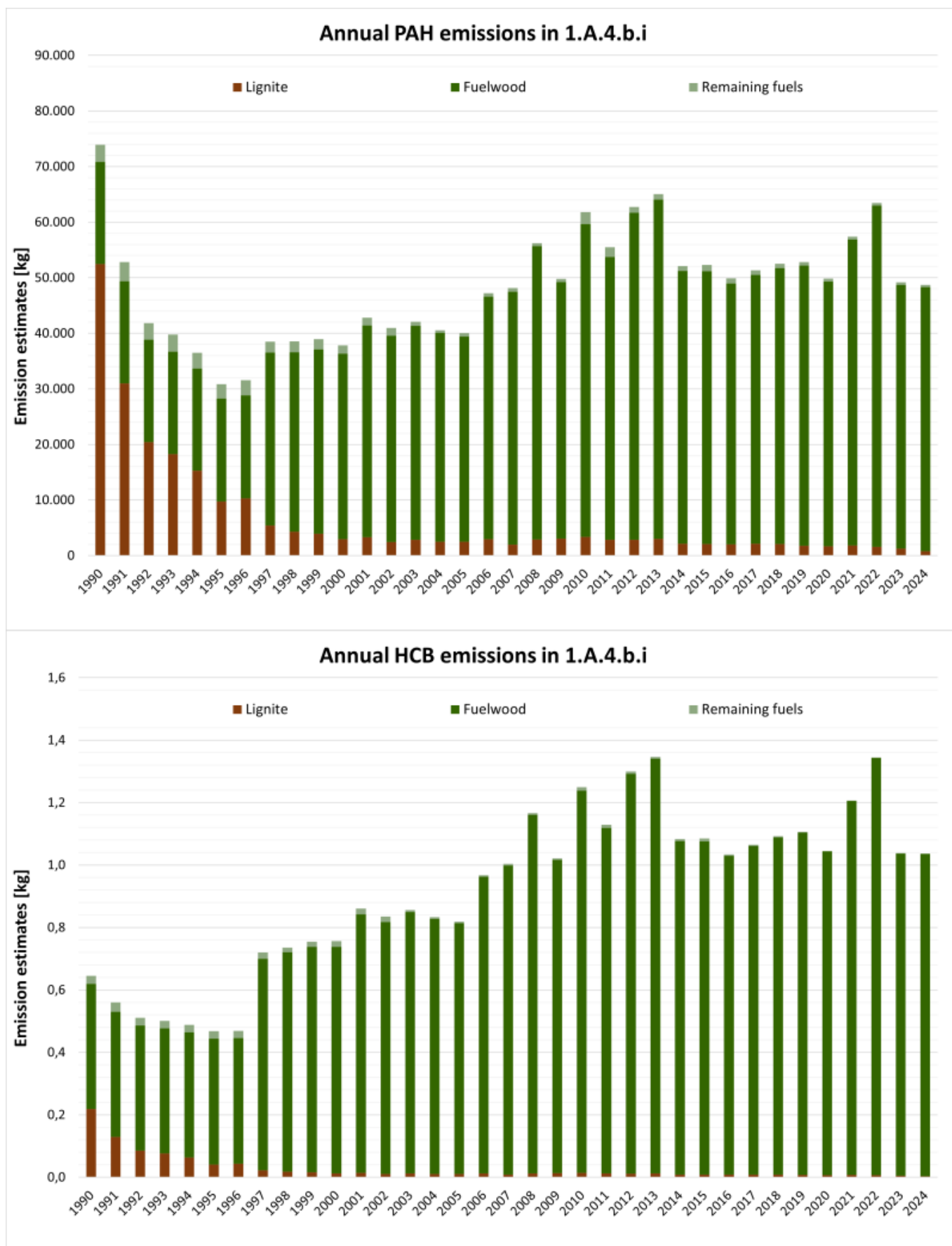
## Persistent Organic Pollutants

The main driver of the POP emission trend are coal and fuelwood combustion. PCDD/F emissions from coal fired furnaces are declining but the effect is retarded by increasing wood consumption. The same influencing variables apply accordingly to the PAH emission trends. The emission trend of HCB shows a high dominance of emissions from wood-burning. Emission factors

for HCB are constant since 1990. Furthermore, the difference between the EFs for coal and fuelwood is very large. Therefore, the emission trend depends solely on the development of fuelwood consumption. Regarding HCB emissions the inventory is incomplete. This is one of the reasons for the importance of emissions from small combustion plants. In 2010, 2012 and 2013 emissions are particularly high because of cold winters.

It is known that in spite of the existing legislation, an unknown quantity of waste wood is illegally burned. However, it's impossible to ascertain the fuel quantity, since the use of waste wood for heating purposes in small combustion plants is illegal. Therefore all emission factors and emissions refer to the use of untreated wood.





## Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the energy balance for 2023 led to recalculations. Moreover, for the purpose of improving data quality, national energy balances go under revisions every two years (for the years starting from 2003) through fine-tuning of the computational

models, consideration of new statistics or re-allocation of activity data. Due to the revisions on the input data for submission 2026, recalculations took place <sup>1)</sup>.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

There is an ongoing research project on new emission factors for small combustion plants using updated data from the chimney sweepers and new measurement data. The project is on its last phase and when the results become available, implementation into the emission inventory will be assessed.

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<sup>1)</sup> AGEB (2025a): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland;  
[https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?\\_jahresbereich-bilanz=2021-2030](https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?_jahresbereich-bilanz=2021-2030), (Aufruf: 04.12.2025), Köln & Berlin, September 2025

## 1.A.4 - Small Combustion: Mobile Sources (OVERVIEW)

### Short description

| NFR-Code                                        | Source category                                                                     |
|-------------------------------------------------|-------------------------------------------------------------------------------------|
| <b>1.A.4</b>                                    | <b>Small Combustion</b>                                                             |
| <i>including mobile sources sub-categories:</i> |                                                                                     |
| 1.A.4.a ii                                      | <a href="#">Commercial / Institutional: Mobile</a>                                  |
| 1.A.4.b ii                                      | <a href="#">Residential: Household and Gardening: Mobile</a>                        |
| 1.A.4.c ii                                      | <a href="#">Agriculture/Forestry/Fishing: Off-road Vehicles and Other Machinery</a> |
| 1.A.4.c iii                                     | <a href="#">Agriculture/Forestry/Fishing: National Fishing</a>                      |

Mobile sources reported under *NFR 1.A.4 - Small combustion* comprise of such versatile mobile equipment as forklifters (1.A.a ii), gasoline-driven lawn mowers used for gardening (1.A.4.b ii) over tractors in agriculture and harvesters and chain saws in forestry (1.A.4.c ii) to the German deep sea fishing fleet (1.A.4.c iii).



For further information on sub-sector specific consumption data, emission factors and emissions as well as further information on emission trends, recalculations and planned improvements, please follow the links above.

### Method

#### Activity data

**Primary activity data** are available from National Energy Balances (NEBs) (AGEB, 2025) <sup>1)</sup>.

Here, aggregated data for NFRs *1.A.a ii*, *1.A.4.c ii* and *1.A.2.g vii* are included in line 67: 'Commercial, trade, services and other consumers'. In contrast, AD for is available directly from line 66: 'Households'. Furthermore, AD for is included partly in NEB lines 6: 'Maritime Bunkers' and 64: 'Coastal and inland navigation'.

Table 1 below tries to demonstrate the breaking-down of primary data in NEB line 67 onto NFRs *1.A.2.g vii*, *1.A.4a ii* and *1.A.4.c ii*. For further information on the resulting specific shares as well as the fuel consumption in NFRs *1.A.4.b ii* and *1.A.4.c iii* please refer to the respective sub-chapters.

Table 1: Primary AD from NEB line 67: 'Commercial, trade, services and other consumers', in terajoules

|                    | 1990    | 1995    | 2000   | 2005   | 2010   | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    | 2024    |
|--------------------|---------|---------|--------|--------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>diesel oil</b>  | 126,920 | 105,800 | 96,425 | 85,271 | 89,724 | 103,913 | 105,767 | 106,896 | 103,499 | 106,106 | 105,611 | 106,135 | 102,375 | 101,113 | 102,648 |
| <b>biodiesel</b>   |         |         |        | 5,446  | 6,945  | 5,699   | 5,656   | 5,707   | 5,975   | 6,028   | 8,742   | 7,368   | 7,084   | 7,522   | 6,284   |
| <b>gasoline</b>    | 26,036  | 17,264  | 14,881 | 14,151 | 9,873  | 8,640   | 8,357   | 8,211   | 8,290   | 8,606   | 8,553   | 8,752   | 8,626   | 8,584   | 8,554   |
| <b>biogasoline</b> |         |         |        | 96.1   | 356    | 363     | 352     | 339     | 362     | 360     | 379     | 404     | 399     | 408     | 400     |
| <b>LPG</b>         |         | 7,963   | 9,238  | 22,317 | 11,765 | 17,325  | 20,656  | 13,288  | 30,599  | 28,422  | 17,638  | 16,953  | 14,750  | 12,998  | 15,990  |

In a first step, annual fuel deliveries to the military as provided in (BAFA, 2025) <sup>2)</sup> ...

Table 2: Annual fuel deliveries to the military as included in NEB line 67, in terajoules

|                    | 1990   | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|--------------------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>diesel oil</b>  | 15,037 | 8,001 | 1,364 | 3,203 | 971   | 578   | 572   | 415   | 281   | 281   | 134   | 138   | 357   | 289   | 869   |
| <b>biodiesel</b>   |        |       |       | 213   | 75.1  | 31.7  | 30.6  | 22.6  | 16.2  | 15.9  | 11.1  | 9.55  | 24.7  | 21.5  | 53.2  |
| <b>gasoline</b>    | 21,508 | 9,800 | 7,477 | 6,860 | 4,792 | 3,388 | 3,051 | 2,538 | 2,371 | 2,272 | 1,824 | 1,981 | 2,107 | 2,040 | 2,032 |
| <b>biogasoline</b> |        |       |       | 46.6  | 185   | 143   | 128   | 104   | 103   | 95.1  | 80.8  | 91.4  | 97.4  | 96.9  | 95.1  |



...are deducted from these primary AD, giving the remaining amounts of gasoline and diesel oil for NFRs 1.A.2.g vii, 1.A.a ii and 1.A.4.c ii:

Table 3: Annual fuel deliveries to the remaining sectors covered by NEB line 67, in terajoules

|                    | 1990    | 1995   | 2000   | 2005   | 2010   | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    | 2024    |
|--------------------|---------|--------|--------|--------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>diesel oil</b>  | 111,883 | 97,799 | 95,061 | 82,068 | 88,754 | 103,336 | 105,195 | 106,481 | 103,218 | 105,825 | 105,477 | 105,998 | 102,019 | 100,824 | 101,779 |
| <b>biodiesel</b>   |         |        |        | 5,232  | 6,870  | 5,668   | 5,625   | 5,684   | 5,959   | 6,012   | 8,731   | 7,358   | 7,059   | 7,501   | 6,231   |
| <b>gasoline</b>    | 4,528   | 7,464  | 7,404  | 7,291  | 5,082  | 5,252   | 5,307   | 5,673   | 5,918   | 6,334   | 6,728   | 6,772   | 6,519   | 6,544   | 6,522   |
| <b>biogasoline</b> |         |        |        | 49.5   | 171    | 220     | 224     | 235     | 258     | 265     | 298     | 312     | 301     | 311     | 305     |
| <b>LPG</b>         |         | 7,963  | 9,238  | 22,317 | 11,765 | 17,325  | 20,656  | 13,288  | 30,599  | 28,422  | 17,638  | 16,953  | 14,750  | 12,998  | 15,990  |

As the National Energy Balances provide no consumption data for LPG before 1995 and as part of the LPG provided in NEB line 67 is used for stationary combustion (whereas all diesel and gasoline fuels are allocated to mobile combustion), activity data for LPG used in in NRMM are taken directly from TREMOD MM (Knörr et al. (2025b)) <sup>3)</sup>.

In another step, the following sub-sectors specific annual percentual contributions to NEB line 67 as computed within TREMOD-MM are applied to these primary AD to deduce sub-sectors specific AD.

Table 4: Annual percentual contributions of NFRs 1.A.2.g vii, 1.A.a ii and 1.A.4.c ii

|                                | 1990        | 1995        | 2000        | 2005        | 2010        | 2015        | 2016        | 2017        | 2018        | 2019        | 2020        | 2021        | 2022        | 2023        | 2024        |
|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <b>DIESEL FUELS</b>            |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |
| <b>1.A.2.g vii</b>             | 29.7%       | 18.9%       | 17.0%       | 15.6%       | 21.6%       | 26.7%       | 27.5%       | 28.2%       | 27.8%       | 28.5%       | 28.8%       | 28.4%       | 28.1%       | 28.2%       | 28.6%       |
| <b>1.A.4.a ii</b>              | 5.98%       | 3.95%       | 3.67%       | 3.64%       | 5.06%       | 5.66%       | 5.68%       | 5.74%       | 5.54%       | 5.58%       | 5.64%       | 5.46%       | 5.51%       | 5.53%       | 5.40%       |
| <b>1.A.4.c ii: Agriculture</b> | 62.4%       | 76.6%       | 78.5%       | 79.7%       | 71.8%       | 65.8%       | 65.2%       | 64.3%       | 64.7%       | 63.9%       | 63.0%       | 63.6%       | 63.9%       | 64.0%       | 64.1%       |
| <b>1.A.4.c ii: Forestry</b>    | 1.91%       | 0.63%       | 0.87%       | 1.12%       | 1.55%       | 1.78%       | 1.62%       | 1.68%       | 1.96%       | 2.11%       | 2.54%       | 2.56%       | 2.52%       | 2.32%       | 1.95%       |
| <b>TOTAL NRMM</b>              | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> |
| <b>GASOLINE FUELS</b>          |             |             |             |             |             |             |             |             |             |             |             |             |             |             |             |
| <b>1.A.2.g vii</b>             | 31.5%       | 59.7%       | 55.1%       | 58.6%       | 64.5%       | 68.0%       | 70.9%       | 71.1%       | 67.9%       | 67.1%       | 63.5%       | 63.4%       | 63.8%       | 66.2%       | 70.9%       |
| <b>1.A.4.c ii: Forestry</b>    | 68.5%       | 40.3%       | 44.9%       | 41.4%       | 35.5%       | 32.0%       | 29.1%       | 28.9%       | 32.1%       | 32.9%       | 36.5%       | 36.6%       | 36.2%       | 33.8%       | 29.1%       |
| <b>TOTAL NRMM</b>              | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> |

source: own estimates, based on TREMOD MM <sup>4)</sup>



For the **NFR-specific activity data and emission factors** please refer to the corresponding chapters linked at the top of this page.

## Recalculations

**Primary activity data** were revised in accordance with the biennial routine revision of the National Energy Balances for all years as of 2003 with the most significant changes occurring for gasoline and LPG.

Table 2: Revised primary activity data 2003-2023, in terajoules

|                            | 2003   | 2005   | 2010   | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    |
|----------------------------|--------|--------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>Diesel oil</b>          |        |        |        |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  | 89,685 | 85,271 | 89,724 | 103,913 | 105,767 | 106,896 | 103,499 | 106,106 | 105,611 | 106,135 | 102,375 | 101,113 |
| <b>previous submission</b> | 89,685 | 85,271 | 89,724 | 103,914 | 105,768 | 106,894 | 103,495 | 106,054 | 104,452 | 106,457 | 102,720 | 101,133 |
| <b>absolute change</b>     | 0.00   | 0.00   | 0.18   | -0.50   | -1.38   | 1.96    | 3.66    | 51.1    | 1.160   | -322.0  | -345    | -20.7   |
| <b>relative change</b>     | 0.00%  | 0.00%  | 0.00%  | 0.00%   | 0.00%   | 0.00%   | 0.00%   | 0.05%   | 1.11%   | -0.30%  | -0.34%  | -0.02%  |
| <b>Biodiesel</b>           |        |        |        |         |         |         |         |         |         |         |         |         |
| <b>current submission</b>  |        | 5,446  | 6,945  | 5,699   | 5,656   | 5,707   | 5,975   | 6,028   | 8,742   | 7,368   | 7,084   | 7,522   |

|                            | 2003   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>previous submission</b> |        | 5,681  | 7,018  | 5,772  | 5,733  | 5,827  | 5,840  | 6,016  | 8,543  | 7,465  | 7,126  | 7,496  |
| <b>absolute change</b>     |        | -235   | -72.7  | -73.1  | -77.1  | -120   | 136    | 12.3   | 198    | -97.4  | -42.3  | 26.9   |
| <b>relative change</b>     |        | -4.14% | -1.04% | -1.27% | -1.35% | -2.05% | 2.33%  | 0.20%  | 2.32%  | -1.31% | -0.59% | 0.36%  |
| <b>Gasoline</b>            |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 14,200 | 14,151 | 9,873  | 8,640  | 8,357  | 8,211  | 8,290  | 8,606  | 8,553  | 8,752  | 8,626  | 8,584  |
| <b>previous submission</b> | 14,200 | 14,151 | 14,923 | 12,227 | 11,588 | 10,895 | 10,806 | 11,040 | 10,489 | 10,833 | 10,872 | 10,769 |
| <b>absolute change</b>     | 0.00   | 0.00   | -5,050 | -3,586 | -3,230 | -2,684 | -2,516 | -2,434 | -1,937 | -2,080 | -2,246 | -2,184 |
| <b>relative change</b>     | 0.00%  | 0.00%  | -33.8% | -29.3% | -27.9% | -24.6% | -23.3% | -22.0% | -18.5% | -19.2% | -20.7% | -20.3% |
| <b>Biogasoline</b>         |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  |        | 96.1   | 356    | 363    | 352    | 339    | 362    | 360    | 379    | 404    | 399    | 408    |
| <b>previous submission</b> |        | 98.1   | 357    | 495    | 473    | 445    | 468    | 455    | 470    | 510    | 504    | 509    |
| <b>absolute change</b>     |        | -1.94  | -1.81  | -132   | -121   | -106   | -106   | -94.8  | -91.6  | -107   | -105   | -101   |
| <b>relative change</b>     |        | -1.98% | -0.51% | -26.7% | -25.6% | -23.8% | -22.7% | -20.8% | -19.5% | -20.9% | -20.9% | -19.8% |
| <b>LPG</b>                 |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 15,397 | 22,317 | 11,765 | 17,325 | 20,656 | 13,288 | 30,599 | 28,422 | 17,638 | 16,953 | 14,750 | 12,998 |
| <b>previous submission</b> | 23,027 | 25,297 | 11,432 | 18,702 | 22,483 | 16,723 | 31,269 | 28,897 | 18,598 | 18,139 | 13,962 | 10,117 |
| <b>absolute change</b>     | -7,629 | -2,980 | 333    | -1,377 | -1,826 | -3,435 | -670   | -476   | -959   | -1,186 | 789    | 2,881  |
| <b>relative change</b>     | -33.1% | -11.8% | 2.91%  | -7.36% | -8.12% | -20.5% | -2.14% | -1.65% | -5.16% | -6.54% | 5.65%  | 28.5%  |

<sup>1)</sup> AGEB (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl Daten für die Bundesrepublik Deutschland; [https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>3), 4)</sup> Knörr et al. (2025b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2025, Heidelberg, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2025.

## 1.A.4.a ii - Commercial / Institutional: Mobile



NFR-specific inventory  
data

### Short description

In *NFR 1.A.4.a ii - Commercial/institutional: Mobile* fuel combustion activities and emissions from non-road diesel and LPG-driven (forklifters) vehicles used in the commercial and institutional sector are taken into account.

| Category Code                                                                             | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.4.a ii                                                                                | T1, T2                               | NS, M | CS, D, M |
| <b>Method(s) applied</b>                                                                  |                                      |       |          |
| <b>D</b>                                                                                  | Default                              |       |          |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |       |          |
| <b>T2</b>                                                                                 | Tier 2*                              |       |          |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |       |          |
| <b>C</b>                                                                                  | CORINAIR                             |       |          |
| <b>CS</b>                                                                                 | Country Specific                     |       |          |
| <b>M</b>                                                                                  | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| <b>(source for) Activity Data</b>                                                         |                                      |       |          |
| <b>NS</b>                                                                                 | National Statistics                  |       |          |
| <b>RS</b>                                                                                 | Regional Statistics                  |       |          |
| <b>IS</b>                                                                                 | International Statistics             |       |          |
| <b>PS</b>                                                                                 | Plant Specific                       |       |          |
| <b>As</b>                                                                                 | Associations, business organisations |       |          |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |       |          |
| <b>M</b>                                                                                  | Model / Modelled                     |       |          |
| <b>C</b>                                                                                  | Confidential                         |       |          |
| <b>(source for) Emission Factors</b>                                                      |                                      |       |          |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |       |          |
| <b>CS</b>                                                                                 | Country Specific                     |       |          |
| <b>PS</b>                                                                                 | Plant Specific                       |       |          |
| <b>M</b>                                                                                  | Model / Modelled                     |       |          |
| <b>C</b>                                                                                  | Confidential                         |       |          |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub>                                                                               | PM <sub>10</sub> | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |  |
|-----------------|--------|-----------------|-----------------|-------------------------------------------------------------------------------------------------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|--|--|
| -/-             | -/-    | -/-             | -/-             | -/-                                                                                             | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | NE  | NE   |  |  |
|                 |        |                 |                 | L/- key source by <b>Level</b> only                                                             |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | -/T key source by <b>Trend</b> only                                                             |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | L/T key source by both <b>Level</b> and <b>Trend</b>                                            |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | -/- no key source for this pollutant                                                            |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | IE emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | NE emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | NA specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 | * no analysis done                                                                              |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 |                                                                                                 |                  |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |  |  |

### Methodology

## Activity data

Sector-specific **diesel** consumption data are included in the primary fuel-delivery data available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2025) <sup>1)</sup>.

Table 1: Sources for primary fuel-deliveries data

|              |                                                                |
|--------------|----------------------------------------------------------------|
| through 1994 | NEB line 79: 'Households and small consumers'                  |
| as of 1995   | NEB line 67: 'Commercial, trade, services and other consumers' |

Following the deduction of diesel oil inputs for military vehicles as provided in (BAFA, 2025) <sup>2)</sup>, the remaining amounts of diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and off-road vehicles in commercial/institutional use (1.A.4.a ii) as well as agriculture and forestry (1.A.4.c ii) based upon annual shares derived from (Knörr et al. (2025b)) <sup>3)</sup> (cf. superordinate chapter).

Table 2: Annual contribution of NFR 1.A.4.a ii to the over-all amounts of diesel oil provided in NEB line 67

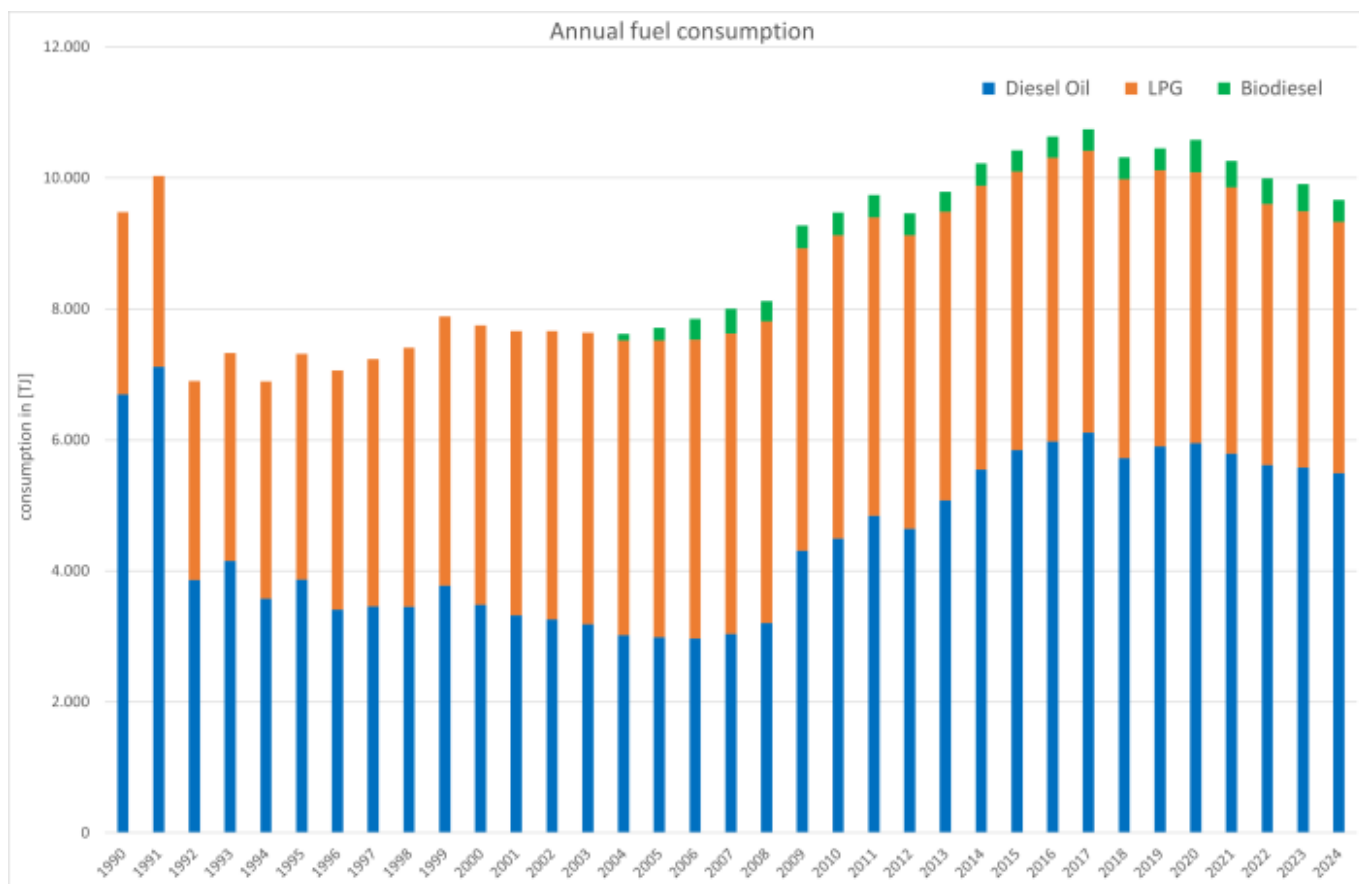
| 1990                            | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 5.98%                           | 3.95% | 3.67% | 3.64% | 5.06% | 5.66% | 5.68% | 5.74% | 5.54% | 5.58% | 5.64% | 5.46% | 5.51% | 5.53% | 5.51% |
| source: TREMOD MM <sup>4)</sup> |       |       |       |       |       |       |       |       |       |       |       |       |       |       |

As the NEB does not distinguish into specific biofuels, consumption data for biodiesel are calculated by applying Germany's official annual shares of biodiesel blended to fossil diesel oil.

In contrast, for **LPG**-driven forklifters, specific consumption data is modelled by Knörr et al. (2025) <sup>5)</sup>. These amounts are then subtracted from the over-all amount available from NEB line 67 to estimate the amount of LPG used in stationary combustion.

Table 3: Annual fuel consumption, in terajoules

|                     | 1990         | 1995         | 2000         | 2005         | 2010         | 2015          | 2016          | 2017          | 2018          | 2019          | 2020          | 2021          | 2022         | 2023         | 2024         |
|---------------------|--------------|--------------|--------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|--------------|--------------|--------------|
| <b>Diesel Oil</b>   | 6,694        | 3,867        | 3,487        | 2,990        | 4,494        | 5,846         | 5,976         | 6,114         | 5,720         | 5,904         | 5,950         | 5,793         | 5,619        | 5,580        | 5,495        |
| <b>Biodiesel</b>    |              |              |              | 191          | 348          | 321           | 320           | 326           | 330           | 335           | 493           | 402           | 389          | 415          | 336          |
| <b>LPG</b>          | 2,787        | 3,450        | 4,261        | 4,533        | 4,629        | 4,256         | 4,336         | 4,301         | 4,264         | 4,213         | 4,139         | 4,063         | 3,987        | 3,912        | 3,836        |
| <b>Σ 1.A.4.a ii</b> | <b>9,480</b> | <b>7,317</b> | <b>7,748</b> | <b>7,713</b> | <b>9,471</b> | <b>10,423</b> | <b>10,632</b> | <b>10,742</b> | <b>10,314</b> | <b>10,453</b> | <b>10,582</b> | <b>10,258</b> | <b>9,995</b> | <b>9,906</b> | <b>9,667</b> |



## Emission factors

The emission factors used here are of rather different quality: Basically, for all **main pollutants, carbon monoxide** and **particulate matter**, annual IEF modelled within TREMOD MM are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

As no such specific EF are available for biofuels, the values used for diesel oil are applied to biodiesel, too.

Table 4: Annual country-specific emission factors from TREMOD MM, in kg/TJ

|                                 | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024 |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|
| <b>Diesel fuels<sup>1</sup></b> |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |
| <b>NH<sub>3</sub></b>           | 0.15  | 0.16  | 0.16  | 0.16  | 0.16  | 0.17  | 0.17  | 0.17  | 0.17  | 0.17  | 0.17  | 0.17  | 0.17  | 0.17  | 0.17 |
| <b>NM VOC</b>                   | 247   | 223   | 197   | 139   | 93.0  | 58.5  | 53.3  | 48.9  | 45.3  | 42.0  | 38.8  | 35.4  | 31.8  | 28.4  | 25.3 |
| <b>NO<sub>x</sub></b>           | 999   | 1.025 | 1.003 | 833   | 633   | 476   | 451   | 426   | 404   | 384   | 364   | 344   | 324   | 304   | 286  |
| <b>SO<sub>x</sub></b>           | 79.6  | 60.5  | 14.0  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37 |
| <b>BC<sup>3</sup></b>           | 107   | 88.6  | 74.4  | 55.3  | 42.2  | 32.1  | 30.0  | 28.3  | 26.8  | 25.5  | 24.0  | 22.3  | 20.4  | 18.3  | 16.4 |
| <b>PM<sup>2</sup></b>           | 194   | 161   | 134   | 93.6  | 64.4  | 43.0  | 39.5  | 36.7  | 34.5  | 32.6  | 30.6  | 28.4  | 26.0  | 23.6  | 21.2 |
| <b>CO</b>                       | 856   | 795   | 725   | 560   | 429   | 321   | 301   | 283   | 266   | 250   | 233   | 215   | 195   | 176   | 158  |
| <b>LPG</b>                      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |      |
| <b>NH<sub>3</sub></b>           | 0.21  | 0.21  | 0.21  | 0.21  | 0.21  | 0.21  | 0.21  | 0.21  | 0.21  | 0.21  | 0.21  | 0.21  | 0.21  | 0.21  | 0.21 |
| <b>NM VOC</b>                   | 147   | 147   | 145   | 145   | 145   | 145   | 145   | 145   | 145   | 144   | 141   | 134   | 126   | 116   | 107  |
| <b>NO<sub>x</sub></b>           | 1,346 | 1,342 | 1,325 | 1,325 | 1,325 | 1,325 | 1,325 | 1,325 | 1,325 | 1,316 | 1,284 | 1,225 | 1,144 | 1,056 | 971  |
| <b>SO<sub>x</sub></b>           | 0.42  | 0.42  | 0.41  | 0.41  | 0.41  | 0.41  | 0.41  | 0.41  | 0.41  | 0.41  | 0.41  | 0.41  | 0.41  | 0.41  | 0.41 |
| <b>BC<sup>3</sup></b>           | 0.13  | 0.13  | 0.13  | 0.13  | 0.13  | 0.13  | 0.13  | 0.13  | 0.13  | 0.12  | 0.12  | 11.6% | 0.11  | 0.10  | 0.09 |
| <b>PM<sup>2</sup></b>           | 0.85  | 0.85  | 0.84  | 0.84  | 0.84  | 0.84  | 0.84  | 0.84  | 0.84  | 0.84  | 0.84  | 0.84  | 0.84  | 0.84  | 0.84 |
| <b>CO</b>                       | 114   | 114   | 112   | 112   | 112   | 112   | 112   | 112   | 112   | 112   | 112   | 112   | 112   | 112   | 112  |

<sup>1</sup> due to lack of better information: similar EF are applied for fossil and biofuels

<sup>2</sup> EF(PM<sub>2.5</sub>) also applied for PM<sub>10</sub> and TSP (assumption: > 99% of TSP consists of PM<sub>2.5</sub>)

|                                                                                                                                                                                                        | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <sup>3</sup> estimated via a f-BCs as provided in <sup>6)</sup> , Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |



With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>6)</sup>



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources. - Here, for lead (Pb) from leaded gasoline and corresponding TSP emissions, additional emissions have been calculated from 1990 to 1997 based upon contry-specific emission factors from TREMOD MM.

## Discussion of emission trends

**NFR 1.A.4.a ii** is no key source.

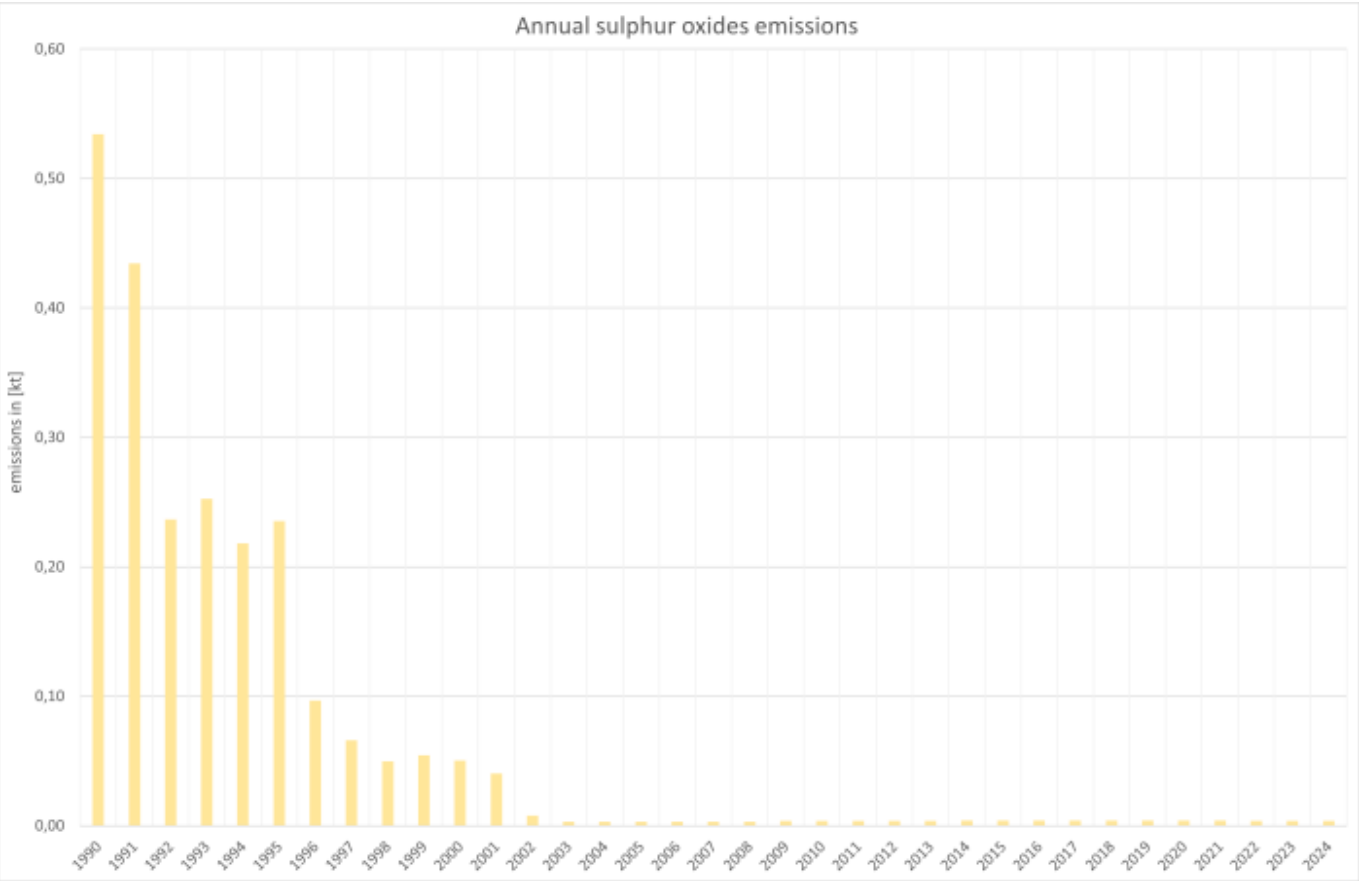
### Unregulated pollutants

For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.

### Regulated pollutants

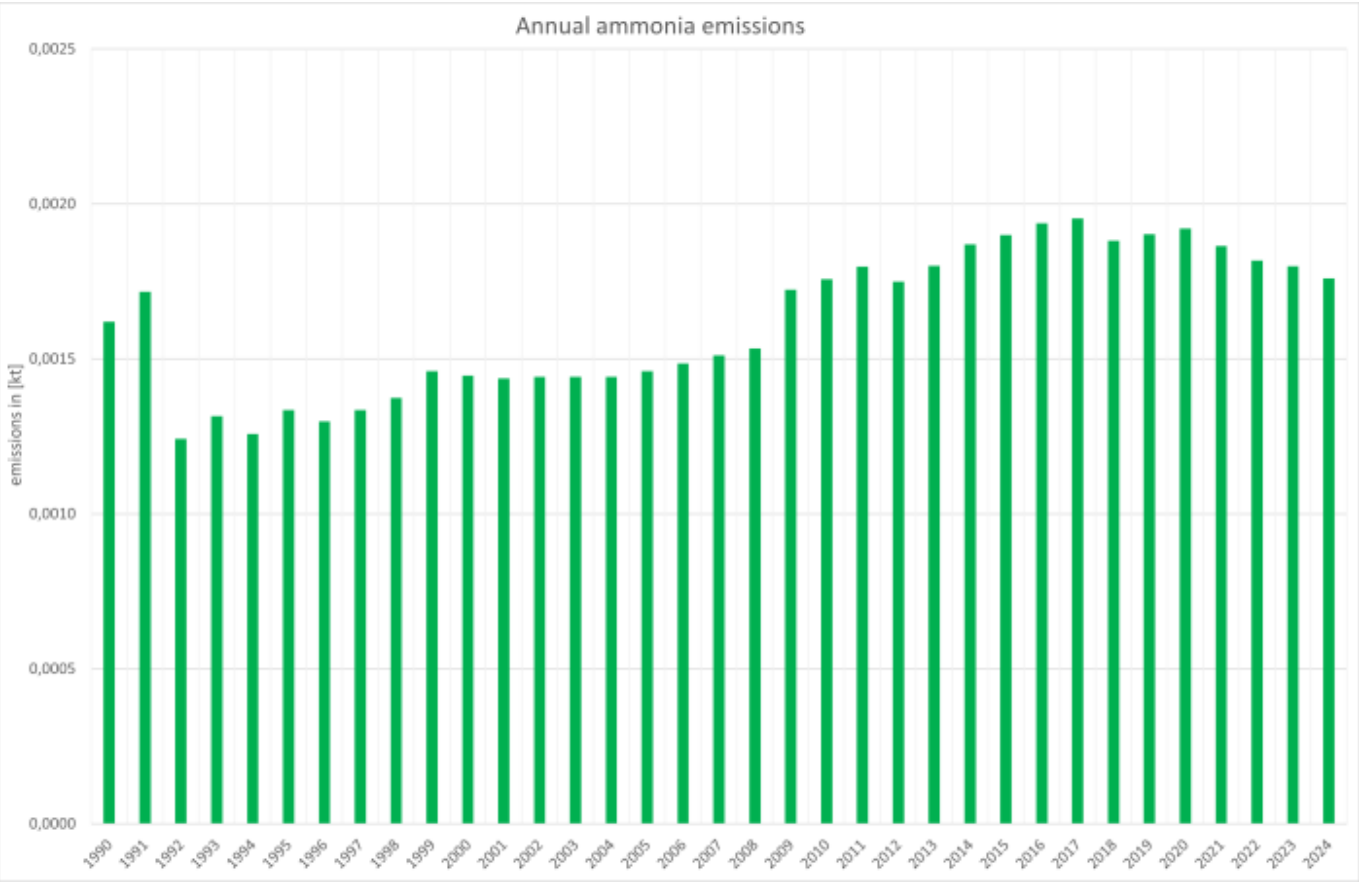
#### Nitrogen oxides and Sulphur dioxide

For all regulated pollutants, emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation. Here, emissions of sulphur oxides follow the step-by-step reduction of sulphur contents in liquid fuels, resulting in a reduction of over 99% since 1990.



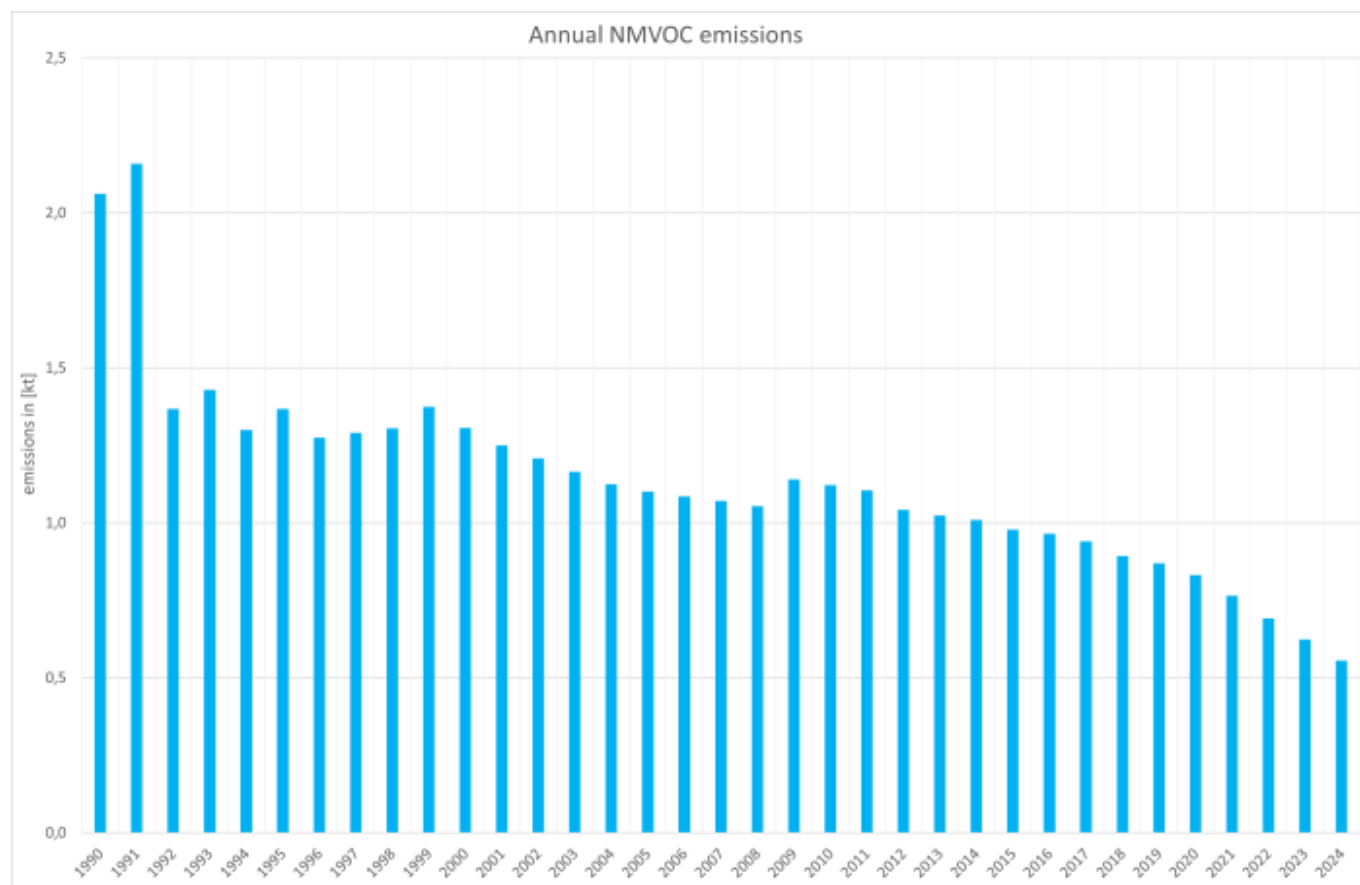
Ammonia

Ammonia emissions are driven by the consumption of LPG with its comparably high emission factor.



## NM VOC

Emissions of NM VOC are again driven by the consumption of LPG with its comparably high emission factor. Here, the ongoing downward trend results from the decrease in the emission factor applied for diesel fuels.



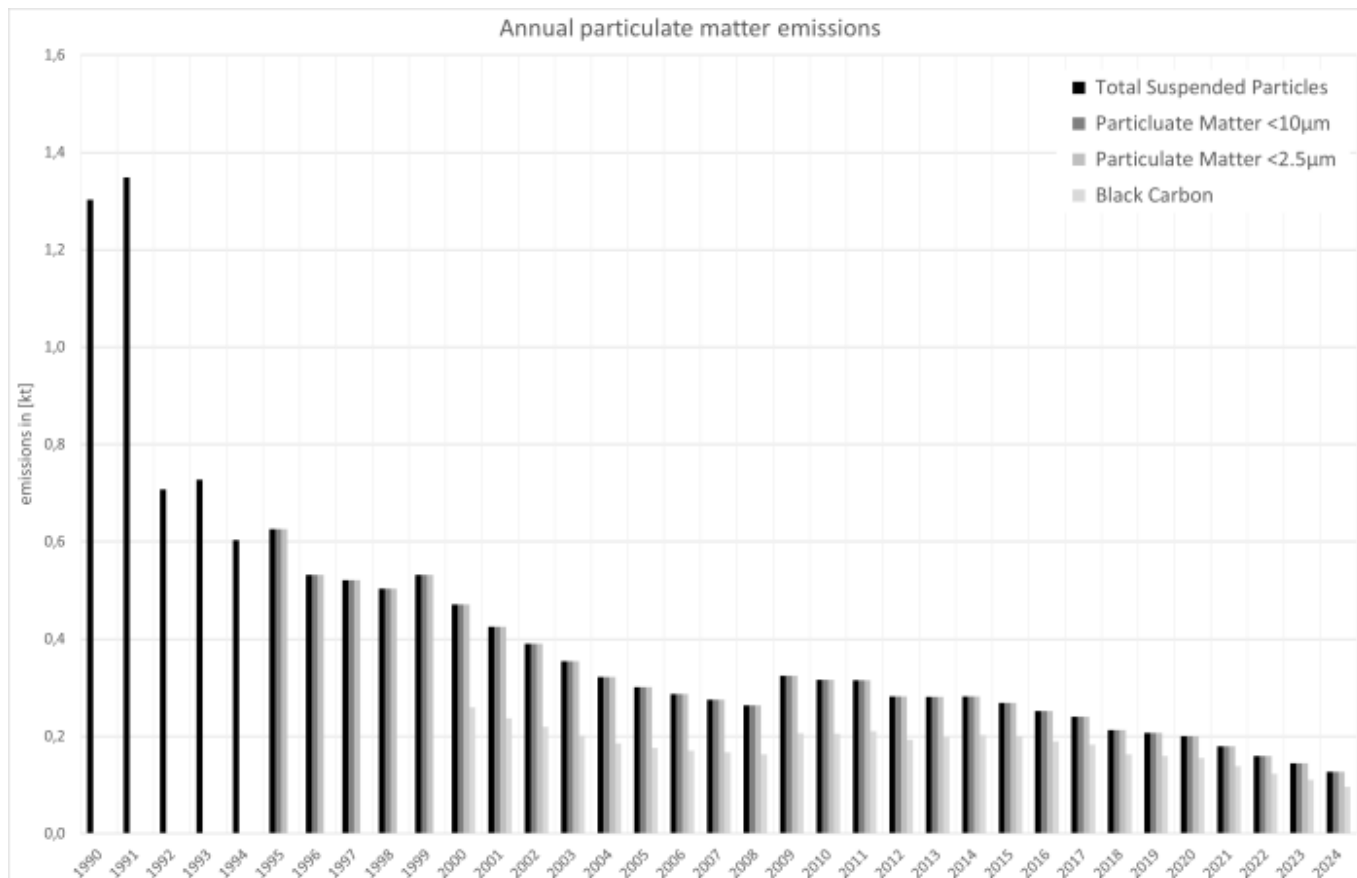
## Particulate matter & Black carbon

Over-all PM emissions are by far dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption between 2000 and 2005. Nonetheless, the decrease of the over-all emission trend was and still is amplified by the expanding use of particle filters especially to eliminate soot emissions.

Additional contributors such as the impact of TSP emissions from the use of leaded gasoline (until 1997) have no significant effect onto over-all emission estimates.

Here, as the EF(BC) are estimated via fractions provided in the 2023 EMEP Guidebook <sup>7)</sup>, black carbon emissions follow the corresponding emissions of PM<sub>2.5</sub>.





## Recalculations

Compared to the previous submission, recalculations in primary activity data (PAD) result from the revision of the National Energy Balance 2022 and the percental shares as compiled in TREMOD MM <sup>8)</sup>.

Table 5: Revised percental shares

|                            | 1990   | 1995   | 2000   | 2005   | 2010   | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  |
|----------------------------|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>current submission</b>  | 0.060  | 0.040  | 0.037  | 0.036  | 0.051  | 0.057 | 0.057 | 0.057 | 0.055 | 0.056 | 0.056 | 0.055 | 0.055 | 0.055 |
| <b>previous submission</b> | 0.060  | 0.040  | 0.037  | 0.037  | 0.051  | 0.054 | 0.054 | 0.054 | 0.048 | 0.049 | 0.049 | 0.046 | 0.043 | 0.040 |
| <b>absolute change</b>     | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.003 | 0.003 | 0.004 | 0.007 | 0.007 | 0.007 | 0.009 | 0.012 | 0.015 |
| <b>relative change</b>     | -0.03% | -0.02% | -0.01% | -0.37% | -0.16% | 4.79% | 5.1%  | 7.0%  | 14.7% | 13.3% | 14.9% | 19.4% | 28.2% | 38.5% |

Source-specific activity data have been revised accordingly:

Table 6: Revised source-specific activity data, in terajoules [TJ]

|                            | 1990   | 1995   | 2000   | 2005   | 2010   | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  |
|----------------------------|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>DIESEL OIL</b>          |        |        |        |        |        |       |       |       |       |       |       |       |       |       |
| <b>current submission</b>  | 6,694  | 3,867  | 3,487  | 2,990  | 4,494  | 5,846 | 5,976 | 6,114 | 5,720 | 5,904 | 5,950 | 5,793 | 5,619 | 5,580 |
| <b>previous submission</b> | 6,696  | 3,868  | 3,487  | 3,001  | 4,501  | 5,579 | 5,686 | 5,714 | 4,985 | 5,209 | 5,122 | 4,866 | 4,397 | 4,029 |
| <b>absolute change</b>     | -1.77  | -0.86  | -0.47  | -11.4  | -7.03  | 267   | 290   | 400   | 735   | 695   | 828   | 927   | 1,222 | 1,551 |
| <b>relative change</b>     | -0.03% | -0.02% | -0.01% | -0.38% | -0.16% | 4.79% | 5.11% | 7.00% | 14.7% | 13.3% | 16.2% | 19.0% | 27.8% | 38.5% |
| <b>BIODIESEL</b>           |        |        |        |        |        |       |       |       |       |       |       |       |       |       |
| <b>current submission</b>  |        |        |        | 191    | 348    | 321   | 320   | 326   | 330   | 335   | 493   | 402   | 389   | 415   |
| <b>previous submission</b> |        |        |        | 200    | 352    | 310   | 308   | 312   | 281   | 295   | 419   | 341   | 305   | 299   |
| <b>absolute change</b>     |        |        |        | -8.96  | -4.19  | 10.7  | 11.4  | 14.9  | 49.0  | 39.9  | 73.5  | 60.9  | 83.8  | 116   |

|                            | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022  | 2023  |
|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|-------|
| <b>relative change</b>     |        |        |        | -4.49% | -1.19% | 3.47%  | 3.7%   | 4.8%   | 17.4%  | 13.5%  | 17.6%  | 17.9%  | 27.5% | 39.0% |
| <b>LPG</b>                 |        |        |        |        |        |        |        |        |        |        |        |        |       |       |
| <b>current submission</b>  | 2,787  | 3,450  | 4,261  | 4,533  | 4,629  | 4,256  | 4,336  | 4,301  | 4,264  | 4,213  | 4,139  | 4,063  | 3,987 | 3,912 |
| <b>previous submission</b> | 2,787  | 3,450  | 4,261  | 4,533  | 4,629  | 4,256  | 4,336  | 4,301  | 4,264  | 4,213  | 4,139  | 4,063  | 3,987 | 3,912 |
| <b>absolute change</b>     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00  | 0.00  |
| <b>relative change</b>     | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00% | 0.00% |
| <b>Σ 1.A.4.a ii</b>        |        |        |        |        |        |        |        |        |        |        |        |        |       |       |
| <b>current submission</b>  | 9,480  | 7,317  | 7,748  | 7,713  | 9,471  | 10,423 | 10,632 | 10,742 | 10,314 | 10,453 | 10,582 | 10,258 | 9,995 | 9,906 |
| <b>previous submission</b> | 9,482  | 7,318  | 7,749  | 7,733  | 9,482  | 10,144 | 10,330 | 10,327 | 9,530  | 9,718  | 9,680  | 9,270  | 8,689 | 8,239 |
| <b>absolute change</b>     | -1.77  | -0.86  | -0.47  | -20.4  | -11.2  | 278    | 302    | 415    | 784    | 735    | 902    | 988    | 1,306 | 1,667 |
| <b>relative change</b>     | -0.02% | -0.01% | -0.01% | -0.26% | -0.12% | 2.74%  | 2.92%  | 4.02%  | 8.22%  | 7.56%  | 9.31%  | 10.7%  | 15.0% | 20.2% |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: "Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland" by (Knörr et al. (2009))<sup>9)</sup>.

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

## Planned improvements

Besides the annual **routine revision** of **TREMOD MM**, no specific improvements are planned.

## FAQs

### **Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?**

The EF provided in<sup>10)</sup> represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained in biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel and bioethanol.

<sup>1)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl-daten für die Bundesrepublik Deutschland; [https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>3), 4), 5)</sup> Knörr et al. (2025b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2025, Heidelberg, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2025.

<sup>6), 7)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook – 2023,

<https://www.eea.europa.eu/publications/emep-eea-guidebook-2023>, Copenhagen, 2023.

<sup>9)</sup> Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; <https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf>, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

<sup>6)</sup>

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

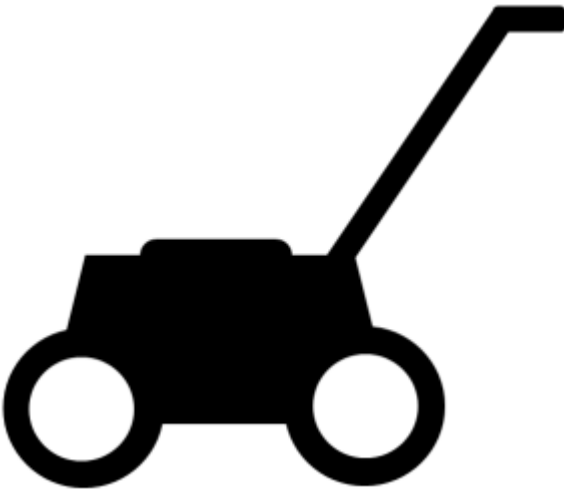
# 1.A.4.b ii - Residential: Household and Gardening: Mobile



[NFR-specific inventory data](#)

## Short description

Under sub-category *1.A.4.b ii - Residential: Mobile Sources in Households and Gardening* fuel combustion activities and resulting emissions from combustion engine driven devices such as motor saws, lawn mowers and small leisure boats are being reported.



| Category Code | Method | AD    | EF       |
|---------------|--------|-------|----------|
| 1.A.4.b ii    | T1, T2 | NS, M | CS, M, D |

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                    | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |    |
|-----------------|--------|-----------------|-----------------|-------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|----|
| -/-             | -/-    | -/-             | -/-             | -/-               | -/-                                                                                 | -/- | -/- | L/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | NE   | NE |
|                 |        |                 |                 | L/-               | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 | -/T               | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 | L/T               | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 | IE                | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |
|                 |        |                 |                 | *                 | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |    |

## Methodology

### Activity data

Activity data are taken from annual fuel deliveries data provided in line 66: 'Households' of the National Energy Balances (NEB) for Germany (AGEB, 2025) <sup>1)</sup>.

Table 1: Sources for consumption data in 1.A.4.b ii

| Relevant years | Data Source                                                |
|----------------|------------------------------------------------------------|
| through 1994   | <b>AGEB</b> - National Energy Balance, line 79: Households |
| since 1995     | <b>AGEB</b> - National Energy Balance, line 66: Households |

Here, given the rare statistics on sold machinery, these activity data is of limited quality only (no annual but cascaded trend).

As the NEB only provides primary activity data for *total biomass* used in 'households', but does not distinguish into specific biofuels, consumption data for bioethanol used in NFR 1.A.4.b ii are calculated by applying Germany's official annual shares

of biogasoline blended to fossil gasoline.

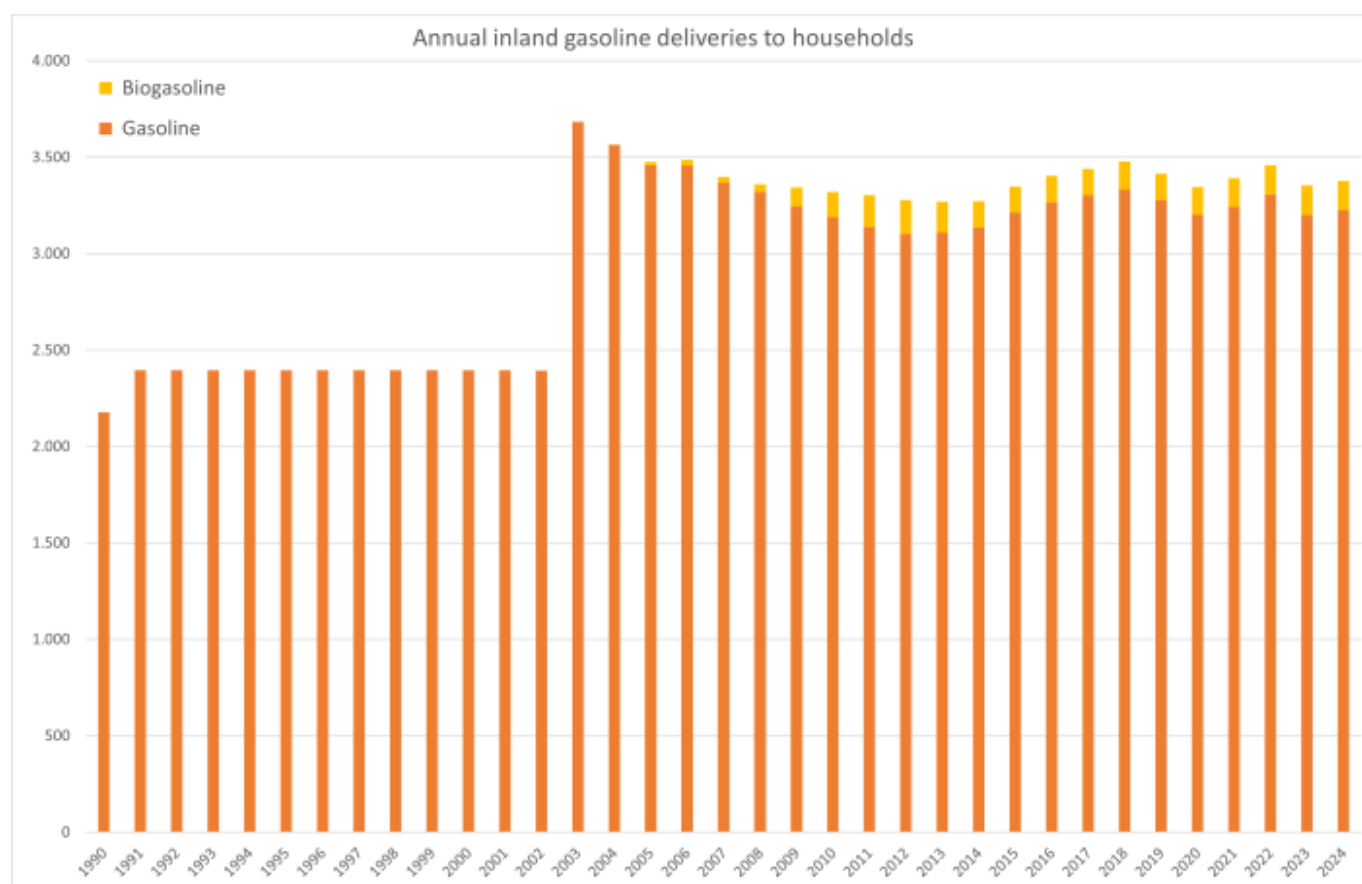
Please note: *Data on gasoline used in households* as provided in the National Energy Balances represents a “residual item” following the allocation of the majority of this fuel to road and military vehicles. Here, fuel sales to road vehicles might also include gasoline acquired on filling stations but used for household equipment.

Due to these reasons, activity data for gasoline consumption in households machinery and, hence, several emission estimates *show no realistic trend but a stepwise development* with significant jumps.

Table 2: Annual over-all fuel deliveries to residential mobile sources, in terajoules

|                     | 1990         | 1995         | 2000         | 2005         | 2010         | 2015         | 2016         | 2017         | 2018         | 2019         | 2020         | 2021         | 2022         | 2023         | 2024         |
|---------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>Gasoline</b>     | 2,177        | 2,395        | 2,395        | 3,459        | 3,190        | 3,212        | 3,267        | 3,303        | 3,333        | 3,278        | 3,203        | 3,242        | 3,307        | 3,201        | 3,226        |
| <b>Biogasoline</b>  | NO           | NO           | NO           | 16.3         | 131          | 135          | 138          | 136          | 145          | 137          | 142          | 150          | 153          | 152          | 151          |
| <b>Σ 1.A.4.b ii</b> | <b>2,177</b> | <b>2,395</b> | <b>2,395</b> | <b>3,475</b> | <b>3,321</b> | <b>3,348</b> | <b>3,404</b> | <b>3,440</b> | <b>3,478</b> | <b>3,415</b> | <b>3,345</b> | <b>3,392</b> | <b>3,459</b> | <b>3,353</b> | <b>3,377</b> |

source: AGEb, 2025 <sup>2)</sup> and TREMOD MM <sup>3)</sup>



These primary activity data can be distributed onto 2- and 4-stroke mobile machinery and boats used in households via annual shares from Knörr et al. (2025b) <sup>4)</sup>.

Table 3: Annual shares of 2- and 4-stroke engines

|                           | 1990        | 1995        | 2000        | 2005        | 2010        | 2015        | 2016        | 2017        | 2018        | 2019        | 2020        | 2021        | 2022        | 2023        | 2024        |
|---------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <b>2-Stroke Machinery</b> | 25.0%       | 43.7%       | 58.4%       | 61.8%       | 65.7%       | 68.1%       | 68.3%       | 68.5%       | 68.6%       | 68.7%       | 68.7%       | 68.9%       | 69.1%       | 69.3%       | 69.5%       |
| <b>4-Stroke Machinery</b> | 63.7%       | 44.2%       | 29.5%       | 27.0%       | 23.4%       | 19.5%       | 19.1%       | 18.7%       | 18.5%       | 18.3%       | 18.1%       | 17.9%       | 17.7%       | 17.5%       | 17.2%       |
| <b>2-Stroke Boats</b>     | 10.1%       | 10.3%       | 8.80%       | 5.61%       | 2.58%       | 2.11%       | 1.99%       | 1.87%       | 1.74%       | 1.60%       | 1.46%       | 1.33%       | 1.19%       | 1.05%       | 0.91%       |
| <b>4-Stroke Boats</b>     | 1.17%       | 1.79%       | 3.31%       | 5.61%       | 8.28%       | 10.3%       | 10.6%       | 10.9%       | 11.2%       | 11.4%       | 11.7%       | 11.8%       | 12.0%       | 12.2%       | 12.4%       |
|                           | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> | <b>100%</b> |

source: TREMOD MM <sup>5)</sup>

Table 4: Resulting estimates for fuel consumption in 2- and 4-stroke engines, in terajoules

|                           | 1990         | 1995         | 2000         | 2005         | 2010         | 2015         | 2016         | 2017         | 2018         | 2019         | 2020         | 2021         | 2022         | 2023         | 2024         |
|---------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>2-stroke machinery</b> |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| <b>Gasoline</b>           | 545          | 1,046        | 1,400        | 2,138        | 2,098        | 2,187        | 2,230        | 2,262        | 2,287        | 2,252        | 2,202        | 2,234        | 2,284        | 2,218        | 2,241        |
| <b>Biogasoline</b>        | NO           | NO           | NO           | 10.1         | 85.8         | 92.0         | 93.9         | 93.4         | 100          | 94.2         | 97.5         | 103          | 106          | 105          | 105          |
| <b>4-stroke machinery</b> |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| <b>Gasoline</b>           | 1,387        | 1,059        | 705          | 933          | 746          | 627          | 625          | 619          | 616          | 600          | 581          | 581          | 586          | 559          | 555          |
| <b>Biogasoline</b>        | NO           | NO           | NO           | 4.39         | 30.5         | 26.4         | 26.3         | 25.6         | 26.9         | 25.1         | 25.7         | 26.8         | 27.1         | 26.6         | 26.0         |
| <b>2-stroke boats</b>     |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| <b>Gasoline</b>           | 25.5         | 43.0         | 79.2         | 194          | 264          | 331          | 347          | 360          | 372          | 374          | 373          | 383          | 397          | 391          | 400          |
| <b>Biogasoline</b>        | NO           | NO           | NO           | 0.91         | 10.8         | 13.9         | 14.6         | 14.9         | 16.2         | 15.6         | 16.5         | 17.7         | 18.4         | 18.6         | 18.7         |
| <b>4-stroke boats</b>     |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
| <b>Gasoline</b>           | 220          | 248          | 211          | 194          | 82.4         | 67.8         | 65.1         | 61.7         | 57.8         | 52.5         | 46.9         | 43.1         | 39.4         | 33.7         | 29.4         |
| <b>Biogasoline</b>        | NO           | NO           | NO           | 0.91         | 3.37         | 2.85         | 2.74         | 2.55         | 2.52         | 2.20         | 2.08         | 1.99         | 1.82         | 1.60         | 1.38         |
| <b>Σ 1.A.4.b ii</b>       | <b>2,177</b> | <b>2,395</b> | <b>2,395</b> | <b>3,475</b> | <b>3,321</b> | <b>3,348</b> | <b>3,404</b> | <b>3,440</b> | <b>3,478</b> | <b>3,415</b> | <b>3,345</b> | <b>3,392</b> | <b>3,459</b> | <b>3,353</b> | <b>3,377</b> |

## Emission factors

The emission factors used here are of rather different quality: For all **main pollutants**, **carbon monoxide** and **particulate matter**, annually changing values computed within TREMOD-MM (Knörr et al. (2025b))<sup>6)</sup> are used, representing the development of mitigation technologies and the effect of fuel-quality legislation.

Here, as no such specific EF are available for biofuels, the values used for gasoline are applied to bioethanol, too.

For lead (Pb) from leaded gasoline and corresponding TSP emissions, additional emissions are calculated from 1990 to 1997 based upon country-specific emission factors from <sup>71</sup>.)

Table 4: Annual country-specific emission factors from TREMOD MM, in kg/TJ

[illegible]

|                                                                                                                                                                                                        | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| NM VOC - exhaust <sup>1</sup>                                                                                                                                                                          | 952    | 1,036  | 1,269  | 1,373  | 1,196  | 897    | 853    | 813    | 779    | 753    | 734    | 722    | 714    | 710    | 708    |
| NM VOC - evaporation <sup>2</sup>                                                                                                                                                                      | 28.8   | 55.3   | 131    | 164    | 196    | 186    | 185    | 185    | 184    | 184    | 184    | 185    | 187    | 188    | 189    |
| NO <sub>x</sub>                                                                                                                                                                                        | 383    | 375    | 353    | 345    | 338    | 341    | 325    | 299    | 276    | 256    | 238    | 223    | 210    | 199    | 190    |
| SO <sub>x</sub>                                                                                                                                                                                        | 10.1   | 8.27   | 3.22   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   |
| BC <sup>3</sup>                                                                                                                                                                                        | 0.38   | 0.38   | 0.38   | 0.38   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   |
| PM <sub>2.5</sub> , PM <sub>10</sub> , TSP <sup>4</sup>                                                                                                                                                | 7.50   | 7.50   | 7.50   | 7.50   | 7.50   | 7.49   | 7.49   | 7.49   | 7.49   | 7.49   | 7.49   | 7.49   | 7.49   | 7.49   | 7.49   |
| CO                                                                                                                                                                                                     | 30,204 | 30,817 | 32,595 | 33,248 | 26,105 | 18,536 | 17,387 | 16,286 | 15,336 | 14,583 | 13,995 | 13,565 | 13,241 | 12,996 | 12,806 |
| <b>2-stroke leisure boats</b>                                                                                                                                                                          |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| NH <sub>3</sub>                                                                                                                                                                                        | 0.06   | 0.06   | 0.06   | 0.06   | 0.06   | 0.06   | 0.06   | 0.06   | 0.06   | 0.06   | 0.06   | 0.06   | 0.06   | 0.06   | 0.06   |
| NM VOC - exhaust <sup>1</sup>                                                                                                                                                                          | 5,614  | 5,674  | 5,835  | 5,952  | 4,268  | 2,261  | 1,938  | 1,630  | 1,364  | 1,138  | 964    | 834    | 740    | 673    | 627    |
| NM VOC - evaporation <sup>2</sup>                                                                                                                                                                      | 159    | 169    | 191    | 204    | 204    | 204    | 204    | 204    | 204    | 204    | 204    | 204    | 204    | 204    | 204    |
| NO <sub>x</sub>                                                                                                                                                                                        | 74.4   | 74.1   | 73.0   | 71.9   | 72.8   | 77.4   | 75.8   | 71.5   | 67.5   | 63.6   | 59.8   | 56.3   | 53.0   | 50.0   | 47.3   |
| SO <sub>x</sub>                                                                                                                                                                                        | 10.1   | 8.27   | 3.22   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   |
| BC <sup>3</sup>                                                                                                                                                                                        | 21.1   | 21.1   | 21.1   | 21.1   | 21.6   | 23.5   | 23.9   | 24.3   | 24.6   | 24.9   | 25.1   | 25.2   | 25.3   | 25.3   | 25.2   |
| PM <sub>2.5</sub> , PM <sub>10</sub> , TSP <sup>4</sup>                                                                                                                                                | 422    | 422    | 422    | 422    | 432    | 471    | 479    | 486    | 492    | 498    | 501    | 504    | 505    | 505    | 505    |
| CO                                                                                                                                                                                                     | 15,101 | 15,160 | 15,311 | 15,415 | 12,723 | 9,056  | 8,462  | 7,933  | 7,475  | 7,090  | 6,804  | 6,604  | 6,473  | 6,398  | 6,361  |
| <b>in addition, applied for any use of leaded gasoline (banned in 1997)</b>                                                                                                                            |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Pb                                                                                                                                                                                                     | 1,471  | 516    | 0.00   |        |        |        |        |        |        |        |        |        |        |        |        |
| TSP from exhaust Pb emissions <sup>5</sup>                                                                                                                                                             | 2.35   | 0.82   | 0.00   |        |        |        |        |        |        |        |        |        |        |        |        |
| <sup>1</sup> from fuel combustion                                                                                                                                                                      |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <sup>2</sup> from gasoline evaporation                                                                                                                                                                 |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <sup>3</sup> estimated via a f-BCs as provided in <sup>8)</sup> , Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <sup>4</sup> EF(PM <sub>2.5</sub> ) also applied for PM <sub>10</sub> and TSP (assumption: > 99% of TSP consists of PM <sub>2.5</sub> )                                                                |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <sup>5</sup> additional TSP formed from Pb emissions from leaded gasoline (until 1997), compare 1.A.3.bi-iv                                                                                            |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |



With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>9)</sup>

For lead (Pb) from leaded gasoline and corresponding TSP emissions, additional emissions are calculated from 1990 to 1997 based upon country-specific emission factors from <sup>10)</sup>.

**NOTE:** For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Discussion of emission trends

Table 4: Outcome of Key Category Analysis for NFR 1.A.4.b ii



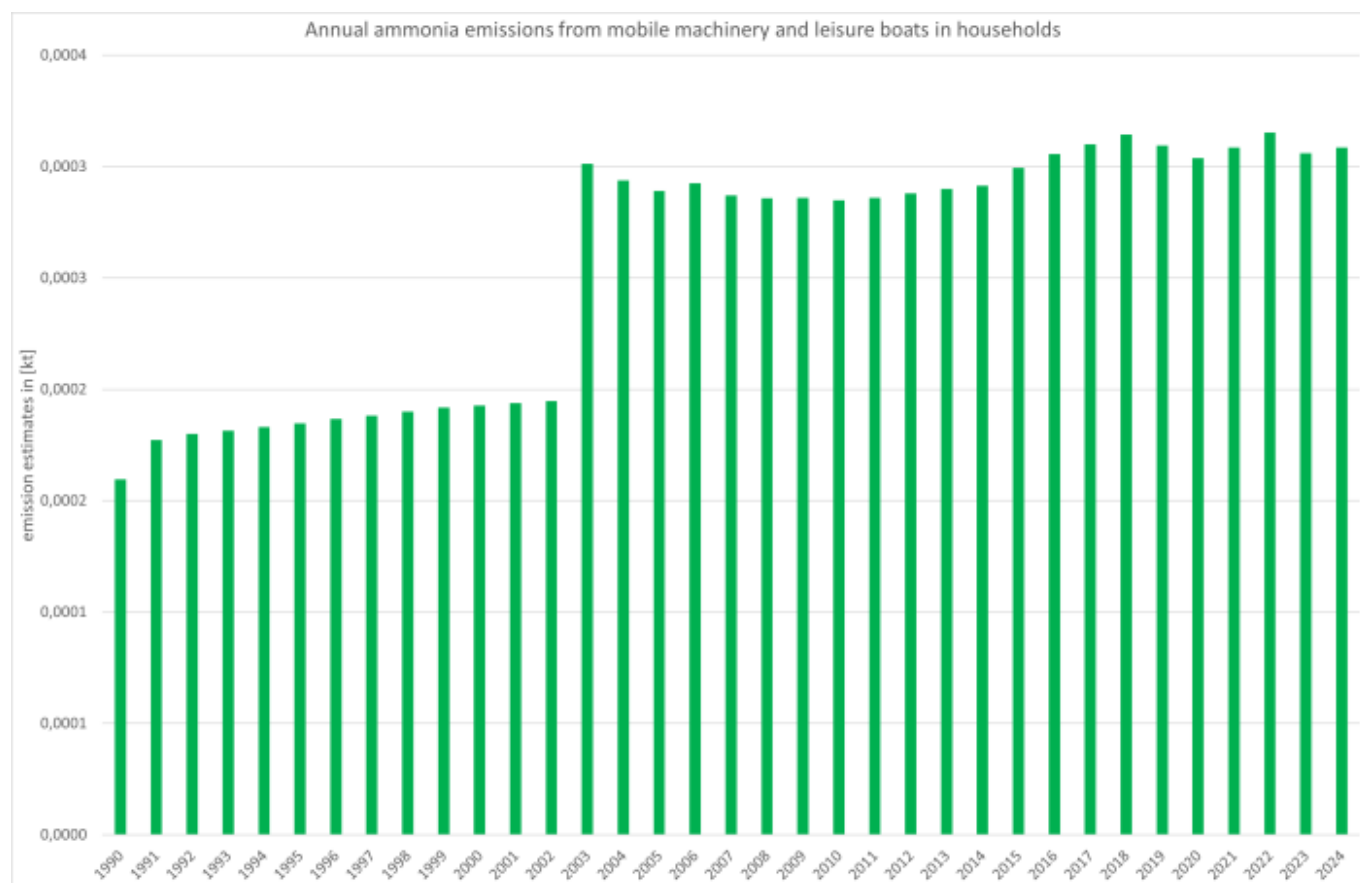
|                 |                                                                                     |            |
|-----------------|-------------------------------------------------------------------------------------|------------|
| key source for: |                                                                                     | <b>CO</b>  |
| by:             |                                                                                     | <b>L/-</b> |
| <b>L/-</b>      | key source by <b>Level</b> only                                                     |            |
| <b>-/T</b>      | key source by <b>Trend</b> only                                                     |            |
| <b>L/T</b>      | key source by both <b>Level</b> and <b>Trend</b>                                    |            |
| <b>-/-</b>      | no key source for this pollutant                                                    |            |
| <b>IE</b>       | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |            |
| <b>NE</b>       | emission of specific pollutant <b>Not Estimated</b> (yet)                           |            |
| <b>NA</b>       | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |            |
| <b>*</b>        | no analysis done                                                                    |            |

Given the limited quality of gasoline-deliveries data from NEB line 66 of the National Energy Balances, the following emission trends are of limited significance only.

Here, the jump in annual inland fuel deliveries between 2002 and 2003 (see table on primary activity data above) resulting in corresponding jumps in the emission trends for the reported pollutants cannot be eliminated by the inventory compiler but is already evident in the in the National Energy Balances compiled by the Working Group on Energy Balances (AGEB).

### Unregulated pollutants (Ammonia, HMs, POPs, ...)

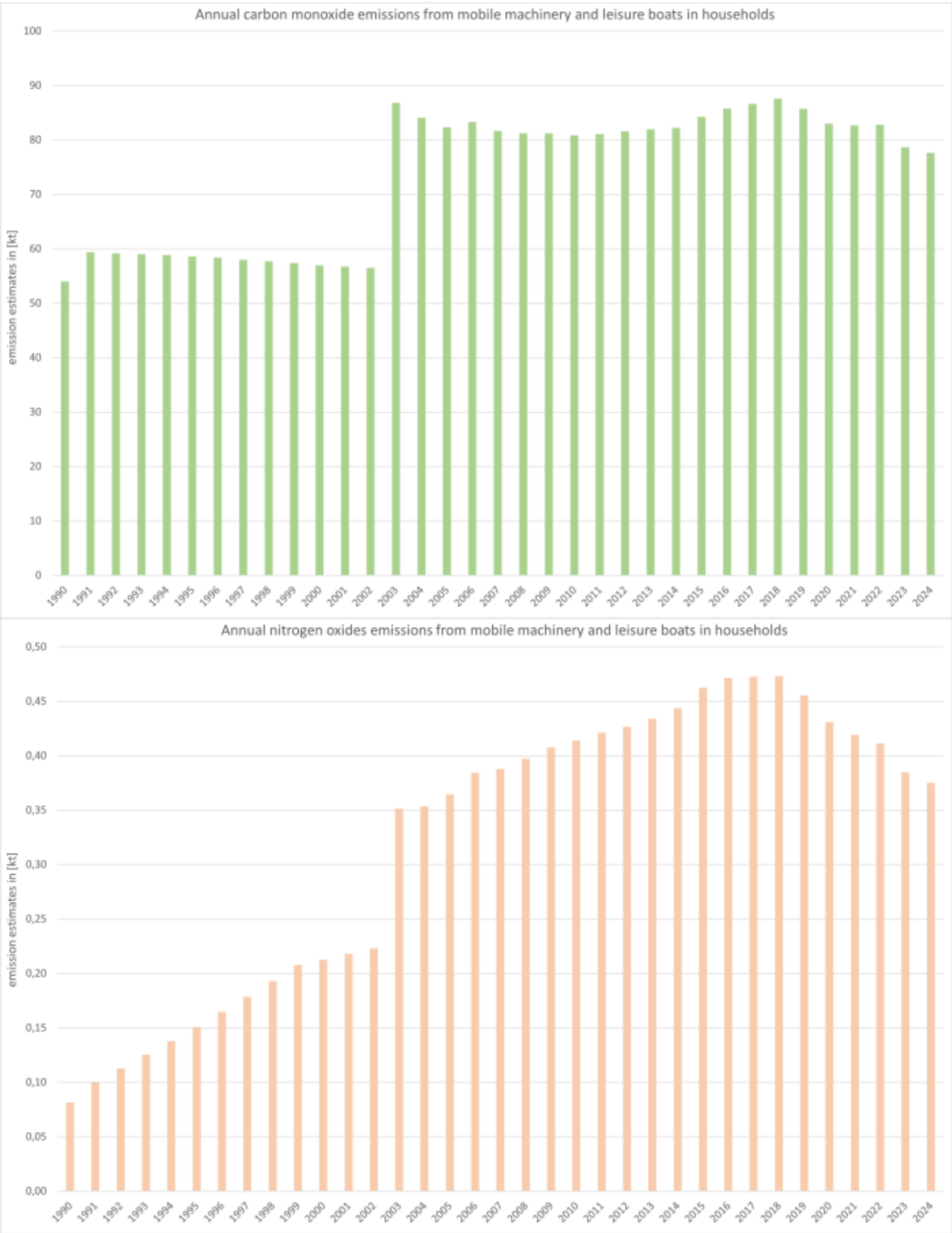
For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.



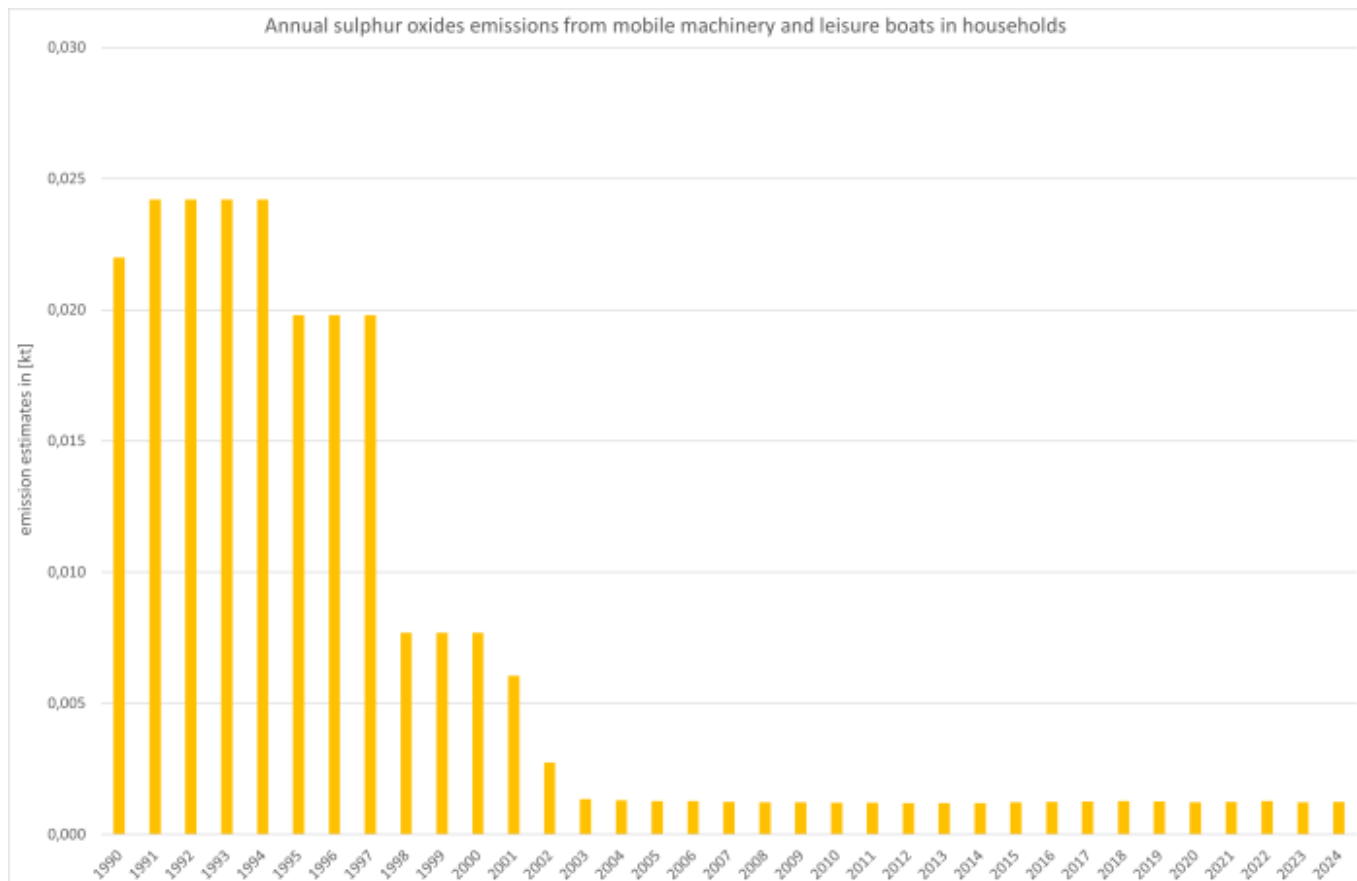
Here, as the emission factors for heavy metals (and POPs) are derived from tier1 default values, the emission's trend is strongly influenced by the share of 2-stroke gasoline fuel (containing lube oil with presumably higher HM content) consumed.

### Regulated pollutants

For all regulated pollutants, emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation. However, especially for CO and NO<sub>x</sub>, trends are strongly influenced by the changes in annual fuel deliveries as provided in NEB line 66.



Here, emissions of sulphur oxides follow the step-by-step reduction of sulphur contents in liquid fuels, resulting in a reduction of over 95% since 1990.

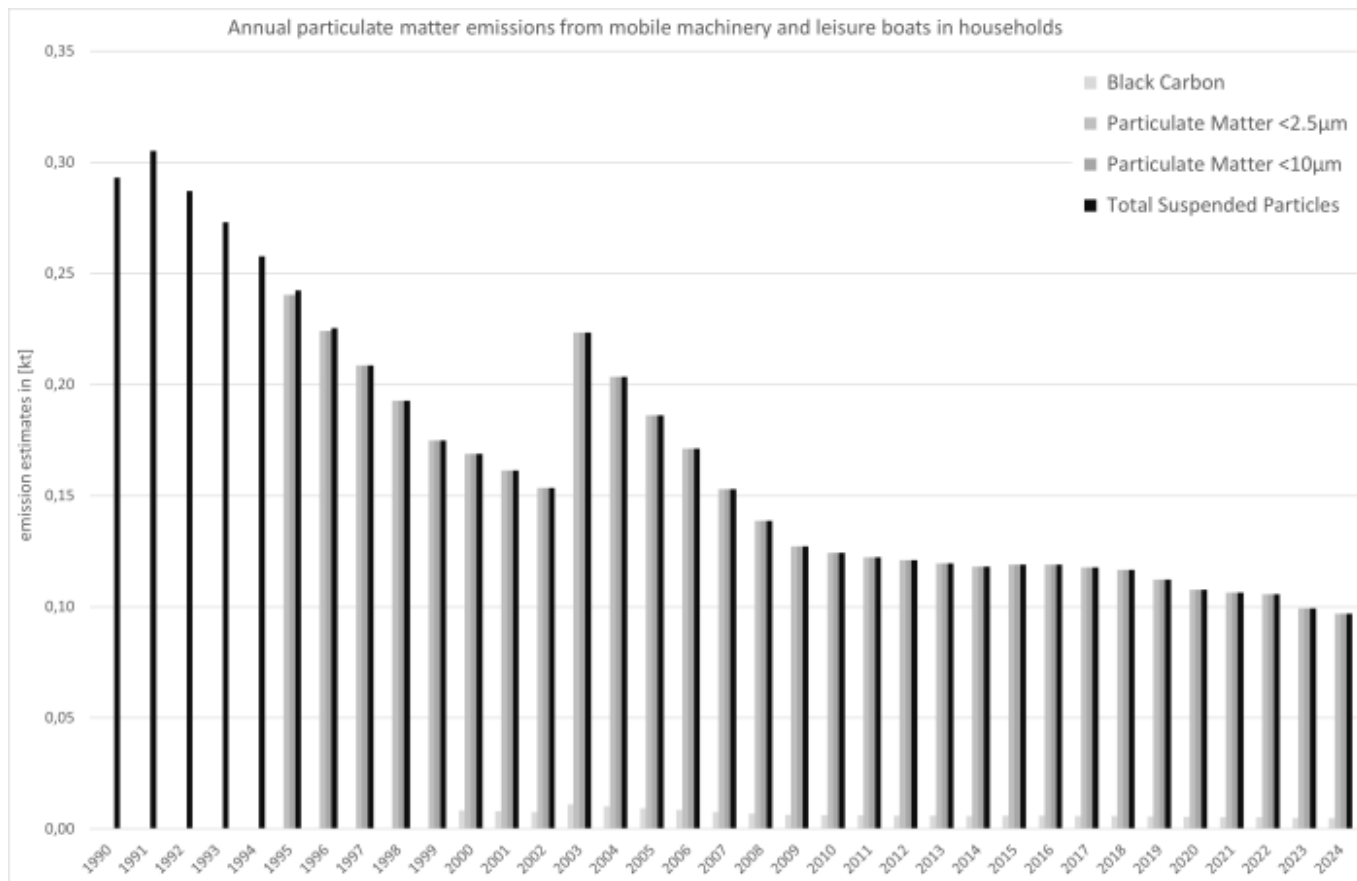


#### Particulate matter

Over-all PM emissions are by far dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption between 2000 and 2005. Nonetheless, the decrease of the over-all emission trend was and still is amplified by the expanding use of particle filters especially to eliminate soot emissions.

Additional contributors such as the impact of TSP emissions from the use of leaded gasoline (until 1997) have no significant effect onto over-all emission estimates.

Here, as the EF(BC) are estimated via fractions provided in <sup>11)</sup>, black carbon emissions follow the corresponding emissions of PM<sub>2.5</sub>.



## Recalculations

Compared to the previous submission, recalculations in **primary activity data** result from the biennial routine revision of the National Energy Balances 2003 to 2023:

Table 5: Revised primary activity data, in terajoules [TJ]

|                     | 2004   | 2005   | 2010  | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|---------------------|--------|--------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>GASOLINE</b>     |        |        |       |        |        |        |        |        |        |        |        |        |
| current submission  | 3,563  | 3,459  | 3,190 | 3,212  | 3,267  | 3,303  | 3,333  | 3,278  | 3,203  | 3,242  | 3,307  | 3,201  |
| previous submission | 3,563  | 3,459  | 3,190 | 3,212  | 3,267  | 3,303  | 3,333  | 3,278  | 3,203  | 3,242  | 3,305  | 3,364  |
| absolute change     | 0.00   | 0.00   | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 1.53   | -163   |
| relative change     | 0.00%  | 0.00%  | 0.00% | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.05%  | -4.84% |
| <b>BIOGASOLINE</b>  |        |        |       |        |        |        |        |        |        |        |        |        |
| current submission  | 2.55   | 16.3   | 131   | 135    | 138    | 136    | 145    | 137    | 142    | 150    | 153    | 152    |
| previous submission | 2.55   | 16.5   | 131   | 139    | 142    | 139    | 150    | 141    | 146    | 154    | 153    | 159    |
| absolute change     | -0.004 | -0.18  | 0.02  | -4.15  | -4.29  | -2.89  | -4.49  | -4.22  | -4.43  | -4.65  | -0.35  | -6.86  |
| relative change     | -0.17% | -1.10% | 0.01% | -2.98% | -3.03% | -2.08% | -3.00% | -2.99% | -3.03% | -3.01% | -0.23% | -4.32% |
| <b>Σ</b>            |        |        |       |        |        |        |        |        |        |        |        |        |
| current submission  | 3,566  | 3,475  | 3,321 | 3,348  | 3,404  | 3,440  | 3,478  | 3,415  | 3,345  | 3,392  | 3,459  | 3,353  |
| previous submission | 3,566  | 3,475  | 3,321 | 3,352  | 3,409  | 3,443  | 3,483  | 3,419  | 3,349  | 3,396  | 3,458  | 3,523  |
| absolute change     | 0.00   | -0.18  | 0.02  | -4.15  | -4.29  | -2.89  | -4.49  | -4.22  | -4.43  | -4.65  | 1.18   | -170   |
| relative change     | 0.00%  | -0.01% | 0.00% | -0.12% | -0.13% | -0.08% | -0.13% | -0.12% | -0.13% | -0.14% | 0.03%  | -4.82% |

Furthermore, revised **percentual shares of 2- and 4-stroke mobile machinery and leisure boats** used in households from TREMOD MM result in slightly revised specific **activity data** applied to 2- and 4-stroke mobile machinery and leisure boats used in households.

Table 6: Revised percentual shares of 2- and 4-stroke mobile machinery and leisure boats used in households

|                            | 1990   | 1995  | 2000  | 2005  | 2010  | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|----------------------------|--------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>4-stroke machinery</b>  |        |       |       |       |       |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 0.250  | 0.437 | 0.584 | 0.618 | 0.657 | 0.681  | 0.683  | 0.685  | 0.686  | 0.687  | 0.687  | 0.689  | 0.691  | 0.693  |
| <b>previous submission</b> | 0.250  | 0.437 | 0.584 | 0.618 | 0.658 | 0.681  | 0.683  | 0.685  | 0.686  | 0.687  | 0.688  | 0.689  | 0.691  | 0.693  |
| <b>absolute change</b>     | 0.000  | 0.000 | 0.000 | 0.000 | 0.000 | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  |
| <b>relative change</b>     | 0.00%  | 0.00% | 0.00% | 0.00% | 0.00% | -0.01% | -0.01% | -0.02% | -0.02% | -0.02% | -0.02% | -0.02% | -0.02% | -0.02% |
| <b>2-stroke machinery</b>  |        |       |       |       |       |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 0.637  | 0.442 | 0.295 | 0.270 | 0.234 | 0.195  | 0.191  | 0.187  | 0.185  | 0.183  | 0.181  | 0.179  | 0.177  | 0.175  |
| <b>previous submission</b> | 0.637  | 0.442 | 0.295 | 0.270 | 0.234 | 0.195  | 0.191  | 0.187  | 0.185  | 0.183  | 0.181  | 0.179  | 0.177  | 0.174  |
| <b>absolute change</b>     | 0.000  | 0.000 | 0.000 | 0.000 | 0.000 | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  |
| <b>relative change</b>     | 0.00%  | 0.00% | 0.00% | 0.00% | 0.01% | 0.06%  | 0.07%  | 0.09%  | 0.10%  | 0.11%  | 0.12%  | 0.12%  | 0.12%  | 0.12%  |
| <b>4-stroke boats</b>      |        |       |       |       |       |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 0.012  | 0.018 | 0.033 | 0.056 | 0.083 | 0.103  | 0.106  | 0.109  | 0.112  | 0.114  | 0.117  | 0.118  | 0.120  | 0.122  |
| <b>previous submission</b> | 0.012  | 0.018 | 0.033 | 0.056 | 0.083 | 0.103  | 0.106  | 0.109  | 0.112  | 0.114  | 0.117  | 0.118  | 0.120  | 0.122  |
| <b>absolute change</b>     | 0.000  | 0.000 | 0.000 | 0.000 | 0.000 | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  |
| <b>relative change</b>     | -0.02% | 0.00% | 0.01% | 0.00% | 0.00% | -0.03% | -0.04% | -0.04% | -0.05% | -0.05% | -0.06% | -0.06% | -0.06% | -0.05% |
| <b>2-stroke boats</b>      |        |       |       |       |       |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 0.101  | 0.103 | 0.088 | 0.056 | 0.026 | 0.021  | 0.020  | 0.019  | 0.017  | 0.016  | 0.015  | 0.013  | 0.012  | 0.011  |
| <b>previous submission</b> | 0.101  | 0.103 | 0.088 | 0.056 | 0.026 | 0.021  | 0.020  | 0.019  | 0.017  | 0.016  | 0.015  | 0.013  | 0.012  | 0.011  |
| <b>absolute change</b>     | 0.000  | 0.000 | 0.000 | 0.000 | 0.000 | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  |
| <b>relative change</b>     | 0.00%  | 0.00% | 0.00% | 0.00% | 0.00% | -0.03% | -0.04% | -0.04% | -0.05% | -0.05% | -0.06% | -0.06% | -0.06% | -0.05% |

Finally, several **emission factors** have been revised within the underlying model (TREMOMM), with the most significant absolute changes occurring for CO from 2- and 4-stroke mobile machinery:

Table 7: Revised country-specific emission factors for CO from 2- and 4-stroke mobile machinery, as of 2010 and in [kg/T]

|                            | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>2-stroke machinery</b>  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 14,681 | 15,064 | 15,880 | 16,404 | 16,575 | 16,743 | 16,903 | 17,051 | 17,188 | 17,306 | 17,399 | 17,473 | 17,527 | 17,564 |
| <b>previous submission</b> | 14,682 | 15,065 | 15,879 | 16,402 | 16,573 | 16,741 | 16,901 | 17,049 | 17,186 | 17,304 | 17,397 | 17,472 | 17,526 | 17,563 |
| <b>absolute change</b>     | -0.48  | -0.46  | 0.78   | 1.88   | 1.97   | 2.00   | 1.99   | 1.95   | 1.88   | 1.79   | 1.71   | 1.57   | 1.44   | 1.33   |
| <b>relative change</b>     | 0.00%  | 0.00%  | 0.00%  | 0.01%  | 0.01%  | 0.01%  | 0.01%  | 0.01%  | 0.01%  | 0.01%  | 0.01%  | 0.01%  | 0.01%  | 0.01%  |
| <b>4-stroke machinery</b>  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 28,012 | 28,264 | 28,505 | 28,726 | 28,923 | 29,087 | 29,216 | 29,307 | 29,383 | 29,339 | 28,975 | 28,374 | 27,721 | 27,044 |
| <b>previous submission</b> | 28,013 | 28,265 | 28,507 | 28,729 | 28,926 | 29,091 | 29,221 | 29,313 | 29,389 | 29,345 | 28,982 | 28,381 | 27,727 | 27,050 |
| <b>absolute change</b>     | -0.43  | -1.18  | -1.99  | -2.80  | -3.57  | -4.29  | -4.95  | -5.53  | -6.05  | -6.46  | -6.78  | -6.54  | -6.16  | -5.63  |
| <b>relative change</b>     | 0.00%  | 0.00%  | -0.01% | -0.01% | -0.01% | -0.01% | -0.02% | -0.02% | -0.02% | -0.02% | -0.02% | -0.02% | -0.02% | -0.02% |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023 (Knörr et al. (2009))<sup>12)</sup>: “Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland”.

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

## Planned improvements

Besides a **routine revision** of the **TREMOD MM** model, no specific improvements are planned.

## FAQs

### *Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?*

The EF provided in<sup>13)</sup> represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained in biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel and bioethanol.

<sup>1), 2)</sup> AGEB (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>3), 4), 5), 6), 7)</sup> Knörr et al. (2025b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2025, Heidelberg, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2025.

<sup>8), 10), 11)</sup> EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019; Copenhagen, 2019

<sup>9)</sup> During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

<sup>12)</sup> Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; URL: <https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf>, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

<sup>13)</sup> Rentz et al. (2008): Rentz, O., Karl, U., Haase, M., Koch, M., Deutsch-Französisches Institut für Umweltforschung, Universität Karlsruhe (TH): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), FKZ 205 67 444, UBA Texte 01/2008, <https://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer>; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008.



| NFR Code                                                                                  | Method                               | AD    | EF       |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----------|
| 1.A.4.c ii                                                                                | T1, T2                               | NS, M | CS, D, M |
| <i>taking in to account emissions from:</i>                                               |                                      |       |          |
| Off-road Vehicles and Other Machinery: Agriculture                                        | T1, T2                               | NS, M | CS, D, M |
| Off-road Vehicles and Other Machinery: Forestry                                           | T1, T2                               | NS, M | CS, D, M |
| <b>Method(s) applied</b>                                                                  |                                      |       |          |
| <b>D</b>                                                                                  | Default                              |       |          |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |       |          |
| <b>T2</b>                                                                                 | Tier 2*                              |       |          |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |       |          |
| <b>C</b>                                                                                  | CORINAIR                             |       |          |
| <b>CS</b>                                                                                 | Country Specific                     |       |          |
| <b>M</b>                                                                                  | Model                                |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |          |
| <b>(source for) Activity Data</b>                                                         |                                      |       |          |
| <b>NS</b>                                                                                 | National Statistics                  |       |          |
| <b>RS</b>                                                                                 | Regional Statistics                  |       |          |
| <b>IS</b>                                                                                 | International Statistics             |       |          |
| <b>PS</b>                                                                                 | Plant Specific                       |       |          |
| <b>As</b>                                                                                 | Associations, business organisations |       |          |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |       |          |
| <b>M</b>                                                                                  | Model / Modelled                     |       |          |
| <b>C</b>                                                                                  | Confidential                         |       |          |
| <b>(source for) Emission Factors</b>                                                      |                                      |       |          |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |       |          |
| <b>CS</b>                                                                                 | Country Specific                     |       |          |
| <b>PS</b>                                                                                 | Plant Specific                       |       |          |
| <b>M</b>                                                                                  | Model / Modelled                     |       |          |
| <b>C</b>                                                                                  | Confidential                         |       |          |

[illegible]

| NO <sub>x</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|------|
| <div> <div>L/-</div> <div>key source by <b>Level</b> only</div> </div> <div> <div>-/T</div> <div>key source by <b>Trend</b> only</div> </div> <div> <div>L/T</div> <div>key source by both <b>Level</b> and <b>Trend</b></div> </div> <div> <div>-/-</div> <div>no key source for this pollutant</div> </div> <div> <div>IE</div> <div>emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category)</div> </div> <div> <div>NE</div> <div>emission of specific pollutant <b>Not Estimated</b> (yet)</div> </div> <div> <div>NA</div> <div>specific pollutant not emitted from this source or activity = <b>Not Applicable</b></div> </div> <div> <div>*</div> <div>no analysis done</div> </div> |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |

## Methodology

### Activity data

Sector-specific consumption data is included in the primary fuel-delivery data are available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2025) <sup>1)</sup>.

Table 1: Sources for primary fuel-delivery data

|              |                                                                                                    |
|--------------|----------------------------------------------------------------------------------------------------|
| through 1994 | AGEB - National Energy Balance, line 79: 'Haushalte und Kleinverbraucher insgesamt'                |
| as of 1995   | AGEB - National Energy Balance, line 67: 'Gewerbe, Handel, Dienstleistungen u. übrige Verbraucher' |

Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2025) <sup>2)</sup>, the remaining amounts of gasoline and diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and commercial/institutional used off-road vehicles (1.A.4.a ii) as well as agriculture and forestry (NFR 1.A.4.c ii) based upon annual shares derived from TREMOD MM (Knörr et al. (2025b)) <sup>3)</sup> (cf. superordinate chapter).

To provide more specific information on mobile sources in agriculture and forestry, the inventory compiler further divides NFR sector 1.A.4.c ii into **1.A.4.c ii (i) - NRMM in agriculture** in and **1.A.4.c ii (ii) - NRMM in forestry**.

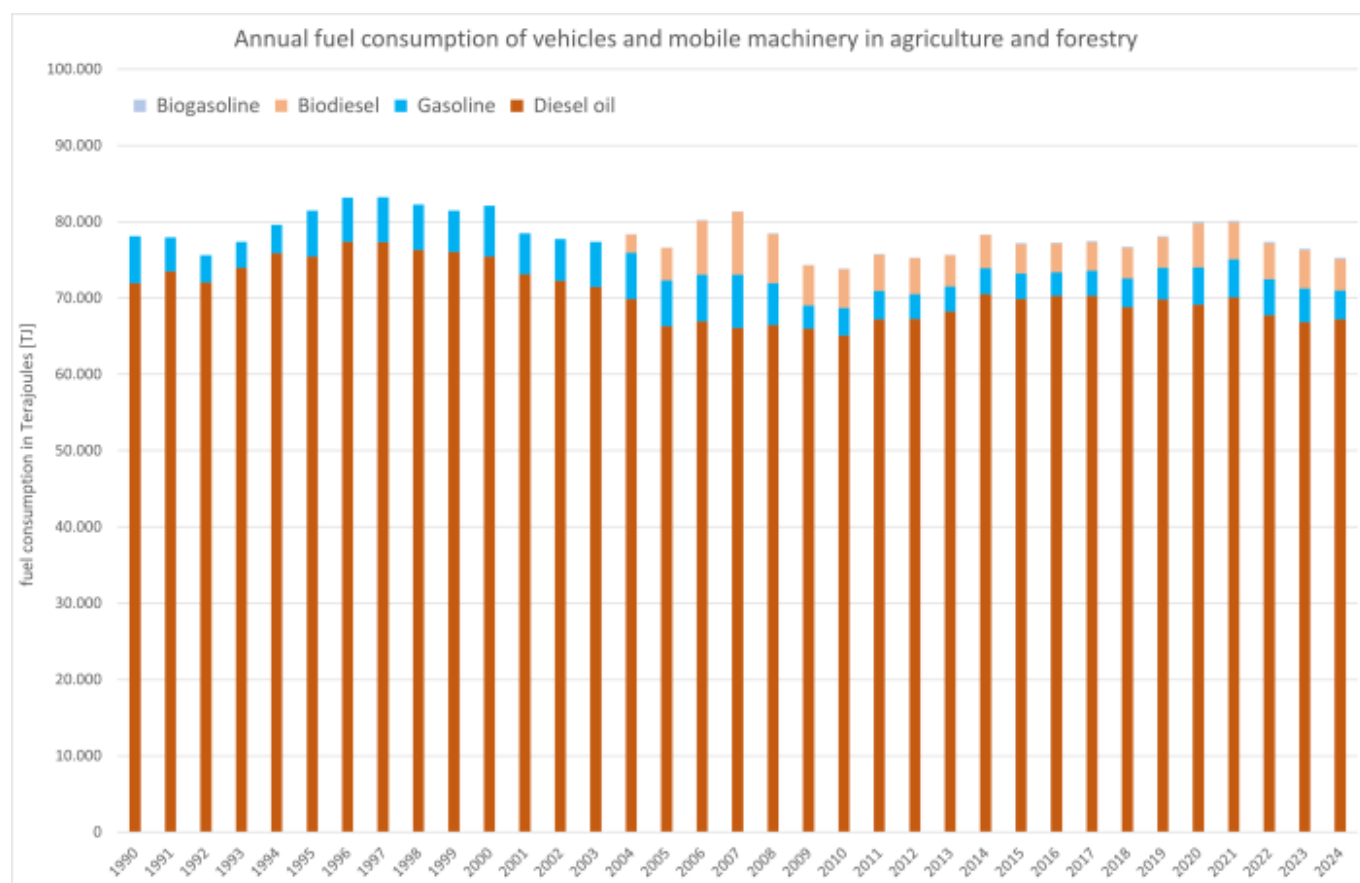
Table 2: Annual percentual contribution of NFR 1.A.4.c ii to the primary fuel delivery data provided in NEB line 67

|                                                                              | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>DIESEL FUELS</b>                                                          |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>1.A.4.c ii (i)</b>                                                        | 62.4% | 76.6% | 78.5% | 79.7% | 71.8% | 65.8% | 65.2% | 64.3% | 64.7% | 63.9% | 63.0% | 63.6% | 63.9% | 64.0% | 64.1% |
| <b>1.A.4.c ii (ii)</b>                                                       | 1.91% | 0.63% | 0.87% | 1.12% | 1.55% | 1.78% | 1.62% | 1.68% | 1.96% | 2.11% | 2.54% | 2.56% | 2.52% | 2.32% | 1.95% |
| <b>GASOLINE FUELS<sup>1)</sup></b>                                           |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>1.A.4.c ii (ii)</b>                                                       | 68.5% | 40.3% | 44.9% | 41.4% | 35.5% | 32.0% | 29.1% | 28.9% | 32.1% | 32.9% | 36.5% | 36.6% | 36.2% | 33.8% | 29.1% |
| source: own estimations based on Knörr et al. (2025b) <sup>4)</sup>          |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <sup>1)</sup> no gasoline used in agricultural vehicles and mobile machinery |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |

Table 3: Annual mobile fuel consumption in agriculture and forestry, in terajoules

|                     | 1990          | 1995          | 2000          | 2005          | 2010          | 2015          | 2016          | 2017          | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
|---------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>Diesel oil</b>   | 71,925        | 75,485        | 75,451        | 66,294        | 65,102        | 69,866        | 70,295        | 70,294        | 68,804        | 69,810        | 69,139        | 70,101        | 67,751        | 66,860        | 67,200        |
| <b>Gasoline</b>     | 6,185         | 6,008         | 6,648         | 6,040         | 3,611         | 3,360         | 3,086         | 3,283         | 3,803         | 4,170         | 4,909         | 4,962         | 4,722         | 4,422         | 3,799         |
| <b>Biodiesel</b>    |               |               |               | 4,227         | 5,039         | 3,832         | 3,759         | 3,753         | 3,972         | 3,966         | 5,723         | 4,866         | 4,688         | 4,974         | 4,114         |
| <b>Biogasoline</b>  |               |               |               | 41.0          | 121           | 141           | 130           | 136           | 166           | 174           | 217           | 229           | 218           | 210           | 178           |
| <b>Σ 1.A.4.c ii</b> | <b>78,111</b> | <b>81,493</b> | <b>82,099</b> | <b>76,601</b> | <b>73,874</b> | <b>77,199</b> | <b>77,270</b> | <b>77,466</b> | <b>76,745</b> | <b>78,121</b> | <b>79,989</b> | <b>80,158</b> | <b>77,380</b> | <b>76,467</b> | <b>75,291</b> |





## Emission factors

The emission factors applied here are of rather different quality:

Basically, for all **main pollutants**, **carbon monoxide** and **particulate matter**, annual IEF modelled within TREMOD MM are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

For Information on the country-specific implied emission factors applied to mobile machinery in agriculture and forestry, please refer to the respective sub-chapters linked above.

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

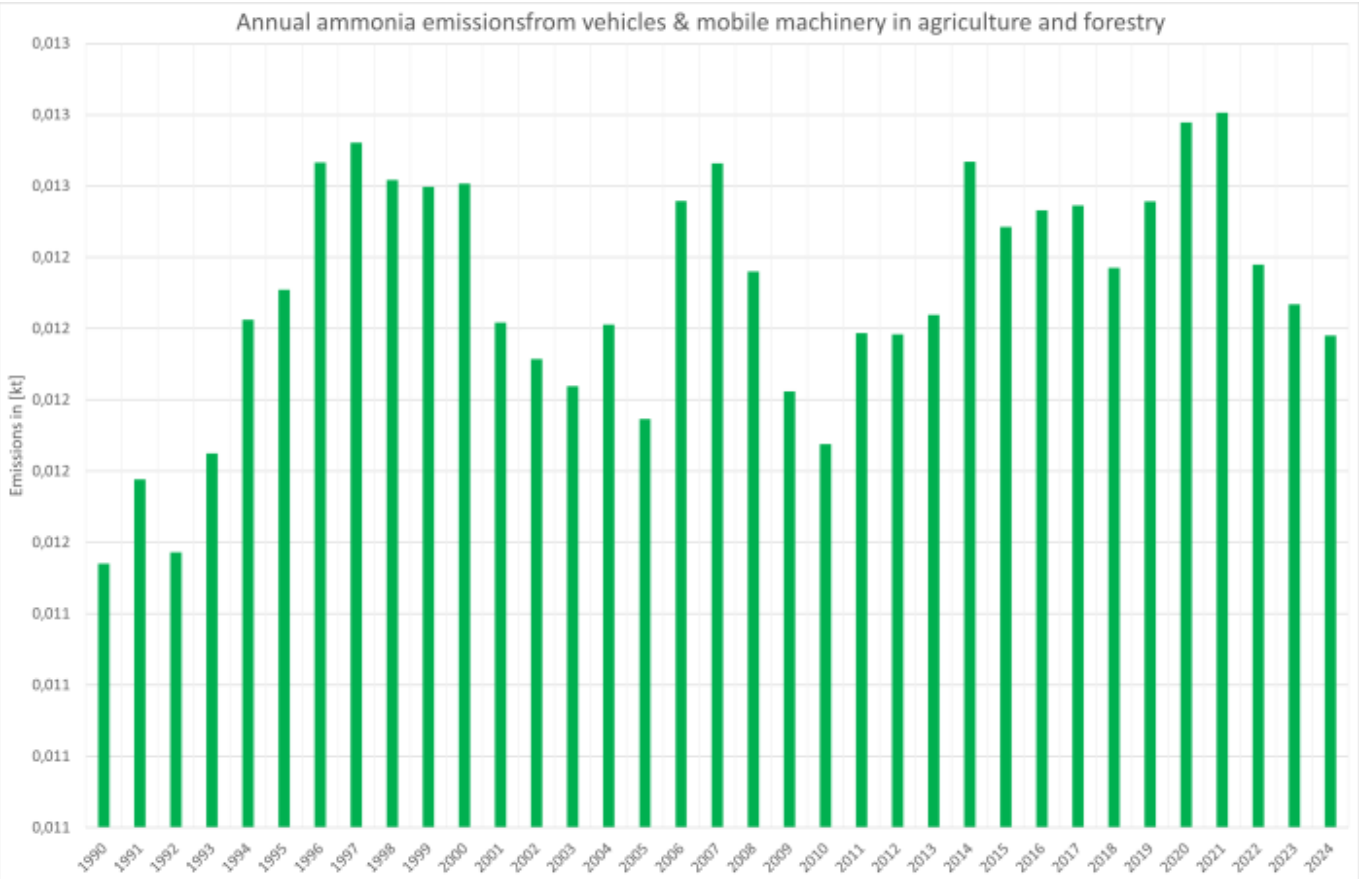
## Discussion of emission trends

Table 4: Outcome of Key Category Analysis for NFR 1.A.4.c ii

|                 |                       |                         |                        |           |
|-----------------|-----------------------|-------------------------|------------------------|-----------|
| key source for: | <b>NO<sub>x</sub></b> | <b>PM<sub>2.5</sub></b> | <b>PM<sub>10</sub></b> | <b>BC</b> |
| by:             | Level of emissions    | Level & Trend           | L/T                    | L/T       |

## Unregulated pollutants (Ammonia, HMs, POPs, ...)

For all unregulated pollutants, emission trends directly follow the trend in fuel consumption.



Here, exemplary for cadmium, the extreme steps in emission estimates result from two effects:

(i) the annual amounts of gasoline fuels allocated to NFR 1.A.4.c ii depend on the amounts delivered to the military also covered in NEB line 67. (see superordinate chapter for further information). This approach results in strong declines in gasoline consumption after 2007 and 2011. In addition, in contrast to the main pollutants, all heavy-metal and POP emissions are calculated via a tier1 approach based on default EF from <sup>5)</sup>.

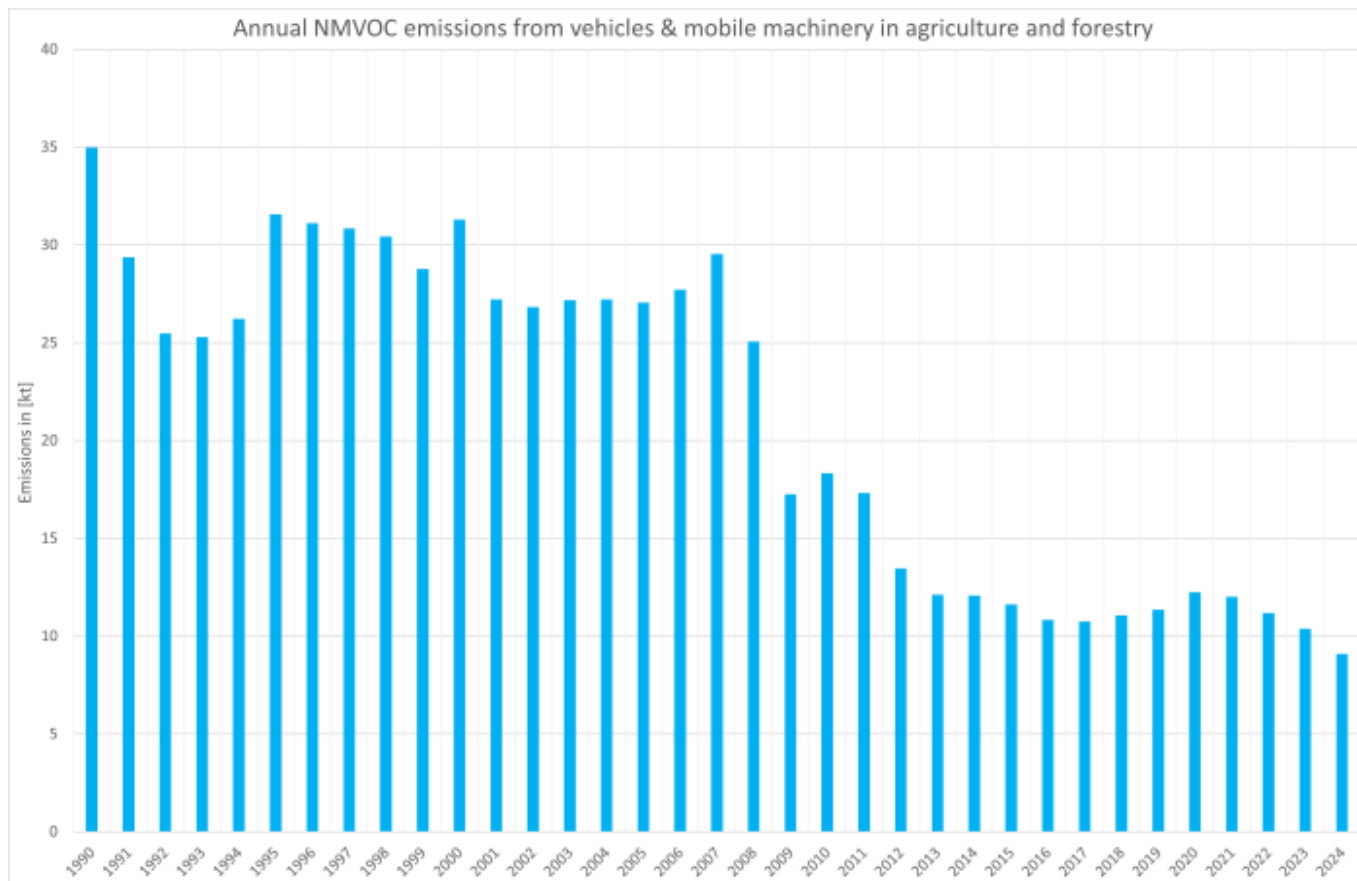


Table 5: Development of gasoline consumption in NFR 1.A.4.c ii, in terajoules

|                    | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>Gasoline</b>    | 6,185 | 6,008 | 6,648 | 6,040 | 3,611 | 3,360 | 3,086 | 3,283 | 3,803 | 4,170 | 4,909 | 4,962 | 4,722 | 4,422 | 3,799 |
| <b>Biogasoline</b> |       |       |       | 41.0  | 121   | 141   | 130   | 136   | 166   | 174   | 217   | 229   | 218   | 210   | 178   |

(ii) All gasoline fuels allocated to NFR 1.A.4.c ii are used in 2-stroke-engines in forestry equipment. As the 2-stroke fuel also includes lubricant oil, the fuel's heavy metal content is significantly higher than that of 4-stroke gasoline (or diesel fuels). (see Appendix 2.3 for more information on the reporting of HM emissions.)

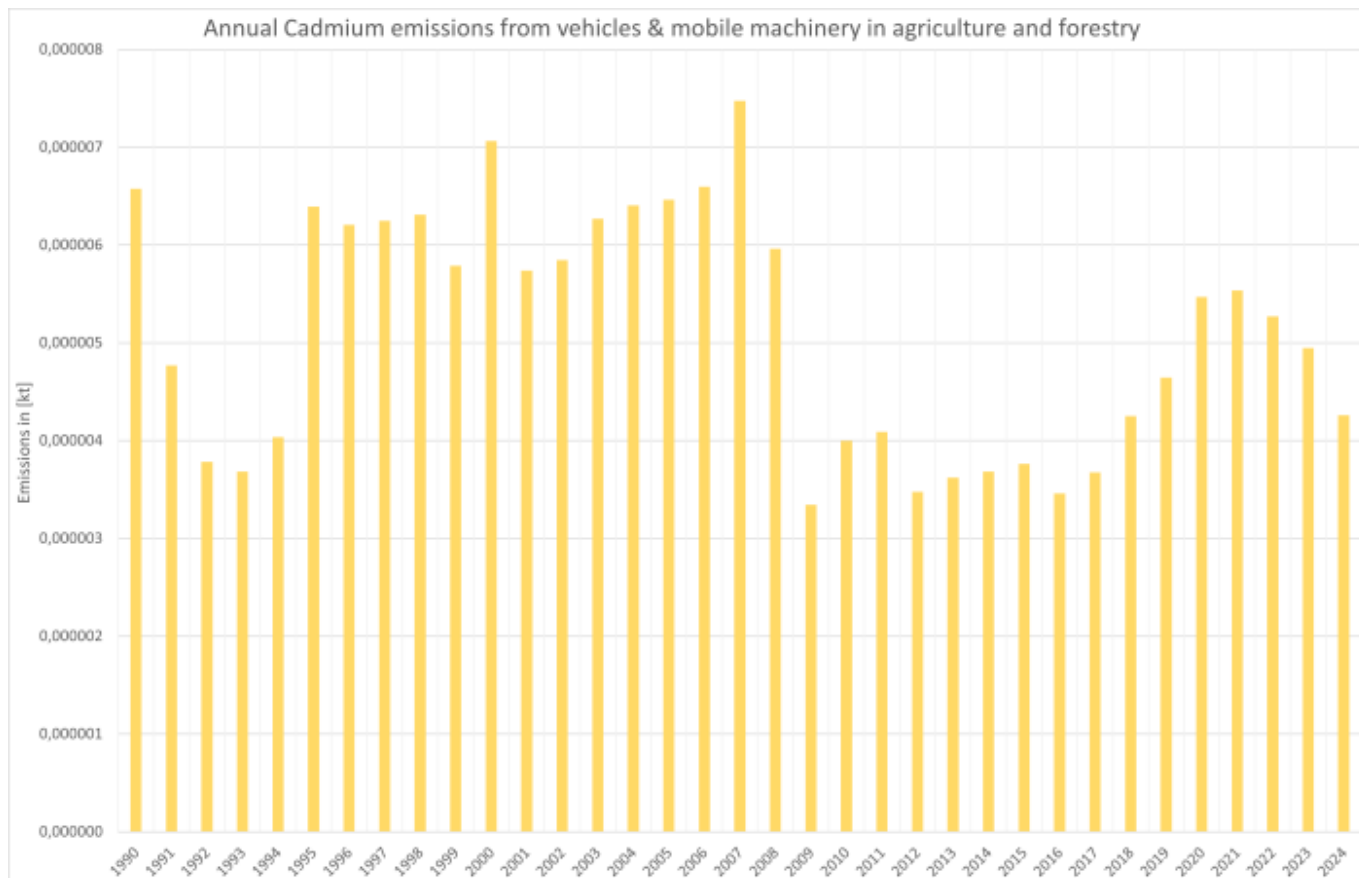
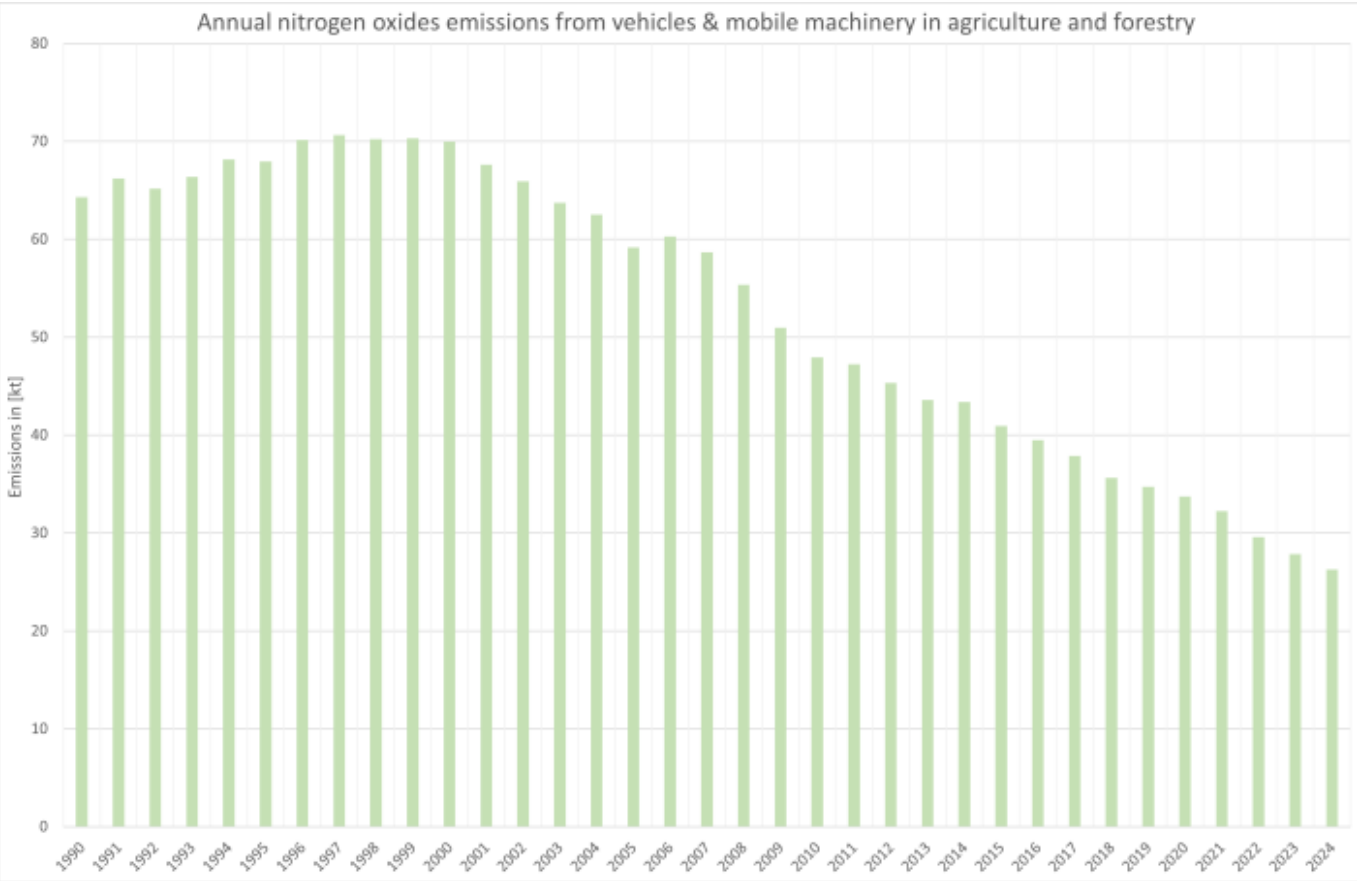


Table 6: Tier1 default emission factors applied to NRMM, in g/TJ

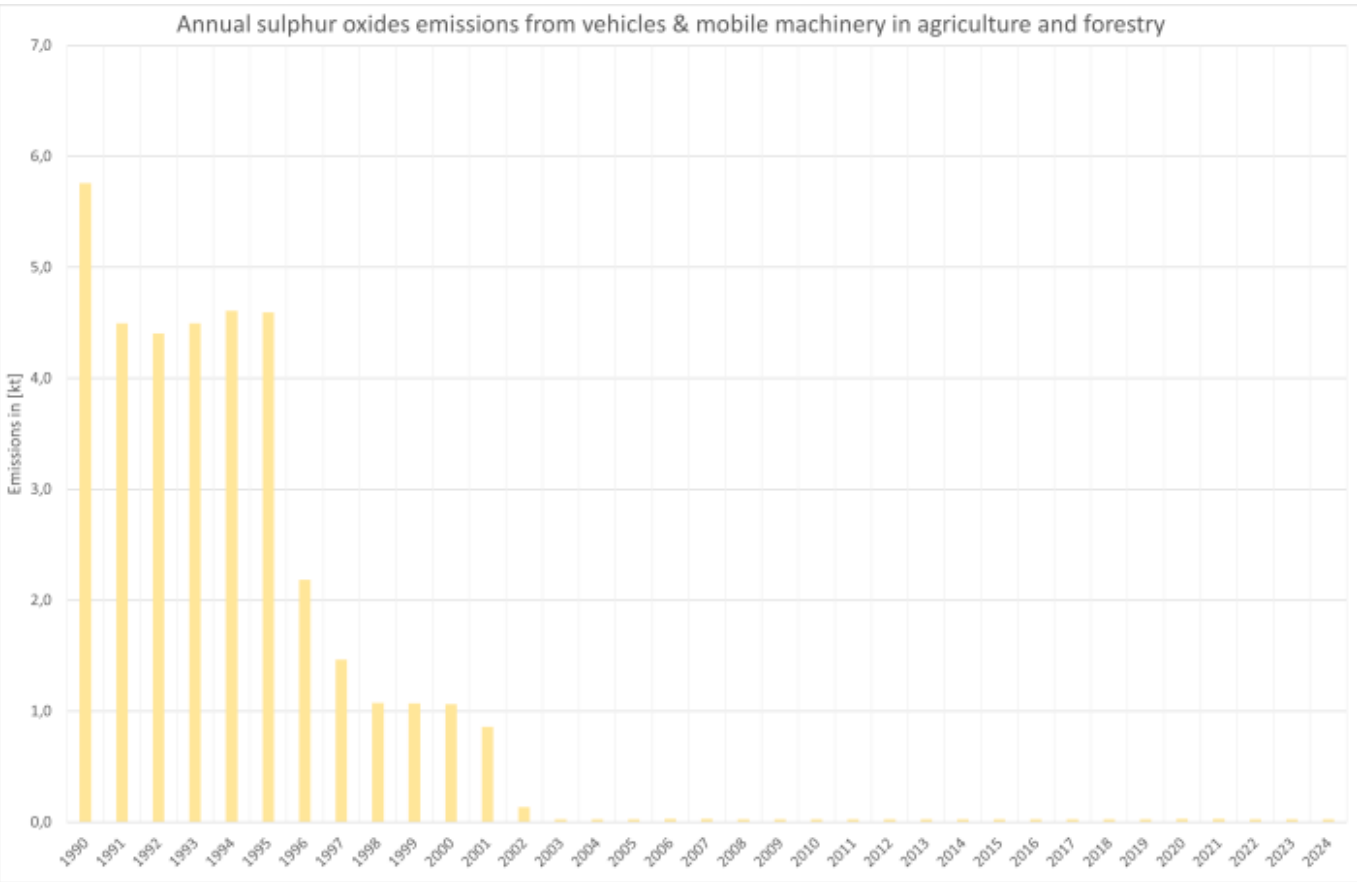
|                                                                                                                                                                                                          | Pb    | Cd    | Hg    | As    | Cr    | Cu    | Ni    | Se    | Zn    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Diesel oil                                                                                                                                                                                               | 0.012 | 0.001 | 0.123 | 0.002 | 0.198 | 0.133 | 0.005 | 0.002 | 0.419 |
| Biodiesel <sup>1</sup>                                                                                                                                                                                   | 0.013 | 0.001 | 0.142 | 0.003 | 0.228 | 0.153 | 0.005 | 0.003 | 0.483 |
| Gasoline fuels - 4-stroke                                                                                                                                                                                | 0.037 | 0.005 | 0.200 | 0.007 | 0.145 | 0.103 | 0.053 | 0.005 | 0.758 |
| Gasoline fuels - 2-stroke <sup>2</sup>                                                                                                                                                                   | 0.051 | 2.10  | 0.196 | 0.007 | 8.96  | 357   | 14.7  | 2.09  | 208   |
| LPG (1.A.4.a ii only)                                                                                                                                                                                    | NE    |       |       |       |       |       |       |       |       |
| <sup>1</sup> values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel                                                                                     |       |       |       |       |       |       |       |       |       |
| <sup>2</sup> including the HM of 1:50 lube oil mixed to the gasoline. (Hence, emission estimates reported for cadmium are significantly higher for years with higher gasoline use (in 2-stroke engines)) |       |       |       |       |       |       |       |       |       |

## Regulated pollutants

For all regulated pollutants, emission trends follow not only the trend in fuel consumption but also reflect the impact of fuel-quality and exhaust-emission legislation.



Here, emissions of sulphur oxides follow the step-by-step reduction of sulphur contents in liquid fuels, resulting in a reduction of over 99% since 1990:





|                                 | 1990   | 1995   | 2000   | 2005   | 2010   | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  |
|---------------------------------|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>current submission</b>       | 0.019  | 0.006  | 0.009  | 0.011  | 0.016  | 0.018 | 0.016 | 0.017 | 0.020 | 0.021 | 0.025 | 0.026 | 0.025 | 0.023 |
| <b>previous submission</b>      | 0.019  | 0.006  | 0.009  | 0.011  | 0.016  | 0.017 | 0.015 | 0.016 | 0.017 | 0.019 | 0.022 | 0.021 | 0.020 | 0.017 |
| <b>absolute change</b>          | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.001 | 0.001 | 0.001 | 0.003 | 0.002 | 0.003 | 0.004 | 0.006 | 0.006 |
| <b>relative change</b>          | -0.03% | -0.02% | -0.01% | -0.37% | -0.16% | 4.79% | 5.10% | 7.00% | 14.7% | 13.3% | 14.9% | 19.4% | 28.2% | 38.5% |
| <b>GASOLINE FUELS: FORESTRY</b> |        |        |        |        |        |       |       |       |       |       |       |       |       |       |
| <b>current submission</b>       | 0.685  | 0.403  | 0.449  | 0.414  | 0.355  | 0.320 | 0.291 | 0.289 | 0.321 | 0.329 | 0.365 | 0.366 | 0.362 | 0.338 |
| <b>previous submission</b>      | 0.685  | 0.403  | 0.449  | 0.414  | 0.355  | 0.320 | 0.291 | 0.289 | 0.321 | 0.329 | 0.365 | 0.366 | 0.362 | 0.338 |
| <b>absolute change</b>          | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| <b>relative change</b>          | -0.01% | -0.01% | -0.01% | 0.00%  | 0.00%  | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

Resulting from the revised annual shares, **activity data** have been re-calculated accordingly:

Table 8: Revision of annual activity data, in terajoules

|                                  | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022    | 2023    |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|
| <b>DIESEL FUELS</b>              |        |        |        |        |        |        |        |        |        |        |        |        |         |         |
| <b>current submission</b>        | 71,925 | 75,485 | 75,451 | 70,520 | 70,142 | 73,698 | 74,054 | 74,047 | 72,776 | 73,776 | 74,862 | 74,967 | 72,439  | 71,835  |
| <b>previous submission</b>       | 71,926 | 75,485 | 75,451 | 70,647 | 70,149 | 75,363 | 75,890 | 76,621 | 77,354 | 78,196 | 79,011 | 81,508 | 80,788  | 81,974  |
| <b>absolute change</b>           | -0.56  | -0.14  | -0.11  | -127   | -7.23  | -1,665 | -1,836 | -2,574 | -4,578 | -4,419 | -4,149 | -6,541 | -8,349  | -10,139 |
| <b>relative change</b>           | 0.00%  | 0.00%  | 0.00%  | -0.18% | -0.01% | -2.21% | -2.42% | -3.36% | -5.92% | -5.65% | -5.25% | -8.02% | -10.3%  | -12.4%  |
| <b>GASOLINE FUELS</b>            |        |        |        |        |        |        |        |        |        |        |        |        |         |         |
| <b>current submission</b>        | 6,185  | 6,008  | 6,648  | 6,081  | 3,732  | 3,501  | 3,216  | 3,419  | 3,969  | 4,345  | 5,127  | 5,191  | 4,940   | 4,632   |
| <b>previous submission</b>       | 6,186  | 6,009  | 6,648  | 6,100  | 7,322  | 5,942  | 5,216  | 5,076  | 5,698  | 6,010  | 6,647  | 6,837  | 6,662   | 6,151   |
| <b>absolute change</b>           | -0.43  | -0.57  | -0.37  | -19.4  | -3,590 | -2,441 | -2,000 | -1,657 | -1,730 | -1,665 | -1,520 | -1,646 | -1,722  | -1,519  |
| <b>relative change</b>           | -0.01% | -0.01% | -0.01% | -0.32% | -49.0% | -41.1% | -38.3% | -32.6% | -30.4% | -27.7% | -22.9% | -24.1% | -25.8%  | -24.7%  |
| <b>OVER-ALL FUEL CONSUMPTION</b> |        |        |        |        |        |        |        |        |        |        |        |        |         |         |
| <b>current submission</b>        | 78,111 | 81,493 | 82,099 | 76,601 | 73,874 | 77,199 | 77,270 | 77,466 | 76,745 | 78,121 | 79,989 | 80,158 | 77,380  | 76,467  |
| <b>previous submission</b>       | 78,112 | 81,494 | 82,100 | 76,747 | 77,471 | 81,305 | 81,106 | 81,697 | 83,052 | 84,205 | 85,657 | 88,345 | 87,451  | 88,125  |
| <b>absolute change</b>           | -1.00  | -0.70  | -0.48  | -146   | -3,597 | -4,106 | -3,836 | -4,231 | -6,307 | -6,084 | -5,669 | -8,187 | -10,071 | -11,659 |
| <b>relative change</b>           | 0.00%  | 0.00%  | 0.00%  | -0.19% | -4.64% | -5.05% | -4.73% | -5.18% | -7.59% | -7.23% | -6.62% | -9.27% | -11.5%  | -13.2%  |

For information on revised **emission factors** please refer to the sub-chapters on mobile sources in agriculture and forestry as linked above.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: "Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland" by (Knörr et al. (2009)) <sup>6)</sup>.

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

## Planned improvements

Besides a **routine revision of TREMOD MM**, no specific improvements are planned.

## FAQs

### *Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?*

The EF provided in <sup>7)</sup> represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained in the biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel and bioethanol.

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<sup>1)</sup> AGEBA (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEBA): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl- und Gasdaten für die Bundesrepublik Deutschland; [https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>3), 4)</sup> Knörr et al. (2025b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2025, on behalf of the Umweltbundesamt, Heidelberg/Dessau-Roßlau, 2025.

<sup>5)</sup> EMEP/EEA, 2023: EMEP/EEA air pollutant emission inventory guidebook – 2023, <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023>, Copenhagen, 2023.

<sup>6)</sup> Knörr et al. (2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; URL: <https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf>, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.



## 1.A.4.c ii (a) - Off-road Vehicles and other Machinery: Agriculture

### Short description

Under sub-category *1.A.4.c ii (a)* fuel combustion activities and resulting emissions from agricultural off-road vehicles and mobile machinery are reported.

| NFR-Code       | Source category                                    | Method | AD    | EF       | Key Category Analysis                     |
|----------------|----------------------------------------------------|--------|-------|----------|-------------------------------------------|
| 1.A.4.c ii (a) | Off-road Vehicles and Other Machinery: Agriculture | T1, T2 | NS, M | CS, D, M | <a href="#">see superordinate chapter</a> |



## Methodology

### Activity data

Subsector-specific consumption data is included in the primary fuel-delivery data are available from NEB line 67: 'Commercial, trade, services and other consumers' (AGEB, 2025) <sup>1)</sup>.

Table 1: Sources for primary fuel-delivery data

|              |                                                                                                    |
|--------------|----------------------------------------------------------------------------------------------------|
| through 1994 | AGEB - National Energy Balance, line 79: 'Haushalte und Kleinverbraucher insgesamt'                |
| as of 1995   | AGEB - National Energy Balance, line 67: 'Gewerbe, Handel, Dienstleistungen u. übrige Verbraucher' |

Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2025) <sup>2)</sup>, the remaining amounts of gasoline and diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and off-road vehicles in commercial/institutional use (1.A.4. ii) as well as agriculture and forestry (NFR 1.A.4.c ii) based upon annual shares derived from TREMOD-MM (Knörr et al. (2025b) <sup>3)</sup> (cf. NFR 1.A.4 - mobile).

Table 2: Annual contribution of agricultural vehicles and mobile machinery to the primary diesel<sup>1</sup> fuels delivery data provided in NEB line 67

| 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 62.4% | 76.6% | 78.5% | 79.7% | 71.8% | 65.8% | 65.2% | 64.3% | 64.7% | 63.9% | 63.0% | 63.6% | 63.9% | 64.0% | 64.1% |

<sup>1</sup> no gasoline used in agricultural vehicles and mobile machinery

Table 3: Annual mobile fuel consumption in agriculture, in terajoules

|            | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Diesel Oil | 69,792 | 74,870 | 74,621 | 65,374 | 63,723 | 68,028 | 68,589 | 68,503 | 66,785 | 67,578 | 66,459 | 67,392 | 65,178 | 64,519 | 65,219 |

|                         | 1990          | 1995          | 2000          | 2005          | 2010          | 2015          | 2016          | 2017          | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
|-------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>Biodiesel</b>        |               |               |               | 4,168         | 4,933         | 3,731         | 3,668         | 3,657         | 3,856         | 3,839         | 5,501         | 4,678         | 4,510         | 4,800         | 3,993         |
| <b>Σ 1.A.4.c ii (i)</b> | <b>69,792</b> | <b>74,870</b> | <b>74,621</b> | <b>69,542</b> | <b>68,656</b> | <b>71,760</b> | <b>72,257</b> | <b>72,161</b> | <b>70,640</b> | <b>71,417</b> | <b>71,960</b> | <b>72,071</b> | <b>69,688</b> | <b>69,319</b> | <b>69,212</b> |

## Emission factors

The emission factors applied here are of rather different quality: For all **main pollutants, carbon monoxide** and **particulate matter**, annual IEF modelled within TREMOD MM <sup>4)</sup> are used, representing the sector's vehicle-fleet composition, the development of mitigation technologies and the effect of fuel-quality legislation.

Table 4: Annual country-specific emission factors<sup>1</sup>, in kg/TJ

|                                                                   | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-------------------------------------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>NH<sub>3</sub></b>                                             | 0.16 | 0.16 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| <b>NMVO</b>                                                       | 237  | 216  | 191  | 155  | 119  | 90.3 | 84.9 | 79.8 | 74.6 | 70.2 | 66.0 | 61.3 | 56.7 | 51.9 | 47.2 |
| <b>NO<sub>x</sub></b>                                             | 889  | 897  | 924  | 836  | 684  | 559  | 537  | 515  | 494  | 476  | 458  | 437  | 416  | 394  | 374  |
| <b>SO<sub>x</sub></b>                                             | 79.6 | 60.5 | 14.0 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 |
| <b>BC<sup>2</sup></b>                                             | 119  | 105  | 88.9 | 71.7 | 55.7 | 43.6 | 41.0 | 38.6 | 36.3 | 34.3 | 32.3 | 30.2 | 28.2 | 25.9 | 23.6 |
| <b>PM<sub>2.5</sub>,<br/>PM<sub>10</sub>,<br/>TSP<sup>3</sup></b> | 218  | 192  | 163  | 128  | 94.4 | 69.6 | 65.0 | 60.8 | 56.6 | 53.1 | 49.9 | 46.5 | 43.3 | 39.9 | 36.4 |
| <b>CO</b>                                                         | 834  | 792  | 738  | 643  | 535  | 444  | 423  | 402  | 379  | 360  | 340  | 318  | 295  | 271  | 249  |

<sup>1</sup> due to lack of better information: similar EF are applied for fossil and biofuels

<sup>2</sup> estimated via a f-BCs as provided in <sup>5)</sup>, Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery

<sup>3</sup> EF(PM<sub>2.5</sub>) also applied for PM<sub>10</sub> and TSP (assumption: > 99% of TSP consists of PM<sub>2.5</sub>)



**NOTE:** With respect to the country-specific emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Recalculations

In addition to the revision of **primary activity data** from the National Energy Balances 2003-2023, annual shares estimated in TREMOD MM <sup>6)</sup> have been updated as follows:

Table 5: Revised annual shares of NEB line 67, in %

|                            | 1990  | 1995  | 2000  | 2005  | 2010  | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|----------------------------|-------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>current submission</b>  | 0.624 | 0.766 | 0.785 | 0.797 | 0.718 | 0.658  | 0.652  | 0.643  | 0.647  | 0.639  | 0.630  | 0.636  | 0.639  | 0.640  |
| <b>previous submission</b> | 0.624 | 0.766 | 0.785 | 0.796 | 0.718 | 0.674  | 0.669  | 0.667  | 0.692  | 0.681  | 0.678  | 0.695  | 0.718  | 0.740  |
| <b>absolute change</b>     | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | -0.016 | -0.017 | -0.023 | -0.045 | -0.042 | -0.048 | -0.059 | -0.079 | -0.100 |
| <b>relative change</b>     | 0.00% | 0.00% | 0.00% | 0.09% | 0.06% | -2.32% | -2.53% | -3.50% | -6.55% | -6.22% | -7.07% | -8.52% | -11.1% | -13.5% |

Resulting from these changes, source-specific **activity data** has been revised accordingly:

Table 7: Revised activity data, in terajoules [TJ]

|                            | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023    |
|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| <b>current submission</b>  | 69,792 | 74,870 | 74,621 | 69,542 | 68,656 | 71,760 | 72,257 | 72,161 | 70,640 | 71,417 | 71,960 | 72,071 | 69,688 | 69,319  |
| <b>previous submission</b> | 69,792 | 74,870 | 74,621 | 69,662 | 68,660 | 73,512 | 74,178 | 74,856 | 75,495 | 76,115 | 76,515 | 79,073 | 78,635 | 80,158  |
| <b>absolute change</b>     |        |        |        | -121   | -3.79  | -1,752 | -1,922 | -2,695 | -4,854 | -4,697 | -4,555 | -7,003 | -8,947 | -10,839 |
| <b>relative change</b>     | 0.00%  | 0.00%  | 0.00%  | -0.17% | -0.01% | -2.38% | -2.59% | -3.60% | -6.43% | -6.17% | -5.95% | -8.86% | -11.4% | -13.5%  |

In addition, several country-specific **emission factors** have been updated in TREMOD MM.

Table 8: Revised country-specific emission factors from TREMOD MM, in [kg/TJ]

|                            | 1990  | 1995  | 2000  | 2005  | 2010  | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|----------------------------|-------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>ammonia</b>             |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 0.157 | 0.160 | 0.163 | 0.166 | 0.167 | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  |
| <b>previous submission</b> | 0.157 | 0.160 | 0.163 | 0.166 | 0.167 | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  | 0.167  |
| <b>absolute change</b>     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   |
| <b>relative change</b>     | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.05%  | 0.05%  | 0.07%  | 0.12%  | 0.11%  | 0.10%  | 0.14%  | 0.19%  | 0.22%  |
| <b>NMVOC</b>               |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 237   | 216   | 191   | 155   | 119   | 90.3   | 84.9   | 79.8   | 74.6   | 70.2   | 66.0   | 61.3   | 56.7   | 51.9   |
| <b>previous submission</b> | 237   | 216   | 191   | 155   | 119   | 90.8   | 85.4   | 80.3   | 75.5   | 70.9   | 66.6   | 62.1   | 57.6   | 52.9   |
| <b>absolute change</b>     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | -0.45  | -0.45  | -0.57  | -0.92  | -0.75  | -0.60  | -0.79  | -0.91  | -0.99  |
| <b>relative change</b>     | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | -0.50% | -0.53% | -0.71% | -1.21% | -1.06% | -0.91% | -1.27% | -1.58% | -1.87% |
| <b>nitrogen oxides</b>     |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 889   | 897   | 924   | 836   | 684   | 559    | 537    | 515    | 494    | 476    | 458    | 437    | 416    | 394    |
| <b>previous submission</b> | 889   | 897   | 924   | 836   | 684   | 560    | 538    | 517    | 497    | 479    | 460    | 440    | 420    | 399    |
| <b>absolute change</b>     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | -0.98  | -1.12  | -1.57  | -2.84  | -2.60  | -2.33  | -3.33  | -4.06  | -4.66  |
| <b>relative change</b>     | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | -0.17% | -0.21% | -0.30% | -0.57% | -0.54% | -0.51% | -0.76% | -0.97% | -1.17% |
| <b>sulphur oxides</b>      |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 79.6  | 60.5  | 14.0  | 0.37  | 0.37  | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   |
| <b>previous submission</b> | 79.6  | 60.5  | 14.0  | 0.37  | 0.37  | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   |
| <b>absolute change</b>     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   |
| <b>relative change</b>     | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  |
| <b>black carbon (BC)</b>   |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 118.9 | 104.5 | 88.9  | 71.7  | 55.7  | 43.6   | 41.0   | 38.6   | 36.3   | 34.3   | 32.3   | 30.2   | 28.2   | 25.9   |
| <b>previous submission</b> | 118.9 | 104.5 | 88.9  | 71.7  | 55.7  | 43.7   | 41.2   | 38.8   | 36.6   | 34.5   | 32.4   | 30.4   | 28.4   | 26.1   |
| <b>absolute change</b>     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | -0.16  | -0.15  | -0.18  | -0.27  | -0.20  | -0.14  | -0.16  | -0.17  | -0.18  |
| <b>relative change</b>     | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | -0.37% | -0.37% | -0.47% | -0.75% | -0.59% | -0.44% | -0.54% | -0.59% | -0.69% |
| <b>particulate matter</b>  |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 218   | 192   | 163   | 128   | 94.4  | 69.6   | 65.0   | 60.8   | 56.6   | 53.1   | 49.9   | 46.5   | 43.3   | 39.9   |
| <b>previous submission</b> | 218   | 192   | 163   | 128   | 94.4  | 69.9   | 65.3   | 61.1   | 57.2   | 53.6   | 50.2   | 46.8   | 43.7   | 40.3   |

|                            | 1990  | 1995  | 2000  | 2005  | 2010  | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|----------------------------|-------|-------|-------|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>absolute change</b>     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | -0.29  | -0.29  | -0.35  | -0.54  | -0.42  | -0.31  | -0.37  | -0.38  | -0.38  |
| <b>relative change</b>     | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | -0.42% | -0.44% | -0.57% | -0.95% | -0.78% | -0.62% | -0.79% | -0.87% | -0.96% |
| <b>carbon monoxide</b>     |       |       |       |       |       |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 834   | 792   | 738   | 643   | 535   | 444    | 423    | 402    | 379    | 360    | 340    | 318    | 295    | 271    |
| <b>previous submission</b> | 834   | 792   | 738   | 643   | 535   | 446    | 425    | 404    | 383    | 363    | 343    | 322    | 300    | 277    |
| <b>absolute change</b>     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | -1.76  | -1.82  | -2.37  | -3.98  | -3.41  | -2.90  | -4.02  | -4.92  | -5.67  |
| <b>relative change</b>     | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | -0.39% | -0.43% | -0.59% | -1.04% | -0.94% | -0.85% | -1.25% | -1.64% | -2.05% |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following chapter [8.1 - Recalculations](#).

<sup>1)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl-daten für die Bundesrepublik Deutschland;

[https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>3), 4), 6)</sup> Knörr et al. (2025b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2025, Heidelberg, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2025.

<sup>5)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; Copenhagen, 2023

# 1.A.4.c ii (b) - Off-road Vehicles and other Machinery: Forestry



inventory data for off-road vehicles and machinery in forestry

## Short description

Under sub-category 1.A.4.c ii (b) fuel combustion activities and resulting emissions from off-road vehicles and mobile machinery used in forestry are reported.



| NFR-Code       | Source category                                 | Method | AD    | EF       | Key Category Analysis                     |
|----------------|-------------------------------------------------|--------|-------|----------|-------------------------------------------|
| 1.A.4.c ii (b) | Off-road Vehicles and Other Machinery: Forestry | T1, T2 | NS, M | CS, D, M | <a href="#">see superordinate chapter</a> |

## Methodology

### Activity data

Primary activity data (PAD) are taken from National Energy Balances (NEBs) line 67: 'Commercial, trade, services and other consumers' (AGEB, 2025) <sup>1)</sup>.

Following the deduction of energy inputs for military vehicles as provided in (BAFA, 2025) <sup>2)</sup>, the remaining amounts of gasoline and diesel oil are apportioned onto off-road construction vehicles (NFR 1.A.2.g vii) and off-road vehicles in commercial/institutional use (1.A.4. ii) as well as agriculture and forestry (NFR 1.A.4.c ii) based upon annual shares derived from TREMOD MM (Knörr et al. (2025b) <sup>3)</sup> (cf. NFR 1.A.4 - mobile).

Table 1: Annual contribution of forestry vehicles and mobile machinery to the primary fuel delivery data provided in NEB line 67

|                                                        | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|--------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| DIESEL FUELS                                           | 1.91% | 0.63% | 0.87% | 1.12% | 1.55% | 1.78% | 1.62% | 1.68% | 1.96% | 2.11% | 2.54% | 2.56% | 2.52% | 2.32% | 1.95% |
| GASOLINE FUELS                                         | 68.5% | 40.3% | 44.9% | 41.4% | 35.5% | 32.0% | 29.1% | 28.9% | 32.1% | 32.9% | 36.5% | 36.6% | 36.2% | 33.8% | 29.1% |
| source: own estimates based on TREMOD MM <sup>4)</sup> |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |

Table 2: Annual mobile fuel consumption in forestry, in terajoules

|                          | 1990         | 1995         | 2000         | 2005         | 2010         | 2015         | 2016         | 2017         | 2018         | 2019         | 2020         | 2021         | 2022         | 2023         | 2024         |
|--------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>Diesel Oil</b>        | 2,133        | 615          | 831          | 920          | 1,379        | 1,838        | 1,707        | 1,791        | 2,019        | 2,232        | 2,680        | 2,708        | 2,573        | 2,341        | 1,981        |
| <b>Gasoline</b>          | 3,093        | 3,004        | 3,324        | 3,020        | 1,806        | 1,680        | 1,543        | 1,641        | 1,901        | 2,085        | 2,455        | 2,481        | 2,361        | 2,211        | 1,900        |
| <b>Biodiesel</b>         |              |              |              | 58.6         | 107          | 101          | 91.3         | 95.6         | 117          | 127          | 222          | 188          | 178          | 174          | 121          |
| <b>Biogasoline</b>       |              |              |              | 20.5         | 60.6         | 70.5         | 65.0         | 68.1         | 82.9         | 87.2         | 109          | 114          | 109          | 105          | 88.9         |
| <b>Σ 1.A.4.c ii (ii)</b> | <b>5,226</b> | <b>3,619</b> | <b>4,155</b> | <b>4,019</b> | <b>3,352</b> | <b>3,689</b> | <b>3,406</b> | <b>3,596</b> | <b>4,120</b> | <b>4,531</b> | <b>5,466</b> | <b>5,492</b> | <b>5,222</b> | <b>4,831</b> | <b>4,091</b> |

## Emission factors

The emission factors used here are of rather different quality: For all **main pollutants**, **carbon monoxide** and **particulate matter**, annually changing values computed within TREMOD MM (Knörr et al. (2025b))<sup>5)</sup> are used, representing the development of mitigation technologies and the effect of fuel-quality legislation.

Table 3: Annual country-specific emission factors from TREMOD MM<sup>1)</sup>

|                                                                    | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|--------------------------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>DIESEL FUELS</b>                                                |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NH<sub>3</sub></b>                                              | 0.16   | 0.17   | 0.17   | 0.18   | 0.18   | 0.18   | 0.18   | 0.18   | 0.18   | 0.18   | 0.18   | 0.18   | 0.18   | 0.18   | 0.18   |
| <b>NM VOC</b>                                                      | 191    | 156    | 130    | 80.2   | 46.5   | 27.7   | 24.1   | 20.6   | 17.5   | 14.7   | 12.2   | 10.1   | 8.34   | 6.79   | 5.49   |
| <b>NO<sub>x</sub></b>                                              | 981    | 1,052  | 1,071  | 834    | 543    | 373    | 343    | 310    | 282    | 255    | 229    | 203    | 177    | 153    | 132    |
| <b>SO<sub>x</sub></b>                                              | 79.6   | 60.5   | 14.0   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   |
| <b>BC<sup>5)</sup></b>                                             | 84.5   | 60.7   | 41.7   | 27.7   | 21.6   | 16.2   | 14.6   | 13.1   | 11.7   | 10.4   | 9.03   | 7.72   | 6.43   | 5.23   | 4.18   |
| <b>PM<sub>2.5</sub>,<br/>PM<sub>10</sub>,<br/>TSP<sup>4)</sup></b> | 155    | 111    | 75.8   | 45.3   | 30.4   | 20.8   | 18.6   | 16.7   | 14.9   | 13.2   | 11.6   | 10.0   | 8.55   | 7.22   | 6.08   |
| <b>CO</b>                                                          | 688    | 618    | 554    | 395    | 282    | 214    | 194    | 173    | 153    | 134    | 116    | 99.4   | 84.1   | 70.3   | 58.2   |
| <b>GASOLINE FUELS</b>                                              |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>NH<sub>3</sub></b>                                              | 0.075  | 0.083  | 0.083  | 0.086  | 0.087  | 0.092  | 0.092  | 0.092  | 0.092  | 0.092  | 0.092  | 0.092  | 0.092  | 0.092  | 0.092  |
| <b>NM VOC<sup>2)</sup></b>                                         | 5,819  | 5,099  | 5,099  | 5,320  | 5,424  | 2,897  | 2,897  | 2,897  | 2,897  | 2,901  | 2,910  | 2,915  | 2,915  | 2,915  | 2,915  |
| <b>NM VOC<sup>3)</sup></b>                                         | 3.04   | 6.37   | 4.67   | 4.56   | 4.83   | 5.00   | 5.32   | 5.19   | 4.30   | 4.03   | 3.46   | 3.35   | 3.53   | 3.94   | 4.54   |
| <b>NO<sub>x</sub></b>                                              | 42.7   | 49.4   | 49.4   | 76.4   | 86.0   | 55.1   | 55.1   | 55.1   | 55.1   | 55.1   | 55.1   | 55.1   | 55.1   | 55.1   | 55.1   |
| <b>SO<sub>x</sub></b>                                              | 10.1   | 8.27   | 3.22   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   | 0.37   |
| <b>BC<sup>5)</sup></b>                                             | 5.09   | 3.73   | 3.73   | 3.86   | 3.91   | 4.13   | 4.13   | 4.13   | 4.13   | 4.13   | 4.13   | 4.13   | 4.13   | 4.13   | 4.13   |
| <b>PM<sub>2.5</sub>,<br/>PM<sub>10</sub>,<br/>TSP<sup>4)</sup></b> | 102    | 74.6   | 74.6   | 77.2   | 78.1   | 82.7   | 82.7   | 82.7   | 82.7   | 82.7   | 82.7   | 82.7   | 82.7   | 82.7   | 82.7   |
| <b>CO</b>                                                          | 16,824 | 14,796 | 14,796 | 15,371 | 15,609 | 16,514 | 16,514 | 16,514 | 16,514 | 16,514 | 16,514 | 16,514 | 16,514 | 16,514 | 16,514 |
| in addition, from leaded gasoline banned after 1997:               |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>Pb</b>                                                          | 1.47   | 0.52   |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>TSP</b>                                                         | 2.35   | 0.82   |        |        |        |        |        |        |        |        |        |        |        |        |        |

<sup>1)</sup> due to lack of better information: similar EF are applied for fossil and biofuels

<sup>2)</sup> from fuel combustion

<sup>3)</sup> from gasoline evaporation

<sup>4)</sup> EF(PM<sub>2.5</sub>) also applied for PM<sub>10</sub> and TSP (assumption: > 99% of TSP consists of PM<sub>2.5</sub>)

<sup>5)</sup> estimated via a f-BCs as provided in <sup>6)</sup>, Chapter 1.A.2.g vii, 1.A.4.a ii, b ii, c ii, 1.A.5.b i - Non-road, note to Table 3-1: Tier 1 emission factors for off-road machinery



With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>7)</sup>

For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Recalculations

In addition to the revision of **primary activity data** from the National Energy Balances 2003-2023, annual shares estimated in TREMOD MM <sup>7)</sup> have been updated as follows:

Table 6: Revised annual shares of NEB line 67, in %

|                            | 1990   | 1995   | 2000   | 2005   | 2010   | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  |
|----------------------------|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| DIESEL FUELS               |        |        |        |        |        |       |       |       |       |       |       |       |       |       |
| <b>currents submission</b> | 0.019  | 0.006  | 0.009  | 0.011  | 0.016  | 0.018 | 0.016 | 0.017 | 0.020 | 0.021 | 0.025 | 0.026 | 0.025 | 0.023 |
| <b>previous submission</b> | 0.019  | 0.006  | 0.009  | 0.011  | 0.016  | 0.017 | 0.015 | 0.016 | 0.017 | 0.019 | 0.022 | 0.021 | 0.020 | 0.017 |
| <b>absolute change</b>     | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.001 | 0.001 | 0.001 | 0.003 | 0.002 | 0.003 | 0.004 | 0.006 | 0.006 |
| <b>relative change</b>     | -0.03% | -0.02% | -0.01% | -0.37% | -0.16% | 4.79% | 5.10% | 7.00% | 14.7% | 13.3% | 14.9% | 19.4% | 28.2% | 38.5% |
| GASOLINE FUELS             |        |        |        |        |        |       |       |       |       |       |       |       |       |       |
| <b>currents submission</b> | 0.685  | 0.403  | 0.449  | 0.414  | 0.355  | 0.320 | 0.291 | 0.289 | 0.321 | 0.329 | 0.365 | 0.366 | 0.362 | 0.338 |
| <b>previous submission</b> | 0.685  | 0.403  | 0.449  | 0.414  | 0.355  | 0.320 | 0.291 | 0.289 | 0.321 | 0.329 | 0.365 | 0.366 | 0.362 | 0.338 |
| <b>absolute change</b>     | 0.000  | 0.000  | 0.000  | 0.000  | 0.000  | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| <b>relative change</b>     | -0.01% | -0.01% | -0.01% | 0.00%  | 0.00%  | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

Resulting from these changes, source-specific **activity data** has been revised accordingly:

Table 7: Revised activity data, in terajoules [TJ]

|                            | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| DIESEL FUELS               |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 2,133  | 615    | 831    | 979    | 1,486  | 1,938  | 1,798  | 1,886  | 2,136  | 2,359  | 2,902  | 2,896  | 2,751  | 2,515  |
| <b>previous submission</b> | 2,134  | 615    | 831    | 985    | 1,489  | 1,851  | 1,712  | 1,765  | 1,859  | 2,081  | 2,496  | 2,435  | 2,153  | 1,816  |
| <b>absolute change</b>     | -0.56  | -0.14  | -0.11  | -6.26  | -3.44  | 87.4   | 86.2   | 122    | 277    | 278    | 406    | 462    | 598    | 700    |
| <b>relative change</b>     | -0.03% | -0.02% | -0.01% | -0.64% | -0.23% | 4.72%  | 5.04%  | 6.89%  | 14.9%  | 13.4%  | 16.3%  | 19.0%  | 27.8%  | 38.5%  |
| GASOLINE FUELS             |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 3,093  | 3,004  | 3,324  | 3,040  | 1,866  | 1,750  | 1,608  | 1,709  | 1,984  | 2,172  | 2,563  | 2,596  | 2,470  | 2,316  |
| <b>previous submission</b> | 3,093  | 3,005  | 3,324  | 3,050  | 3,661  | 2,971  | 2,608  | 2,538  | 2,849  | 3,005  | 3,323  | 3,418  | 3,331  | 3,076  |
| <b>absolute change</b>     | -0.22  | -0.28  | -0.18  | -9.72  | -1.795 | -1.221 | -1.000 | -829   | -865   | -833   | -760   | -823   | -861   | -760   |
| <b>relative change</b>     | -0.01% | -0.01% | -0.01% | -0.32% | -49%   | -41.1% | -38.3% | -32.6% | -30.4% | -27.7% | -22.9% | -24.1% | -25.8% | -24.7% |
| OVER-ALL FUEL CONSUMPTION  |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>current submission</b>  | 5,226  | 3,619  | 4,155  | 4,019  | 3,352  | 3,689  | 3,406  | 3,596  | 4,120  | 4,531  | 5,466  | 5,492  | 5,222  | 4,831  |
| <b>previous submission</b> | 5,227  | 3,620  | 4,155  | 4,035  | 5,150  | 4,822  | 4,319  | 4,303  | 4,708  | 5,086  | 5,819  | 5,853  | 5,485  | 4,892  |
| <b>absolute change</b>     | -0.78  | -0.42  | -0.29  | -16.0  | -1.798 | -1.133 | -914   | -707   | -588   | -555   | -354   | -361   | -263   | -60.1  |
| <b>relative change</b>     | -0.01% | 0.0%   | 0.0%   | -0.4%  | -34.9% | -23.5% | -21.2% | -16.4% | -12.5% | -10.9% | -6.1%  | -6.17% | -4.8%  | -1.23% |

In contrast, all country-specific **emission factors** derived from TREMOD MM remain unaltered.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following chapter [8.1 - Recalculations](#).

<sup>1)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl-daten für die Bundesrepublik Deutschland;

[https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>3), 4), 5), 7)</sup> Knörr et al. (2025b): Knörr, W., Heide, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOD MM) 2025, Heidelberg, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2025.

<sup>6)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; Copenhagen, 2023

<sup>7)</sup>

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likelihood of condensation. So over-all condensables are very likely to occur but different to real-world conditions.





NFR-specific inventory data

In NFR sub-category 1.A.4.c *iii* fuel consumption and emissions of Germany's maritime fishing fleet are reported.

| Category Code                                                                             | Method                               | AD    | EF               |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|------------------|
| 1.A.4.c iii                                                                               | T1, T2                               | NS, M | D, M, CS, T1, T2 |
| Method(s) applied                                                                         |                                      |       |                  |
| D                                                                                         | Default                              |       |                  |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |                  |
| T2                                                                                        | Tier 2*                              |       |                  |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |                  |
| C                                                                                         | CORINAIR                             |       |                  |
| CS                                                                                        | Country Specific                     |       |                  |
| M                                                                                         | Model                                |       |                  |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |                  |
| (source for) Activity Data                                                                |                                      |       |                  |
| NS                                                                                        | National Statistics                  |       |                  |
| RS                                                                                        | Regional Statistics                  |       |                  |
| IS                                                                                        | International Statistics             |       |                  |
| PS                                                                                        | Plant Specific                       |       |                  |
| As                                                                                        | Associations, business organisations |       |                  |
| Q                                                                                         | specific Questionnaires (or surveys) |       |                  |
| M                                                                                         | Model / Modelled                     |       |                  |
| C                                                                                         | Confidential                         |       |                  |
| (source for) Emission Factors                                                             |                                      |       |                  |
| D                                                                                         | Default (EMEP Guidebook)             |       |                  |
| CS                                                                                        | Country Specific                     |       |                  |
| PS                                                                                        | Plant Specific                       |       |                  |
| M                                                                                         | Model / Modelled                     |       |                  |
| C                                                                                         | Confidential                         |       |                  |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                    | TSP | BC  | CO  | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|
| -/-             | -/-    | -/-             | -/-             | -/-               | -/-                                                                                 | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | -/- | -/-  |
|                 |        |                 |                 | L/-               | key source by <b>Level</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | -/T               | key source by <b>Trend</b> only                                                     |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | L/T               | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | IE                | emission of specific pollutant Included <b>Elsewhere</b> (i.e. in another category) |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | *                 | no analysis done                                                                    |     |     |     |     |     |     |     |     |     |     |     |     |        |       |       |       |       |        |     |      |



|                                                                                                                                                                                                    | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>NH<sub>3</sub></b>                                                                                                                                                                              | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  | 0.32  |
| <b>NMVOC</b>                                                                                                                                                                                       | 58.9  | 58.9  | 58.9  | 58.9  | 58.9  | 69.6  | 68.2  | 64.3  | 58.0  | 58.7  | 57.5  | 58.7  | 57.8  | 62.1  | 58.4  |
| <b>NO<sub>x</sub></b>                                                                                                                                                                              | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,120 | 1,126 | 1,114 | 1,103 | 1,109 | 1,117 | 1,113 | 1,108 | 1,110 | 1,113 |
| <b>SO<sub>x</sub></b>                                                                                                                                                                              | 466   | 419   | 233   | 186   | 69.8  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  |
| <b>BC<sup>2</sup></b>                                                                                                                                                                              | 1.70  | 1.70  | 1.70  | 1.70  | 1.70  | 1.82  | 1.85  | 1.80  | 1.77  | 1.75  | 1.69  | 1.68  | 1.69  | 1.72  | 1.75  |
| <b>PM<sub>2.5</sub></b>                                                                                                                                                                            | 35.3  | 35.3  | 35.3  | 35.3  | 35.3  | 37.7  | 38.4  | 37.4  | 36.8  | 36.2  | 35.1  | 34.8  | 35.1  | 35.7  | 36.4  |
| <b>PM<sub>10</sub></b>                                                                                                                                                                             | 37.8  | 37.8  | 37.8  | 37.8  | 37.8  | 40.4  | 41.1  | 40.0  | 39.4  | 38.8  | 37.5  | 37.2  | 37.6  | 38.2  | 38.9  |
| <b>TSP</b>                                                                                                                                                                                         | 37.8  | 37.8  | 37.8  | 37.8  | 37.8  | 40.4  | 41.1  | 40.0  | 39.4  | 38.8  | 37.5  | 37.2  | 37.6  | 38.2  | 38.9  |
| <b>CO</b>                                                                                                                                                                                          | 51.3  | 51.3  | 51.3  | 51.3  | 51.3  | 53.3  | 52.2  | 53.3  | 52.4  | 55.9  | 56.5  | 56.6  | 55.8  | 53.1  | 54.7  |
| <b>HEAVY FUEL OIL</b>                                                                                                                                                                              |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>NH<sub>3</sub></b>                                                                                                                                                                              | 0.33  | 0.33  | 0.33  | 0.33  | 0.33  |       |       |       |       |       | NA    |       |       |       |       |
| <b>NMVOC</b>                                                                                                                                                                                       | 36.4  | 36.4  | 36.4  | 36.4  | 36.4  |       |       |       |       |       | NA    |       |       |       |       |
| <b>NO<sub>x</sub></b>                                                                                                                                                                              | 1,258 | 1,258 | 1,258 | 1,258 | 1,258 |       |       |       |       |       | NA    |       |       |       |       |
| <b>SO<sub>x</sub></b>                                                                                                                                                                              | 1,319 | 1,332 | 1,323 | 1,336 | 496   |       |       |       |       |       | NA    |       |       |       |       |
| <b>BC<sup>22</sup></b>                                                                                                                                                                             | 64.9  | 65.5  | 65.1  | 65.7  | 24.4  |       |       |       |       |       | NA    |       |       |       |       |
| <b>PM<sub>2.5</sub><sup>3</sup></b>                                                                                                                                                                | 541   | 546   | 542   | 548   | 203   |       |       |       |       |       | NA    |       |       |       |       |
| <b>PM<sub>10</sub></b>                                                                                                                                                                             | 595   | 601   | 597   | 602   | 224   |       |       |       |       |       | NA    |       |       |       |       |
| <b>TSP</b>                                                                                                                                                                                         | 595   | 601   | 597   | 602   | 224   |       |       |       |       |       | NA    |       |       |       |       |
| <b>CO</b>                                                                                                                                                                                          | 200   | 200   | 200   | 200   | 200   |       |       |       |       |       | NA    |       |       |       |       |
| <sup>1</sup> similar EF applied to diesel oil and light fuel oil                                                                                                                                   |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <sup>2</sup> estimated from a BC-fraction derived from <sup>5)</sup> , chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Table 3-1 (0.017 for heavy fuel oil) and 3-2 (0.045 for diesel oil) |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <sup>3</sup> ratios PM <sub>2.5</sub> : PM <sub>10</sub> : TSP derived from the tier1 default EF as provided in <sup>6)</sup>                                                                      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |



**NOTE:** For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Trend discussion for Key Sources

**NFR 1.A.4.c iii - National Fishing** is no key source.



## Recalculations

With all **activity data** remaining unaltered, changes against the previous submission result solely from revised **implied emisison factors** computed within the E.M.M.A. model maintianes at BSH <sup>7)</sup>. Here, the most significant changes occur for BC and particulate matter for which default values from the EMEP/EEA guidebook 2023 have been implemented:

Table: Revised emission factors, in [kg/T]

|                               | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   |
|-------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| DIESEL / LIGHT FUEL OIL       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Black carbon - BC             |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission            | 1,70   | 1,70   | 1,70   | 1,70   | 1,70   | 1,82   | 1,85   | 1,80   | 1,77   | 1,75   | 1,69   | 1,68   | 1,69   | 1,72   |
| previous submission           | 83,7   | 75,3   | 41,8   | 33,5   | 12,5   | 12,5   | 12,7   | 12,4   | 12,2   | 12,0   | 11,6   | 11,5   | 11,7   | 11,8   |
| absolute change               | -82,0  | -73,6  | -40,1  | -31,8  | -10,8  | -10,7  | -10,9  | -10,6  | -10,4  | -10,3  | -9,94  | -9,87  | -9,96  | -10,1  |
| relative change               | -98,0% | -97,7% | -95,9% | -94,9% | -86,5% | -85,5% | -85,5% | -85,5% | -85,5% | -85,5% | -85,5% | -85,5% | -85,5% | -85,5% |
| Particulate matter 2.5µm      |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission            | 35,3   | 35,3   | 35,3   | 35,3   | 35,3   | 37,7   | 38,4   | 37,4   | 36,8   | 36,2   | 35,1   | 34,8   | 35,1   | 35,7   |
| previous submission           | 270    | 243    | 135    | 108    | 40,5   | 40,4   | 41,1   | 40,0   | 39,4   | 38,8   | 37,5   | 37,2   | 37,6   | 38,2   |
| absolute change               | -235   | -208   | -99,6  | -72,6  | -5,17  | -2,64  | -2,69  | -2,62  | -2,58  | -2,54  | -2,45  | -2,44  | -2,46  | -2,50  |
| relative change               | -86,9% | -85,5% | -73,8% | -67,3% | -12,8% | -6,54% | -6,54% | -6,5%  | -6,5%  | -6,5%  | -6,5%  | -6,5%  | -6,5%  | -6,5%  |
| Particulate matter 10µm & TSP |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission            | 37,8   | 37,8   | 37,8   | 37,8   | 37,8   | 40,4   | 41,1   | 40,0   | 39,4   | 38,8   | 37,5   | 37,2   | 37,6   | 38,2   |
| previous submission           | 289    | 260    | 144    | 115    | 43,3   | 43,2   | 43,9   | 42,8   | 42,1   | 41,5   | 40,1   | 39,8   | 40,2   | 40,9   |
| absolute change               | -251   | -222   | -106,6 | -77,7  | -5,53  | -2,83  | -2,87  | -2,80  | -2,76  | -2,71  | -2,63  | -2,61  | -2,63  | -2,68  |
| relative change               | -86,9% | -85,5% | -73,8% | -67,3% | -12,8% | -6,54% | -6,54% | -6,54% | -6,54% | -6,54% | -6,54% | -6,54% | -6,54% | -6,54% |
| Carbon monoxide - CO          |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission            | 51,3   | 51,3   | 51,3   | 51,3   | 51,3   | 53,3   | 52,2   | 53,3   | 52,4   | 55,9   | 56,5   | 56,6   | 55,8   | 53,1   |
| previous submission           | 102    | 102    | 102    | 102    | 102    | 110    | 112    | 109    | 107    | 106    | 103    | 103    | 103    | 100    |
| absolute change               | -50,3  | -50,3  | -50,3  | -50,3  | -50,3  | -57,0  | -60,2  | -56,0  | -54,7  | -49,9  | -46,6  | -46,3  | -47,3  | -47,0  |
| relative change               | -49,5% | -49,5% | -49,5% | -49,5% | -49,5% | -51,7% | -53,6% | -51,2% | -51,1% | -47,2% | -45,2% | -45,0% | -45,9% | -47,0% |
| HEAVY FUEL OIL                |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Black carbon - BC             |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission            | 3,40   | 3,44   | 3,42   | 3,45   | 3,45   |        |        |        |        |        |        |        |        |        |
| previous submission           | 64,9   | 65,5   | 65,1   | 65,7   | 24,4   |        |        |        |        |        |        |        |        |        |
| absolute change               | -61,5  | -62,1  | -61,7  | -62,3  | -20,9  |        |        |        |        |        |        |        |        |        |
| relative change               | -94,8% | -94,8% | -94,8% | -94,8% | -85,8% |        |        |        |        |        |        |        |        |        |
| Particulate matter 2.5µm      |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| current submission            | 187    | 189    | 188    | 190    | 190    |        |        |        |        |        |        |        |        |        |
| previous submission           | 541    | 546    | 542    | 548    | 203    |        |        |        |        |        |        |        |        |        |
| absolute change               | -354   | -357   | -354,7 | -358,1 | -13,29 |        |        |        |        |        |        |        |        |        |
| relative change               | -65,4% | -65,4% | -65,4% | -65,4% | -6,5%  |        |        |        |        |        |        |        |        |        |
| Particulate matter 10µm & TSP |        |        |        |        |        |        |        |        |        |        |        |        |        |        |

|                         | 1990   | 1995   | 2000   | 2005   | 2010   | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|-------------------------|--------|--------|--------|--------|--------|------|------|------|------|------|------|------|------|------|
| DIESEL / LIGHT FUEL OIL |        |        |        |        |        |      |      |      |      |      |      |      |      |      |
| current submission      | 200    | 202    | 201    | 203    | 203    |      |      |      |      |      |      |      |      |      |
| previous submission     | 595    | 601    | 597    | 602    | 224    |      |      |      |      |      |      |      |      |      |
| absolute change         | -395   | -398   | -396   | -400   | -20    |      |      |      |      |      |      |      |      |      |
| relative change         | -66,3% | -66,3% | -66,3% | -66,3% | -9,1%  |      |      |      |      |      |      |      |      |      |
| Carbon monoxide - CO    |        |        |        |        |        |      |      |      |      |      |      |      |      |      |
| current submission      | 74,3   | 74,3   | 74,3   | 74,3   | 74,3   |      |      |      |      |      |      |      |      |      |
| previous submission     | 200    | 200    | 200    | 200    | 200    |      |      |      |      |      |      |      |      |      |
| absolute change         | -126   | -126   | -126   | -126   | -126   |      |      |      |      |      |      |      |      |      |
| relative change         | -62,9% | -62,9% | -62,9% | -62,9% | -62,9% |      |      |      |      |      |      |      |      |      |

## Uncertainties

Uncertainty estimates for **emission factors** were adopted from NFR 1.A.3.d i as a comparable emission source.

## Planned improvements

Besides routine maintenance and further development of the BSH model, the proxy emission factors applied for PAH emissions from vessels/ships derived from tier1 defaults provided for railways and heavy-duty vehicles in the EMEP/EEA Guidebook 2019 will be replaced by values derived from Chapter 1.A.3.d Navigation (shipping) 2023 of the EMEP/EEA Guidebook 2023 (see also: [https://iir.umweltbundesamt.de/2026/general/planned\\_improvements/start](https://iir.umweltbundesamt.de/2026/general/planned_improvements/start) and [https://iir.umweltbundesamt.de/2026/appendices/appendix2.4\\_pops\\_from\\_mobile\\_sources](https://iir.umweltbundesamt.de/2026/appendices/appendix2.4_pops_from_mobile_sources)).

With respect to the strong increase in activity data from 2015 to 2016: This issue is under discussion with the BSH Hamburg as the agency in charge of the underlying model. However, these activity data are based on ship movement data showing a correspondingly increasing trend. Nonetheless, the model is under steady revision and erroneous calculations and results will be corrected whenever they are determined.

<sup>1)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2), 3), 7)</sup> Deichnik (2025): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs; Federal Maritime and Hydrographic Agency (BSH - Bundesamt für Seeschifffahrt und Hydrographie Hamburg); on behalf of the Umweltbundesamt, Hamburg / Dessau-Roßlau, 2025.

<sup>4), 5), 6)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, URL: <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-d-navigation>; Copenhagen, 2023.

## 1.A.5 - Other (including Military) (OVERVIEW)

### Short description

In category *1.A.5 - Other: Military* emissions from military fuel combustion (stationary and mobile) within Germany are reported.

| NFR-Code | Source category                                        |
|----------|--------------------------------------------------------|
| 1.A.5.a  | <a href="#">Other: Stationary (including Military)</a> |
| 1.A.5.b  | <a href="#">Other: Mobile (including Military)</a>     |

Within NFR sub-category *1.A.5.a*, emissions from **stationary fuel combustion in military facilities** are reported whereas within NFR sub-category *1.A.5.b*, emissions from **mobile military fuel combustion** in ground vehicles, aircraft and ships are reported.

For further details on sub-scetor specific acitivity data, emission factors and emissions please see the sub-category chapters linked above.

## 1.A.5.a - Other, Stationary (including Military)

### Short description

In sub-category 1.A.5.a - Other, Stationary (including Military) emissions from stationary fuel combustion in military facilities are reported.

| NFR Code                                                                                  | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 1.A.5.a                                                                                   | T2, T3                               | NS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                    | TSP | BC  | CO  | Pb | Cd | Hg  | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | I(x)P | PAHs | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|-------------------------------------------------------------------------------------|-----|-----|-----|----|----|-----|----|----|----|----|----|----|--------|-------|-------|-------|------|-----|------|
| -/-             | L/T    | -/-             | -/-             | -/-               | -/-                                                                                 | -/- | -/- | -/- | NE | NE | -/- | NE | NE | NE | NE | NE | NE | -/-    | -/-   | -/T   | -/-   | -/-  | -/- | -/-  |
|                 |        |                 |                 | L/-               | key source by <b>Level</b> only                                                     |     |     |     |    |    |     |    |    |    |    |    |    |        |       |       |       |      |     |      |
|                 |        |                 |                 | -/T               | key source by <b>Trend</b> only                                                     |     |     |     |    |    |     |    |    |    |    |    |    |        |       |       |       |      |     |      |
|                 |        |                 |                 | L/T               | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |    |    |     |    |    |    |    |    |    |        |       |       |       |      |     |      |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                    |     |     |     |    |    |     |    |    |    |    |    |    |        |       |       |       |      |     |      |
|                 |        |                 |                 | IE                | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |    |    |     |    |    |    |    |    |    |        |       |       |       |      |     |      |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |    |    |     |    |    |    |    |    |    |        |       |       |       |      |     |      |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |    |    |     |    |    |    |    |    |    |        |       |       |       |      |     |      |
|                 |        |                 |                 | *                 | no analysis done                                                                    |     |     |     |    |    |     |    |    |    |    |    |    |        |       |       |       |      |     |      |

### Methodology

#### Activity Data

The National Energy Balance of the Federal Republic of Germany (NEB) provides the basis for the activity data used.

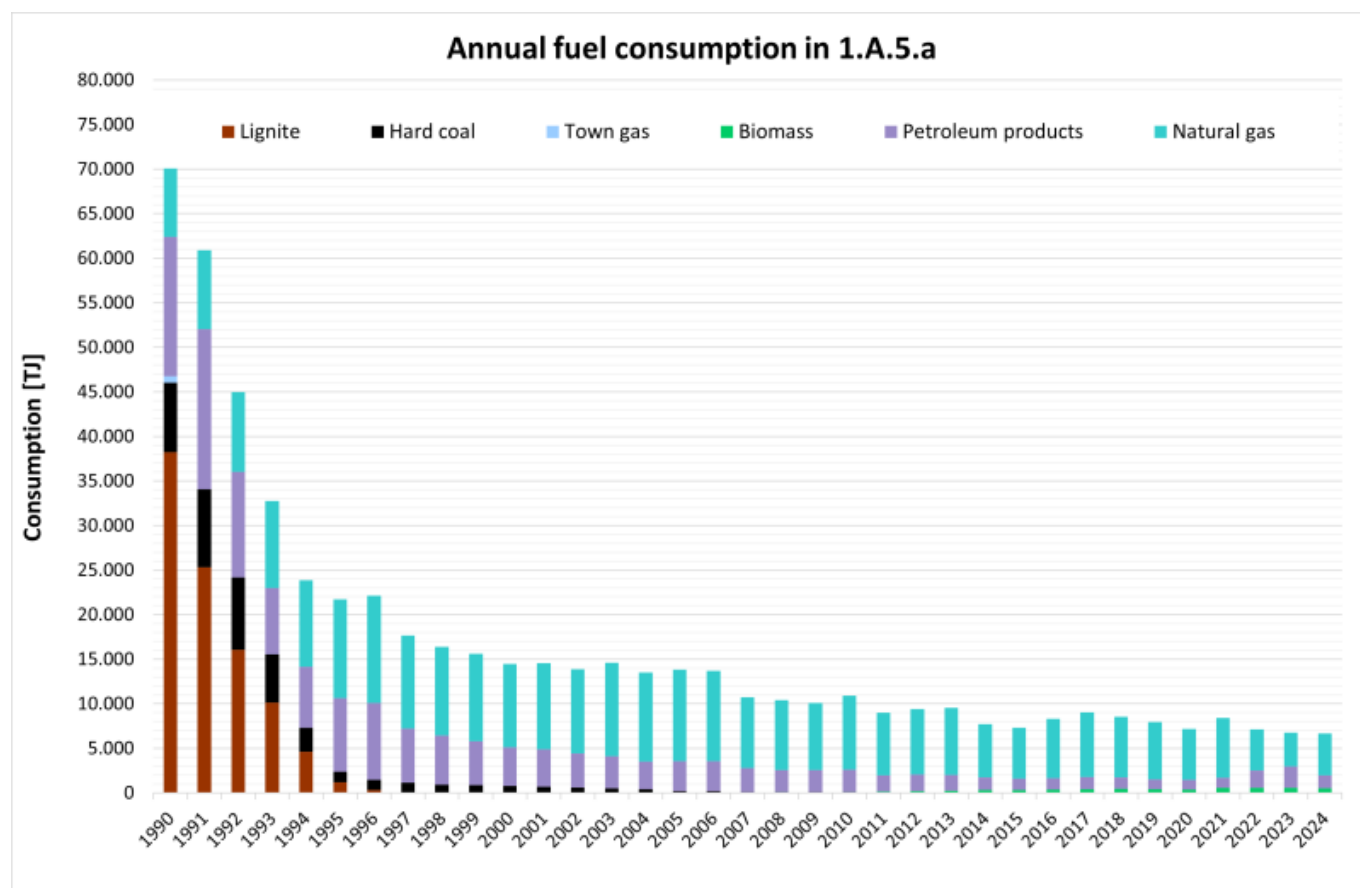
However, since 1995 the NEB does not provide separate listings of military agencies' final energy consumption. Instead, this data is included in NEB line 67: 'commerce, trade, services and other consumers'. Therefore, additional energy statistics and



fuel-specific data from the Federal Ministry of Defence (BMVg, 2020)<sup>1)</sup> is being used, providing the “Energy input for heat production in the German Federal Armed Forces” for all years as of 2000.

For liquid fuels, data is derived from the official mineral-oil data of the Federal Republic of Germany (Amtliche Mineralölstatistik der Bundesrepublik Deutschland), compiled annually by the Federal Office of Economics and Export Control (BAFA, 2025)<sup>2)</sup>. The consumption figures given in units of [1.000 t] are converted into [TJ] based on the relevant heating statistics published by the Working Group on Energy Balances.

All non-NEB figures are deducted from the over-all figures provided in NEB line 67 (commerce, trade, services) and are reported in 1.A.5, rather than in 1.A.4.



## Emission Factors

The database for the emission factors used for source category 1.A.5.a consists of the results of a research project carried out by the University of Stuttgart, under commission to the Federal Environment Agency (Struschka et al., 2008)<sup>3)</sup>. Within this project, device-related and source-category-specific emission factors for combustion systems in military agencies were calculated, with a high level of detail, for all important emissions components for the reference year 2005. The method used to determine the factors conforms to that described for source category 1.A.4.

Along with project results, calculations from experts are also used. The following table shows the sectoral emission factors for 1.A.5.a.

Table 1: Emission factors for Military stationary combustion plants

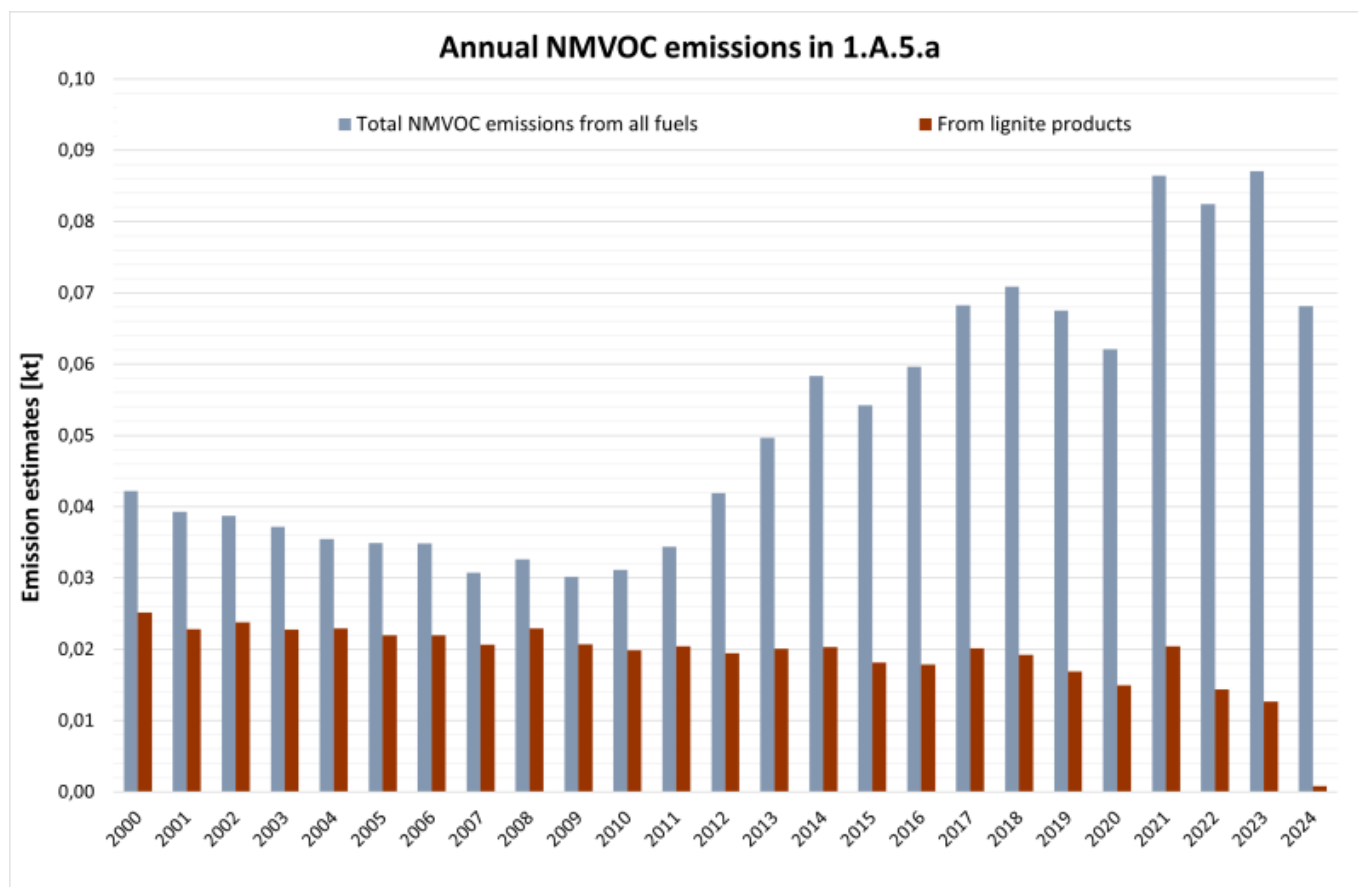
|                              | NO <sub>x</sub> | SO <sub>x</sub> | NM VOC |
|------------------------------|-----------------|-----------------|--------|
|                              | [kg/TJ]         |                 |        |
| <b>Hard coal</b>             | 132             | 608             | 1.2    |
| <b>Brown coal briquettes</b> | 68              | 161             | 421    |
| <b>Light heating oil</b>     | 44              | 2.4             | 2.6    |
| <b>Gaseous fuels</b>         | 25              | 0.14            | 0.34   |

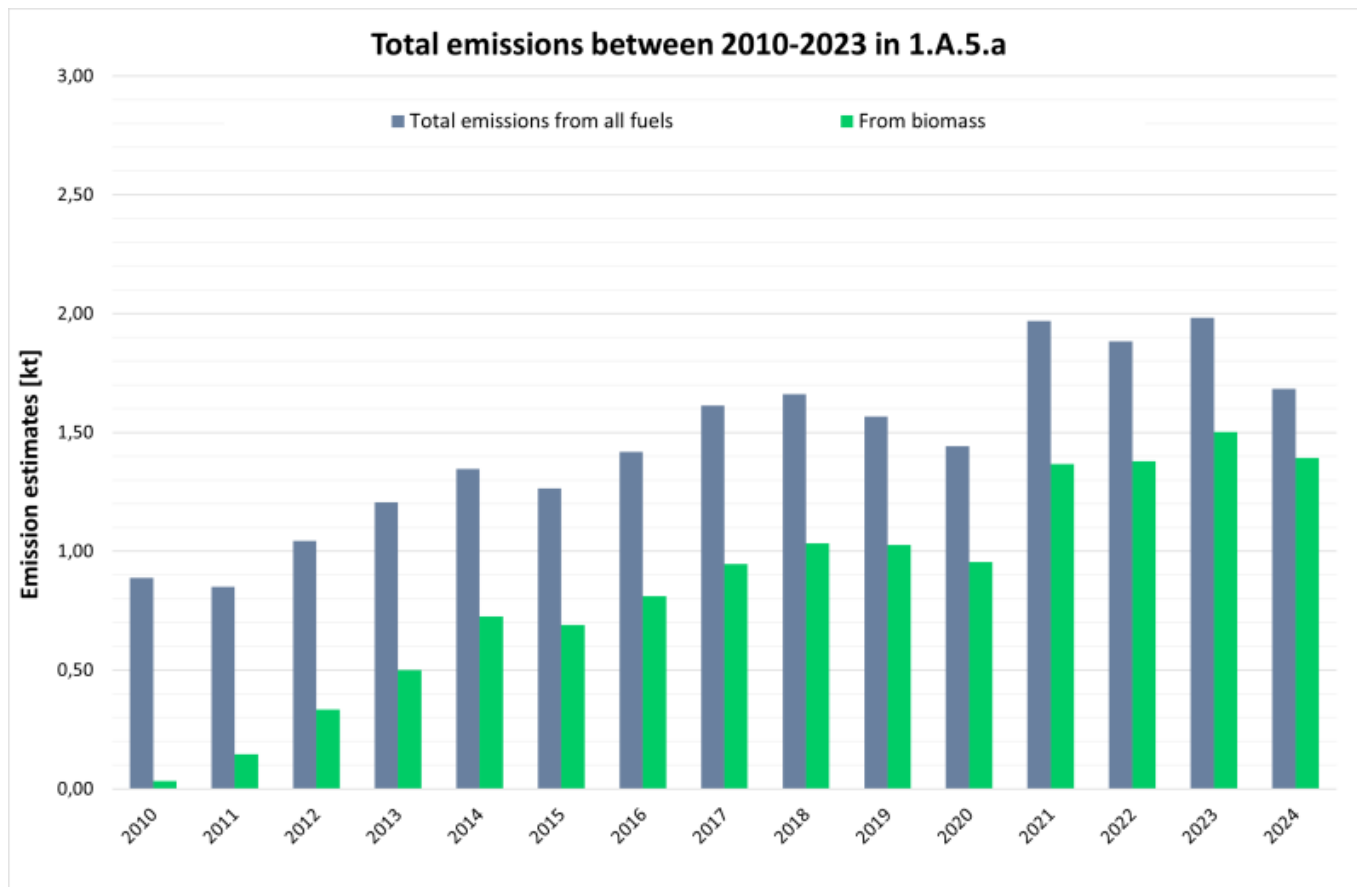
## Trend discussion for key sources

NMVOC emissions show a remarkable declining trend with an overall reduction of 99.95% between 1990 and 2023 due to the closure of military agencies especially at the beginning of the 1990s as well as the reduced use of lignite for heating purposes (see activity data chart above).

However, since 2010, total emissions are increasing again on a very low level due to the increased use of biomass.

The following charts give an overview of the emission trends.





## Recalculations

At the time of compiling the inventory, national energy balance is only available provisionally. Therefore, the finalization of the energy balance for 2023 led to recalculations. Moreover, for the purpose of improving data quality, national energy balances go under revisions every two years (for the years starting from 2003) through fine-tuning of the computational models, consideration of new statistics or re-allocation of activity data. Due to the revisions on the input data for submission 2026, recalculations took place <sup>4)</sup>.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> BMVg (2020): Bundesministerium der Verteidigung: Energieeinsatz zur Wärmeversorgung der Bundeswehr, 2020 (unpublished).

<sup>2)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl-daten für die Bundesrepublik Deutschland; [https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>3)</sup> Struschka et al. (2008): Struschka, Dr. M., Kilgus, D., Springmann, M.; Baumbach, Prof.Dr. Günter: Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung; UBA Forschungsbericht 205 42 322;

<https://www.umweltbundesamt.de/publikationen/effiziente-bereitstellung-aktueller-emissionsdaten>; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008.

<sup>4)</sup> AGEB (2025a): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland;  
[https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?\\_jahresbereich-bilanz=2021-2030](https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?_jahresbereich-bilanz=2021-2030), (Aufruf: 04.12.2025), Köln & Berlin, September 2025

#### 1.A.5.b - Other, Mobile (including Military)

### Short description

In sub-category *1.A.5.b - Other, Mobile (including Military)* emissions from landbased, air- and waterborne military vehicles are reported.

| NFR-Code                                                                                  | Name of Category                            | Method                   | AD    | EF       |
|-------------------------------------------------------------------------------------------|---------------------------------------------|--------------------------|-------|----------|
| 1.A.5.b                                                                                   | Other, Mobile (including Military)          | see sub-category details |       |          |
| consisting of:                                                                            |                                             |                          |       |          |
| 1.A.5.b i                                                                                 | Land-based military transport and machinery | T1, T2                   | NS    | CS, D    |
| 1.A.5.b ii                                                                                | Military Aviation                           | T1, T2                   | NS    | CS, D    |
| 1.A.5.b iii                                                                               | Military Navigation                         | T1, T2, T3               | NS, M | CS, D, M |
| Method(s) applied                                                                         |                                             |                          |       |          |
| D                                                                                         | Default                                     |                          |       |          |
| T1                                                                                        | Tier 1 / Simple Methodology *               |                          |       |          |
| T2                                                                                        | Tier 2*                                     |                          |       |          |
| T3                                                                                        | Tier 3 / Detailed Methodology *             |                          |       |          |
| C                                                                                         | CORINAIR                                    |                          |       |          |
| CS                                                                                        | Country Specific                            |                          |       |          |
| M                                                                                         | Model                                       |                          |       |          |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                             |                          |       |          |
| (source for) Activity Data                                                                |                                             |                          |       |          |
| NS                                                                                        | National Statistics                         |                          |       |          |
| RS                                                                                        | Regional Statistics                         |                          |       |          |
| IS                                                                                        | International Statistics                    |                          |       |          |
| PS                                                                                        | Plant Specific                              |                          |       |          |
| As                                                                                        | Associations, business organisations        |                          |       |          |
| Q                                                                                         | specific Questionnaires (or surveys)        |                          |       |          |
| M                                                                                         | Model / Modelled                            |                          |       |          |
| C                                                                                         | Confidential                                |                          |       |          |
| (source for) Emission Factors                                                             |                                             |                          |       |          |
| D                                                                                         | Default (EMEP Guidebook)                    |                          |       |          |
| CS                                                                                        | Country Specific                            |                          |       |          |
| PS                                                                                        | Plant Specific                              |                          |       |          |
| M                                                                                         | Model / Modelled                            |                          |       |          |
| C                                                                                         | Confidential                                |                          |       |          |

[illegible]

| NO <sub>x</sub>                                                                           | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |
|-------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|------|--|
| <b>Method(s) applied</b>                                                                  |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>D</b> Default                                                                          |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>T1</b> Tier 1 / Simple Methodology *                                                   |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>T2</b> Tier 2*                                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>T3</b> Tier 3 / Detailed Methodology *                                                 |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>C</b> CORINAIR                                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>CS</b> Country Specific                                                                |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>M</b> Model                                                                            |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>(source for) Activity Data</b>                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>NS</b> National Statistics                                                             |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>RS</b> Regional Statistics                                                             |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>IS</b> International Statistics                                                        |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>PS</b> Plant Specific                                                                  |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>As</b> Associations, business organisations                                            |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>Q</b> specific Questionnaires (or surveys)                                             |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>M</b> Model / Modelled                                                                 |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>C</b> Confidential                                                                     |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>(source for) Emission Factors</b>                                                      |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>D</b> Default (EMEP Guidebook)                                                         |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>CS</b> Country Specific                                                                |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>PS</b> Plant Specific                                                                  |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>M</b> Model / Modelled                                                                 |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
| <b>C</b> Confidential                                                                     |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |



For further information on sub-sector specific consumption data, emission factors and emissions as well as further information on emission trends, recalculations and planned improvements, please follow the links above.

## Methodology

### Activity data

Basically, all fuel deliveries to the military are included in the primary fuel delivery data provided by the National Energy Balances (NEB) <sup>1)</sup>. As the NEB does not provide specific data for military use, the following additional sources are used:

#### Military land-based vehicles and aviation:

For the years as of 1995, the official mineral-oil data of the Federal Republic of Germany (Amtliche Mineralöl-daten der Bundesrepublik Deutschland), prepared by the Federal Office of Economics and Export Control (BAFA), are used <sup>2)</sup>. Provided in units of [1,000 t], these amounts have to be converted into [TJ] on the basis of the relevant net calorific values given by <sup>3)</sup>.

As the official mineral-oil data does not distinguish into fossil and biofuels but does provide amounts for inland deliveries of total diesel and gasoline fuels, no data on the consumption of biodiesel and bioethanol is available directly at the moment. Therefore, activity data for biofuels used in military vehicles are calculated by applying Germany's official annual biofuel shares to the named total deliveries (see also: info on EF).

As there is no consistent NEB data available for aviation gasoline, delivery data from BAFA is applied for the entire time series.

#### Military navigation:

Primarily, fuel deliveries to military navigation is included in the NEB data provided in NEB lines 6: 'International Deep-Sea Bunkers' and 64: 'Coastal and inland navigation' but cannot be derived directly. Therefore, starting with this submission, fuel use in military navigation is estimated within a specific model used for estimating emissions from German maritime activities <sup>4)</sup>.

Table 1: Sources for consumption data in 1.A.5.b

| Mode of Military Transport                                              | Specific AD included in:                                                                | Sources for specific data                                            | Relevant years |
|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------|----------------|
| <b>Military ground vehicles and mobile machinery, military aviation</b> | NEB line 67 - 'Commerce, Trade, Services and other Consumers'                           | Special evaluation 1990-1994 carried out by AGEB                     | 1990 - 1994    |
|                                                                         |                                                                                         | Official oil data, table 7j, column: 'An das Militär', <sup>5)</sup> | as of 1995     |
| <b>Military Navigation</b>                                              | NEB lines 6 - 'International Deep-Sea Bunkers' and 64 - 'Coastal and Inland Navigation' | AD estimated within <sup>6)</sup>                                    | as of 1990     |

Table 2: Annual over-all fuel consumption in military vehicles and mobile equipment, in terajoules

|                        | 1990          | 1995          | 2000          | 2005          | 2010         | 2015         | 2016         | 2017         | 2018         | 2019         | 2020         | 2021         | 2022         | 2023         | 2024         |
|------------------------|---------------|---------------|---------------|---------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>DIESEL OIL</b>      | 15,417        | 8,264         | 1,592         | 3,375         | 1,121        | 732          | 713          | 571          | 380          | 281          | 134          | 138          | 357          | 289          | 869          |
| <b>GASOLINE</b>        | 21,508        | 9,800         | 7,477         | 6,860         | 4,792        | 3,388        | 3,051        | 2,538        | 2,371        | 2,272        | 1,824        | 1,981        | 2,107        | 2,040        | 2,032        |
| <b>BIODIESEL</b>       | NO            | NO            | NO            | 213           | 75.1         | 31.7         | 30.6         | 22.6         | 16.2         | 15.9         | 11.1         | 9.6          | 24.7         | 21.5         | 53.2         |
| <b>BIOGASOLINE</b>     | NO            | NO            | NO            | 46.6          | 185          | 143          | 128          | 104          | 103          | 95.1         | 80.8         | 91.4         | 97.4         | 96.9         | 95.1         |
| <b>JET KEROSENE</b>    | 38,385        | 16,143        | 9,862         | 2,200         | 3,286        | 3,726        | 3,845        | 1,507        | 1,025        | 3,746        | 2,904        | 4,810        | 3,551        | 3,875        | 40.0         |
| <b>AVGAS</b>           | 15.2          | 6.35          | 1.09          | 0.26          | 0.17         | 0.00         | 0.13         | 0.00         | 0.17         | 0.04         | 0.00         | 0.09         | 0.30         | 0.00         | 0.00         |
| <b>HEAVY FUEL OIL</b>  | 152           | 104           | 90.4          | 67.4          | 59.0         | NO           | NO           | NO           | NO           | NO           | NO           | NO           | NO           | NO           | NO           |
| <b>LIGHT FUEL OIL*</b> | NO            | NO            | NO            | NO            | NO           | NO           | NO           | NO           | 33.2         | 164          | 390          | 118          | 131          | 135          | 97.6         |
| <b>Σ 1.A.5.b</b>       | <b>75,477</b> | <b>34,317</b> | <b>19,022</b> | <b>12,762</b> | <b>9,518</b> | <b>8,021</b> | <b>7,768</b> | <b>4,742</b> | <b>3,929</b> | <b>6,574</b> | <b>5,345</b> | <b>7,148</b> | <b>6,268</b> | <b>6,457</b> | <b>3,187</b> |

data sources: (BAFA, 2025) <sup>7)</sup>: Table 7j: "an das Militär" ("to the military"), (AGEB, 2025) <sup>8)</sup>: NEB line 6, and own estimates for blended biofuels, BSH model <sup>9)</sup>

\* as of 2018: replacing diesel oil used in navigation (source: National Energy Balances)

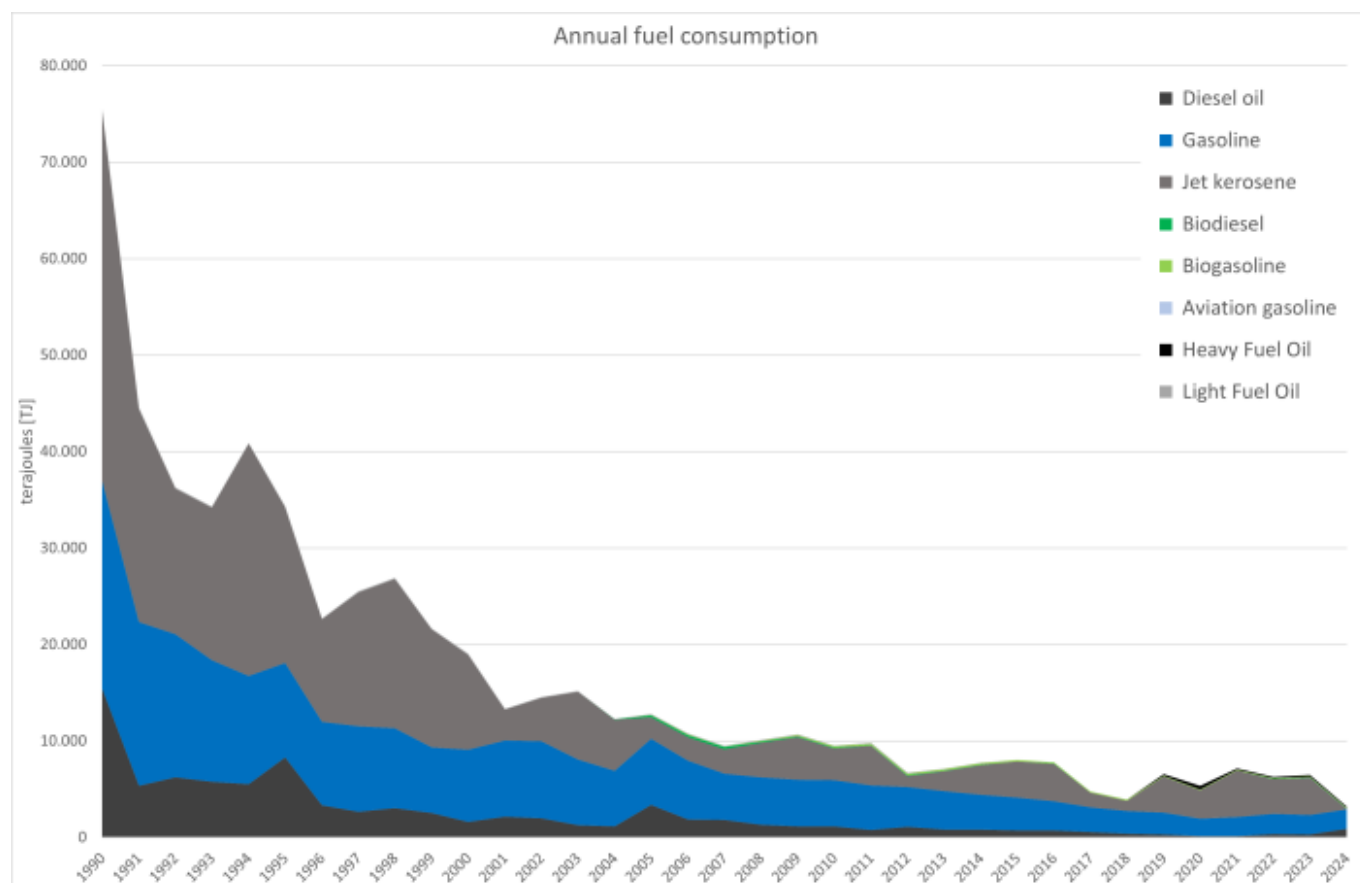
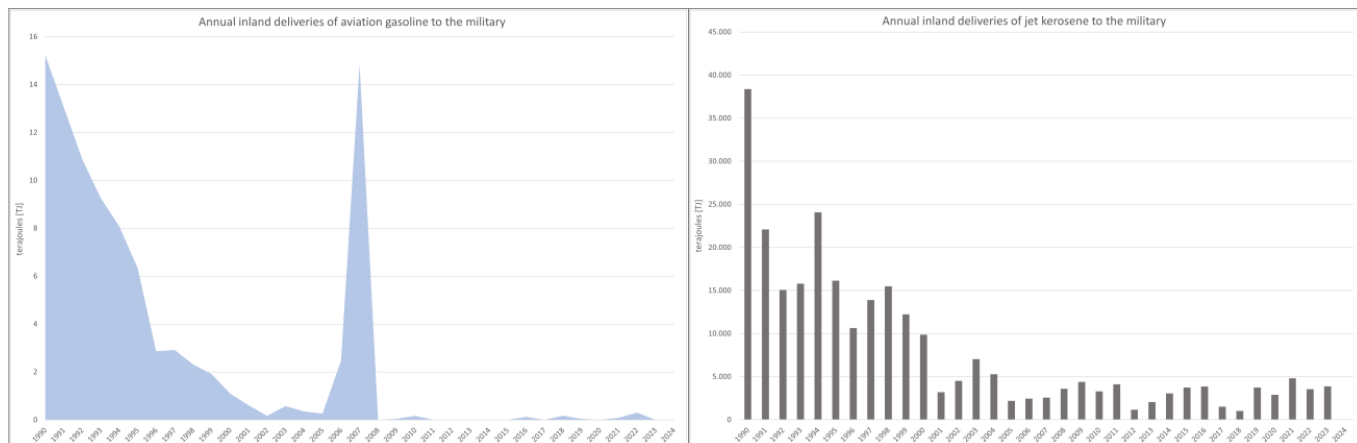


Table 3: Further break-down of annual military fuel consumption, in terajoules

|                                                                                                                                                                                           | 1990          | 1995          | 2000          | 2005          | 2010         | 2015         | 2016         | 2017         | 2018         | 2019         | 2020         | 2021         | 2022         | 2023         | 2024         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---------------|---------------|---------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>used in military ground vehicles and machinery</b>                                                                                                                                     |               |               |               |               |              |              |              |              |              |              |              |              |              |              |              |
| <b>Diesel Oil</b>                                                                                                                                                                         | 15,037        | 8,001         | 1,364         | 3,203         | 971          | 578          | 572          | 415          | 281          | 281          | 134          | 138          | 357          | 289          | 869          |
| <b>Biodiesel</b>                                                                                                                                                                          | NO            | NO            | NO            | 213           | 75.1         | 31.7         | 30.6         | 22.6         | 16.2         | 15.9         | 11.1         | 9.6          | 24.7         | 21.5         | 53.2         |
| <b>Gasoline</b>                                                                                                                                                                           | 21,508        | 9,800         | 7,477         | 6,860         | 4,792        | 3,388        | 3,051        | 2,538        | 2,371        | 2,272        | 1,824        | 1,981        | 2,107        | 2,040        | 2,032        |
| <b>Biogasoline</b>                                                                                                                                                                        | NO            | NO            | NO            | 46.6          | 185          | 143          | 128          | 104          | 103          | 95.1         | 80.8         | 91.4         | 97.4         | 96.9         | 95.1         |
| <b>used in military aircraft</b>                                                                                                                                                          |               |               |               |               |              |              |              |              |              |              |              |              |              |              |              |
| <b>Jet Kerosene</b>                                                                                                                                                                       | 38,385        | 16,143        | 9,862         | 2,200         | 3,286        | 3,726        | 3,845        | 1,507        | 1,025        | 3,746        | 2,904        | 4,810        | 3,551        | 3,875        | 40.0         |
| <b>Aviation Gasoline</b>                                                                                                                                                                  | 15.2          | 6.35          | 1.09          | 0.26          | 0.17         | 0.00         | 0.13         | 0.00         | 0.17         | 0.04         | 0.00         | 0.09         | 0.30         | 0.00         | 0.00         |
| <b>used in military navigation</b>                                                                                                                                                        |               |               |               |               |              |              |              |              |              |              |              |              |              |              |              |
| <b>Diesel Oil</b>                                                                                                                                                                         | 380           | 263           | 228           | 171           | 150          | 154          | 141          | 156          | 99.5         | NO           | NO           | NO           | NO           | NO           | NO           |
| <b>Light Fuel Oil*</b>                                                                                                                                                                    | NO            | NO            | NO            | NO            | NO           | NO           | NO           | NO           | 33.2         | 164          | 390          | 118          | 131          | 135          | 97.6         |
| <b>Heavy Fuel Oil</b>                                                                                                                                                                     | 152           | 104           | 90.4          | 67.4          | 59.0         | NO           | NO           | NO           | NO           | NO           | NO           | NO           | NO           | NO           | NO           |
| <b>Σ 1.A.5.b</b>                                                                                                                                                                          |               |               |               |               |              |              |              |              |              |              |              |              |              |              |              |
| <b>all types of fuels applied</b>                                                                                                                                                         | <b>75,477</b> | <b>34,317</b> | <b>19,022</b> | <b>12,762</b> | <b>9,518</b> | <b>8,021</b> | <b>7,768</b> | <b>4,742</b> | <b>3,929</b> | <b>6,574</b> | <b>5,345</b> | <b>7,148</b> | <b>6,268</b> | <b>6,457</b> | <b>3,187</b> |
| data sources: (BAFA, 2025) <sup>10)</sup> : “an das Militär” (“to the military”); (AGEB, 2025) <sup>11)</sup> : line 6; BSH model <sup>12)</sup> , and own estimates for blended biofuels |               |               |               |               |              |              |              |              |              |              |              |              |              |              |              |
| * as of 2018: replacing diesel oil used in navigation (source: National Energy Balances)                                                                                                  |               |               |               |               |              |              |              |              |              |              |              |              |              |              |              |

Here, the **activity data** provided represents original annual fuel deliveries data derived from the Official Mineral Oil Data as compiled and published by BAFA <sup>13)</sup>. Where the ups and downs visible for **aviation gasoline** appear to be influenced by stock-keeping activities, no clear explanation can be provided for **jet kerosene**, where a sharp decrease in inland deliveries is visible for 2024 that cannot be clarified at the moment.



## Emission factors



For further information on sub-sector specific emission factors, please refer to the sub-chapters on [ground-based](#), [airborne](#) and [naval](#) military activities.

## Discussion of emission trends

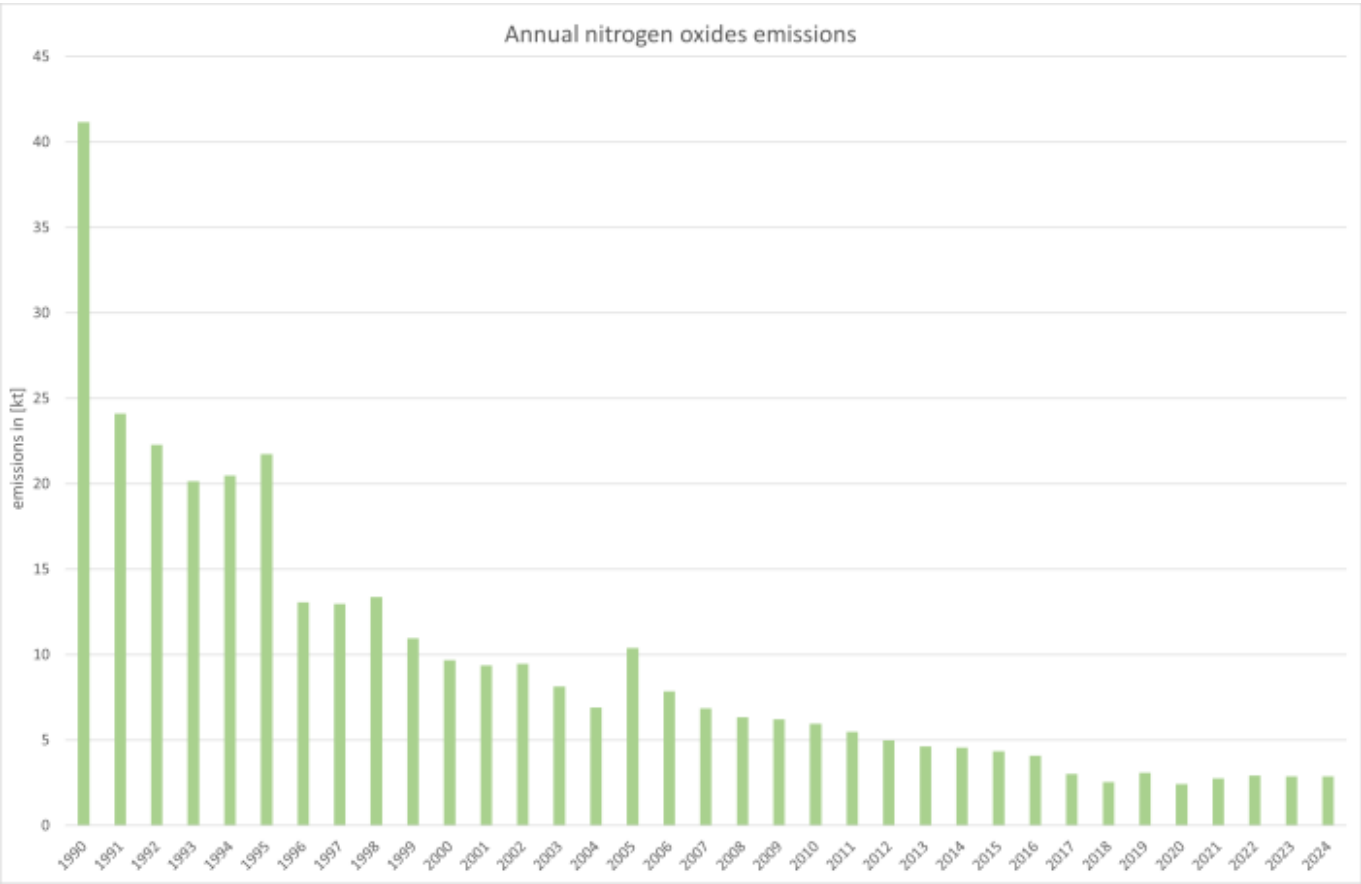
Table: Outcome of Key Category Analysis



|      |                 |
|------|-----------------|
| for: | NO <sub>x</sub> |
| by:  | Trend           |

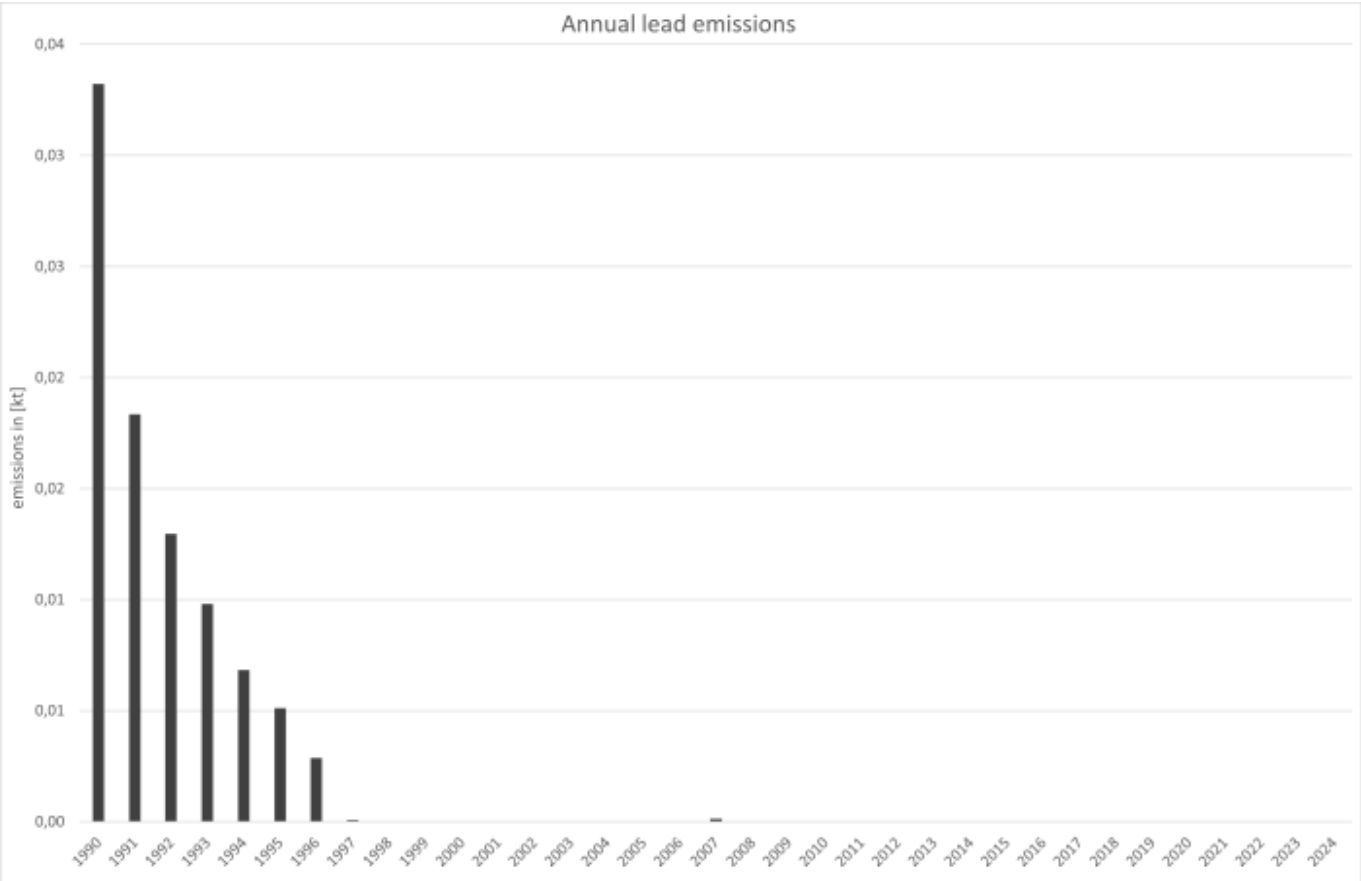
Here, due to the tier1 emission factors applied, annual emissions strongly correspond with activity data, therefore showing strong decline after 1990 and an ongoing downward trend.

Regarding the peak in NO<sub>x</sub> emissions 2005: The dominating source of NO<sub>x</sub> (and PM) emissions is the use of diesel oil in militar ground vehicles and machinery as well as military vessels. Here, the underlying activity data (annual diesel oil inland deliveries) for 2005 are well above the values of previous and following years but cannot be revised in a sensible way.

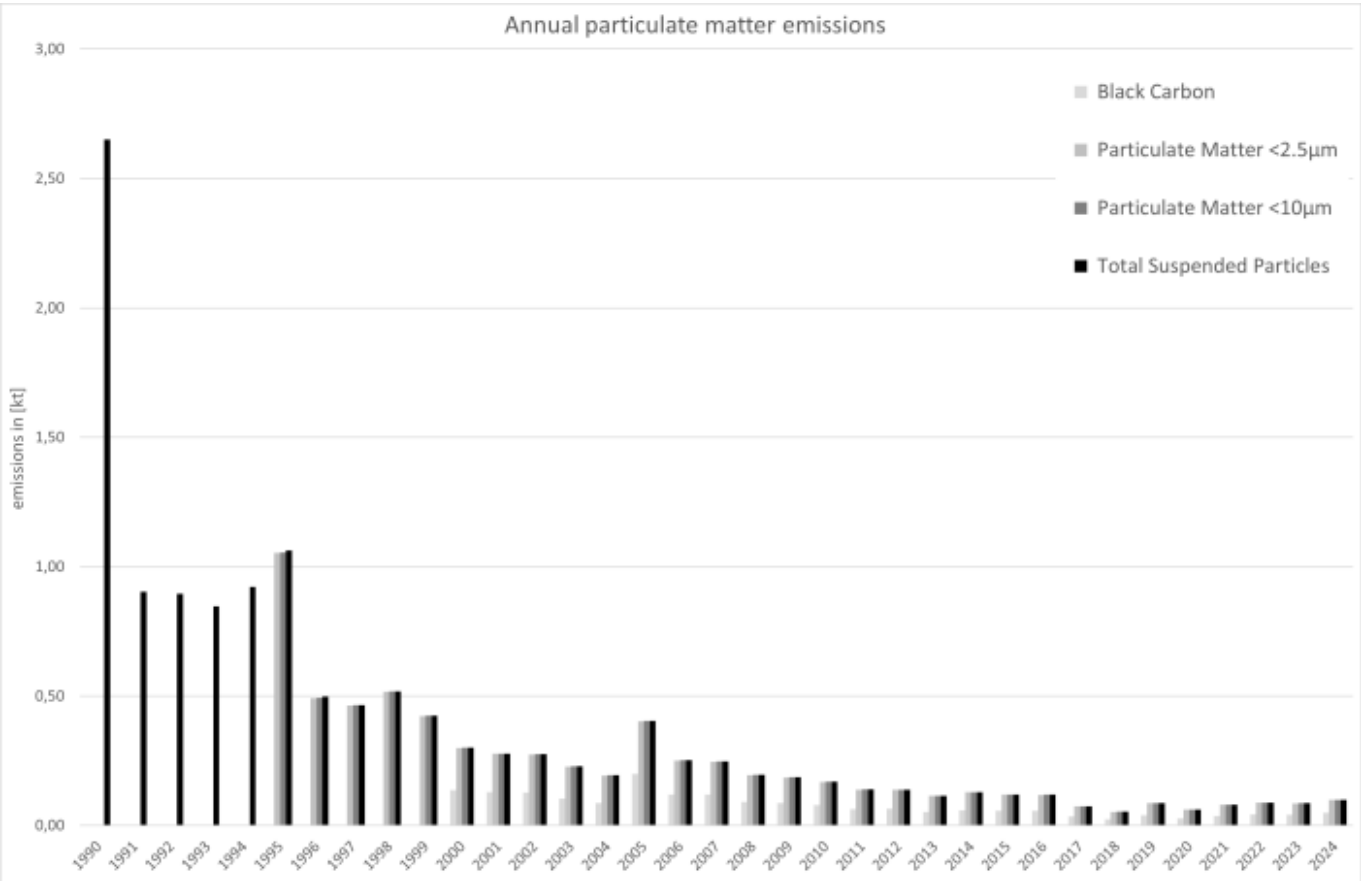


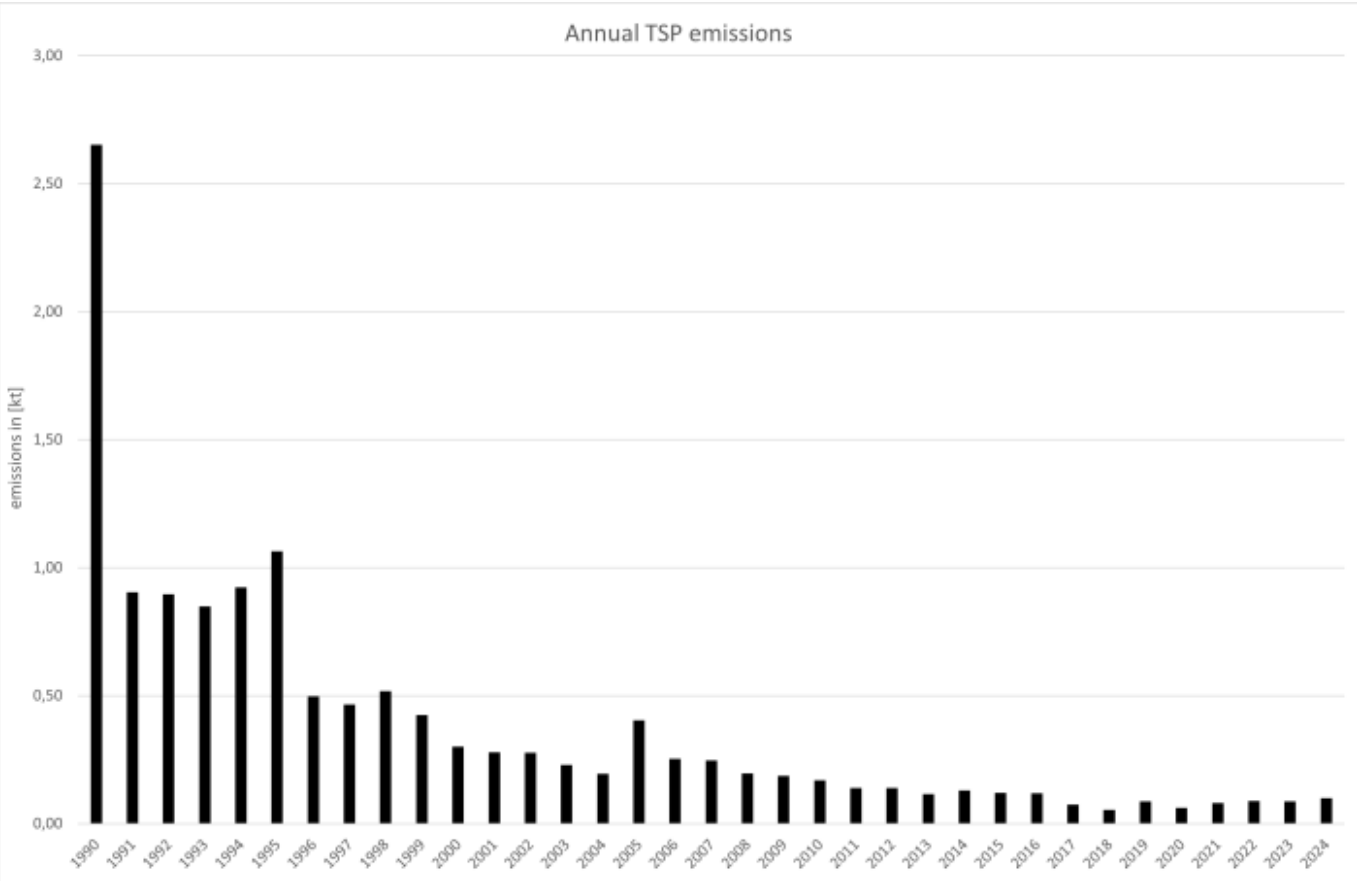
Furthermore, this NFR category shows interesting trends for emissions of **Lead (Pb)** from leaded gasoline (until 1997) and aviation gasoline:

Until 1997, lead emissions were dominated by the combustion of leaded gasoline in military ground-based vehicles. Therefore, the over-all trend for lead emissions from military vehicles and aircraft is driven mostly by the abolition of leaded gasoline in 1997. Towards this date, the amount of leaded gasoline decreased significantly. After 1997, the only source for lead from mobile fuel combustion is avgas used in military aircraft. As for avgas, the trend of consumption is more or less decreasing steadily until 2005 but then shows a strong increase for 2006 and '07 (!), followed by no or very small deliveries. As mentioned above, there are no real consumption data available: AD is based on fuel deliveries to the military only. Thus, especially the trends for the use of aviation gasoline and the resulting emissions show this significant jumps in 2006 and 07. The party is aware of this issue and will try to solve it as soon as data allows. (see also: FAQ)

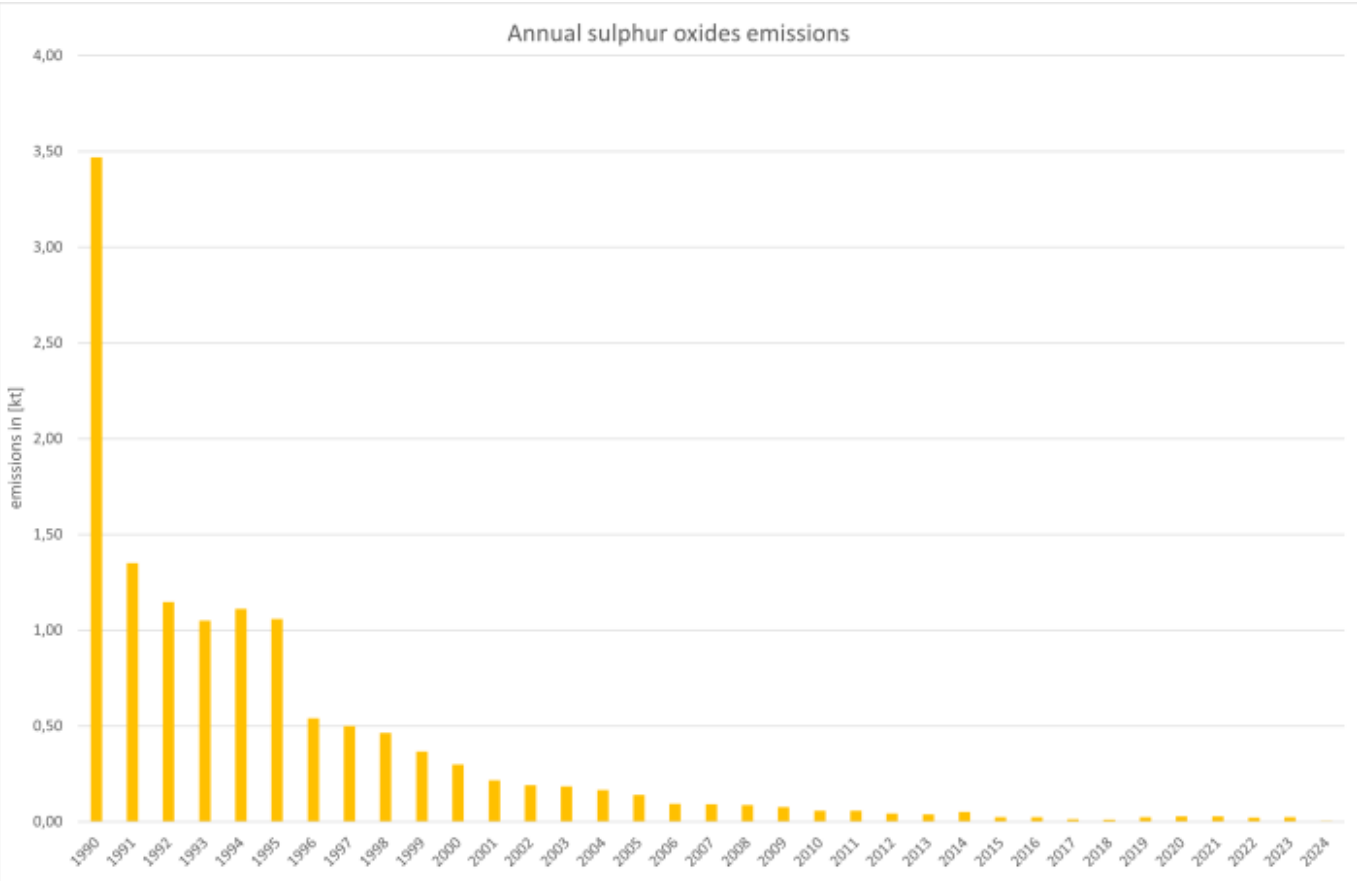


The trend for **TSP** emissions reflects the impact of leaded gasoline at least for 1990 to 1997. For all other years, **particulate matter** emissions simply follow the trend in over-all fuel consumption. Here, as already explained for NO<sub>x</sub>, the increased 2005 emissions result from a corresponding jump in inland diesel-oil deliveries (see information on annual activity data above).





Regarding **sulphur dioxide**, emissions not only reflect the trend of fuel consumption but also the impact of fuel-sulphur legislation.



For all other reported pollutants, due to the application of tier1 emission factors, emission trends reported for this sub-category only reflect the trend in fuel deliveries.

## Recalculations

Recalculations against last year's submission occur mainly due to the revision of the underlying National Energy Balances (NEB) 2003 to 2023.

Due to the enormous amount of input data (AIS ship movement data), no such re-calculations are carried out within the BSH model yet, leaving the amounts of diesel oil/light fuel oil and heavy fuel oil consumed in military vessels unaltered compared to the previous submission. Here, recalculations occur only due to revised emission factors (see sub-chapter on 1.A.5.b iii linked above).

Table: Revised activity data 2003-2023, in terajoules [TJ]

|                          | 2003   | 2004   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018  | 2019   | 2020  | 2021   | 2022   | 2023   |
|--------------------------|--------|--------|--------|--------|--------|--------|--------|-------|--------|-------|--------|--------|--------|
| <b>DIESEL OIL</b>        |        |        |        |        |        |        |        |       |        |       |        |        |        |
| current submission       | 1,257  | 1,120  | 3,375  | 1,121  | 732    | 713    | 571    | 380   | 281    | 134   | 138    | 357    | 289    |
| previous submission      | 1,257  | 1,118  | 3,368  | 1,126  | 733    | 718    | 571    | 379   | 281    | 134   | 137    | 359    | 292    |
| absolute change          | -0.17  | 2.06   | 7.21   | -5.03  | -1.12  | -4.83  | 0.05   | 1.10  | -0.02  | 0.80  | 0.16   | -2.30  | -3.08  |
| relative change          | -0.01% | 0.18%  | 0.21%  | -0.45% | -0.15% | -0.67% | 0.01%  | 0.29% | -0.01% | 0.60% | 0.11%  | -0.64% | -1.05% |
| <b>BIODIESEL</b>         |        |        |        |        |        |        |        |       |        |       |        |        |        |
| current submission       | NO     | 33.2   | 213    | 75.1   | 31.7   | 30.6   | 22.6   | 16.2  | 15.9   | 11.1  | 9.55   | 24.7   | 21.5   |
| previous submission      | NO     | 35.2   | 223    | 76.3   | 32.2   | 31.3   | 22.1   | 15.8  | 15.9   | 10.9  | 9.64   | 24.9   | 21.6   |
| absolute change          |        | -2.02  | -9.36  | -1.18  | -0.47  | -0.68  | 0.47   | 0.43  | 0.02   | 0.20  | -0.09  | -0.2   | -0.15  |
| relative change          |        | -5.72% | -4.20% | -1.55% | -1.46% | -2.17% | 2.12%  | 2.73% | 0.15%  | 1.81% | -0.89% | -0.90% | -0.68% |
| <b>GASOLINE</b>          |        |        |        |        |        |        |        |       |        |       |        |        |        |
| current submission       | 6,799  | 5,780  | 6,860  | 4,792  | 3,388  | 3,051  | 2,538  | 2,371 | 2,272  | 1,824 | 1,981  | 2,107  | 2,040  |
| previous submission      | 6,797  | 5,780  | 6,838  | 4,790  | 3,300  | 2,969  | 2,464  | 2,305 | 2,273  | 1,771 | 1,923  | 2,082  | 2,076  |
| absolute change          | 2.34   | 0.04   | 22.11  | 1.30   | 88.4   | 81.2   | 74.5   | 65.9  | -1.39  | 52.78 | 58.3   | 25.7   | -35.7  |
| relative change          | 0.03%  | 0.00%  | 0.32%  | 0.03%  | 2.68%  | 2.73%  | 3.02%  | 2.86% | -0.06% | 2.98% | 3.03%  | 1.23%  | -1.72% |
| <b>BIOGASOLINE</b>       |        |        |        |        |        |        |        |       |        |       |        |        |        |
| current submission       | NO     | 6.15   | 46.6   | 185    | 143    | 128    | 104    | 103   | 95.1   | 80.8  | 91.4   | 97.4   | 96.9   |
| previous submission      | NO     | 6.37   | 47.4   | 186    | 133    | 121    | 104    | 100   | 93.7   | 79.4  | 90.6   | 96.5   | 98.0   |
| absolute change          |        | -0.22  | -0.80  | -0.93  | 9.37   | 7.28   | -0.23  | 3.65  | 1.39   | 1.34  | 0.81   | 0.92   | -1.16  |
| relative change          |        | -3.44% | -1.68% | -0.50% | 7.04%  | 6.00%  | -0.22% | 3.66% | 1.49%  | 1.69% | 0.89%  | 0.96%  | -1.18% |
| <b>JET KEROSENE</b>      |        |        |        |        |        |        |        |       |        |       |        |        |        |
| current submission       | 7,029  | 5,280  | 2,200  | 3,286  | 3,726  | 3,845  | 1,507  | 1,025 | 3,746  | 2,904 | 4,810  | 3,551  | 3,875  |
| previous submission      | 7,029  | 5,280  | 2,200  | 3,286  | 3,726  | 3,845  | 1,507  | 1,025 | 3,746  | 2,904 | 4,810  | 3,551  | 3,369  |
| absolute change          | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00  | 0.00   | 0.00  | 0.00   | 0.00   | 506    |
| relative change          | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00%  | 0.00% | 0.00%  | 0.00% | 0.00%  | 0.00%  | 15.0%  |
| <b>AVIATION GASOLINE</b> |        |        |        |        |        |        |        |       |        |       |        |        |        |
| current submission       | 0.57   | 0.35   | 0.26   | 0.17   | 0      | 0.13   | 0      | 0.17  | 0.04   | 0     | 0.09   | 0.30   | 0      |
| previous submission      | 0.57   | 0.35   | 0.26   | 0.17   | 0.00   | 0.13   | 0.00   | 0.17  | 0.04   | 0.00  | 0.09   | 0.30   | 0.00   |
| absolute change          | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00  | 0.00   | 0.00  | 0.00   | 0.00   | 0.00   |
| relative change          | 0.00%  | 0.00%  | 0.00%  | 0.00%  |        | 0.00%  |        | 0.00% | 0.00%  |       | 0.00%  | 0.00%  |        |
| <b>Σ 1.A.5.b</b>         |        |        |        |        |        |        |        |       |        |       |        |        |        |
| current submission       | 15,158 | 12,291 | 12,762 | 9,518  | 8,021  | 7,768  | 4,742  | 3,929 | 6,574  | 5,345 | 7,148  | 6,268  | 6,457  |
| previous submission      | 15,156 | 12,291 | 12,743 | 9,524  | 7,925  | 7,685  | 4,667  | 3,858 | 6,574  | 5,289 | 7,089  | 6,244  | 5,991  |
| absolute change          | 2.17   | -0.13  | 19.2   | -5.84  | 96.1   | 82.9   | 74.8   | 71.1  | 0.00   | 55.1  | 59.2   | 24.1   | 466    |
| relative change          | 0.01%  | 0.00%  | 0.15%  | -0.06% | 1.21%  | 1.08%  | 1.60%  | 1.84% | 0.00%  | 1.04% | 0.83%  | 0.39%  | 7.77%  |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: "Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland" by Knörr et al. (2009) <sup>14)</sup>.

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has not yet been published.

## Planned improvements

With respect to NFR 1.A.5.b as such, no overarching improvements are planned. For further information on possible sub-sector specific improvements, please follow the links above.

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<sup>1), 3), 8), 11)</sup> AGEB (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD24p2-1.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2), 7), 10), 13)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralölzeiten für die Bundesrepublik Deutschland; [https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>9), 12)</sup> Deichnik (2025): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs; Federal Maritime and Hydrographic Agency (BSH - Bundesamt für Seeschifffahrt und Hydrographie Hamburg); on behalf of the Umweltbundesamt, Hamburg / Dessau-Roßlau, 2025.

<sup>14)</sup> Knörr et al.(2009): Knörr, W., Heldstab, J., & Kasser, F.: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland; final report; <https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3937.pdf>, FKZ 360 16 023, Heidelberg & Zürich, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009.

## 1.A.5.b i - Military Ground Vehicles and Vehicles

### Short description

In sub-category 1.A.5.b i - *Other, Mobile (including Military)* emissions from military ground-vehicles and mobile machinery are reported.

| Method | AD | EF    | Key Category Analysis                     |
|--------|----|-------|-------------------------------------------|
| T1, T2 | NS | CS, D | see <a href="#">superordinate chapter</a> |

### Methodology

#### Activity data

Basically, all fuel consumption in military vehicles is included in the primary activity data provided by the National Energy Balances (NEB) (AGEB, 2025) <sup>1)</sup>.

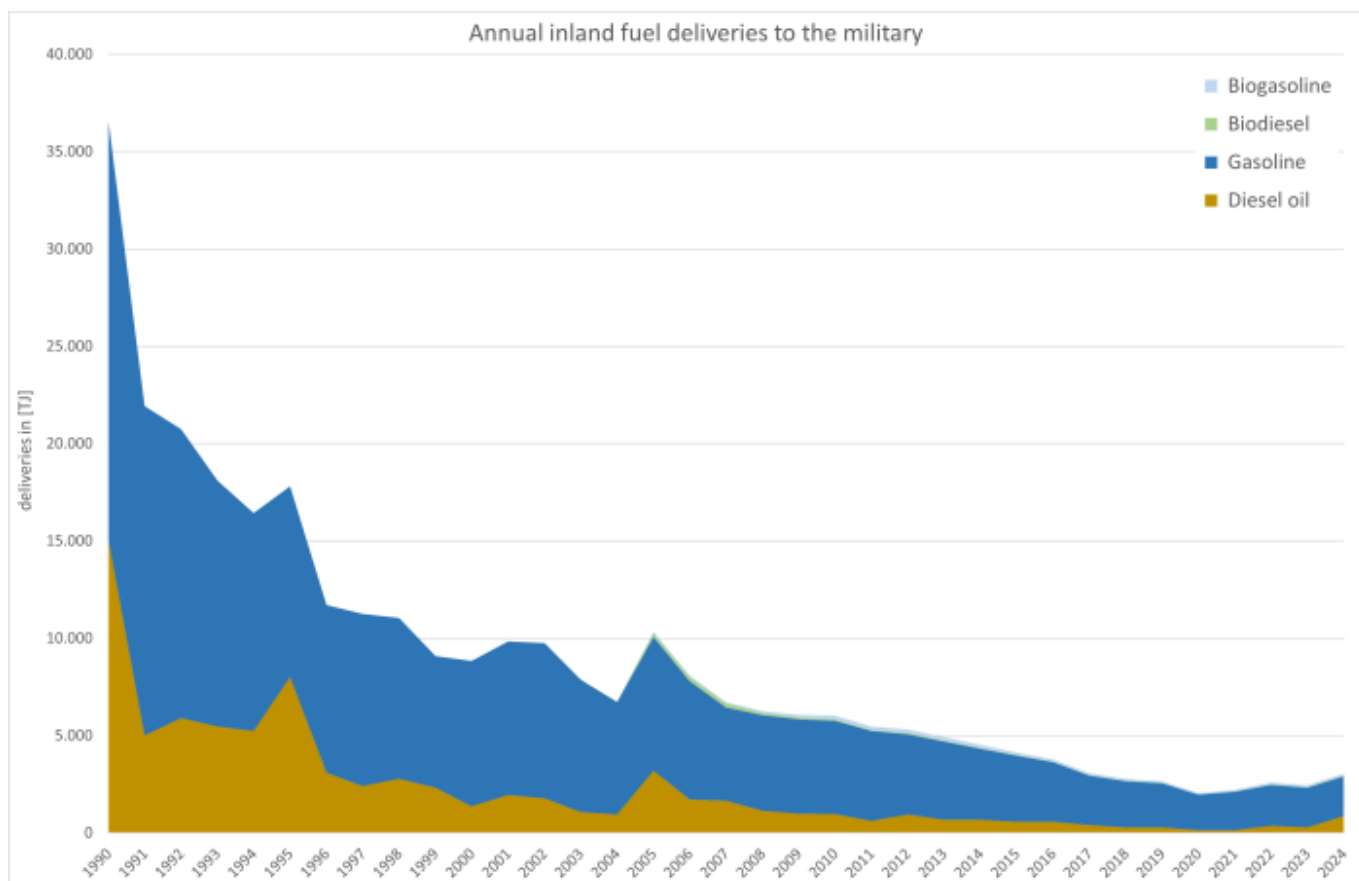
As the NEB does not provide specific data for military use, the following additional sources are used:

For the years as of 1995, the official mineral-oil data of the Federal Republic of Germany (Amtliche Mineralöl-daten der Bundesrepublik Deutschland), prepared by the Federal Office of Economics and Export Control (BAFA), are used (BAFA, 2025) <sup>2)</sup>. Provided in units of [1,000 t], these amounts have to be converted into [TJ] on the basis of the relevant net calorific values given by <sup>3)</sup>.

As the official mineral-oil data does not distinguish into fossil and biofuels but does provide amounts for inland deliveries of total diesel and gasoline fuels, no data on the consumption of biodiesel and bioethanol is available directly at the moment. Therefore, activity data for biofuels used in military vehicles are calculated by applying Germany's official annual biofuel shares to the named total deliveries (see also: info on EF).

Table 1: Annual fuel deliveries to the military for ground-vehicles and machinery, in terajoules

|                    | 1990          | 1995          | 2000         | 2005          | 2010         | 2015         | 2016         | 2017         | 2018         | 2019         | 2020         | 2021         | 2022         | 2023         | 2024         |
|--------------------|---------------|---------------|--------------|---------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>Diesel Oil</b>  | 15,037        | 8,001         | 1,364        | 3,203         | 971          | 578          | 572          | 415          | 281          | 281          | 134          | 138          | 357          | 289          | 869          |
| <b>Biodiesel</b>   | 21,508        | 9,800         | 7,477        | 6,860         | 4,792        | 3,388        | 3,051        | 2,538        | 2,371        | 2,272        | 1,824        | 1,981        | 2,107        | 2,040        | 2,032        |
| <b>Gasoline</b>    |               |               |              | 213           | 75.1         | 31.7         | 30.6         | 22.6         | 16.2         | 15.9         | 11.1         | 9.6          | 24.7         | 21.5         | 53.2         |
| <b>Biogasoline</b> |               |               |              | 46.6          | 185          | 143          | 128          | 104          | 103          | 95.1         | 80.8         | 91.4         | 97.4         | 96.9         | 95.1         |
| <b>Σ 1.A.5.b i</b> | <b>36,545</b> | <b>17,801</b> | <b>8,841</b> | <b>10,323</b> | <b>6,023</b> | <b>4,140</b> | <b>3,782</b> | <b>3,079</b> | <b>2,772</b> | <b>2,663</b> | <b>2,050</b> | <b>2,219</b> | <b>2,586</b> | <b>2,447</b> | <b>3,050</b> |



## Emission factors

Table 2: Annual country-specific emission factors<sup>1</sup>, in kg/TJ

|                        | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>DIESEL FUELS</b>    |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>NH<sub>3</sub></b>  | 4.00  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>NMVOC</b>           | 316   | 274   | 274   | 274   | 274   | 274   | 274   | 274   | 274   | 274   | 274   | 274   | 274   | 274   | 274   |
| <b>NO<sub>x</sub></b>  | 1,195 | 1,360 | 1,360 | 1,360 | 1,360 | 1,360 | 1,360 | 1,360 | 1,360 | 1,360 | 1,360 | 1,360 | 1,360 | 1,360 | 1,360 |
| <b>SO<sub>x</sub></b>  | 125   | 60.5  | 14.0  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0.37  | 0,37  |
| <b>PM<sup>2</sup></b>  | 53.0  | 53.0  | 53.0  | 53.0  | 53.0  | 53.0  | 53.0  | 53.0  | 53.0  | 53.0  | 53.0  | 53.0  | 53.0  | 53.0  | 53.0  |
| <b>BC<sup>3</sup></b>  | 134   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   |
| <b>CO</b>              | 515   | 350   | 350   | 350   | 350   | 350   | 350   | 350   | 350   | 350   | 350   | 350   | 350   | 350   | 350   |
| <b>GASOLINE FUELS</b>  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>NH<sub>3</sub></b>  | 4.00  |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>NMVOC</b>           | 594   | 373   | 373   | 373   | 373   | 373   | 373   | 373   | 373   | 373   | 373   | 373   | 373   | 373   | 373   |
| <b>NO<sub>x</sub></b>  | 682   | 725   | 725   | 725   | 725   | 725   | 725   | 725   | 725   | 725   | 725   | 725   | 725   | 725   | 725   |
| <b>SO<sub>x</sub></b>  | 11.8  | 8.30  | 3.20  | 0.40  | 0.40  | 0.40  | 0.40  | 0.40  | 0.40  | 0.40  | 0.40  | 0.40  | 0.40  | 0.40  | 0.40  |
| <b>PM<sup>2</sup></b>  | 3.63  | 3.55  | 3.13  | 2.66  | 2.14  | 1.91  | 1.91  | 1.91  | 1.91  | 1.91  | 1.91  | 1.91  | 1.91  | 1.91  | 1.91  |
| <b>BC<sup>3</sup></b>  | 0.44  | 0.43  | 0.38  | 0.32  | 0.26  | 0.23  | 0.23  | 0.23  | 0.23  | 0.23  | 0.23  | 0.23  | 0.23  | 0.23  | 0.23  |
| <b>CO</b>              | 4,199 | 4,010 | 4,010 | 4,010 | 4,010 | 4,010 | 4,010 | 4,010 | 4,010 | 4,010 | 4,010 | 4,010 | 4,010 | 4,010 | 4,010 |
| <b>TSP<sup>4</sup></b> | 2.46  | 0.82  | NA    |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>Pb<sup>4</sup></b>  | 1.54  | 0.52  | NA    |       |       |       |       |       |       |       |       |       |       |       |       |

<sup>1</sup> Due to lack of better information: similar EF are applied for fossil fuels and biofuels.

<sup>2</sup> EF(PM<sub>2.5</sub>) also applied for PM<sub>10</sub> and TSP (assumption: > 99% of TSP from diesel oil combustion consists of PM<sub>2.5</sub>)

<sup>3</sup> EF(BC) estimated from tier1 default f-BC values provided in <sup>4)</sup>, chapter 1.A.3.b, table 3-11 - Table 3-11: Tier 1 BC fractions of PM (f-BC=0.12 for gasoline passenger cars and =0.53 for diesel hdv)

<sup>4</sup> from leaded gasoline (until 1997), based on country-specific emission factors from TREMOD <sup>5)</sup>



With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>8)</sup>



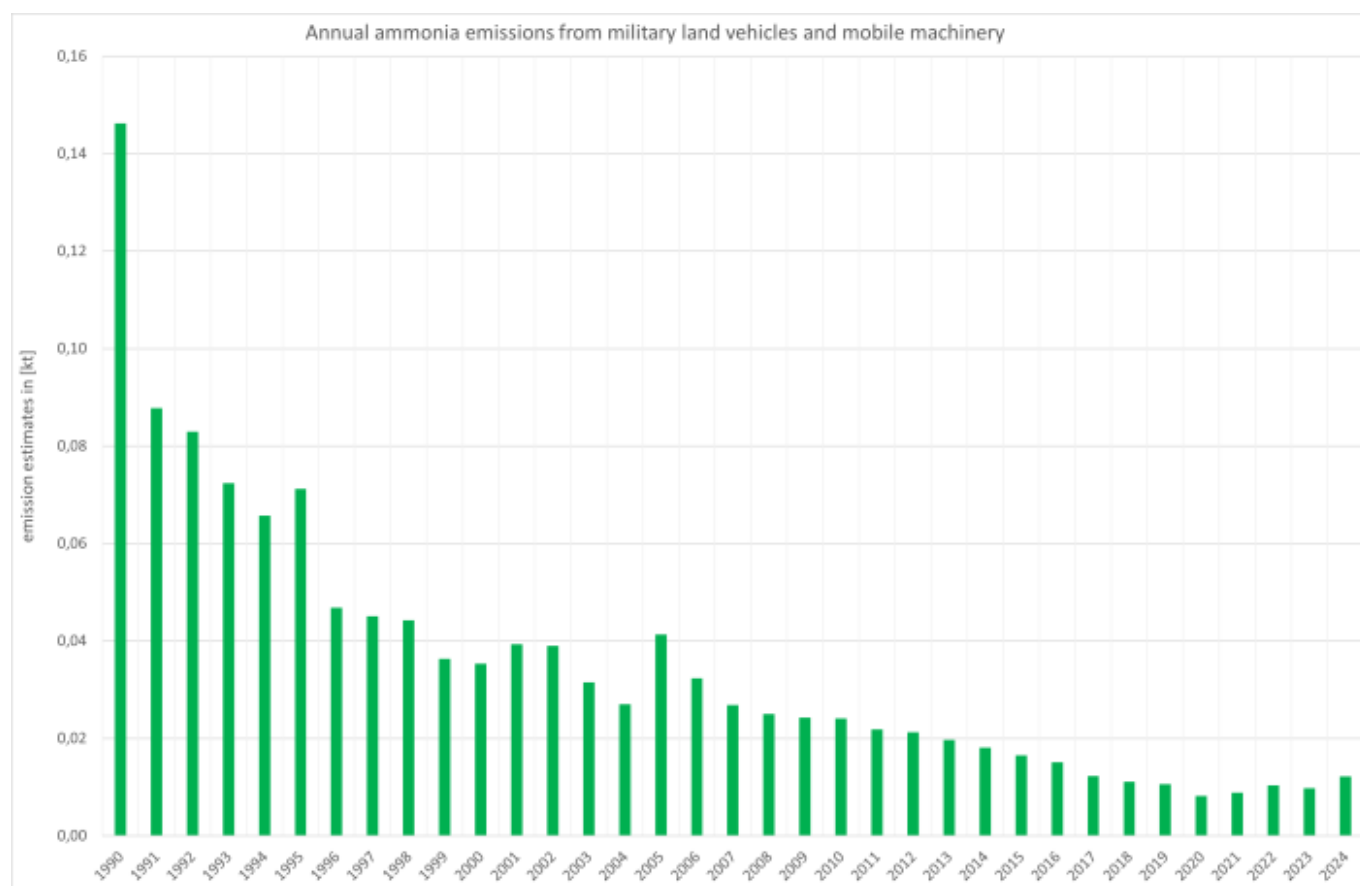
For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Discussion of emission trends



As only NFR 1.A.5.b as a whole is taken into account within the key category analysis, this country-specific sub-sector is not considered separately.

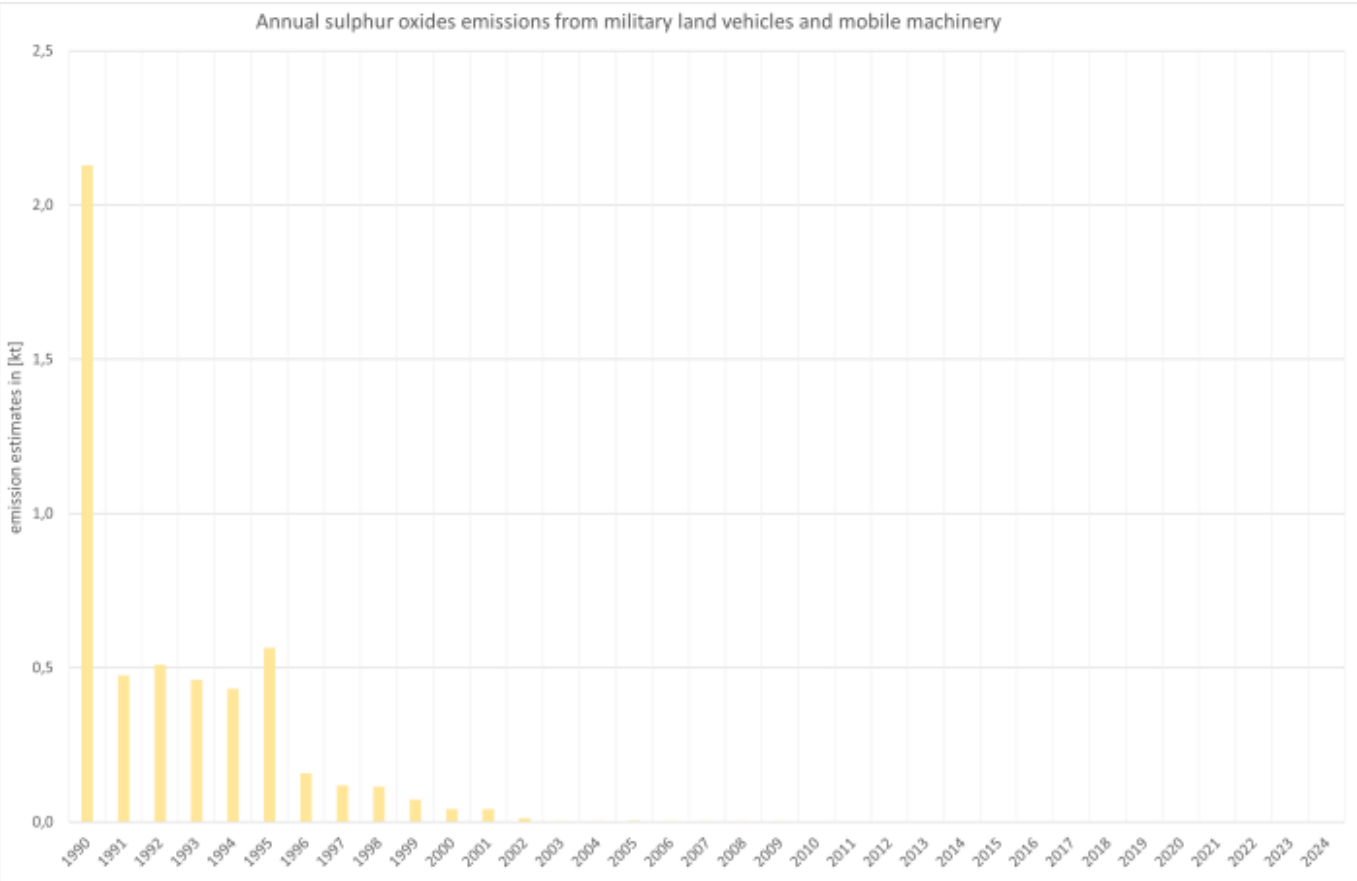
Due to the application of very several tier1 emission factors, most emission trends reported for this sub-category only reflect the trend in fuel deliveries. Therefore, the fuel-consumption dependent trends in emission estimates are only influenced by the annual fuel mix.



Here, diesel oil deliveries data show a peak in 2005 resulting in emission estimates well above the values of previous and following years. Due to the applied approach, the resulting outliers especially for NO<sub>x</sub> and PM emissions have already been looked into in several NEC and CLRTAP Reviews. However, given the underlying activity data, the noticeable emission estimates cannot be revised in a sensible way.

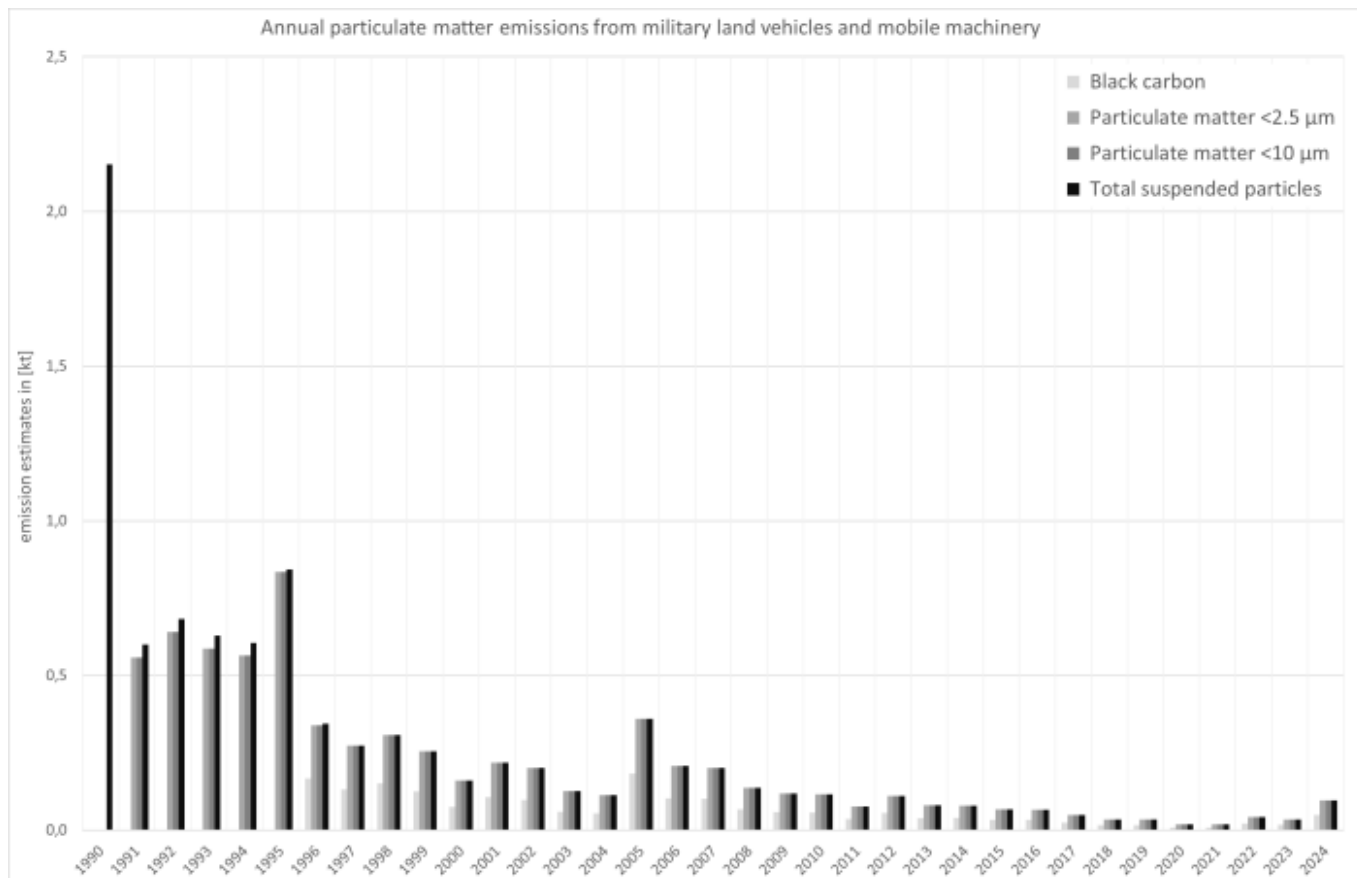
Here, for **sulphur dioxide**, this consumption-based falling trend is intensified by the impact of fuel-sulphur legislation.





Over-all **particulate matter** emissions are dominated by emissions from diesel oil combustion with the falling trend basically following the decline in fuel consumption. Here, until 1997, the emission values reported for **total suspended particles (TSP)** are slightly higher than those reported for PM<sub>2.5</sub> and PM<sub>10</sub> due to the additional TSP emissions from leaded gasoline that was banned in 1997.

Regarding the peak in PM emissions 2005: The dominating source of particulate matter (and NO<sub>x</sub>) emissions is the use of diesel oil in militar ground vehicles and machinery as well as military vessels. Here, the underlying activity data (annual diesel oil inland deliveries) for 2005 are well above the values of previous and following years but cannot be revised in a sensible way.



## Recalculations



For information on revised inventory data, please see the [superordinate chapter](#).

## Planned improvements

Given the limited quality of the emission factors applied, the inventory compiler will check a possible revision at least for the main pollutants.

## FAQs

<sup>1)</sup> AGEB (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD24p2-1.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl-daten für die Bundesrepublik Deutschland; [https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>3)</sup> AGEB (2025b): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Zusatzinformationen - Heizwerte der Energieträger und Faktoren für die Umrechnung von spezifischen Mengeneinheiten in Wärmeinheiten (2005-2020); URL: [https://ag-energiebilanzen.de/wp-content/uploads/EBD24p2\\_Heizwerte.xlsx](https://ag-energiebilanzen.de/wp-content/uploads/EBD24p2_Heizwerte.xlsx), (Aufruf: 13.12.2025) Köln & Berlin, 2025.

<sup>4)</sup> EMEP/EEA, 2023: EMEP/EEA air pollutant emission inventory guidebook – 2023, Chapter 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv Passenger cars, light commercial trucks, heavy-duty vehicles including buses, mopeds and motorcycles, <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/@download/file>; Copenhagen, 2023.

8)

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

# 1.A.5.b ii - Military Aviation

## Short description

In sub-category *1.A.5.b ii - Other, Mobile (including Military)* emissions from military aviation are reported.

| Method | AD | EF    | Key Category Analysis                     |
|--------|----|-------|-------------------------------------------|
| T1     | NS | CS, D | see <a href="#">superordinate chapter</a> |

## Methodology

### Activity data

The Energy Balance of the Federal Republic of Germany (AGEB) provides the basis for the activity data used. Since the Energy Balance does not provide separate listings of military agencies' final energy consumption as of 1995 – and includes this consumption in line 67, under “commerce, trade, services and other consumers” – additional sources of energy statistics had to be found for source category 1.A.5.

For source category 1.A.5.b, consumption data for **kerosene**, until 1995, were drawn from a special analysis of the Working Group on Energy Balances (AGEB).

For the years as of 1995, the official mineral-oil data of the Federal Republic of Germany (Amtliche Mineralöl­daten der Bundesrepublik Deutschland 2012), prepared by the Federal Office of Economics and Export Control (BAFA), are used (BAFA, 2025) <sup>1)</sup>. Provided in units of 1,000 tonnes [kt], these amounts have to be converted into terajoules [TJ] on the basis of the relevant net calorific values given by (AGEB, 2025b) <sup>2)</sup>.

As there is no consistent AGEB data available for **aviation gasoline**, delivery data from BAFA is used.

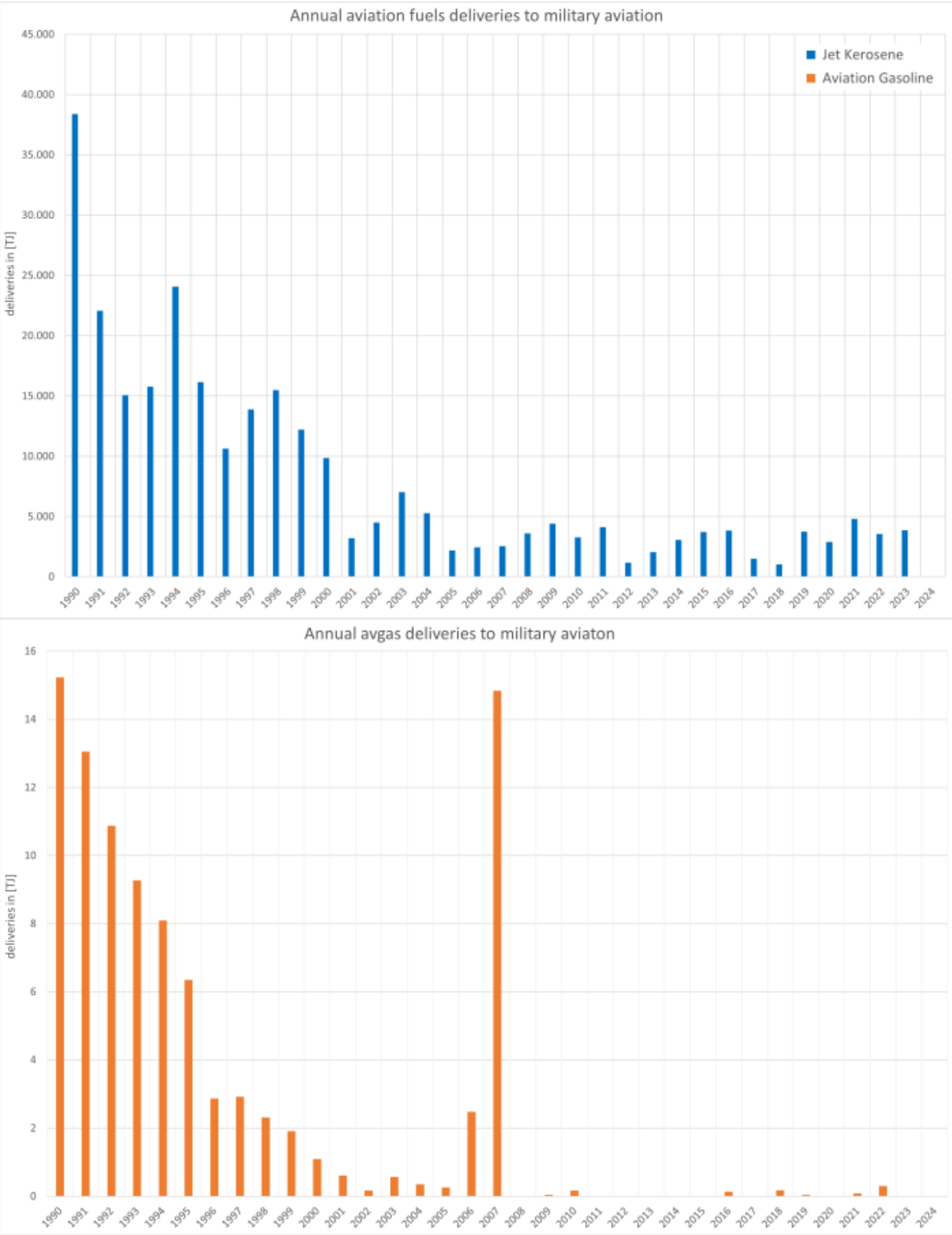
Table 1: Sources for consumption data in 1.A.5.b

| Relevant years | Data Source                                                                   |
|----------------|-------------------------------------------------------------------------------|
| through 1994   | <b>AGEB</b> - Special evaluation 1990-1994                                    |
| since 1995     | <b>BAFA</b> - Official mineral oil data: 'An das Militär' ('to the military') |

Table 2: Annual aviation fuel deliveries to the military, in terajoules

|                          | 1990          | 1995          | 2000         | 2005         | 2010         | 2015         | 2016         | 2017         | 2018         | 2019         | 2020         | 2021         | 2022         | 2023         | 2024        |
|--------------------------|---------------|---------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|-------------|
| <b>Jet Kerosene</b>      | 38,385        | 16,143        | 9,862        | 2,200        | 3,286        | 3,726        | 3,845        | 1,507        | 1,025        | 3,746        | 2,904        | 4,810        | 3,551        | 3,875        | 40.0        |
| <b>Aviation Gasoline</b> | 15.2          | 6.35          | 1.09         | 0.26         | 0.17         | 0.00         | 0.13         | 0.00         | 0.17         | 0.04         | 0.00         | 0.09         | 0.30         | 0.00         | 0.00        |
| <b>Σ 1.A.5.b ii</b>      | <b>38,400</b> | <b>16,149</b> | <b>9,863</b> | <b>2,200</b> | <b>3,286</b> | <b>3,726</b> | <b>3,845</b> | <b>1,507</b> | <b>1,025</b> | <b>3,746</b> | <b>2,904</b> | <b>4,810</b> | <b>3,551</b> | <b>3,875</b> | <b>40.0</b> |

<sup>1</sup> possible reason for jumps in delivered amounts: storage (resulting in no (2008, 2011+) or very small deliveries (2009) (see also: FAQs)



Here, as already stated in the superordinate chapter, the **activity data** provided represents original annual fuel deliveries data derived from the Official Mineral Oil Data as compiled and published by BAFA <sup>3)</sup>. Where the ups and downs visible for **aviation gasoline** appear to be influenced by stock-keeping activities, no clear explanation can be provided for **jet kerosene**, where a sharp decrease in inland deliveries is visible for 2024 that cannot be clarified further at the moment.

## Emission factors

Without better information, constant tier1 values are used mainly (see table below).

NOTE: As the aircraft used for military purposes differ strongly from those used in civil aviation, the country specific EF used for kerosene in 1.A.3.a could not be used for reporting emissions from 1.A.5.b as well. Therefore, and due to missing information on the technical developments within the military aircraft fleet, the EF values applied show no trend.

Table 3: Country-specific emission factors, in kg/TJ

|                          | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017   | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|--------------------------|------|------|------|------|------|------|------|--------|------|------|------|------|------|------|------|
| <b>JET KEROSENE</b>      |      |      |      |      |      |      |      |        |      |      |      |      |      |      |      |
| <b>NH<sub>3</sub></b>    |      |      |      |      |      |      |      | 4.00   |      |      |      |      |      |      |      |
| <b>NMVOC</b>             |      |      |      |      |      |      |      | 98.0   |      |      |      |      |      |      |      |
| <b>NO<sub>x</sub></b>    |      |      |      |      |      |      |      | 205    |      |      |      |      |      |      |      |
| <b>SO<sub>x</sub></b>    | 25.1 | 15.2 | 8.46 | 6.34 | 4.65 | 4.65 | 4.65 | 4.65   | 4.65 | 4.65 | 4.65 | 4.65 | 4.65 | 4.65 | 4.65 |
| <b>BC<sup>1</sup></b>    |      |      |      |      |      |      |      | 5.76   |      |      |      |      |      |      |      |
| <b>PM<sup>2</sup></b>    |      |      |      |      |      |      |      | 12.0   |      |      |      |      |      |      |      |
| <b>CO</b>                |      |      |      |      |      |      |      | 485    |      |      |      |      |      |      |      |
| <b>AVIATION GASOLINE</b> |      |      |      |      |      |      |      |        |      |      |      |      |      |      |      |
| <b>NH<sub>3</sub></b>    |      |      |      |      |      |      |      | NE     |      |      |      |      |      |      |      |
| <b>NMVOC</b>             |      |      |      |      |      |      |      | 300    |      |      |      |      |      |      |      |
| <b>NO<sub>x</sub></b>    |      |      |      |      |      |      |      | 302    |      |      |      |      |      |      |      |
| <b>SO<sub>x</sub></b>    |      |      |      |      |      |      |      | 0.51   |      |      |      |      |      |      |      |
| <b>BC<sup>1</sup></b>    |      |      |      |      |      |      |      | 1.10   |      |      |      |      |      |      |      |
| <b>PM<sup>2</sup></b>    |      |      |      |      |      |      |      | 7.50   |      |      |      |      |      |      |      |
| <b>TSP<sup>3</sup></b>   |      |      |      |      |      |      |      | 22.7   |      |      |      |      |      |      |      |
| <b>CO</b>                |      |      |      |      |      |      |      | 15,000 |      |      |      |      |      |      |      |

<sup>1</sup> estimated via a f-BCs (avgas: 0.15, jet kerosene: 0.48) as provided in the EMEP/EEA GB 2023 in Table A3.2 - Tables in this chapter of the guidebook that contain f-BC fraction data <sup>4)</sup>

<sup>2</sup> EF(PM<sub>2.5</sub>) also applied for PM<sub>10</sub>, and TSP (assumption: > 99% of TSP from diesel oil combustion consists of PM<sub>2.5</sub>)

<sup>3</sup> TSP from leaded aviation gasoline = EF(Pb) x 1.6 (see also: FAQs)



For the country-specific emission factors applied for particulate matter, no clear indication is available, whether or not condensables are included.



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources. - Here, regarding lead and TSP from leaded avgas, constant tier1 EFs based on the average lead content of AvGas 100 LL are used.

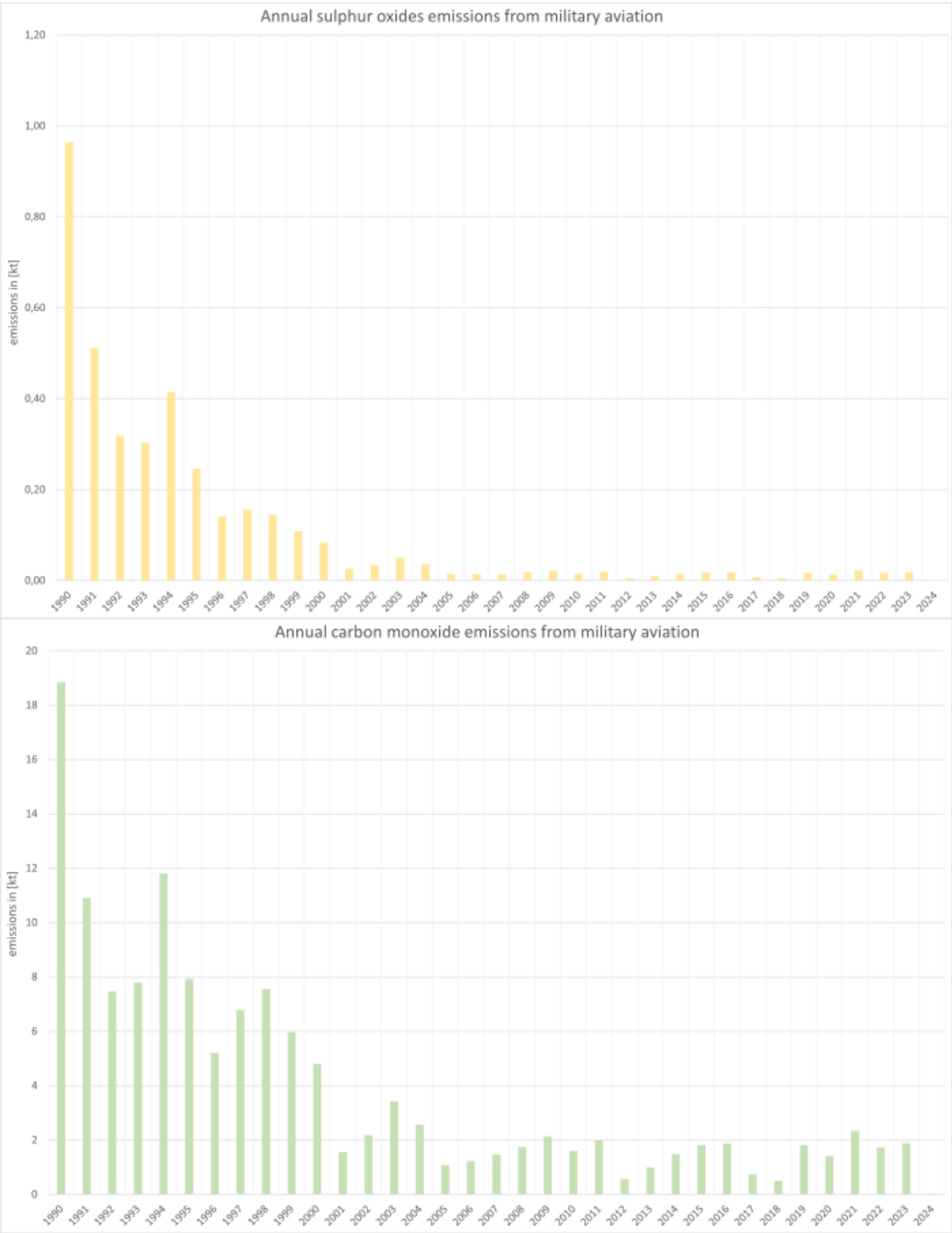
## Discussion of emission trends



As only NFR 1.A.5.b as a whole is taken into account within the key category analysis, this country-specific sub-sector is not considered separately.

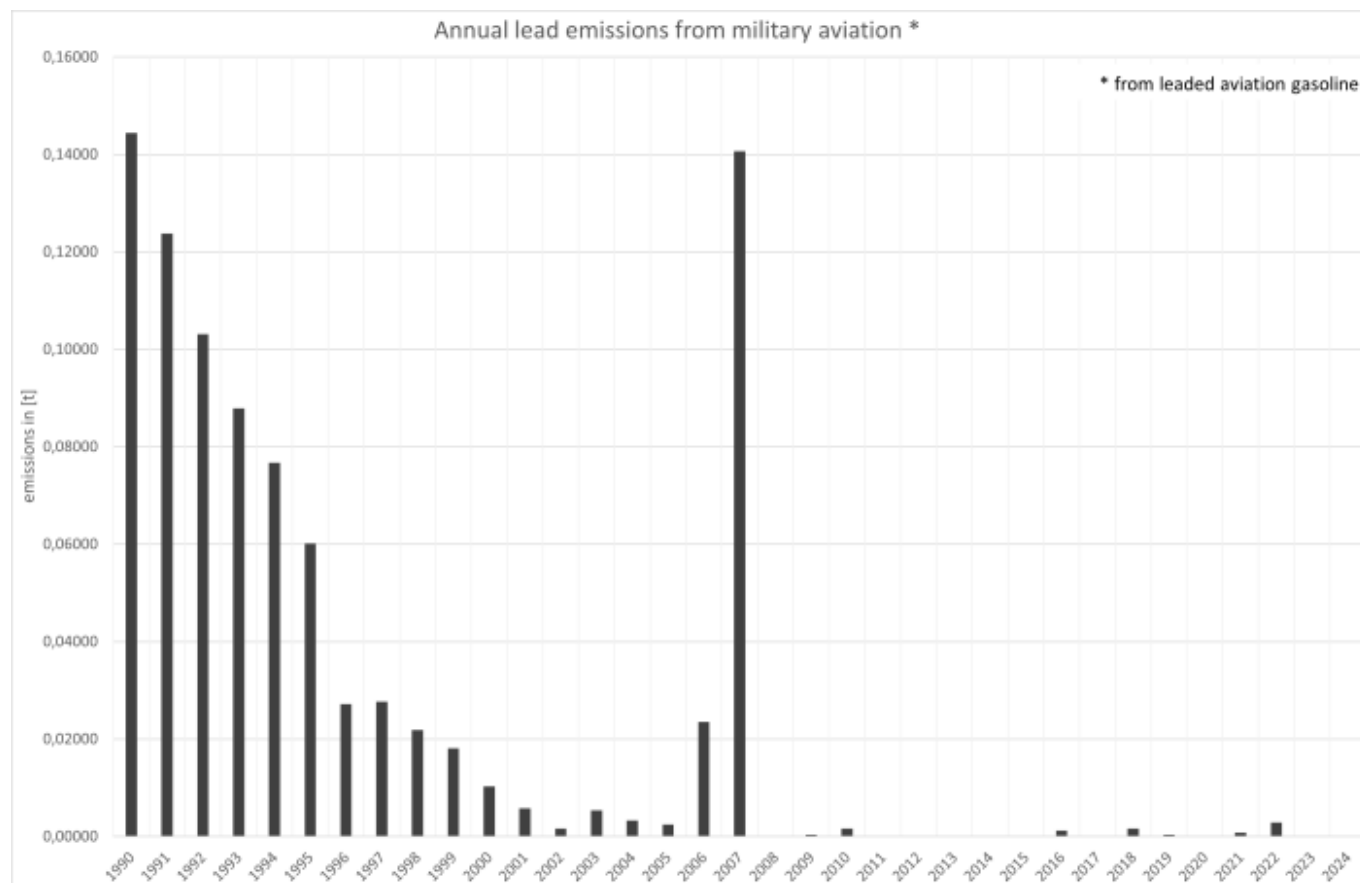
Due to the application of very several tier1 emission factors, most emission trends reported for this sub-category only reflect

the trend in fuel deliveries. Therefore, the fuel-consumption dependend trends in emission estimates are only influenced by the annual fuel mix.



Here, as the EF(BC) are estimated via fractions provided in <sup>5)</sup>, black carbon emissions follow the corresponding emissions of PM<sub>2.5</sub>.

Nonetheless, this NFR category shows interesting trends for emissions of **Lead (Pb)** from leaded gasoline (until 1997) and aviation gasoline:



Until 1997, lead emissions were dominated by the combustion of leaded gasoline in military ground-based vehicles. Therefore, the over-all trend for lead emissions from military vehicles and aircraft is driven mostly by the abolition of leaded gasoline in 1997. Towards this date, the amount of leaded gasoline decreased significantly. After 1997, the only source for lead from mobile fuel combustion is avgas used in military aircraft. As for avgas, the trend of consumption is more or less decreasing steadily until 2005 but then shows a strong increase for 2006 and '07 (!), followed by no (2008 and 2011) or very small deliveries (2009, 2010). As mentioned above, there are no real consumption data available: AD is based on fuel deliveries to the military only. Thus, especially the trends for the use of aviation gasoline and the resulting emissions show this significant jumps in 2006 and 07, falling back to zero in 2008 and 2011ff. The party is aware of this issue and will try to solve it as soon as data allows. (see also: FAQ)

## Recalculations



For information on revised inventory data, please see the [superordinate chapter](#).

## Uncertainties

Uncertainty estimates for **activity data** of mobile sources derive from research project FKZ 360 16 023: "Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland". For detailed information, please refer to the project's final report [<https://www.umweltbundesamt.de/publikationen/ermittlung-unsicherheiten-den-modellen-tremod> here] (German version only!).

Uncertainty estimates for **emission factors** were compiled during the PAREST research project. Here, the final report has



not yet been published.

## Planned improvements

There are no specific improvements planned at the moment.

## FAQs

### ***What is the reason for the big jumps in the consumption of aviation gasoline in 2006 & '07 and the zero-consumption in 2008?***

As mentioned above, consumption is deducted from AGEB and BAFA data on the amounts of fuels delivered to the sector. Therefore, the big jumps reported for 2006 & '07 might result from the storage of aviation gasoline in military stocks. Consequentially, the 0.00 TJ reported for 2008 show the missing of any deliveries to the military and should not be misunderstood as a non-use. The party is aware of this issue and will try to solve it as soon as data allows.

### ***On which basis does the party estimate the reported lead emissions from aviation gasoline?***

assumption by party: aviation gasoline = AvGas 100 LL (AvGas 100 LL is the predominant sort of aviation gasoline in Western Europe) <sup>6)</sup> (Wikipedia: "...Common in North America and western Europe, limited availability elsewhere worldwide.")

lead content of AvGas 100 LL: 0.56 g lead/liter (as tetra ethyl lead) ("Thus, general emission factors for the stationary combustion of kerosene and the combustion of gasoline in cars may be applied. The only exception is lead. Lead is added to aviation gasoline to increase the octane number. The lead content is higher than in leaded car gasoline, and the maximum permitted levels in the UK are shown below. A value of 0.6 g of lead per litre of gasoline should be used as the default value if there is an absence of more accurate information. Actual data may be obtained from oil companies.") <sup>7)</sup>

The applied procedure is similar to the one used for calculating lead emissions from leaded gasoline used in road transport. (There, in contrast to aviation gasoline, the lead content constantly declined resulting in a ban of leaded gasoline in 1997.)

### ***What is the country-specific methodology for estimating the reported TSP emissions from aviation gasoline?***

The TSP emissions calculated depend directly on the reported lead emissions: The emission factor for TSP is 1.6 times the emission factor used for lead:  $EF(TSP) = 1.6 \times EF(Pb)$ . - The applied procedure is similar to the one used for calculating TSP emissions from leaded gasoline used in road transport.

### ***Why does the party report TSP emissions from leaded avgas, but no such $PM_{2.5}$ or $PM_{10}$ emissions?***

The  $EF(TSP)$  is estimated from the  $EF(Pb)$  which has been calculated from the lead content of Avgas 100 LL. There is no information on the percutual shares of  $PM_{2.5}$  &  $PM_{10}$  in the reported TSP and therefore no  $EF(PM_{2.5})$  &  $EF(PM_{10})$  were deducted.

### ***Why are similar EF applied for estimating exhaust heavy metal emissions from both fossil and biofuels?***

The EF provided in <sup>8)</sup> represent summatory values for (i) the fuel's and (ii) the lubricant's heavy-metal content as well as (iii) engine wear. Here, there might be no heavy metal contained the biofuels. But since the specific shares of (i), (ii) and (iii) cannot be separated, and since the contributions of lubricant and engine wear might be dominant, the same emission factors are applied to biodiesel and bioethanol.

<sup>1), 3)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralölnoten für die Bundesrepublik Deutschland;  
[https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html), Eschborn, 2025.

<sup>2)</sup> AGEB (2025b): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Zusatzinformationen - Heizwerte der Energieträger und Faktoren für die Umrechnung von spezifischen Mengeneinheiten in Wärmeeinheiten (aktuelle Bilanz) - 2022; URL:[https://ag-energiebilanzen.de/wp-content/uploads/EBD24p2\\_Heizwerte.xlsx](https://ag-energiebilanzen.de/wp-content/uploads/EBD24p2_Heizwerte.xlsx), (Aufruf: 09.12.2025) Köln & Berlin, 2025.

<sup>4), 7)</sup> EMEP/EEA (2023): EMEP/EEA EMEP/EEA air pollutant emission inventory guidebook 2023; Chapter 1.A.3.a, 1.A.5.b Aviation, Annex 2, page 44, Table A2.1;  
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-a-aviation-2023/@download/file>, Copenhagen, 2023

<sup>5), 8)</sup> EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook – 2019, Copenhagen, 2019.

<sup>6)</sup> <https://en.wikipedia.org/wiki/Avgas>

# 1.A.5.b iii - Military Navigation

## Short description

In sub-category 1.A.5.b iii - Other, Mobile (including Military) emissions from military navigation are reported.

| Method | AD    | EF               | Key Category Analysis                     |
|--------|-------|------------------|-------------------------------------------|
| T1, T2 | NS, M | D, M, CS, T1, T3 | see <a href="#">superordinate chapter</a> |

## Methodology

### Activity Data

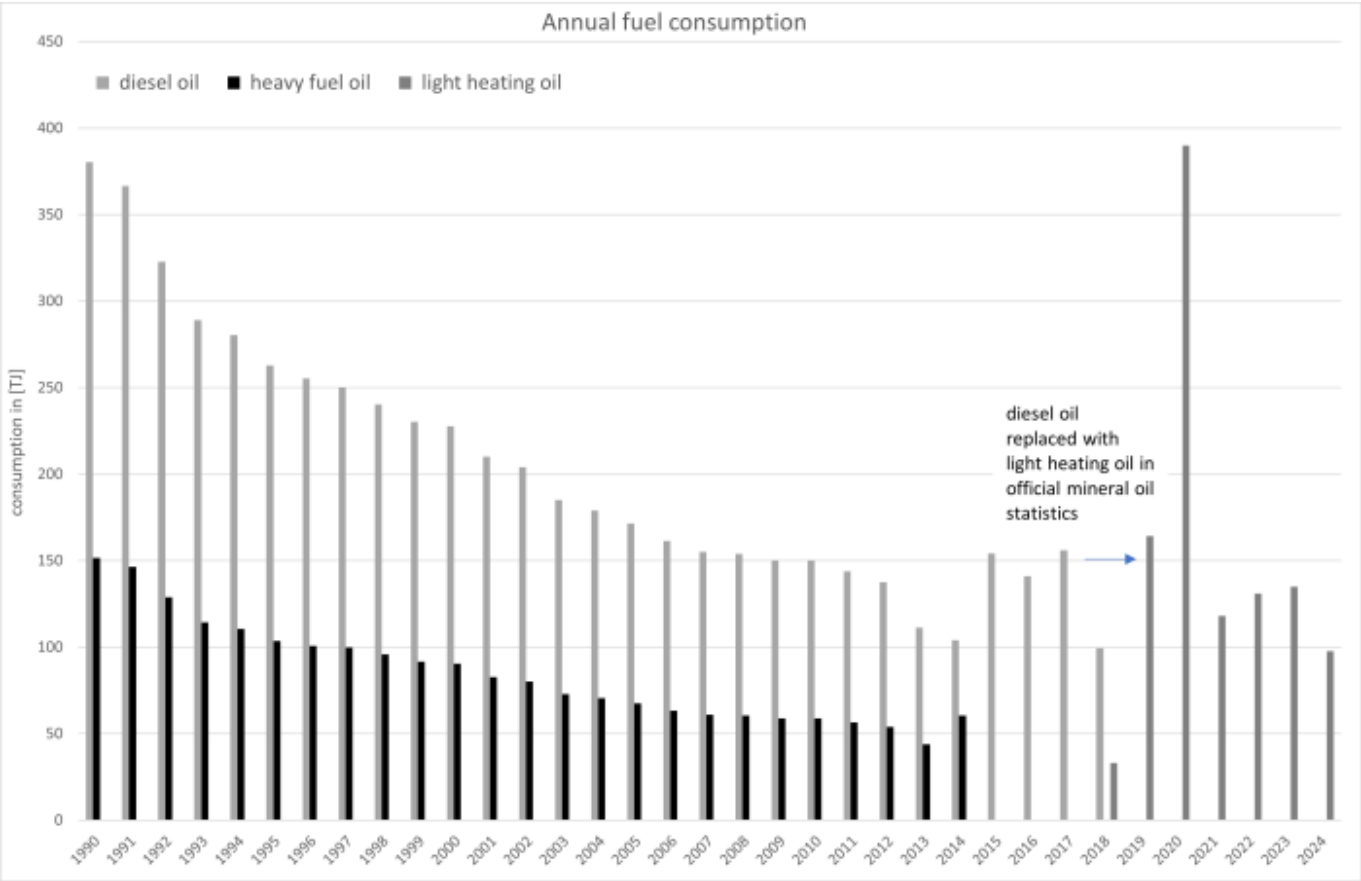
Primary fuel data for national military waterborne activities is included in NEB lines 6 ('International Deep-Sea Bunkers') and 64 ('Coastal and Inland Navigation') for IMO-registered and not registered ships respectively. (AGEB,2025) <sup>1)</sup>

The annual shares used within NFR 1.A.5.b iii are therefore calculated within (Deichnik, K. (2025)) <sup>2)</sup>, where ship movement data (AIS signal) allows for a bottom-up approach providing the needed differentiation.

Table 1: Annual fuel consumption, in terajoules

|                | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|----------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| Diesel Oil     | 380  | 263  | 228  | 171  | 150  | 154  | 141  | 156  | 99.5 | NO   |      |      |      |      |      |
| Light Fuel Oil | NO   |      |      |      |      |      |      |      | 33.2 | 164  | 390  | 118  | 131  | 135  | 97.6 |
| Heavy Fuel Oil | 152  | 104  | 90.4 | 67.4 | 59.0 | NO   |      |      |      |      |      |      |      |      |      |
| Σ 1.A.5.b iii  | 532  | 366  | 318  | 239  | 209  | 154  | 141  | 156  | 133  | 164  | 390  | 118  | 131  | 135  | 97.6 |

source: Deichnik, K. (2025): BSH model 2025



PLEASE NOTE: For the time being, there is no explanation for the jump in fuel consumption reported for 2020. However, as this data is calculated based on actual ship movement data, there should be no statistical or methodological error. On the other hand, if there is indeed an error, it should automatically be corrected with the current and fundamental revision of the model.

## Emission factors

The emission factors applied here, are derived from different sources and therefore are of very different quality.

For the main pollutants, country-specific implied values are used, that are based on tier3 EF included in (Deichnik (2024)) which mainly relate on values from the EMEP/EEA guidebook 2023 <sup>3)</sup>. These modelled IEFs take into account the ship specific information derived from AIS data as well as the mix of fuel-qualities applied depending on the type of ship and the current state of activity.

Table 2: Annual country-specific implied emission factors, in kg/TJ

|                                                                                                                                                                                                    | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020 | 2021 | 2022 | 2023 | 2024 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|
| <b>DIESEL OIL &amp; LIGHT FUEL OIL<sup>1</sup></b>                                                                                                                                                 |       |       |       |       |       |       |       |       |       |       |      |      |      |      |      |
| <b>NH<sub>3</sub></b>                                                                                                                                                                              | 0.33  | 0.33  | 0.33  | 0.33  | 0.33  | 0.33  | 0.33  | 0.33  | 0.33  | 0.33  | 0.17 | 0.33 | 0.22 | 0.27 | 0.23 |
| <b>NMVOC</b>                                                                                                                                                                                       | 80.1  | 80.1  | 80.1  | 80.1  | 80.1  | 86.6  | 84.0  | 79.6  | 69.1  | 79.3  | 38.9 | 30.7 | 35.8 | 45.7 | 42.3 |
| <b>NO<sub>x</sub></b>                                                                                                                                                                              | 1,176 | 1,176 | 1,176 | 1,176 | 1,176 | 1,214 | 1,228 | 1,236 | 1,085 | 1,206 | 682  | 570  | 680  | 820  | 855  |
| <b>SO<sub>x</sub></b>                                                                                                                                                                              | 466   | 419   | 233   | 186   | 69.8  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2  | 37.2 | 37.2 | 37.2 | 37.2 | 37.2 |
| <b>BC</b>                                                                                                                                                                                          | 14.5  | 14.5  | 14.5  | 14.5  | 14.5  | 14.8  | 14.2  | 13.8  | 15.0  | 14.3  | 6.79 | 12.2 | 8.30 | 10.3 | 9.28 |
| <b>PM<sub>2.5</sub></b>                                                                                                                                                                            | 46.8  | 46.8  | 46.8  | 46.8  | 46.8  | 47.8  | 45.8  | 44.7  | 48.5  | 46.1  | 21.9 | 39.4 | 26.8 | 33.2 | 29.9 |
| <b>PM<sub>10</sub></b>                                                                                                                                                                             | 50.1  | 50.1  | 50.1  | 50.1  | 50.1  | 51.2  | 49.1  | 47.8  | 51.9  | 49.3  | 23.4 | 42.2 | 28.6 | 35.6 | 32.0 |
| <b>TSP</b>                                                                                                                                                                                         | 50.1  | 50.1  | 50.1  | 50.1  | 50.1  | 51.2  | 49.1  | 47.8  | 51.9  | 49.3  | 23.4 | 42.2 | 28.6 | 35.6 | 32.0 |
| <b>CO</b>                                                                                                                                                                                          | 24.0  | 24.0  | 24.0  | 24.0  | 24.0  | 15.1  | 15.5  | 15.8  | 22.3  | 20.4  | 23.3 | 25.3 | 32.7 | 32.2 | 41.5 |
| <b>HEAVY FUEL OIL</b>                                                                                                                                                                              |       |       |       |       |       |       |       |       |       |       |      |      |      |      |      |
| <b>NH<sub>3</sub></b>                                                                                                                                                                              | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  |       |       |       |       |       | NA   |      |      |      |      |
| <b>NMVOC</b>                                                                                                                                                                                       | 80.5  | 80.5  | 80.5  | 80.5  | 80.5  |       |       |       |       |       | NA   |      |      |      |      |
| <b>NO<sub>x</sub></b>                                                                                                                                                                              | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 |       |       |       |       |       | NA   |      |      |      |      |
| <b>SO<sub>x</sub></b>                                                                                                                                                                              | 1,319 | 1,332 | 1,323 | 1,336 | 496   |       |       |       |       |       | NA   |      |      |      |      |
| <b>BC</b>                                                                                                                                                                                          | 14.6  | 14.8  | 14.7  | 14.8  | 14.9  |       |       |       |       |       | NA   |      |      |      |      |
| <b>PM<sub>2.5</sub></b>                                                                                                                                                                            | 122   | 123   | 122   | 124   | 124   |       |       |       |       |       | NA   |      |      |      |      |
| <b>PM<sub>10</sub></b>                                                                                                                                                                             | 131   | 132   | 131   | 132   | 132   |       |       |       |       |       | NA   |      |      |      |      |
| <b>TSP</b>                                                                                                                                                                                         | 131   | 132   | 131   | 132   | 132   |       |       |       |       |       | NA   |      |      |      |      |
| <b>CO</b>                                                                                                                                                                                          | 60.9  | 60.9  | 60.9  | 60.9  | 60.9  |       |       |       |       |       | NA   |      |      |      |      |
| <sup>1</sup> similar EFs applied for diesel oil and light fuel oil (as of 2018)                                                                                                                    |       |       |       |       |       |       |       |       |       |       |      |      |      |      |      |
| <sup>2</sup> ratio PM <sub>2.5</sub> : PM <sub>10</sub> : TSP derived from the tier1 default EF as provided in <sup>4)</sup>                                                                       |       |       |       |       |       |       |       |       |       |       |      |      |      |      |      |
| <sup>3</sup> estimated from a BC-fraction derived from <sup>5)</sup> , chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation, Table 3-1 (0.017 for heavy fuel oil) and 3-2 (0.045 for diesel oil) |       |       |       |       |       |       |       |       |       |       |      |      |      |      |      |



With respect to the emission factors applied for particulate matter, given the circumstances during test-bench measurements, condensables are most likely included at least partly. <sup>12)</sup>



For information on the **emission factors for heavy-metal and POP exhaust emissions**, please refer to Appendix 2.3 - Heavy Metal (HM) exhaust emissions from mobile sources and Appendix 2.4 - Persistent Organic Pollutant (POP) exhaust emissions from mobile sources.

## Discussion of emission trends



As only NFR 1.A.5.b as a whole is taken into account within the key category analysis, this country-specific sub-sector is not considered separately.

## Recalculations



For information on revised inventory data, please see the [superordinate chapter](#).

## Uncertainties



For uncertainty information, please see the [superordinate chapter](#).

## Planned improvements

Besides routine maintenance and further development of the BSH model, the proxy emission factors applied for PAH emissions from vessels/ships derived from tier1 defaults provided for railways and heavy-duty vehicles in the EMEP/EEA Guidebook 2019 will be replaced by values derived from Chapter 1.A.3.d Navigation (shipping) 2023 of the EMEP/EEA Guidebook 2023 (see also: [https://iir.umweltbundesamt.de/2026/general/planned\\_improvements/start](https://iir.umweltbundesamt.de/2026/general/planned_improvements/start) and [https://iir.umweltbundesamt.de/2026/appendices/appendix2.4\\_pops\\_from\\_mobile\\_sources](https://iir.umweltbundesamt.de/2026/appendices/appendix2.4_pops_from_mobile_sources)).

<sup>1)</sup> AGEB (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD24p2-1.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>2)</sup> Deichnik (2025): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs; Federal Maritime and Hydrographic Agency (BSH - Bundesamt für Seeschifffahrt und Hydrographie Hamburg); on behalf of the Umweltbundesamt, Hamburg / Dessau-Roßlau, 2025.

<sup>3), 4), 5)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2019, Copenhagen, 2023.

<sup>12)</sup>

During test-bench measurements, temperatures are likely to be significantly higher than under real-world conditions, thus reducing condensation. On the contrary, smaller dilution (higher number of primary particles acting as condensation germs) together with higher pressures increase the likeliness of condensation. So over-all condensables are very likely to occur but different to real-world conditions.

# 1.B - Fugitive Emissions from fossil fuels

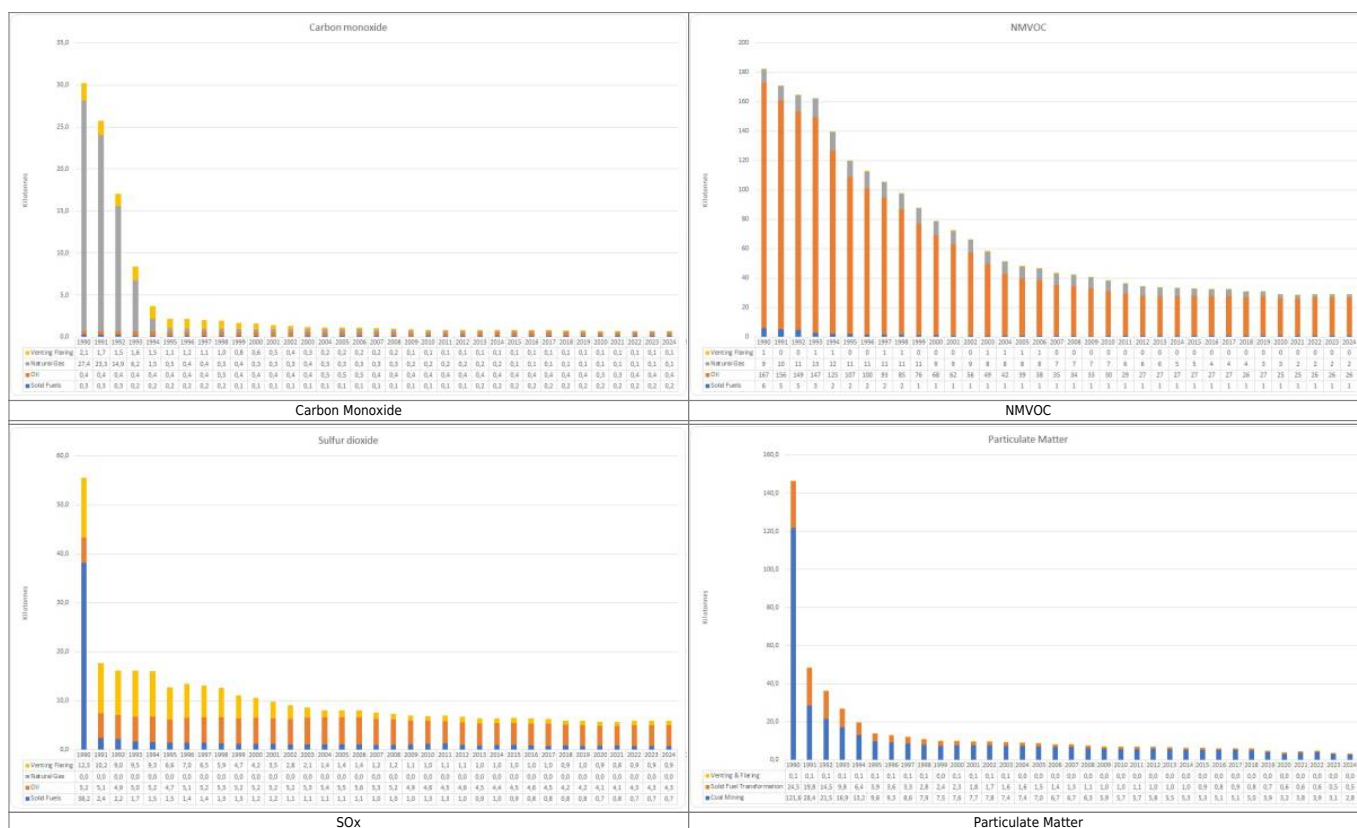
During all stages of fuel production and use, from extraction of fossil fuels to their final use, fuel components can escape or be released as fugitive emissions.

While NMVOC, TSP and SO<sub>x</sub> are the most important emissions within the source category *solid fuels*, fugitive emissions of oil and natural gas include substantial amounts of NMVOC and SO<sub>x</sub>.

1.B - "Fugitive emission from fuels" consist of following sub-categories:

| NFR-Code       | Name of category           |
|----------------|----------------------------|
| <b>1.B.1</b>   | <b>Solid Fuels</b>         |
| <b>1.B.2.a</b> | <b>Oil</b>                 |
| <b>1.B.2.b</b> | <b>Gas</b>                 |
| <b>1.B.2.c</b> | <b>Venting and Flaring</b> |
| <b>1.B.3</b>   | <b>Geothermal Energy</b>   |

## Trends in emissions



**Sulphur Dioxide** emissions occur during the production of hard-coal coke. The value of the year 1990 is partly based on the GDR's emission report, chapter "Produktion" (=production) which has no clear differentiation between mining, transformation and handling of coal. The total emission as reported in the emission report is allocated in the NFR categories 1.B.1 and 2. The split factor is based on estimation of experts.

The apparently steep decline from 2007 to 2008 is the result of a research project in 2010, where new emission factors were determined for coke production for the years 2008. In sub-category 1.B.2, one main driver of shrinking SO<sub>2</sub> emission is the decreasing amount of flared natural gas. The shrinking emissions are also attributed to the declining emissions from desulphurisation, that are a result of the implementation of modern technology.

**Particulate matter** emissions occur during the transformation of lignite and hard coal. The very steep decline of the emissions in the early 1990s is due to the shrinking production of lignite briquettes (almost 90% in the first five years). The value of the year 1990 is partly based on the GDR's emission report, chapter "Produktion" (=production) which has no clear differentiation between mining, transformation and handling of lignite. The total emission as reported in the emission report is allocated in the NFR categories 1.B.1 and 2. The split factor is based on estimation of experts.

**NMVOC** emissions occur during the production of hard-coal coke. The shrinking emissions are mainly attributed to the hard-coal coke production and the decommissioning of outdated plants. The main sources of NMVOC emissions from total petrol distribution (1.B.2.a.v) were fugitive emissions from handling and transfer (filling/unloading) and container losses (tank breathing). These emissions have decreased by round about 65 % since 1990. The decrease in fugitive emissions during this period is the result of implementation of the Technical Instructions on Air Quality Control (TA-Luft 2002) and of the 20th and 21st Ordinance on the Execution of the Federal Immission Control Act (20. and 21. BImSchV), involving introduction of vapour recovery systems. It is also the result of reduced petrol consumption.

Currently, about 13 million m<sup>3</sup> of petrol fuels are transported in Germany via railway tank cars. This transport volume entails a maximum of 300,000 handling processes (loading and unloading). Some 5,000 to 6,000 railway tank cars for transport of petrol are in service. Transfer/handling (filling/unloading) and tank losses result in emissions of only 1.4 kt VOC per year. The emissions situation points to the high technical standards that have been attained in railway tank cars and pertinent handling facilities. On the whole, oil consumption is expected to stagnate or decrease. As a result, numbers of oil storage facilities can be expected to decrease as well.

**Carbon monoxide** emissions occur during the production of coke. A trend-reversing issue was the decommissioning of outdated plants in the 1990s. Flaring in oil refineries is the main source for carbon monoxide emission in category 1.B.2. In the early 1990s, emissions from distribution of town gas were also taken into account in calculations. In 1990, the town-gas distribution network accounted for a total of 16 % of the entire gas network. Of that share, 15 % consisted of grey cast iron lines and 84 % consisted of steel and ductile cast iron lines. Since 1997 no town gas has been distributed in Germany's gas mains. Town-gas was the only known source of CO emissions in category 1.B.2.b.

## Recalculations

Due to the implementation of the data from (Zimmermann, 2025), <sup>1)</sup> the following recalculations were made for NMVOC for 1B2a (see Table)

| Submission | 1990   | 2000  | 2010  | 2020  | 2023  |
|------------|--------|-------|-------|-------|-------|
| 2026       | 158,42 | 64,61 | 31,18 | 25,84 | 25,53 |
| 2025       | 166,94 | 67,93 | 30,41 | 25,27 | 25,00 |



For **pollutant-specific information on recalculated emission estimates reported for Base Year and 2023**, please see the recalculation tables following chapter [Chapter 9.1 - Recalculations](#).

## Improvements planned for future submissions

- an ongoing research project estimates emissions from storage and cleaning of tanks for oil and oil products - results are planned to be implemented into the inventory in 2026

## 1.B.1 - Solid Fuels



### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 1.B.1.a                                                                                   | T2, M                                | AS | CS |
| 1.B.1.b                                                                                   | T2, T3                               | AS | CS |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| Key Category | NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC  | CO  | Pb | Cd | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCB | PCB |
|--------------|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|-----|-----|----|----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|------|-----|-----|
| 1.B.1.a      | NA              | -/-    | NA              | NA              | -/-               | -/T              | -/- | NA  | NA  | NA | NA | NA  | NA  | NA  | NA  | NA  | NA  | NA  | NA     | NA    | NA    | NA    | NA    | NA   | NA  | NA  |
| 1.B.1.b      | -/-             | -/-    | -/-             | -/-             | -/-               | -/-              | L/T | -/- | -/- | NA | NA | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | L/T   | -/T   | L/T   | -/T   | L/T  | NA  | NA  |



|            |                                                                                     |
|------------|-------------------------------------------------------------------------------------|
| <b>L/-</b> | key source by <b>Level</b> only                                                     |
| <b>-/T</b> | key source by <b>Trend</b> only                                                     |
| <b>L/T</b> | key source by both <b>Level</b> and <b>Trend</b>                                    |
| <b>-/-</b> | no key source for this pollutant                                                    |
| <b>IE</b>  | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |
| <b>NE</b>  | emission of specific pollutant <b>Not Estimated</b> (yet)                           |
| <b>NA</b>  | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |
| <b>*</b>   | no analysis done                                                                    |

Source category **1.B.1 - Solid fuels** consists of two sub-source subcategories – the source subcategory Coal mining (1.B.1.a) and the source subcategory Coal transformation (1.B.1.b). This chapter discusses fugitive emissions from coal mining, coal handling, including door leakages from coke ovens and quenching (emissions from the furnace are covered by category 1.A.1.c), and emissions from the beneficiation of solid fuels. In the mining sector, a distinction is made between open-pit mines, in which raw materials are extracted from pits open to the surface, and closed-pit mines, in which seams are mined underground. In Germany, hard coal used to be mined in closed-pits only (until 2018), while lignite is mined in four coal fields since 2003 with the open-pit method only.

Until 2018 Germany produced significant amounts of hard coal in underground mines. Since 2019, hard coal has been imported exclusively. NMVOC emissions are considered insignificant as the coal outgassed along the import route. Particle emissions from loading and unloading as well as storage are reported under **2.L(a) - Handling of Bulk Products**“

## Methodology

### Lignite production



Activity data for lignite production have been taken from the *Statistik der Kohlenwirtschaft's* website (in German only) <sup>1)</sup>. Extracted coal is moved directly to processing and to power stations.

The emission factors used for calculating emissions from lignite production (TSP, PM<sub>10</sub> and PM<sub>2.5</sub>) already include possible emissions from transport and storage. The PM<sub>10</sub> factor is taken from a 2021 research project <sup>2)</sup>. TSP and PM<sub>2.5</sub> have been reduced the same way on the basis of the previous values <sup>3)</sup>.

**Table 1: Annual amounts of extracted raw lignite, in [Mt]**

| 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 357  | 193  | 168  | 178  | 169  | 178  | 172  | 171  | 166  | 131  | 107  | 126  | 131  | 102  | 92   |

Table 2: Emission factors applied for lignite extraction, in [kg/t]

| Pollutant         | Value |
|-------------------|-------|
| TSP               | 0.03  |
| PM <sub>10</sub>  | 0.015 |
| PM <sub>2.5</sub> | 0.002 |

**Lignite coke production**

Table 3: Annual amounts of lignite coke produced, in [Mt]

| 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 3.36 | 0.19 | 0.18 | 0.17 | 0.18 | 0.17 | 0.16 | 0.15 | 0.16 | 0.16 | 0.15 | 0.16 | 0.14 | 0.16 | 0.15 |

Emissions from lignite production other than listed below are reported by plant operator. Particle emission factors were verified in a research project (Emissionen und Maßnahmenanalyse Feinstaub 2000-2020) by Jörß et al. (2007)<sup>4)</sup>.

Table 4: Emission factors applied for lignite-coke production

| Pollutant         | Unit | Value |
|-------------------|------|-------|
| TSP               | kg/t | 0.1   |
| PM <sub>10</sub>  | kg/t | 0.048 |
| PM <sub>2.5</sub> | kg/t | 0.013 |
| PAH               | mg/t | 55    |
| PCDD/F            | µg/t | 0.03  |

**Hard coal coke production**

The activity rates for hard coal coke production have been taken from the *Statistik der Kohlenwirtschafts's* website (in German only)<sup>5)</sup>.

Table 5: Annual amounts of hard coal coke produced, in [Mt]

| 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 18.5 | 11.1 | 9.12 | 8.40 | 8.15 | 8.80 | 9.39 | 9.34 | 9.36 | 8.91 | 7.94 | 8.25 | 8.27 | 8.03 | 8.26 |

The emission factors for hard coal coke production have been obtained from the research project "Emission factors for the iron and steel industry, for purposes of emissions reporting" ("Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichterstattung") by Hensmann et al. (2011)<sup>6)</sup>.

Table 6: Emission factors for hard coal coke production

| Pollutant         | Unit | Value    |
|-------------------|------|----------|
| CO                | kg/t | 0.015    |
| NH <sub>3</sub>   | kg/t | 0.000243 |
| NMVOC             | kg/t | 0.096    |
| SO <sub>2</sub>   | kg/t | 0.004    |
| TSP               | kg/t | 0.011    |
| PM <sub>10</sub>  | kg/t | 0.004    |
| PM <sub>2.5</sub> | kg/t | 0.004    |
| PAH               | mg/t | 55       |
| PCDD/F            | µg/t | 0.0015   |

There are many potential sources of PAH emissions from coking plants. The dominant emission sources are leakages from coke oven doors and from charging operations. As there is limited data available on PAH emissions, the uncertainties of the estimated emission factors are very high. It should also be taken into account that emissions from coke production greatly vary between different coke production plants. The emission factors for benzo[a]pyrene and mixed PAH have been revised by research projects in 2010 <sup>7)8)</sup>. Split factors for Black Carbon (BC) are based on the EMEP Guidebook 2016 <sup>9)</sup>.

### Decommissioned hard-coal mines

NMVOC Emissions from decommissioned hard-coal mines play a role in this sub- source category. When a hard-coal mine is decommissioned, mine gas can escape from neighbouring rock, and from coal remaining in the mine, into the mine's network of shafts and passageways. Since the mine is no longer artificially ventilated, the mine gas collects and can then reach the surface via gas pathways in the overlying rock or via the mine's own shafts and passageways. Such mine gas was long seen primarily as a negative environmental factor. Recently, increasing attention has been given to the gas' positive characteristics as a fuel (due to its high methane content, it is used for energy recovery). In the past, use of mine gas was rarely cost-effective. This situation changed fundamentally in 2000 with the Renewable Energy Sources Act (EEG). Although mine gas is a fossil fuel in finite supply, its use supports climate protection, and thus the gas was included in the EEG. The Act requires network operators to accept, and provide specified compensation for, electricity generated with mine gas and fed into the grid.

The NMVOC emissions from decommissioned hard-coal mines have been calculated in the research project "Potential for release and utilisation of mine gas" ("Potential zur Freisetzung und Verwertung von Grubengas") <sup>10)</sup>. The relevant calculations were carried out for all mining-relevant deposits in Germany.

Table 7: NMVOC emission factor for decommissioned hard-coal mines, in [kg/m<sup>13</sup>]

| EF       |
|----------|
| 0.001599 |

### Recalculations



For more details please refer to the super-ordinate chapter [1.B - Fugitive Emissions from fossil fuels](#)

### Planned improvements



At the moment, no further category-specific improvements are planned.

<sup>1)</sup> Statistik der Kohlenwirtschaft (2019) [External Link](#) (last pageview: March 2025)

<sup>2)</sup> Dokumentation zur Berechnung des PM10-Austrags aus dem Tagebau Hambach im Jahr 2013 und Ableitung eines Emissionsfaktors (2021) [External Link](#) (last pageview: March 2025)

<sup>3)</sup> Co-ordinated European Programme on Particulate Matter Emission Inventories, Projections and Guidance (CEPMEIP) [External Link](#)

<sup>4)</sup> Jörß et al. (2007): Jörß, W.; Handke, V. (Institut für Zukunftsstudien und Technologiebewertung (IZT), Berlin) mit Beiträgen von Lambrecht, U., Dünnebeil, Fr. (Institut für Energie und Umweltforschung Heidelberg (ifeu)): Emissionen und Maßnahmenanalyse Feinstaub 2000–2020. UBA-TEXTE Nr. 38/200; URL: <https://www.umweltbundesamt.de/publikationen/emissionen-massnahmenanalyse-feinstaub-2000-2020>; on behalf of the Umweltbundesamt; Dessau-Roßlau, 2007.

<sup>6)</sup> Hensmann et al. (2011): Hensmann, M., Haardt, S., Ebert, D.: Emission factors for the iron and steel industry, for purposes of emissions reporting" ("Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichterstattung"; <https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/4362.pdf>; on behalf of the Umweltbundesamt, Dessau-Roßlau, October 2012

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- <sup>7)</sup> Federal Environment Agency and DFIU research project "Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationale Richtlinien, Teilbericht Prioritäre Quellen", on behalf of the Umweltbundesamt, 2010 (not available online)
- <sup>8)</sup> Federal Environment Agency and BFI research project No. 3707 42 301 "Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichterstattung", 2011 [External Link](#)
- <sup>9)</sup> EMEP/EEA Air Pollutant Emission Inventory Guidebook 2016;  
<https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/1-energy/1-b-fugitives>, Copenhagen, 2016
- <sup>10)</sup> Meiners, H. (2014): Potential zur Freisetzung und Verwertung von Grubengas

# 1.B.2 - Oil And Natural Gas



|            |                                                                                     |
|------------|-------------------------------------------------------------------------------------|
| <b>L/-</b> | key source by <b>Level</b> only                                                     |
| <b>-/T</b> | key source by <b>Trend</b> only                                                     |
| <b>L/T</b> | key source by both <b>Level</b> and <b>Trend</b>                                    |
| <b>-/-</b> | no key source for this pollutant                                                    |
| <b>IE</b>  | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |
| <b>NE</b>  | emission of specific pollutant <b>Not Estimated</b> (yet)                           |
| <b>NA</b>  | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |
| <b>*</b>   | no analysis done                                                                    |

### 1.B.2.a.i - Exploration, production, transport

Emissions from exploration consist of emissions from activities of drilling companies and other actors in the exploration sector. Gas and oil exploration takes place in Germany. According to the BVEG (former WEG) <sup>1)</sup>, virtually no fugitive emissions occur in connection with drilling operations, since relevant measurements are regularly carried out at well sites (with use of methane sensors in wellhead-protection structures, ultrasound measurements and annulus manometers) and old / decommissioned wells are backfilled and normally covered with concrete caps.

Table 1: Activity data applied for emissions from oil exploration

|                         | Unit | 1990   | 1995    | 2000   | 2005   | 2010   | 2015   | 2020  | 2023   | 2024   |
|-------------------------|------|--------|---------|--------|--------|--------|--------|-------|--------|--------|
| number of wells         | No.  | 12     | 17      | 15     | 23     | 16     | 18     | 12    | 12     | 18     |
| total of drilling meter | m    | 50,140 | 109,187 | 41,378 | 63,994 | 51,411 | 32,773 | 6,220 | 29.380 | 27.917 |

Since pertinent measurements are not available for the individual wells involved, a conservative approach is used whereby VOC emissions for wells are calculated on the basis of the share ratio of VOC = 9 NMVOC : 1 CH<sub>4</sub>, using the default methane factor of the IPCC Guidelines 2006 <sup>2)</sup>.

Table 2: NMVOC emission factor applied for emissions from oil exploration, in [kg/No.]

| Value |
|-------|
| 576   |

Emissions from extraction (crude oil) and first treatment of raw materials (petroleum) in the petroleum industry are included in 1.B.2.a.i as well. Because Germany's oil fields are old, oil production in Germany is highly energy-intensive (thermal extraction, operation of pumps to inject water into oil-bearing layers). The first treatment that extracted petroleum (crude oil) undergoes in processing facilities serves the purpose of removing gases, water and salt from the oil. Crude oil in the form present at wellheads contains impurities, gases and water and thus, does not conform to requirements for safe, easy transport in pipelines. No substance transformations take place. Impurities – especially gases (petroleum gas), salts and water – are removed in order to yield crude oil of suitable quality for transport in pipelines.

Table 3: Annual amounts of oil produced, in [kt]

| 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2020  | 2023  | 2024  |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 3,606 | 2,959 | 3,123 | 3,573 | 2,516 | 2,414 | 1,907 | 1,636 | 1,627 |

The emissions from production and processing are measured or calculated by the operators, and the pertinent data is published in the annual reports of the Federal association of the natural gas, oil and geothermal energy industries (BVEG) <sup>3)</sup>. The emission factors are determined from the reported emissions and the activity data.

Table 4: NMVOC emission factor applied for emissions from oil production, in [g/m<sup>3</sup>]

| Substance | Emission Factor |
|-----------|-----------------|
| NMVOC     | 63              |
| Mercury   | 0,001           |

Transport emissions are tied to activities of logistics companies and of pipeline operators and pipeline networks. After the

first treatment, crude oil is transported to refineries. Almost all transport of crude oil takes place via pipelines. Pipelines are stationary and, normally, run underground. In contrast to other types of transport, petroleum transport is not interrupted by handling processes.

Table 5: Activity data applied for emissions from oil transportation, in [kt]

| Activity                                     | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2020   | 2023   | 2024   |
|----------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Transport of domestically produced crude oil | 3,660  | 2,940  | 3,123  | 3,572  | 2,516  | 2,414  | 1,907  | 1,636  | 1,627  |
| Transport of imported crude oil              | 84,043 | 86,063 | 89,280 | 97,474 | 93,270 | 91,275 | 83,049 | 77,198 | 84,026 |
| Transport via inland-waterway tankers        | 89     | 67     | 112    | 176    | 6      | 43     | 46     | 44     | 5      |

For pipelines, the emission factor for inland-waterway tankers has been estimated by experts. The pertinent emission factors have been confirmed by the research project “Determination of emission factors and activity data in areas 1.B.2.a.i through vi”<sup>4)</sup>. Since long-distance pipelines are continually monitored and disruptive incidents in such pipelines are very rare<sup>5)</sup>, emissions occur – in small quantities – only at their transfer points. The emission factor is thus highly conservative. The emission factor covers the areas of transfer / injection into pipelines at pumping stations, all infrastructure along pipelines (connections, control units, measuring devices), and transfer at refineries, and it has been determined on the basis of conservative assumptions. For imported quantities, only one transfer point (the withdrawal station) is assumed, since the station for input into the pipeline network does not lie on Germany's national territory.

Table 6: NMVOC emission factor applied for emissions from oil transportation, in [kg/t]

| Activity                                      | Value |
|-----------------------------------------------|-------|
| Transports of domestically produced crude oil | 0.13  |
| Transports of imported crude oil              | 0.064 |
| Transports via inland-waterway tankers        | 0.34  |

### 1.B.2.a.iv- Refining / storage



Emissions in category 1.B.2.a.iv - Refining / storage consist of emissions from activities of refineries and of refining companies in the petroleum industry. Crude oil and intermediate petroleum products are processed in Germany. For the most part, the companies concerned receive crude oil for refining and processing. To some extent, intermediate petroleum products undergo further processing outside of refineries in processing networks. Such processing takes place in state-of-the-art plants.

Refinery tank storage systems are used to store both crude oil and intermediate and finished petroleum products. They thus differ from non-refinery tank storage systems in terms of both the products they store and the quantities they handle. Tank-storage facilities outside of refineries are used especially for interim storage of heating oil, gasoline and diesel fuel. The storage capacities of storage caverns for petroleum products are listed separately. In light of the ways in which storage caverns are structured, it may be assumed that no emissions of volatile compounds occur. This is taken into account in the emissions calculation.

Tanks are emptied and cleaned routinely before tank inspections and repairs. In tank cleaning, a distinction is made



between crude-oil tanks and product tanks. Because sediments accumulate in crude oil tanks, cleaning these tanks, in comparison to cleaning product tanks, is a considerably more laborious process. The substances in product tanks produce no sediments and thus are cleaned only when the products they contain are changed. In keeping with an assessment of Müller-BBM (2010)<sup>6)</sup>, the emission factors for storage of crude oil and of petroleum products may be assumed to take the cleaning processes into account.

Table 8: Activity data applied for emissions from oil refinement and storage

| Activity                                                          | unit                | 1990    | 1995    | 2000    | 2005    | 2010    | 2015    | 2020    | 2023    | 2024    |
|-------------------------------------------------------------------|---------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Quantity of crude oil refined                                     | kt                  | 107,058 | 96,475  | 107,632 | 114,589 | 95,378  | 93,391  | 83,990  | 78,946  | 85,402  |
| Capacity utilisation in refineries                                | %                   | 106     | 92      | 95      | 99      | 81      | 91      | 82      | 75      | 83      |
| Crude-oil-refining capacity in refineries                         | kt                  | 100,765 | 104,750 | 112,940 | 115,630 | 117,630 | 103,080 | 105,655 | 104,086 | 102,943 |
| Tank-storage capacity in refineries and pipeline terminals        | Mill m <sup>3</sup> | 27,1    | 28,4    | 24,9    | 24      | 22,5    | 22      | 20,7    | 21,1    | 21,1    |
| Storage capacity of tank-storage facilities outside of refineries | Mill m <sup>3</sup> | 15,4    | 15,9    | 18,1    | 17      | 15,9    | 15,3    | 15,3    | 15      | 15      |
| Storage capacity of caverns                                       | Mill m <sup>3</sup> | 26,6    | 25,3    | 27,9    | 27,2    | 27,2    | 25,5    | 25,5    | 28,3    | 28,3    |

**Processing** The emission factors used for NMVOC, CO, NO<sub>x</sub> and SO<sub>2</sub> were determined by evaluating the emission declarations of the period 2004 through 2016 in the framework of a research project (Bender & von Müller, 2020)<sup>7)</sup>.

#### Tank-storage facilities in refineries

In keeping with the results of the research project “Processing of data of emissions declarations pursuant to the 11th Ordinance Implementing the Federal Immission Control Act – the area of storage facilities” (Müller-BBM, 2010)<sup>8)</sup>, the crude-oil-distillation capacity is used as the activity data for estimating emissions from storage in refineries. The fugitive VOC emissions value specified in the VDI Guideline 2440<sup>9)</sup>, 0.16 kg/t, may be used as the emission factor. The EF for methane was derived from it (5-10 % of 0.16 kg) and then suitably deducted.

#### Tank-storage facilities outside of refineries

According to Müller-BBM (2010)<sup>10)</sup>, no emission factors could be derived by evaluating emission declarations for storage systems, which would be representative of individual systems. This is due, according to the same source, to the widely differing emission behaviours of different individual systems. It was possible, however, to form aggregated emission factors. For each relevant group of data, this was done by correlating the sums of all emissions with the sums of all capacities. For non-refinery tank-storage systems, storage of liquid petroleum products can be differentiated from storage of gaseous petroleum products, since the relevant data is suitably differentiated.

#### Claus plants

The emission factors used for NMVOC, CO, NO<sub>x</sub> and SO<sub>2</sub> were determined by evaluating emission declarations from refineries for the period 2004 through 2016, in the framework of a research project (Bender & von Müller, 2020)<sup>11)</sup>. Since no data was available for earlier years, the data obtained this way was used for all years as of 1990.

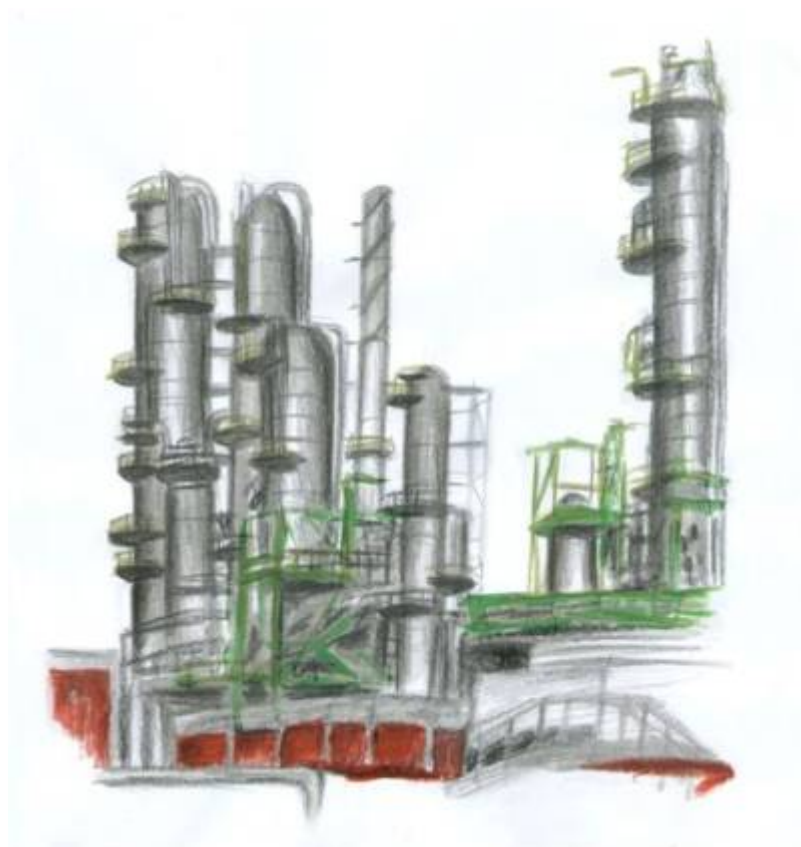


Table 9: Emission factors applied for emissions from oil refinement and storage

| Activity                                                                               | Substance       | Unit             | Value    |
|----------------------------------------------------------------------------------------|-----------------|------------------|----------|
| Fugitive emissions at refineries                                                       | NMVOC           | kg/t             | 0.0072   |
| Fugitive emissions at refineries                                                       | NO <sub>x</sub> | kg/t             | 0.00602  |
| Fugitive emissions at refineries                                                       | SO <sub>2</sub> | kg/t             | 0.00085  |
| Fugitive emissions at refineries                                                       | CO              | kg/t             | 0.000494 |
| Storage and cleaning of crude oil in tank-storage facilities of refineries             | NMVOC           | kg/t             | 0.0227   |
| Storage of liquid petroleum products in tank-storage facilities outside of refineries  | NMVOC           | g/m <sup>3</sup> | 0.59     |
| Storage of gaseous petroleum products in tank-storage facilities outside of refineries | NMVOC           | g/m <sup>3</sup> | 14.7     |
| Claus Plants                                                                           | NMVOC           | kg/t             | 0.000025 |
| Claus Plants                                                                           | NO <sub>x</sub> | kg/t             | 0.0022   |
| Claus Plants                                                                           | SO <sub>2</sub> | kg/t             | 0.048    |
| Claus Plants                                                                           | CO              | kg/t             | 0.0036   |



Emissions from storage consider all refinery products. According to the EMEP guidebook, fuel-related emissions are reported under 1.B.2. Emissions other than fuels (like naphtha, methanol etc.) are reported under [2.B.10.b - Storage, Handling and Transport of Chemical Products](#).

A new study by (Zimmermann, 2025), <sup>12)</sup> and based on this calculations by (Boettcher, 2025), <sup>13)</sup> provided new data on NMVOC emissions for the storage of liquid and gaseous petroleum products, which resulted in an appreciable drop in the emission factors of NMVOC of tank storage facilities.

### 1.B.2.a.v- Distribution of oil products

In category 1.B.2.a.v - Distribution of oil products, the emissions from distribution of oil products are described. Petroleum products are transported by ship, product pipelines, railway tanker cars and tanker trucks, and they are transferred from tank to tank. The main sources of NMVOC emissions from petrol distribution as a whole were fugitive emissions from handling and transfer (filling/unloading) and container losses (tank breathing). Experts consider the emissions from aircraft refuelling to be non-existent, since the equipment used for such refuelling is fitted with dry couplings. The emissions from

filling private heating-oil tanks are also very low thanks to high safety standards. In this category, petroleum products that have undergone fractional distillation in refineries are handled and distributed, i.e. processes in which gaseous products are separated out. For this reason, no significant methane emissions are expected. Only in storage of certain petroleum products can small quantities of methane escape.

Table 10: Annual activity data for the distribution of oil products

| Activity                          | Unit | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2020   | 2023   | 2024   |
|-----------------------------------|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| number of petrol stations         | No   | 19,317 | 17,957 | 16,324 | 15,187 | 14,744 | 14,531 | 14,459 | 14,442 | 14,376 |
| distribution of diesel            | kt   | 21,817 | 26,208 | 28,922 | 28,531 | 32,128 | 36,756 | 35,163 | 33,279 | 32,455 |
| distribution of jet fuel          | kt   | 4,584  | 5,455  | 6,939  | 8,049  | 8,465  | 8,550  | 4,725  | 9,479  | 9,016  |
| distribution of light heating oil | kt   | 31,803 | 34,785 | 27,875 | 25,380 | 21,005 | 16,127 | 15,558 | 11,493 | 10,736 |
| distribution of domestic petrol   | kt   | 31,257 | 30,333 | 28,833 | 23,431 | 19,634 | 18,226 | 16,218 | 17,394 | 17,650 |

## Transport

Inland-waterway gasoline tankers retain considerable quantities of gasoline vapours in their tanks after their gasoline has been unloaded. When the ships change loads or spend time in port, their tanks have to be ventilated. With such ships being ventilated on average 277 times per year, the quantity of NMVOC emitted in these operations amounts to 336 to 650 t<sup>14)</sup>. The highest value in the range is used to calculate the relevant emissions.

About 13 million m<sup>3</sup> of gasoline fuel are transported annually in Germany via railway tank cars. Transfer/handling (filling/unloading) and tank losses result in annual emissions of only 1,400 t VOC<sup>15)</sup>. The emissions situation points to the high technical standards that have been attained in railway tank cars and pertinent handling facilities.

## Filling stations

Significant quantities of fugitive VOC emissions are released into the environment during transfers from tanker vehicles to storage facilities and during refuelling of vehicles. To determine emissions, a standardised emission factor of 1.4 kg/t is used. This value refers to the saturation concentration for hydrocarbon vapours and thus, corresponds to the maximum possible emissions level in the absence of reduction measures.

The immission-control regulations issued in 1992 and 1993 (20th BImSchV<sup>16)</sup>; 21st BImSchV,<sup>17)</sup> that required filling stations to limit such emissions promoted a range of reduction measures. The relevant reductions affect both the area of gasoline transfer and storage (20th BImSchV) and the area of fuelling of vehicles with gasoline at filling stations (21st BImSchV). The use of required emissions-control equipment, such as vapour-balancing (20th BImSchV) and vapour-recovery (21st BImSchV) systems, along with the use of automatic monitoring systems (via the amendment of the 21st BImSchV on 6 May 2002), have brought about continual reductions of VOC emissions; the relevant high levels of use of such equipment are shown in the table below (Table 151). In emissions calculation, the two ordinances' utilisation and efficiency requirements for filling stations in service are taken into account. The following assumptions, based on the technical options currently available, are applied:

| Ordinance    | Factor           |                       |      |
|--------------|------------------|-----------------------|------|
| 20th BImSchV | Vapour balancing | Degree of utilisation | 98 % |
| 20th BImSchV | Vapour balancing | Efficiency            | 98 % |
| 21st BImSchV | Vapour recovery  | Degree of utilisation | 98 % |
| 21st BImSchV | Vapour recovery  | Efficiency            | 85 % |

In addition, permeation of hydrocarbons occurs in tank hoses. The DIN EN 1360 standard sets a limit of 12 ml / hose meter per day for such permeation. From analysis of measurements, UBA experts have adopted a conservative factor of 10ml/m per day. That factor is used to determine the NMVOC emissions. The calculation is carried out in accordance with the pertinent formula of the University of Stuttgart's Institute for Machine Components<sup>18)</sup>:

Number of service stations \* number of fuel pumps per service station \* number of hoses per fuel pump \* hose length \* emission factor.

## Cleaning of transport vehicles

Tank interiors are cleaned prior to tank repairs and safety inspections, in connection with product changes and with lease

changes. The inventory currently covers cleaning of railway tank cars. The residual amounts remaining in railway car tanks after these have been emptied – normally, between 0 and 30 litres (up to several hundred litres in exceptional cases) – are not normally able to evaporate completely. They thus produce emissions when the insides of tanks are cleaned.

Each year, some 2,500 cleaning operations are carried out on railway tank cars that transport gasoline. The emissions released, via exhaust air, in connection with cleaning tank cars' interiors amount to about 40,000 kg/a VOC (Joas et al., 2004), p. 34.<sup>19)</sup>

Any additional prevention and reduction measures could affect emissions in this category only slightly. At the same time, emissions can be somewhat further reduced from their current levels via a combination of various technical and organizational measures. Emissions during handling – for example, during transfer to railway tank cars – are produced especially by residual amounts of gasoline that remain after tanks have been emptied. Such left-over quantities in tanks can release emissions via manholes the next time the tanks are filled. A study is thus underway to determine the extent to which “best practice” is being followed at all handling stations, and whether this extent has to be taken into account in emissions determination. In addition, improvements of fill nozzles enhance efficiency in prevention of VOC emissions during refuelling.

Pursuant to the UBA text (Joas et al., 2004),<sup>20)</sup> a total of 1/3 of all relevant transports are carried out with railway tank cars. The remaining 2/3 of all transports are carried out by other means – primarily with road tankers.

The 1/3 to 2/3 relationship given by the report is assumed to be also applicable to the emissions occurring in connection with cleaning. Currently, the inventory includes 36,000 kg of NMVOC emissions from cleaning of railway tank cars. Emissions from cleaning of other transport equipment – primarily road tankers – are derived from that figure; they amount to about 70,000 kg NMVOC.

More-thorough emissions collection upon opening of manholes of railway tank cars (a volume of about 14.6 m<sup>3</sup> escapes), along with more thorough treatment of exhaust from cleaning tank interiors, could further reduce VOC emissions. Exhaust cleansing is assumed to be carried out via one-stage active-charcoal adsorption. For an initial load of 1 kg/m<sup>3</sup>, exhaust concentration levels can be reduced by 99.5 %, to less than 5 g/m<sup>3</sup>. As a result, the remaining emissions amount to only 1.1 t. This is equivalent to a reduction of about 97 % from the determined level of 36.5 t/a (without adsorption) (Joas et al. (2004), p. 34)<sup>21)</sup>.

Generally, the emission factors listed below have been verified by the study<sup>22)</sup>.

| Process responsible for NMVOC emissions                                                                                                 |                   | EF in [kg/t] |
|-----------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------|
| Drip losses in refuelling at filling stations                                                                                           | gasoline          | 0.117        |
| Transfers from road tankers to filling stations (20th Ordinance Implementing the Federal Immission Control Act – vapour displacement)   | gasoline          | 1.4          |
| Ventilation in connection with transports with inland-waterway tankers                                                                  | gasoline          | 0.025        |
| Transfers from filling station tanks to vehicle tanks (21st Ordinance Implementing the Federal Immission Control Act – vapour recovery) | gasoline          | 1.4          |
| Drip losses in refuelling at filling stations                                                                                           | diesel            | 0.1          |
| Transports from refineries to transport vehicles                                                                                        | diesel            | 0.008        |
| Transfers from filling-station tanks to vehicle tanks                                                                                   | diesel            | 0.003        |
| Drip losses in refuelling at transfer stations                                                                                          | light heating oil | 0.0011       |
| Transports from refineries to transport vehicles                                                                                        | light heating oil | 0.0053       |
| Transfers from filling-station tanks to vehicle tanks                                                                                   | light heating oil | 0.0063       |

The following emission factors for cleaning operations on product storage tanks were derived from (Zimmermann, 2025),<sup>23)</sup> (see table below). Their impact on the inventory have been published by (Boettcher, 2025).<sup>24)</sup>

| Activity                            | EF NMVOC                              |
|-------------------------------------|---------------------------------------|
| cleaning of pipelines               | 0 kg/t                                |
| cleaning of ship tankers            | 0.0235 kg/t                           |
| cleaning of road tankers            | 0.029 kg/t                            |
| cleaning of railway tankers         | 0.0045 kg/t                           |
| cleaning of tank storage facilities | 0.0012 kg VOC/m <sup>3</sup> capacity |

## Recalculations

Due to the implementation of the data from (Zimmermann, 2025),<sup>25)</sup> the following recalculations were made for NMVOC (see

Table)

| Submission | 1990   | 2000  | 2010  | 2020  | 2023  |
|------------|--------|-------|-------|-------|-------|
| 2026       | 158,42 | 64,61 | 31,18 | 25,84 | 25,53 |
| 2025       | 166,94 | 67,93 | 30,41 | 25,27 | 25,00 |



For more details please refer to the super-ordinate chapter [1.B - Fugitive Emissions from fossil fuels](#)

## Planned improvements

<sup>1)</sup> WEG (2008). Report of the Association of Oil and Gas Producing “Erdgas – Erdöl. Entstehung-Suche-Förderung”, Hannover, 34 S. [External Link](#), [PDF](#)

<sup>2)</sup> IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. [External Link](#)

<sup>3)</sup> BVEG (2019). Annual report of the Association of Oil and Gas Producing “Die E&P-Industrie in Zahlen. Statistischer Bericht 2019: Zahlen”. [External Link](#)

<sup>4), 22)</sup> Theloke, J., Kampffmeyer, T., Kugler, U., Friedrich, R., Schilling, S., Wolf, L., & Springwald, T. (2013). Ermittlung von Emissionsfaktoren und Aktivitätsraten im Bereich IPCC (1996) 1.B.2.a. i-vi - Diffuse Emissionen aus Mineralöl und Mineralölprodukten (Förderkennzeichen 360 16 033), on behalf of the Umweltbundesamt, Stuttgart, 2013.

<sup>5)</sup> Cech, M., Davis, P., Gambardella, F., Haskamp, A., González, P. H., Spence, M., & Larivé, J.-F. (2017). Performance of European cross-country oil pipelines - Statistical summary of reported spillages in 2015 and since 1971 [External Link](#)

<sup>6), 8), 10)</sup> Müller-BBM (2010). UBA research project No. 3707 42 103/ 01, Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV aus dem Jahre 2004 für die Verwendung bei der UNFCCC- und UNECE-Berichterstattung - Bereich Lageranlagen (Bericht Nr. M74 244/7, UBA FKZ 3707 42 103/01). [External Link](#)

<sup>7), 11)</sup> Bender, M., & von Müller, G. (2020). Emissionsfaktoren zu Raffinerien für die nationale Emissionsberichterstattung (FKZ 3716 41 107 0).

<sup>9)</sup> VDI (2000). VDI-Richtlinie 2440: Emissionsminderung - Mineralölraffinerien, published by V. D. I.

<sup>12), 23), 25)</sup> Zimmermann T. (2025). “Ist-Analyse der VOC-Emissionen von Mineralölprodukten bei der Reinigung von Eisenbahnkesselwagen, Binnentankschiffen, Straßentankfahrzeugen, Pipelines, Lagertanks und Tankcontainern”, UBA-Texte 103/2025, Dessau. <https://www.umweltbundesamt.de/publikationen/ist-analyse-der-voc-emissionen-bei-der-reinigung> [Link](#)

<sup>13), 24)</sup> Boettcher, C. (2025). “Aktualisierung der VOC-Emissionen für die Bereitstellung von Mineralölprodukten”, UBA-Texte 119/2025, Dessau. <https://doi.org/10.60810/openumwelt-8092> [Link](#)

<sup>14)</sup> Bauer, S., Polcher, D. A., & Greßmann, A. (2010). Evaluierung der Anforderungen der 20. BImSchV für Binnentankschiffe im Hinblick auf die Wirksamkeit der Emissionsminderung klimarelevanter Gase (FKZ 3709 45 326). München.

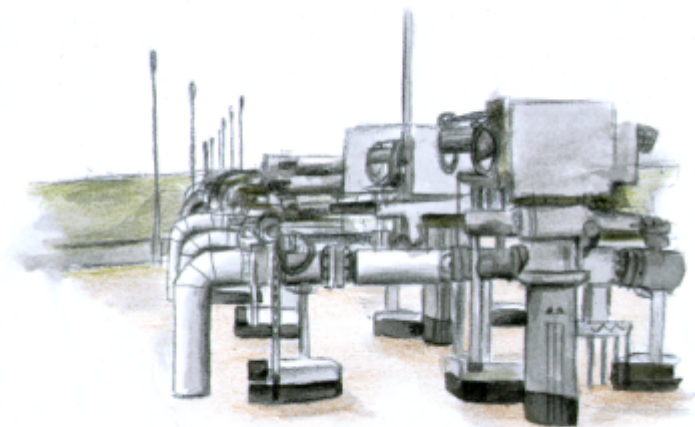
<sup>15), 19), 20), 21)</sup> Dr. R. Joas; A. Potrykus; R. Schott; S. Wenzel (2004). “VOC-Minderungspotenzial beim Transport und Umschlag von Mineralölprodukten mittels Kesselwagen”, FKZ 202 44 372, UBA-Texte 12/2004, Dessau. [External Link](#)

<sup>16)</sup> 20. BImSchV - Zwanzigste Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung zur Begrenzung der Emissionen flüchtiger organischer Verbindungen beim Umfüllen oder Lagern von Ottokraftstoffen, Kraftstoffgemischen oder Rohbenzin) in der Fassung der Bekanntmachung vom 18. August 2014 (BGBl. I S. 1447), die durch Artikel 2 der Verordnung vom 24. März 2017 (BGBl. I S. 656) geändert worden ist, published by BGBl. (2017).

<sup>17)</sup> 21. BImSchV - Verordnung zur Begrenzung der Kohlenwasserstoffemissionen bei der Betankung von Kraftfahrzeugen in der Fassung der Bekanntmachung vom 18. August 2014 (BGBl. I S. 1453), die zuletzt durch Artikel 3 der Verordnung vom 24. März 2017 (BGBl. I S. 656) geändert worden ist, published by BGBl. (2017).

<sup>18)</sup> Haas, W. (2015). Kraftstoffpermeation an Zapfsäulen.

## 1.B.2.b - Natural Gas



| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 1.B.2.b                                                                                   | T2, T3, M                            | AS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO  | Pb | Cd | Hg  | Other HM | POPs |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|-----|----|----|-----|----------|------|
| -/-             | -/-    | -/-             | NA              | NA                | NA               | NA  | NA | -/- | NA | NA | -/- | NA       | NA   |



|            |                                                                                     |
|------------|-------------------------------------------------------------------------------------|
| <b>L/-</b> | key source by <b>Level</b> only                                                     |
| <b>-/T</b> | key source by <b>Trend</b> only                                                     |
| <b>L/T</b> | key source by both <b>Level</b> and <b>Trend</b>                                    |
| <b>-/-</b> | no key source for this pollutant                                                    |
| <b>IE</b>  | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |
| <b>NE</b>  | emission of specific pollutant <b>Not Estimated</b> (yet)                           |
| <b>NA</b>  | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |
| <b>*</b>   | no analysis done                                                                    |

### 1.B.2.b.i - Exploration

Source category 1.B.2.b.i is considered together with source category 1.B.2.a.i (Oil, exploration). Consequently, the aggregated, non-subdivided data of 1.B.2.b.i are included in source category 1.B.2.a.i.

### 1.B.2.b.ii - Production

The emissions of source category 1.B.2.b.ii consist of emissions related to production. Since 1998, the Federal Association of the Natural gas, Oil and Geothermal Energy Industries (BVEG) has determined the emissions from production and published the relevant data in its statistical report.

Table 1: Produced quantities of natural gas, in [Billion m<sup>3</sup>]

| 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2023 | 2024 |
|------|------|------|------|------|------|------|------|------|
| 15.3 | 19.1 | 20.1 | 18.8 | 12.7 | 8.6  | 5.2  | 4.3  | 4.2  |

Table 2: Emission factors for Natural gas production, in [g/1.000m<sup>3</sup>]

| Substance | Emission Factor |
|-----------|-----------------|
| NMVOC     | 2               |
| Mercury   | 0.0007          |

### 1.B.2.b.iii - Processing

The emissions of this category consist of emissions from the activities of pretreatment and processing. After being brought up from underground reserves, natural gas is first treated in drying and processing plants. As a rule, such pretreatment of the natural gas takes place in facilities located directly at the pumping stations. Such processes separate out associated water from reserves, along with liquid hydrocarbons and various solids. Glycol is then used to remove the water vapour remaining in the gas (p. 25)<sup>1)</sup>. Natural gas dehydration systems are closed systems. For safety reasons, all of such a system's overpressure protection devices are integrated within a flare system. When such protection devices are triggered, the surplus gas is guided to a flarehead, where it can be safely burned. After drying, the natural gas is ready for sale and can be delivered to customers directly, via pipelines<sup>2)</sup>. The relevant quantities of flared gas are reported under 1.B.2.c. The natural gas drawn from Germany's Zechstein geological formation contains hydrogen sulphide. In this original state, the gas – known as “sour gas” – has to be subjected to special treatment. Due to the hazardousness of hydrogen sulphide, this gas is transported via separate, specially protected pipelines to German processing plants that wash out its hydrogen sulphide via chemical and physical processes. About 40 % of the natural gas extracted in Germany is sour gas<sup>3)</sup>. The natural gas that leaves processing plants is ready for use. The hydrogen sulphide is converted into elementary sulphur and is used primarily by the chemical industry, as a basic raw material.

Table 3: Sulphur production from natural gas production, in [kt]

| 1990 | 1995  | 2000  | 2005  | 2010 | 2015 | 2020 | 2023 | 2024 |
|------|-------|-------|-------|------|------|------|------|------|
| 915  | 1,053 | 1,100 | 1,050 | 832  | 628  | 353  | 277  | 280  |

For processing of sour gas, data of the BVEG (the former WEG) for the period since 2000 are used. This data is the result of the BVEG members' own measurements and calculations. For calculation of emissions from sour-gas processing, a split factor of 0.4 relative to the activity data is applied. That split factor is based on the BVEG report<sup>4)</sup> on sour-gas processing.

Table 4: Emission factors for emissions from treatment of natural gas, in [kg/ 1000 m<sup>3</sup>]

|                       | Value |
|-----------------------|-------|
| <b>NMVOC</b>          | 0.005 |
| <b>CO</b>             | 0.043 |
| <b>NO<sub>x</sub></b> | 0.011 |
| <b>SO<sub>2</sub></b> | 0.140 |

### 1.B.2.b.iv - Transmission

This source category's emissions consist of emissions from activities of gas producers and suppliers. In Germany, natural gas is transported from production and processing companies/plants to gas suppliers and other processors. In addition, natural gas is imported and transmitted via long-distance pipelines. Almost all of the pipelines used to transmit natural gas are steel pipelines <sup>5)</sup>.

One important emissions pathway consists of the compressors that are used to maintain pressure in pipelines. They are spaced at intervals of about 100 km along lines <sup>6)</sup>. At present, the compressors involved have a total power output of about 2,585 MW <sup>7)</sup>. The pipelines are also fitted with shut-off devices (sliding sleeves), which are safety mechanisms located at intervals of about 30 km along high-pressure pipelines, and with systems for regulating and measuring gas pressure.

In pipeline inspection and cleaning, tools known as pipeline inspection gauges ("pigs") are used. In a pipeline system, a pig moves, driven by the gas flow, from a launching station to a receiving station (pig trap). Systems for launching and catching pigs can be either fixed or portable. Small quantities of methane are emitted in both insertion and removal of pigs. In addition, pig traps can develop leaks. Normally, however, such traps are regularly monitored for leaks and repaired as necessary. Not all types of pipelines can be pigged; diameter reductions, isolation valves, bends, etc. in pipelines can block pigs. These emissions have been estimated in the framework of a study carried out by the firm of DBI Gas- und Umwelttechnik GmbH <sup>8)</sup>.

Table 5: Activity data applied for NFR 1.B.2.b.iv

|                                  | Unit                   | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2020   | 2023   | 2024   |
|----------------------------------|------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Length of transmission pipelines | km                     | 22,696 | 28,671 | 32,214 | 34,086 | 35,503 | 34,270 | 33,809 | 34,035 | 34,035 |
| Cavern reservoirs                | Billion m <sup>3</sup> | 2.8    | 4.8    | 6.1    | 6.8    | 9.2    | 14.3   | 15.1   | 14.3   | 14     |
| Porous-rock reservoirs           | Billion m <sup>3</sup> | 5.2    | 8.5    | 12.5   | 12.4   | 12.1   | 9.8    | 8.6    | 8.6    | 8.6    |

Most of the gas extracted in Germany is moved via pipelines from gas fields and their pumping stations (either on land or off the coast). Imported gas is also transported mainly via pipelines.

The emission factor for underground natural gas storage was derived via surveys of operators and analysis of statistics on accidents / incidents <sup>9)</sup>, and it is valid for porous storage and cavern-storage facilities. The NMVOC split factor have been obtained from the research project <sup>10)</sup> described on chapter 6.

Table 6: NMVOC content of natural gas, mean values from <sup>11)</sup>

| 1990  | 2000  | 2010  | 2020  |
|-------|-------|-------|-------|
| 2,57% | 2,87% | 3,43% | 3,50% |

### 1.B.2.b.v - Distribution

The emissions caused by gas distribution have decreased slightly, even though gas throughput has increased considerably and the distribution network has been enlarged considerably with respect to its size in 1990. One important reason for this improvement is that the gas-distribution network has been modernised, especially in eastern Germany. In particular, the share of grey cast-iron lines in the low-pressure network has been reduced, with such lines being supplanted by low-emissions plastic pipelines. Another reason for the reduction is that fugitive losses in distribution have been reduced through a range of technical improvements (tightly sealing fittings such as flanges, valves, pumps, compressors) undertaken in keeping with emissions-control provisions in relevant regulations (TA Luft (1986) and TA Luft (2002)).

Table 7: Length of natural gas distribution network, in [km]



| 1990    | 1995    | 2000    | 2005    | 2010    | 2015    | 2020    | 2023    | 2024    |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 282,612 | 366,987 | 362,388 | 402,391 | 471,886 | 474,570 | 503,543 | 529,000 | 557,000 |

### Pipeline network

The calculation was carried out using the Tier 3 method, on the basis of the available network statistics of the German Association of Energy and Water Industries (BDEW) <sup>12)</sup> and of own surveys. In the early 1990s, emissions from distribution of town gas were also taken into account in calculations. In 1990, the town gas distribution network accounted for a total of 16 % of the entire gas network. Of that share, 15 % consisted of grey cast-iron lines and 85 % consisted of steel and ductile cast-iron lines. The emission factors have been obtained from the research project <sup>13)</sup> with using the split factor described on chapter 6..

### Storage reservoirs

Man-made above-ground storage facilities, for storage of medium-sized quantities of natural gas, help meet and balance rapid fluctuations in demand. In Germany, spherical and pipe storage tanks, and other types of low-pressure containers, are used for this purpose. Results from a relevant research project <sup>14)</sup> have made it possible to derive new country-specific emission factors for this area. The emissions have been calculated in accordance with the Tier 2 method.

### Liquefied natural gas (LNG)

Natural gas can be liquefied, at a temperature of -161°C, for ease of transport. The liquefaction process is highly energy-intensive, however, and is normally used only in connection with long-distance transports. Germany did not have LNG terminals before 2022. Gas imports arrive mostly in gaseous form, via long-distance pipelines, and they are included in 1.B.2.b.iv. Germany now has one natural gas liquefaction facility and two satellite LNG storage facilities. Since the storage and transfer processes at those facilities are subject to the most stringent standards possible, emissions there can be ruled out. Gas can escape only in connection with maintenance work, and the gas quantities involved are extremely small. The quantities do not exceed more than a few hundred kilograms <sup>15)</sup>.



In the 1990s, town gas (=coal gas) was supplied to households via distribution systems in East Germany and West-Berlin. The composition of coal gas varied in the different regions, consisting of hydrogen, carbon monoxide, methane and nitrogen.

### 1.B.2.b.vi - Post-Meter Emissions

The category describes emissions from leakage in the industrial sector and in the residential and institutional/commercial sectors as well as from natural gas-powered vehicles.

#### Leakage in the industrial sector and in the residential and institutional/commercial sectors

The activity data is based on own surveys.

Table 8: Number of gas meters in the residential and institutional / commercial sector, in Millions

| 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2023 | 2024 |
|------|------|------|------|------|------|------|------|------|
| 10.3 | 12.7 | 12.8 | 13.3 | 12.9 | 13.0 | 13.1 | 13.2 | 13.3 |

The emission factors are country-specific, and they were determined via the research project by DVGW and GWI <sup>16)</sup>. They include start-stop losses at all enduser devices. The study covers methane only. The appropriate NMVOC factor was derived from the publication <sup>17)</sup> (refer to chapter 6).

### Natural-gas-powered vehicles, and CNG fuelling stations

Use of vehicles running on natural gas continues to increase in Germany. Such vehicles are refuelled at CNG fuelling stations connected to the public gas network. In such refuelling, compressors move gas from high-pressure on-site tanks. Some 900 CNG fuelling stations are now in operation nationwide. In keeping with the stringent safety standards applying to refuelling operations and to the tanks themselves, the pertinent emissions are very low. In the main, emissions result via tank

pressure tests and emptying processes.

Table 9: Number of natural-gas-powered vehicles

| 1990 | 1995 | 2000  | 2005   | 2010   | 2015   | 2020    | 2023    | 2024    |
|------|------|-------|--------|--------|--------|---------|---------|---------|
| -.-  | -.-  | 7,500 | 28,500 | 90,000 | 97,804 | 100,807 | 100,000 | 100,000 |

## Recalculations



For more details please refer to the super-ordinate chapter [1.B - Fugitive Emissions from fossil fuels](#)

## Planned improvements



At the moment, no further category-specific improvements are planned.

<sup>1), 3)</sup> WEG (2008): Report of the Association of Oil and Gas Producing (WEG - Wirtschaftsverband Erdöl- und Erdgasgewinnung e.V.): "Erdgas – Erdöl. Entstehung-Suche-Förderung", <https://web.archive.org/web/20220119003912/https://www.bveg.de/content/download/1990/11317/file/Erdgas%20Erd%C3%B6l%20Entstehung%20Suche%20F%C3%B6rderung.pdf>; Hannover, 2008

<sup>2)</sup> EXXON (2014): Förderung von Erdgas in Deutschland.

<sup>4)</sup> BVEG (2022). Statistischer Jahresbericht 2021 [External Link](#)

<sup>5)</sup> Zöllner, S. (2014): Überführung der Bestands- und Ereignisdaten des DVGW in die Emissionsdatenbank des Umweltbundesamts.

<sup>6)</sup> GASUNIE (2014). Verdichterstationen.

<sup>7)</sup> Ohlen, N. v. (2019): Umsetzungsbericht zum Netzentwicklungsplan Gas 2018-2028 der Fernleitungsnetzbetreiber; [https://fnb-gas.de/wp-content/uploads/2021/09/2019\\_04\\_01\\_umsetzungsbericht\\_2019\\_1.pdf](https://fnb-gas.de/wp-content/uploads/2021/09/2019_04_01_umsetzungsbericht_2019_1.pdf)

<sup>8)</sup> Grosse, C. (2019). Qualitätsprüfung der Texte für den nationalen Inventarbericht und Datenerhebung in der Quellgruppe.1.B.2.b (PNr. 1252 30).

<sup>9), 14), 15)</sup> Langer, B. u. (2012). Ermittlung von Emissionsfaktoren und Aktivitätsraten im Bereich IPCC (1996) 1.B.2.b.iii (Bericht Nr. M96023/01, UBA FKZ 360 16 035).

<sup>10), 11), 13), 17)</sup> Boettcher, C. (2022) Aktualisierung der Emissionsfaktoren für Methan für die Erdgasbereitstellung, published by UBA [External Link](#)

<sup>12)</sup> German Association of Energy and Water Industries (BDEW) (2016). 2016 Gas Statistics "Gasstatistik 2016".

<sup>16)</sup> Entwicklung der Methanemissionen in der Gasanwendung, published by DVGW and GWI (2022) [External Link](#)

## 1.B.2.c - Venting and Flaring

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 1.B.2.c                                                                                   | T2                                   | AS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC                                                                                       | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC  | CO  | Pb | Cd | Hg  | Other HM | POPs |
|-----------------|----------------------------------------------------------------------------------------------|-----------------|-----------------|-------------------|------------------|-----|-----|-----|----|----|-----|----------|------|
| -/-             | -/-                                                                                          | -/-             | NA              | -/-               | -/-              | -/- | -/- | -/- | NA | NA | -/- | NA       | NA   |
| <b>L/-</b>      | key source by <b>L</b> evel only                                                             |                 |                 |                   |                  |     |     |     |    |    |     |          |      |
| <b>-/T</b>      | key source by <b>T</b> rend only                                                             |                 |                 |                   |                  |     |     |     |    |    |     |          |      |
| <b>L/T</b>      | key source by both <b>L</b> evel and <b>T</b> rend                                           |                 |                 |                   |                  |     |     |     |    |    |     |          |      |
| -/-             | no key source for this pollutant                                                             |                 |                 |                   |                  |     |     |     |    |    |     |          |      |
| <b>IE</b>       | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                 |                 |                   |                  |     |     |     |    |    |     |          |      |
| <b>NE</b>       | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                 |                 |                   |                  |     |     |     |    |    |     |          |      |
| <b>NA</b>       | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                 |                 |                   |                  |     |     |     |    |    |     |          |      |
| *               | no analysis done                                                                             |                 |                 |                   |                  |     |     |     |    |    |     |          |      |

Pursuant to general requirements of the Technical Instructions on Air Quality Control TA Luft (2002), gases, steam, hydrogen and hydrogen sulphide released from pressure valves and venting equipment must be collected in a gas-collection system. Wherever possible, gases so collected are burned in process combustion. Where such use is not possible, the gases are piped to a flare. Flares used for flaring of such gases must fulfill at least the requirements for flares for combustion of gases from operational disruptions and from safety valves. For refineries and other types of plants in categories 1.B.2, flares are indispensable safety components. In crude-oil refining, excessive pressures can build up in process systems, for various reasons.

Such excessive pressures have to be reduced via safety valves, to prevent tanks and pipelines from bursting. Safety valves release relevant products into pipelines that lead to flares. Flares carry out controlled burning of gases released via excessive pressures. When in place, flare-gas recovery systems liquify the majority of such gases and return them to refining processes or to refinery combustion systems. In the process, more than 99 % of the hydrocarbons in the gases are converted to CO<sub>2</sub> and H<sub>2</sub>O. When a plant has such systems in operation, its flarehead will seldom show more than a small pilot flame.

Table 1: Activity data applied for 1.B.2.c

|                            | Unit                       | 1990 | 1995 | 2000  | 2005  | 2010 | 2015 | 2020 | 2023 | 2024 |
|----------------------------|----------------------------|------|------|-------|-------|------|------|------|------|------|
| Flared natural gas         | millions of m <sup>3</sup> | 36   | 33   | 36    | 18.7  | 12.1 | 10.5 | 14.1 | 10.8 | 9.7  |
| Refined crude-oil quantity | millions of t              | 107  | 96.5 | 107.6 | 114.6 | 95.4 | 93.4 | 84.0 | 79.1 | 85.4 |

Flaring takes place in extraction and pumping systems and at refineries. In refineries, flaring operations are subdivided into regular operations and start-up / shut-down operations in connection with disruptions.

Table 2: Emission factors applied for flaring emissions in natural gas extraction, in [kg/ 1000 m<sup>3</sup>]

|                       | Value |
|-----------------------|-------|
| <b>NM VOC</b>         | 0.005 |
| <b>NO<sub>x</sub></b> | 1.269 |
| <b>SO<sub>2</sub></b> | 8.885 |
| <b>CO</b>             | 0.726 |

Table 3: Emission factors applied for flaring emissions at petroleum production facilities

|                       | Unit | Value |
|-----------------------|------|-------|
| <b>NO<sub>x</sub></b> | kg/t | 0.008 |
| <b>SO<sub>2</sub></b> | kg/t | 0.010 |
| <b>CO</b>             | g/t  | 0.1   |

Table 4: Emission factors applied for flaring emissions at at refineries: normal flaring operations

|                       | Unit              | Value |
|-----------------------|-------------------|-------|
| <b>NM VOC</b>         | kg/m <sup>3</sup> | 0.004 |
| <b>CO</b>             | kg/m <sup>3</sup> | 0.001 |
| <b>SO<sub>2</sub></b> | kg/m <sup>3</sup> | 0.003 |
| <b>NO<sub>x</sub></b> | g/m <sup>3</sup>  | 0.4   |

Table 5: Emission factors applied for flaring emissions at at refineries: disruptions of flaring operations, in [kg/t]

|                       | Value |
|-----------------------|-------|
| <b>NM VOC</b>         | 0.001 |
| <b>CO</b>             | 0.001 |
| <b>SO<sub>2</sub></b> | 0.007 |
| <b>NO<sub>x</sub></b> | 0.004 |

The emission factors have been derived from the 2004 and 2008 emissions declarations Theloke et al. 2013 <sup>1)</sup>. In 2019, they were updated for CH<sub>4</sub>, N<sub>2</sub>O, CO, NM VOC, NO<sub>x</sub> and SO<sub>2</sub>, on the basis of Bender & von Müller, 2019 <sup>2)</sup>.

Venting emissions are taken into account in category 1.B.2.b.iii. The SO<sub>2</sub> emissions are obtained from the activity data for the flared natural gas (Table 178) and an emission factor of 0.140 kg / 1,000 m<sup>3</sup>, a factor which takes account of an average H<sub>2</sub>S content of 5 % by volume. The emission factors are determined on the basis of emissions reports, crude-oil-refining capacity and total capacity utilisation at German refineries. The guide for this work consists of the evaluation assessment of Theloke et al. (2013) <sup>3)</sup>.

## Recalculations



For more details please refer to the super-ordinate chapter [1.B - Fugitive Emissions from fossil fuels](#)

## Planned improvements



At the moment, no further category-specific improvements are planned.

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<sup>1), 3)</sup> Theloke et al. (2013): Theloke, J., Kampffmeyer, T., Kugler, U., Friedrich, R., Schilling, S., Wolf, L., & Springwald, T.: Ermittlung von Emissionsfaktoren und Aktivitätsraten im Bereich IPCC - Diffuse Emissionen aus Mineralöl und Mineralölprodukten; Institut für Energiewirtschaft und Rationelle Energieanwendung (IER) (University of Stuttgart) with Eurofins GfA GmbH (Mannheim) and Ökopol GmbH (Hamburg), on behalf of the Umweltbundesamt, Dessau-Roßlau, 2013 (not available online)

<sup>2)</sup> Bender, M., & von Müller, G. (2019). Konsolidierung der Treibhausgasemissionsberechnungen unter der 2. Verpflichtungsperiode des Kyoto-Protokolls und der neuen Klimaschutz-Berichterstattungs-pflichten an die EU (FKZ 3716 41 107 0).

### 1.B.3 - Geothermal Energy

Operation of geothermal power stations and heat stations in Germany produces no emissions. The thermal-water circuits of such installations are closed and airtight, both above and below ground level. As a result, no emissions occur during their operation. Even a release of the gases dissolved in the heat-carrying fluid – primarily, hydrogen (H<sub>2</sub>), methane (CH<sub>4</sub>), carbon dioxide (CO<sub>2</sub>), and hydrogen sulphide (H<sub>2</sub>S) – would not lead to concentrations worthy of reporting.

No emission factors for pollutants that could escape in connection with drilling for tapping of geothermal energy (both near-surface and deep energy) are known for Germany at present.

From a geoscientific standpoint, however, it is clear that virtually any drilling will lead to releases of gases bound in underground layers – and the gases involved can include H<sub>2</sub>, CH<sub>4</sub>, CO<sub>2</sub>, H<sub>2</sub>S and Rn <sup>1)</sup>.

In many cases, and especially in drilling for tapping of geothermal energy near the surface, such emissions would be expected to be very low. “Blow-out preventers”, which are safety devices that guard against gas releases, are now used in connection with all deep drilling. In addition, specially modified drilling fluids are used that force gases that are released into the well back into the penetrated rock layers.

In drilling operations for near-surface geothermal energy, as in drilling of wells for drinking water, only low emissions levels are normally encountered, due to the low gas concentrations found near the surface. In the interest of preventing gas releases, drilling of deep geothermal wells is subject to the same safety regulations that apply to hydrocarbon exploration, including obligations to use Christmas trees and blowout preventers, to prevent accidents. A study by Frick et al. (2007) <sup>2)</sup> estimates that NMVOC emissions from geothermal drilling sum up to nearly 30 kg/a.

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<sup>1)</sup> Theloke et al. (2013): Theloke, J., Kampffmeyer, T., Kugler, U., Friedrich, R., Schilling, S., Wolf, L., & Springwald, T.: Ermittlung von Emissionsfaktoren und Aktivitätsraten im Bereich IPCC - Diffuse Emissionen aus Mineralöl und Mineralölprodukten; Institut für Energiewirtschaft und Rationelle Energieanwendung (IER) (University of Stuttgart) with Eurofins GfA GmbH (Mannheim) and Ökopol GmbH (Hamburg), on behalf of the Umweltbundesamt, Dessau-Roßlau, 2013 (not available online)

<sup>2)</sup> Frick et al. (2007): Frick, St., Schröder, G., Rychtyk, M., and Bohnenschäfer, W.: Umwelteffekte einer geothermischen Stromerzeugung -Analyse und Bewertung der klein-und großräumigen Umwelteffekte der geothermischen Stromerzeugung (FKZ 205 421 10), Institute for Energy and Environment (Institut für Energetik und Umwelt gGmbH (IE)), on behalf of the Umweltbundesamt;  
[https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/endbericht\\_fkz\\_205\\_42\\_110-gesamtausgabe.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/endbericht_fkz_205_42_110-gesamtausgabe.pdf); Leipzig, 2007

# CHAPTER 4: NFR 2 - Industrial Processes and Product Use (IPPU)

Industrial processes are an important emission source for most pollutants. Due to Germany's high-level, differentiated industry featuring numerous companies and a large number of plants for each sector, emission estimation for industrial processes is very complex. Please refer to the sub-sections below for details.

In the area of industrial processes, production data from association statistics and of manufacturers' information is used. In the interest of the inventory's completeness and reliability, checking of source-category definitions and data-collection methods will stay a priority where emissions reporting is based on such sources. The inventory is considered complete for the main industrial processes. [!- (Should be described at the source category level) Nevertheless, there are still certain categories awaiting further examination, though only negligible contributions to the national total emissions are expected. -]

**NFR 2 consists of the following and sub-categories:**

|                                                               |
|---------------------------------------------------------------|
| <b>2.A Mineral Industry</b>                                   |
| 2.A.1 Cement Production                                       |
| 2.A.2 Lime Production                                         |
| 2.A.3 Glass Production                                        |
| 2.A.5.a Quarrying and Mining of Minerals other than Coal      |
| 2.A.5.b Construction and Demolition                           |
| 2.A.5.c Storage, Handling and Transport of Mineral Products   |
| 2.A.6 Other Mineral Products                                  |
| <b>2.B Chemical Industry</b>                                  |
| 2.B.1 Ammonia Production                                      |
| 2.B.2 Nitric Acid Production                                  |
| 2.B.3 Adipic Acid Production                                  |
| 2.B.5 Carbide Production                                      |
| 2.B.6 Titanium Dioxide Production                             |
| 2.B.7 Soda Ash Production                                     |
| 2.B.10.a Other                                                |
| 2.B.10.b Storage, Handling and Transport of Chemical Products |
| <b>2.C Metal Industry</b>                                     |
| 2.C.1 Iron and Steel Production                               |
| 2.C.2 Ferroalloys Production                                  |
| 2.C.3 Aluminum Production                                     |
| 2.C.4 Magnesium Production                                    |
| 2.C.5 Lead Production                                         |
| 2.C.6 Zinc Production                                         |
| 2.C.7.a Copper Production                                     |
| 2.C.7.b Nickel Production                                     |
| 2.C.7.c Other Metal Production                                |
| 2.C.7.d Storage, Handling and Transport of Metal Products     |
| <b>2.D Other Solvent and Product Use</b>                      |
| 2.D.3.a Domestic Solvent Use including fungicides             |
| 2.D.3.b Road Paving with Asphalt                              |
| 2.D.3.c Asphalt Roofing                                       |
| 2.D.3.d Coating Applications                                  |
| 2.D.3.e Degreasing                                            |
| 2.D.3.f Dry Cleaning                                          |
| 2.D.3.g Chemical Products                                     |
| 2.D.3.h Printing                                              |
| 2.D.3.i Other Solvent Use                                     |
| <b>2.G Other Product Use</b>                                  |
| 2.G.4 Use of Fireworks                                        |

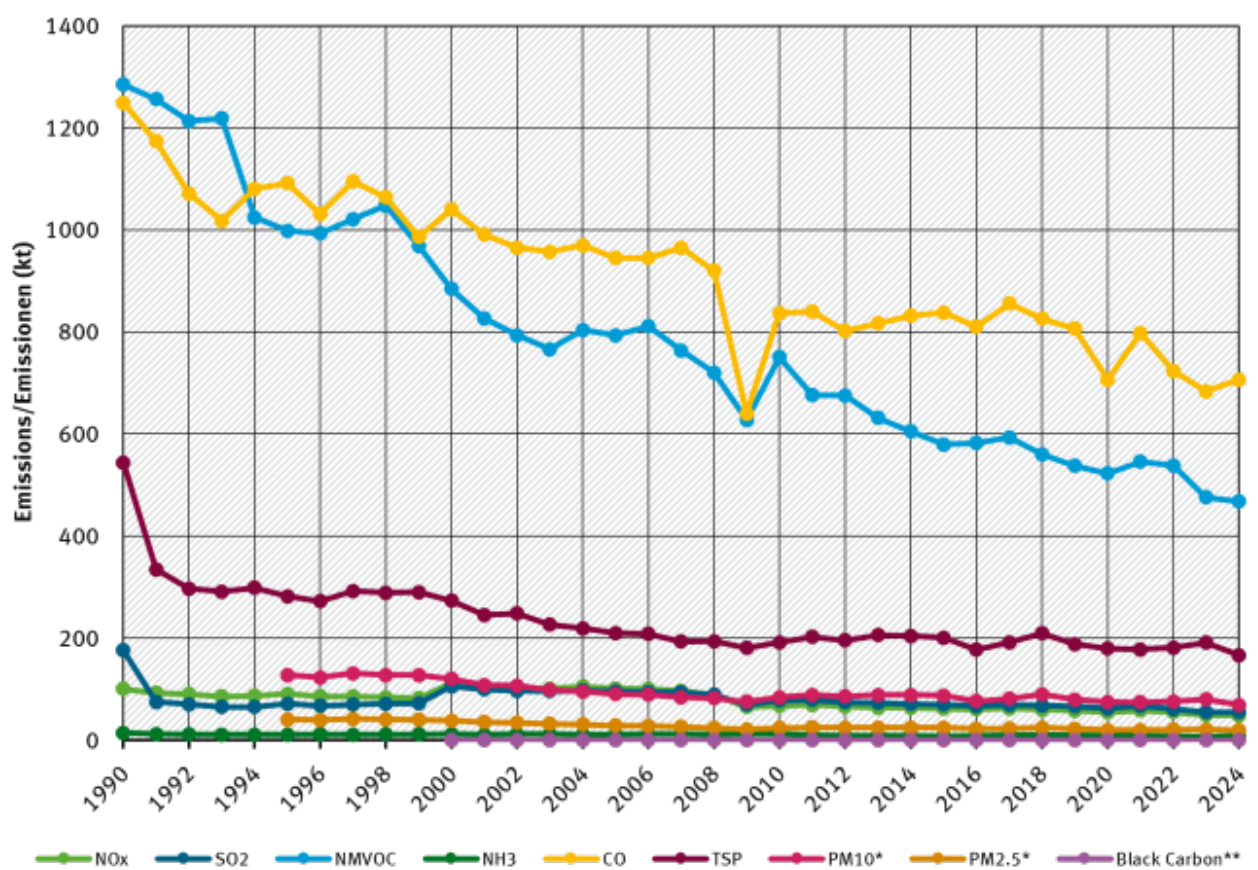
|                                                                                                |
|------------------------------------------------------------------------------------------------|
| <b>2.A Mineral Industry</b>                                                                    |
| 2.G.4 Use of Tobacco                                                                           |
| 2.G.4 Use of Charcoal                                                                          |
| 2.G.4 Use of Lubricants                                                                        |
| <b>2.H Other (Pulp &amp; Paper, Food)</b>                                                      |
| 2.H.1 Pulp and Paper Industry                                                                  |
| 2.H.2 Food and Beverages Industry                                                              |
| 2.H.3 Other Industrial Processes                                                               |
| <b>2.I Wood Processing</b>                                                                     |
| <b>2.J Production of POPs</b>                                                                  |
| <b>2.K Consumption of POPs and Heavy Metals</b>                                                |
| <b>2.L Other Production, Consumption, Storage, Transportation or Handling of Bulk Products</b> |
| 2.L(a) Handling of Bulk Products                                                               |
| 2.L(b) Diffuse Emissions From Industrial Establishments                                        |

## Visual overview

Emission trends for main pollutants in *NFR 2 - Industrial Processes*:

### Industrial processes/Industrieprozesse (NFR 2)

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

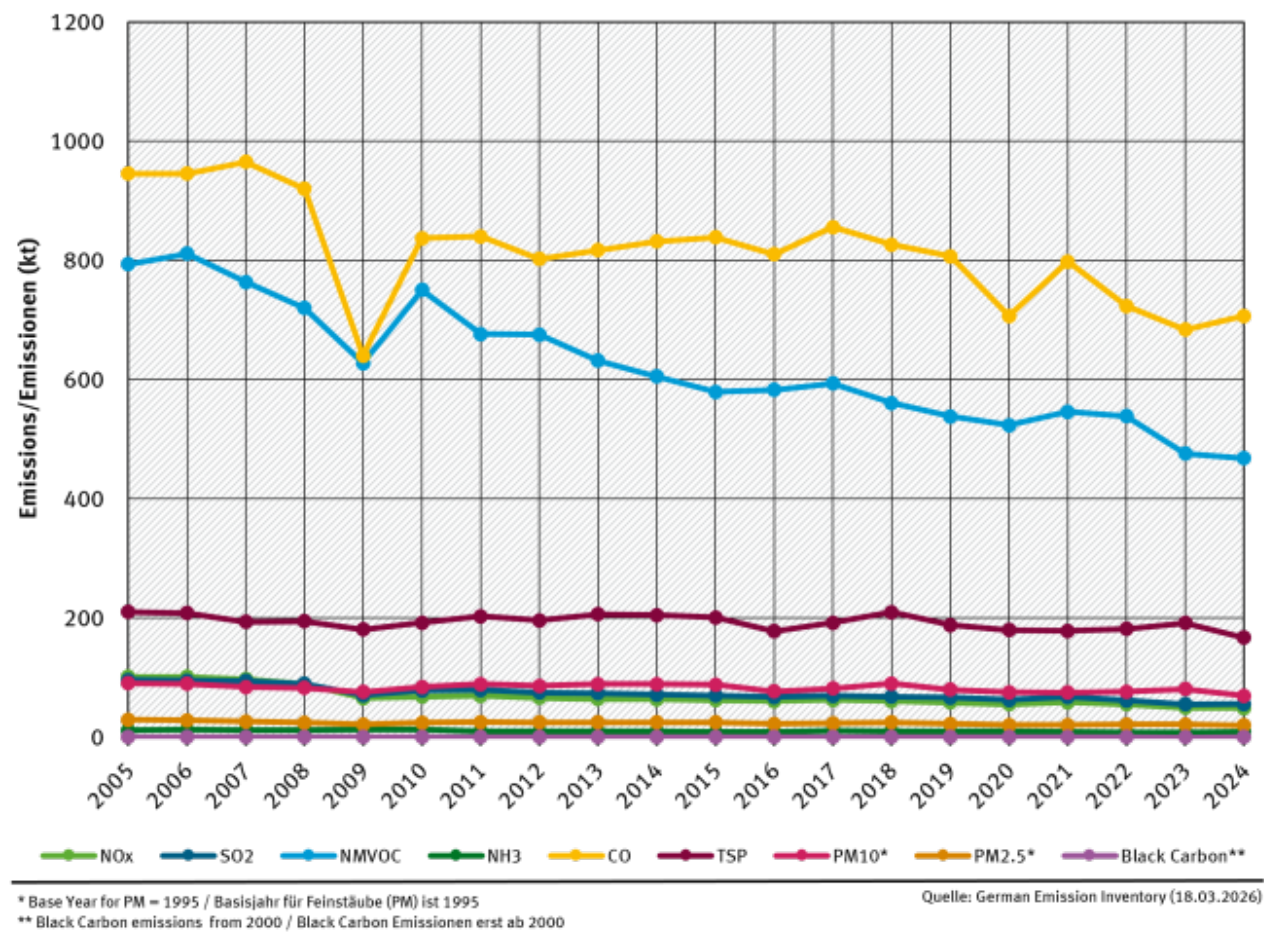
\*\* Black Carbon emissions from 2000 / Black Carbon Emissionen erst ab 2000

Quelle: German Emission Inventory (18.03.2026)



Industrial processes/Industrieprozesse (NFR 2)

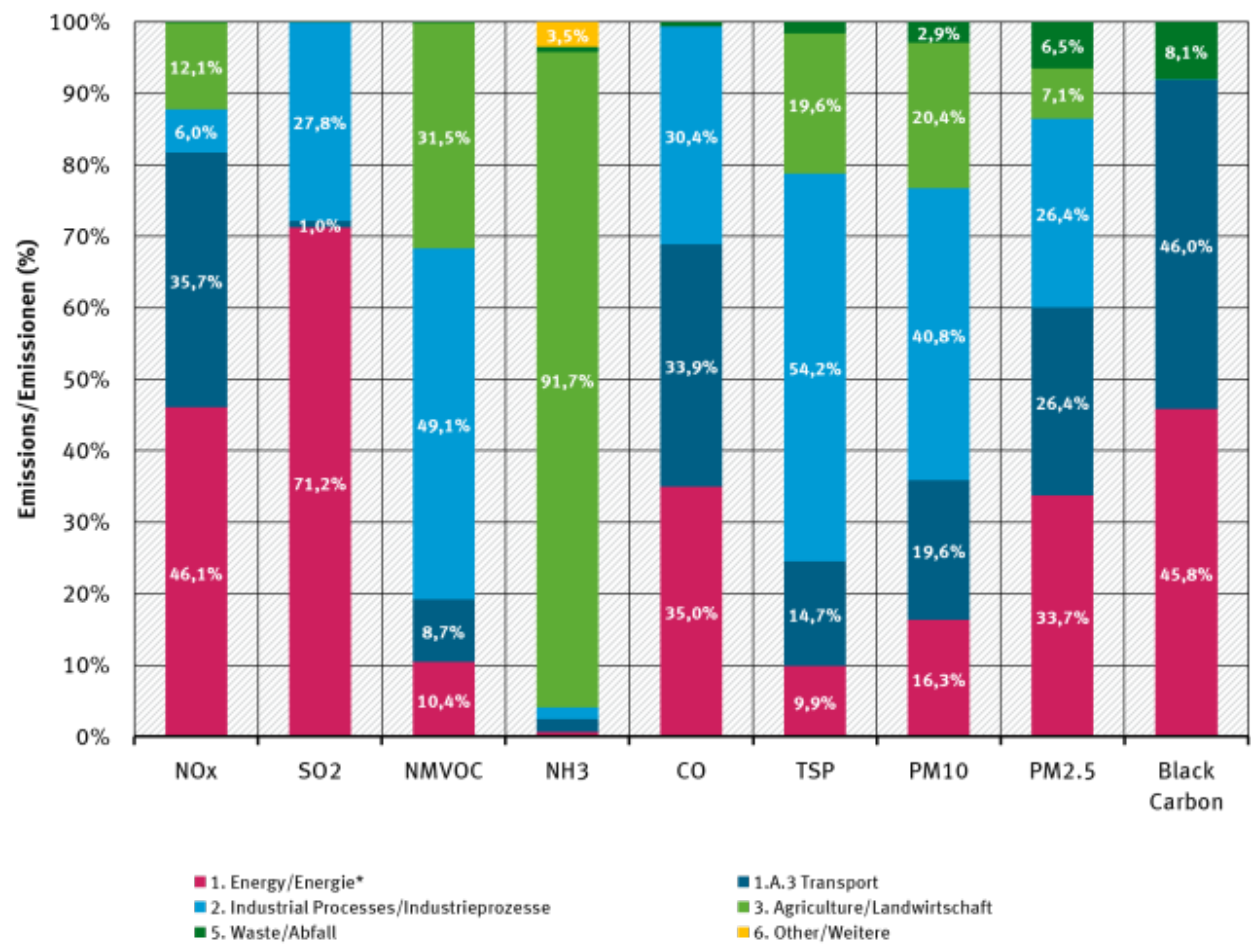
Emissions by pollutant / Emissionen nach Schadstoff



[Contribution of NFRs 1 to 6 to the National Totals](#)

Contribution of NFR categories to the emissions/Anteile der NFR-Kategorien an den Emissionen

2024 percentages per air pollutant / Anteile pro Luftschadstoff für 2024



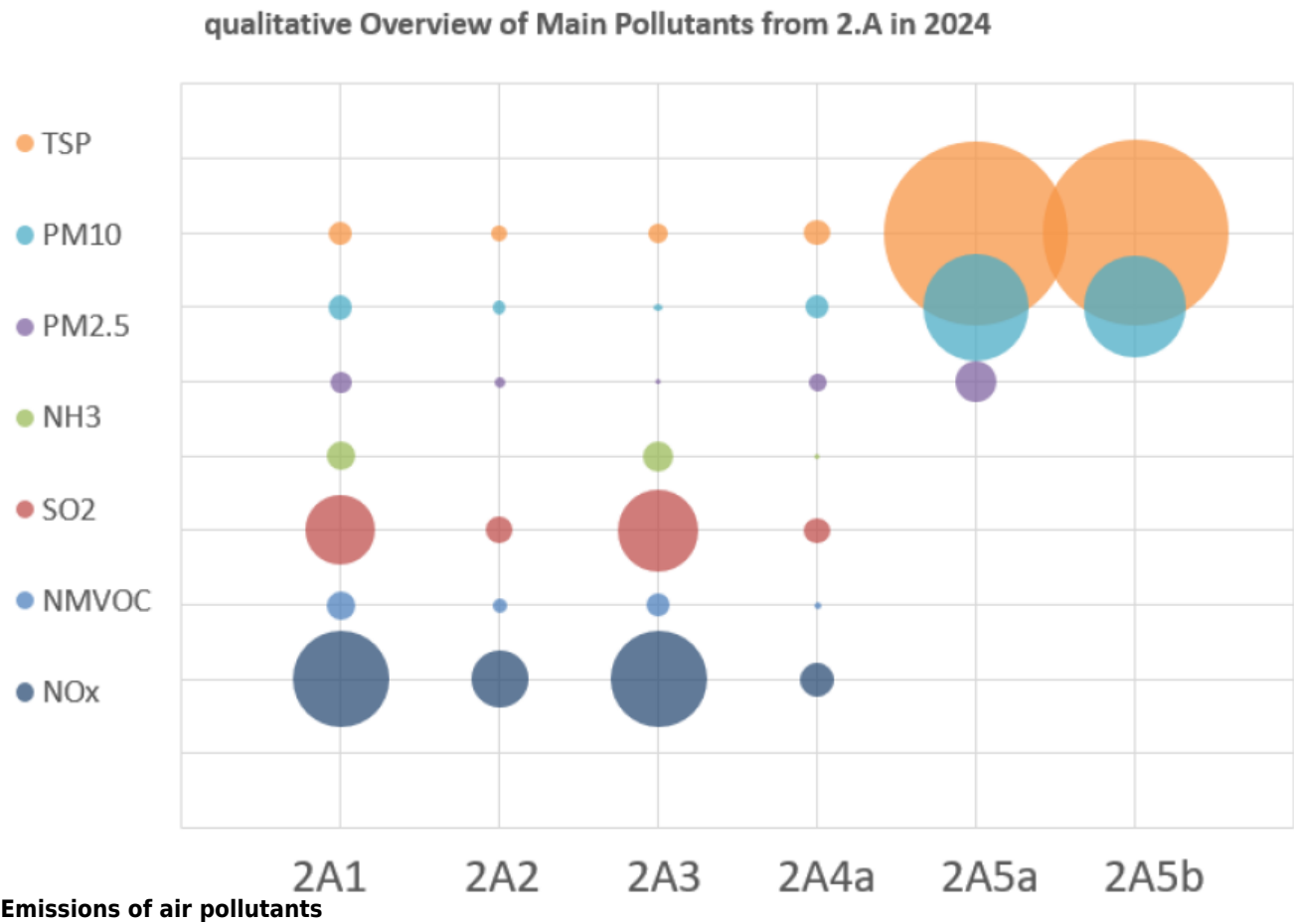
\* without transport ( ohne Verkehr (1.A.3)

Quelle: German Emission Inventory (06.02.2026)

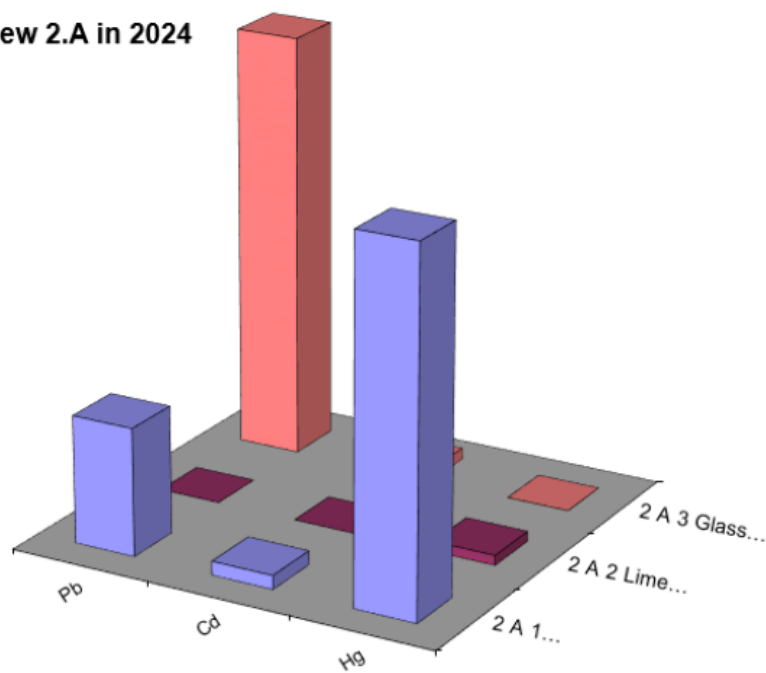
## 2.A - Mineral Industry (OVERVIEW)

|                                                             |
|-------------------------------------------------------------|
| 2.A - Mineral Industry                                      |
| 2.A.1 Cement Production                                     |
| 2.A.2 Lime Production                                       |
| 2.A.3 Glass Production                                      |
| 2.A.5.a Quarrying and Mining of Minerals other than Coal    |
| 2.A.5.b Construction and Demolition                         |
| 2.A.5.c Storage, Handling and Transport of Mineral Products |
| 2.A.6 Other Mineral Products: Ceramics                      |

The Mineral Industry comprises six different sub-categories partly divergent to reporting format of Greenhouse Gases (CRF). The main categories are the Cement Production (2.A.1), Lime Production (2.A.2), Glass Production (2.A.3). But further mineral industries are important regarding other specific emissions, highlighted here: Mining other than coal (2.A.5.a), Construction (2.A.5.b) and Ceramics Production (2.A.6).



comparative Overview 2.A in 2024



all values in Mg

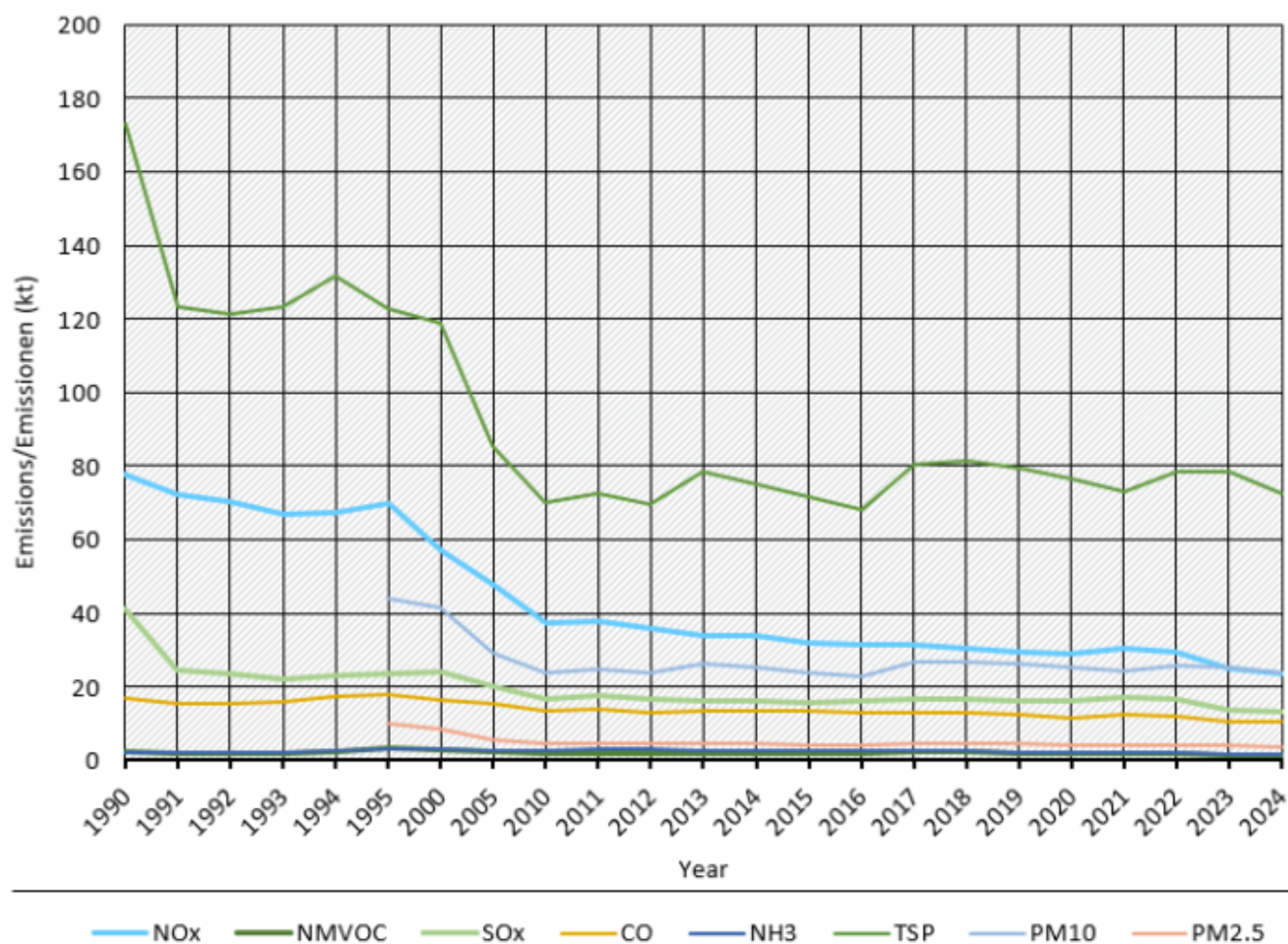
|                         | Pb   | Cd   | Hg   |
|-------------------------|------|------|------|
| 2 A 1 Cement Production | 0,17 | 0,02 | 0,48 |
| 2 A 2 Lime Production   | 0,00 | 0,00 | 0,01 |
| 2 A 3 Glass Production  | 0,57 | 0,02 | 0,00 |

Emissions of heavy metals

Discussion of emission Trends

## Trends of Emissions in Germany in Mineral Industry

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

### Emission trends in NFR 2.A

The steep reduction especially for TSP and SO<sub>2</sub> at the beginning of the 1990s was due especially to closures in the eastern German industrial sector. The last statistic of the GDR<sup>1)</sup> is the source for emissions data of year 1990 for eastern Germany in cases of TSP and SO<sub>2</sub>, in principle absolute amounts of emissions not old emission factors within a calculation. These unusual emissions are allocated to [2.A.6 Other Mineral Products](#).

<sup>1)</sup> Emissionsberichte 1985 - 1989 / released by Statistischen Amt der DDR, not public, but existing copy in UBA-Library under signature LU350633/1989



## 2.A.1 - Cement Production

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.A.1                                                                                     | T1                                   | AS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP                                                                                    | BC | CO | Pb  | Cd  | Hg  | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |  |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|----------------------------------------------------------------------------------------|----|----|-----|-----|-----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|------|--|
| -/-             | -/-    | -/-             | -/-             | -/T               | -/T              | -/-                                                                                    | NE | IE | -/- | -/- | L/- | NE | NE | NE | NE | NE | NE | -/-    | -/-   | IE    | IE    | IE    | -/-    | NA  | -/-  |  |
|                 |        |                 |                 |                   |                  | L/- key source by <b>Level</b> only                                                    |    |    |     |     |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 |                   |                  | -/T key source by <b>Trend</b> only                                                    |    |    |     |     |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 |                   |                  | L/T key source by both <b>Level</b> and <b>Trend</b>                                   |    |    |     |     |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 |                   |                  | -/- no key source for this pollutant                                                   |    |    |     |     |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 |                   |                  | IE emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |    |    |     |     |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 |                   |                  | NE emission of specific pollutant <b>Not Estimated</b> (yet)                           |    |    |     |     |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 |                   |                  | NA specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |    |    |     |     |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |
|                 |        |                 |                 |                   |                  | * no analysis done                                                                     |    |    |     |     |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |  |

The remarks below refer to production of cement clinkers and clinker grinding (only relevant as a source for particulate matter). The clinker-burning with intensive use of energy emits climate-relevant gases. CO<sub>2</sub> accounts for the great majority of these emissions, but heavy metals are important too.

### Methodology

#### Activity data

*cement clinker*

Activity data are determined via summation of figures for individual plants (until 1994, activity data were determined on the basis of data of the official member association BDZ). As of 1995, following optimisation of data collection within the association, activity data were compiled by the [German Cement Works Association](#) (VDZ), and by its [VDZ research institute](#) (located in Düsseldorf), via surveys of German cement plants. The data are supplemented with data for plants that are not BDZ members (in part, also VDZ estimates).

For internal reasons within the association, the data for the years from 2015 onwards is not available from the VDZ. Instead, the cement clinker specification is based on aggregated plant specific ETS-data of DEHSt. A comparison for the years 2005-2014 showed a good correlation between information of the European Emissions Trading (ETS) and the cement clinker production data of the VDZ. So, the cement clinker information from 2015 onwards is based on aggregated data of ETS. All companies are required to report production data within the framework of CO<sub>2</sub>-ETS. The EU monitoring guidelines for emissions trading specify a maximum accuracy of 2.5%. Furthermore CKD was taken into account.

According to the VDZ, the share of bypass dust in clinker production was between 1% and 2% between 2009 and 2016. For the inclusion as an activity rate, it can be assumed that the share was 2 % from 2009 onwards, for time before only 1%.

#### *grinded cement*

The annual amount of grinded cement is provided by VDZ, too, but calculated based on statistical data <sup>1)</sup>

## Emission factors

The emission factors used for emissions calculation are based on figures from research projects <sup>2)3)</sup> as well as from expert judgements.

In the German cement industry, dust separated from clinker burning exhaust gas is returned to the burning process. As a result, there is no need to take account of significant losses of particles via the exhaust-gas pathway. - On the other hand, particulate matter emissions occur during clinker grinding.

The EF applied for Hg fits very well with aggregated figures from individual plants as available from the PRTR-reporting.

Table 1: Overview of emission factors applied for 2019 (or most recently available) up to the current cut-off point

|                                                                                                                                       | EF           | Unit | Trend before |
|---------------------------------------------------------------------------------------------------------------------------------------|--------------|------|--------------|
| emissions from clinker burning                                                                                                        |              |      |              |
| <b>NO<sub>x</sub></b>                                                                                                                 | 0.51         | kg/t | falling      |
| <b>SO<sub>2</sub></b>                                                                                                                 | 0.27         | kg/t | falling      |
| <b>NM VOC</b>                                                                                                                         | 0.046 (2013) | kg/t | constant     |
| <b>NH<sub>3</sub></b>                                                                                                                 | 0.044        | kg/t | falling      |
| <b>Hg</b>                                                                                                                             | 0.026        | g/t  | falling      |
| <b>Pb</b>                                                                                                                             | 0.0092       | g/t  | falling      |
| <b>Cd</b>                                                                                                                             | 0.001        | g/t  | falling      |
| <b>PCB</b>                                                                                                                            | 28.0 (2004)  | µg/t | constant     |
| <b>PCDD</b>                                                                                                                           | 0.0035       | µg/t | falling      |
| <b>B(a)P<sup>1</sup></b>                                                                                                              | 1.0 (2004)   | mg/t | constant     |
| <b>PAH-16<sup>2</sup></b>                                                                                                             | 240.0 (2004) | mg/t | constant     |
| emissions from clinker grinding                                                                                                       |              |      |              |
| <b>TSP</b>                                                                                                                            | 0.022        | kg/t | falling      |
| <b>PM<sub>10</sub></b>                                                                                                                | 0.022        | kg/t | falling      |
| <b>PM<sub>2.5</sub></b>                                                                                                               | 0.018        | kg/t | falling      |
| <sup>1</sup> The data for PAH 1-4 provided in the NFR tables only represents the sum the four PAHs, in this case even only for B[a]P  |              |      |              |
| <sup>2</sup> Outside NFR tables, several more PAH specimen are known to be emitted here (research result for EPA-PAH, PAH16 standard) |              |      |              |

According to research results, HCB emissions are not occurring from cement production and are, hence, reported as not applicable (NA).

The table of EF is related to two different AD sets. For the majority pollutants, annual amounts of *burnt* clinker are applied as activity data. In contrast, regarding PM emissions, the annual amount of *grinded* clinker is applied (included in further

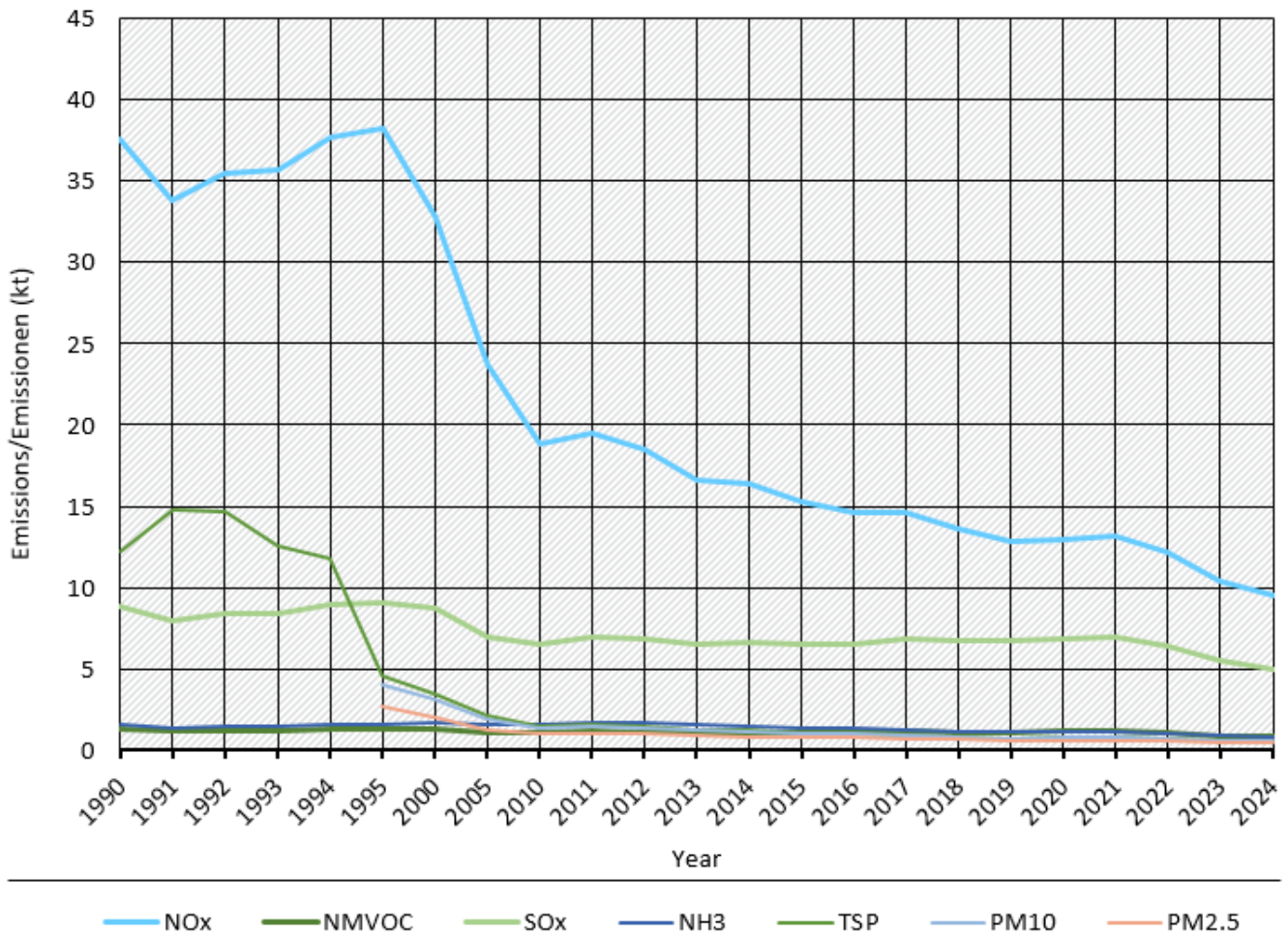
materials as domestic burnt clinker). Unfortunately, within the NFR tables only one AD (burnt clinker) can be provided.

Trends in emissions

All trends in emissions correspond to trends of emission factors in table above. No rising trends are to identify.

Trends of Emissions in Germany from production of cement clinker

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

Emission trends in NFR 2.A.1

Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

Planned improvements







At the moment, no category-specific improvements are planned.

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<sup>1)</sup> Sum of two Statistical-IDs: GP19-235112100 and GP19-235112900

<sup>2)</sup> Ruppert et al. (2009): Ruppert, J., Scheuer, W., Schäfer, St.: „Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarungen für ausgewählte Industriebranchen: Teilvorhaben, UBA-FB 001334, available <https://search.ebscohost.com/login.aspx?direct=true&db=cat04356a&AN=fuu.02331791&lang=de&site=eds-live>, ReFoPlan Forschungskennzahl 370742301/03; Forschungsinstitut der Zementindustrie, Düsseldorf, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2009

<sup>3)</sup> Schäfer et al. (2022): Schäfer, Dr. St., Ruppert, Dr. J., Furth, Dr. G., Schulte, S.; VDZ Technology gGmbH, Düsseldorf: “Überarbeitung der Emissionsfaktoren für Luftschadstoffe in den Branchen Zementklinkerproduktion und Glasherstellung; Teilbericht - Zementklinkerproduktion”; Forschungskennzahl 3719 52 1010; FB000678; ISSN 1862-4804; <https://www.umweltbundesamt.de/publikationen/ueberarbeitung-der-emissionsfaktoren-fuer-0>; on behalf of the Umweltbundesamt, Dessau-Roßlau, February 2022

## 2.A.2 - Lime Production

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.A.2                                                                                     | T1                                   | AS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub>                                                                                 | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO  | Heavy Metals | POPs |
|-------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|-----|--------------|------|
| -/-                                                                                             | -/-    | -/-             | IE              | -/-               | -/-              | -/- | NE | -/- | NA           | NA   |
| <b>L/-</b> key source by <b>L</b> evel only                                                     |        |                 |                 |                   |                  |     |    |     |              |      |
| <b>-/T</b> key source by <b>T</b> rend only                                                     |        |                 |                 |                   |                  |     |    |     |              |      |
| <b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend                                   |        |                 |                 |                   |                  |     |    |     |              |      |
| -/- no key source for this pollutant                                                            |        |                 |                 |                   |                  |     |    |     |              |      |
| IE emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |        |                 |                 |                   |                  |     |    |     |              |      |
| NE emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |        |                 |                 |                   |                  |     |    |     |              |      |
| NA specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |        |                 |                 |                   |                  |     |    |     |              |      |
| * no analysis done                                                                              |        |                 |                 |                   |                  |     |    |     |              |      |

The statements made below regarding source category 2.A.2 refer solely to the amounts of burnt lime and dolomite lime produced in German lime works. Other lime-producing processes are included in NFRs 2.C.1 and 2.H.2.

Because of the wide range of applications covered by the sector's products, lime production is normally more isolated from economic fluctuations than is production of other mineral products such as cement. Production has fluctuated relatively little since the end of the 1990s. Dolomite-lime production, of which significantly smaller amounts are produced, basically exhibits similar fluctuations.

### Methodology

The pertinent emissions level is obtained by multiplying the amount of product in question (quick lime or dolomite lime) and the relevant emission factor.

## Activity data

The Federal Association of the German Lime Industry (Bundesverband der Deutschen Kalkindustrie e. V. - BVK) <sup>1)</sup> collects and provides plant-specific production data for the entire time series.

Production amounts are determined via several different concurrent procedures resulting in adequately assured data quality (Tier 2).

Most companies are also required to report lime-production data within the framework of CO<sub>2</sub> emissions trading. The EU monitoring guidelines for emissions trading specify a maximum accuracy of 2.5%. It is additionally assumed that 2% of the burnt lime is separated as dust in all years as of 1990 via appropriate exhaust gas purification systems and is not returned to the production process. This is taken into account by a potential 2% increase in activity rates.

## Emission factors

Due to a recommendation during NEC-Review 2021, the calculation of CO emissions from lime production is allocated to process emissions and based on default EF. All other EF are country-specific values derived from different research projects.

Table 1: Emission factors for quick-lime production

|                         | EF    | unit | Trend                                      |
|-------------------------|-------|------|--------------------------------------------|
| <b>NO<sub>x</sub></b>   | 0.59  | kg/t | falling                                    |
| <b>SO<sub>2</sub></b>   | 0.12  | kg/t | falling                                    |
| <b>NMVOC</b>            | 0.041 | kg/t | constant over time                         |
| <b>CO</b>               | 1.940 | kg/t | default from EMEP/EEA (2019) <sup>2)</sup> |
| <b>TSP</b>              | 0.050 | kg/t | falling                                    |
| <b>PM<sub>10</sub></b>  | 0.038 | kg/t | falling                                    |
| <b>PM<sub>2.5</sub></b> | 0.023 | kg/t | falling                                    |
| <b>Hg</b>               | 2.62  | mg/t | falling                                    |

Table 2: Emission factors for dolomite production

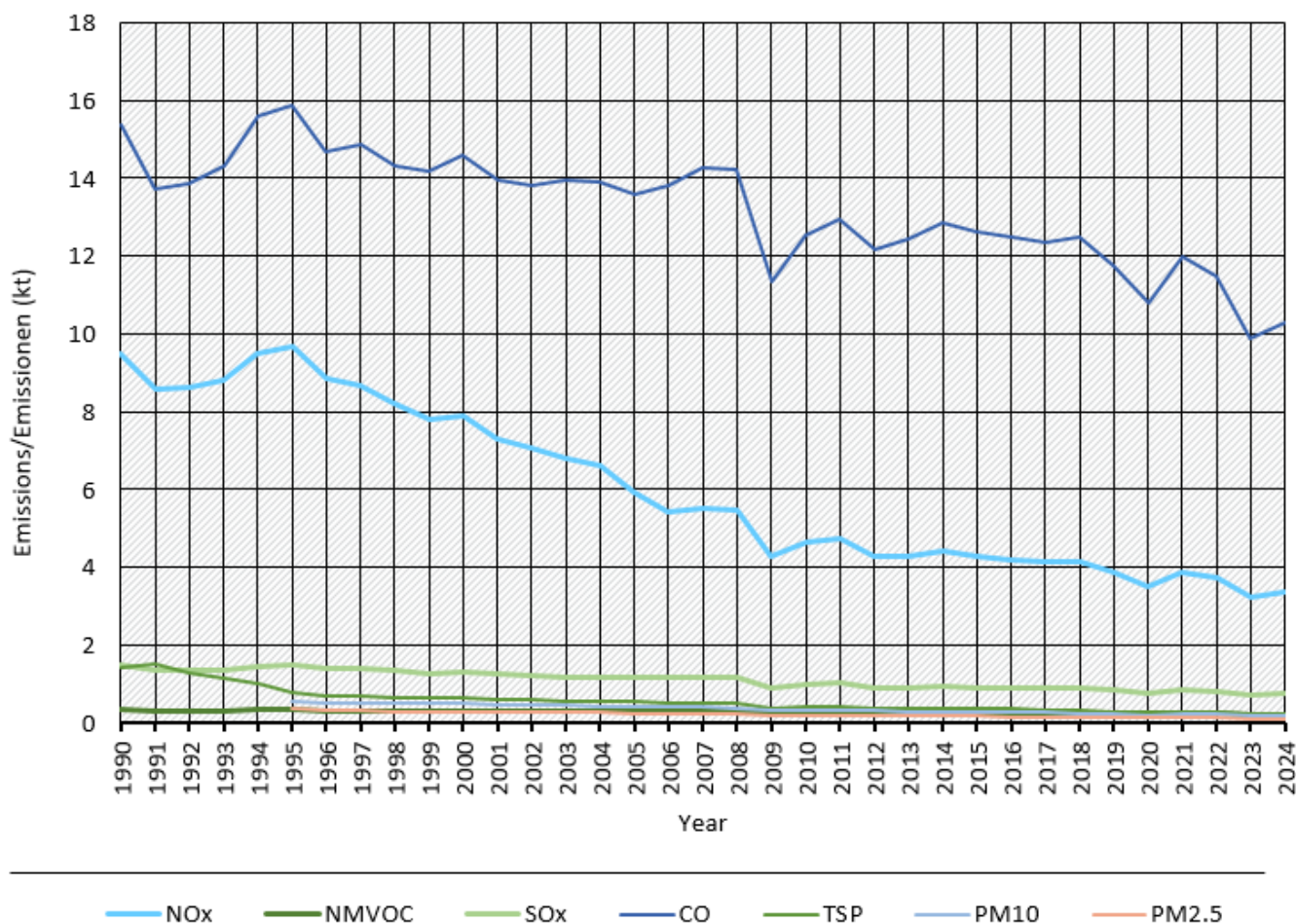
|                         | EF    | unit | Trend                                      |
|-------------------------|-------|------|--------------------------------------------|
| <b>NO<sub>x</sub></b>   | 1.73  | kg/t | falling                                    |
| <b>SO<sub>2</sub></b>   | 0.58  | kg/t | falling                                    |
| <b>NMVOC</b>            | 0.041 | kg/t | constant over time                         |
| <b>CO</b>               | 1.940 | kg/t | default from EMEP/EEA (2019) <sup>3)</sup> |
| <b>TSP</b>              | 0.034 | kg/t | falling                                    |
| <b>PM<sub>10</sub></b>  | 0.026 | kg/t | falling                                    |
| <b>PM<sub>2.5</sub></b> | 0.015 | kg/t | falling                                    |
| <b>Hg</b>               | 2.63  | mg/t | falling                                    |

## Trends in emissions

All trends in emissions correspond to trends of emission factors in table above. No rising trends are identified.

## Trends of Emissions in Germany from production of lime

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

### Emission trends in NFR 2.A.2

## Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> Federal Association of the German Lime Industry (Bundesverband der Deutschen Kalkindustrie e. V. - BVK): <https://www.kalk.de/>

<sup>2), 3)</sup> EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, chapter 2.A.2 Lime production 2019: Table

3-23 Tier 2 emission factors for source category 1.A.2.f.i, Lime production:

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/2-industrial-processes/2-a-mineral-products/2-a-2-lime-production/@download/file>; EEA, Copenhagen, 2019

## 2.A.3 - Glass Production

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.A.3                                                                                     | T2                                   | AS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub>                                                                 | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO  | Pb  | Cd  | Hg | As  | Cr  | Cu  | Ni  | Se  | Zn | POPs |
|---------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|-----|-----|-----|----|-----|-----|-----|-----|-----|----|------|
| -/-                                                                             | -/-    | L/-             | -/-             | -/-               | -/-              | -/- | NE | -/- | -/- | -/- | NA | -/- | -/- | -/- | -/- | L/T | NA | NA   |
| L/- key source by Level only                                                    |        |                 |                 |                   |                  |     |    |     |     |     |    |     |     |     |     |     |    |      |
| -/-T key source by Trend only                                                   |        |                 |                 |                   |                  |     |    |     |     |     |    |     |     |     |     |     |    |      |
| L/T key source by both Level and Trend                                          |        |                 |                 |                   |                  |     |    |     |     |     |    |     |     |     |     |     |    |      |
| -/- no key source for this pollutant                                            |        |                 |                 |                   |                  |     |    |     |     |     |    |     |     |     |     |     |    |      |
| IE emission of specific pollutant Included Elsewhere (i.e. in another category) |        |                 |                 |                   |                  |     |    |     |     |     |    |     |     |     |     |     |    |      |
| NE emission of specific pollutant Not Estimated (yet)                           |        |                 |                 |                   |                  |     |    |     |     |     |    |     |     |     |     |     |    |      |
| NA specific pollutant not emitted from this source or activity = Not Applicable |        |                 |                 |                   |                  |     |    |     |     |     |    |     |     |     |     |     |    |      |
| * no analysis done                                                              |        |                 |                 |                   |                  |     |    |     |     |     |    |     |     |     |     |     |    |      |

Germany's glass industry produces a wide range of different glass types that differ in their chemical composition.

The national glass production sector includes of the following sub-sectors:

- container glass (bottles, jars, drinkware, and bowls),
- flat glass (used for windows, glass doors, transparent walls etc.),
- domestic glass,
- special glass

and

- mineral fibres (glass and stone wool).

The largest production quantities are found in the sectors of container glass and flat glass. Further processing and treatment

of glass and glass objects are not considered.

The glass industry, in particular container glass production, is the main factor in selenium emissions. It accounted for more than 60 % in 1990 and around 45 % in recent years, reaching a peak of almost 80 % in 1995. A complete analysis over all categories is not done (see above <sup>\*)</sup>).

## Methodology

The emissions are calculated via a higher Tier method resembling a Tier 2 method, as the activity rates are tied to specific emission factors for different glass types. For the current identification as key source of SO<sub>2</sub> from the 2026 submission onwards, please refer to the specific SO<sub>2</sub> emission factors listed below.

### Activity data

The production figures are taken from the regularly appearing annual reports of the [Federal Association of the German Glass Industry](#) (Bundesverband Glasindustrie; BV Glas). "Production" refers to the amount of glass produced, which is considered to be equivalent to the amount of glass melted down.

### Emission factors

The procedure used to determine emission factors for the various glass types involved and the pertinent emissions is described in detail in reports of two research projects (2008: Report-No. 001264<sup>1)</sup>, 2021: Texte 45/2021<sup>2)</sup>). The emission factors were calculated for the various industry sectors. The factors vary over time in keeping with industry monitoring, not only as steady trends, but falling in most cases. The most recently EF are for different glass types the following:

Table 1: Overview of most recently applied emission factors

|                         | Unit | Container glass | flat glass    | domestic glass | special glass | fibre optics | stone wool   |
|-------------------------|------|-----------------|---------------|----------------|---------------|--------------|--------------|
| <b>NO<sub>x</sub></b>   | kg/t | 1.0766          | 1.7708        | 2.8602         | 3.5558        | 0.8          | 1.877        |
| <b>SO<sub>2</sub></b>   | kg/t | 0.759           | <b>1.5677</b> | 0.0599         | 0.1157        | 0.1847       | <b>2.229</b> |
| <b>NM VOC</b>           | kg/t | NA              | NA            | NA             | NA            | 0.6          | 0.657        |
| <b>CO</b>               | kg/t | 0.0732          | 0.0241        | 0.0661         | 0.1195        | 0.06         | 0.185        |
| <b>NH<sub>3</sub></b>   | kg/t | 0.0026          | 0.0191        | NA             | 0.0295        | 1.10         | 1.163        |
| <b>TSP</b>              | kg/t | 0.00863         | 0.01681       | 0.015          | 0.00765       | 0.01096      | 0.643        |
| <b>PM<sub>10</sub></b>  | kg/t | 0.00742         | 0.01429       | 0.0129         | 0.0065        | 0.00932      | 0.0234       |
| <b>PM<sub>2.5</sub></b> | kg/t | 0.00483         | 0.00773       | 0.0069         | 0.00352       | 0.00504      | 0.0128       |
| <b>As</b>               | g/t  | 0.0279          | 0.0104        | 0.0023         | 0.1143        | 0.0354       | NE           |
| <b>Pb</b>               | g/t  | 0.1237          | 0.0104        | 0.0076         | 0.1158        | 0.1571       | NE           |
| <b>Cd</b>               | g/t  | 0.0032          | 0.0005        | 0.0000         | 0.0028        | 0.0041       | NE           |
| <b>Cr</b>               | g/t  | 0.0186          | 0.0029        | 0.0007         | 0.0148        | 0.0236       | NE           |
| <b>Cu</b>               | g/t  | 0.0035          | 0.02          | 0.0002         | 0.0085        | 0.0056       | NE           |
| <b>Ni</b>               | g/t  | 0.0048          | 0.0061        | 0.0003         | 0.0142        | 0.0061       | NE           |
| <b>Se</b>               | g/t  | 0.2794          | 0.0427        | 0.1273         | 0.0454        | 0.01         | NE           |

For each glass type the estimated EF are explained in 'Texte 45/2021' with an expert votum and uncertainty estimation.

The highlighted SO<sub>2</sub>-EF are relevant for the identification as key source.

Emissions of BC are not estimated, but there is no evidence from the industry monitoring for this.

## Trends in emissions

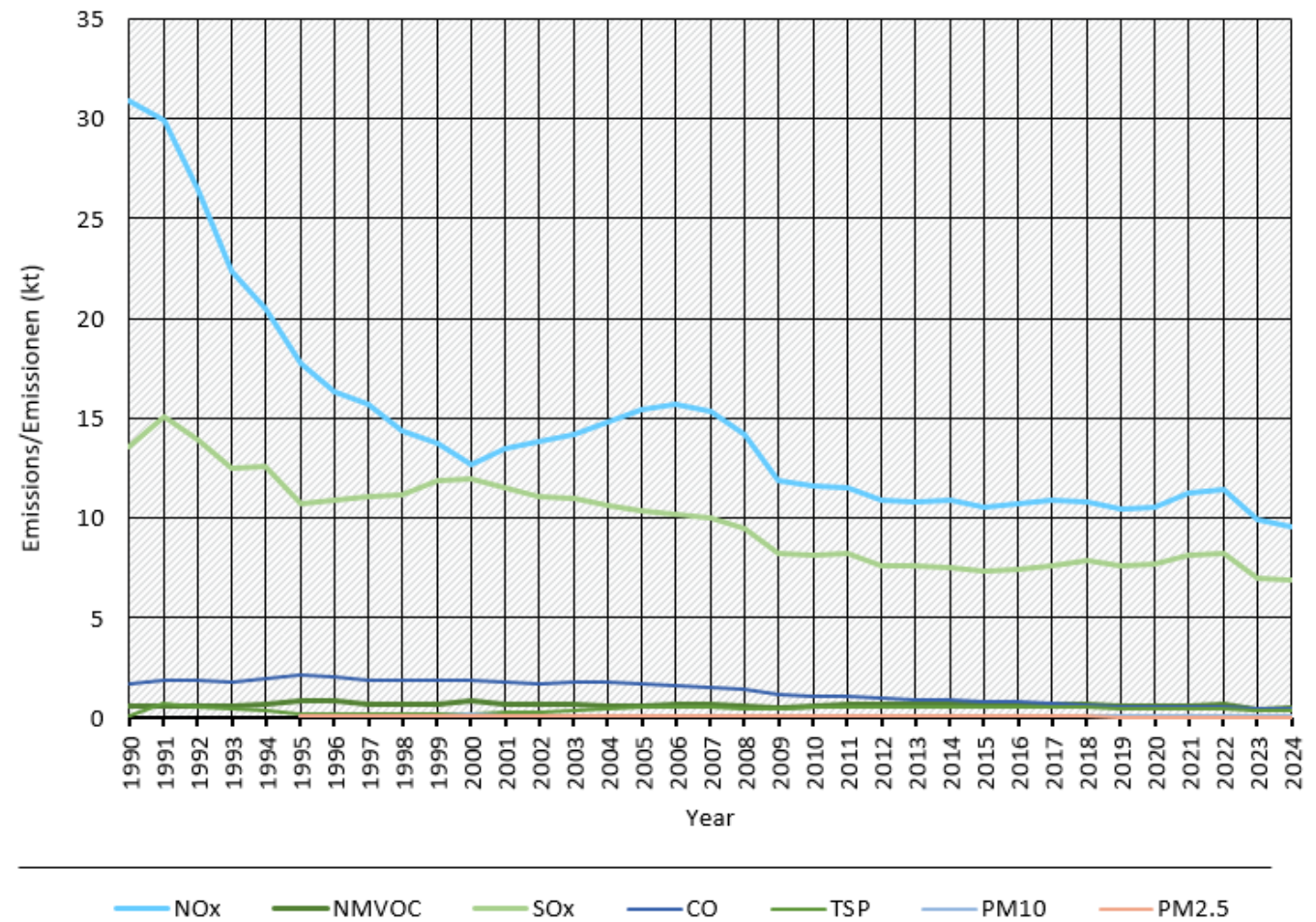
Trends in emissions correspond to trends of emission factors and of production development. The resulting trends are not constant, as a result of different EF for various glass types. So emissions of NO<sub>x</sub> and SO<sub>2</sub> couldn't decrease last years due to



increased production Level of relevant products.

### Trends of Emissions in Germany from production of glass

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

### Emission trends in NFR 2.A.3

## Recalculations

Recalculations were necessary due to an update of several production figures in 2023.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.



---

<sup>1)</sup> UFoPlan FKZ 206 42 300/02: Teilvorhaben 02: „Providing up-to-date emission data for the glass and mineral fiber industry“ downloading via search “UBA-FB 001264” in (<https://doku.uba.de> ⇒ OPAC ⇒ use parameter ‘Signatur’

<sup>2)</sup> ReFoPlan FKZ – 3719 52 1010: „Revision of emission factors for air pollutants in the cement clinker production and glass manufacturing sectors“ downloading via  
[https://www.umweltbundesamt.de/sites/default/files/medien/5750/publikationen/2021-03-18\\_texte\\_45-2021\\_luftschadstoff\\_glasindustrie.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/5750/publikationen/2021-03-18_texte_45-2021_luftschadstoff_glasindustrie.pdf)

## 2.A.5.a - Quarrying & Mining - Other Than Coal

| Category Code                                                                             | Method                               | AD       | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----------|----|
| 2.A.5.a                                                                                   | T1/T2                                | NS/IS/AS | CS |
| Method(s) applied                                                                         |                                      |          |    |
| D                                                                                         | Default                              |          |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |          |    |
| T2                                                                                        | Tier 2*                              |          |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |          |    |
| C                                                                                         | CORINAIR                             |          |    |
| CS                                                                                        | Country Specific                     |          |    |
| M                                                                                         | Model                                |          |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |          |    |
| (source for) Activity Data                                                                |                                      |          |    |
| NS                                                                                        | National Statistics                  |          |    |
| RS                                                                                        | Regional Statistics                  |          |    |
| IS                                                                                        | International Statistics             |          |    |
| PS                                                                                        | Plant Specific                       |          |    |
| As                                                                                        | Associations, business organisations |          |    |
| Q                                                                                         | specific Questionnaires (or surveys) |          |    |
| M                                                                                         | Model / Modelled                     |          |    |
| C                                                                                         | Confidential                         |          |    |
| (source for) Emission Factors                                                             |                                      |          |    |
| D                                                                                         | Default (EMEP Guidebook)             |          |    |
| CS                                                                                        | Country Specific                     |          |    |
| PS                                                                                        | Plant Specific                       |          |    |
| M                                                                                         | Model / Modelled                     |          |    |
| C                                                                                         | Confidential                         |          |    |

| NO <sub>x</sub>                                                                                        | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|--------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA                                                                                                     | NA     | NA              | NA              | L/-               | L/T              | L/- | NA | NA | NA           | NA   |
| <b>L/-</b> key source by <b>L</b> evel only                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>T</b> rend only                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend                                          |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/-</b> no key source for this pollutant                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b> emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b> emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b> specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |        |                 |                 |                   |                  |     |    |    |              |      |
| * no analysis done                                                                                     |        |                 |                 |                   |                  |     |    |    |              |      |

Quarrying & Mining is the main source for particulate matter emissions within the entire **Mineral industries sub-sector (2.A)**.

### Short description

Generally, mining processes emit relevant amounts of particles.

**NFR 2.A.5.a - Quarrying and mining of minerals (other than coal)** includes the mining of limestone, hard rock, and building sands, as well as the increasing use of corresponding recyclates.

Due to the country-specific approach applied, the production of (potash and rock) salt is a sub-category of the mining processes considered in the German air pollutant emissions inventory.

## Methodology

With the German air pollutant emissions inventory, different approaches are applied for (i) sands and rocks, and (ii) salts:

### Sands and Rocks

By applying the 2023 EMEP/EEA Guidebook method <sup>1)</sup>, a tier2 method is available reflecting different national conditions, in particular specific input variables on humidity and wind speed, which are localized according to the German federal states. Here, as the three German city-states (Berlin, Hamburg, and Bremen) do not represent average weather conditions, they are considered part of the surrounding federal states (Brandenburg, Schleswig-Holstein, and Niedersachsen). Parameters on weather as well as on areas can thus be improved in the model mentioned above. In a first approach, this was done by using weather data from the German Weather Service (DWD), which can be obtained as daily station data from (DWD, most recent year)<sup>2)</sup>. No area information from the Corine land cover before 2010 is used (consistent data sets). In addition, information from CLC category 131 (Mineral extraction sites) had to be adjusted for areas of active open-pit lignite mines. (Copernicus, 2019)<sup>3)</sup>

### Salts

Salt mining represents only a minor portion (less than 4%, depending on the PM fraction) of the particulate-matter emissions reported for NFR 2.A.5.a.

With respect to this limited scale of both activity and emissions, salt mining is considered too insignificant for the application of a higher tier (Please see trend discussion below). Therefore, in contrast to the mining/quarrying of sands and rocks described above, a tier1 approach based on information on production of salts and country-specific emission factors for TSP and PM is applied.

## Activity Data

### Sands and Rocks

As provided in the calculation model presented with the EMEP/EEA Guidebook, specific activity data for hard rock, sand, and recycled material are applied. Here, due to incomplete national statistics, these specific AD are taken from national and international association information available from Aggregates Europe – UEPG (2025) <sup>4)</sup>.

Within the framework of technical consultations, historical data were confirmed by the National Association for Mineral Resources <sup>5)</sup>.

However, additional information and figures on mineral raw materials are compiled by the Federal Institute for Geosciences and Natural Resources, but are not yet available.

Therefore, for time series consistency, data gaps are closed via interpolation or expert adjustments.

### Salts

Production data for potash and rock salt are included in national statistics, with data gaps being filled as already described for sands and rocks above. Here, as potash salt is dominating, all reported emissions are modelled as resulting from potash salt.

## Emission factors

### Sands and Rocks

As described above, the calculation model provided by the EEA as part of the EMEP/EEA GB takes into account national circumstances and reduction measures. The calculations are available in from of more than ten MS Excel files (individual years since 1990, annually from 2010). Since the GB tool in principle calculates emissions for exactly one year <sup>6)</sup>, files must be available for those years for which specific input data are available. In case of data gaps, intermediate years are interpolated .

With the help of the GB tools, annual implied EFs are estimated which are used for the inventory method ( $EM = AR \times EF$ ). As

the calculation of this implied emission factors is influenced by national circumstances and weather conditions, the EF are considered as being country-specific.

## Salts

The emission factors for salt production are based on analogy to bulk product handling by an UBA expert judgement:

Table 2: Overview of emission factors applied for salt mining, in [kg/t salt]

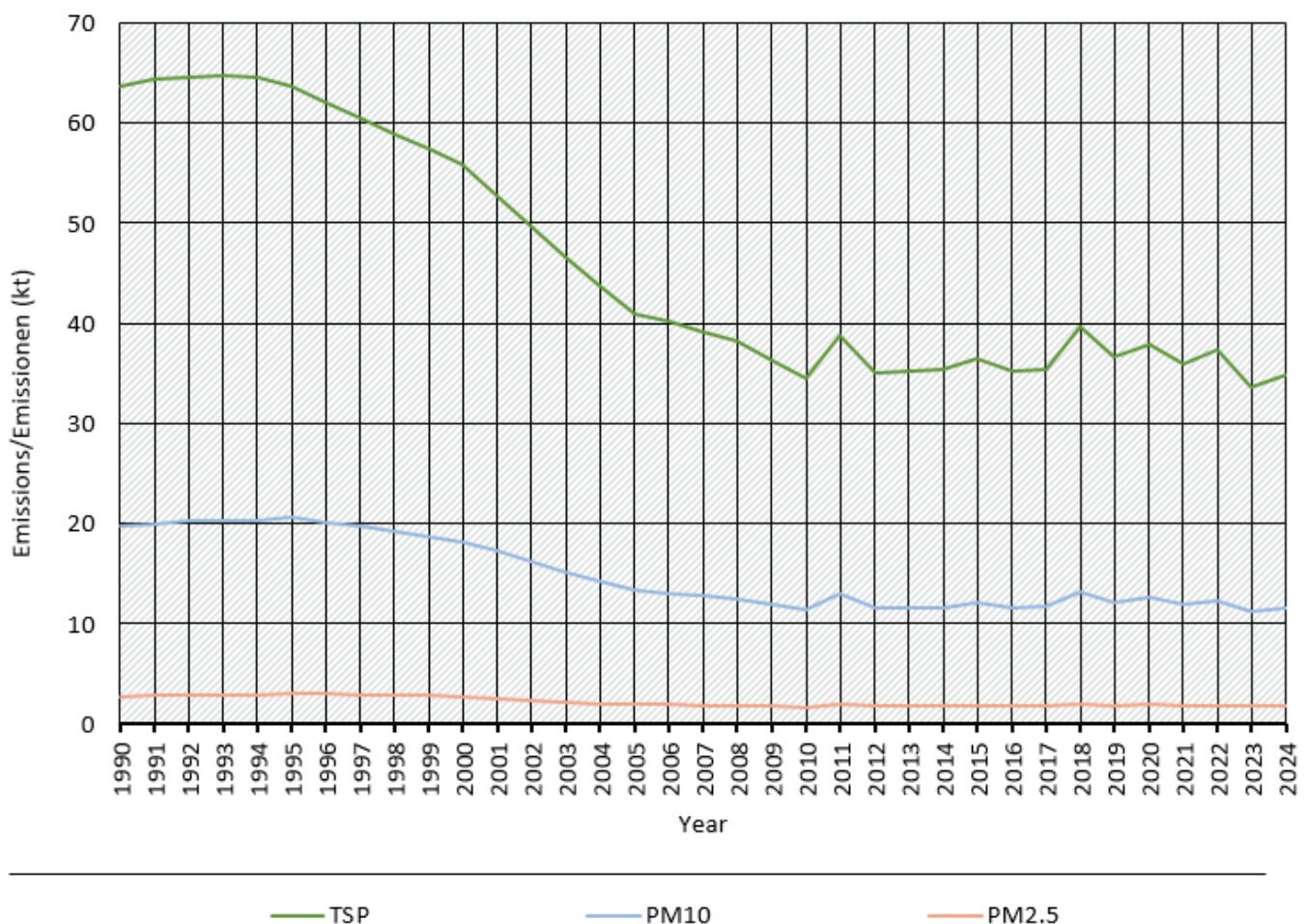
|                         | value | trend              |
|-------------------------|-------|--------------------|
| <b>TSP</b>              | 0.031 | constant over time |
| <b>PM<sub>10</sub></b>  | 0.016 | constant over time |
| <b>PM<sub>2.5</sub></b> | 0.003 | constant over time |

## Trend discussion

Trends in emissions follow the shrinking mining activities.

### Trends of Emissions in Germany from quarrying & mining - other than coal

Emissions by pollutant / Emissionen nach Schadstoff

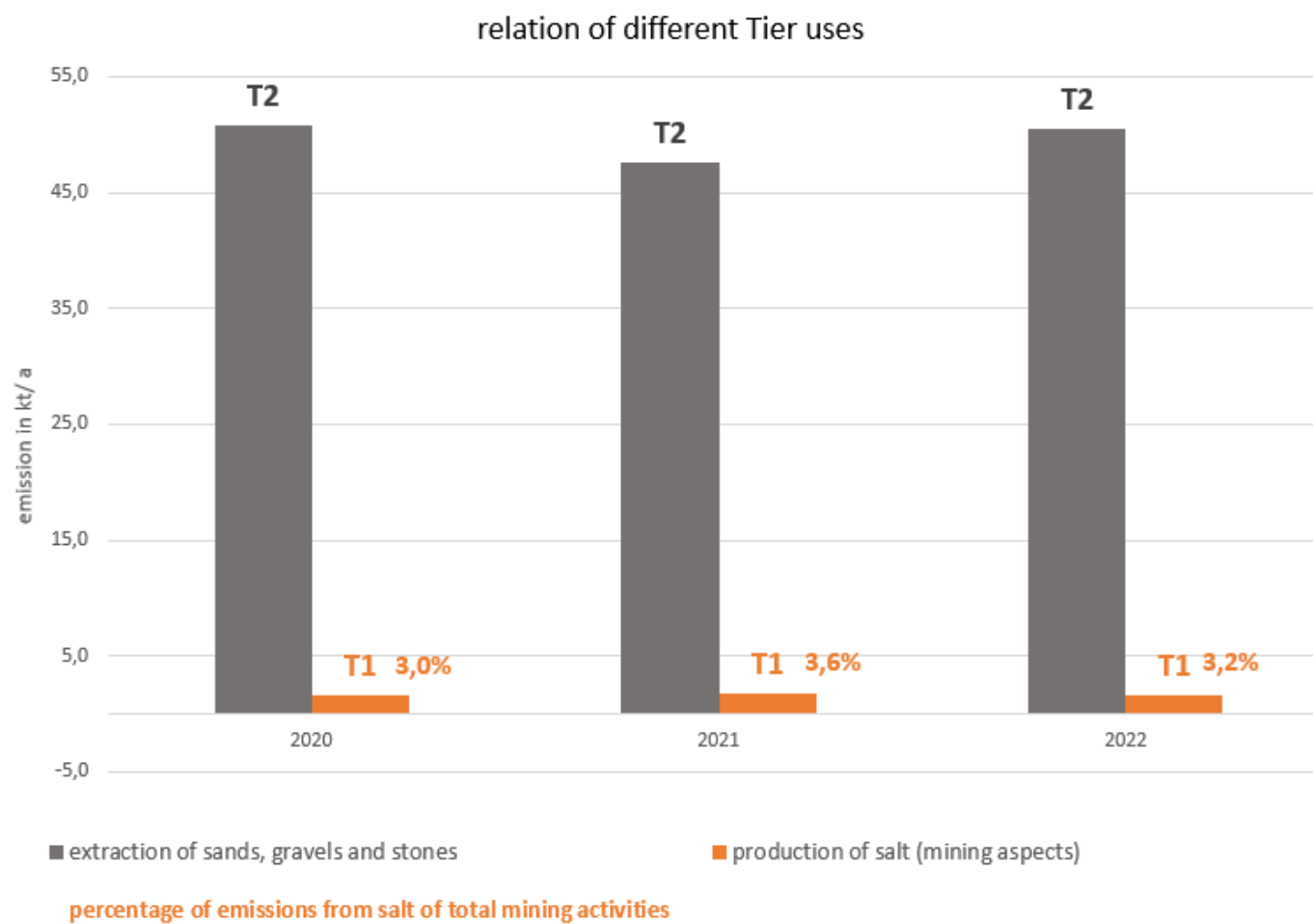


\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

### Emission trends in NFR 2.A.5.a

As mentioned above, emissions from salt mining represent only a small portion (less than 4%) of the total emissions allocated to NFR sub-sector 2.A.5.a, depending on the specific pm fraction. Following this is presented for three years as example.



share-of-salt-in-mining

Recalculations

Recalculations were necessary due to updated production figures for the most recent year.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

Planned improvements



It is planned to further evaluate country-specific conditions.

<sup>1), 6)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-a-mineral-products/2-a-5-a-quarrying-1/view>; Copenhagen, 2023

<sup>2)</sup> DWD (most recent year): ClimateDataCenter (CDC): [https://opendata.dwd.de/climate\\_environment/CDC/observations\\_germany/climate/daily/kl/](https://opendata.dwd.de/climate_environment/CDC/observations_germany/climate/daily/kl/)

<sup>3)</sup> Copernicus (2019): CLC-classes, <https://land.copernicus.eu/user-corner/technical-library/corine-land-cover-nomenclature-guidelines/html/index-clc-131.html>

<sup>4)</sup> Aggregates Europe – UEPG (2025): aggregates production data for European countries: <https://www.aggregates-europe.eu/facts-figures/figures/>; Brussels, Belgium, 2025

<sup>5)</sup> BV-Miro (2024): National Association for Mineral Resources: <https://www.bv-miro.org/>

## 2.A.5.b - Construction and Demolition

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.A.5.b                                                                                   | T1/T2                                | NS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub>                                                                                        | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|--------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA                                                                                                     | NA     | NA              | NA              | -/-               | L/T              | L/- | NA | NA | NA           | NA   |
| <b>L/-</b> key source by <b>L</b> evel only                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>T</b> rend only                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend                                          |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/-</b> no key source for this pollutant                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b> emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b> emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b> specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |        |                 |                 |                   |                  |     |    |    |              |      |
| * no analysis done                                                                                     |        |                 |                 |                   |                  |     |    |    |              |      |

Regarding particle emissions, construction is the second-largest emissions source within NFR 2.A - Mineral industries.

### Methodology

Since the last update of the EMEP/EEA air pollutant emission inventory guidebook, a tier1 method is applied to estimate particulate matter emissions. However, this tier1 method is applied with various adaptations to national conditions improving it to a rather higher tier, perhaps T1/T2.

The approach for uncontrolled fugitive emissions from 2.A.5.b was adapted for national circumstances within a research project by Kampffmeyer & Visschedijk (2016)<sup>1)</sup>, partly considering existing emission-control technologies. As a result,

statistical information is combined with modified default emission factors for TSP and PM.

## Activity data

Activity data are determined taking into account figures for various construction activities and based on national production statistics.

AD is a result of multiplying the number of houses constructed and a conversion factor.

According to the method applied, figures of area of land affected by construction activities per building were concluded from statistical data and multiplied with emission factors, as explained below.

## Emission factors

The emission factors used are results of the adaptation of EMEP/EEA Guidebook defaults (EMEP/EEA, 2023)<sup>2)</sup>, for our inventory so-called 'applied emission factors' with following parameters:

- pollutant-specific emission factor, not corrected for soil moisture and silt content (kg of emitted pollutants/m<sup>2</sup> affected area/year),
- average affected area as product of number of buildings constructed multiplied with conversion factor (average affected area per building),
- duration of construction activity from default values (EMEP/EEA, 2023)<sup>3)</sup>,
- specification of precipitation-evaporation index and soil silt content as constants,
- efficiency of emission control measures at the moment see FAQ below.

Table 1: Overview of applied emission factors, in [kg/m<sup>2</sup> \* y], for roads in [tons/km<sup>2</sup> \* y]

| type of building             | pollutant         | EF value | EF trend           |
|------------------------------|-------------------|----------|--------------------|
| single and two-family houses | TSP               | 0.0638   | constant over time |
|                              | PM <sub>10</sub>  | 0.0191   | constant over time |
|                              | PM <sub>2.5</sub> | 0.0019   | constant over time |
| apartment buildings          | TSP               | 0.329    | constant over time |
|                              | PM <sub>10</sub>  | 0.099    | constant over time |
|                              | PM <sub>2.5</sub> | 0.0099   | constant over time |
| non-residential              | TSP               | 0.631    | constant over time |
|                              | PM <sub>10</sub>  | 0.189    | constant over time |
|                              | PM <sub>2.5</sub> | 0.0189   | constant over time |
| roads                        | TSP               | 1,674    | constant over time |
|                              | PM <sub>10</sub>  | 502      | constant over time |
|                              | PM <sub>2.5</sub> | 50.2     | constant over time |

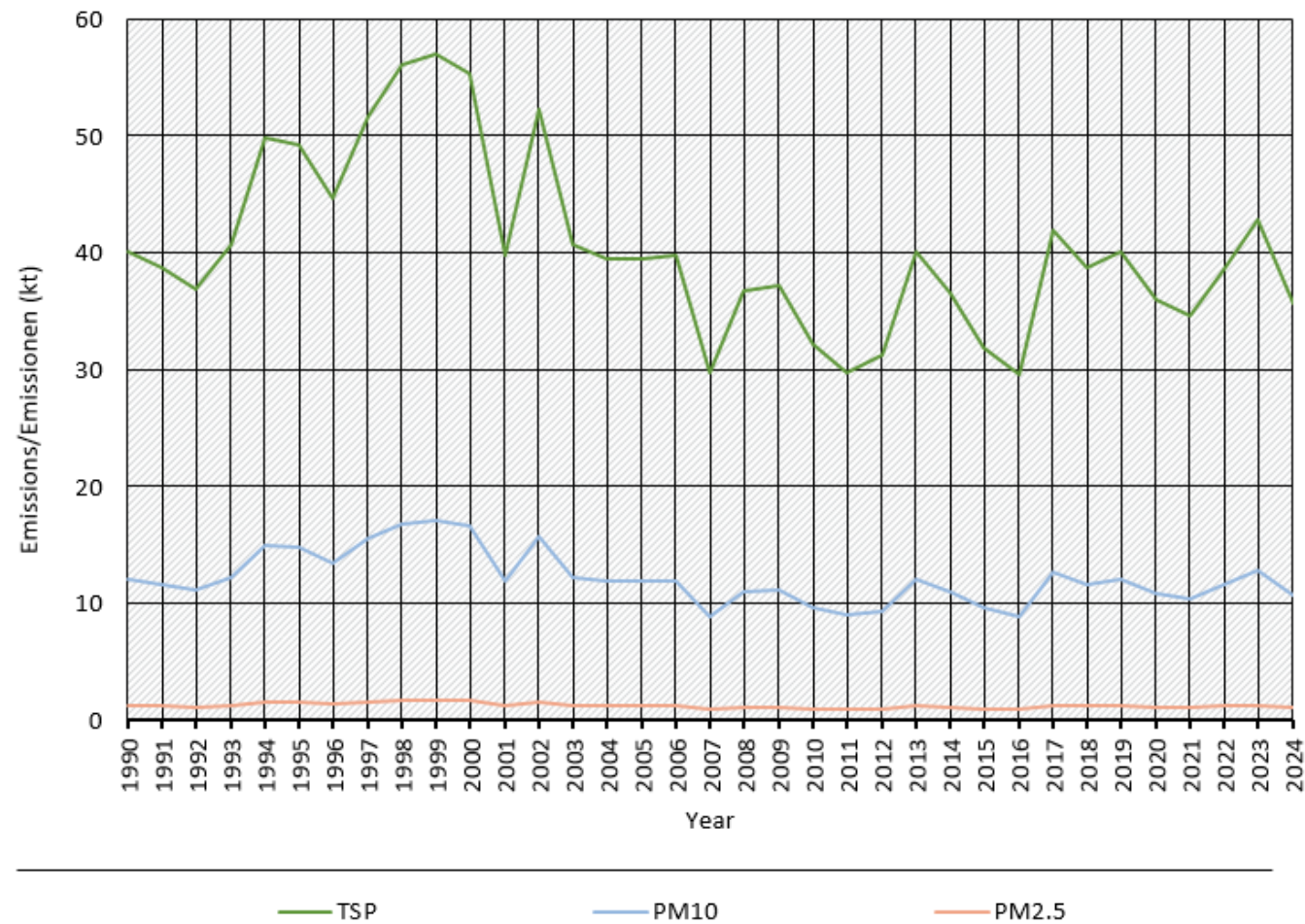
## Trends in emissions

All trends in emissions as product of EF and AD correspond to trends of construction activities.



## Trends of Emissions in Germany from construction

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

### Emission trends in NFR 2.A.5.b

Notes on PCB emissions from old buildings are provided in chapter [2.K - Consumption of POPs and Heavy Metals](#) of this report.

## Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.

## FAQs

**Where can I find emissions estimation of demolition activities?** - Demolishing without any significant new construction is not covered and there are no other emission factors available for demolition activities only. Nevertheless you can find Information about emissions from [5.E.2 - Other Waste: Building Fires](#).

**Why do German EFs differ from EEA defaults?** - It has to do with the default 50% reduction for non-residential buildings and roads (as a result of wetting unpaved temporary roads) that is assumed in the calculations for Germany. This is also already accounted for in the EPA emission factors. It is a result of a control measure that is nearly always taken but in principle optional. In the Guidebook a 50% reduction is advised.

---

<sup>1)</sup> Kampffmeyer, T., Visschedijk, A.: Development of Methods for the Generation of Emission Data for Air Pollutants from Building Activity and Construction Zones,  
<https://research.ebsco.com/linkprocessor/plink?id=46c9c9e5-c6f9-3229-b7af-6585eb409115>; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2016

<sup>2), 3)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023;  
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-a-mineral-products/2-a-5-b-construction/@download/file>; Copenhagen, 2023

## 2.A.5.c - Storage, Handling and Transport of Mineral Products



All emissions from storage, handling and transport of chemical products are included elsewhere ('IE') in the values reported in NFR 2.L - Other production, consumption, storage, transportation or handling of bulk products.

## 2.A.6 - Other Mineral Products: Ceramics

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.A.6                                                                                     | T1                                   | NS | CS |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub>                                                                                 | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | Other HM | POPs |
|-------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----------|------|
| -/-                                                                                             | -/-    | -/-             | -/-             | -/-               | -/-              | L/- | NA | IE | NE | NE | NE | NA       | NA   |
| L/- key source by <b>L</b> evel only                                                            |        |                 |                 |                   |                  |     |    |    |    |    |    |          |      |
| -/T key source by <b>T</b> rend only                                                            |        |                 |                 |                   |                  |     |    |    |    |    |    |          |      |
| L/T key source by both <b>L</b> evel and <b>T</b> rend                                          |        |                 |                 |                   |                  |     |    |    |    |    |    |          |      |
| -/- no key source for this pollutant                                                            |        |                 |                 |                   |                  |     |    |    |    |    |    |          |      |
| IE emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |        |                 |                 |                   |                  |     |    |    |    |    |    |          |      |
| NE emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |        |                 |                 |                   |                  |     |    |    |    |    |    |          |      |
| NA specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |        |                 |                 |                   |                  |     |    |    |    |    |    |          |      |
| * no analysis done                                                                              |        |                 |                 |                   |                  |     |    |    |    |    |    |          |      |

NFR category 2.A.6 (other) is unknown under the CRF structure, but here you can find the same figures as CRF category 2.A.4.a Ceramics production.

The ceramics industry in Germany is very heterogeneous. It involves a large number of products that are characterized by different fields of application and corresponding chemical compositions. In addition to clay (as the main raw material), sand and other natural raw material amounts, synthetically produced materials such as aluminium oxide and silicon dioxide are also used. The mixture, which is homogeneously mixed from primary raw materials and only in small quantities of secondary raw materials, is burned mainly in tunnel kilns and hearth furnaces at kiln temperatures between 1,100 - 1,300°C.

## Method

In contrast to carbon dioxide, emissions of air pollutants are calculated using only the Tier 1 method, since no product-specific data are available and this source category is not a key source. In relation to the quantity produced, bricks and refractory products as well as wall and floor tiles are important.

### Activity data

For submission in 2018, the production figures (activity rates) were evaluated as completely as possible by the Federal Statistical Office. In order to complete the data available, the annual production of each product category was determined in the context of an expert study in cooperation with the Federal Statistical Office (J. Gottwald et al., 2017)<sup>1)</sup>. Data from the Federal Statistical Office are available in different units (tonnes, square metres, pieces, value) depending on the product. In order to ensure consistent processing of the data, it is necessary to standardize the dimensions in tonnes by using conversion factors. The conversion factors for facing bricks, backing bricks and roof tiles are calculated differently. On information provided by the Bundesverband der Deutschen Ziegelindustrie e. V. this calculation in respect of technical discussions were fundamentally revised. Up to now, for the conversion of the volume data of the official statistics for the whole time series an average value for the gross density from 1994 is used. Now new average values for the bulk density of backing bricks for the year 2016 (BV Ziegel, 2019). The bulk density has increased over time since 1994 has fallen steadily, which is due to the increase in the proportion of well-insulating lightweight bricks. The Values for raw densities for the years between 1994 and 2016 were interpolated linearly. The brick product group has by far the largest share in the ceramic Total production. A review of the methodology for the other sectors of ceramic industry was not necessary.

### Emission factors

Process-related emissions originate in the raw materials for production (normally, locally available loams and clays with varying concentrations of organic impurities and specific raw material mixes). Some EF are documented in detail in a report of a research Project (Stein, Gronewäller, 2010)<sup>2)</sup> taking into account information of industry monitoring. Other EF are based on an expert judgements from UBA due to lack in EMEP/EEA air pollutant emission inventory guidebook.

Table 1: Overview of applied emission factors, in kg/t

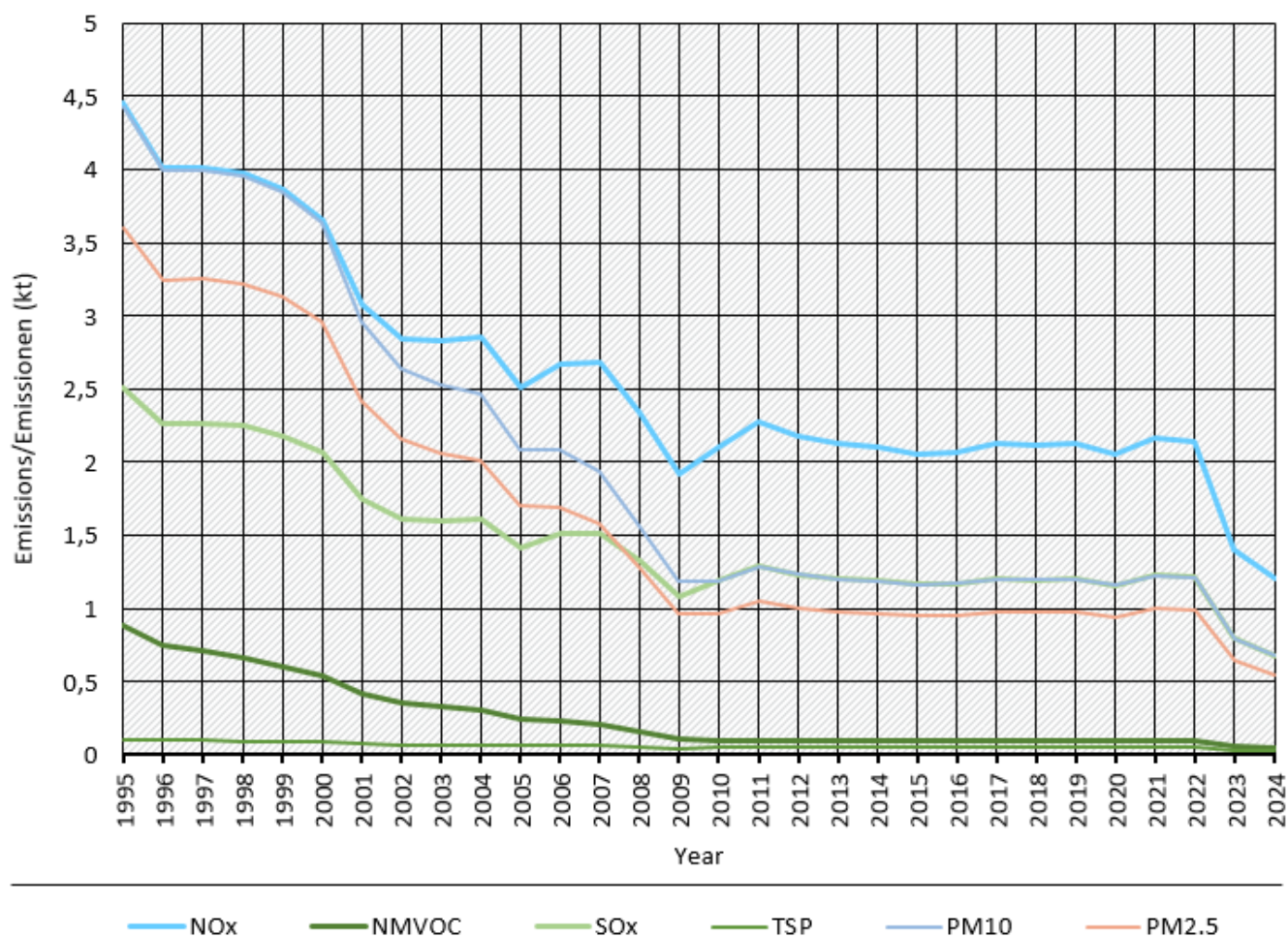
|                         | EF value | EF trend |
|-------------------------|----------|----------|
| <b>NO<sub>x</sub></b>   | 0.177    | constant |
| <b>SO<sub>2</sub></b>   | 0.10     | constant |
| <b>NMVOC</b>            | 0.008    | falling  |
| <b>NH<sub>3</sub></b>   | 0.004    | constant |
| <b>TSP</b>              | 0.10     | falling  |
| <b>PM<sub>10</sub></b>  | 0.08     | falling  |
| <b>PM<sub>2.5</sub></b> | 0.05     | falling  |

### Trends of emissions

Advice for NFR-tables: The steep reduction for TSP and SO<sub>2</sub> from 1990 to 1991 is not result of ceramic Industry: The source for emissions data of year 1990 for eastern Germany is in cases of TSP and SO<sub>2</sub> the last statistic of the GDR for Mineral products and allocated at 2A6-level.

## Trends of Emissions in Germany from ceramics production

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1995, (03/2026)

### Emission trends in NFR 2.A.6

note: trends of emissions follow the deep production decrease of this industry

## Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> J. Gottwald et al., 2017: Prüfung der Vollständigkeit der Berichterstattungskategorie 'Keramische Erzeugnisse'

insbesondere feinkeramische Erzeugnisse, Dessau-Roßlau, 2017;

[https://www.umweltbundesamt.de/sites/default/files/medien/1968/publikationen/2017-01-19\\_dokumentationen\\_01-2017\\_emissionsrelevanz-feinkeramikbranche.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/1968/publikationen/2017-01-19_dokumentationen_01-2017_emissionsrelevanz-feinkeramikbranche.pdf)

<sup>2)</sup> Stein, Gronewäller, 2010: Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV aus dem Jahre 2004 für die Verwendung bei der UNFCCC- und UNECE-Berichterstattung

<https://www.umweltbundesamt.de/sites/default/files/medien/461/publikationen/3923.pdf>



# 2.B - Chemical Industry (OVERVIEW)

|                                                               |
|---------------------------------------------------------------|
| 2.B Chemical Industry                                         |
| 2.B.1 Ammonia Production                                      |
| 2.B.2 Nitric Acid Production                                  |
| 2.B.3 Adipic Acid Production                                  |
| 2.B.5 Carbide Production                                      |
| 2.B.6 Titanium Dioxide Production                             |
| 2.B.7 Soda Ash Production                                     |
| 2.B.10.a Other chemical industry                              |
| 2.B.10.b Storage, Handling and Transport of Chemical Products |



## 2.B.1 - Ammonia Production

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.B.1                                                                                     | T2                                   | PS | D  |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub>                                                                        | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO  | Heavy Metals | POPs |
|----------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|-----|--------------|------|
| -/-                                                                                    | NA     | NA              | -/-             | NA                | NA               | NA  | NA | -/- | NA           | NA   |
| <b>L/-</b> key source by <b>Level</b> only                                             |        |                 |                 |                   |                  |     |    |     |              |      |
| <b>-/T</b> key source by <b>Trend</b> only                                             |        |                 |                 |                   |                  |     |    |     |              |      |
| <b>L/T</b> key source by both <b>Level</b> and <b>Trend</b>                            |        |                 |                 |                   |                  |     |    |     |              |      |
| -/- no key source for this pollutant                                                   |        |                 |                 |                   |                  |     |    |     |              |      |
| IE emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |        |                 |                 |                   |                  |     |    |     |              |      |
| NE emission of specific pollutant <b>Not Estimated</b> (yet)                           |        |                 |                 |                   |                  |     |    |     |              |      |
| NA specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |        |                 |                 |                   |                  |     |    |     |              |      |
| * no analysis done                                                                     |        |                 |                 |                   |                  |     |    |     |              |      |

Ammonia is synthesised from hydrogen and nitrogen, using the Haber-Bosch process. Hydrogen is produced from synthetic gas – which in turn is produced from natural gas – via a highly integrated process, steam reforming. Nitrogen is produced via air dissociation. The various plant types involved in the production of ammonia cannot be divided into individual units nor be considered as independent process parts, due to the highly integrated character of the procedure. In **steam reforming**, the following process parts are distinguished:

- ACP - Advanced Conventional Process - with a fired primary reformer and secondary reforming with excess air (stoichiometric H/N ratio)
- RPR - Reduced Primary Reformer Process - under mild conditions in a fired primary reformer and secondary splitting with excess air (sub-stoichiometric H/N ratio)

and

- HPR - Heat Exchange Primary Reformer Process – autothermic splitting with heat exchange using a steam reformer heated with process gas (heat exchange reformer) and a separate secondary reformer or a combined autothermic reformer using excess air or enriched air (sub-stoichiometric or stoichiometric H/N ratio).

The following process is also used for ammonia synthesis: **partial oxidation**, which is the gasification of fractions of heavy mineral oil or vacuum residues in the production of synthetic gas. Most plants operate using steam-reforming, with naphtha or natural gas. Only 3% of European plants use partial oxidation.

The production decrease of more than 15% in the first year after German reunification was the result of a market shakeup, over 2/3 of which was borne by the new German Länder. The production level then remained nearly constant in the succeeding years until 1994. The reasons for the re-increase as of 1995 back to the 1990 level are not understood; the re-increase may however be due to a change in statistical survey methods. After 1990, production levels fluctuated only slightly. Since then, the rate of ammonia production has been stable.

## Method

There were five plants in Germany which produced ammonia, using both steam reforming and partial oxidation. Since mid-2014 there are only four left, but both processes are still used.

### Activity data

As ammonia production is a key category regarding the CO<sub>2</sub> emissions, activity data is collected plant-specifically.

The data is compiled based on a co-operation agreement between UBA and the German ammonia producers represented by the industry association Agrar (Industrieverband Agrar - IVA). Before delivery to UBA, the plant specific data is anonymized by the IVA <sup>1)</sup>.

### Emission factor

For NO<sub>x</sub> and NH<sub>3</sub> and CO, default emission factors from the EMEP/EEA Emission Inventory Guidebook 2023 are applied :

Table 1: Default emission factors, in [kg/t NH<sub>3</sub>]

| Pollutant       | EF   |
|-----------------|------|
| NO <sub>x</sub> | 1    |
| CO              | 0.1  |
| NH <sub>3</sub> | 0.01 |

from (EMEP/EEA, 2023) <sup>2)</sup>

The CO emission factor has been included with submission 2022.

## Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

## Planned improvements



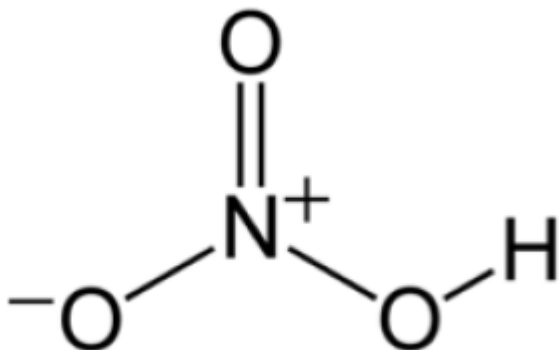
At the moment, no category-specific improvements are planned.

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<sup>1)</sup> IVA (2024): Industrierverband Agrar - IVA, <https://www.iva.de/verband>, Frankfurt am Main

<sup>2)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 2.B Chemical industry 2023, Oct 2023: page 15, Table 3.2: Tier 1 emission factors for source category 2.B.1 Ammonia production:  
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-b-chemical-industry/2-b-chemical-industry-2023/@download/file>: Copenhagen, 2023

### Short description



| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.B.2                                                                                     | T2                                   | PS | D  |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

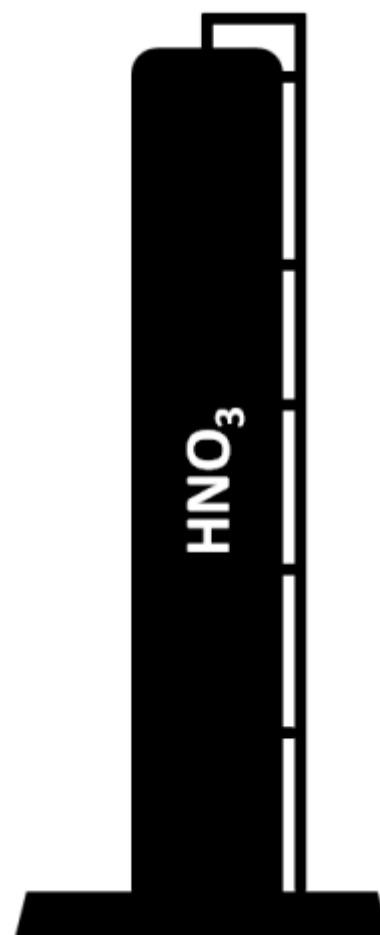
[illegible]

|            |                                                                                              |
|------------|----------------------------------------------------------------------------------------------|
| <b>L/-</b> | key source by <b>L</b> evel only                                                             |
| <b>-/T</b> | key source by <b>T</b> rend only                                                             |
| <b>L/T</b> | key source by both <b>L</b> evel and <b>T</b> rend                                           |
| <b>-/-</b> | no key source for this pollutant                                                             |
| <b>IE</b>  | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |
| <b>NE</b>  | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |
| <b>NA</b>  | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |
| <b>*</b>   | no analysis done                                                                             |

During the production of nitric acid (HNO<sub>3</sub>), nitrogen oxide is produced unintentionally in a secondary reaction during the catalytic oxidation of ammonia (NH<sub>3</sub>). HNO<sub>3</sub> production occurs in two process stages:

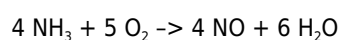
- Oxidation of NH<sub>3</sub> to NO and
- Conversion of NO to NO<sub>2</sub> and absorption in H<sub>2</sub>O.

Details of the process are outlined below:

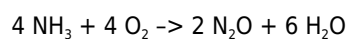
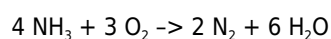


### Catalytic oxidation of ammonia

A mixture of ammonia and air at a ratio of 1:9 is oxidised, in the presence of a platinum catalyst alloyed with rhodium and/or palladium, at a temperature of between 800 and 950 °C. The reaction according to the Oswald process is as follows:



Simultaneously, nitrogen, nitrous oxide and water are formed by the following undesired secondary reactions:



All three oxidation reactions are exothermic. Heat may be recovered to produce steam for the process and for export to

other plants and/or to preheat the residual gas. The reaction water is condensed in a cooling condenser, during the cooling of the reaction gases, and is then conveyed into the absorption column.

## Method

### Activity data

In Germany, there are currently nine nitric acid plants.

As this source category is key category for N<sub>2</sub>O emissions, plant specific activity data is collected here according to the IPCC guidelines.

This data is made available basically via a co-operation agreement with the nitric acid producers and the IVA (Industrieverband Agrar). As the data provided by the producers has to be treated as confidential, it is anonymised by the IVA before submitting it to the UBA, with one producer as exception who is delivering its data directly to the UBA. After checking this specific data, it is merged with that provided by the IVA.

According to the IVA, catalytic reduction is used as an abatement method in some of the plants.

### Emission factors

Different tier 2 default NO<sub>x</sub> emission factors based on different technology types and abatement systems are used from the EEA Emission Inventory Guidebook 2023 (EF for medium and high pressure processes and for catalytic reduction of low, medium and high pressure process)<sup>1)</sup>. The applied emissions factors are listed in **Table 1**.

Table 1: Tier 2 emission factors for source category 2.B.2 Nitric acid production, in [kg/t]

| EF  | Process                                                      |
|-----|--------------------------------------------------------------|
| 7.5 | medium pressure process                                      |
| 3   | high pressure process                                        |
| 0.4 | catalytic reduction of low, medium and high pressure process |

## Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Part B: sectoral guidance chapters, 2.B Chemical industry: pp.21-23, Table 3.11, Table 3.12 and Table 3.14., Copenhagen, 2023



|            |                                                                                              |
|------------|----------------------------------------------------------------------------------------------|
| <b>L/-</b> | key source by <b>L</b> evel only                                                             |
| <b>-/T</b> | key source by <b>T</b> rend only                                                             |
| <b>L/T</b> | key source by both <b>L</b> evel and <b>T</b> rend                                           |
| <b>-/-</b> | no key source for this pollutant                                                             |
| <b>IE</b>  | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |
| <b>NE</b>  | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |
| <b>NA</b>  | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |
| <b>*</b>   | no analysis done                                                                             |

## Method

As this source category is a key category for N<sub>2</sub>O emissions, plant specific activity data is collected according to the IPCC guidelines that is obtained basically via a co-operation agreement with the adipic acid producers.

A single data collection of plant specific NO<sub>x</sub> and CO emissions and related emission factors for one year (2016) was sufficient as the emissions are below the threshold of significance. The derived emission factors are applied to the entire time series and for every plant.

### Activity Data

Due to confidentiality concerns, this data is not published (see short description).

### Emission factors

Due to confidentiality concerns, this data is not published (see short description).

## Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.



## 2.B.5 - Carbide Production

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.B.5                                                                                     | T3                                   | PS | PS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub>                                                                                 | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|-------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA                                                                                              | NA     | NA              | NA              | -/-               | -/-              | -/- | NA | NA | NA           | NA   |
| <b>L/-</b> key source by <b>L</b> evel only                                                     |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>T</b> rend only                                                     |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend                                   |        |                 |                 |                   |                  |     |    |    |              |      |
| -/- no key source for this pollutant                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| IE emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |        |                 |                 |                   |                  |     |    |    |              |      |
| NE emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |        |                 |                 |                   |                  |     |    |    |              |      |
| NA specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |        |                 |                 |                   |                  |     |    |    |              |      |
| * no analysis done                                                                              |        |                 |                 |                   |                  |     |    |    |              |      |

During the German Reunification period, **calcium carbide** production took place mainly in the new German federal states (Neue Bundesländer), where production stopped shortly thereafter and there is only one producer left in the old German federal states. In the period under consideration, this producer cut its production by about 50 percent.

According to the responsible specialised association within the VCI, **no more silicon carbide** has been produced in Germany since 1993. Emissions from this process thus no longer occur.

### Method

## Activity data

Since Germany has only one producer, the relevant data must be kept confidential.

Only the data which consists of the amount of production in the former GDR was published, until 1989, by the country's central statistical authority. In combination with existing estimates for 1991 and 1992, those figures were used to interpolate production in the new German Länder in 1990.

## Emission factors

In covered furnaces, producers collect all the carbon monoxide produced from the process and recycle it for further use. Following such use as energy recovery – i.e., following its combustion to produce carbon dioxide – it serves as an auxiliary substance for production of lime nitrogen and secondary products. Reactions in these processes yield carbon dioxide in a mineral form, as black chalk. In this form, it is used in agriculture. Upon request, the relevant producer provides the UBA with the production data.

The emission factor for TSP is provided by the producer and is also confidential.

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.



### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.B.6                                                                                     | T3                                   | C  | C  |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| <b>NO<sub>x</sub></b> | NM VOC                                                                              | <b>SO<sub>2</sub></b> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | <b>TSP</b> | BC | <b>CO</b> | Heavy Metals | POPs |
|-----------------------|-------------------------------------------------------------------------------------|-----------------------|-----------------|-------------------|------------------|------------|----|-----------|--------------|------|
| -/-                   | NA                                                                                  | -/-                   | NA              | NA                | NA               | -/-        | NA | -/-       | NA           | NA   |
| L/-                   | key source by <b>Level</b> only                                                     |                       |                 |                   |                  |            |    |           |              |      |
| -/T                   | key source by <b>Trend</b> only                                                     |                       |                 |                   |                  |            |    |           |              |      |
| L/T                   | key source by both <b>Level</b> and <b>Trend</b>                                    |                       |                 |                   |                  |            |    |           |              |      |
| -/-                   | no key source for this pollutant                                                    |                       |                 |                   |                  |            |    |           |              |      |
| IE                    | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |                       |                 |                   |                  |            |    |           |              |      |
| NE                    | emission of specific pollutant <b>Not Estimated</b> (yet)                           |                       |                 |                   |                  |            |    |           |              |      |
| NA                    | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |                       |                 |                   |                  |            |    |           |              |      |
| *                     | no analysis done                                                                    |                       |                 |                   |                  |            |    |           |              |      |

## Method

### Activity Data

There are two kinds of processes for the production of titanium dioxide: chloride process and sulfate process. The total production amount of these two processes is attained from the German Federal Statistical Office<sup>1)</sup>.

For the calculation of individual production from each process, the fraction of chloride process is determined based on the estimated total production capacity in Germany (480 kt/y) and the production capacity via chloride process (165 kt/y)<sup>2)3)</sup>.

### Emission Factors

Emission factors for titanium dioxide production are the tier 2 emission factors from EMEP/EEA Guidebook 2023<sup>4)</sup>: NO<sub>x</sub>, CO, and TSP are provided for the chloride process, while for the sulfate process only factors for NO<sub>x</sub> and TSP are available.

The applied tier 2 emission factors derived from the EMEP/EEA Guidebook 2023 are listed in Table 1.

Table 1: Tier 2 emission factors for source category 2.B.6 Titanium dioxide production, in [kg/t]

| Pollutant       | Name of process | Emission factor |
|-----------------|-----------------|-----------------|
| CO              | Chloride        | 159             |
| NO <sub>x</sub> |                 | 0.1             |
| TSP             |                 | 0.2             |
| NO <sub>x</sub> | Sulfate         | 0.108           |
| TSP             |                 | 0.3             |

### Emissions

The Titanium Dioxide Manufacturers Association (TDMA) reports the sum of SO<sub>2</sub> emissions from both processes directly to the UBA.

Since submission 2022, these emissions are no longer confidential and were therefore re-allocated from 2.B.10. Besides, CO, NO<sub>x</sub> and TSP emissions are reported since submission 2022.

Except for SO<sub>2</sub>, emissions of the other mentioned pollutants are calculated through the multiplication of activity data and corresponding emission factors.

As all emission factors are constant over time, the emission trend is influenced only by the fluctuations of the production.

## Recalculations

For SO<sub>2</sub> emissions from the production of **titanium dioxide** and **sulphuric acid**, estimates reported for the *second to last year* of the time series are routinely actualised by the producers. Furthermore, final emissions for the *last year of the time series* are not yet available at the time the inventory is compiled. Therefore, the values reported here represent a prediction and are updated with each new submission as well.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

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<sup>1)</sup> Destatis (2024): Federal Statistical Office (Statistisches Bundesamt, Destatis): Production statistics: Until 1994 GP89 - 4612 50, 1995 until 2008 GP241211500 and GP201211500 from 2009 onwards; Wiesbaden, 2024

<sup>2)</sup> <https://forum-titandioxid.de/2020/03/12/sachlage-zu-titandioxid-und-titandioxidhaltigen-farben-und-lacken/>

<sup>3)</sup> <https://www.kronosww.com/products/about-tio2/>

<sup>4)</sup> EMEP/EEA (2023): European Environment Agency: EMEP/EEA air pollutant emission inventory guidebook 2023, Part B: sectoral guidance chapters, 2.B Chemical industry (Oct 2023): pp.25-26, table 3.19 and table 3.20, Copenhagen, 2023

## 2.B.7 - Soda Ash Production

### Short description

| Category Code                                                                             | Method                               | AD    | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|----|
| 2.B.7                                                                                     | T1                                   | NS/PS | C  |
| <b>Method(s) applied</b>                                                                  |                                      |       |    |
| <b>D</b>                                                                                  | Default                              |       |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |       |    |
| <b>T2</b>                                                                                 | Tier 2*                              |       |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |       |    |
| <b>C</b>                                                                                  | CORINAIR                             |       |    |
| <b>CS</b>                                                                                 | Country Specific                     |       |    |
| <b>M</b>                                                                                  | Model                                |       |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |    |
| <b>(source for) Activity Data</b>                                                         |                                      |       |    |
| <b>NS</b>                                                                                 | National Statistics                  |       |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |       |    |
| <b>IS</b>                                                                                 | International Statistics             |       |    |
| <b>PS</b>                                                                                 | Plant Specific                       |       |    |
| <b>As</b>                                                                                 | Associations, business organisations |       |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |       |    |
| <b>M</b>                                                                                  | Model / Modelled                     |       |    |
| <b>C</b>                                                                                  | Confidential                         |       |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |       |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |       |    |
| <b>CS</b>                                                                                 | Country Specific                     |       |    |
| <b>PS</b>                                                                                 | Plant Specific                       |       |    |
| <b>M</b>                                                                                  | Model / Modelled                     |       |    |
| <b>C</b>                                                                                  | Confidential                         |       |    |

| NO <sub>x</sub>                                                                                 | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|-------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA                                                                                              | NA     | NA              | -/-             | NE                | NE               | -/- | NE | NA | NA           | NA   |
| <b>L/-</b> key source by <b>L</b> evel only                                                     |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>T</b> rend only                                                     |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend                                   |        |                 |                 |                   |                  |     |    |    |              |      |
| -/- no key source for this pollutant                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| IE emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |        |                 |                 |                   |                  |     |    |    |              |      |
| NE emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |        |                 |                 |                   |                  |     |    |    |              |      |
| NA specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |        |                 |                 |                   |                  |     |    |    |              |      |
| * no analysis done                                                                              |        |                 |                 |                   |                  |     |    |    |              |      |

In Germany, soda ash is produced in three facilities, all of which use the Solvay process. The production data is thus confidential.

### Method

#### Activity data

The total amounts of soda ash produced in Germany are determined with the help of two data suppliers. The Federal Statistical Office has long time series for this area. Due to the presence of a nearly inexplicable trend in the data of the Federal Statistical Office for the period since 2015, the relevant producers were contacted, and in 2021 cooperation

agreements were signed with both producers (for all three production sites). The German Environment Agency (UBA), which consolidates the relevant data, has decided that as of 2013 the pertinent time series is to be filled with the producers’ data (this overlaps with a comparison carried out for the period 2013 through 2021).

Since Germany has only two producers, the production-quantity data from the two sources must be kept confidential.

Emission factor

Emission factors (for TSP and NH<sub>3</sub>) are confidential due to restrictions on activity data.

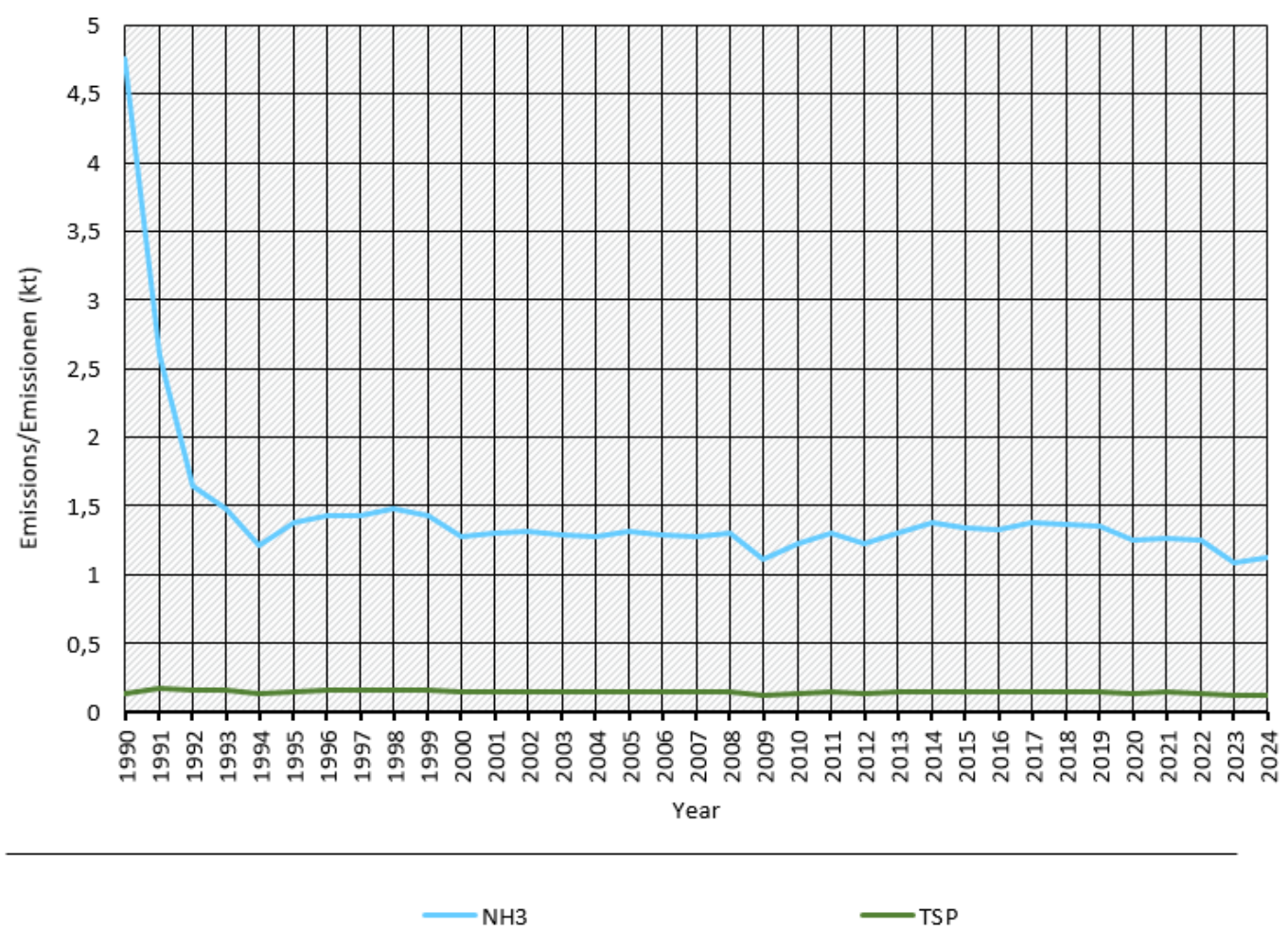
Discussion of emission trends

The steep reduction—especially for NH<sub>3</sub>—at the beginning of the 1990s was due to closures in the eastern German industrial sector. For the year 1990 in the case of TSP for eastern Germany, a summary figure is reported for the Chemical Industry as a whole. However, after 1992, emissions of NH<sub>3</sub> occur at a lower level.

All trends in emissions correspond to trends of emission factors. No rising trends are to identify.

Trends of Emissions of Soda Ash Production

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

Emission trends in NFR 2.B.7

## Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.



| NO <sub>x</sub> | NMVOc | SO <sub>2</sub>                                                                                 | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC  | CO  | Pb | Cd | Hg  | As | Cr | Cu | Ni | Se | Zn | PCDD/F | PAH | HCB | PCBs |
|-----------------|-------|-------------------------------------------------------------------------------------------------|-----------------|-------------------|------------------|-----|-----|-----|----|----|-----|----|----|----|----|----|----|--------|-----|-----|------|
| NA              | -/-   | L/-                                                                                             | -/-             | -/-               | -/-              | -/- | -/- | -/- | NA | NA | -/- | NA | NA | NA | NA | NA | NA | -/-    | NA  | NA  | NA   |
|                 |       | L/- key source by <b>L</b> evel only                                                            |                 |                   |                  |     |     |     |    |    |     |    |    |    |    |    |    |        |     |     |      |
|                 |       | -/T key source by <b>T</b> rend only                                                            |                 |                   |                  |     |     |     |    |    |     |    |    |    |    |    |    |        |     |     |      |
|                 |       | L/T key source by both <b>L</b> evel and <b>T</b> rend                                          |                 |                   |                  |     |     |     |    |    |     |    |    |    |    |    |    |        |     |     |      |
|                 |       | -/- no key source for this pollutant                                                            |                 |                   |                  |     |     |     |    |    |     |    |    |    |    |    |    |        |     |     |      |
|                 |       | IE emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                 |                   |                  |     |     |     |    |    |     |    |    |    |    |    |    |        |     |     |      |
|                 |       | NE emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                 |                   |                  |     |     |     |    |    |     |    |    |    |    |    |    |        |     |     |      |
|                 |       | NA specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                 |                   |                  |     |     |     |    |    |     |    |    |    |    |    |    |        |     |     |      |
|                 |       | * no analysis done                                                                              |                 |                   |                  |     |     |     |    |    |     |    |    |    |    |    |    |        |     |     |      |

## Method

### Large volume organic chemicals

The annual production volumes for all large volume organic chemicals are extracted from national production statistics by the Federal Statistical Office <sup>1)</sup>.

These chemicals comprise:

- Acrylonitrile
- Ethylene
- Ethylbenzene
- Ethylene Dichloride
- Ethylene Oxide
- Formaldehyde (Methanal)
- Methanol
- Phthalic Anhydride
- Propene
- Styrene
- Vinyl Chloride
- Polyethylene (LD/HD)
- Polypropylene
- Polystyrene
- Polyvinyl Chloride
- Styrene Copolymers

The emission factors for the production of organic chemicals as shown in Tables 2 and 3 are derived from best reference documents for polymers and LVOC mostly for the early years. For later years, plant-specific data on an aggregated level were used.

Table 2: National NMVOC emission factors for the production of organic chemicals, in kg/t

|                  | Acrylonitrile | Ethylbenzene | Ethylene | Ethylene Dichloride | Ethylene Oxide | Formaldehyde (Methanal) | Methanol | Phthalic Anhydride | Propene | Styrene | Vinyl Chloride |
|------------------|---------------|--------------|----------|---------------------|----------------|-------------------------|----------|--------------------|---------|---------|----------------|
| <b>1990-1994</b> | 5             | 0.6          | 5        | C                   | 5              | 5                       | 0.04     | 5                  | 2.5     | 0.02    | 0.2            |
| <b>1995</b>      | 0.07          | 0.02         | 0.4      | C                   | 0.06           | 0.02                    | 0.04     | 0.2                | 0.2     | 0.02    | 0.2            |
| <b>1996</b>      | 0.05          | 0.015        | 0.3      | C                   | 0.045          | 0.015                   | 0.04     | 0.15               | 0.15    | 0.02    | 0.15           |
| <b>1997</b>      | 0.05          | 0.015        | 0.3      | C                   | 0.045          | 0.015                   | 0.04     | 0.15               | 0.15    | 0.02    | 0.15           |
| <b>1998</b>      | 0.04          | 0.012        | 0.25     | C                   | 0.04           | 0.012                   | 0.04     | 0.12               | 0.12    | 0.02    | 0.12           |
| <b>1999</b>      | 0.04          | 0.012        | 0.25     | C                   | 0.04           | 0.012                   | 0.04     | 0.12               | 0.12    | 0.02    | 0.12           |
| <b>from 2000</b> | 0.035         | 0.01         | 0.2      | C                   | 0.03           | 0.01                    | 0.04     | 0.1                | 0.1     | 0.02    | 0.1            |

Table 3: National NMVOC emission factors for the production of polymers, in kg/t

|                  | Polyethylene (PE) |                   | Polypropylene (PP) | Polystyrene (PS) | Polyvinyl Chloride (PVC) | Styrene Copolymers |
|------------------|-------------------|-------------------|--------------------|------------------|--------------------------|--------------------|
|                  | Low density (LD)  | High density (HD) |                    |                  |                          |                    |
| <b>1990-1994</b> | 8                 | 6                 | 8                  | 1                | 0.25                     | 5                  |
| <b>1995</b>      | 2.2               | 1                 | 1                  | 0.6              | 0.25                     | 0.6                |
| <b>1996</b>      | 1.6               | 0.75              | 0.75               | 0.4              | 0.25                     | 0.5                |
| <b>1997</b>      | 1.6               | 0.75              | 0.75               | 0.4              | 0.25                     | 0.5                |
| <b>1998</b>      | 1.3               | 0.6               | 0.6                | 0.32             | 0.25                     | 0.4                |
| <b>1999</b>      | 1.3               | 0.6               | 0.6                | 0.32             | 0.25                     | 0.4                |
| <b>from 2000</b> | 1.1               | 0.5               | 0.5                | 0.27             | 0.14                     | 0.3                |

### Carbon Black

The figures for carbon black production in the new German Länder in 1990 were taken from the Statistical Yearbook (Statistisches Jahrbuch) for the Federal Republic of Germany; the production for 1991 and 1992 were estimated, due to confidentiality requirements. The other data for carbon-black production as of 1990 were obtained from national production

statistics.

From 2005 onwards, Germany uses activity data, which is calculated from the CO<sub>2</sub> emissions of the Emission Trading System (ETS), delivered by the German emission trading authority (DEHSt), and the default CO<sub>2</sub> emission factor from the IPCC Guidelines 2006 for carbon black production. A comparison of the statistical data and the emission trading data leads to the conclusion that the statistical data is most probably overestimated.

Table 4: Emission factors of carbon black in Germany, in kg/t

|           | CO   | SO <sub>2</sub> | TSP  | PM <sub>10</sub> | PM <sub>2.5</sub> |
|-----------|------|-----------------|------|------------------|-------------------|
| 1990      | 4.80 | 19.16           | 0.28 |                  |                   |
| 1991      | 4.60 | 19.01           | 0.28 |                  |                   |
| 1992      | 4.40 | 18.50           | 0.27 |                  |                   |
| 1993      | 4.20 | 18.00           | 0.26 |                  |                   |
| 1994      | 4.00 | 17.50           | 0.25 |                  |                   |
| 1995      | 3.75 | 17.00           | 0.25 | 0.23             | 0.12              |
| 1996      | 3.50 | 16.00           | 0.25 | 0.23             | 0.12              |
| 1997      | 3.25 | 15.00           | 0.25 | 0.23             | 0.12              |
| 1998      | 3.00 | 14.00           | 0.25 | 0.23             | 0.12              |
| 1999      | 2.90 | 13.40           | 0.25 | 0.23             | 0.12              |
| 2000      | 2.80 | 12.80           | 0.25 | 0.23             | 0.12              |
| 2001      | 2.70 | 12.54           | 0.25 | 0.23             | 0.12              |
| 2002      | 2.65 | 12.28           | 0.25 | 0.23             | 0.12              |
| 2003      | 2.60 | 12.00           | 0.25 | 0.23             | 0.12              |
| 2004      | 2.55 | 11.70           | 0.25 | 0.23             | 0.12              |
| 2005      | 2.50 | 11.50           | 0.25 | 0.23             | 0.12              |
| 2006      | 2.50 | 11.20           | 0.24 | 0.22             | 0.12              |
| 2007      | 2.50 | 10.90           | 0.23 | 0.21             | 0.11              |
| 2008      | 2.50 | 10.60           | 0.22 | 0.20             | 0.11              |
| 2009      | 2.50 | 10.30           | 0.21 | 0.19             | 0.10              |
| from 2010 | 2.50 | 10.00           | 0.20 | 0.18             | 0.10              |

## Fertilizer production

The activity data is also extracted from national production statistics by the Federal Statistical Office<sup>2)</sup> and consists of mono and multicomponent fertilizers.

The emission factors are country specific values derived from Jörß et al. (2006)<sup>3)</sup> and are presented in the following table.

Table 5: Emission factors of fertilizers in Germany

|           | PM <sub>10</sub> | PM <sub>2.5</sub> | TSP         |
|-----------|------------------|-------------------|-------------|
| 1990      | NA               | NA                | 1.420376946 |
| 1991-1994 | NA               | NA                | 2           |
| from 1995 | 0.115938         | 0.0781395         | 0.1695      |

## Urea production

The activity data is from the federal statistical office of Germany (GP 2015 31 300). The amount of urea is reported there in t-N. As the emission factor is in kg/t urea, the reported amount of urea in t-N is multiplied with the molar mass of urea and divided with the molar mass of nitric (60.06/14).

AR of urea (in t) = AR of urea (in t-N) \* (molar mass of urea) / (molar mass of N)

The emission factor of 2.5 kg/t urea is a tier 2 default value from the EMEP/EEA Guidebook 2023<sup>4)</sup>.

## Sulphuric acid

The activity data for sulphuric acid production is from the Federal Statistical Office of Germany.

A survey for the EF of SO<sub>x</sub> for sulphuric acid production was made in 2019. The producers were directly requested to provide information by the association. Based on the data obtained from producers, new EFs for the years 2017 and 2018 were developed.

All emissions were measured by the producers respectively or limit values are specified in the permit decision for the installation. The derived (implied) EF is weighted by the amount of H<sub>2</sub>SO<sub>4</sub> produced. Therefore, large producers have a greater influence on the (implied) EF.

However, due to significant process optimizations and technology improvements implemented since 1990, the applied country-specific EF is well below the default value.

## Chlor-alkali industry

For the mercury (Hg) losses from the Chlor-alkali industry, Germany used to apply the data annually published by OSPAR<sup>5)</sup> on plant specific production capacity for the AD and plant specific emissions from the chlor-alkali industry.

Because of the BAT (best available technique) conclusion for the Chlor-alkali industry, the production based upon the amalgam process stopped in 2017. Most production sites have switched to membrane technology.

However, Hg emissions are still occurring because two production sites still continue to use the amalgam process for the production of certain alcoholates, which is not regulated by the BAT conclusions for Chlor-alkali production. Before 2018, these Hg-emissions were reported together with the Hg from Chlor-alkali production. But the OSPAR convention does not request the Hg emissions from alcoholate production to be reported, so CEFIC no longer reports these emissions to OSPAR. Therefore, as of 2018, PRTR data has been used to determine mercury emissions from the alcoholate production.

## Recalculations

For SO<sub>2</sub> emissions from sulphuric acid production, and for Hg emissions from chlor-alkali industry, the emissions of the two last years are always actualized. This is because the emissions of the last year are always a prediction, as the final emissions are still not published by the time of reporting.

From Submission 2022 onwards, the SO<sub>2</sub> emissions from titanium dioxide production are no longer confidential and are therefore reallocated back to category 2.B.6. Since then, the SO<sub>2</sub> emissions reported here are only from the sulphuric acid production. Besides, Germany reports the NH<sub>3</sub> and TSP emissions from urea production instead of from nitric fertilizer production based on the Emep/EEA Guidebook method by using statistical data from the federal statistical office.

Otherwise no recalculations of SO<sub>2</sub> from the sulphuric acid production, NH<sub>3</sub> and TSP from urea production are necessary compared to last year's submission.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> DESTATIS, Fachserie 4, Reihe 3.1, Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe ("manufacturing industry; production in the manufacturing industry")

<sup>2)</sup> Federal Statistical Office (Statistisches Bundesamt - Destatis): Fachserie 4, Reihe 3.1, Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe ("manufacturing industry; production in the manufacturing industry"), Wiesbaden, 2024

<sup>3)</sup> Jörß et al. (2007): Jörß, W.; Handke, V. (Institut für Zukunftsstudien und Technologiebewertung (IZT), Berlin) mit Beiträgen von Lambrecht, U., Dünnebeil, Fr. (Institut für Energie und Umweltforschung Heidelberg (ifeu)): Emissionen und Maßnahmenanalyse Feinstaub 2000–2020. Annex A, chapter A.2.4.8, UBA-TEXTE Nr. 38/200;

<https://www.umweltbundesamt.de/publikationen/emissionen-massnahmenanalyse-feinstaub-2000-2020>; on behalf of the Umweltbundesamt; Dessau-Roßlau, 2007.

<sup>4)</sup> EMEP/EEA (2023): European Environment Agency: EMEP/EEA air pollutant emission inventory guidebook 2023, Part B: sectoral guidance chapters, 2.B Chemical industry (Oct 2023): chapter 3.3.2, pp.32, table 3-29, Copenhagen, 2019

<sup>5)</sup> ODIMS (OSPAR Data & Information Management System); [https://odims.ospar.org/en/search/?dataset=chlor\\_alkali\\_data](https://odims.ospar.org/en/search/?dataset=chlor_alkali_data)

## 2.B.10.b - Storage, Handling and Transport of Chemical Products

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.B.10.b                                                                                  | T2                                   | NS | CS |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub>                                                                                      | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|--------------------------------------------------------------------------------------------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|------|
| NA              | -/-    | NA              | NA              | IE                                                                                                     | IE               | IE  | NE | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA     | NA    | NA    | NA    | NA    | NA     | NA  | NA   |
|                 |        |                 |                 | <b>L/-</b> key source by <b>L</b> evel only                                                            |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | <b>-/T</b> key source by <b>T</b> rend only                                                            |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | <b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend                                          |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | <b>-/-</b> no key source for this pollutant                                                            |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | <b>IE</b> emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | <b>NE</b> emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | <b>NA</b> specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |
|                 |        |                 |                 | * no analysis done                                                                                     |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |      |

### Short description

Emissions from storage cover all refinery products. According to the EMEP guidebook, fuel-related emissions are reported under 1.B.2. (see Chapter 3., 1.B.2.a Oil ). Emissions from other mineral oil products that are not used as fuel (like naphtha, methanol etc.) are reported separately here. Based on the research project result, this category also includes the cleaning of storage tanks for crude oil and petroleum product and transport container tanks.

### Method

A distinction of mineral oil products is only made between fuels and naphtha. The evaluation of several research projects has led to new findings. The calculation methods and emission factors are published in a separate publication <sup>1)</sup>.

## Activity data

The annual production of naphtha through the time series is listed in **Table 1** below.

Table 1: Annual naphtha production, in [kt]

|             |          |
|-------------|----------|
| <b>1990</b> | 11546.09 |
| <b>1991</b> | 12566.84 |
| <b>1992</b> | 12705.24 |
| <b>1993</b> | 12986.79 |
| <b>1994</b> | 13393.21 |
| <b>1995</b> | 13369.77 |
| <b>1996</b> | 13430.44 |
| <b>1997</b> | 15070.53 |
| <b>1998</b> | 15959.62 |
| <b>1999</b> | 15810.00 |
| <b>2000</b> | 16091.47 |
| <b>2001</b> | 16736.24 |
| <b>2002</b> | 16660.01 |
| <b>2003</b> | 16981.74 |
| <b>2004</b> | 17895.30 |
| <b>2005</b> | 18024.31 |
| <b>2006</b> | 17016.65 |
| <b>2007</b> | 16708.99 |
| <b>2008</b> | 15744.92 |
| <b>2009</b> | 15236.77 |
| <b>2010</b> | 16610.69 |
| <b>2011</b> | 15708.84 |
| <b>2012</b> | 15770.00 |
| <b>2013</b> | 16213.82 |
| <b>2014</b> | 17065.99 |
| <b>2015</b> | 16331.02 |
| <b>2016</b> | 15797.92 |
| <b>2017</b> | 15605.03 |
| <b>2018</b> | 11439.19 |
| <b>2019</b> | 11263.72 |
| <b>2020</b> | 11804.49 |
| <b>2021</b> | 13686.27 |
| <b>2022</b> | 12669.02 |
| <b>2023</b> | 10580.86 |
| <b>2024</b> | 12237.64 |

## Emission factors

The emission factors are published in a separate publication (Böttcher, 2025)<sup>2)</sup>.

## Recalculations

Based on the results of the above mentioned research project, recalculations were performed, which are shown in the following publication (Böttcher, 2025)<sup>3)</sup>.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

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<sup>1), 2), 3)</sup> Böttcher (2025): Aktualisierung der VOC-Emissionen für die Bereitstellung von Mineralölprodukten, Dessau-Roßlau, 2025



## 2.C - Metal Industry (OVERVIEW)

The Metal industry comprises the following categories and sub-categories:

|                                                                           |
|---------------------------------------------------------------------------|
| <b>2.C Metal Industry</b>                                                 |
| <a href="#">2.C.1 Iron and Steel Production</a>                           |
| <a href="#">2.C.2 Ferroalloys Production</a>                              |
| <a href="#">2.C.3 Aluminium Production</a>                                |
| <a href="#">2.C.4 Magnesium Production</a>                                |
| <a href="#">2.C.5 Lead Production</a>                                     |
| <a href="#">2.C.6 Zinc Production</a>                                     |
| <a href="#">2.C.7.a Copper Production</a>                                 |
| <a href="#">2.C.7.b Nickel Production</a>                                 |
| <a href="#">2.C.7.c Other Metal Production</a>                            |
| <a href="#">2.C.7.d Storage, Handling and Transport of Metal Products</a> |

Within NFR sub-category **2.C.1 - Iron and Steel production**, Germany covers emisisions from the production of sinter, pig-iron production, oxygen and electric steel, hot and cold rolling and iron and steel castings.

The sub-categories **NFR 2.C.2 - Production of Ferroalloys**, **2.C.5 - Lead production**, **2.C.6 - Zinc production** and **2.C.7.a - Copper production** are listed directly as such in the CSE.

**NFR 2.C.3 - Aluminium production** covers both primary and remelted (=secondary) aluminium.

Sub-category **NFR 2.C.7.c - Other metal production** also includes thermal galvanisation.

## 2.C.1 - Iron & Steel Production

### Short description

The source subcategory *NFR 2.C.1 - Iron & Steel Production* comprises process-related emissions from oxygen steel and electric steel production.

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.C.1                                                                                     | T2                                   | NS | CS |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                       | TSP | BC | CO  | Pb  | Cd  | Hg  | As | Cr  | Cu | Ni  | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCBs |  |  |
|-----------------|--------|-----------------|-----------------|-------------------|----------------------------------------------------------------------------------------|-----|----|-----|-----|-----|-----|----|-----|----|-----|----|----|--------|-------|-------|-------|-------|--------|-----|------|--|--|
| L/-             | -/-    | L/-             | -/-             | L/T               | L/T                                                                                    | L/- | NE | L/- | L/T | L/T | L/T | NE | L/T | NE | -/- | NE | NE | L/T    | NE    | NE    | NE    | NE    | L/T    | L/- | L/T  |  |  |
|                 |        |                 |                 |                   | L/- key source by <b>Level</b> only                                                    |     |    |     |     |     |     |    |     |    |     |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 |                   | -/T key source by <b>Trend</b> only                                                    |     |    |     |     |     |     |    |     |    |     |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 |                   | L/T key source by both <b>Level</b> and <b>Trend</b>                                   |     |    |     |     |     |     |    |     |    |     |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 |                   | -/- no key source for this pollutant                                                   |     |    |     |     |     |     |    |     |    |     |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 |                   | IE emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |    |     |     |     |     |    |     |    |     |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 |                   | NE emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |    |     |     |     |     |    |     |    |     |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 |                   | NA specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |    |     |     |     |     |    |     |    |     |    |    |        |       |       |       |       |        |     |      |  |  |
|                 |        |                 |                 |                   | * no analysis done                                                                     |     |    |     |     |     |     |    |     |    |     |    |    |        |       |       |       |       |        |     |      |  |  |

In 2024, a total of 26.5 million tonnes of raw steel were produced in six integrated steelworks. Electrical steel production amounted to another 10.8 million tonnes.

Other structural elements are sinter production, hot iron production, hot rolling, iron and steel foundries (including malleable casting). The last Siemens-Martin steelworks (Stahlwerk Brandenburg) was shut down shortly after 1990. The last Thomas steelworks (Maxhütte Sulzbach-Rosenberg) discontinued its production in 2002. Due to their minor relevance and their phase-out, the emissions from Siemens-Martin and Thomas steel production are jointly calculated with the emissions from oxygen steel production.

Energy-related emissions from steel production for the years 1990 to 1994 (for individual pollutants until 1999) are reported

under 1.A Fuel combustions in the respective subcategory [1.A.2.a](#). A detailed explanation for the individual pollutants is also found there.



## Method

### Activity data

Activity data is collected from plant operators by national institutions. Since the discontinuation of the special public statistics for iron and steel production (FS. 4, R. 8.1), the information is collected by the German steel trade association Wirtschaftsvereinigung Stahl (WV Stahl) based on a formal agreement.

In the iron and steel industry, only minor amounts of secondary fuels are used for pig iron production in individual blast furnaces. They are used as substitute reducing agents of coke and coal. To date, these materials have not yet been included in the national statistics nor in the Energy Balance. For this reason, the data used is also provided by WV Stahl.

### Emission factors

The emission factors used to calculate emissions are based on emission data from individual plants. The emission factors for 1995 to 2001 were determined by the German Environment Agency (UBA for its initials in German) itself and those for 2008 and later through a research project. (Hensman et al., 2011)<sup>1)</sup>

As the EF for the years 1995 to 2001 as well as for 2008 are based on real stack emission data. Since both combustion and process-related emissions are released through the same stacks, emission factors could not be calculated individually for combustion or process-related emissions. Hence, wherever plant-based EF were available, as it the case for most pollutants for the years 1995 and later, all emissions are reported under 2.C.1.

Please note that the reported emissions also cover diffuse emissions from sources that are not covered in the EMEP/EEA Guidebook. For many pollutants and sources, individual EFs for channelled as well as diffuse emissions have been determined. While there is sufficient knowledge and measurement data of channelled emissions, the emission data concerning diffuse sources is usually based on estimations using parameters adapted to the local conditions of the individual emission source. Therefore, emission data for one source of diffuse emissions is not significant for the diffuse emissions from other plants. The emission factors given below were calculated as the weighted average of the pollution loads reported by the plant operators for individual diffuse sources, in relation to their corresponding production amounts.

Table 1: Overview of the emission factors applied for sinter production

|                         | Type of source | EF 1990         | EF 1995  | EF 2000  | EF 2005 | EF 2010 | Unit |
|-------------------------|----------------|-----------------|----------|----------|---------|---------|------|
| <b>Cd</b>               |                | 0.098           |          |          | 0.052   | 0.017   | g/t  |
| <b>CO</b>               |                | 19.152          | 17.325   | 15.497   | 14.4    |         | kg/t |
| <b>Cr</b>               |                | 0.077           |          |          | 0.044   | 0.02    | g/t  |
| <b>HCB</b>              |                | 0.03            |          |          |         |         | mg/t |
| <b>Hg</b>               |                | 0.059           |          |          | 0.028   | 0.005   | g/t  |
| <b>Ni</b>               |                | 0.139           |          |          | 0.068   | 0.015   | g/t  |
| <b>NM VOC</b>           |                | 0.12            |          |          |         |         | kg/t |
| <b>NO<sub>x</sub></b>   |                | IE <sup>1</sup> |          | 0.558    | 0.46    | 0.401   | kg/t |
| <b>PAH</b>              | channelled     | 320.00          | 248.571  | 177.143  | 120     |         | mg/t |
| <b>Pb</b>               |                | 5.299           |          |          | 3.242   | 1.7     | g/t  |
| <b>PCB</b>              |                | 3.0             | 2.285714 | 1.571429 | 1       |         | mg/t |
| <b>PCDD/F</b>           |                | 6.0             | 4.575    | 3.149    | 1.724   | 0.796   | µg/t |
| <b>SO<sub>2</sub></b>   |                | IE <sup>1</sup> |          | 1.08     | 0.837   | 0.691   | kg/t |
| <b>TSP</b>              | channelled     |                 | 0.65     | 0.465    | 0.234   | 0.096   | kg/t |
| <b>TSP</b>              | diffuse        |                 |          |          |         | 0.046   | kg/t |
| <b>PM<sub>10</sub></b>  | channelled     |                 | 0.445    | 0.336    | 0.177   | 0.07    | kg/t |
| <b>PM<sub>10</sub></b>  | diffuse        |                 |          |          |         | 0.016   | kg/t |
| <b>PM<sub>2.5</sub></b> | channelled     |                 | 0.214    | 0.206    | 0.13    | 0.056   | kg/t |

<sup>1</sup> emissions reported under NRF 1.A.2.a

Table 2: Overview of the emission factors applied for pig iron production

|                       | Type of source | EF 1995          | EF 2000  | EF 2005  | EF 2010 | Unit |
|-----------------------|----------------|------------------|----------|----------|---------|------|
| <b>PAH</b>            | channelled     | 0.5 <sup>1</sup> |          |          |         | mg/t |
| <b>Cd</b>             | channelled     | 4.0              |          |          |         | mg/t |
| <b>Cd</b>             | diffuse        | 0.203            |          |          |         | mg/t |
| <b>CO</b>             | channelled     | 1.18             | 0.915    | 0.65     | 0.491   | kg/t |
| <b>CO</b>             | diffuse        | 0.398            |          |          |         | kg/t |
| <b>Cr</b>             | channelled     | 0.019            | 0.006    | 0.002    | 0.001   | g/t  |
| <b>Cr</b>             | diffuse        | 0.008            |          |          |         | g/t  |
| <b>Hg</b>             | channelled     | 2.436            | 0.192    | 0.015    | 0.003   | mg/t |
| <b>Hg</b>             | diffuse        | 0.005            |          |          |         | mg/t |
| <b>Ni</b>             | channelled     | 21.0             | 6.0      | 2.0      | 1.0     | mg/t |
| <b>Ni</b>             | diffuse        | 8.0              |          |          |         | mg/t |
| <b>NM VOC</b>         |                | 18.525           |          |          |         | g/t  |
| <b>NO<sub>x</sub></b> | channelled     | 0.051938         | 0.051938 | 0.051938 | 0.0517  | kg/t |
| <b>NO<sub>x</sub></b> | diffuse        | 0.001            |          |          |         | g/t  |
| <b>Pb</b>             | channelled     | 0.022            |          |          |         | g/t  |
| <b>Pb</b>             | diffuse        | 0.011            |          |          |         | g/t  |
| <b>PCDD/F</b>         |                | 0.026            | 0.009    | 0.004    | 0.004   | µg/t |
| <b>SO<sub>2</sub></b> | channelled     | 0.242            |          |          |         | kg/t |

|                                       | Type of source | EF 1995 | EF 2000 | EF 2005 | EF 2010 | Unit |
|---------------------------------------|----------------|---------|---------|---------|---------|------|
| <b>SO<sub>2</sub></b>                 | diffuse        | 0.04    |         |         |         | kg/t |
| <b>TSP</b>                            | channelled     | 0.022   | 0.015   | 0.01    | 0.008   | kg/t |
| <b>TSP</b>                            | diffuse        | 0.016   |         |         |         | kg/t |
| <b>PM<sub>10</sub></b>                | channelled     | 0.013   | 0.009   | 0.006   | 0.006   | kg/t |
| <b>PM<sub>10</sub></b>                | diffuse        | 0.007   |         |         |         | kg/t |
| <b>PM<sub>2.5</sub></b>               | channelled     | 0.009   | 0.007   | 0.005   | 0.004   | kg/t |
| <sup>1</sup> see section on PAH below |                |         |         |         |         |      |

Table 3: Overview of the emission factors applied for oxygen steel production

|                         | Type of source | EF 1995 | EF 2000 | EF 2005 | EF 2010 | Unit |
|-------------------------|----------------|---------|---------|---------|---------|------|
| <b>Cd</b>               |                | 0.053   | 0.038   | 0.024   | 0.016   | g/t  |
| <b>CO</b>               |                | 11.500  | 11.077  | 10.654  | 10.400  | kg/t |
| <b>Cr</b>               | channelled     | 0.715   | 0.306   | 0.125   | 0.028   | g/t  |
| <b>Cr</b>               | diffuse        | 0.069   |         |         |         | g/t  |
| <b>Ni</b>               | channelled     | 0.090   | 0.060   | 0.030   | 0.006   | g/t  |
| <b>Ni</b>               | diffuse        | 0.004   |         |         |         | g/t  |
| <b>NO<sub>x</sub></b>   | channelled     | 0.006   | 0.005   | 0.005   | 0.004   | kg/t |
| <b>NO<sub>x</sub></b>   | diffuse        | 0.0037  |         |         |         | kg/t |
| <b>PAH</b>              | channelled     | 0.100   |         |         |         | mg/t |
| <b>Pb</b>               | channelled     | 2.941   | 1.883   | 0.824   | 0.189   | g/t  |
| <b>Pb</b>               | diffuse        | 0.278   |         |         |         | g/t  |
| <b>PCB</b>              |                | 2.670   | 1.740   | 1       | 1       | mg/t |
| <b>PCDD/F</b>           |                | 0.070   | 0.070   | 0.070   | 0.069   | µg/t |
| <b>SO<sub>2</sub></b>   | diffuse        | 0.001   |         |         |         | kg/t |
| <b>TSP</b>              | channelled     | 0.155   | 0.145   | 0.145   | 0.024   | kg/t |
| <b>TSP</b>              | diffuse        | 0.049   |         |         |         | kg/t |
| <b>PM<sub>10</sub></b>  | channelled     | 0.099   | 0.093   | 0.093   | 0.020   | kg/t |
| <b>PM<sub>10</sub></b>  | diffuse        | 0.019   |         |         |         | kg/t |
| <b>PM<sub>2.5</sub></b> | channelled     | 0.025   | 0.023   | 0.023   | 0.017   | kg/t |

Table 4: Overview of the emission factors applied for electric steel production

|                       | Type of source | EF 1995 | EF 2000 | EF 2005 | EF 2010 | Unit |
|-----------------------|----------------|---------|---------|---------|---------|------|
| <b>Cd</b>             |                | 0.240   | 0.157   | 0.065   | 0.016   | g/t  |
| <b>CO</b>             | channelled     | 1.700   | 1.187   | 0.674   | 0.366   | kg/t |
| <b>CO</b>             | diffuse        | 0.001   |         |         |         | kg/t |
| <b>Cr</b>             | channelled     | 0.481   | 0.206   | 0.258   | 0.323   | g/t  |
| <b>Cr</b>             | diffuse        | 0.851   |         |         |         | g/t  |
| <b>Hg</b>             | channelled     | 0.306   | 0.288   | 0.154   | 0.070   | g/t  |
| <b>Ni</b>             | channelled     | 0.483   | 0.207   | 0.145   | 0.124   | g/t  |
| <b>Ni</b>             | diffuse        | 0.284   |         |         |         | g/t  |
| <b>NMVOC</b>          |                | 0.035   | 0.024   | 0.012   | 0.006   | kg/t |
| <b>NO<sub>x</sub></b> | channelled     | 0.122   | 0.12    | 0.106   | 0.098   | kg/t |
| <b>NO<sub>x</sub></b> | diffuse        | 0.014   |         |         |         | kg/t |
| <b>PAH</b>            |                | 45      | 22.1    | 3.798   | 3.793   | mg/t |
| <b>Pb</b>             | channelled     | 4.075   | 1.747   | 0.720   | 0.170   | g/t  |
| <b>Pb</b>             | diffuse        | 0.056   |         |         |         | g/t  |
| <b>PCB</b>            |                | 5.68    | 3.360   | 1.500   | 1.500   | mg/t |
| <b>PCDD/F</b>         |                | 0.466   | 0.295   | 0.158   | 0.158   | µg/t |
| <b>SO<sub>2</sub></b> | channelled     | 0.113   |         |         |         | kg/t |
| <b>SO<sub>2</sub></b> | diffuse        | 0.004   |         |         |         | kg/t |
| <b>TSP</b>            | channelled     | 0.28    | 0.12    | 0.074   | 0.018   | kg/t |

|                         | Type of source | EF 1995 | EF 2000 | EF 2005 | EF 2010 | Unit |
|-------------------------|----------------|---------|---------|---------|---------|------|
| <b>TSP</b>              | diffuse        |         |         |         | 0.043   | kg/t |
| <b>PM<sub>10</sub></b>  | channelled     | 0.179   | 0.08    | 0.051   | 0.013   | kg/t |
| <b>PM<sub>10</sub></b>  | diffuse        |         |         |         | 0.007   | kg/t |
| <b>PM<sub>2.5</sub></b> | channelled     | 0.045   | 0.04    | 0.038   | 0.011   | kg/t |

Table 5: Overview of the emission factors applied for hot and cold rolling

|                         | Type of source | EF 1995 | EF 2000 | EF 2005 | EF 2010 | unit | Trend    |
|-------------------------|----------------|---------|---------|---------|---------|------|----------|
| <b>CO</b>               |                |         |         |         | 5.0     | g/t  | constant |
| <b>NH<sub>3</sub></b>   |                |         |         | 0.700   |         | g/t  | constant |
| <b>NM VOC</b>           |                |         |         | 3.0     |         | g/t  | constant |
| <b>NO<sub>x</sub></b>   |                |         | 0.410   | 0.276   | 0.196   | kg/t | falling  |
| <b>SO<sub>2</sub></b>   |                |         | 0.059   | 0.050   | 0.044   | kg/t | falling  |
| <b>TSP</b>              | channelled     |         |         |         | 0.020   | kg/t | constant |
| <b>TSP</b>              | diffuse        |         |         |         | 0.010   | kg/t | constant |
| <b>PM<sub>10</sub></b>  | channelled     |         |         |         | 0.304   | g/t  | constant |
| <b>PM<sub>10</sub></b>  | diffuse        |         |         |         | 0.645   | g/t  | constant |
| <b>PM<sub>2.5</sub></b> | channelled     |         |         |         | 0.266   | g/t  | constant |

Table 6: Overview of the emission factors applied for iron and steel casting

|                         | EF 2010 | Unit | Trend    |
|-------------------------|---------|------|----------|
| <b>NH<sub>3</sub></b>   | 0.027   | kg/t | falling  |
| <b>NM VOC</b>           | 0.150   | kg/t | constant |
| <b>NO<sub>x</sub></b>   | 0.242   | kg/t | falling  |
| <b>PAH</b>              | 0.011   | g/t  | constant |
| <b>PCDD/F</b>           | 0.190   | µg/t | constant |
| <b>SO<sub>2</sub></b>   | 0.256   | kg/t | falling  |
| <b>TSP</b>              | 0.200   | kg/t | constant |
| <b>PM<sub>10</sub></b>  | 0.137   | kg/t | constant |
| <b>PM<sub>2.5</sub></b> | 0.0836  | kg/t | constant |

## HCB

For the calculation of HCB emissions in **sinter production**, the standard emission factor is used. By implementing the EMEP/EEA Guidebook standard emission factor, Germany is following recommendations provided by the Expert Review Team for the NECD-Review in 2020.

## PAH

In the 2021 review the application of a consistent methodology in reporting of PAH emissions in 2C1-iron and steel production was claimed. As there was not enough data available to report individual PAHs Germany decided to only report total-PAHs for the whole time. Therefore a national total-PAH emission factor for **pig iron production** was needed as the national inventory solely included BaP emissions for that source.

Emissions of PAH depend on the coating material used. As tar-free materials are used for coating and the blast furnace gas is conducted and used PAH emissions should not play any role. But as PAH emissions could not be surely ruled out and in order to avoid an underestimation of PAH emissions in pig iron production the emission factor for total-PAH is set to the 10-fold of the BaP emission factor following a conservative ansatz and not changing the overall PAH emission trend.

## Discussion of emission trends

The trends in emissions correspond to the trends of emission factors given in the tables above, which are often driven by regulatory measures.

However, since 2010, the main driver of the emission trends in most cases is the activity data.

## Recalculations

Recalculations were necessary for 2023 due to the implementation of the now finalised National Energy Balance.



For more **information on recalculated emission estimates for the Base Year and 2023**, please see the pollutant specific recalculation tables in the following chapter [9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

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<sup>1)</sup> Hensmann et al. (2011): Hensmann, M., Haardt, S., Ebert, D.: Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichterstattung (FKZ 3707 42 301); <https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/4362.pdf>, on behalf of the Umweltbundesamt, Dessau-Roßlau, October 2012

## 2.C.2 - Ferroalloys Production

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.C.2                                                                                     | T1                                   | IS | CS |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | POPs |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|------|
| NE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | NE     | NE              | NA              | -/-               | -/-              | -/- | NE | NE | NE | NE | NE | NA | NE | NA | NA | NA | NA | NA   |
| <b>L/-</b> key source by <b>L</b> evel only<br><b>-/T</b> key source by <b>T</b> rend only<br><b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend<br><b>-/-</b> no key source for this pollutant<br><b>IE</b> emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category)<br><b>NE</b> emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)<br><b>NA</b> specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable<br><b>*</b> no analysis done |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |      |

Source category *Ferroalloys Production* is of minor significance and not a key source. Ferroalloys are non-ferrous metal aggregates used in steel production.

Germany has five producers of ferrochrome, silicon metal and ferrosilicon. These materials are used as alloying agents in stainless-steel production. The only process applied in Germany since 1995 is the electric arc process generating only a small amount of process-related emissions (specifically due to electrode consumption). The blast-furnace process, which produces much higher emissions, was used, to some extent, until 1995.

In 2024, ferroalloys production amounted to 52.2 kt.



## Method

### Activity data

The activity data from the years 1990 to 1994 has been taken from official production statistics of the Federal Statistical Office. Since 1995, the data from the official production statistics is no longer suitable to use in this context. Since then, data from the British Geological Survey <sup>1)</sup> has been used instead.

The most recent activity data is available for 2021. This data has been carried forward into 2022. As soon as updated statistical data is available - in general, every two years -, a recalculation will be carried out.

### Emission factors

The emission factor for TSP (0.1 kg/t for the current year and back to 1998) and the splitting factors for PM<sub>10</sub> and PM<sub>2.5</sub> were determined in a research project (Jörß et al., 2007) <sup>2)</sup>. There were higher but decreasing EF for the period 1990-1997 due to the technology changes.

### Uncertainties

The uncertainties for the production amounts are 50% and for the emission factors not more than 300%.

## Recalculations



With **all input data remaining unrevised**, no recalculations were made compared to the previous submission.

## Planned improvements

Actualized production figures of the world mineral production report for the years 2019-2022 are not implemented because the reasons for the changes are not explained. These revision only belong to estimated values of the category "other ferro-alloys". The justification of the new values for implementation must be postponed to submission 2027.

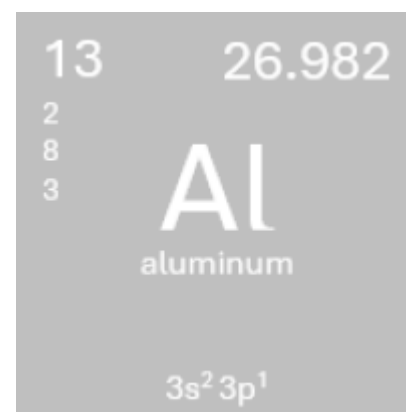
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<sup>1)</sup> Idoine, N.E.; Raycraft, E.R.; Hobbs, S.F.; Everett, P.; Evans, E.J.; Mills, A.J.; Currie, D.; Horn, S.; Shaw, R.A.: World mineral production 2018-22. British Geological Survey, 98pp. Keyworth, Nottingham; URL: <https://nora.nerc.ac.uk/id/eprint/537241/>; Nottingham, UK, 2024.

<sup>2)</sup> Jörß et al. (2007): Jörß, W., Handke, V. (Institut für Zukunftsstudien und Technologiebewertung (IZT), Berlin) with Lambrecht, U., Dünnebeil, Fr. (Institut für Energie und Umweltforschung Heidelberg (ifeu)): Emissionen und Maßnahmenanalyse Feinstaub 2000-2020. UBA-TEXTE Nr. 38/200; <https://www.umweltbundesamt.de/publikationen/emissionen-massnahmenanalyse-feinstaub-2000-2020>; on behalf of the Umweltbundesamt; Dessau-Roßlau, 2007.

## 2.C.3 - Aluminium Production

### Short description



Within category 2.C.3 - *Aluminium production*, emissions from primary aluminium and secondary aluminium production are reported.

| Category Code                                                                            | Method                               | AD | EF    |
|------------------------------------------------------------------------------------------|--------------------------------------|----|-------|
| 2.C.3                                                                                    | T2, T3                               | AS | D, CS |
| Method(s) applied                                                                        |                                      |    |       |
| D                                                                                        | Default                              |    |       |
| T1                                                                                       | Tier 1 / Simple Methodology *        |    |       |
| T2                                                                                       | Tier 2*                              |    |       |
| T3                                                                                       | Tier 3 / Detailed Methodology *      |    |       |
| C                                                                                        | CORINAIR                             |    |       |
| CS                                                                                       | Country Specific                     |    |       |
| M                                                                                        | Model                                |    |       |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters |                                      |    |       |
| (source for) Activity Data                                                               |                                      |    |       |
| NS                                                                                       | National Statistics                  |    |       |
| RS                                                                                       | Regional Statistics                  |    |       |
| IS                                                                                       | International Statistics             |    |       |
| PS                                                                                       | Plant Specific                       |    |       |
| As                                                                                       | Associations, business organisations |    |       |
| Q                                                                                        | specific Questionnaires (or surveys) |    |       |
| M                                                                                        | Model / Modelled                     |    |       |
| C                                                                                        | Confidential                         |    |       |
| (source for) Emission Factors                                                            |                                      |    |       |
| D                                                                                        | Default (EMEP Guidebook)             |    |       |
| CS                                                                                       | Country Specific                     |    |       |
| PS                                                                                       | Plant Specific                       |    |       |
| M                                                                                        | Model / Modelled                     |    |       |
| C                                                                                        | Confidential                         |    |       |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO  | Pb  | Cd  | Hg  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCb |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|-----|-----|-----|-----|--------|-------|-------|-------|-------|------|-----|
| -/-             | NE     | -/-             | NA              | -/-               | -/-              | -/- | NE | -/- | -/- | -/- | -/- | -/-    | -/T   | -/-   | -/-   | -/-   | -/-  | L/T |



According to the BREF for Non-ferrous metals Industries the measurement and detection of PAH emission is often done using Benzo(a)pyrene (BaP) as a marker. That's why an emission factor of BaP could be determined through analysis of emissions reports in a research project <sup>4)</sup>.

A NEC-review recommendation was to assess the use of default emission factors for the 3 other PAHs to complete PAH emission reporting. The ratio for BbF, BkF and IxP is applied on BaP according to Berdowski et al. 1995 <sup>5)</sup> in table 3-1 of the 2023 EMEP/EEA air pollutant emission inventory guidebook <sup>6)</sup>.

Table 2: Emission factors applied for primary aluminium production

|                   | EF (2004) | Unit | Trend    |
|-------------------|-----------|------|----------|
| CO                | 120       | kg/t | constant |
| SO <sub>2</sub>   | 8.951     | kg/t | constant |
| TSP               | 0.83      | kg/t | constant |
| PM <sub>10</sub>  | 0.7055    | kg/t | constant |
| PM <sub>2.5</sub> | 0.581     | kg/t | constant |
| Cd                | 0.15      | g/t  | constant |
| Ni                | 0.162     | g/t  | constant |
| Zn                | 10        | g/t  | constant |
| NO <sub>x</sub>   | 1         | kg/t | constant |

Nitrogen oxide emissions essentially arise from the nitrogen content of the fuels in combustion processes. At temperatures above 1,000 ° C, Nitrogen oxide can also form from nitrogen in the air. Another source of NO<sub>x</sub> is the electrolysis in primary aluminium production due to the presence of nitrogen in the anode, which can be oxidized to NO<sub>x</sub>. All these emission sources resulting from energy-related processes are included in 1.A.2.b. It is not known whether other sources of NO<sub>x</sub> have quantitative effects. In order not to miss process-related NO<sub>x</sub> emissions, the standard emission factor is also used. Germany is following recommendations provided by the Expert Review Team for the NECD Review 2017.

Table 3: Emission factors applied for secondary aluminium (resmelted aluminium) production

|                       | EF      | Unit | Trend    |
|-----------------------|---------|------|----------|
| TSP                   | 0.055   | kg/t | constant |
| PM <sub>10</sub>      | 0.047   | kg/t | constant |
| PM <sub>2.5</sub>     | 0.03843 | kg/t | constant |
| Cd                    | 7       | mg/t | constant |
| Cu                    | 8.411   | mg/t | constant |
| Hg                    | 1.7     | mg/t | constant |
| Pb                    | 4.452   | mg/t | constant |
| Zn                    | 4       | g/t  | constant |
| HCB (years 1990-2001) | 5       | g/t  | constant |

For the period between 1990 and 2001, however, no data on national emissions of HCB in secondary aluminium industries is available. In order to be able to calculate these HCB emissions, the default emission factor for HCB was used.

## Uncertainties

The uncertainties for the production amounts are 5% and for the emission factors not more than 200%.

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

## Planned improvements

No category-specific improvements are planned.

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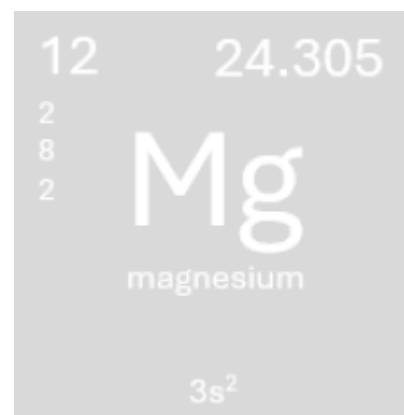
<sup>1)</sup> WVMetalle, 2021: German association for non-ferrous metals (Wirtschaftsvereinigung Metalle): Annual statistical report: <https://www.wvmetalle.de>

<sup>2), 6)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.C.3 - Aluminium production 2023; <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-c-metal-production/2-c-3-aluminium-production-2023/@download/file>; Copenhagen, 2023.

<sup>3), 4)</sup> Ökopöl, IER Universität Stuttgart, IZT Berlin, Institut für Gießereitechnik (IfG) 2010: Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarung für ausgewählte Industriebranchen TV02: NE-Metallindustrie, Gießereien, Kalkindustrie, FKZ 3707 42 301/02, Auftraggeber: Umweltbundesamt, 2010

<sup>5)</sup> Berdowski, J.J.M, Veldt, C., Baas, J., Bloos, J.P.J. and Klein, A.E., 1995. Technical Paper to the PSPARCOM\_HELCOM-UNECE Emission Inventory of Heavy Metals and Persistent Organic Pollutants. TNO-MEP - R 95/247.

## 2.C.4 - Magnesium Production



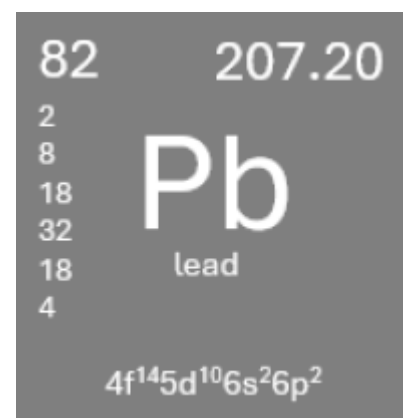
There is no primary magnesium production in Germany (not occurring - NO).  
Emissions of NO<sub>x</sub>, NMVOC, SO<sub>2</sub>, NH<sub>3</sub> and CO from the production of secondary magnesium are reported in sub-category 1.A.2.b.

### Planned improvements

Change of notation keys of NO<sub>x</sub>, NMVOC, SO<sub>2</sub>, NH<sub>3</sub> and CO in the NFR-tables in order to match IIR description will be done in the submission 2027.

## 2.C.5 - Lead Production

### Short description



Within this NFR subcategory, SO<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub>, TSP, As, Cd, Cu, Hg, Pb, Zn, PCB and PCDD/F emissions from the production of lead are reported.

| Category Code                                                                             | Method                               | AD | EF    |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|-------|
| 2.C.5                                                                                     | T2                                   | AS | D, CS |
| Method(s) applied                                                                         |                                      |    |       |
| D                                                                                         | Default                              |    |       |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |       |
| T2                                                                                        | Tier 2*                              |    |       |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |       |
| C                                                                                         | CORINAIR                             |    |       |
| CS                                                                                        | Country Specific                     |    |       |
| M                                                                                         | Model                                |    |       |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |       |
| (source for) Activity Data                                                                |                                      |    |       |
| NS                                                                                        | National Statistics                  |    |       |
| RS                                                                                        | Regional Statistics                  |    |       |
| IS                                                                                        | International Statistics             |    |       |
| PS                                                                                        | Plant Specific                       |    |       |
| As                                                                                        | Associations, business organisations |    |       |
| Q                                                                                         | specific Questionnaires (or surveys) |    |       |
| M                                                                                         | Model / Modelled                     |    |       |
| C                                                                                         | Confidential                         |    |       |
| (source for) Emission Factors                                                             |                                      |    |       |
| D                                                                                         | Default (EMEP Guidebook)             |    |       |
| CS                                                                                        | Country Specific                     |    |       |
| PS                                                                                        | Plant Specific                       |    |       |
| M                                                                                         | Model / Modelled                     |    |       |
| C                                                                                         | Confidential                         |    |       |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb  | Cd  | Hg  | As  | Cr | Cu  | Ni | Se | Zn  | PCDD/F | PAHs | HCB | PCB |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|-----|-----|-----|-----|----|-----|----|----|-----|--------|------|-----|-----|
| NA              | NA     | -/-             | NA              | -/-               | -/-              | -/- | NE | NA | -/- | -/- | -/- | -/- | NA | -/- | NA | NE | -/- | -/-    | NA   | NA  | L/T |

|            |                                                                                     |
|------------|-------------------------------------------------------------------------------------|
| <b>L/-</b> | key source by <b>Level</b> only                                                     |
| <b>-/T</b> | key source by <b>Trend</b> only                                                     |
| <b>L/T</b> | key source by both <b>Level</b> and <b>Trend</b>                                    |
| <b>-/-</b> | no key source for this pollutant                                                    |
| <b>IE</b>  | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |
| <b>NE</b>  | emission of specific pollutant <b>Not Estimated</b> (yet)                           |
| <b>NA</b>  | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |
| <b>*</b>   | no analysis done                                                                    |

## Method

### Activity data

Annual production figures are derived from the annual statistical report of the German association for non-ferrous metals <sup>1)</sup>. In **2024**, the primary and secondary lead production amounted to **311 kt**:

Table 1: Annual total (primary + secondary) amount of lead produced, in [kt]

| 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 381  | 314  | 387  | 342  | 405  | 377  | 343  | 357  | 313  | 328  | 334  | 306  | 229  | 305  | 311  |

### Emission factors

The emission factor for SO<sub>x</sub> is a tier1 default value according to the EMEP/EEA air pollutant emission inventory guidebook 2023 <sup>2)</sup> and is supposed to be constant over time. All other emission factors are tier2 values with a decreasing trend and determined in research projects. For heavy metals (HM), the applied emission factors are derived from a research project <sup>3)</sup>.

Table 2: emission factors applied for primary and secondary lead production

|                         | EF (primary) | EF (secondary) | Unit |
|-------------------------|--------------|----------------|------|
| <b>SO<sub>2</sub></b>   | 2.05         |                | kg/t |
| <b>PM<sub>2.5</sub></b> | 17.5         |                | g/t  |
| <b>PM<sub>10</sub></b>  | 21.3         |                | g/t  |
| <b>TSP</b>              | 25           |                | g/t  |
| <b>As</b>               | 49.213       | 41.179         | mg/t |
| <b>Cd</b>               | 62.448       | 19.767         | mg/t |
| <b>Cu</b>               | 162.663      |                | mg/t |
| <b>Hg</b>               | 0.3          | 0.325          | g/t  |
| <b>Pb</b>               | 6.028        | 4.506          | g/t  |
| <b>Zn</b>               | 664          | 50             | mg/t |
| <b>PCB</b>              | 2.1          |                | mg/t |
| <b>PCDD/F</b>           | 0.34         |                | µg/t |

### Uncertainties

The uncertainties for the production amounts are 5% and for the emission factors not more than 300%. Only for dioxines the upper bond uncertainty is about 900%.

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.



## Planned improvements

The emission factor applied for PCB is still based on values from older versions of the EMEP/EEA Guidebook and seems to be too high due to legal terms. As the emission factor could not be updated with the current submission, this revision will be scheduled for submission 2026.

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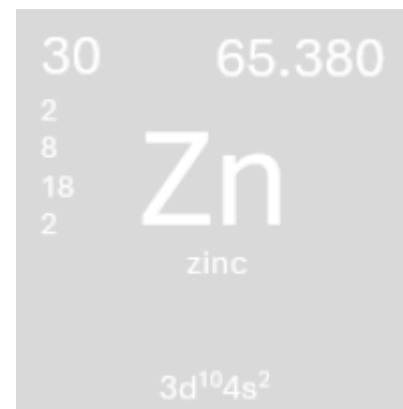
<sup>1)</sup> WVMetalle (2021): German association for non-ferrous metals (WirtschaftsVereinigung Metalle): Annual statistical report: <https://www.wvmetalle.de>

<sup>2)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.C.5 Lead production 2023 FINAL; Copenhagen, 2023.  
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-c-metal-production/2-c-5-lead-production-2023/@download/file>

<sup>3)</sup> Ökopol, IER Universität Stuttgart, IZT Berlin, Institut für Gießereitechnik (IfG) 2010: Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarung für ausgewählte Industriebranchen TV02: NE-Metallindustrie, Gießereien, Kalkindustrie, FKZ 3707 42 301/02, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2010

## 2.C.6 - Zinc Production

### Short description



Within this NFR subcategory, SO<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub>, TSP, As, Cd, Hg, Pb, Zn, PCDD/F, and PCB emissions from the production of zinc are reported.

| Category Code                                                                             | Method                               | AD | EF   |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|------|
| 2.C.6                                                                                     | T2                                   | AS | D,CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |      |
| <b>D</b>                                                                                  | Default                              |    |      |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |      |
| <b>T2</b>                                                                                 | Tier 2*                              |    |      |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |      |
| <b>C</b>                                                                                  | CORINAIR                             |    |      |
| <b>CS</b>                                                                                 | Country Specific                     |    |      |
| <b>M</b>                                                                                  | Model                                |    |      |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |      |
| <b>(source for) Activity Data</b>                                                         |                                      |    |      |
| <b>NS</b>                                                                                 | National Statistics                  |    |      |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |      |
| <b>IS</b>                                                                                 | International Statistics             |    |      |
| <b>PS</b>                                                                                 | Plant Specific                       |    |      |
| <b>As</b>                                                                                 | Associations, business organisations |    |      |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |      |
| <b>M</b>                                                                                  | Model / Modelled                     |    |      |
| <b>C</b>                                                                                  | Confidential                         |    |      |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |      |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |      |
| <b>CS</b>                                                                                 | Country Specific                     |    |      |
| <b>PS</b>                                                                                 | Plant Specific                       |    |      |
| <b>M</b>                                                                                  | Model / Modelled                     |    |      |
| <b>C</b>                                                                                  | Confidential                         |    |      |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb  | Cd  | Hg  | As  | Cu | Cr | Ni | Se | Zn  | PCDD/F | PAHs | HCB | PCBs |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|-----|-----|-----|-----|----|----|----|----|-----|--------|------|-----|------|
| NA              | NA     | -/-             | NA              | -/-               | -/-              | -/- | NE | NA | -/- | -/- | -/- | -/- | NA | NA | NA | NE | L/- | -/-    | NA   | NA  | L/T  |

|            |                                                                                              |
|------------|----------------------------------------------------------------------------------------------|
| <b>L/-</b> | key source by <b>L</b> evel only                                                             |
| <b>-/T</b> | key source by <b>T</b> rend only                                                             |
| <b>L/T</b> | key source by both <b>L</b> evel and <b>T</b> rend                                           |
| <b>-/-</b> | no key source for this pollutant                                                             |
| <b>IE</b>  | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |
| <b>NE</b>  | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |
| <b>NA</b>  | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |
| <b>*</b>   | no analysis done                                                                             |

## Method

### Activity data

The yearly production figures were taken from the annual statistical report of the German association for non-ferrous metals <sup>1)</sup>. After zinc production dropped sharply due to reduced production outputs or even production stops in 2023, production output recovered partly in 2024. However, the figures for 2023 and 2024 had to be classified as confidential and therefore cannot be published here.

Table 1: Annual total zinc production (primary + secondary), in [kt]

| 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 390  | 356  | 357  | 335  | 165  | 171  | 169  | 176  | 177  | 177  | 165  | 168  | 135  | C    | C    |

### Emission factors

The emission factor for SO<sub>x</sub> is a tier1 default value according to the EMEP/EEA air pollutant emission inventory guidebook 2023 <sup>2)</sup> and is supposed to be constant. All other emission factors are tier2 values with a decreasing trend and determined in research projects. The EF for the heavy metals (HM) are taken from a research project <sup>3)</sup>.

Table 2: emission factors applied for primary and secondary zinc production

|                         | EF (primary) | EF (secondary) | Unit |
|-------------------------|--------------|----------------|------|
| <b>SO<sub>2</sub></b>   | 1.35         |                | kg/t |
| <b>PM<sub>2.5</sub></b> | 38.5         |                | g/t  |
| <b>PM<sub>10</sub></b>  | 61.3         |                | g/t  |
| <b>TSP</b>              | 100          |                | g/t  |
| <b>As</b>               | 123.882      | 30             | mg/t |
| <b>Cd</b>               | 1085         | 230            | mg/t |
| <b>Hg</b>               | 500          | 1.5            | mg/t |
| <b>Pb</b>               | 19.605       | 0.95           | g/t  |
| <b>Zn</b>               | 51.968       | 9              | g/t  |
| <b>PCB</b>              | 1            |                | mg/t |
| <b>PCDD/F</b>           | 0.15         |                | µg/t |

### Uncertainties

The uncertainties for the production amounts are 5% and for the emission factors not more than 300%. Only for dioxines the upper bond uncertainty is about 900%.

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.

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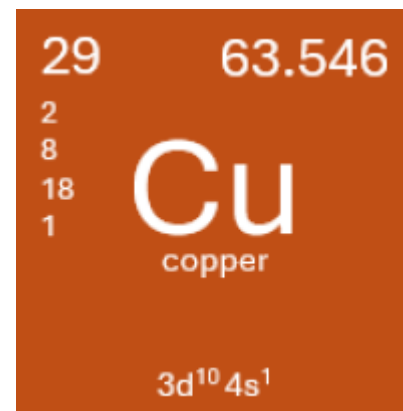
<sup>1)</sup> WVMetalle (20219: German association for non-ferrous metals (WirtschaftsVereinigung Metalle): Annual statistical report: <https://www.wvmetalle.de>

<sup>2)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.C.6 - Zinc production 2023; <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-c-metal-production/2-c-6-zinc-production-2023/@download/file>; Copenhagen, 2023.

<sup>3)</sup> Ökopol, IER Universität Stuttgart, IZT Berlin, Institut für Gießereitechnik (IfG) 2010: Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarung für ausgewählte Industriebranchen TV02: NE-Metallindustrie, Gießereien, Kalkindustrie, FKZ 3707 42 301/02, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2010

## 2.C.7.a - Copper Production

### Short description



Within this NFR subcategory, SO<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub>, TSP, PCDD/F, HCB, As, Cd, Cu, Hg, and Pb emissions from the production of copper are reported.

| Category Code                                                                             | Method                               | AD | EF    |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|-------|
| 2.C.7.a                                                                                   | T2                                   | AS | D, CS |
| Method(s) applied                                                                         |                                      |    |       |
| D                                                                                         | Default                              |    |       |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |       |
| T2                                                                                        | Tier 2*                              |    |       |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |       |
| C                                                                                         | CORINAIR                             |    |       |
| CS                                                                                        | Country Specific                     |    |       |
| M                                                                                         | Model                                |    |       |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |       |
| (source for) Activity Data                                                                |                                      |    |       |
| NS                                                                                        | National Statistics                  |    |       |
| RS                                                                                        | Regional Statistics                  |    |       |
| IS                                                                                        | International Statistics             |    |       |
| PS                                                                                        | Plant Specific                       |    |       |
| As                                                                                        | Associations, business organisations |    |       |
| Q                                                                                         | specific Questionnaires (or surveys) |    |       |
| M                                                                                         | Model / Modelled                     |    |       |
| C                                                                                         | Confidential                         |    |       |
| (source for) Emission Factors                                                             |                                      |    |       |
| D                                                                                         | Default (EMEP Guidebook)             |    |       |
| CS                                                                                        | Country Specific                     |    |       |
| PS                                                                                        | Plant Specific                       |    |       |
| M                                                                                         | Model / Modelled                     |    |       |
| C                                                                                         | Confidential                         |    |       |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb  | Cd  | Hg  | As  | Cr | Cu  | Ni | Se | Zn  | PCDD/F | PAHs | HCB |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|-----|-----|-----|-----|----|-----|----|----|-----|--------|------|-----|
| NA              | NA     | -/-             | NA              | -/-               | -/-              | -/- | NE | NA | -/- | L/T | -/- | L/- | NA | -/- | NE | NE | -/- | -/-    | NA   | L/- |

|            |                                                                                              |
|------------|----------------------------------------------------------------------------------------------|
| <b>L/-</b> | key source by <b>L</b> evel only                                                             |
| <b>-/T</b> | key source by <b>T</b> rend only                                                             |
| <b>L/T</b> | key source by both <b>L</b> evel and <b>T</b> rend                                           |
| <b>-/-</b> | no key source for this pollutant                                                             |
| <b>IE</b>  | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |
| <b>NE</b>  | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |
| <b>NA</b>  | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |
| <b>*</b>   | no analysis done                                                                             |

## Method

### Activity data

The annual production figures were taken from the annual statistical report of the German association for non-ferrous metals (WirtschaftsVereinigung Metalle) <sup>1)</sup> until 2020. Since 2021 the production figures for primary copper have been derived directly from the producer whereas for secondary copper no updating was possible. In 2024, copper production amounted to 464 kt.

Table 1: Annual copper production (primary + secondary), in [kt]

| 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 528  | 616  | 709  | 639  | 704  | 678  | 671  | 694  | 670  | 600  | 637  | 632  | 595  | 560  | 464  |

### Emission factors

The emission factors are either default values according to the EMEP/EEA air pollutant emission inventory guidebook 2023 <sup>2)</sup> or determined in research projects <sup>3)</sup>, <sup>4)</sup>, <sup>5)</sup> or from companies environmental reports <sup>6)</sup>. Nickel emissions in secondary copper production are not reported.

Table 2: Tier 1 emission factors applied for entire time series (primary and secondary copper production)

|               | EF  | Unit | Source                                                                                   |
|---------------|-----|------|------------------------------------------------------------------------------------------|
| <b>HCB</b>    | 1   | mg/t | German association for non-ferrous metals (WirtschaftsVereinigung Metalle) <sup>7)</sup> |
| <b>PCDD/F</b> | 2.9 | µg/t | Rentz et al. 2008 <sup>8)</sup>                                                          |

Table 3: Emission factors applied for primary copper production

|                         | EF     | Unit | Source                          |
|-------------------------|--------|------|---------------------------------|
| <b>TSP</b>              | 0.09   | kg/t | Aurubis, 2023 <sup>9)</sup>     |
| <b>PM<sub>10</sub></b>  | 0.0765 | kg/t | calculated from Aurubis, 2023   |
| <b>PM<sub>2.5</sub></b> | 0.063  | kg/t | calculated from Aurubis, 2023   |
| <b>SO<sub>2</sub></b>   | 3.6    | kg/t | Aurubis, 2023                   |
| <b>As</b>               | 0.8    | g/t  | Aurubis, 2023                   |
| <b>Cd</b>               | 15     | g/t  | EMEP/EEA GB 2023 <sup>10)</sup> |
| <b>Cu</b>               | 13.8   | g/t  | Aurubis, 2023                   |
| <b>Hg</b>               | 0.031  | g/t  | EMEP/EEA GB 2023                |
| <b>Pb</b>               | 3.1    | g/t  | Aurubis, 2023                   |

Table 4: Emission factors applied for secondary copper production

|                         | EF    | Unit | Source                     |
|-------------------------|-------|------|----------------------------|
| <b>TSP</b>              | 0.100 | kg/t | PAREST 2013 <sup>11)</sup> |
| <b>PM<sub>10</sub></b>  | 0.085 | kg/t | PAREST 2013                |
| <b>PM<sub>2.5</sub></b> | 0.07  | kg/t | PAREST 2013                |
| <b>SO<sub>2</sub></b>   | 3.0   | kg/t | EMEP/EEA GB 2023           |

|           | EF        | Unit | Source                     |
|-----------|-----------|------|----------------------------|
| <b>As</b> | 2         | g/t  | EMEP/EEA GB 2023           |
| <b>Cd</b> | 486.428   | mg/t | NE-G-K 2010 <sup>12)</sup> |
| <b>Cu</b> | 46,088.62 | mg/t | NE-G-K 2010                |
| <b>Hg</b> | 2.644     | mg/t | NE-G-K 2010                |
| <b>Pb</b> | 21,977.15 | mg/t | NE-G-K 2010                |

## Uncertainties

The uncertainties for the production amounts are 7% and for the emission factors not more than 50% for primary and 200% for secondary copper production.

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

## Planned improvements



It is intended to gather emission data of heavy metals not reported yet through the analysis of emission reports. This task depends on the project financing and results could not be available before submission 2028 or 2029.

<sup>1), 7)</sup> WVMetalle (2021): German association for non-ferrous metals (WirtschaftsVereinigung Metalle): Annual statistical report: <https://www.wvmetalle.de>

<sup>2), 10)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.C.7.a Copper production 2023; <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-c-metal-production/2-c-7-a-copper/view> | <https://www.eea.europa.eu>, Copenhagen, 2023

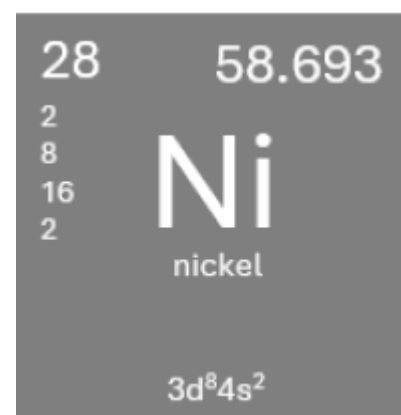
<sup>3), 8)</sup> Rentz et al. (2008): Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, <https://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuehrungsplan-unter-stockholmer>; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2008

<sup>4), 12)</sup> Ökopol, IER Universität Stuttgart, IZT Berlin, Institut für Gießereitechnik (IfG) 2010: Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarung für ausgewählte Industriebranchen TV02: NE-Metallindustrie, Gießereien, Kalkindustrie, FKZ 3707 42 301/02, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2010

<sup>5)</sup> Theloke et al. (2013): Theloke, J., Kugler, U., Kampffmeyer, T., Uzbisich, M., Kuhn, A., Dämmgen, U.: Beschreibung der Minderungsmaßnahmen im Projekt PAREST Maßnahmenblätter; Teilbericht zum F&E-Vorhaben „Strategien zur Verminderung der Feinsatubbelastung - PAREST - UBA Texte 48/2013, <https://www.umweltbundesamt.de/publikationen/beschreibung-minderungsmaßnahmen-im-projekt-parest>, on behalf of the Umweltbundesamt, Dessau-Roßlau, 2013

<sup>6), 9)</sup> Aurubis, 20243: Aurubis, Umwelterklärungen 2023, Aurubis AG, <https://www.aurubis.com/>

## 2.C.7.b - Nickel Production



In subcategory *NFR 2.C.7.b - Nickel production* the TSP, SO<sub>2</sub>, and Ni emissions from nickel mining are reported.

Reporting only covers the year 1990 because in 1991 nickel mining stopped in Germany.

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.C.7.b                                                                                   | T1                                   | AS | D  |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

[illegible]



|            |                                                                                              |
|------------|----------------------------------------------------------------------------------------------|
| <b>L/-</b> | key source by <b>L</b> evel only                                                             |
| <b>-/T</b> | key source by <b>T</b> rend only                                                             |
| <b>L/T</b> | key source by both <b>L</b> evel and <b>T</b> rend                                           |
| <b>-/-</b> | no key source for this pollutant                                                             |
| <b>IE</b>  | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |
| <b>NE</b>  | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |
| <b>NA</b>  | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |
| <b>*</b>   | no analysis done                                                                             |

## Method

### Activity data

Annual production data were derived from the World Mineral Statistics report of the British Geological Survey 1990-94 <sup>1)</sup>.

Here, Nickel was produced only in the former GDR, in the New German Länder and only until 1990:

Table 1: Nickel production, in [t]

| 1990              | as of 1991 |
|-------------------|------------|
| 872 <sup>2)</sup> | NO         |

### Emission factors

The emission factors are the default values according to the EMEP/EEA air pollutant emission inventory guidebook 2023 <sup>3)</sup>.

Table 2: applied Tier1 emission factors, in [kg/t]

|                       | EF    |
|-----------------------|-------|
| <b>SO<sub>2</sub></b> | 18    |
| <b>TSP</b>            | 0.3   |
| <b>Ni</b>             | 0.025 |

### Uncertainties

## Recalculations



There is no primary nickel production in Germany. Therefore it is **not necessary to update** the activity data and emission factors.

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1), 2)</sup> Taylor et. al (1995): Taylor, L.E., Loft, G.J., Hillier, J.A., Fellows, M.E., Bate, D.G., Linley, K.A., Mills, A.J., White, R.: BRITISH GEOLOGICAL SURVEY: World Mineral Statistics 1990-94: [https://nora.nerc.ac.uk/id/eprint/535237/1/WMS\\_1990\\_1994.pdf](https://nora.nerc.ac.uk/id/eprint/535237/1/WMS_1990_1994.pdf); here: page 192: Mine Production of Nickel; Keyworth, Nottingham, UK, 1995

<sup>3)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; Chapter 2.C.7.b - Nickel production FINAL;

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<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-c-metal-production/2-c-7-b-nickel/@@download/file>, Copenhagen, 2023

## 2.C.7.c - Other Metal Production

### Short description

In source category *NFR C.7.c - Other Metal Production* thermal galvanisation is reported and the main pollutants are PM. The share of TSP emissions from other metal production amounts to 0,06% of the TSP emissions of the whole metal industry in 2024.

| Category Code                                                                             | Method                               | AD | EF     |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|--------|
| 2.C.7.c                                                                                   | T1                                   | AS | PS, CS |
| Method(s) applied                                                                         |                                      |    |        |
| D                                                                                         | Default                              |    |        |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |        |
| T2                                                                                        | Tier 2*                              |    |        |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |        |
| C                                                                                         | CORINAIR                             |    |        |
| CS                                                                                        | Country Specific                     |    |        |
| M                                                                                         | Model                                |    |        |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |        |
| (source for) Activity Data                                                                |                                      |    |        |
| NS                                                                                        | National Statistics                  |    |        |
| RS                                                                                        | Regional Statistics                  |    |        |
| IS                                                                                        | International Statistics             |    |        |
| PS                                                                                        | Plant Specific                       |    |        |
| As                                                                                        | Associations, business organisations |    |        |
| Q                                                                                         | specific Questionnaires (or surveys) |    |        |
| M                                                                                         | Model / Modelled                     |    |        |
| C                                                                                         | Confidential                         |    |        |
| (source for) Emission Factors                                                             |                                      |    |        |
| D                                                                                         | Default (EMEP Guidebook)             |    |        |
| CS                                                                                        | Country Specific                     |    |        |
| PS                                                                                        | Plant Specific                       |    |        |
| M                                                                                         | Model / Modelled                     |    |        |
| C                                                                                         | Confidential                         |    |        |

| NO <sub>x</sub>                                                                 | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP                         | BC | CO | Heavy Metals | POPs |
|---------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----------------------------|----|----|--------------|------|
| NA                                                                              | NA     | NE              | NA              | -/-               | -/-              | L <sub>(base year)</sub> /T | NE | NA | NA           | NA   |
| L/- key source by Level only                                                    |        |                 |                 |                   |                  |                             |    |    |              |      |
| -/T key source by Trend only                                                    |        |                 |                 |                   |                  |                             |    |    |              |      |
| L/T key source by both Level and Trend                                          |        |                 |                 |                   |                  |                             |    |    |              |      |
| -/- no key source for this pollutant                                            |        |                 |                 |                   |                  |                             |    |    |              |      |
| IE emission of specific pollutant Included Elsewhere (i.e. in another category) |        |                 |                 |                   |                  |                             |    |    |              |      |
| NE emission of specific pollutant Not Estimated (yet)                           |        |                 |                 |                   |                  |                             |    |    |              |      |
| NA specific pollutant not emitted from this source or activity = Not Applicable |        |                 |                 |                   |                  |                             |    |    |              |      |
| * no analysis done                                                              |        |                 |                 |                   |                  |                             |    |    |              |      |

### Method

#### Activity data

Annual production figures were provided by the German association "Industrieverband Feuerverzinken e.V" (IFV) back to 2010 <sup>1)</sup> with figures based on annual queries of its member companies.

As the market share covered by the members of IFV used to be about 45%, the IFV extrapolated the total values for Germany on this basis.

### Emission factors

The emission factor for TSP was determined on the basis of data supplied for the FMP (Ferrous Metals Processing) BREF review.

The split factors originate from (Jörß et al., 2007) <sup>2)</sup>.

As produced amounts are considered confidential, no emission factors can be published here.

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.

---

<sup>1)</sup> IFV (2011): Industrierverband Feuerverzinken e.V. (IFV), <https://www.feuverzinken.com/>

<sup>2)</sup> Jörß et al. (2007): Jörß, W.; Handke, V. (Institut für Zukunftsstudien und Technologiebewertung (IZT), Berlin) with Lambrecht, U., Dünnebeil, Fr. (Institut für Energie und Umweltforschung Heidelberg (ifeu)): Emissionen und Maßnahmenanalyse Feinstaub 2000–2020. UBA-TEXTE Nr. 38/200; <https://www.umweltbundesamt.de/publikationen/emissionen-massnahmenanalyse-feinstaub-2000-2020>., on behalf of the Umweltbundesamt; Dessau-Roßlau, 2007.

## 2.C.7.d - Storage, Handling and Transport of Metal Products



All emissions from storage, handling and transport of metal products are included elsewhere ('IE') in the values reported in NFR 2.L - Other production, consumption, storage, transportation or handling of bulk products.

## 2.D - Solvent Use And Product Use (OVERVIEW)

The *solvent and product use* subsector comprises very different products not only in use but also in production. All products are assigned to one of the following nine source categories covering altogether 37 SNAP codes.

| 2.D Solvent Use and Product Use                                   | relevant SNAP Codes                       |
|-------------------------------------------------------------------|-------------------------------------------|
| <a href="#">2.D.3.a Domestic Solvent Use including fungicides</a> | 60408, 60411                              |
| <a href="#">2.D.3.b Road Paving with Asphalt</a>                  | 040611, not use of solvents               |
| <a href="#">2.D.3.c Asphalt Roofing</a>                           | 040610, not use of solvents               |
| <a href="#">2.D.3.d Coating Applications</a>                      | 60101 - 60108                             |
| <a href="#">2.D.3.e Degreasing</a>                                | 60201, 60203, 60204                       |
| <a href="#">2.D.3.f Dry Cleaning</a>                              | 60202                                     |
| <a href="#">2.D.3.g Chemical Products</a>                         | 60301 - 60314                             |
| <a href="#">2.D.3.h Printing</a>                                  | 60403                                     |
| <a href="#">2.D.3.i Other Solvent Use</a>                         | 60401, 60402, 60404 - 60407, 60409, 60412 |



This site provides general information relevant for all product groups covered by NFR 2.D. For more specific information and data please refer to the category-specific sites linked above.

Please note: Emissions from **2.D.3.b & c** are not calculated via the solvent containing model and therefore **excluded from this description and trend discussion**.

### General description for 2.D.3.a, d, e, f, g, h and i

| Category Code       | Method | AD | EF |
|---------------------|--------|----|----|
| 2.D.3.a,d,e,f,g,h,i | T2     | NS | CS |

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub>                                                                               | NM VOC                         | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|-----------------------------------------------------------------------------------------------|--------------------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA                                                                                            | <b>L/-</b><br><b>(2.D.3.a)</b> | NA              | NA              | NA                | NA               | NA  | NA | NA | NA           | NA   |
| <b>L/-</b> key source by <b>Level</b> only                                                    |                                |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>Trend</b> only                                                    |                                |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>Level</b> and <b>Trend</b>                                   |                                |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/-</b> no key source for this pollutant                                                   |                                |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b> emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |                                |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b> emission of specific pollutant <b>Not Estimated</b> (yet)                           |                                |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b> specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |                                |                 |                 |                   |                  |     |    |    |              |      |
| * no analysis done                                                                            |                                |                 |                 |                   |                  |     |    |    |              |      |

'NMVOC' is defined in accordance with the VOC definition found in the EC solvents directive. For purposes of the definition of solvents, the term 'solvent use' is also defined in accordance with the EC solvents directive.

## Method

NMVOC emissions are calculated in accordance with a product-consumption-oriented approach.

In this approach, solvent-based products or solvents are allocated to the source category, and then the relevant NMVOC emissions are calculated from those solvent quantities via specific emission factors. Thus, the use of this method is possible with the following valid input figures for each product group:

- Quantities of VOC-containing (pre-) products and agents used in the report year,
- The VOC concentrations in these products (substances and preparations),
- The relevant application and emission conditions (or the resulting specific emission factor).

The quantity of the solvent-based (pre-)product corresponds to the consumption, e.g. the production plus imports minus exports.

$$EM_{NMVOC} = AD_{(consumption\ of\ product\ X)} \times solvent\ content \times EF_{NMVOC}(product\ X)$$

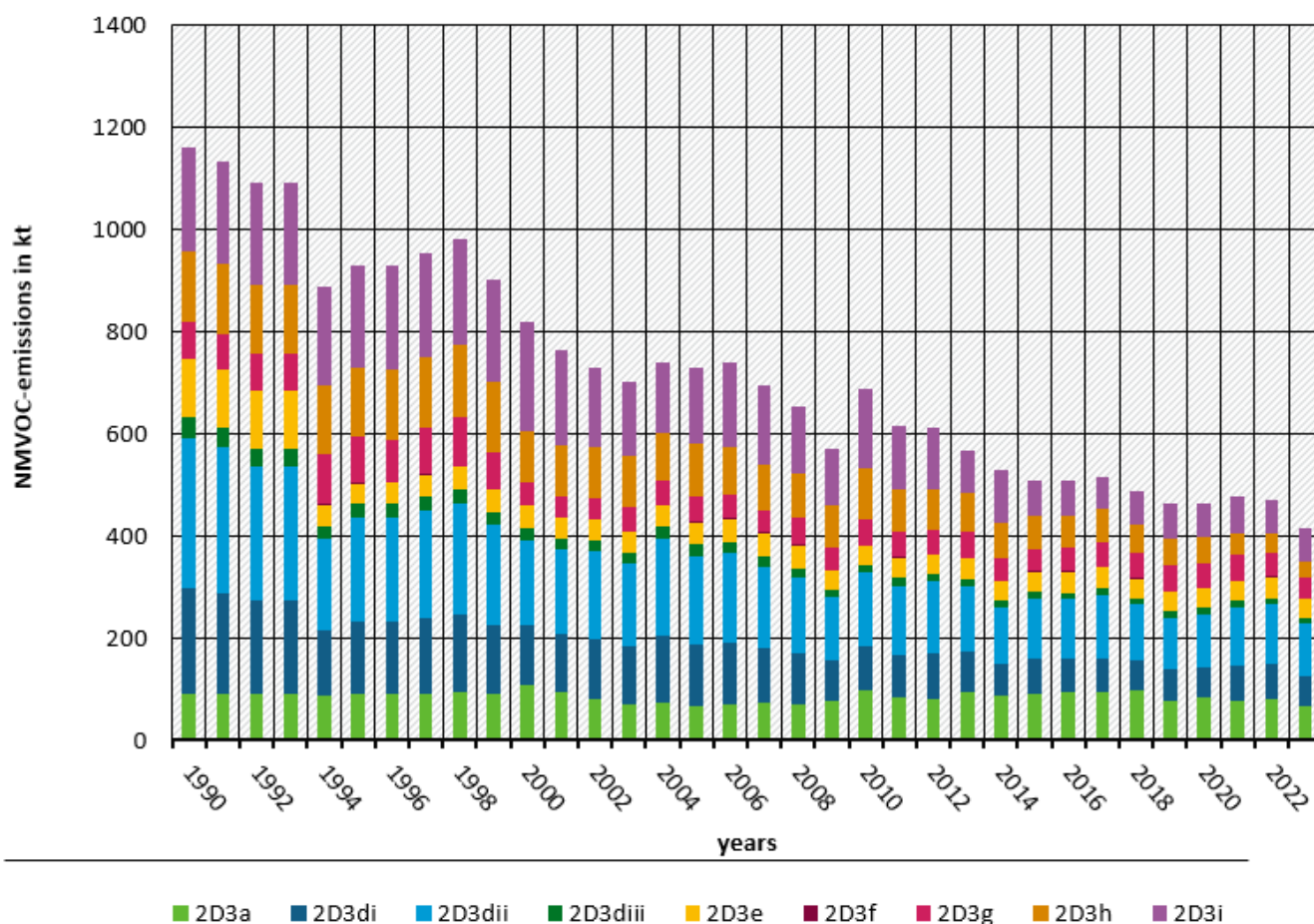
The calculated NMVOC emissions of different product groups for a source category are then aggregated.

The product / substance quantities used are determined at the product-group level with the help of production and foreign-trade statistics. Where possible, the so-determined consumption quantities are then further verified via cross-checking with industry statistics.

## Discussion of emission trends

Since 1990, so the data, NMVOC emissions from use of solvents and solvent-containing products in general have decreased by nearly 60%. The main emissions reductions have been achieved in the years since 1999. This successful reduction has occurred especially as a result of regulatory provisions such as the 31st Ordinance on the execution of the Federal Immissions Control Act (Ordinance on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain facilities – 31. BImSchV)<sup>1)</sup>, the 2nd such ordinance (Ordinance on the limitation of emissions of highly volatile halogenated organic compounds – 2. BImSchV)<sup>2)</sup> and the TA Luft.

### NMVOC-emissions from solvents-based products and applications (2.D.3.a,d-i)



## Uncertainties

Uncertainties for emissions for each product were obtained by error propagation and refer to the 95% confidence interval. For the majority of activity data (domestic consumption) based on official statistics, a relative uncertainty of  $\pm 10\%$  has been applied.



Regarding the solvent content, for each product a relative error at  $\pm 15\%$  was applied, but not exceeding 100% or falling below 0%.

As for emission factors, for each product a relative error at  $\pm 15\%$  was applied, but not exceeding 100% or falling below 0%. Hence the overall uncertainty of emissions caused by application of products of this source group is 40% with exception of 'antifreeze agents for cars' at 60%.

## Recalculations

Routinely, NMVOC emissions of the last year covered by the previous submission are updated with final data of the foreign trade statistics.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements

There are not yet implemented review recommendations for categories in 2.D.3 solvent use due to an missing national sector expert. In detail an improvement should be carried out

- for the description of solvent use over the years especially emission factors and solvent consumption (all categories)
- for the description of how the impact of regulations mentioned in the IIR 2024 has been determined (all categories)
- for trend explanation (2D3f and 2D3h)
- in reallocation of NMVOC emissions related to pesticides from source category 2.D.3.a to 2.D.3.i, concrete additives and plant protectives from source category 2.D.3.i to source category 2.G
- in trying to use surrogate data to avoid trend inconsistency (2.D.3.e)
- merge time-series in one unique consistent series by using methods to resolve data gap (2.D.3.e)

To fulfill all these tasks fundamental changes to the method descriptions and extensive research need to be done. How this can be accomplished still needs to be clarified. The tasks only could be executed according to their priority rank of all tasks.

Improvements specific for the several sub-categories are provided on the category-specific sites linked above.

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<sup>1)</sup> 31. BImSchV: Ordinance on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain facilities; [https://www.gesetze-im-internet.de/bimschv\\_31\\_2024/BJNR0070A0024.html](https://www.gesetze-im-internet.de/bimschv_31_2024/BJNR0070A0024.html)

<sup>2)</sup> 2. BImSchV: Ordinance on the limitation of emissions of highly volatile halogenated organic compounds; [https://www.gesetze-im-internet.de/bimschv\\_2\\_1990/index.html](https://www.gesetze-im-internet.de/bimschv_2_1990/index.html)

## 2.D.3.a - Domestic Solvent Use, including Fungicides

### Short description



For a general product and method description refer to [2.D.3](#). This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level.

The following product groups are taken into consideration:

#### i) Domestic solvent use (SNAP code 60408)

- **Soaps**
- **Laundry detergents, dishwashing detergents and cleaning products** (fabric softeners; universal detergents; washing agents; auxiliary washing preparations; dishwashing liquids; detergents for dishwashers; floor detergents; carpet shampoos; car cleaning shampoos; glass cleaners; WC cleaners)
- **Care products for footwear, leather articles, furniture, floors and cars**
- **Polishing agents** (for metal)
- **Deodorizers** (for rooms and others)
- **Perfumes** (including after shaves; eau de toilette, perfumes)
- **Cosmetic and make-up preparations** (make-up; hand care products; nail care products; pedicure products; face cleanser; suntan lotions; face and body care products and others)
- **Shampoos and hair care products** (shampoos; preparations for permanent waving or straightening; hair sprays; lotions and brilliantines; toning shampoos; hair colouring products; hair bleaching and other)
- **Other personal care products** (shaving creams; personal deodorants and antiperspirants; bath essences; depilatories, deodorants, preparations for intimate hygiene and other)
- **Antifreeze agents for cars**

#### ii) Domestic use of pharmaceutical products (SNAP code 60411)

#### Specific information

Calculation of domestic consumption was based on:

- the German production statistics and external trade statistics for the subgroup “Domestic solvent use”.
- turnover values of pharmaceuticals produced in Germany for the subgroup “Domestic use of pharmaceutical products”,

Solvent contents for this product group corresponds to personal information from industrial associations and German literature <sup>1)</sup>.

For alcohol-based cleaning detergents an emission factor of 3% was assumed for calculations <sup>2)</sup>. For all other products of this source category (e.g. hair spray, after shave, perfumes), an emission factor of 95% was applied.

### Discussion of emission trends

#### Specific information

Until 1999, data of the present source categories 2.D.3.a, 2.D.3.h and 2.D.3.i were treated as one source group. Since 2000, a more detailed data collection enables to follow the development of source group 2.D.3.a, which accounts for about 8 to 20 per cent of total NMVOC emissions from solvent-based products. For more than 30 years there have not been observed a

decreasing trend.

The following four product groups account for 44 to 69 per cent of 2.D.3.a emissions:

- hair sprays,
- antifreeze agents for cars,
- eau de toilette
- pharmaceutical products.

As emission factors and solvent contents largely remained robust since 2000, domestic consumption of products caused visible changes in NMVOC emissions. For instance, the annual amount of used 'antifreeze agents for cars' primarily depends on the weather situation of the specific year. As antifreeze agents have one of the highest domestic consumption values of the category 'domestic solvent use', they significantly effect the final value of emitted NMVOC of this category. The increase in emissions in 2010 can be explained by a long-lasting cold season. For few product groups, such as personal deodorants, antiperspirants and car surface protectants, domestic consumption and hence NMVOC emissions show a declining trend compared to 2005. However, for many product groups, such as soaps, hair sprays, eau de toilette and pharmaceutical products domestic consumption and emissions increased for in the same period.

## Uncertainties



For the majority uncertainties of activity data (domestic consumption) and emission factors see [2.D.3.](#)

For the product group of 'antifreeze agents for cars' a relative uncertainty of  $\pm 20\%$  is applied for the activity data and of  $\pm 25\%$  for the emission factors based on expert estimation.

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<sup>1)</sup> Berner (1996): Berner, P.: Maßnahmen zur Minderung der Emissionen flüchtiger organischer Verbindungen aus der Lackanwendung - Vergleich zwischen Abluftreinigung und primären Maßnahmen am Beispiel Baden-Württembergs, Stuttgart: Institut für Energiewirtschaft und Rationelle Energieanwendung, Universität Stuttgart, Forschungsbericht Band 42, 1996 - Dissertation, Stuttgart, 1996

<sup>2)</sup> Wooley et al. (1990): Wooley, J., Nazaroff, W.N., Hodgson, A.T.: Release of ethanol to the atmosphere during use of consumer cleaning products, J. Air Waste Manage. Assoc. 40, 1114-1120, Berkeley, California, 1990.

## 2.D.3.b - Road Paving

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.D.3.b                                                                                   | T1                                   | AS | CS |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | PCDD/F | PAHs | HCb | PCBs |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|--------|------|-----|------|
| -/-                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | -/-    | -/-             | NA              | -/-               | -/-              | -/- | NE | IE | NA           | NA     | NE   | NA  | NA   |
| <b>L/-</b> key source by <b>L</b> evel only<br><b>-/T</b> key source by <b>T</b> rend only<br><b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend<br><b>-/-</b> no key source for this pollutant<br><b>IE</b> emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category)<br><b>NE</b> emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)<br><b>NA</b> specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable<br><b>*</b> no analysis done |        |                 |                 |                   |                  |     |    |    |              |        |      |     |      |

Currently, the report tables list produced quantities of mixed asphalt products (from stationary installations only) and NMVOC, NO<sub>x</sub> and SO<sub>2</sub> emissions caused of this. Only emissions from asphalt production are reported. Figures relative to emissions released during laying of asphalt have not been examined.

### Method

#### Activity data

The applicable quantity of mixed asphalt products produced (activity rate) has been taken from communications of the

Deutscher Asphaltverband (DAV; German asphalt association). In total about 660 asphalt-mixing plants produce most recently 38 Million tonnes of hot-mix for road paving <sup>1)</sup>.

## Emission factors

Emission factors have been determined country-specifically, pursuant to Tier 2. For determination of emission factors for emissions measurements from over 400 asphalt-mixing plants, made during the period 1989 through 2000, were used. The majority of the emissions occur during drying of pertinent mineral substances. Almost all of the NMVOC emissions originate in the organic raw materials used, and they are released primarily in parallel-drum operation, as well as from mixers and loading areas. On average, about 50% of the NO<sub>x</sub> and SO<sub>x</sub> involved come from the mineral substances (proportional process emissions). CO emissions are calculated solely in connection with fuel inputs.

Table 1: Overview of applied emission factors for production of mixed asphalt, in [kg/t]

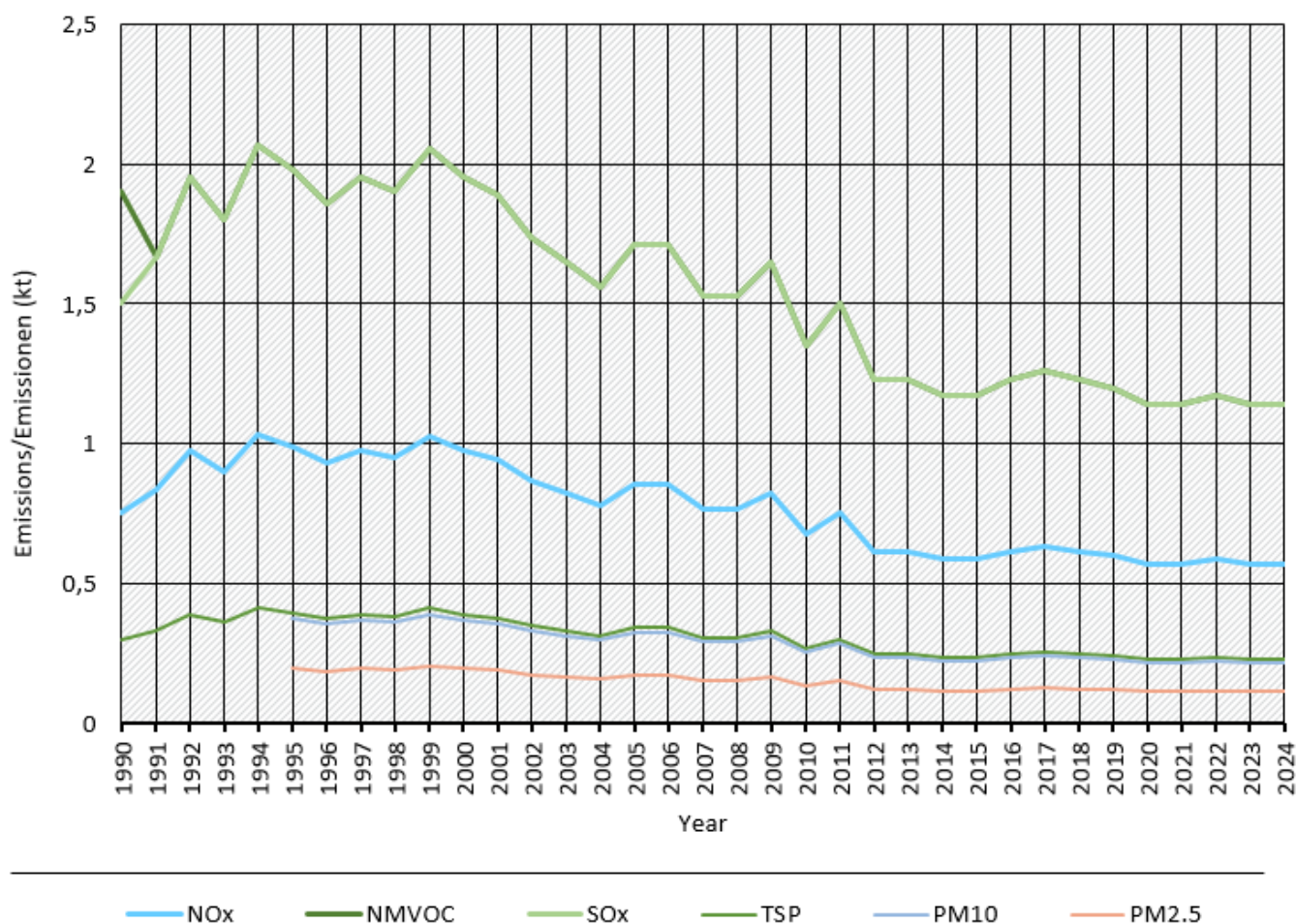
|                         | EF value | EF trend |
|-------------------------|----------|----------|
| <b>NMVOC</b>            | 0.030    | constant |
| <b>NO<sub>x</sub></b>   | 0.015    | constant |
| <b>SO<sub>x</sub></b>   | 0.030    | constant |
| <b>TSP</b>              | 0.006    | constant |
| <b>PM<sub>10</sub></b>  | 0.0057   | constant |
| <b>PM<sub>2.5</sub></b> | 0.003    | constant |

## Trends in emissions

All trends in emissions correspond to trends of production amount. No rising trends are to identify.

## Trends of Emissions in Germany from road paving

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

### Emission trends of road paving

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> <https://asphalt.de/fachinformationen-asphaltproduktion/>

## 2.D.3.c - Asphalt Roofing

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.D.3.c                                                                                   | T1                                   | AS | CS |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | PCDD/F | PAHs | HCB | PCBs |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|--------|------|-----|------|
| NA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | -/-    | NA              | NA              | -/-               | -/-              | -/- | NA | NA | NA           | NA     | NE   | NA  | NA   |
| <b>L/-</b> key source by <b>L</b> evel only<br><b>-/T</b> key source by <b>T</b> rend only<br><b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend<br><b>-/-</b> no key source for this pollutant<br><b>IE</b> emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category)<br><b>NE</b> emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)<br><b>NA</b> specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable<br><b>*</b> no analysis done |        |                 |                 |                   |                  |     |    |    |              |        |      |     |      |

Bitumen is used in production and laying of roof and sealing sheeting. Roof and sealing sheeting is laid by means of both hot and cold processes.

The hot process, involving welding of sheeting, produces significant emissions of organic substances.

The relevant emissions trends depend primarily on trends in quantities of polymer bitumen sheeting produced. Use of solvent-containing primers is not considered here; it is covered via the solvents model – cf. 2.D.3.a Domestic Solvent Use.

Because of importance from other sources as solvents use, NMVOC emissions are considered and taken into account in this part of the emissions inventory.

## Method

### Activity data

Since a cooperation agreement was concluded, annual quantities of roof and sealing sheeting produced (activity data) are provided by the Verband der Dachbahnenindustrie (VDD) <sup>1)</sup>, the roof-sheeting manufacturers association (VDD, actual table exchanged with UBA).

### Emission factors

#### NMVOC

In the process, a distinction is made between emissions from (i) the production and (ii) the laying of roof and sealing sheeting.

The emission factor for **production of roof and sealing sheeting** was obtained via a calculation in accordance with current technological standards of German manufacturers (VDD, see activity data).

The emission factor for laying of **polymer-bitumen sheeting** has been derived from an ecological balance sheet <sup>2)</sup>.

The implied emission factor applied for the entire source category has been increasing slightly, as a result of the increasing impact of polymer-bitumen sheeting. However, since no pertinent detailed data are available, NMVOC emissions are calculated in keeping with a Tier 1 method.

Table 1: Overview of applied NMVOC emission factors, in [kg/m<sup>2</sup>]

| source of emissions             | EF value             | EF trend           |
|---------------------------------|----------------------|--------------------|
| production of roofing materials | 0.00035795           | constant over time |
| roofing of sheeting and shingle | 0.000027 to 0.000040 | rising             |

Please note that emissions from the use of solvents are reported within the specific categories of solvents-use as based on the underlying model. Therefore, the emission factors applied here are comparably low. The trend of emission is not influenced importantly by the changing use of material types.

#### PM

During reviews a recommendation was developed: Germany should include an emission estimate for the PM components. Following this we have newly implemented EF for PM with the submission 2026.

The Guidebook Tier 1 method is used (EMEP/EEA, 2023) <sup>3)</sup>, but the reference used is tonnage [t], not the area produced in m<sup>2</sup> as required for national calculations. Therefore, the default emission factor for PM provided in [g PM per Mg shingle] only can be applied with converted national activity data.

So the calculation of the bitumen consumption for the roofing materials is used for the national bitumen quantities.

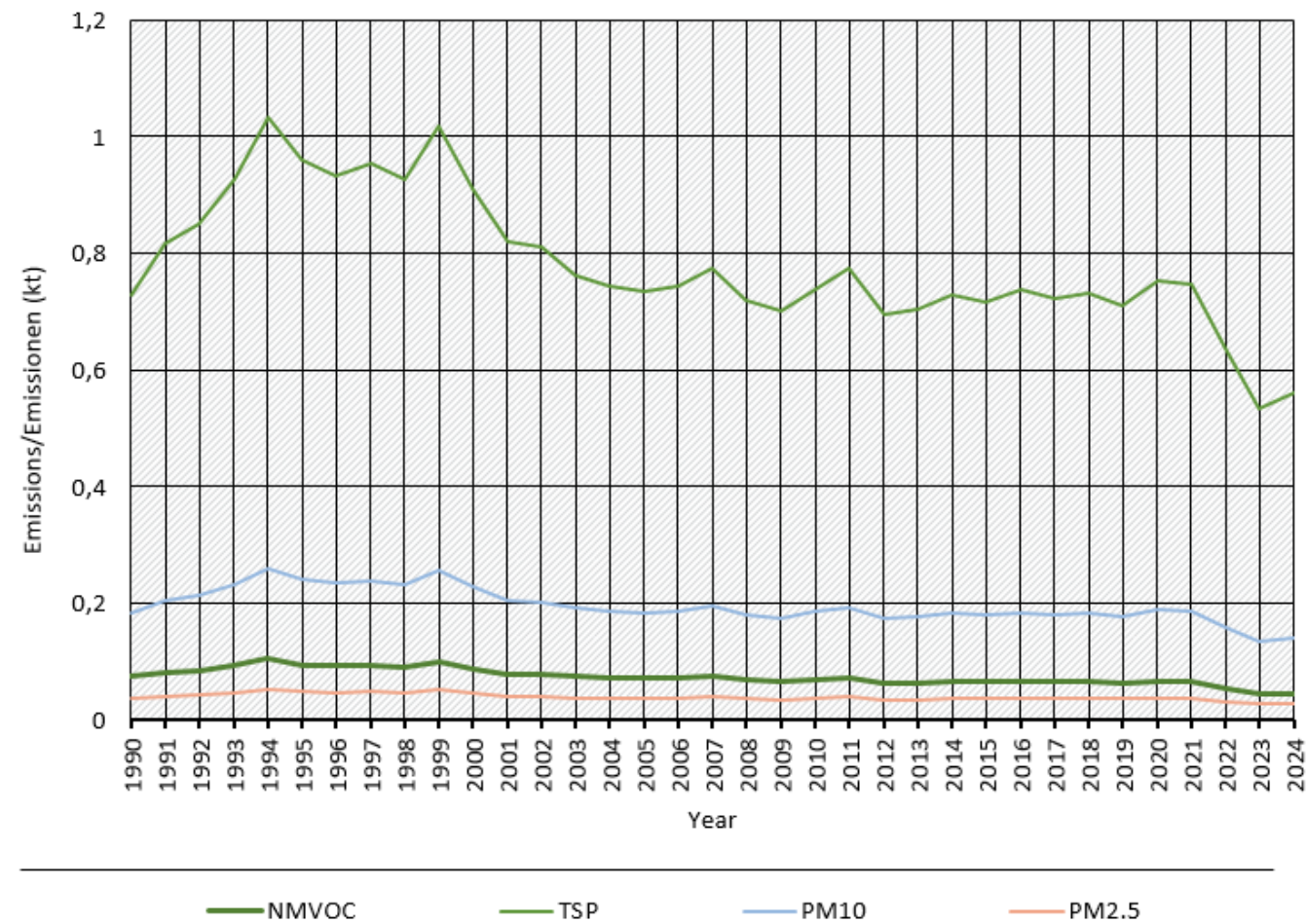
## Trends in emissions

The trend of emissions corresponds to the trend of produced amounts. No rising trends are to identify.



## Trends of Emissions in Germany from asphalt roofing

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

### Emission trends of road paving

## Recalculations

Recalculations were necessary due to first use of PM EF for the whole time series.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

- 
- <sup>1)</sup> vdd Industrierband Dach- und Dichtungsbahnen e. V. (VDD);  
<https://www.derdichtebau.de/vdd-industrieverband-dach-und-dichtungsbahnen-e-v/>
- <sup>2)</sup> Kreißig, J. (1996): Ganzheitliche Bilanzierung von Dachbahnen aus Bitumen : Kurzbericht. Frankfurt am Main, 1996
- <sup>3)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023;  
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-d-2-l-other/2-d-3-c-asphalt/@download/file>; Copenhagen, 2023

## 2.D.3.d - Coating Application

### Short Description



For a general product and method description refer to [2.D.3](#). This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level and trend.

This source category comprises NMVOC emissions from the use of solvent-based products of three major sub-categories: Decorative coating applications, industrial coating applications and other non-industrial paint application.

The following product groups are taken into consideration:

#### i) Decorative coating applications:

- **Application of paints and lacquers in Car repairing (SNAP code 60102)**
- **\*Professional application of paints and lacquers for Construction and Building (SNAP code 60103)** (emulsion paints for indoor application; silicate exterior paints; synthetic resin plasters / silicate; varnishes; primers and protection coatings; other coatings)
- **Do-it-yourself application of paints and lacquers for Building (SNAP code 60104)** (emulsion paints for indoor application; silicate exterior paints; synthetic resin plasters / silicate; varnishes; primers and protection coatings; other coatings)
- **Application of paints and lacquers for Wood surfaces (SNAP code 60107)** (wooden interiors, carpentry)

#### ii) Industrial coating applications

- **Application of paints and lacquers for Manufacture of cars (SNAP code 60101)** (primers, fillers, top coat / clear lacquers)
- **Application of paints and lacquers for Car Repairing of commercial vehicles (SNAP code 60102)**
- **Application of paints and lacquers for Coil Coating (SNAP code 60105)**
- **Application of paints and lacquers for Boat Building (SNAP code 60106)**
- **Application of paints and lacquers for Wood surfaces (SNAP code 60107)** (furniture)
- **Other industrial paint application (SNAP code 60108)** (such as paint spray, electrical appliances, mechanical engineering, automotive accessories, metal goods, wire enamel, synthetic materials, paper/foil)

#### iii) Other non-industrial paint application (SNAP code 60109)

- **marking paints**
- **corrosion protection**
- **other**

### Method

#### Specific information

An emission factor of 95% was allocated to all open applications (e. g. all decorative coating applications). For installation-related industrial applications specific emission factors were assessed and applied.

### Discussion of emission trends

### Specific information

After the reunification of East and West Germany, the paints and coating application industries had economically good years. The emissions from 1990 to 1993 stayed on a high level. After 1993, this economic hype ended. In consequence, also the emissions declined. The significant dip in the time series in 1994 may relate to an over-estimation for the years until 1994. But the difference between 1993 and 1994 has to be mainly linked to the enhancement of the emission calculation method as from 1996. Since then national production and foreign trade statistics has been used for the calculation of product and solvent consumption instead of expert judgements. However, a recalculation could only be done backwards to the year 1994 due to the unavailability of production and foreign trade statistics in the necessary differentiation before (German reunification). Since 2000, a more detailed data collection procedure enables to follow the development of different applications, which altogether account for 35-47 % of total NMVOC emissions from solvent-based products.

The clear decrease in the NMVOC emissions in 2.D.3.d has ended in 2015.

The following seven applications caused major emissions and developments in category 2.D.3.d: Wooden furniture, Mechanical engineering, Varnishes DIY, Varnishes professional, Wooden interiors, Manufacture of cars and Corrosion protection

A major reason for the decrease of overall emissions in this source category is the fulfillment of the Decopaint-Directive according to maximum solvent contents. The German "Blauer Engel" ("Blue Angel") environmental quality seal supported this development by certifying a range of products, including low-solvent paints and lacquers.



For general uncertainties, recalculations and improvements of activity data and emission factors see [2.D.3.](#)

## 2.D.3.e - Degreasing

### Short Description



For a general product and method description refer to [2.D.3](#). This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level and trend.

This source category comprises NMVOC emissions from the use of solvents in following processes:

- **Metal degreasing (SNAP code 60201)**
- **Electronic component manufacturing (SNAP code 60203)**
- **Other industrial cleaning (SNAP code 60204)** (e.g. precision mechanics, optics, manufacture of watches and clocks)

### Discussion of emission trends

#### Specific information

Until 1999, data of the present source categories 2.D.3.e and f were treated as one source group. From 1990 to 1993 only a rough expert estimation was carried out, which since 1994 in a first step and since 2000 in a second step could be improved by a more detailed data collection that enables to follow the development of source group 2.D.3.e. Since 2000, the share of this source group accounts for about 5-9 % of total NMVOC emissions from solvent-based products on a very stable niveau.

### Uncertainties

The relative overall uncertainty of emissions caused by applications of this source group is estimated at 50%.



For general uncertainties, recalculations and improvements of activity data and emission factors see [2.D.3](#).

## 2.D.3.f - Dry Cleaning

### Short Description



For a general product and method description refer to [2.D.3](#). This site only contains product group specific information.

This source category comprises NMVOC emissions from **Solvent application for professional textile cleaning (SNAP code 60202)**. The German inventory summarizes hydrocarbon solvents and perchloroethylene as solvent.

### Discussion of emission trends

#### Specific information

Until 1999, data of the present source categories 2.D.3.e and f were treated as one source group. Source group 2.D.3.f accounts for about not more than 0.3 % of total NMVOC emissions from solvent-based products and remained stable.

### Uncertainties

The overall uncertainty of emissions caused by applications of this source group is estimated as 50%.



For general uncertainties, recalculations and improvements of activity data and emission factors see [2.D.3](#).

## 2.D.3.g - Chemical Products



original inventory data  
for bitumen blowing

### Short description



For a general product and method description refer to [2.D.3](#). This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level.

Source category *NFR 2.D.3.g - Chemical products* comprises NMVOC emissions from the use of solvents in the following manufacture processes:

- Polyester processing (SNAP code 60301)
- Polyvinylchloride processing (SNAP code 60302)
- Polyurethane processing (SNAP code 60303)
- Polystyrene foam processing (SNAP code 60304)
- Rubber processing (SNAP code 60305)
- Pharmaceutical products manufacturing (SNAP code 60306)
- Manufacture of paints and lacquers (SNAP code 60307)
- Manufacture of inks (SNAP code 60308)
- Glues manufacturing (SNAP code 60309)
- [Bitumen blowing](#) (SNAP code 60310)
- Adhesive manufacturing, magnetic tapes manufacturing, photographs manufacturing (SNAP code 60311)
- Textile finishing (SNAP code 60312)
- Solvents manufacturing(SNAP code 60314):
  - Manufacture of wood preservatives
  - Manufacture of building material additives
  - Manufacture of solvent-based consumer goods
  - Manufacture of surface cleaning agents
  - Manufacture of antifreeze agents and de-icers
  - Manufacture of waxing and dewaxing agents
  - Manufacture of paint strippers

### Discussion of emission trends

#### Specific information

The data recording of source category 2.D.3.g started in 1990. Since 2000, a more detailed data collection procedure enables to follow the development of different applications, which altogether accounts for about 6-11 % of total NMVOC emissions from solvent-based products. Since that time total emissions of NMVOC emissions of 2.D.3.g remain relatively stable. In some major activities amounts of NMVOC emissions raised, such as from solvents used in polystyrene foam processing and the manufacture of solvent-based consumer products.

### Bitumen blowing

## Method

Bitumen used for road paving, roof coating and other application like pipe sealing needs some enhanced properties that can be achieved by air blowing.

This is done in so-called *bitumen blowing units* (BBU) that can operate either in continuous or in batch mode. The BBU usually are located in refineries or can be part of road paving or roof coating plants.

Thermal post-combustion in combination with closed capture systems to control emissions are best available technology and demanded by relevant legislation in Germany.

In the EMEP/EEA air pollutant emission inventory guidebook 2023 <sup>1)</sup>, tier2 emission factors for bitumen blowing are presented for NMVOC, TSP, Cd, As, Cr, Ni, Se and PAH. As most of them are unreferenced and based on US plants before 1980 they seem to be unsuitable to represent national conditions. Therefore, country-specific emission factors are applied instead.

## Activity data

The applicable quantities of treated bitumen are calculated from the total-bitumen-production figures published annually by the Federal Office of Economics and Export Control (BAFA), in its official mineral-oil data (Amtliche Mineralölstatistik) (BAFA, 2024) <sup>2)</sup>.

The applicable percental share of blown bitumen was obtained from a one-time data survey of the association Arbeitsgemeinschaft der Bitumenindustrie e.V (bitumen industry working group) <sup>3)</sup> that was carried out for the year 1994 and in the framework of the research project (Theloke et al., 2000) <sup>4)</sup> commissioned by the Federal Environment Agency (UBA). The percentage share remains constant for all years in question, and it amounts to 10%.

## Emission factors

NMVOC and PAH emissions from bitumen blowing are calculated with emission factors derived from the uncontrolled standard emission factor of the EMEP/EEA air pollutant emission inventory guidebook 2023 <sup>5)</sup> taking account of the maximum permitted levels and reduction-measures requirements specified in the Technical Instructions on Air Quality Control (TA Luft).

The emission factors for Cd, Cr and Ni were derived from original measurements with an increased safety factor (maximum or ten-fold).

All emission factors remain constant for all years in question.

Table 1: Overview of tier-2 emission factors applied for bitumen blowing with post-combustion

|              | EF 2010 | Unit | Reference                                               |
|--------------|---------|------|---------------------------------------------------------|
| <b>NMVOC</b> | 27.20   | g/t  | based on EMEP/EEA (2023) <sup>6)</sup>                  |
| <b>TSP</b>   | 10.00   | g/t  | from measurements (Trumbore et al., 1998) <sup>7)</sup> |
| <b>Cd</b>    | 0.03    | mg/t | from measurements (Trumbore et al., 1998)               |
| <b>As</b>    | 0.50    | mg/t | default from EMEP/EEA (2023) <sup>8)</sup>              |
| <b>Cr</b>    | 4.00    | mg/t | from measurements (Trumbore et al., 1998)               |
| <b>Ni</b>    | 21.00   | mg/t | from measurements (Trumbore et al., 1998)               |
| <b>Se</b>    | 0.50    | mg/t | default from EMEP/EEA (2023)                            |
| <b>PAH</b>   | 2.55    | mg/t | based on EMEP/EEA (2023)                                |

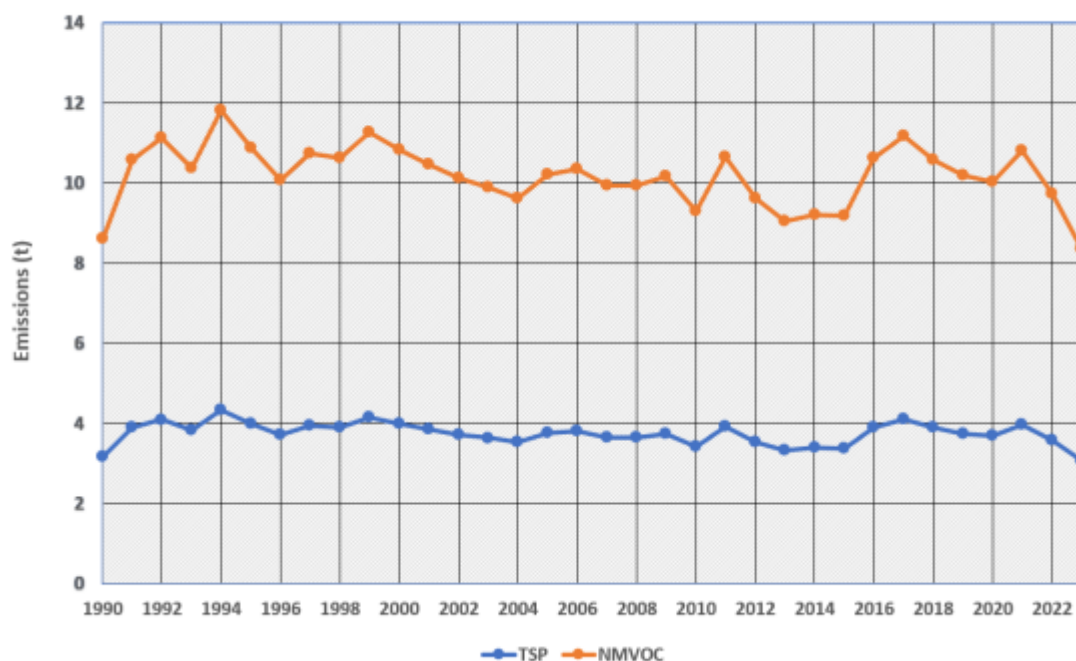
## Discussion of emission trends

All trends in emissions correspond to trends of the production development. No rising trends are to identify.



## trends of emissions of bitumen blowing

Emissions by pollutant



Trend of annual NMVOC and TSP emissions from bitumen blowing

## Uncertainties

Emission factors: Relative error rates at  $\pm 15\%$  and  $\pm 25\%$  (Adhesive manufacturing, magnetic tapes manufacturing, photographs manufacturing) were applied, but not exceeding 100% or falling below 0%.

For **bitumen blowing** emission factor uncertainties are on a higher level just to 100%. For Cd and TSP the uncertainty are even greater than a factor of two.



For general uncertainties, recalculations and improvements of activity data and emission factors see 2.D.3.

<sup>1), 5), 6), 8)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-d-2-l-other/2-d-3-g-chemical/view>, table 3-8., Copenhagen, 2023

<sup>2)</sup> BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Amtliche Mineralöl-daten für die Bundesrepublik Deutschland; [https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2023\\_12.xlsx?\\_\\_blob=publicationFile&v=2](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2023_12.xlsx?__blob=publicationFile&v=2), Eschborn, 2024.

<sup>3)</sup> Eisele, F.: oral information of the Arbeitsgemeinschaft der Bitumenindustrie e.V, Persönliche Information, Institut für Energiewirtschaft und Rationelle Energieanwendung (IER), Universität Stuttgart, Stuttgart

<sup>4)</sup> Theloke et al. (2000): Theloke J., Obermeier A., Friedrich R.: Ermittlung der Lösemittelmissionen 1994 in Deutschland und Methoden zur Fortschreibung; <https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/2484.pdf>; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2000

<sup>7)</sup> Trumbore, D. C. (Owens Corning, Asphalt Technology Laboratory, Summit, IL 60501; Spring 1998): The Magnitude and Source of Air Emissions from Asphalt blowing operations. *Environmental Progress*, Vol. 17, No. 1; <https://onlinelibrary.wiley.com/doi/epdf/10.1002/ep.670170120>

## 2.D.3.h - Printing



For a general product and method description refer to [2.D.3](#). This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level and trend.

This source category comprises NMVOC emissions from the **use of solvent-based products during printing and in arts (SNAP code 60403)**. The following technologies / applications / products are taken into consideration:

- **Offset printing** (coldset web presses)
- **Sheetfed offset** (conventional; UV colours)
- **Offset printing** (heatset)
- **Endless offset printing**
- **Printing of books**
- **Flexography** (solvent-based inks; water-based inks)
- **Rotogravure package printing** (solvent-based inks; water-based inks)
- **Publication gravure printing**
- **Screen printing**
- **Other printing applications**
- **Inks / paints for artists**
- **Ink for writing and drawing**

### Method

#### Specific information

Solvent contents and emission factors for the different printing technologies are based on a study carried out in 1999 by Jepsen et al.<sup>1)</sup>

### Discussion of emission trends

#### Specific information

Until 1999, data of the present source categories 2.D.3.a, 2.D.3.h and 2.D.3.i were treated as one source group. Since 2000, a more detailed data collection enables to follow the development of source group 2.D.3.h, which accounts for about 8 - 15 % of total NMVOC emissions from solvent-based products. Emissions of this source group decreased in the whole time-series more than 70 % among others due to minor application of isopropanol and more environmentally friendly technologies.

Furthermore, the importance of single technologies changed (e.g. printing of books got less important, digital printing raises gained in importance), which influences total emissions of 2.D.3.h.



For general uncertainties, recalculations and improvements of activity data and emission factors see [2.D.3](#).

<sup>1)</sup> Jepsen et al. (19990): Jepsen, D., Grauer, A., Tebert, C.: Ermittlung des Standes der Technik und der Emissionsminderungspotenziale zur Senkung der VOC-Emissionen aus Druckereien, Ökopool GmbH on behalf of the Umweltbundesamt, FKZ 297 44 906/01,  
[https://oekopol.de/oekopol\\_archiv/de/Archiv/betrieblicher%20und%20kommunaler%20US/voc\\_druckereien/vocdekurz.pdf](https://oekopol.de/oekopol_archiv/de/Archiv/betrieblicher%20und%20kommunaler%20US/voc_druckereien/vocdekurz.pdf),

Berlin / Dessau-Roßlau, 1999.

## 2.D.3.i - Other Solvent Use

### Short description



For a general product and method description refer to [2.D.3](#). This site only contains product group specific information.

This category is a key source of NMVOC emissions in terms of emissions level and trend.

In source category *2.D.3.i - Other Solvent Use*, emissions from various product groups and processes are reported. Relevant pollutants are NMVOC and some heavy metals.

Emissions from lubricants use in stationary and mobile applications were reported here just to the submission 2023. Then emissions of all lubricants use are reallocated to 2.G.4 due to a NECD review recommendation.

| NO <sub>x</sub> | NMVOC | SO <sub>2</sub>                                                                        | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCB | PCB |
|-----------------|-------|----------------------------------------------------------------------------------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|------|-----|-----|
| NA              | L/T   | NA                                                                                     | NA              | NA                | NA               | NA  | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA     | NA    | NA    | NA    | NA    | NA   | NA  | NA  |
|                 |       | L/- key source by <b>Level</b> only                                                    |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |       | -/T key source by <b>Trend</b> only                                                    |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |       | L/T key source by both <b>Level</b> and <b>Trend</b>                                   |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |       | -/- no key source for this pollutant                                                   |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |       | IE emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |       | NE emission of specific pollutant <b>Not Estimated</b> (yet)                           |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |       | NA specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |       | * no analysis done                                                                     |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |

### 2.D.3.i - Other solvent use

#### Method

In sub-category *2.D.3.i - Other product use: Other solvent use* the following product groups and processes are taken into consideration:

- **Glass and mineral wool enduction (SNAP code 60401/02)**
- **Fat, edible and non-edible oil extraction (SNAP code 60404)**
- **Application of glues and adhesives (SNAP code 60405)** (paper and packaging; wood; footwear; transport; Do-it-yourself-applications; others)
- **Preservation of wood (SNAP code 60406)**
- **Underseal treatment and conservation of vehicles (SNAP code 60407)**
- **Vehicles dewaxing (SNAP code 60409)**
- **Other: (SNAP code 60412)**
  - Plant protectives
  - Dichloromethane in strippers
  - Removal of paints from incorrectly coated aluminium parts
  - Removal of paint from steel parts
  - Concrete additives
  - De-icing (Aircraft de-icing; De-icing of operated areas; Other de-icing applications)
  - Applications in scientific laboratories (R&D; analyses; universities)

#### Discussion of emission trends

#### Specific information

Until 1999, data of the present source categories 2.D.3.a, 2.D.3.h and 2.D.3.i were treated as one source group.

Since 2000, a more detailed data collection enables to follow the development of source category 2.D.3.i, which accounts for about 12 to 26 % of total NMVOC emissions from solvent-based products.

The following product groups cause major emissions in category 2.D.3.i:

- Concrete additives,
- Underseal treatment and conservation of vehicles,
- Application of glues and additives,
- Deicing and
- Fat, edible and non-edible oil extraction

In total, these six activities account for between 88 and 93 per cent of total NMVOC emissions from 2.D.3.i.

A decrease in these NMVOC emissions can be observed since 2005 mainly due to a clearly reduced consumption of concrete additives.

## Uncertainties

Uncertainties for emissions for each technology / application were obtained by error propagation and refer to the 95% confidence interval.

Exceptions were de-icing applications, applications in scientific laboratories with a relative error at 25%.



For general uncertainties, recalculations and improvements of activity data and emission factors see [2.D.3](#).

NFR 2.G includes emissions from fireworks, tobacco, charcoal used for barbecues and the stationary and mobile application of lubricants.

Not included is the use of shoes (SNAP code 060603): Here, according to the EMEP/EEA Guidebook 2023, only the manufacturing of shoes is a relevant sector for application of adhesives and therefore a likely source of NMVOC emissions. Also, the default emission factor for NMVOC in table 3-16 - *Tier 2 emission factor for source category 2.D.3.i, 2.G Other solvent and product use. Other. Use of Shoes* refers to the manufacturing process and not the use of shoes<sup>11</sup>.

For detailed information on applied methods, activity data, emission factors, emissions and recalculations, please refer to the sub-chapters linked below.

| Category Code                                                                             | SNAP Code                            | Method | AD     | EF    |
|-------------------------------------------------------------------------------------------|--------------------------------------|--------|--------|-------|
| Use of Fireworks                                                                          | 060601                               | CS     | NS, AS | D, CS |
| Use of Tobacco                                                                            | 060602                               | T2     | NS     | CS, D |
| Use of Charcoal for barbecues                                                             |                                      | T1     | NS     | D     |
| Use of Lubricants                                                                         | 060604                               | T1, T2 | NS, M  | CS, D |
| Method(s) applied                                                                         |                                      |        |        |       |
| D                                                                                         | Default                              |        |        |       |
| T1                                                                                        | Tier 1 / Simple Methodology *        |        |        |       |
| T2                                                                                        | Tier 2*                              |        |        |       |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |        |        |       |
| C                                                                                         | CORINAIR                             |        |        |       |
| CS                                                                                        | Country Specific                     |        |        |       |
| M                                                                                         | Model                                |        |        |       |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |        |        |       |
| (source for) Activity Data                                                                |                                      |        |        |       |
| NS                                                                                        | National Statistics                  |        |        |       |
| RS                                                                                        | Regional Statistics                  |        |        |       |
| IS                                                                                        | International Statistics             |        |        |       |
| PS                                                                                        | Plant Specific                       |        |        |       |
| As                                                                                        | Associations, business organisations |        |        |       |
| Q                                                                                         | specific Questionnaires (or surveys) |        |        |       |
| M                                                                                         | Model / Modelled                     |        |        |       |
| C                                                                                         | Confidential                         |        |        |       |
| (source for) Emission Factors                                                             |                                      |        |        |       |
| D                                                                                         | Default (EMEP Guidebook)             |        |        |       |
| CS                                                                                        | Country Specific                     |        |        |       |
| PS                                                                                        | Plant Specific                       |        |        |       |
| M                                                                                         | Model / Modelled                     |        |        |       |
| C                                                                                         | Confidential                         |        |        |       |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                    | TSP | BC  | CO  | Pb  | Cd  | Hg | As | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCB | PCB |
|-----------------|--------|-----------------|-----------------|-------------------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|----|----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|------|-----|-----|
| -/-             | L/-    | -/-             | -/-             | L/-               | L/-                                                                                 | -/- | -/- | -/- | -/- | L/- | NA | NA | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-  | -/- | NA  |
|                 |        |                 |                 | L/-               | key source by <b>Level</b> only                                                     |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | -/T               | key source by <b>Trend</b> only                                                     |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | L/T               | key source by both <b>Level</b> and <b>Trend</b>                                    |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                    |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | IE                | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | *                 | no analysis done                                                                    |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |

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<sup>1)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 2.D.3.i, 2.G Other solvent and product use;  
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-d-2-l-other/2-d-3-i-2/@download/file>; Copenhagen, 2023

## 2.G(a) - Fireworks

### Short description

| NFR Code | Name of Category             | Method | AD     | EF    |
|----------|------------------------------|--------|--------|-------|
| 2.G(a)   | Other Product use: Fireworks | CS     | NS, AS | D, CS |

In sub-category of 2.G - *Other product use*, Germany reports the following emissions resulting from fireworks on new years eve and on the rest of the year:

| NO <sub>x</sub>                                                                                 | SO <sub>2</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO  | Pb             | Cd | Hg | As | Cr | Cu  | Ni | Se | Zn | POPs |
|-------------------------------------------------------------------------------------------------|-----------------|-------------------|------------------|-----|----|-----|----------------|----|----|----|----|-----|----|----|----|------|
| -/-                                                                                             | -/-             | -/-               | -/-              | -/- | NE | -/- | -/- until 2003 | NA | NA | NA | NA | -/- | NA | NE | NE | NA   |
| L/- key source by <b>Level</b> only                                                             |                 |                   |                  |     |    |     |                |    |    |    |    |     |    |    |    |      |
| -/T key source by <b>Trend</b> only                                                             |                 |                   |                  |     |    |     |                |    |    |    |    |     |    |    |    |      |
| L/T key source by both <b>Level</b> and <b>Trend</b>                                            |                 |                   |                  |     |    |     |                |    |    |    |    |     |    |    |    |      |
| -/- no key source for this pollutant                                                            |                 |                   |                  |     |    |     |                |    |    |    |    |     |    |    |    |      |
| IE emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                 |                   |                  |     |    |     |                |    |    |    |    |     |    |    |    |      |
| NE emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                 |                   |                  |     |    |     |                |    |    |    |    |     |    |    |    |      |
| NA specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                 |                   |                  |     |    |     |                |    |    |    |    |     |    |    |    |      |
| * no analysis done                                                                              |                 |                   |                  |     |    |     |                |    |    |    |    |     |    |    |    |      |

The sold amounts of fireworks have increased strongly from 1990 to 1995. From 1995 to 1997 the emissions were relatively high but decreased from 1997 to 2000. Since then, the emissions have remained on rather constant level showing only small fluctuations. As the public sale of fireworks were temporarily forbidden in 2020 and 2021 due to corona restrictions, emission estimates for these two years are well below previous years.

In 2022, the restrictions were suspended and the consumed fireworks reached a normal level again. The sales based on the returned fireworks of the previous year. It was not until next year that the import quota normalized. In 2024, **42,589 t** of fireworks were consumed in Germany.

### Methodology

In 2019, measurements were made by a Finnish laboratory for the VPI - Verband der pyrotechnischen Industrie (Association of the pyrotechnical industry) of dust emissions during the burning of fire works. The experiments were made in a container in which the whole fireworks were burned.

In 2020, VPI and UBA had an intensive information exchange, in which the VPI presented the results of these measurements. The different emission factors were discussed and finally, based on the expert judgement, it was decided which EFs shall be used for the reporting. In a next step, activity data were updated to allow for more differentiation. More detailed information about the revised methodology for the calculation of fine particulate emissions from firework is published in the professional journal "Gefahrstoffe" by Dauert et al. (2002) <sup>1)</sup>. Furthermore, the other EFs have been discussed resulting in some changes to these values. The results are presented below. In February 2021, the VPI published an article in the paper "Propellants, Explosives, Pyrotechnics" providing a description of the experiment together with the measurement results (Keller & Schragen, 2021) <sup>2)</sup>.

### Activity data

For the calculation of the activity data the following formula is used:

$$AD = production + imports - exports - disposal + return_{(previous\ year)} - return_{(recent\ year)}$$

The data on **production, imports and exports, disposal<sup>1</sup> and return<sup>2</sup>** (current and previous year) are updated annually by the VPI.

<sup>1</sup> Amount of disposed unsold fireworks damaged during transport from producer to seller <sup>2</sup> Amount of unsold fireworks



returned to producer

## Emission factors

The emission factors of SO<sub>2</sub>, CO, NO<sub>x</sub>, Cu, Pb and Zn are the Default-EFs derived from the EMEP/EEA Guidebook 2023 <sup>3)</sup>.

Table 2: Default Tier2 emission factors applied, in [g/t product]

|                        | Default-EF |
|------------------------|------------|
| <b>SO<sub>2</sub></b>  | 3.020      |
| <b>CO</b>              | 7.150      |
| <b>NO<sub>x</sub></b>  | 260        |
| <b>Cu</b>              | 444        |
| <b>Pb (until 2003)</b> | 784        |
| <b>Zn</b>              | 260        |

The emission factors for PM<sub>10</sub>, PM<sub>2.5</sub> and TSP are measured values from the VPI.

Table 3: Country-specific PM emission factors applied, in [g/t product]

|                      | 1990-2004 | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|----------------------|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>NEW YEARS EVE</b> |           |       |       |       |       |       |       |       |       |       |       |       |       |
| PM <sub>2.5</sub>    | 41.46     | 38.13 | 36.54 | 39.38 | 39.54 | 39.91 | 39.71 | 40.03 | 34.73 | 42.70 | 40.34 | 40.08 | 40.34 |
| PM <sub>10</sub>     | 52.00     | 47.51 | 44.83 | 47.47 | 47.52 | 47.85 | 48.27 | 48.09 | 42.98 | 51.42 | 48.12 | 47.65 | 48.01 |
| TSP                  | 52.00     | 47.51 | 44.83 | 47.47 | 47.52 | 47.85 | 48.27 | 48.09 | 42.98 | 51.42 | 48.12 | 47.65 | 48.01 |
| <b>REST OF YEAR</b>  |           |       |       |       |       |       |       |       |       |       |       |       |       |
| PM <sub>2.5</sub>    | 49.64     | 57.17 | 54.75 | 53.21 | 52.25 | 52.13 | 50.21 | 49.97 | 55.40 | 42.00 | 48.10 | 49.02 | 51.76 |
| PM <sub>10</sub>     | 62.80     | 72.32 | 69.25 | 67.31 | 66.09 | 65.94 | 63.52 | 63.22 | 70.08 | 53.13 | 60.85 | 62.01 | 65.48 |
| TSP                  | 62.80     | 72.32 | 69.25 | 67.31 | 66.09 | 65.94 | 63.52 | 63.22 | 70.08 | 53.13 | 60.85 | 62.01 | 65.48 |

The EMEP/EEA GB 2023 offers default-EFs for the pollutants As, Hg, Ni and Cr <sup>4)</sup>. However, the VPI has proofed that these emissions do not occur in Germany, further proofing that no Pb is emitted from fireworks after 2003.

See the following explanations:

**As and Hg:** As confirmed by the members of the VPI, these two heavy metals went out of use in 1980. Since about 1980 the explosives administrative regulation (Sprengverwaltungsvorschrift) is regulating which substances are allowed to be used and As and Hg are forbidden to be used. In 2003 the DIN EN 14035:2003 came into force, which did forbid these substances. The actual follow-up norm DIN EN 15947-5 was published in February 2016 and describes the German implementation of the harmonized and in the official journal of the European Union 2017, C 149/2 published norm EN 15947:2015.

**Pb:** As the DIN EN 14035:2003 entered into force as from 2003, which did forbid this substance, there are no such emissions from 2003 onwards. The actual follow-up norm DIN EN 15947-5 was published in February 2016 and describes the German implementation of the harmonized and in the official journal of the European Union 2017, C 149/2 published norm EN 15947:2015.

**Cd:** The members of the VPI were asked and did explain, that Cd was never used, because it has no pyrotechnical effect. Since 2013 Cd is on the candidates list of the substances of Very High Concern (SVHC), published according article 59, para. 10 of the REACH-ordinance.

**Ni:** The members of the VPI informed that Ni was never used, because it has no pyrotechnical effect. It is part of the harmonized assessment according the ordinance (EG) Nr. 1272/2008 (CLP). Belonging to this, it is assessed as cancerogen category 2.

**Cr:** According the information from the members of the VPI Cr is not anymore used since the beginning of the 1980. Since 2012 (REACH Annex XIV (Ordinance (EU) Nr. 125/2012) Cr was implemented in the REACH Annex XIV. So from that year a permission duty is necessary. So far, none of the fireworks producers has requested for a permission.

## Uncertainties

The uncertainty for the AD is given as 10% and for the EF as 20%.

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.

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<sup>1)</sup> Dauert et al. (2002): Dauert, U., Keller, F., Kessinger, S., Kuntze, D., Schragen, C.: "Feinstaubemissionen aus Feuerwerk zu Silvester und deren Einfluss auf die Luftqualität" (Particulate Matter Emissions from New Year's Eve Fireworks and their Influence on Air Quality – Novel Method for Quantification of Emissions). journal "Gefahrstoffe", Jahrgang 82 (2002) No.1&2, p. 5-22; doi.org/10.37544/0949-8036-2022-01-02; Dessau-Roßlau, 2002.

<sup>2)</sup> Keller, F. and Schragen, Chr. (2021): Determination of Particulate Matter Emission Factors of Common Pyrotechnic Articles; <https://onlinelibrary.wiley.com/doi/epdf/10.1002/prop.202000292>, DOI: 10.1002/prop.202000292, 2021.

<sup>3), 4)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.D.3.i, 2.G Other solvent and product use, Table: 3-14: Tier 2 emission factor for source category 2.D.3.i, 2.G Other solvent and product use, Other, Use of Fireworks., <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-d-2-l-other/2-d-3-i-2/@download/file>, Copenhagen, 2023

## 2.G(b) - Other Product use: Tobacco

### Short description

| Category Code | Name of Category           | Method | AD | EF   |
|---------------|----------------------------|--------|----|------|
| 2.G(b)        | Other Product use: Tobacco | T2     | NS | CS/D |

In this sub-category, Germany reports the emissions from the smoking of cigarettes, small cigars (zigarillos) and cigars. PM<sub>2.5</sub>, PM<sub>10</sub>, TSP and BC have only been reported since 1995.

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub>                                                                              | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC  | CO  | Cu  | Ni  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|-----------------|--------|-----------------|----------------------------------------------------------------------------------------------|-------------------|------------------|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|--------|-----|------|
| -/-             | -/-    | NE              | -/-                                                                                          | -/-               | -/-              | -/- | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-    | NA  | NA   |
|                 |        | L/-             | key source by <b>L</b> evel only                                                             |                   |                  |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        | -/T             | key source by <b>T</b> rend only                                                             |                   |                  |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        | L/T             | key source by both <b>L</b> evel and <b>T</b> rend                                           |                   |                  |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        | -/-             | no key source for this pollutant                                                             |                   |                  |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        | IE              | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                   |                  |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        | NE              | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                   |                  |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        | NA              | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                   |                  |     |     |     |     |     |     |        |       |       |       |       |        |     |      |
|                 |        | *               | no analysis done                                                                             |                   |                  |     |     |     |     |     |     |        |       |       |       |       |        |     |      |

The **quantity of consumed tobacco** has been for many years on a constant level. Since 2002 it has been decreased to a historic low value of 99,434 t in 2023. In 2024 again more tobacco was consumed.

### Method

#### Activity data

Statistical data from the tax registration of sold tobacco, cigarettes and cigars provide by the Federal Statistical Office (DESTATIS) <sup>1)</sup> are used as **activity data**.

For estimating the **overall consumption quantity of tobacco** the default quantity of tobacco for cigarettes and cigars of the emission EMEP/EEA Guidebook 2023 (note to table 3-15 p. 23) <sup>2)</sup> is applied:

Table 1: average tobacco contents from EMEP/EEA GB 2023, in [g/No.]

|           | average tobacco content |
|-----------|-------------------------|
| cigarette | 1g                      |
| cigar     | 5g                      |

#### Emission factors

The emission factors applied in the German inventory were derived from a study by (Toenges-Schuller et al.)<sup>3)</sup> for the Umweltbundesamt Germany. Based on this study, most of the applied emission factors represent average values from different studies.

Table 3: tier2 emission factors applied

|                                         | Value  | Unit         | Data source                 |
|-----------------------------------------|--------|--------------|-----------------------------|
| NO <sub>x</sub>                         | 1.8    | kg/t tobacco | EMEP/EEA 2023 <sup>4)</sup> |
| NM VOC                                  | 9.56   | kg/t tobacco | average value               |
| NH <sub>3</sub>                         | 5.33   | kg/t tobacco | average value               |
| CO                                      | 112.51 | kg/t tobacco | average value               |
| TSP/PM <sub>10</sub> /PM <sub>2.5</sub> | 18.85  | kg/t tobacco | average value               |

|                      |       |              |               |
|----------------------|-------|--------------|---------------|
| <b>BC</b>            | 0.074 | kg/t tobacco | average value |
| <b>Cd</b>            | 5.4   | g/t tobacco  | EMEP/EEA 2023 |
| <b>Cu</b>            | 5.4   | g/t tobacco  | EMEP/EEA 2023 |
| <b>Ni</b>            | 2.7   | g/t tobacco  | EMEP/EEA 2023 |
| <b>Zn</b>            | 2.16  | g/t tobacco  | average value |
| <b>PCDD/F</b>        | 0.1   | µg/t tobacco | EMEP/EEA 2023 |
| <b>B[a]P</b>         | 0.21  | g/t tobacco  | average value |
| <b>B[b]F</b>         | 0.26  | g/t tobacco  | average value |
| <b>B[k]F</b>         | 0.26  | g/t tobacco  | average value |
| <b>I[1,2,3-c,d]P</b> | 0.42  | g/t tobacco  | average value |

## Uncertainties

As tax registration statistics has a high level of accuracy, its uncertainty is expected to be below 5% whereas the uncertainty for the amount of tobacco in cigarettes is set to 20%. In contrast, as the tobacco quantity for cigars varies much stronger, the uncertainty is set to 100% here.

## Recalculations

Recalculated emission estimates result from changes of the used statistical data. For the year 2023 the data was slightly revised, but for the years 2021 and 2022 the statistical data is only published with less accuracy.

Table 4: Revised activity data for 2021, 2022 and 2023, in [t]

|                            | <b>2021</b> | <b>2022</b> | <b>2023</b> |
|----------------------------|-------------|-------------|-------------|
| <b>current submission</b>  | 118,908     | 103,864     | 99,449      |
| <b>previous submission</b> | 118,909     | 103,863     | 99,434      |
| <b>absolute change</b>     | -1.40       | 0.94        | 15.0        |
| <b>relative change</b>     | 0.00%       | 0.00%       | 0.02%       |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> Destatis (2023): Statistisches Bundesamt (DESTATIS): Code 73411 - Tabaksteuerstatistik; <https://www-genesis.destatis.de/datenbank/online/statistic/73411/details/search/s/NzM0MTE=>, Statistisches Bundesamt, Wiesbaden, 2024.

<sup>2), 4)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter: 2.D.3.i, 2.G Other solvent and product use, Table: 3-15 Tier 2 emission factors for source category 2.D.3.i, 2.G Other solvent and product use, Tobacco combustion

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-d-2-l-other/2-d-3-i-2/@download/file> Copenhagen, 2023.

<sup>3)</sup> Toenges et al. (2016): Toenges-Schuller, N., Joppe, S., Tremöhlen, M.: "Entwicklung von Methoden zur Berechnung von Emissionen von Luftschadstoffen aus der Verwendung von Holzkohle, Tabak, Feuerwerk und Kerzen sowie aus dem Entfachen von Brauchtuumsfeuern", EF000814, Aviso GmbH Aachen; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2016.



## 2.G(c) - Use of Charcoal for barbecues

| Category Code                                                                             | Name of Category                     | Method | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|--------|----|----|
| 2.G©                                                                                      | Other Product use: Fireworks         | T1     | NS | C  |
| Method(s) applied                                                                         |                                      |        |    |    |
| D                                                                                         | Default                              |        |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |        |    |    |
| T2                                                                                        | Tier 2*                              |        |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |        |    |    |
| C                                                                                         | CORINAIR                             |        |    |    |
| CS                                                                                        | Country Specific                     |        |    |    |
| M                                                                                         | Model                                |        |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |        |    |    |
| (source for) Activity Data                                                                |                                      |        |    |    |
| NS                                                                                        | National Statistics                  |        |    |    |
| RS                                                                                        | Regional Statistics                  |        |    |    |
| IS                                                                                        | International Statistics             |        |    |    |
| PS                                                                                        | Plant Specific                       |        |    |    |
| As                                                                                        | Associations, business organisations |        |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |        |    |    |
| M                                                                                         | Model / Modelled                     |        |    |    |
| C                                                                                         | Confidential                         |        |    |    |
| (source for) Emission Factors                                                             |                                      |        |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |        |    |    |
| CS                                                                                        | Country Specific                     |        |    |    |
| PS                                                                                        | Plant Specific                       |        |    |    |
| M                                                                                         | Model / Modelled                     |        |    |    |
| C                                                                                         | Confidential                         |        |    |    |

In this sub-category of 2.G - *Other product use*, Germany reports the following emissions resulting from the burning of charcoal for barbecues:

| NO <sub>x</sub>                                                                                        | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|--------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NE                                                                                                     | NE     | NE              | NE              | -/-               | -/-              | -/- | NE | NE | NE           | NE   |
| <b>L/-</b> key source by <b>L</b> evel only                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>T</b> rend only                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend                                          |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/-</b> no key source for this pollutant                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b> emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b> emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b> specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |        |                 |                 |                   |                  |     |    |    |              |      |
| * no analysis done                                                                                     |        |                 |                 |                   |                  |     |    |    |              |      |

### Method

The amount of charcoal used for barbecue has been ever-expanding from 1990 to 2012 and is predominantly imported. After several years with stable demand, consumption has been declining since 2019.

However, as there is only one big producer, used amounts and emission factors are considered confidential and cannot be provided here.

## Activity data

The annual charcoal consumption for barbecue is calculated as

$$AD = \text{domestic production} + \text{imports} - \text{exports}$$

with the relevant amounts of charcoal derived from national statistics provided by the Federal Statistical Office (DESTATIS). The model is based on the two assumptions that (i) there is no storage of charcoal and that (ii) all charcoal is burned during usage.

Other applications for charcoal are not included.

## Emission factors

The emission factors are comparable as those from the CEPMEIP Database (SNAP: 060508) (CEPMEIP, 2018) <sup>1)</sup>.

## Emissions

Table 1: Annual emissions of TSP in [t]

| 1990  | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 73.69 | 185.07 | 331.97 | 418.93 | 569.49 | 595.48 | 520.64 | 548.76 | 572.80 | 536.08 | 379.96 | 350.07 | 333.44 | 275.58 | 243.11 |

## Uncertainties

The uncertainties of consumption are 20% and the uncertainties of emission are not more than 54% for the lower and upper bounds.

## Recalculations

The import and export data for 2023 were changed as revised activity data for the foreign sale was available from the Federal Statistical Office. The emissions of PM<sub>2.5</sub>, PM<sub>10</sub> and TSP reported for 2023 increase by 1.88 %.

Table 2: Revised emission data of TSP 2023, in [t]

|                            |        |
|----------------------------|--------|
| <b>current submission</b>  | 275.58 |
| <b>previous submission</b> | 270.50 |
| <b>absolute change</b>     | 5.08   |
| <b>relative change</b>     | 1.88%  |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following chapter [9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> CEPMEIP (2018): Co-ordinated European Programme on Particulate Matter Emission Inventories, Projections and Guidance

(CEPMEIP), CEPMEIP Database, SNAP code : 060508;

[http://www.air.sk/tno/cepmeip/em\\_factors.php?PHPSESSID=cc235582eb4e09bf725d6f859deb382d](http://www.air.sk/tno/cepmeip/em_factors.php?PHPSESSID=cc235582eb4e09bf725d6f859deb382d)



## 2.G.4 - Use of Lubricants

### Short description

In source category 2.G.4 - *Other Product Use: Lubricants*, emissions from both stationary and mobile application of lubricants are reported.

| Category Code                                                                             | Method                               | AD    | EF    |
|-------------------------------------------------------------------------------------------|--------------------------------------|-------|-------|
| 2.G.4                                                                                     | T1, T2                               | NS, M | CS, D |
| covering emissions from:                                                                  |                                      |       |       |
| use of lubricants in stationary applications                                              | T2                                   | NS    | CS    |
| use of lubricants in mobile applications                                                  | T1                                   | NS, M | D     |
| Method(s) applied                                                                         |                                      |       |       |
| D                                                                                         | Default                              |       |       |
| T1                                                                                        | Tier 1 / Simple Methodology *        |       |       |
| T2                                                                                        | Tier 2*                              |       |       |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |       |       |
| C                                                                                         | CORINAIR                             |       |       |
| CS                                                                                        | Country Specific                     |       |       |
| M                                                                                         | Model                                |       |       |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |       |       |
| (source for) Activity Data                                                                |                                      |       |       |
| NS                                                                                        | National Statistics                  |       |       |
| RS                                                                                        | Regional Statistics                  |       |       |
| IS                                                                                        | International Statistics             |       |       |
| PS                                                                                        | Plant Specific                       |       |       |
| As                                                                                        | Associations, business organisations |       |       |
| Q                                                                                         | specific Questionnaires (or surveys) |       |       |
| M                                                                                         | Model / Modelled                     |       |       |
| C                                                                                         | Confidential                         |       |       |
| (source for) Emission Factors                                                             |                                      |       |       |
| D                                                                                         | Default (EMEP Guidebook)             |       |       |
| CS                                                                                        | Country Specific                     |       |       |
| PS                                                                                        | Plant Specific                       |       |       |
| M                                                                                         | Model / Modelled                     |       |       |
| C                                                                                         | Confidential                         |       |       |

| NO <sub>x</sub>                                                                                                                                                                               | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub>                                                                            | PM <sub>10</sub> | TSP   | BC    | CO    | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | PAH   | HCB   | PCB   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|----------------------------------------------------------------------------------------------|------------------|-------|-------|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|-------|-------|
| NA/IE                                                                                                                                                                                         | L/-    | NA/IE           | NA/IE           | NA/IE                                                                                        | NA/IE            | NA/IE | NA/IE | NA/IE | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | -/- | NA/IE  | NA/IE | NA/IE | NA/IE |
| IE: for lubricants unintentionally burned in mobile sources, air pollutant emissions are considered to be already covered in the emission estimates provided for the different mobile sources |        |                 |                 |                                                                                              |                  |       |       |       |     |     |     |     |     |     |     |     |     |        |       |       |       |
|                                                                                                                                                                                               |        |                 | L/-             | key source by <b>L</b> evel only                                                             |                  |       |       |       |     |     |     |     |     |     |     |     |     |        |       |       |       |
|                                                                                                                                                                                               |        |                 | -/T             | key source by <b>T</b> rend only                                                             |                  |       |       |       |     |     |     |     |     |     |     |     |     |        |       |       |       |
|                                                                                                                                                                                               |        |                 | L/T             | key source by both <b>L</b> evel and <b>T</b> rend                                           |                  |       |       |       |     |     |     |     |     |     |     |     |     |        |       |       |       |
|                                                                                                                                                                                               |        |                 | -/-             | no key source for this pollutant                                                             |                  |       |       |       |     |     |     |     |     |     |     |     |     |        |       |       |       |
|                                                                                                                                                                                               |        |                 | IE              | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                  |       |       |       |     |     |     |     |     |     |     |     |     |        |       |       |       |
|                                                                                                                                                                                               |        |                 | NE              | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                  |       |       |       |     |     |     |     |     |     |     |     |     |        |       |       |       |
|                                                                                                                                                                                               |        |                 | NA              | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                  |       |       |       |     |     |     |     |     |     |     |     |     |        |       |       |       |
|                                                                                                                                                                                               |        |                 | *               | no analysis done                                                                             |                  |       |       |       |     |     |     |     |     |     |     |     |     |        |       |       |       |

### Use of lubricants in stationary applications

## Method

This sub-category comprises the entire use phase including the process stages of input and output. The products or lubricants covered here, are:

- Compressor oils
- Turbine oils
- Gear oils (automotive oils including automatic transmission fluids, industrial-gear oils)
- Hydraulic oils
- Insulating oils
- Machine oils
- Process oils
- Other industrial oils not for lubricating purposes
- Metal working fluids (hardening oils, water-miscible and not water-miscible metal working fluids, anticorrosive oils)
- Greases
- Base oils
- Extracts from lubricant refining

The EMEP/air pollutant EEA emission inventory guidebook 2023 distinguishes two use cases for lubricants: applications for cooling and applications without specification. Therefore, a double counting could not be excluded with the use of both emission factors. As cooling lubricants are part of metal working fluids they are included in the German national inventory. To avoid a double counting and to have a view as good as possible on the NMVOC emissions of lubricants in stationary applications, the above mentioned lubricants are considered with an own emission factor instead using the single general emission factor for all lubricant applications.



2-stroke engine oils are excluded here as they are considered to be part of the 2-stroke fuel and are therefore burned *intentionally* in 2-stroke engines as applied in road vehicles (mopeds) and other mobile machinery (chainsaws, lawn mowers etc.). In contrast, emissions from the *unintended* co-incineration of lubricants in mobile machinery and vehicles are reported in [Use of lubricants in mobile applications](#).



'NMVOC' is defined in keeping with the VOC definition found in the EC solvents directive. For purposes of the definition of solvents, the term 'solvent use' is also defined in keeping with the EC solvents directive.

The consumption of lubricants in stationary applications in Germany has remained at a relatively constant level since 1990, apart from a sharp decrease in the crisis years 2009 and 2020.

After a slight rebound in 2021, the **stationary consumption of lubricants** fell to a historically low level of just 533 kt in 2023 and recovered only slightly in **2024** with **542 kt**.

### Activity data

The emissions calculation method follows a Tier-2 approach. It uses national statistical data from BAFA <sup>1)</sup> for the quantities placed on the market specific per lubricant types as activity rate and specific emission factors for each lubricant type. It is assumed that the amount of lubricants placed on the market per year equals the lubricant use (consumption) in the same year.

### Emission factors

Along the life cycle of the different lubricant types, different kinds of losses occur. Only some types of losses are of relevance with regard to air emissions and the different lubricants types differ significantly from each other. Relevant emitted pollutants identified for lubricants are NMVOC and CO<sub>2</sub>. But only for engine oils used in machinery and in vehicles emission

of both could be accounted for due to combustion of a small fraction of lubricating oils directly resulting in CO<sub>2</sub> emissions.

For insulating oils <sup>2) 3)</sup>, process oils <sup>4) 5) 6)</sup>, greases <sup>7) 8)</sup> and extracts from lubricant production <sup>9) 10) 11)</sup> no emissions are expected to arise.

All emission factors are constant in the entire time series. They were determined in a research project (Zimmermann, 2018) <sup>12)</sup>.

Table 1: Tier2 emission factors for specific lubricant-type groups in percent

| Lubricant-type group                    | Proportion range of total sales since 1990 | NMVOC   |        | Reference                          |
|-----------------------------------------|--------------------------------------------|---------|--------|------------------------------------|
|                                         |                                            | Default | Range  |                                    |
| Compressor oils                         | ≤ 1 %                                      | 1.5 %   | 1-2 %  | <sup>13) 14) 15) 16) 17) 18)</sup> |
| Turbine oils                            | < 1 %                                      | 0.5 %   | 0-1 %  | <sup>19) 20) 21)</sup>             |
| Automotive gear oils                    | 5-10 %                                     | 1 %     | 0-2 %  |                                    |
| Industrial gear oils                    | 2-3 %                                      | 1.5 %   | 1-2 %  |                                    |
| Hydraulic oils                          | 6-15 %                                     | 1.5 %   | 1-2 %  |                                    |
| Machine oils                            | 1-7 %                                      | 2.5 %   | 0-5 %  | <sup>22) 23) 24)</sup>             |
| Other oils not for lubricating purposes | 2-7 %                                      | 25 %    | 0-50 % | <sup>25) 26) 27) 28)</sup>         |
| Metalworking fluids                     | 5-9 %                                      | 5 %     | 0-10 % | <sup>29) 30) 31)</sup>             |
| Base oils                               | 4-16 %                                     | 10 %    | 5-15 % | <sup>32)</sup>                     |

In 1995 four categories fell away/ceased to exist (Table 2) and three type groups were newly introduced due to modifications/changes in the Mineral Oil Statistics concerning lubricants. A slight adjustment of the procedure for the years 1990-1994 was needed. Table 2 shows the affected categories as well as the ways in which they were handled in the calculation procedure.

Table 2: Handling of categories in the Mineral Oil Statistics, 1990-1994

| Category                                                                    | Remarks concerning the procedure                                                                                                                                       | EF <sub>NMVOC</sub> |
|-----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| Other lubricating oils, specialty and other lubricating oils, non-specialty | These are handled like the “machine oils” group, which is lacking in the 1990-1994 period. This group includes various specialty and non-specialty lubricating oils.   | 2.5 %               |
| Other mineral oils for special applications                                 | This category contains no lubricating oils. It is handled like the category “Other industrial oils not used for lubrication” which is lacking in the 1990-1994 period. | 25 %                |
| Light-coloured plasticisers and extender oils                               | Extender oils and plasticisers are classified with the process oils. They are handled accordingly.                                                                     | 0 %                 |

#### Uncertainties

For activity data, an uncertainty of 5 percent is assumed considering the well developed national statistics.

The emission factors are based on a broad review of literature and results from relevant research projects and have been discussed with senior lubricant experts. The experts suggested using ranges which are provided in the emission factor table 1.

The modifications of the Mineral Oil Statistics in 1995 show no impact of overall amount of lubricants. Only a reclassification of lubricants from unspecified application categories to specified application categories was made. The emissions for the years 1990-1994 could therefore be just up to 25% to high.

#### Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

## Planned improvements



No category-specific improvements are planned.

## Use of lubricants in mobile applications

In sub-category 2.D.3.i - *Other product use: Use of lubricants in mobile applications*, the German air pollutant emissions inventory includes emissions from the unintentional co-incineration of lubricants in mobile sources.

As emissions from the use of lubricants in stationary machinery result mostly from the evaporation whereas emissions from mobile machinery result mostly from the unintentional co-incineration within the engine, the methods for emission calculation differ widely.

Therefore, the approaches for estimating emissions from these two areas of lubricant application are looked at in separate sub-chapters linked below.

## Methodology

### Activity data

Basically, the amounts of lubricants unintentionally co-incinerated in engines other than 2-strokes is estimated from the annual amounts of fuels used in these engines, excluding the amounts of fuels used for international aviation and navigation.

Here, the majority of lubricant co-incineration takes place in road vehicles. These related amounts of co-incinerated lubricants are calculated directly within TREMOD <sup>33)</sup>.

Table 1: Annual amounts of lubricants co-incinerated in mobile vehicles and machinery - excluding 2-stroke engines, in terajoules

| 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1,400 | 1,601 | 1,713 | 1,757 | 1,803 | 1,922 | 1,951 | 1,976 | 1,985 | 1,999 | 1,757 | 1,796 | 1,797 | 1,818 | 1,836 |

source: own estimations and TREMOD <sup>34)</sup>

The **emission factors** are derived from chapter 1.A.3.b.i-iv *Road transport 2023*, Table 3-87 of the EMEP/EEA air pollutant emission inventory guidebook 2023 <sup>35)</sup>.

**Table 3-87: Heavy metal emission factors for all vehicle categories in ppm/wt lubricant**

| Category               | Pb     | Cd   | Cu  | Cr   | Ni    | Se   | Zn    | Hg | As |
|------------------------|--------|------|-----|------|-------|------|-------|----|----|
| Passenger cars, petrol | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| Passenger cars, diesel | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| LCVs, petrol           | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| LCVs, diesel           | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| HDVs, petrol           | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| HDVs, diesel           | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| L-category             | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |

These default values were transferred via a NCV of 0.03985 GJ/kg into the following energy-related values:

Table 2: tier1 emission factors for heavy-metal emissions from co-incinerated lubricants, in g/TJ

| As   | Cd  | Cr  | Cu     | Hg   | Ni  | Pb   | Se  | Zn     |
|------|-----|-----|--------|------|-----|------|-----|--------|
| 0.00 | 114 | 482 | 19,523 | 0.00 | 800 | 0.81 | 114 | 11,297 |

## Discussion of emission trends

With default emission factors applied, emissions' trends depend solely on the amounts of unintentionally co-incinerated lubricants (see Table 1).

Table 3: Annual heavy-metal emissions from co-incinerated lubricants, in metric tonnes

|           | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>As</b> | NA     |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>Cd</b> | 0.16   | 0.18   | 0.20   | 0.20   | 0.21   | 0.22   | 0.22   | 0.23   | 0.23   | 0.23   | 0.20   | 0.21   | 0.21   | 0.21   | 0.21   |
| <b>Cr</b> | 0.67   | 0.77   | 0.83   | 0.85   | 0.87   | 0.93   | 0.94   | 0.95   | 0.96   | 0.96   | 0.85   | 0.87   | 0.87   | 0.88   | 0.88   |
| <b>Cu</b> | 27.3   | 31.3   | 33.4   | 34.3   | 35.2   | 37.5   | 38.1   | 38.6   | 38.8   | 39.0   | 34.3   | 35.1   | 35.1   | 35.5   | 35.8   |
| <b>Hg</b> | NA     |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| <b>Ni</b> | 1.12   | 1.28   | 1.37   | 1.41   | 1.44   | 1.54   | 1.56   | 1.58   | 1.59   | 1.60   | 1.41   | 1.44   | 1.44   | 1.45   | 1.47   |
| <b>Pb</b> | 0.0011 | 0.0013 | 0.0014 | 0.0014 | 0.0015 | 0.0016 | 0.0016 | 0.0016 | 0.0016 | 0.0016 | 0.0014 | 0.0015 | 0.0015 | 0.0015 | 0.0015 |
| <b>Se</b> | 0.16   | 0.18   | 0.20   | 0.20   | 0.21   | 0.22   | 0.22   | 0.23   | 0.23   | 0.23   | 0.20   | 0.20   | 0.20   | 0.21   | 0.21   |
| <b>Zn</b> | 15.8   | 18.1   | 19.3   | 19.8   | 20.4   | 21.7   | 22.0   | 22.3   | 22.4   | 22.6   | 19.8   | 20.3   | 20.3   | 20.5   | 20.7   |

## Recalculations

**Activity data** (annual amounts of unintentionally co-incinerated lubricants) have been revised slightly for the entire time series.

Table 4: Revised annual amounts of unintentionally co-incinerated lubricants, in terajoules

|                            | 2003   | 2004   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018  | 2019  | 2020   | 2021   | 2022   | 2023  |
|----------------------------|--------|--------|--------|--------|--------|--------|--------|-------|-------|--------|--------|--------|-------|
| <b>current submission</b>  | 1,754  | 1,784  | 1,757  | 1,803  | 1,922  | 1,951  | 1,976  | 1,985 | 1,999 | 1,757  | 1,796  | 1,797  | 1,818 |
| <b>previous submission</b> | 1,754  | 1,784  | 1,757  | 1,804  | 1,922  | 1,951  | 1,977  | 1,985 | 1,999 | 1,770  | 1,801  | 1,803  | 1,811 |
| <b>absolute change</b>     | -0.13  | -0.35  | -0.44  | -0.29  | -0.32  | -0.33  | -0.38  | -0.05 | 0.12  | -13.3  | -4.58  | -5.99  | 7.11  |
| <b>relative change</b>     | -0.01% | -0.02% | -0.02% | -0.02% | -0.02% | -0.02% | -0.02% | 0.00% | 0.01% | -0.75% | -0.25% | -0.33% | 0.39% |

On the other hand, the tier1 **emission factors** applied so far, remain unaltered compared to last year's submission.

Therefore, the changes in the **emission estimates** reported for this sub-category result solely from the named revisions in activity data.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following chapter [9.1 - Recalculations](#).

## Planned improvements

Although there are no improvements planned for this specific sub-category, several routine model revisions are scheduled for mobile sources with impact on fuel consumption data and, hence, the amounts of unintentionally co-incinerated lubricants.

<sup>1)</sup> BAFA (2025): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA):

Amtliche Mineralölstatistik für die Bundesrepublik Deutschland,

[https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel\\_amtliche\\_daten\\_2024\\_12.html](https://www.bafa.de/SharedDocs/Downloads/DE/Energie/Mineraloel/moel_amtliche_daten_2024_12.html); Eschborn, 2025.

<sup>2)</sup>, <sup>14)</sup>, <sup>20)</sup>, <sup>25)</sup> Zimmermann, T. & Jepsen, D. (2018): A framework for calculating waste oil flows in the EU and beyond – the cases of Germany and Belgium 2015. Resources, Conservation and Recycling. 134. 10.1016/j.resconrec.2018.02.011.; Hamburg, 2017.

<sup>3)</sup>, <sup>16)</sup>, <sup>21)</sup>, <sup>23)</sup> Sander, K.; Jepsen, D.; Zangl, S.; Schilling, S.: Stoffstrom- und Marktanalyse zur Sicherung der Altölsorgung. Forschungsbericht 204 31 32 UBA-FB 000883:

<https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3030.pdf>, Dessau-Roßlau, 2006.

<sup>4)</sup>, <sup>15)</sup>, <sup>30)</sup> Zimmermann, T., Jepsen, D., Sander, K. (2017): Survey of the structure of the waste oil collection market and optimization potentials for higher waste oil qualities with regard to the waste hierarchy - Erhebung der Struktur des Altölsammelmarktes und Optimierungspotenziale für bessere Altölqualitäten im Kontext der Abfallhierarchie.; FKZ 3714 31 3270; on behalf of the Umweltbundesamt, Dessau-Roßlau, 2016.

<sup>5)</sup>, <sup>7)</sup>, <sup>10)</sup>, <sup>26)</sup> Möller, U. J.: Altölsorgung durch Verwertung und Beseitigung; Kontakt & Studium Bd. 253; Expert Verlag: Renningen, 2004.

<sup>6)</sup>, <sup>11)</sup>, <sup>27)</sup> Bartz, W. J.; Springer, G.; Blanke, H.-J.: Expert Praxislexikon Tribologie Plus: 2010 Begriffe für Studium und Beruf, 2., völlig neubearb. Aufl. des Lexikons der Schmierstechnik von G. Vögtle; Expert Verlag: Renningen, 2000.

<sup>8)</sup>, <sup>28)</sup> VSI: Grundöle; <https://www.vsi-schmierstoffe.de/index.php>.)

[(KOLSHORN1996> Kolshorn, K.-U.; Wiesert, P.; Götz, R.; Rippen, G.: Ermittlung von Altölvermeidungspotentialen: UBA-Forschungsvorhaben Nr. 103 60 111; Trischler und Partner GmbH: Darmstadt, 1996.

<sup>9)</sup>, <sup>13)</sup>, <sup>19)</sup>, <sup>22)</sup>, <sup>29)</sup> Ökopool: Consultation of different senior lubricant experts and manufacturers: Hamburg, 2017.

<sup>12)</sup>, <sup>32)</sup> Zimmermann, T., Jepsen, D. (2018): Entwicklung von Methoden zur Berechnung von Treibhausgas- und Luftschadstoffemissionen aus der Verwendung von Schmierstoffen und Wachsen.; Ökopool;

[https://oekopol.de/archiv-de/DE\\_718/](https://oekopol.de/archiv-de/DE_718/); on behalf of the Umweltbundesamt, Dessau-Roßlau, 2018

<sup>17)</sup> Kline & Company: Lubricant Consumption and Used Oil Generation in California: A Segmented Market Analysis: Part II: Collectable Used Oil Availability in California, 2000-2011. <https://www2.calrecycle.ca.gov/Publications/Details/1512>; published 03/03/2015: Sacramento, CA, USA, 2012.

<sup>18)</sup> UNEP: Compendium of Recycling and Destruction Technologies for Waste Oils;

<https://www.unep.org/resources/report/compendium-recycling-and-destruction-technologies-waste-oils>; Osaka, Japan, 2012.

<sup>24)</sup> Vidal-Abarca, G. C.; Kaps, R.; Oliver, W.; Escamilla, M.; Josa, J.; Riera, M. R.; Benedicto, E.: Revision of European Ecolabel Criteria for Lubricants. Preliminary Report:

<https://ec.europa.eu/environment/ecolabel/documents/Final%20Report%20EU%20Ecolabel%20Lubricants.pdf>; Sevilla, 2016.

<sup>34)</sup> Knörr et al. (2025a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, on behalf of the Umweltbundesamt, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2025.

<sup>35)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023,

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/@download/file>; Copenhagen, 2023.

## 2.H - Other: Pulp & Paper, Food (OVERVIEW)

Within NFR category 2.H - Other, emissions from the production of pulp & paper as well as food & beverages are reported.

|                                                   |
|---------------------------------------------------|
| <a href="#">2.H.1 Pulp and Paper Industry</a>     |
| <a href="#">2.H.2 Food and Beverages Industry</a> |
| <a href="#">2.H.3 Other Industrial Processes</a>  |

## 2.H.1 - Pulp and Paper Industry

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.H.1                                                                                     | T1                                   | AS | CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO  | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCb | PCB |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|-----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|------|-----|-----|
| -/-                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | -/-    | -/-             | NE              | -/-               | -/-              | -/- | NE | -/- | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA     | NA    | NA    | NA    | NA    | NA   | NA  | NA  |
| <b>L/-</b> key source by <b>Level</b> only<br><b>-/T</b> key source by <b>Trend</b> only<br><b>L/T</b> key source by both <b>Level</b> and <b>Trend</b><br><b>-/-</b> no key source for this pollutant<br><b>IE</b> emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category)<br><b>NE</b> emission of specific pollutant <b>Not Estimated</b> (yet)<br><b>NA</b> specific pollutant not emitted from this source or activity = <b>Not Applicable</b><br><b>*</b> no analysis done |        |                 |                 |                   |                  |     |    |     |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |

The fibre pulp for paper production is produced, via chemical or mechanical processes, either from fresh fibre or from processed recycled paper. A distinction is made between integrated and non-integrated pulp and paper mills. Non-integrated pulp mills solely produce pulp for sale on the open market.

On the other hand, integrated mills produce both pulp and paper, at integrated sites. A paper mill can either produce paper from fibre material produced at other locations or be integrated within complete pulping processes set up at one site.

Sulphate pulp mills normally operate in both integrated and non-integrated modes, whereas sulphite pulp mills are normally only integrated – i.e. part of paper-production chains. Mechanical pulping and recycled fibre processing is usually an integrated part of the papermaking but has become a stand alone activity in a few single cases.



## Fibre production processes

In the chemical pulping process the fibres are liberated from the wood matrix as the lignin is removed by dissolving in the cooking chemical solution at high temperature.

### Sulphate process

The sulphate or kraft process is the world's most common pulping process, since it yields higher pulp strengths and can be used with all types of wood. In the kraft pulp process the active cooking chemicals (white liquor) are sodium hydroxide (NaOH) and sodium sulphate (Na<sub>2</sub>S). The term "sulphate" is derived from the make up chemical sodium sulphate which is added in the recovery cycle to compensate for chemical losses. As a result of the large amount of sodium hydroxide used, the pH value at the start of cooking is between 13 and 14 (alkaline pulping process). In the two German plants, carbonate is extracted from the circulation of liquor via bonding with calcium (causticising) and then, in a separate lime oven; the burnt lime is then reused for causticising.

This process produces atmospheric emissions in chemical recovery (boilers), in bark combustion, from lime kiln - from the combustion of strong and weak non-condensable gases (NCG) in dedicated burner, in wood-handling, in pulp cooking, in pulp washing, in bleaching, in bleaching-chemical processing, in evaporation, in processing of circulating water and in operation of various types of tanks. Such emissions include fugitive emissions that occur at various processing points - primarily in (liquor)-recovery boilers, lime kilns and auxiliary boilers. The main components of emissions include nitrogen oxides, sulphur-containing compounds, such as sulphur dioxide, and NCG which consists mainly out of total reduced sulphur (TRS), namely, methyl mercaptan (MM), dimethyl sulphide (DMS), dimethyl disulphide (DMDS), and hydrogen sulphide (H<sub>2</sub>S).

The two German sulphate-pulping plants are fitted with a system for post-incineration of NCG equipped with wet scrubbers for SO<sub>x</sub> removal and with systems for NO<sub>x</sub>-reduced combustion in recovery boilers (>20 % NO<sub>x</sub> reduction; figures of the German Pulp and Paper Association (VDP, September 2004). Because of the odours of reduced sulphur compounds, the two relevant plants are practically leak-proof and fitted with an advanced collection and odour abatement technique - otherwise they would not be permitted in Germany. All residues end up in (liquor)-recovery boilers and do not emit in reduced form.

### Sulphite process

Sulphite pulp is produced in 4 of 6 installations in Germany. In such plants, pulping is based on the use of aqueous sulphur dioxide (SO<sub>2</sub>) and a base - calcium, sodium, magnesium or ammonium. The four German mills use the acid bisulphite method. Acid processes are those in which the pH is 1 to 2.5. Sulphite pulping for papermaking derives its name from the use of a bisulphite solution as the delignifying medium. The cation used for papermaking pulp is magnesium (all four mills in Germany). The sulphate process and the sulphite process have numerous similarities, including similarities with regard to possibilities for using various internal and external measures to reduce emissions. From the standpoint of environmental protection, the main differences between the two pulp-production processes have to do with chemical aspects of the cooking process and the temperature in the recovery boiler, with aspects of preparation and post-processing of chemicals and with bleaching intensity - bleaching in sulphite plants is less intensive, since sulphite pulp is whiter than sulphate pulp.

Atmospheric emissions occur especially in recovery (boilers) and in bark combustion. Waste-gas emissions with less concentrated SO<sub>2</sub> are released in washing and sorting processes, and they are released by ventilation shafts of evaporators and by various tanks. Such emission escape - in part, as fugitive emissions - at various points of the process. They consist primarily of sulphur dioxide, nitrogen oxides and dust.

All four sulphite pulping plants in Germany are operated with a collection system for concentrated and less concentrated sulphur dioxide-containing and odorous gases (organic acids) and they include multistage SO<sub>2</sub> scrubbers fitted downstream from recovery boilers (>98 % SO<sub>2</sub> reduction) and recirculation of the recovered chemicals (SO<sub>2</sub> cycle). One plant is fitted with equipment for NO<sub>x</sub>-reduced combustion in recovery and auxiliary boilers (total of >40 % NO<sub>x</sub> reduction, loc. cit.).

A number of measures are available for reducing consumption of fresh steam and electrical energy and for increasing plant-internal generation of steam and electricity. Sulphite pulp mills can generate their own heat and electricity by using the thermal energy in concentrated liquor, bark and waste wood. The recovery boiler acts as a power station where the concentrated spent sulphite liquor is burnt. Generated heat is utilised for the generation of high-pressure, superheated steam. Part of the energy content in the high-pressure steam is utilised for generating power in a back-pressure turbine.

Medium-pressure steam extracted from the turbine and low-pressure exit steam are utilised for covering the heat energy demand in the pulp process. Integrated plants that operate a recovery boiler are nearly electricity self-sufficient and only need limited supply of fossil-fuel-based power. However; these additional amounts can be generated in either in on-site

facilities or at off-site locations. Integrated sulphite pulp and paper mills consume 18 to 24 GJ of process heat, and 1.2 to 1.5 MWh of electrical energy, per tonne of pulp.

Explanation of the management of process related sulphur and ammonia emissions for pulping processes occurring in Germany Sulphur emission levels from sulphite mills and the potential for further reductions are highly dependent on the type of mill. Due to differences between different sulphite processes, the emission levels might show higher variations than in kraft (sulphate)pulp mills.: Many sulphite pulp mills (e.g. all mills in Austria and Germany) have installed a system for the collection of the vent gases from nearly all processes that may release diffuse SO<sub>2</sub>. The vast majority of these diffuse gases are captured by the weak gas collection system and used as combustion air in the recovery boiler. Well designed, maintained and operated gas collection systems allow the recovery of almost all fugitive SO<sub>2</sub> emissions of the mill so that no significant diffuse SO<sub>2</sub> emissions are released to the environment. All SO<sub>2</sub>-containing gases are collected and treated and SO<sub>2</sub> is recovered.

Emissions of odorous gases in sulphite pulping are normally limited compared to kraft (sulphate) pulping. However, emissions of furfural mercaptan and H<sub>2</sub>S might cause odour and emissions of gaseous sulphur may also cause annoyances. At many mills, emissions of odorous gases are collected and burnt in the recovery boiler (all German and Austrian mills). Another option is treatment in wet scrubbers.

Exceptions with ammonia emissions are prohibited and actually excluded. Both circumstances are therefore not relevant for Germany.

## Mechanical pulp

Mechanical pulp is produced in 8 plants in Germany. In mechanical pulping, wood fibres are separated from each other via mechanical energy applied to the wood matrix. This process is designed to conserve most of the lignin in the wood, in order to maximise yields while ensuring that the pulp has adequate strength and whiteness. In German mills two main processes are differentiated:

- the groundwood process (GW), in which pieces of wood are wettened and pressed against a rotating grinder

and

- the thermomechanical pulping process (TMP), in which wood chips are broken down into fibres in disk refiners.

Mechanical-pulp properties can be influenced by increasing the process temperature and, in the case of the refiner process, by chemical pre-treatment of the wood chips. The pulping process in which wood is chemically pre-softened and then broken down into fibres, under pressure, is known as chemical-thermal-mechanical pulping (CTMP).

In most cases, the waste-gas emissions consist of emissions from heat and energy generation in auxiliary boilers and of emissions of volatile organic carbon (VOC). VOC emissions occur in storage of wood chips, in removal of air from containers for washing wood chips, as well as from other containers. They also occur in connection with condensates that are produced in recovery of steam from refiners and contaminated with volatile wood components. Some of these emissions are released as fugitive emissions, from various parts of mills.

## Paper and carton production

Paper is made from fibre materials, water and chemical additives. The entire paper-making process consumes large amounts of energy. Electricity is required primarily for operation of various motors and for grinding of fibres. Process heat is used primarily for heating water, other liquids and air, as steam in the drying process of paper machines and for converting steam into electrical energy (with heat/power cogeneration). Large amounts of water are required as process water and for cooling. Various additives are used in the paper production process as process supplies and to enhance product properties (paper additives).

Most of the waste-gas emissions produced by non-integrated paper mills are produced by steam-production and electricity-generation systems. The boilers used in such systems are standard boilers that do not differ from those of other combustion systems. It is assumed that such systems are operated in the same manner as other auxiliary boilers of the same capacity.

Overall, most product-specific waste-gas emissions are site-dependent (for example, they depend on the type of fuel used, the size and type of the relevant facility, whether the plant is integrated or non-integrated, whether it generates electricity). The auxiliary boilers used in Germany cover a wide spectrum of different sizes (from 10 to more than 200 MW). With smaller boilers, the only useful approach is to use low-sulphur fuels and the pertinent combustion technologies, while secondary

reduction measures can also be effective with larger boilers.

## Methodology

### Activity data

The figures are available from the base year 1990 onwards and are collected annually by the Association of German Paper Mills compiled in a so-called Performance Report <sup>1)</sup>. The separate AD of sulphate pulp and sulphite pulp may not be published, but only in sum.

### Emissions factors

Since 2005 real emission factors from German plants for pulp production are available (German contribution to revision of the Best Available Technique Reference Document (BREF) for the pulp and paper industry, 2007). For this reason, in many cases interpolations were carried out between default and country specific values for 1990 and the real, plant-based values (valid from 1995 up to now). In 2022 the national expert evaluated the used EFs with new figures of the producers <sup>2)</sup>. Some changes have been necessary with the following results:

Table 1: Overview of most recently applied emission factors, in [kg/t]

|                   | EF sulphate pulp | EF sulphite pulp |
|-------------------|------------------|------------------|
| CO                | 0.47             | 0.1              |
| NO <sub>x</sub>   | 1.07             | 1.7              |
| NM VOC            | C                | NA               |
| SO <sub>2</sub>   | 0.02             | 1.5              |
| TSP               | 0.09             | 0.14             |
| PM <sub>10</sub>  | 0.07             | 0.11             |
| PM <sub>2.5</sub> | 0.05             | 0.07             |

A range of measures in sulphite pulp production, carried out on a continual basis, led to reductions of SO<sub>2</sub> emissions. EF of NM VOC is confidential since the AD of sulphate pulp is confidential.

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> and other short statistics: <https://www.papierindustrie.de/papierindustrie/statistik>

<sup>2)</sup> Figures of facilities: „Data of periodic monitoring“ made available by industry association, but not public available because of confidentiality issues

## 2.H.2 - Food & Beverages Industry

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.H.2                                                                                     | T1                                   | NS | CS |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub>                                                                    | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCb | PCB |
|-----------------|--------|-----------------|-----------------|-------------------|-------------------------------------------------------------------------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|------|-----|-----|
| NA              | -/-    | NA              | NA              | -/-               | -/-                                                                                 | -/- | NE | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA     | NA    | NA    | NA    | NA    | NA   | NA  | NA  |
|                 |        |                 |                 | <b>L/-</b>        | key source by <b>Level</b> only                                                     |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | <b>-/T</b>        | key source by <b>Trend</b> only                                                     |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | <b>L/T</b>        | key source by both <b>Level</b> and <b>Trend</b>                                    |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | -/-               | no key source for this pollutant                                                    |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | IE                | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | NE                | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | NA                | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | *                 | no analysis done                                                                    |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |

Emissions occurring in this sector in Germany derive from the following production processes which are analogous to the IPCC category (Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual (Volume 3)):

### Alcoholic beverages

- Wine
- Beer
- Spirits

### Bread and other foods

- Meat, fish and poultry
- Sugar
- Margarine, hard/hardened fats
- Cake, cookies and breakfast cereals
- Bread

- Animal feedstuffs
- Coffee roasting

Following pollutants are reported:

- volatile organic compounds (NMVOC),
- particulate matter (PM<sub>2.5</sub>, PM<sub>10</sub> and TSP).

Pursuant to the 1993 Classification of Economic Activities (WZ 93), the food and beverage industry is divided into nine groups and a total of 33 classes. Governmental statistical evaluations are oriented to this classification. The German food industry includes an especially large number of small and medium-sized enterprises (SMEs); nearly 80 percent of its companies have fewer than 100 employees, and only 3 per cent have more than 500 employees (BpB, 2002, p.51).

Energy related emissions from the sugar industry are reported under category 1.A.2.e.

## Methodology

The Inventory Database (CSE) lists activity rates (produced amounts) and emission factors for the relevant sectors. The activity rates for the various products / product groups, with the exception of that for feedstuffs, were obtained from the Federal Statistical Office <sup>1)2)</sup>.

### Activity data

Annual activity data for feedstuffs are obtained from the Federal Ministry of Food, Agriculture and Consumer Protection <sup>3)</sup>.

The produced amounts serve as activity data for the following products:

- Animal fat, in [t],
- Animal food,
- Bread production (craft and industrial),
- Cake & cookies,
- Coffee,
- Dried fodder,
- Meat,
- Smoked Products,
- Sugar,
- Beverages such as red, white, sparkling and other wines, beers, and spirits, in [hl]

For the purpose of international comparability, the inventory team aggregates all products to the common unit of kilotons. These totals can be found in CRF tables and NFR tables as activity data, but this approximately converted figure is not statistically published. The procedure for the uniform reporting of the activity rate shows a high degree of uncertainty due to the very different products of official statistics.

### Emission factors

For emissions calculations, country-specific emission factors were used where available. These emission factors were evaluated and updated by a research study carried out by Theloke et al. (2008) <sup>4)</sup>. Otherwise, the emission factors recommended by IPCC and CORINAIR were used.

All NMVOC emission factors except for beer were perpetuated during the complete time series. The emission factor for beer changed in 2000.

Table 1: Overview of NMVOC emission factors applied

|                          | Unit  | EF    | Source                           |
|--------------------------|-------|-------|----------------------------------|
| <b>Animal Fat</b>        | kg/t  | 1     | Expert judgement                 |
| <b>Animal Feed</b>       | kg/t  | 0.1   | Expert judgement                 |
| <b>Beer</b>              | kg/hl | 0.002 | Expert judgement                 |
| <b>Bread (artisanry)</b> | kg/t  | 3     | Guidebook 2019 (Bouscaren, 1992) |

|                                   | Unit  | EF       | Source                           |
|-----------------------------------|-------|----------|----------------------------------|
| <b>Bread (industry)</b>           | kg/t  | 0.3      | Expert judgement                 |
| <b>Cakes &amp; Cookies</b>        | kg/t  | 0.1      | Expert judgement                 |
| <b>Coffee</b>                     | kg/t  | 0.06885  | Expert judgement                 |
| <b>Meat</b>                       | kg/t  | 0.03     | Guidebook 2019 (Bouscaren, 1992) |
| <b>Other Wine/ sparkling Wine</b> | kg/hl | 0.058    | Expert judgement                 |
| <b>Red Wine</b>                   | kg/hl | 0.08     | IPCC GB 1996                     |
| <b>Smoked Meat &amp; Fish</b>     | kg/t  | 0.0023   | Expert judgement                 |
| <b>Spirits</b>                    | kg/hl | 2.93     | Expert judgement                 |
| <b>Sugar</b>                      | kg/t  | 0.898368 | Expert judgement                 |
| <b>White Wine</b>                 | kg/hl | 0.035    | IPCC GB 1996                     |

EF applied for TSP, PM<sub>10</sub> and PM<sub>2.5</sub> are presented in the following table:

Table 2: Particulate matter emission factors applied, in [kg/t]

|                                  | Value     | Source           |
|----------------------------------|-----------|------------------|
| <b>Sugar (TSP)</b>               | 0.19      | Expert judgement |
| <b>Sugar (PM<sub>10</sub>)</b>   | 0.10526   | Expert judgement |
| <b>Sugar (PM<sub>2.5</sub>)</b>  | 0.0589    | Expert judgement |
| <b>Coffee (TSP)</b>              | 0.00905   | Expert judgement |
| <b>Coffee (PM<sub>10</sub>)</b>  | 0.00318   | Expert judgement |
| <b>Coffee (PM<sub>2.5</sub>)</b> | 0.0009055 | Expert judgement |
| <b>Dried fodder (TSP)</b>        | 0.85      | Expert judgement |

## Trends in emissions

Emissions of the food and drink industry are reported, in summary form, in the inventory in of the sectoral report for industrial processes. Emissions in detail for the resp. products are presented following tables:

Table 3: Trends of NMVOC emissions, in metric tonnes [t]

| Product                         | 2011            | 2012            | 2013            | 2014            | 2015            | 2016            | 2017            | 2018            | 2019            | 2020            | 2021            | 2022            | 2023            | 2024            |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| <b>Animal fat</b>               | 345.0           | 351.9           | 348.9           | 388.3           | 428.8           | 374.1           | 345.6           | 320.4           | 295.2           | 287.2           | 293.5           | 225.7           | 213.9           | 234.9           |
| <b>Animal food</b>              | 2,104.5         | 2,141.7         | 2,293.9         | 2,338.9         | 2,433.1         | 2,511.9         | 2,570.2         | 2,607.4         | 2,616.4         | 2,651.7         | 2,629.3         | 2,486.8         | 2,450.7         | 2,465.3         |
| <b>Beer</b>                     | 178.9           | 177.0           | 173.0           | 174.5           | 174.4           | 173.6           | 169.6           | 173.1           | 169.2           | 158.9           | 158.4           | 161.7           | 156.0           | 156.5           |
| <b>Bread production (total)</b> | 3,865.5         | 4,174.5         | 4,037.9         | 4,074.6         | 4,154.8         | 4,172.4         | 4,180.9         | 4,175.2         | 4,214.3         | 4,690.6         | 4,132.7         | 4,333.3         | 4,318.3         | 5,064.1         |
| <b>Cake &amp; cookies...</b>    | 158.7           | 152.3           | 153.9           | 165.0           | 165.7           | 164.9           | 167.8           | 167.8           | 171.2           | 184.1           | 186.7           | 198.7           | 197.1           | 196.2           |
| <b>Coffee</b>                   | 37.2            | 37.5            | 38.2            | 36.6            | 35.3            | 37.4            | 38.0            | 38.0            | 39.4            | 39.4            | 38.7            | 36.7            | 35.0            | 35.6            |
| <b>Meat, fish</b>               | 51.8            | 50.8            | 50.0            | 50.9            | 52.2            | 53.9            | 54.5            | 55.7            | 55.5            | 54.5            | 50.2            | 51.9            | 49.4            | 50.6            |
| <b>Spirituous beverages</b>     | 3,497.8         | 3,535.3         | 3,554.2         | 3,456.6         | 3,536.3         | 3,545.8         | 3,503.4         | 3,595.1         | 3,571.7         | 3,538.0         | 3,652.1         | 4,267.2         | 4,105.8         | 3,721.5         |
| <b>Sugar</b>                    | 3,974.2         | 4,004.0         | 3,326.6         | 3,600.0         | 3,049.9         | 3,267.0         | 3,814.5         | 4,072.0         | 3,677.0         | 3,507.0         | 3,825.8         | 3,998.3         | 3,450.6         | 4,079.8         |
| <b>Wine (total)</b>             | 534.3           | 522.8           | 484.2           | 514.4           | 521.6           | 490.7           | 416.2           | 537.9           | 450.4           | 453.2           | 473.1           | 505.7           | 476.5           | 429.7           |
| <b>TOTAL</b>                    | <b>14,747.8</b> | <b>15,147.9</b> | <b>14,461.0</b> | <b>14,799.6</b> | <b>14,552.1</b> | <b>14,791.7</b> | <b>15,260.7</b> | <b>15,742.5</b> | <b>15,260.3</b> | <b>15,564.7</b> | <b>15,440.5</b> | <b>16,266.0</b> | <b>15,453.4</b> | <b>16,434.2</b> |

Table 4: Trends of particulate matter emissions, in metric tonnes [t]

|                         | Product    | 2011          | 2012          | 2013          | 2014          | 2015          | 2016          | 2017          | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
|-------------------------|------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <b>PM<sub>2.5</sub></b> | Coffee     | 1.73          | 1.74          | 1.78          | 1.70          | 1.64          | 1.73          | 1.76          | 1.76          | 1.83          | 1.83          | 1.80          | 1.70          | 1.62          | 1.65          |
|                         | Sugar      | 464.80        | 468.30        | 389.06        | 421.04        | 356.70        | 382.09        | 446.13        | 476.24        | 430.04        | 410.17        | 447.45        | 467.62        | 403.56        | 477.15        |
|                         | <b>SUM</b> | <b>466.53</b> | <b>470.04</b> | <b>390.84</b> | <b>422.74</b> | <b>358.34</b> | <b>383.83</b> | <b>447.89</b> | <b>478.00</b> | <b>431.87</b> | <b>411.99</b> | <b>449.24</b> | <b>469.33</b> | <b>405.19</b> | <b>478.80</b> |
| <b>PM<sub>10</sub></b>  | Coffee     | 4.91          | 4.96          | 5.05          | 4.83          | 4.66          | 4.93          | 5.01          | 5.01          | 5.20          | 5.20          | 5.11          | 4.84          | 4.62          | 4.70          |
|                         | Sugar      | 839.00        | 845.30        | 702.28        | 760.00        | 643.86        | 689.70        | 805.29        | 859.64        | 776.25        | 740.37        | 807.66        | 844.08        | 728.45        | 861.28        |
|                         | <b>SUM</b> | <b>843.91</b> | <b>850.26</b> | <b>707.33</b> | <b>764.83</b> | <b>648.52</b> | <b>694.63</b> | <b>810.30</b> | <b>864.66</b> | <b>781.45</b> | <b>745.57</b> | <b>812.77</b> | <b>848.93</b> | <b>733.07</b> | <b>865.98</b> |

|     | Product      | 2011            | 2012            | 2013          | 2014          | 2015          | 2016          | 2017            | 2018            | 2019          | 2020          | 2021          | 2022            | 2023          | 2024            |
|-----|--------------|-----------------|-----------------|---------------|---------------|---------------|---------------|-----------------|-----------------|---------------|---------------|---------------|-----------------|---------------|-----------------|
| TSP | Coffee       | 4.91            | 4.96            | 5.05          | 4.83          | 4.66          | 4.93          | 5.01            | 5.01            | 5.20          | 5.20          | 5.11          | 4.84            | 4.62          | 4.70            |
|     | Dried fodder | 205.70          | 209.95          | 191.25        | 168.30        | 146.20        | 146.20        | 198.90          | 207.40          | 180.20        | 187.00        | 187.00        | 187.00          | 187.00        | 187.00          |
|     | Sugar        | 839.00          | 845.30          | 702.28        | 760.00        | 643.86        | 689.70        | 805.29          | 859.64          | 776.25        | 740.37        | 807.66        | 844.08          | 728.45        | 861.28          |
|     | <b>SUM</b>   | <b>1,049.61</b> | <b>1,060.21</b> | <b>898.58</b> | <b>933.13</b> | <b>794.72</b> | <b>840.83</b> | <b>1,009.20</b> | <b>1,072.06</b> | <b>961.65</b> | <b>932.57</b> | <b>999.77</b> | <b>1,035.93</b> | <b>920.07</b> | <b>1,052.98</b> |

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

## Planned improvements

For purposes of updating the emission factors applied, a research project <sup>5)</sup> was launched in 2020, with the delayed results expected to be available for the next annual submission.

<sup>1)</sup> Destatis (2024a): Federal Statistical Office (Statistisches Bundesamt - Destatis): Tabelle 42131-0004: "Produktionswert, -menge, -gewicht und Unternehmen der Vierteljährlichen Produktionserhebung: Deutschland, Jahre, Güterverzeichnis (9-Steller)", ("manufacturing industry; production in the manufacturing industry");

<https://www-genesis.destatis.de/datenbank/online/statistic/42131/table/42131-0004>, Wiesbaden, 2024.

<sup>2)</sup> Destatis (2024b): Federal Statistical Office (Statistisches Bundesamt - Destatis): "Erzeugter Wein: Deutschland, Jahre, Rebsorte, Weinkategorien", ("Wine produced: Germany, years, vine variety, wine categories")

<https://www-genesis.destatis.de/datenbank/online/statistic/41254/table/41254-0001>; Wiesbaden, 2024.

<sup>3)</sup> BMELV, annually: Federal Ministry of Food, Agriculture and Consumer Protection (BMELV): Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten; <https://www.ble-medien-service.de/solr/search/index/?q=jahrbuch>; Bonn, 2024

<sup>4)</sup> Theloke et al. (2008): Theloke, S., Wagner, S., Jepsen, D. Hackmack, U.: "Emissionen aus der Nahrungsmittelindustrie", FKZ 206 42 101/01; [https://oekopol.de/archiv-de/DE\\_450/](https://oekopol.de/archiv-de/DE_450/); Hamburg & Dessau-Roßlau, 2008

<sup>5)</sup> ReFoPlan FKZ – 3720533040: „Aktualisierung der Datengrundlagen zu Emissionen aus der Nahrungsmittelindustrie“; on behalf of the Umweltbundesamt, ongoing

## 2.H.3 - Other



Germany does not yet report any activities or related emissions under this category.



## 2.1 - Wood Processing

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 2.1                                                                                       | T1                                   | NS | CS |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub>                                                                      | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCB | PCB |  |  |
|-----------------|--------|-----------------|-----------------|----------------------------------------------------------------------------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|------|-----|-----|--|--|
| NA              | -/-    | NA              | NA              | -/-                                                                                    | -/-              | -/- | NE | IE | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA     | NA    | NA    | NA    | NA    | NA   | NA  | NA  |  |  |
|                 |        |                 |                 | L/- key source by <b>Level</b> only                                                    |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |  |  |
|                 |        |                 |                 | -/T key source by <b>Trend</b> only                                                    |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |  |  |
|                 |        |                 |                 | L/T key source by both <b>Level</b> and <b>Trend</b>                                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |  |  |
|                 |        |                 |                 | -/- no key source for this pollutant                                                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |  |  |
|                 |        |                 |                 | IE emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |  |  |
|                 |        |                 |                 | NE emission of specific pollutant <b>Not Estimated</b> (yet)                           |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |  |  |
|                 |        |                 |                 | NA specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |  |  |
|                 |        |                 |                 | * no analysis done                                                                     |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |  |  |

This industrial sector essentially includes the production of chipboards. It is of minor meaning with view on emissions.

Chipboards are made from wood chips with added binders under the influence of pressure and heat. The main source of NMVOC emissions are the wood chips used, from which NMVOCs are emitted during drying due to the effect of heat. NMVOC can also be emitted from wood and binder during the pressing process.

CO emissions from the fuel use for production steam are allocated under 1.A.2.

Chipboards are produced in about 20 plants in Germany with the industrial sector being dominated by few larger companies.

### Activity data

The activity data are taken from the national statistics <sup>1)</sup>, but must be converted from volume to mass data for further use.

This data from national statistics from 1995 onwards was recalculated in 2025 using a complete dataset from the Federal Statistical Office. This resulted in only minor changes to the absolute figures in some cases, but the time series is now consistent.

Table 1: Produced amounts, in kilotonnes [kt]

| 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 5,436 | 5,302 | 5,859 | 6,108 | 4,991 | 4,402 | 4,585 | 4,709 | 4,562 | 4,490 | 4,431 | 4,776 | 4,366 | 4,041 | 4,006 |

## Emissions factors

The emission factors of 0.9 kg/t for NMVOC and 0.3 kg/t for PM were estimated on the basis of expert judgements.

## Recalculations

Revised activity data against the previous submission for several years from 1995 are causing changed emissions data in the same manner.

Table: Revised annual activity data, in [kt]

|                     | 1990  | 1995   | 2000   | 2005   | 2010  | 2015  | 2016  | 2017   | 2018  | 2019  | 2020  | 2021  | 2022  | 2023   |
|---------------------|-------|--------|--------|--------|-------|-------|-------|--------|-------|-------|-------|-------|-------|--------|
| current submission  | 5,436 | 5,302  | 5,859  | 6,108  | 4,991 | 4,402 | 4,585 | 4,709  | 4,562 | 4,490 | 4,431 | 4,776 | 4,366 | 4,041  |
| previous submission | 5,436 | 5,710  | 6,310  | 6,575  | 4,561 | 4,402 | 4,560 | 4,709  | 4,322 | 4,490 | 4,431 | 4,775 | 4,366 | 4,060  |
| absolute change     | 0.00  | -408   | -451   | -467   | 430   | -0.05 | 24.72 | -0.48  | 240   | 0.00  | 0.00  | 0.00  | 0.00  | -18.6  |
| relative change*    | 0.00% | -7.14% | -7.14% | -7.11% | 9.43% | 0.00% | 0.54% | -0.01% | 5.56% | 0.00% | 0.00% | 0.00% | 0.00% | -0.46% |

\* The same relative changes occur for the reported emissions.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following [chapter 9.1 - Recalculations](#).

<sup>1)</sup> Federal Statistical Office, reporting numbers until 2018: 1621 13 131; 1621 13 132; 1621 13 133; 1621 13 161; 1621 13 163; 1621 13 190 1621 13 500, reporting numbers from 2019: 162112001, 162112002, 162112003, 162113160, 162114190, 162114500, converted and summarised in tonnes

## 2.J - Production of POPs

### Short description

In Germany, the POP pesticides (Aldrin, Dieldrin, Chlordane, Toxaphene, Mirex, Endrin, Heptachlor, DDT) listed in Annex A & B of the Stockholm Convention are not specifically produced or applied ([see overview](#)). Lindane has not been produced in Germany since 1984 (in the former GDR since 1989).

Dioxins, furans and PAHs have never been produced by the chemical industry on a technical scale in Germany. They are by-products that can be formed unintentionally in all combustion processes in the presence of chlorine and organic carbon. Only HCB played some role just before 1990.

In the Federal Republic of Germany, the production of polychlorinated biphenyls was discontinued by Bayer AG in 1983<sup>13)</sup>. By the Chairman of the Council of Ministers of the GDR on March 6, 1984, with Order No. 54/84<sup>14)</sup>, stipulations were made for the protection of working people, for the controlled use of PCBs and for the harmless disposal and replacement of PCBs by the development and production of suitable PCB-free agents. Since the [Stockholm Convention](#) came into force in 2004, there has been a worldwide ban on these substances.

Thus, no emissions are reported for the period 1990 until today from the source category NFR 2.J (not occurring, NO).

<sup>13)</sup>

Peter Kredel: Herstellung und Verwendung von PCB in der chemischen Industrie. In: Gefahrstoffe – Reinhalt. Luft. 71, Nr. 1/2, 2011, S. 7-9.

<sup>14)</sup>

<https://www.ddd-im-blick.de/jahrgaenge/jahrgang-1989/report/probleme-mit-pcb-1/>

## 2.K - Consumption of POPs and Heavy Metals

### Short description

Former pesticides: As stated in the chapter on NFR 2.J, POP pesticides (Aldrin, Dieldrin, Chlordane, Toxaphene, Mirex, Endrin, Heptachlor, DDT) listed in Annexes A & B of the Stockholm Convention have not been in use since 1989.

The PCP ban was enacted in 1989 with the PCP Prohibition Ordinance. The use of lindane was severely restricted in the 1980s; there is no longer any approved lindane-containing wood preservative on the market in Germany.

HCB: In the Federal Republic of Germany, HCB-containing pesticides may no longer be used since 1981; in the GDR, the ban has been in force since 1984. More information is given in chapter [3.D.f - Agriculture other including use of pesticides](#).

Dioxins and furans are neither produced or applied intentionally but are by-products that can be formed unintentionally in all combustion processes in the presence of chlorine and organic carbon.

PAHs occur as impurities of other substances or in uncontrolled combustion processes.

*Therefore, no emissions of dioxins and furans, PAHs, and HCB would be reported.*

PCBs: Source category 2.K considers PCB emissions from use of polychlorinated biphenyls (PCBs) in transformers, small and large capacitors, anti-corrosive paints and joint sealants. Since 1989, polychlorinated biphenyls (PCBs) may no longer be manufactured and placed on the market in Germany (PCB Prohibition Ordinance 1989, adopted in the Chemicals Prohibition Ordinance 1993). However, due to their long lifetime, PCBs can still enter the environment as longterm or secondary emissions, e.g. through open applications in buildings, use in wall paints, joint sealants, varnishes and applications as flame retardants.

However, data on open applications in buildings are subject to large uncertainties; in particular, the different amounts of PCBs used in eastern and western Germany and the many application sites (public, private, and industrial buildings) cannot be plausibly quantified. The figures of a research project we have investigated are not applicable for reporting but for scientific discussion <sup>1)</sup>.

An emission factor in the EEA/EMEP Guidebook 2023<sup>2)</sup> is only be reported for PCB. As the calculation simply is linked to the capita disregarding existing prohibitions this emission factor would lead to unjustified high emissions.

*For this reason and to be consistent with the reporting Guidelines, the notation key NE for PCB and NA for the other pollutants is used in the NFR tables.*

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<sup>1)</sup> See research report (in german only):

<https://www.umweltbundesamt.de/publikationen/analyse-der-novellierten-nec-richtlinie-bezueglich>

<sup>2)</sup> EMEP/EEA, 2023: EMEP/EEA air pollutant emission inventory guidebook 2023, Copenhagen, 2023,

<https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/2-industrial-processes-and-product-use/2-k-consumption-of-pops/2-k-consumption-of-pops/view>

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub>                                                                               | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCB | PCB |
|-----------------|--------|-----------------|-----------------|-------------------------------------------------------------------------------------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|------|-----|-----|
| NA              | NA     | NA              | NA              | L/T                                                                                             | L/T              | L/T | NE | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA     | NA    | NA    | NA    | NA    | NA   | NA  | NA  |
|                 |        |                 |                 | L/- key source by <b>L</b> evel only                                                            |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | -/T key source by <b>T</b> rend only                                                            |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | L/T key source by both <b>L</b> evel and <b>T</b> rend                                          |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | -/- no key source for this pollutant                                                            |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | IE emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | NE emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | NA specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | * no analysis done                                                                              |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |      |     |     |

Even though these emissions are reported as a sum under NFR 2.L, this report provides seperate specific information regarding emission from the handling of bulk products (2.L(a)) and from industrial establishments (2.L(b)). For these **detailed information**, please refer to the **sub-chapters** linked above.

Methodology

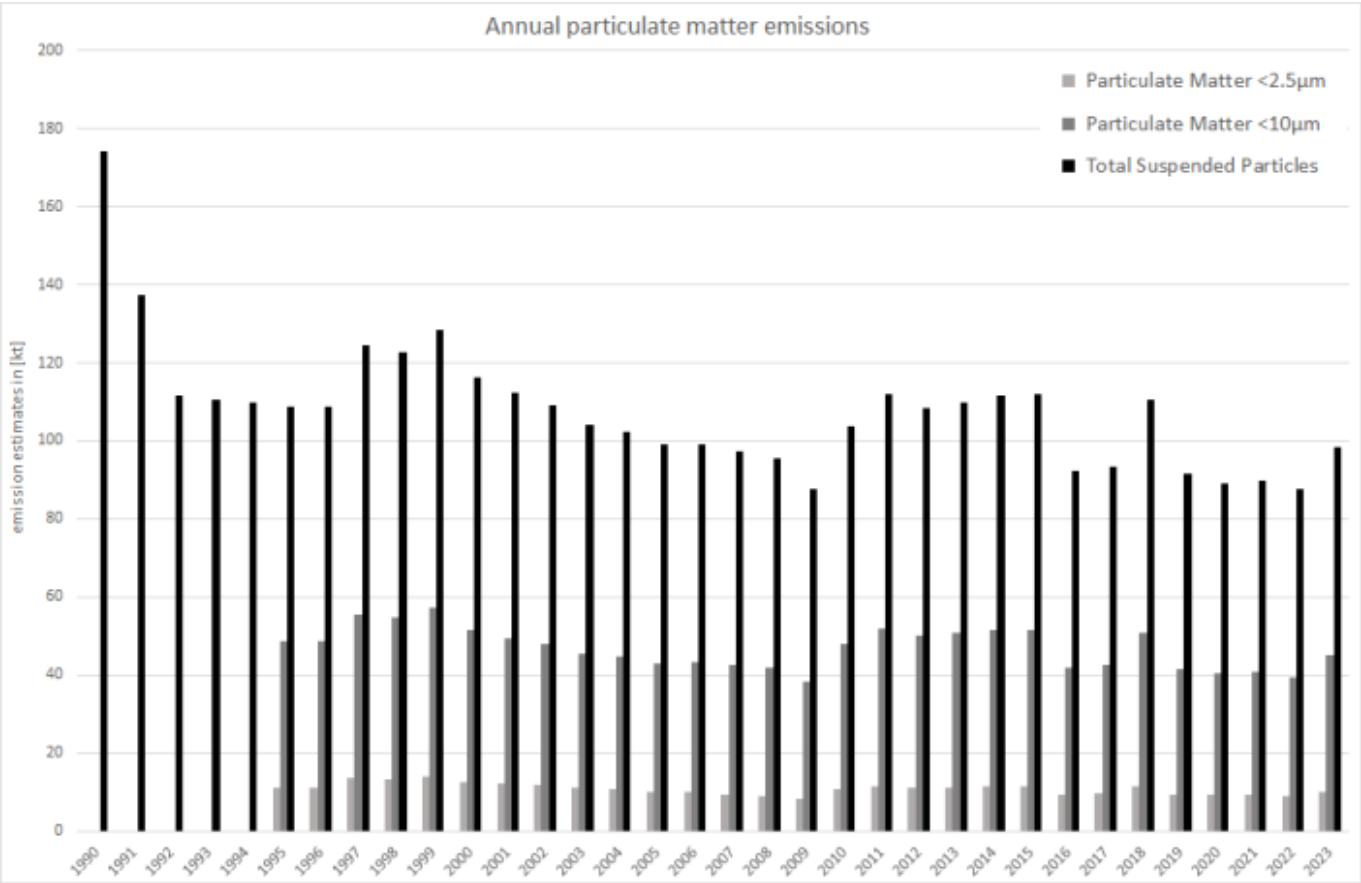
For specific information on applied methods, activity data and emission factors please refer to the sub-chapters linked above.

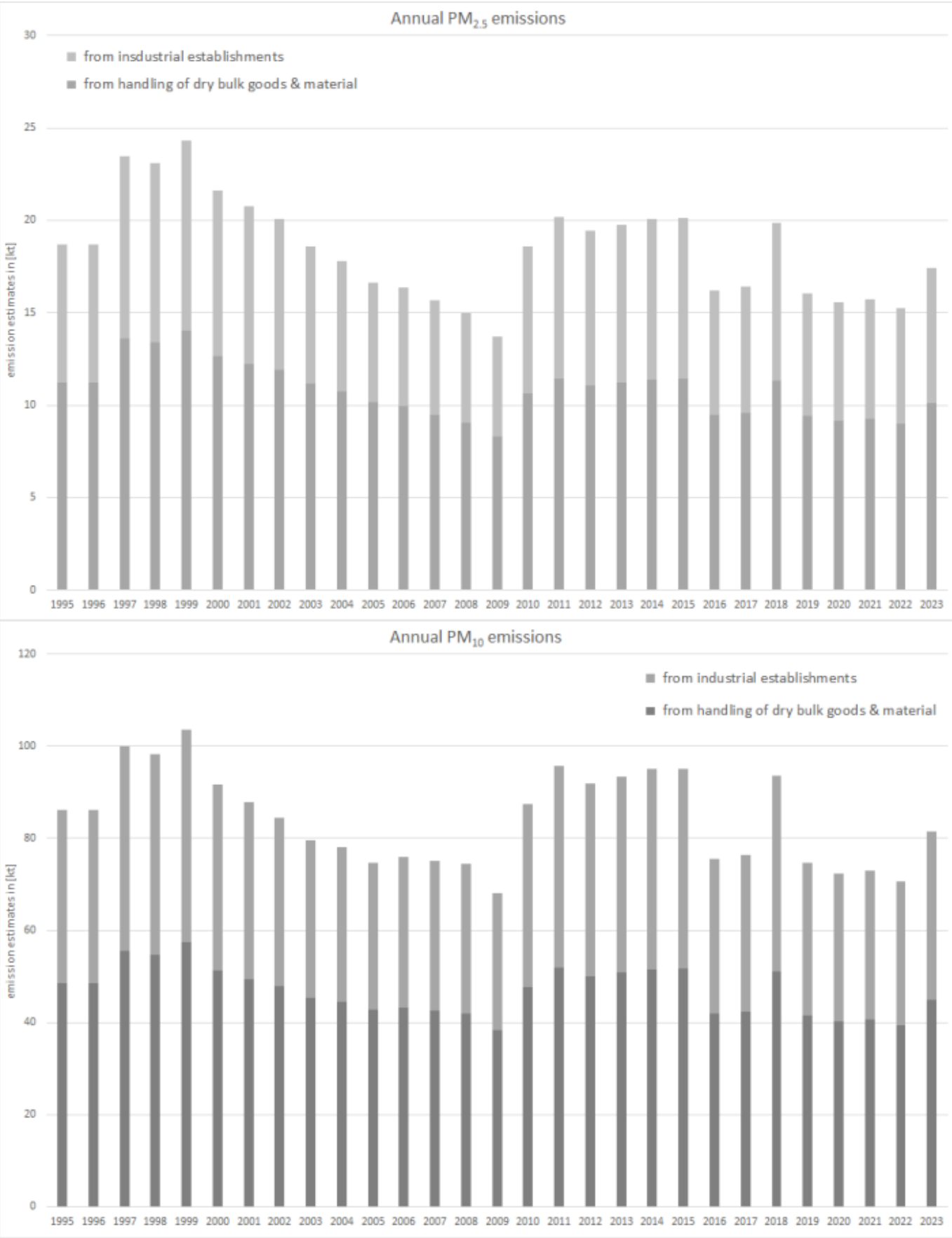
Discussion of emission trends

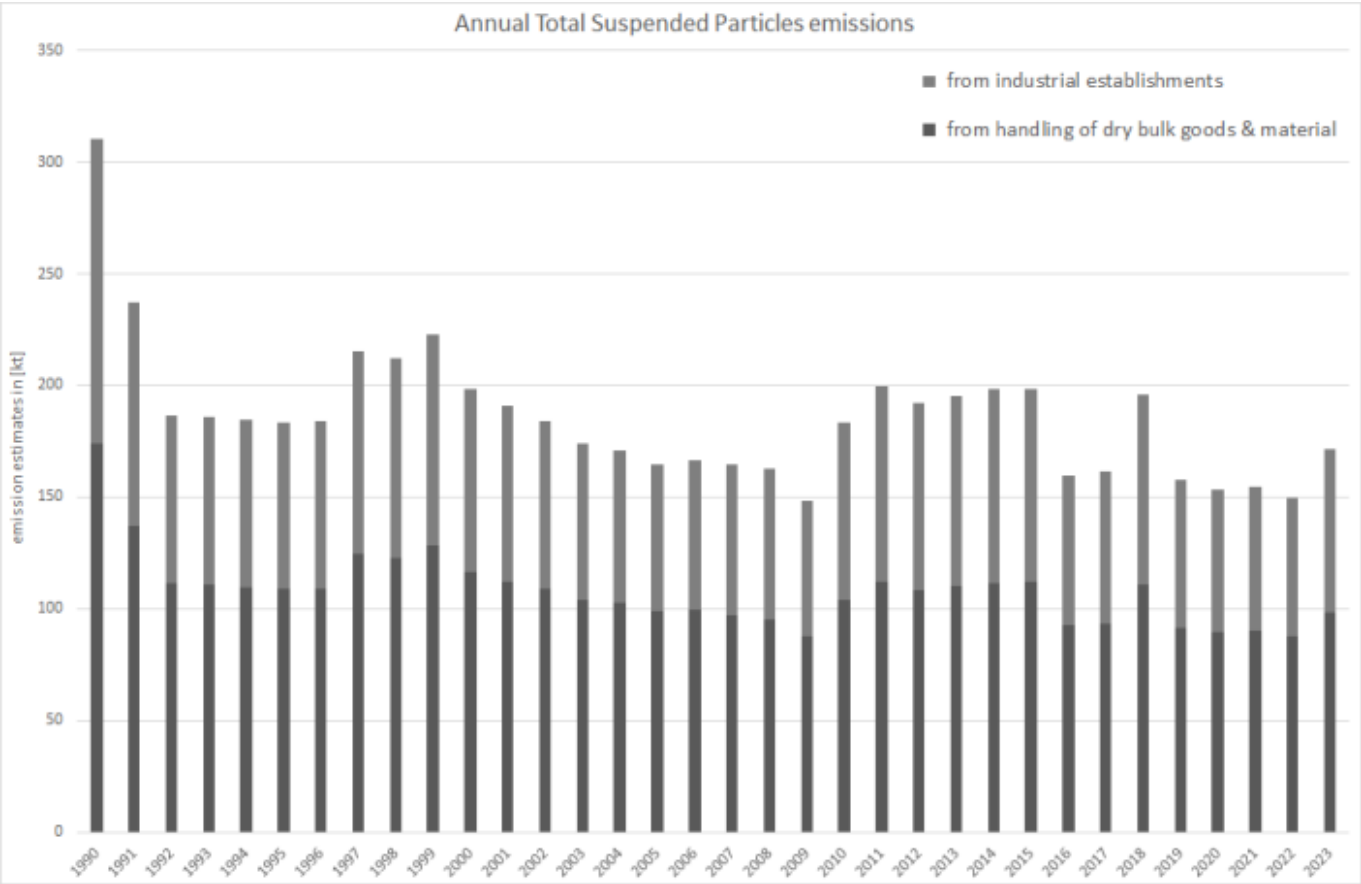
Table: Outcome of Key Category Analysis

|      |     |                  |                   |
|------|-----|------------------|-------------------|
| for: | TSP | PM <sub>10</sub> | PM <sub>2.5</sub> |
| by:  | L/T | L/-              | L/-               |

In general, diffuse particulate matter emissions depend strongly on the amounts of dry bulk goods handled and transported. In addition, due to efforts to prevent such particle emissions, the time series of the emission factors applied for all three fractions of particulate matter show a falling trend.







Recalculations

Recalulations against the previous submission result from a revised total number of inhabitants as applied as **activity data** for diffuse PM emissions from industrial establishments.

Table 2: Revised population data for Germany and for 2022 and 2023

|                     | 2022       | 2023       |
|---------------------|------------|------------|
| current submission  | 83.118.501 | 83.456.045 |
| previous submission | 82.711.282 | 82.711.282 |
| absolute change     | 407.219    | 744.763    |
| relative change     | 0,49%      | 0,90%      |

In contrast, amounts of dry bulk goods and products as well as all **emission factors** remain unrevised compared to last year's submission.

Table 3: Revised particulate-matter emissions 2022 & 2023, in [kt]

|                                        | 2022   | 2023   |
|----------------------------------------|--------|--------|
| <b>PM<sub>2.5</sub></b>                |        |        |
| current submission                     | 9.03   | 10.13  |
| previous submission                    | 9.01   | 10.10  |
| absolute change                        | 0.01   | 0.03   |
| relative change                        | 0.15%  | 0.25%  |
| <b>PM<sub>10</sub></b>                 |        |        |
| current submission                     | 39.5   | 44.9   |
| previous submission                    | 39.5   | 45.0   |
| absolute change                        | -0.04  | -0.08  |
| relative change                        | -0.10% | -0.17% |
| <b>TOTAL SUSPENDED PARTICLES - TSP</b> |        |        |
| current submission                     | 87.7   | 98.7   |



|                     | 2022  | 2023  |
|---------------------|-------|-------|
| previous submission | 87.6  | 98.5  |
| absolute change     | 0.12  | 0.23  |
| relative change     | 0.14% | 0.23% |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



For improvements planned for NFR sub-categories 2.L(a) and 2.L(b) please refer to the corresponding sub-chapters linked above.

## 2.L(a) - Handling of Bulk Products

### Short description

Under category 2.L(a) - *Handling of Bulk Products* dust emissions from bulk material handling (loading and unloading) including agricultural bulk materials offsite the fields are reported. Emissions from quarrying and mining of minerals and from point source emissions are excluded.

### Methodology

For 1990 to 1996, only simplified estimates without a differentiation of handled materials and products exist. For all following years, emissions are calculated using a tier1 method taking into account detailed data on handled materials and products.

### Activity data

Official statistics are of limited use in determining handling of bulk products. There are only transport statistics available providing the amounts of several transported materials.

During a research project carried out by (Müller-BBM) <sup>1)</sup>, activity data was derived from primary statistical data from the Federal Statistical Office for Germany (Statistisches Bundesamt, Destatis) and the Federal Motor Transport Authority (Kraftfahrt-Bundesamt, KBA). Here, data on goods transported by railways and ships is gathered by Destatis whereas data for road transport is collected by the KBA.

Here, for all years until 2009, the collection of data for transported goods followed the official **NST/R (1968) nomenclature and regulation** (Eurostat, 2015a) <sup>2)</sup>.

As of 2010, statistical data following the newly implemented **NST-2007** <sup>3), 4)</sup> **nomenclature and regulation** from Destatis and KBA is applied instead.

Table 1: Overview of primary activity data sources over time

|                   |                                                                   |
|-------------------|-------------------------------------------------------------------|
| <b>1990-1996</b>  | simplified estimates without differentiation of handled materials |
| <b>1997-2009</b>  | statistical data following NST/R nomenclature                     |
| <b>as of 2010</b> | statistical data following NST-2007 nomenclature                  |

Here, NST/R allowed the distribution of a broad variety of goods and materials (e.g. barley, corn, oats, rice, rye, and wheat), whereas NST-2007 provides only a very condensed list of classes of goods (e.g. 'crops').

Due to these methodological breaks, activity data and emissions show inconsistencies (especially on the level of specific goods and materials) that cannot be eliminated at the moment. Nonetheless, on a aggregate level, these breaks are balanced out more or less automatically as the total amount of transported dry materials does not change too much with changing statistical approaches.

For estimating the amount of moved bulk materials as well as emissions from the loading and unloading of bulk materials, these primary activity data (PAD, including the amounts of imported and exported goods as well as goods transported within Germany) have to be calculated from the amounts of transported goods:

$$PAD_{(totalmateriali)} = PAD_{(importmateriali)} + 2 \times PAD_{(domestichandlingmateriali)} + PAD_{(exportmateriali)}$$

where:

- $PAD_{(importmateriali)}$  = amount of imported good or material,
- $PAD_{(domestichandlingmateriali)}$  = amount of good or material transported within Germany
- $PAD_{(exportmateriali)}$  = amount of exported good or material

As the basic statistics provide only total amounts of imported, exported and domestically transported dry goods without any distinction into bulk and packed goods, the shares of bulk goods had to be estimated via expert judgement during the workshop mentioned above.

During this workshop, experts, for comparable kinds of dry bulk material, discussed specific shares displaying which part of the total amount of dry material  $i$  loaded and/or unloaded within Germany might be transported as bulk material thus causing PM emissions.

So the activity data finally used for estimating specific particulate matter emissions for every bulk material is calculated as a specific share  $s$  of the amount of this material  $i$  loaded and/or unloaded within Germany:

$$AD_{(bulkmaterial\ i)} = PAD_{(totalmaterial\ i)} \times s_{(bulkshare)}$$

where:

- $PAD_{(totalmaterial\ i)}$  = total amount of good or material imported to, transported within, and exported from Germany,
- $s_{(bulkshare)}$  = percental share of a specific good/material that is considered to be handled as dry bulk good causing particulate matter emissions during handling

Table 2: Amounts of dry, dusty bulk goods handled in Germany 2010-2023, in tonnes

|                                         | transport mode     | 2010       | 2015       | 2016       | 2017       | 2018       | 2019       | 2020       | 2021       | 2022       | 2023       | 2024       |
|-----------------------------------------|--------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| other herbal products                   | inland vessel      | 3,273,975  | 2,479,720  | 2,532,347  | 2,776,593  | 2,978,726  | 2,896,408  | 3,398,570  | 2,775,621  | 3,185,121  | 2,595,900  | 2,533,487  |
|                                         | railways           | 17,849,146 | 21,867,000 | 19,270,679 | 18,928,775 | 18,679,111 | 17,758,000 | 14,257,000 | 13,930,000 | 14,929,000 | 11,841,000 | 10,277,000 |
|                                         | heavy-duty vehicle | 1,544,488  | 2,757,516  | 2,470,814  | 2,552,567  | 2,172,344  | 1,972,384  | 1,483,783  | 1,522,528  | 1,298,793  | 1,386,189  | 1,268,801  |
|                                         | sea-going vessel   | 69,407,200 | 86,441,400 | 76,251,684 | 77,289,169 | 99,899,785 | 82,985,300 | 82,091,500 | 73,636,700 | 80,938,771 | 77,535,124 | 59,020,622 |
| raw mineral chemicals                   | inland vessel      | 9,827,059  | 9,273,000  | 9,627,577  | 9,885,631  | 10,634,917 | 9,158,000  | 8,714,000  | 8,238,000  | 7,877,000  | 6,220,000  | 8,836,000  |
|                                         | railways           | 6,794,922  | 2,366,579  | 2,573,770  | 2,696,029  | 11,798,872 | 11,909,168 | 11,706,333 | 11,957,508 | 11,484,122 | 8,643,716  | 9,055,974  |
|                                         | heavy-duty vehicle | 78,928,400 | 82,363,000 | 10,043,513 | 11,351,314 | 63,713,624 | 11,315,500 | 9,742,600  | 7,608,000  | 7,944,572  | 49,320,612 | 5,940,880  |
|                                         | sea-going vessel   | 5,550,621  | 7,905,516  | 7,888,208  | 8,131,408  | 7,386,700  | 4,839,421  | 5,150,665  | 6,158,004  | 5,183,607  | 3,642,320  | 5,071,187  |
| raw organic chemicals                   | inland vessel      | 16,287,803 | 21,094,000 | 18,661,643 | 18,339,593 | 0          | 17,607,000 | 17,718,000 | 18,922,000 | 16,764,000 | 16,059,000 | 16,588,000 |
|                                         | railways           | 6,299,350  | 57,126     | 114,803    | 175,726    | 6,667,823  | 6,528,823  | 6,025,705  | 6,242,593  | 5,843,685  | 5,793,783  | 6,242,134  |
|                                         | heavy-duty vehicle | 11,345,600 | 4,570,800  | 0          | 828,916    | 12,601,908 | 0          | 0          | 532,800    | 598,840    | 12,277,973 | 218,053    |
|                                         | sea-going vessel   | 3,638,264  | 2,478,579  | 2,341,016  | 2,413,459  | 2,463,615  | 2,623,994  | 2,370,156  | 2,620,126  | 2,316,765  | 2,545,075  | 1,655,210  |
| iron ore                                | inland vessel      | 2,409,311  | 1,361,655  | 2,003,004  | 2,129,778  | 1,560,991  | 1,870,568  | 1,635,431  | 1,646,949  | 1,540,486  | 1,604,070  | 1,687,550  |
|                                         | railways           | 22,499,503 | 6,721,000  | 6,610,955  | 6,456,917  | 8,421,754  | 6,743,000  | 4,712,000  | 3,633,000  | 3,456,000  | 2,978,000  | 2,497,000  |
|                                         | heavy-duty vehicle | 802,164    | 48,778     | 43,760     | 135,197    | 25,450     | 21,898     | 18,396     | 136,867    | 545,520    | 258,722    | 406,678    |
|                                         | sea-going vessel   | 11,801,600 | 15,401,600 | 7,065,314  | 8,549,595  | 13,182,782 | 6,653,300  | 3,878,200  | 3,596,000  | 8,319,232  | 4,139,129  | 3,581,298  |
| crops                                   | inland vessel      | 9,816,233  | 11,243,918 | 10,046,500 | 9,546,963  | 7,715,977  | 8,128,252  | 9,593,182  | 9,174,271  | 9,175,097  | 7,969,907  | 7,966,389  |
|                                         | railways           | 2,982,548  | 4,583,000  | 3,545,040  | 3,759,205  | 2,985,786  | 3,169,000  | 4,513,000  | 5,223,000  | 5,415,000  | 4,918,000  | 4,950,000  |
|                                         | heavy-duty vehicle | 9,319,143  | 12,142,981 | 10,735,948 | 8,851,781  | 7,672,262  | 7,985,888  | 9,630,445  | 7,423,593  | 6,861,301  | 6,889,485  | 6,301,819  |
|                                         | sea-going vessel   | 65,464,800 | 70,614,200 | 58,304,413 | 61,639,154 | 58,957,570 | 56,315,100 | 55,307,700 | 57,393,200 | 57,542,622 | 61,876,197 | 55,345,640 |
| potatoes                                | inland vessel      | 2,852      | 0          | 465,039    | 381,098    | 349,419    | 645,000    | 506,000    | 399,000    | 288,000    | 166,000    | 162,000    |
|                                         | railways           | 1,782,712  | 4,133,053  | 5,180,094  | 5,368,877  | 5,275,005  | 5,506,351  | 5,509,211  | 5,289,677  | 4,708,901  | 3,364,175  | 3,290,685  |
|                                         | heavy-duty vehicle | 97,539,400 | 99,568,200 | 75,685,582 | 69,634,714 | 99,763,916 | 69,628,300 | 74,421,000 | 75,421,200 | 67,185,245 | 88,464,233 | 65,977,641 |
|                                         | sea-going vessel   | 3,104,125  | 3,525,359  | 3,586,612  | 3,747,650  | 3,788,108  | 4,001,310  | 4,365,473  | 3,372,983  | 3,797,498  | 3,764,560  | 3,736,274  |
| coal products                           | inland vessel      | 25,728,177 | 25,203,179 | 25,755,504 | 25,193,580 | 22,796,286 | 21,531,669 | 18,676,735 | 20,936,706 | 20,416,412 | 20,470,884 | 20,332,226 |
|                                         | railways           | 38,565,334 | 37,708,000 | 37,434,377 | 37,586,847 | 38,252,864 | 36,601,000 | 32,240,000 | 35,795,000 | 34,599,000 | 31,513,000 | 34,270,000 |
|                                         | heavy-duty vehicle | 13,922,885 | 13,967,430 | 13,365,447 | 14,810,135 | 14,761,129 | 14,521,110 | 12,666,336 | 14,496,550 | 13,755,726 | 13,805,930 | 12,853,375 |
|                                         | sea-going vessel   | 203,800    | 0          | 1,764,223  | 534,846    | 1,680,885  | 731,400    | 0          | 1,035,800  | 0          | 1,968,726  | 0          |
| products from grinding & shelling mills | inland vessel      | 760,174    | 305,202    | 281,603    | 255,398    | 197,705    | 202,054    | 138,138    | 154,680    | 158,954    | 137,626    | 241,756    |
|                                         | railways           | 4,122,535  | 3,424,000  | 3,619,997  | 3,581,858  | 3,224,654  | 2,756,000  | 3,000,000  | 4,297,000  | 4,969,000  | 4,061,000  | 3,277,000  |
|                                         | heavy-duty vehicle | 117,224    | 409,515    | 256,924    | 323,622    | 311,822    | 392,516    | 406,221    | 480,587    | 490,794    | 607,817    | 403,513    |
|                                         | sea-going vessel   | 7,923,200  | 4,322,000  | 1,338,908  | 1,006,750  | 1,814,964  | 1,423,800  | 2,364,000  | 1,046,400  | 3,866,610  | 3,599,113  | 2,639,409  |

|                                                                                                                     | transport mode     | 2010          | 2015          | 2016          | 2017          | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
|---------------------------------------------------------------------------------------------------------------------|--------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| mineral fertilisers                                                                                                 | inland vessel      | 56,517,180    | 43,958,000    | 43,837,499    | 39,960,787    | 41,345,431    | 43,057,000    | 44,816,000    | 50,082,000    | 51,545,000    | 49,114,000    | 43,162,000    |
|                                                                                                                     | railways           | 40,518,020    | 31,927,501    | 33,178,046    | 36,072,381    | 35,475,139    | 38,522,204    | 36,093,810    | 33,268,472    | 34,596,242    | 29,332,344    | 26,729,878    |
|                                                                                                                     | heavy-duty vehicle | 1,655,747,400 | 1,853,177,400 | 1,669,958,849 | 1,672,131,248 | 1,838,142,737 | 1,639,276,500 | 1,609,497,100 | 1,633,052,300 | 1,605,183,983 | 1,577,704,165 | 1,363,053,770 |
|                                                                                                                     | sea-going vessel   | 8,739,096     | 9,739,769     | 10,353,589    | 13,515,063    | 12,463,686    | 13,506,136    | 12,271,288    | 13,020,839    | 13,113,287    | 13,178,697    | 13,458,546    |
| natural sands, gravel & stones                                                                                      | inland vessel      | 5,737,386     | 5,104,076     | 4,930,755     | 4,742,988     | 4,466,442     | 4,975,009     | 4,881,285     | 4,221,526     | 3,898,815     | 3,174,195     | 3,767,411     |
|                                                                                                                     | railways           | 15,708,472    | 14,091,000    | 13,614,102    | 14,066,445    | 12,318,493    | 11,774,000    | 11,651,000    | 11,850,000    | 11,180,000    | 10,993,000    | 11,918,000    |
|                                                                                                                     | heavy-duty vehicle | 5,309,443     | 6,509,499     | 7,011,855     | 7,392,865     | 7,239,705     | 7,385,920     | 7,868,139     | 6,943,731     | 6,206,307     | 6,396,579     | 5,601,954     |
|                                                                                                                     | sea-going vessel   | 37,454,600    | 71,366,600    | 28,434,989    | 30,619,530    | 68,151,044    | 29,142,700    | 28,658,700    | 26,005,100    | 26,816,891    | 61,307,868    | 24,989,977    |
| non-iron ores                                                                                                       | inland vessel      | 1,512,246     | 2,964,925     | 2,827,648     | 3,199,797     | 3,043,062     | 2,749,584     | 3,389,500     | 3,282,220     | 3,550,037     | 2,974,380     | 2,414,849     |
|                                                                                                                     | railways           | 29,742        | 8,000         | 6,642         | 16,877        | 61,486        | 22,000        | 250,000       | 28,000        | 385,000       | 114,000       | 25,000        |
|                                                                                                                     | heavy-duty vehicle | 2,687,815     | 2,850,350     | 3,870,273     | 4,368,429     | 4,621,799     | 3,488,596     | 4,680,063     | 4,398,542     | 3,761,297     | 2,258,568     | 3,459,432     |
|                                                                                                                     | sea-going vessel   | 705,600       | 0             | 0             | 827,676       | 512,051       | 0             | 675,600       | 0             | 0             | 485,527       | 0             |
| raw coals                                                                                                           | inland vessel      | 5,523,633     | 39,189,603    | 38,498,874    | 34,508,319    | 30,305,094    | 6,279,089     | 6,745,999     | 6,438,938     | 5,834,164     | 6,165,052     | 6,629,672     |
|                                                                                                                     | railways           | 1,242,916     | 470,000       | 547,545       | 532,253       | 445,547       | 613,000       | 588,000       | 743,000       | 731,000       | 479,000       | 467,000       |
|                                                                                                                     | heavy-duty vehicle | 4,052,384     | 6,376,068     | 7,164,149     | 6,953,293     | 6,614,999     | 6,067,598     | 6,535,195     | 6,402,964     | 6,314,380     | 6,114,091     | 5,637,522     |
|                                                                                                                     | sea-going vessel   | 20,847,400    | 34,166,200    | 22,918,493    | 24,118,587    | 35,511,100    | 18,815,200    | 18,718,500    | 25,919,300    | 22,471,870    | 27,708,882    | 18,551,576    |
| secondary raw materials                                                                                             | inland vessel      | 1,383         | 0             | 0             | 1,056         | 0             | 49,119        | 46,427        | 0             | 597           | 0             | 1,124         |
|                                                                                                                     | railways           | 17,135        | 0             | 0             | 4,581,528     | 4,896,748     | 0             | 0             | 0             | 8,000         | 14,000        | 32,000        |
|                                                                                                                     | heavy-duty vehicle | 29,296,456    | 21,170,067    | 20,406,870    | 22,490,149    | 20,701,636    | 25,168,423    | 22,127,609    | 18,406        | 17,061        | 21,834        | 24,585        |
|                                                                                                                     | sea-going vessel   | 10,627,000    | 9,956,800     | 4,683,480     | 5,039,904     | 9,621,800     | 4,789,300     | 5,227,200     | 5,502,200     | 5,013,672     | 9,227,068     | 6,092,053     |
| rock & saline salt                                                                                                  | inland vessel      | 36,652,759    | 0             | 0             | 0             | 19,571        | 26,136,332    | 18,399,530    | 25,256,586    | 25,510,105    | 20,664,710    | 16,782,554    |
|                                                                                                                     | railways           | 58,433,815    | 67,749,000    | 61,034,978    | 51,142,196    | 48,277,288    | 41,538,000    | 32,449,000    | 33,689,000    | 40,216,000    | 35,146,000    | 31,715,000    |
|                                                                                                                     | heavy-duty vehicle | 13,299,295    | 16,476,145    | 14,401,269    | 15,919,606    | 16,187,881    | 12,695,386    | 7,439,063     | 10,027,842    | 11,851,034    | 7,707,321     | 7,284,011     |
|                                                                                                                     | sea-going vessel   | 10,561,400    | 13,275,800    | 11,858,051    | 16,057,484    | 12,593,015    | 12,603,300    | 6,404,100     | 13,025,600    | 11,662,471    | 10,496,670    | 9,056,931     |
| nitrogen fertilisers                                                                                                | inland vessel      | 2,769,356     | 3,939,437     | 3,651,498     | 4,115,651     | 3,977,618     | 4,621,784     | 4,370,103     | 4,366,688     | 4,431,492     | 3,286,950     | 3,606,666     |
|                                                                                                                     | railways           | 3,067,187     | 2,575,000     | 2,362,886     | 2,603,115     | 3,017,352     | 2,673,000     | 2,078,000     | 2,723,000     | 2,751,000     | 2,679,000     | 2,722,000     |
|                                                                                                                     | heavy-duty vehicle | 567,059       | 919,251       | 888,593       | 812,124       | 1,116,411     | 961,803       | 624,742       | 926,648       | 877,961       | 779,913       | 782,987       |
|                                                                                                                     | sea-going vessel   | 21,579,000    | 7,887,600     | 7,238,776     | 10,591,977    | 11,820,822    | 8,527,200     | 5,613,400     | 12,493,000    | 7,482,911     | 9,334,781     | 6,699,019     |
| white cement, lime, cement                                                                                          | inland vessel      | 5,047,097     | 5,810,444     | 5,057,435     | 4,173,386     | 3,427,249     | 3,502,952     | 3,465,765     | 3,552,873     | 3,328,845     | 2,507,790     | 2,324,648     |
|                                                                                                                     | railways           | 422,570,000   | 490,299,000   | 161,493,436   | 171,462,235   | 502,448,809   | 175,973,100   | 164,093,200   | 121,392,900   | 81,280,591    | 427,926,405   | 65,394,662    |
|                                                                                                                     | heavy-duty vehicle | 25,614,264    | 22,113,000    | 21,261,312    | 22,147,649    | 20,565,387    | 17,627,000    | 14,626,000    | 16,501,000    | 17,558,000    | 15,610,000    | 14,588,000    |
|                                                                                                                     | sea-going vessel   | 15,691,876    | 11,521,886    | 11,212,165    | 12,089,358    | 15,101,718    | 16,441,457    | 16,504,345    | 15,622,479    | 15,264,191    | 14,748,686    | 16,358,182    |
| sugar beet                                                                                                          | inland vessel      | 0             | 6,366,439     | 6,426,328     | 6,396,070     | 5,912,659     | 0             | 4,265         | 1,274         | 0             | 0             | 850           |
|                                                                                                                     | railways           | 123,598       | 24,000        | 64,094        | 37,555        | 0             | 2,000         | 2,000         | 127,000       | 2,000         | 96,000        | 19,000        |
|                                                                                                                     | heavy-duty vehicle | 17            | 2,872         | 3,125         | 9,676         | 3,277         | 0             | 3,257         | 12,340        | 6,313         | 7,900         | 9,475         |
|                                                                                                                     | sea-going vessel   | 26,946,200    | 36,601,000    | 22,159,060    | 32,853,554    | 31,023,482    | 32,540,800    | 31,424,000    | 31,685,800    | 46,174,132    | 40,603,995    | 41,925,666    |
| sources of activity data: annual data deliveries DESTATIS & KBA (for heavy-duty vehicles) to the inventory compiler |                    |               |               |               |               |               |               |               |               |               |               |               |

## Emission factors

Emission factors are based on the methodology according VDI guidelines 3790. The values used here originate from a research project by (Müller-BBM, 2011) <sup>5)</sup> taking into account information of an expert panel of industry and administration. For details see the [<https://www.umweltbundesamt.de/publikationen/konsistenzpruefung-verbesserungspotenzial> project report] (German version only).

Within the study, PM emission factors are estimated for each material or good that might be transported as dry and unpacked bulk. These very specific EF are then assigned to the classes of materials/goods available from the different different statistics (NST/R, NST-2007) to form implied Ef for these class of bulk material.

As NST/R provided a wide variety of goods and materials, whereas NST-2007 provides only a very condensed list of classes of goods, the very specific EF derived during the study and the joint expert workshop have been aggregated in order to match the classes of goods following NST-2007.

Table 3: specific emission factors applied for PM emissions from NST/R products, in [kg/t], as used for 2023 estimates

|                                               | <b>TSP</b> | <b>PM<sub>10</sub></b> | <b>PM<sub>2.5</sub></b> |
|-----------------------------------------------|------------|------------------------|-------------------------|
| <b>Other herbal products</b>                  | 0.032000   | 0.016000               | 0.003200                |
| <b>Raw Chemicals: mineralic</b>               | 0.041000   | 0.020500               | 0.004100                |
| <b>Raw organic chemicals</b>                  | 0.024000   | 0.012000               | 0.002400                |
| <b>Iron ore</b>                               | 0.057000   | 0.028500               | 0.005700                |
| <b>Crops</b>                                  | 0.045000   | 0.022500               | 0.004500                |
| <b>Potatoes</b>                               | 0.007000   | 0.003500               | 0.000700                |
| <b>Coal products</b>                          | 0.019000   | 0.009500               | 0.001900                |
| <b>Grinding &amp; shelling mills products</b> | 0.003000   | 0.001500               | 0.000300                |
| <b>Mineral fertilisers</b>                    | 0.024000   | 0.012000               | 0.002400                |
| <b>Natural sands, gravel, and stones</b>      | 0.027000   | 0.013500               | 0.002700                |
| <b>Non-iron ores</b>                          | 0.066000   | 0.033000               | 0.006600                |
| <b>Raw coals</b>                              | 0.016000   | 0.008000               | 0.001600                |
| <b>Secondary raw materials</b>                | 0.027000   | 0.013500               | 0.002700                |
| <b>Rock &amp; saline salt</b>                 | 0.068000   | 0.034000               | 0.006800                |
| <b>Nitrogen fertilisers</b>                   | 0.024000   | 0.012000               | 0.002400                |
| <b>White cement, lime, cement</b>             | 0.005000   | 0.002500               | 0.000500                |
| <b>Sugar beet</b>                             | 0.000240   | 0.000120               | 0.000024                |

### Ratio TSP : PM<sub>10</sub> : PM<sub>2.5</sub>

The shares of PM<sub>10</sub> and PM<sub>2.5</sub> of the entire amounts of emitted TSP have been set to fixed values used for the entire time series.

Assumptions:

1. TSP = 100%,
2. 50% of TSP are  $\leq 10 \mu\text{m}$ . Therefore, the EF(PM<sub>10</sub>) are assumed as 1/2 of the corresponding EF(TSP), and
3. 10% of TSP are  $\leq 2.5 \mu\text{m}$ . Therefore, the EF(PM<sub>2.5</sub>) are assumed as 1/10 of the corresponding EF(TSP).

The ratios of TSP, PM<sub>10</sub>, and PM<sub>2.5</sub> were also discussed in the research project mentioned above, but without generating any new data. Nonetheless, the ratios might be too low at the moment and will be checked furthermore.

## Recalculations



For information on revised inventory data, please see the [superordinate chapter](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1), 5)</sup> Müller-BBM (2011): Bender, Dr. M., Gronewäller, L., Langer, D.: Konsistenzprüfung und Verbesserungspotenzial der Schüttgutemissionsberechnung - Umweltforschungsplan des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit, FKZ 3708 49 107 2 - FB 00 1453 UBA; Müller-BBM GmbH, <https://www.umweltbundesamt.de/publikationen/konsistenzpruefung-verbesserungspotenzial>, on behalf of the Umweltbundesamt, Planegg / Dessau-Roßlau, 2011.

<sup>2)</sup> Eurostat (2015a): Standard Goods Classification for Transport Statistics/Revised (1967) NST/R - [URL](#)

<sup>3)</sup> Eurostat (2015b): Standard Goods Classification for Transport Statistics, 2007 - [URL](#)

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<sup>4)</sup> Destatis (2013): Federal Statistical Office (Statistisches Bundesamt - Destatis): Verkehr, NST-2007: Einheitliches Güterverzeichnis für die Verkehrsstatistik - 2007 - [URL](#), Wiesbaden, 2013.

## 2.L(b) - Diffuse Emissions from Industrial Establishments

### Short description

NFR category 2.L(b) - *Diffuse Emissions from Industrial Establishments* includes also diffuse emissions from enterprises in general kind.

### Methodology

As no detailed data are available and as *NFR 2.L(b)* is no key category, all emissions are calculated via a tier1 method. Estimations are based on an European method computing emissions per person of population.

### Activity data

Table 1: Population development in Germany since 1990

| 1990       | 1995       | 2000       | 2005       | 2010       | 2015       | 2016       | 2017       | 2018       | 2019       | 2020       | 2021       | 2022       | 2023       | 2024       |
|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 79,753,227 | 81,307,715 | 81,456,617 | 81,336,663 | 80,284,071 | 82,175,684 | 82,521,653 | 82,792,351 | 83,019,213 | 83,166,711 | 83,155,031 | 83,237,124 | 83,118,501 | 83,456,045 | 83,577,140 |

### Emission factors

Emission factors originate in the results of a research project with respect to the European RAINS model. - The EF time series for all three fractions of particulate matter show a falling trend.

Table 2: EF used for 2023 emission estimates, in [kg/capita]

|                                        |        |
|----------------------------------------|--------|
| <b>Total suspended particles - TSP</b> | 0.3052 |
| <b>PM<sub>10</sub></b>                 | 0.1008 |
| <b>PM<sub>2.5</sub></b>                | 0.0336 |

### Discussion of emission trends

The diffuse particulate matter emissions reported here, depend on (a) the number of inhabitants in Germany, serving as activity data, and (b) on the trend in emission factors that shall reflect the efforts to prevent such particle emissions. Hence, the emission time-series for all three fractions of particulate matter show a downward trend.

### Recalculations

Recalculations specific for this sub-category of NFR 2.L result from revised population data for the years 2022 and 2023:

Table 3: Revised population data for 2022 and 2023

|                            | 2022       | 2023       |
|----------------------------|------------|------------|
| <b>current submission</b>  | 83,118,501 | 83,456,045 |
| <b>previous submission</b> | 82,711,282 | 82,711,282 |
| <b>absolute change</b>     | 407,219    | 744,763    |
| <b>relative change</b>     | 0.49%      | 0.90%      |



For more information on revised inventory data, please see the [superordinate chapter](#).

## Planned improvements



At the moment, no category-specific improvements are planned.



## CHAPTER 5: NFR 3 - Agriculture (OVERVIEW)

| NFR-Code | Name of Category                                           |
|----------|------------------------------------------------------------|
| 3.B      | <a href="#">3.B Manure Management</a>                      |
| 3.D      | <a href="#">3.D Agricultural Soils</a>                     |
| 3.F      | <a href="#">3.F Field Burning Of Agricultural Residues</a> |
| 3.I      | <a href="#">3.I Agricultural: Other</a>                    |

### Short description

Emissions occurring in the agricultural sector in Germany derive from manure management (NFR 3.B), agricultural soils (NFR 3.D) and agriculture other (NFR 3.I).

As burning of agricultural residues is prohibited by law (see Vos et al., 2026)<sup>11</sup>, Germany does not report emissions in category field burning (NFR 3.F) (notation key: 'NO'),

The pollutants reported are:

- ammonia (NH<sub>3</sub>),
- nitric oxides (NO<sub>x</sub>),
- volatile organic compounds (NMVOC),
- particulate matter (PM<sub>2.5</sub>, PM<sub>10</sub> and TSP) and
- hexachlorobenzene (HCB).

No heavy metal emissions are reported.

In 2024, the agricultural sector emitted 484.0 kt of NH<sub>3</sub>, 98.0 kt of NO<sub>x</sub>, 300.6 kt of NMVOC, 60.4 kt of TSP, 34.7 kt of PM<sub>10</sub> and 5.3 kt of PM<sub>2.5</sub> and 0.53 kg HCB.

The trends from 1990 onwards is shown in the graph at the bottom of this page. Here, the sharp decrease of emissions from 1990 to 1991 is due to a reduction of livestock population in the New Länder (former GDR) following the German reunification. The increase of NH<sub>3</sub> emissions since 2005 is mostly due to the expansion of anaerobic digestion of energy crops, especially the application of the digestion residues. This emission source also affects NO<sub>x</sub> emissions. The decrease of NH<sub>3</sub> emissions since 2015 is mostly due to a decline in the amounts of mineral fertilizer sold and stricter regulations concerning application of urea fertilizers, as well as declining livestock numbers. Further details concerning trends can be found in Vos et al. (2026) chapter "Emissions results submission 2026".

As depicted in the chart below, in 2024 91.7 % of Germany's total NH<sub>3</sub> emissions derived from the agricultural sector, while nitric oxides reported as NO<sub>x</sub> contributed 12.1 % and NMVOC 31.5 % to the total NO<sub>x</sub> and NMVOC emissions of Germany. Regarding the emissions of PM<sub>2.5</sub>, PM<sub>10</sub> and TSP the agricultural sector contributed 7.1 % (PM<sub>2.5</sub>), 20.4 % (PM<sub>10</sub>) and 19.6 % (TSP) to the national particle emissions. HCB emissions of pesticide use contributed 13.5 % to the total German emissions.

### Mitigation measures

The agricultural inventory model can represent several abatement measures for emissions of NH<sub>3</sub> and particles. The measures comprise:

- changes in animal numbers and amount of applied fertilizers
- air scrubbing techniques: yearly updated data on frequencies of air scrubbing facilities and the removal efficiency are provided by KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft / Association for Technology and Structures in Agriculture) and also based on the agricultural census 2020. The average removal efficiency of NH<sub>3</sub> is 80 % for swine and 70 % for poultry, while for TSP and PM<sub>10</sub> the rates are set to 90 % and for PM<sub>2.5</sub> to 70 % for both animal categories. For swine two types of air scrubbers are distinguished: first class systems that remove both NH<sub>3</sub> and particles, and second class systems that remove only particles reliably and have an ammonia removal efficiency of 20%.
- reduced raw protein content in feeding of fattening pigs: the German animal nutrition association (DVT, Deutscher Verband Tiernahrung e.V.) provides data on the raw protein content of fattening pig feed, therefore enabling the inventory to depict the changes in N-excretions over the time series. The time series is calibrated using data from

official and representative surveys conducted by the Federal Statistical Office.

- reduced raw protein content in feeding and feed conversion rates of broilers: the German animal nutrition association (DVT, Deutscher Verband Tiernahrung e.V.) provides data on the raw protein content of fattening broiler feed, and feed conversion rates of broilers. This makes it possible to model the changes in N-excretions over the timeseries.
- low emission spreading techniques of manure: official agricultural censuses survey the prevalence of different manure spreading techniques and how fast organic fertilizers are incorporated into the soil. Germany uses distinct emission factors for different methods, techniques and incorporation durations.
- Depicting effects of changes in dairy cow feeding reflecting optimization of raw protein content over the time series, as the N and TAN excretions are estimated using milk urea content and milk protein content.
- covering of slurry storage: agricultural censuses survey the prevalence of different slurry covers. Germany uses distinct emission factors for the different covers.
- use of urease inhibitors: for urea fertilizer the German fertilizer ordinance prescribes the use of urease inhibitors or the direct incorporation into the soil from 2020 onwards. The  $\text{NH}_3$  emission factor for urea fertilizers is therefore reduced by 70% from 2020 onwards for the direct incorporation, according to Bittman et al. (2014, Table 15)<sup>2)</sup>. For the use of urease inhibitors the  $\text{NH}_3$  emission factor is reduced by 60% from 2020 onwards, see Vos et al. (2026), Chapter 5.2.1.2<sup>3)</sup>.

For  $\text{NO}_x$  and NMVOC no mitigation measures are included.

## Reasons for recalculations

(see [Chapter 9.1 - Recalculations](#))

The following list summarizes the most important reasons for recalculations. Recalculations result from improvements in input data and methodologies (for details see Vos et al. (2026), Chapter 1.3)<sup>4)</sup>.

1. Adding of a transport module in the inventory model PY-GAS-EM: substrate transports to biogas plants and manure transports across district borders (NUTS 3 areas) are considered. Since manure application techniques differ between the NUTS 3 areas, this leads to slightly different  $\text{NH}_3$  emissions at the federal level compared with the situation in the last submission without transports across district borders.
2. Mineral fertilizers: The  $\text{NH}_3$  emission factors for straight fertilizers used in the last sub-mission (0.084 kg  $\text{NH}_3$  per kg N) has been corrected to a lower value (0.024  $\text{NH}_3$  per kg N) following a correction in EMEP/EEA (2023)<sup>5)</sup>.
3. Dairy cows: N and TAN excretions are now estimated from milk yield, milk urea content and protein content of milk instead of from the modeled feed.
4. Dairy cows: The officially recorded final milk yields for 2023 are significantly higher than the preliminary official figures used in the 2025 submission. This is due to an improved calculation method that will continue to be used in the future and which was subsequently applied for 2022. For reporting purposes a method was developed to adjust the officially recorded milk yields for the years before 2022 upwards, to achieve time series consistency.
5. Sows: The animal category sow was subdivided into gilts and old sows, with different weights and therefore different energy requirements. In comparison with Submission 2025 the mean animal weight and energy requirements are lower in aggregate. As a consequence, the  $\text{NH}_3$  emissions are also lower.
6. Horses: Due to updated feed recommendations for heavy horses, N excretions were adjusted (increased) for the year 2020. The respective values used for Submission 2025 are still used until the year 2010; between the years 2010 and 2020, they are linearly interpolated.
7. Deer: Due to new data for 2023, the number of animals from 2009 onwards is slightly reduced by interpolation.
8. Dairy cows: Milk yield and slaughter weights for 2023 have been slightly corrected in the official statistics.
9. Heifers: 2023 slaughter weights have been slightly corrected in the official statistics.
10. Male beef cattle: In some years, slaughter ages and slaughter weights have been updated in the HIT database.
11. Air scrubber systems pigs: new information on replaced facilities with minor effects on the number of animal places with air scrubbers in one federal state back to the year 2005.
12. Sows: For several federal states, the number of piglets per sow for 2023 and 2019 were corrected.
13. Fattening pigs: for several federal states growth rates, start weights and final weights for 2023 and 2019 were corrected.
14. Broilers: Update of the national gross production of broiler meat for 2022 and 2023.
15. Crop residues: The number of grassland cuts were updated for all years due to the introduction of a new procedure for outlier identification..
16. Application of sewage sludge: Replacement of extrapolated activity data in 2023 with data from the Federal

Statistical Office.

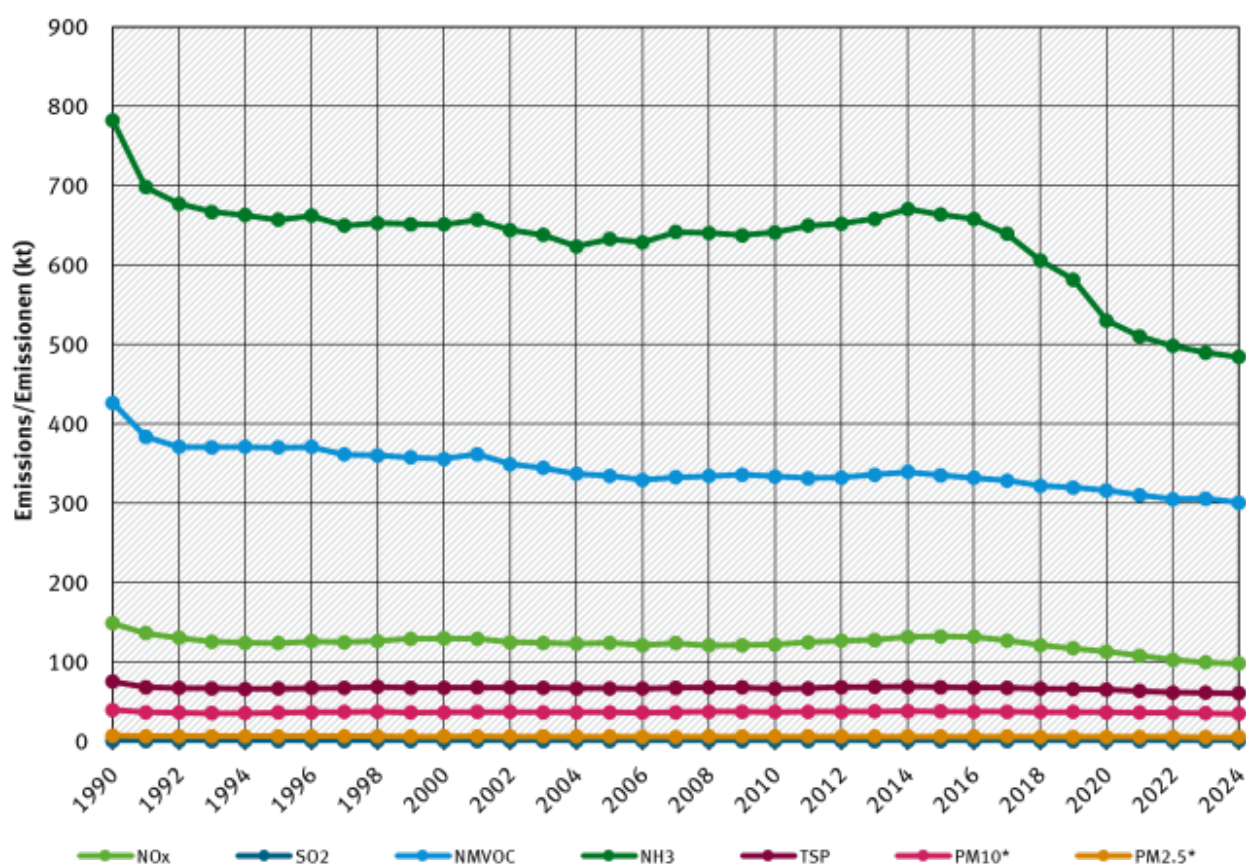
17. Anaerobic digestion: Due to the newly introduced substrate transports, the percentage of digested manure N in the total production of manure is no longer used as the input variable, but the absolute amount of N that goes into digestion.
18. Anaerobic digestion of energy crops: dry matter input for 2023 has been updated.
19. Imported manure: The amounts of imported manure from the Netherlands have been updated for years after 2009 in official NL statistics. This results in higher N application rates except for 2012, 2016, 2018 and 2022.
20. Compost and digested waste: input data for 2023 has been updated.

## Visual overview

Emission trends for main pollutants in *NFR 3 - Agriculture*:

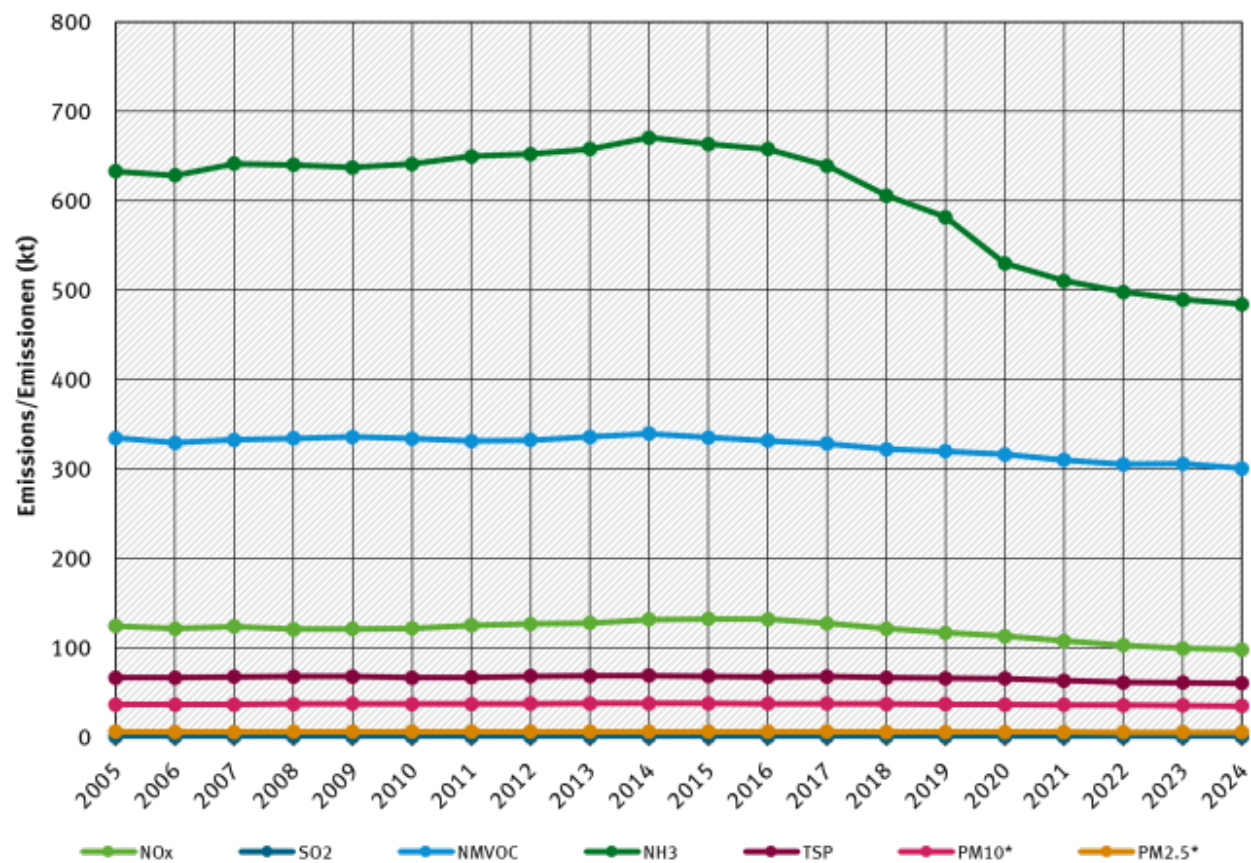
### Agriculture/Landwirtschaft (NFR 3)

Emissions by pollutant / Emissionen nach Schadstoff



Agriculture/Landwirtschaft (NFR 3)

Emissions by pollutant / Emissionen nach Schadstoff

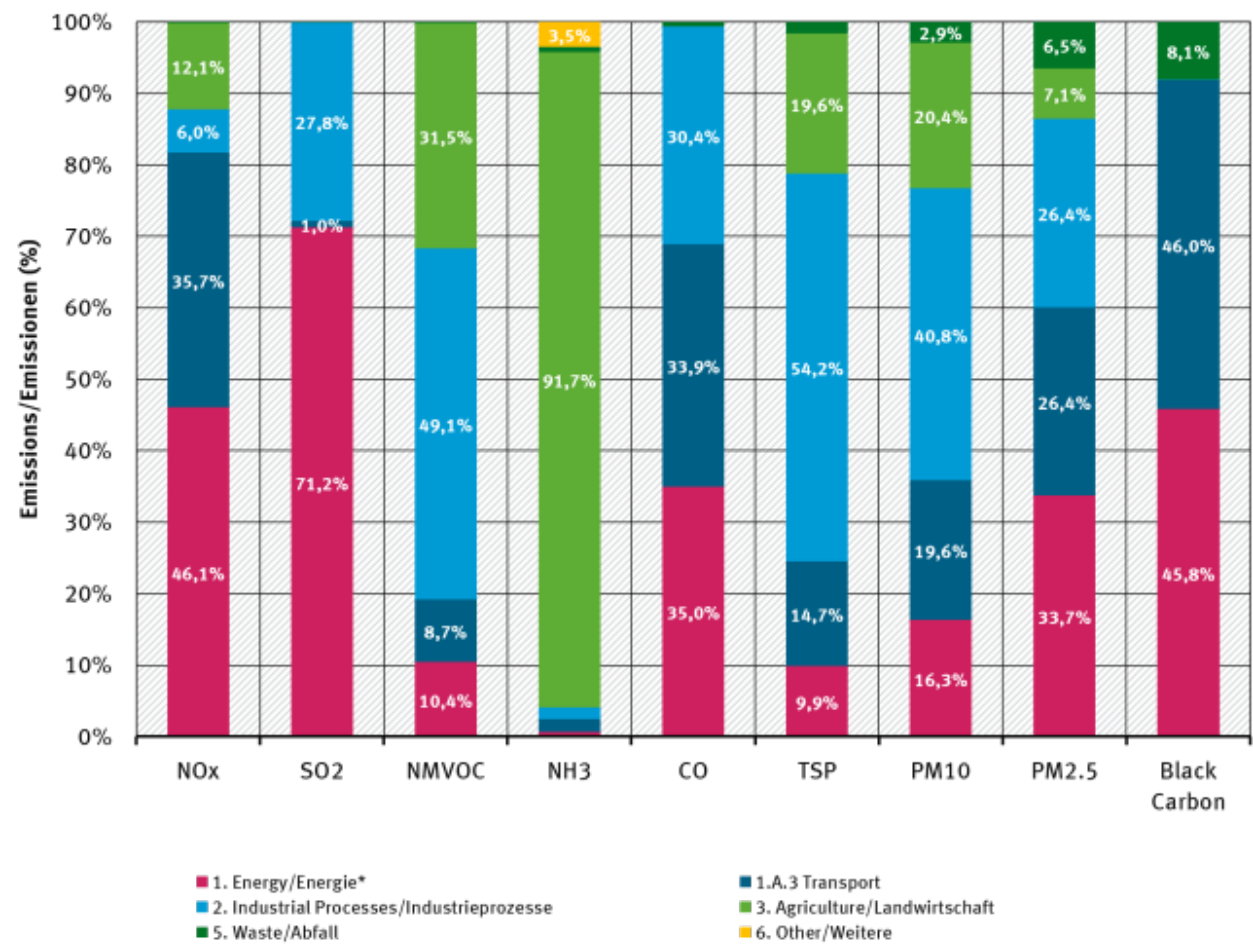


[Contribution of NFRs 1 to 6 to the National Totals](#)



Contribution of NFR categories to the emissions/Anteile der NFR-Kategorien an den Emissionen

2024 percentages per air pollutant / Anteile pro Luftschadstoff für 2024



\* without transport ( ohne Verkehr (1.A.3)

Quelle: German Emission Inventory (06.02.2026)

Specific QA/QC procedures for the agriculture sector

Numerous input data were checked for errors resulting from erroneous transfer between data sources and the tabular database used for emission calculations. The German IEFs and other data used for the emission calculations were compared with EMEP default values and data of other countries (see Vos et al., 2026). Changes of data and methodologies are documented in detail (see Vos et al. 2026, Chapter 1.3).

A comprehensive review of the emission calculations was carried out by comparisons with the results of Submission 2025 and by plausibility checks.

Once emission calculations with the German inventory model Py-GAS-EM are completed for a specific submission, activity data (AD) and implied emission factors (IEFs) are transferred to the CSE database (Central System of Emissions) to be used to calculate the respective emissions within the CSE. These CSE emission results are then cross-checked with the emission results obtained by Py-GAS-EM.

Furthermore, in addition to UNFCCC, UNECE and NEC reviews, the Py-GAS-EM model is continuously validated by experts of KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft, Association for Technology and Structures in Agriculture) and the EAGER group (European Agricultural Gaseous Emissions Inventory Researchers Network).

1), 3), 4) Vos, C., Rösemann, C., Haenel, H.-D., Dämmgen, U., Döring, U., Wulf, S., Eurich-Menden, Döhler, H., Steuer, B., Osterburg, B., Fuß, R. (2026): Calculations of gaseous and particulate emissions from German agriculture 1990 – 2024: Report on methods and data (RMD) Submission 2026. [www.eminv-agriculture.de](http://www.eminv-agriculture.de), 2026

2) Bittman, S., Dedina, M., Howard C.M., Oenema, O., Sutton, M.A., (eds) (2014): Options for Ammonia Mitigation. Guidance

from the UNECE task Force on Reactive Nitrogen. Centre for Ecology and Hydrology, Edinburgh, UK, 2014

<sup>5)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, EEA Report No 06/2023, <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023>; Copenhagen, 2023

## 3.B - Manure Management

### Short description

| NFR-Code                                                                                  | Name of Category                                    | Method                                                                                               | AD     | EF                                                                                             |
|-------------------------------------------------------------------------------------------|-----------------------------------------------------|------------------------------------------------------------------------------------------------------|--------|------------------------------------------------------------------------------------------------|
| 3.B                                                                                       | Manure Management                                   | see sub-category details                                                                             |        |                                                                                                |
| consisting of / including source categories                                               |                                                     |                                                                                                      |        |                                                                                                |
| 3.B.1.a & 3.B.1.b                                                                         | Cattle                                              | T3 (NH <sub>3</sub> ), T2 (NO <sub>x</sub> , TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC)      | NS, RS | CS (NH <sub>3</sub> , NO <sub>x</sub> ), D (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC) |
| 3.B.2, 3.B.4.d, 3.B.4.e                                                                   | Sheep, Goats, Horses                                | T2 (NH <sub>3</sub> , NO <sub>x</sub> , TSP, PM <sub>10</sub> , PM <sub>2.5</sub> ), T1 (NMVOC)      | NS, RS | CS (NH <sub>3</sub> , NO <sub>x</sub> ), D (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC) |
| 3.B.3                                                                                     | Swine                                               | T3 (NH <sub>3</sub> ), T2 (NO <sub>x</sub> , TSP, PM <sub>10</sub> , PM <sub>2.5</sub> ), T1 (NMVOC) | NS, RS | CS (NH <sub>3</sub> , NO <sub>x</sub> ), D (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC) |
| 3.B.4.a                                                                                   | Buffalo                                             | until 1995: NO, since 1996: IE (in 3.B.1.b)                                                          |        |                                                                                                |
| 3.B.4.f                                                                                   | Mules and asses                                     | IE (in 3.B.4.e)                                                                                      |        |                                                                                                |
| 3.B.4.g i-iv                                                                              | Poultry                                             | T2 (NH <sub>3</sub> , NO <sub>x</sub> , TSP, PM <sub>10</sub> , PM <sub>2.5</sub> ), T1 (NMVOC)      | NS, RS | CS (NH <sub>3</sub> , NO <sub>x</sub> ), D (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC) |
| 3.B.4.h                                                                                   | Other animals (Deer, Rabbits, Ostrich, Fur animals) | T2 (NH <sub>3</sub> , NO <sub>x</sub> ), T1 (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC)      | AS, M  | CS (NH <sub>3</sub> , NO <sub>x</sub> ), D (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC) |
| Method(s) applied                                                                         |                                                     |                                                                                                      |        |                                                                                                |
| D                                                                                         | Default                                             |                                                                                                      |        |                                                                                                |
| T1                                                                                        | Tier 1 / Simple Methodology *                       |                                                                                                      |        |                                                                                                |
| T2                                                                                        | Tier 2*                                             |                                                                                                      |        |                                                                                                |
| T3                                                                                        | Tier 3 / Detailed Methodology *                     |                                                                                                      |        |                                                                                                |
| C                                                                                         | CORINAIR                                            |                                                                                                      |        |                                                                                                |
| CS                                                                                        | Country Specific                                    |                                                                                                      |        |                                                                                                |
| M                                                                                         | Model                                               |                                                                                                      |        |                                                                                                |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                                     |                                                                                                      |        |                                                                                                |
| (source for) Activity Data                                                                |                                                     |                                                                                                      |        |                                                                                                |
| NS                                                                                        | National Statistics                                 |                                                                                                      |        |                                                                                                |
| RS                                                                                        | Regional Statistics                                 |                                                                                                      |        |                                                                                                |
| IS                                                                                        | International Statistics                            |                                                                                                      |        |                                                                                                |
| PS                                                                                        | Plant Specific                                      |                                                                                                      |        |                                                                                                |
| As                                                                                        | Associations, business organisations                |                                                                                                      |        |                                                                                                |
| Q                                                                                         | specific Questionnaires (or surveys)                |                                                                                                      |        |                                                                                                |
| M                                                                                         | Model / Modelled                                    |                                                                                                      |        |                                                                                                |
| C                                                                                         | Confidential                                        |                                                                                                      |        |                                                                                                |
| (source for) Emission Factors                                                             |                                                     |                                                                                                      |        |                                                                                                |
| D                                                                                         | Default (EMEP Guidebook)                            |                                                                                                      |        |                                                                                                |
| CS                                                                                        | Country Specific                                    |                                                                                                      |        |                                                                                                |
| PS                                                                                        | Plant Specific                                      |                                                                                                      |        |                                                                                                |
| M                                                                                         | Model / Modelled                                    |                                                                                                      |        |                                                                                                |
| C                                                                                         | Confidential                                        |                                                                                                      |        |                                                                                                |

|             | NO <sub>x</sub> | NMVOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|-------------|-----------------|-------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| 3.B.1.a     | -/-             | L/-   | NA              | L/-             | L/-               | -/-              | -/- | NA | NA | NA           | NA   |
| 3.B.1.b     | -/-             | L/T   | NA              | L/T             | -/-               | -/-              | -/- | NA | NA | NA           | NA   |
| 3.B.2       | -/-             | -/-   | NA              | -/-             | -/-               | -/-              | -/- | NA | NA | NA           | NA   |
| 3.B.3       | -/-             | -/-   | NA              | L/T             | -/-               | -/-              | L/- | NA | NA | NA           | NA   |
| 3.B.4.d     | -/-             | -/-   | NA              | -/-             | -/-               | -/-              | -/- | NA | NA | NA           | NA   |
| 3.B.4.e     | -/-             | -/-   | NA              | L/-             | -/-               | -/-              | -/- | NA | NA | NA           | NA   |
| 3.B.4.g.i   | -/-             | -/-   | NA              | -/-             | -/-               | -/-              | L/- | NA | NA | NA           | NA   |
| 3.B.4.g.ii  | -/-             | -/-   | NA              | -/-             | -/-               | -/-              | -/- | NA | NA | NA           | NA   |
| 3.B.4.g.iii | -/-             | -/-   | NA              | -/-             | -/-               | -/-              | -/- | NA | NA | NA           | NA   |

|            |                                                                                     |     |    |     |     |     |     |    |    |    |    |
|------------|-------------------------------------------------------------------------------------|-----|----|-----|-----|-----|-----|----|----|----|----|
| 3.B.4.g.iv | -/-                                                                                 | -/- | NA | -/- | -/- | -/- | -/- | NA | NA | NA | NA |
| <b>L/-</b> | key source by <b>Level</b> only                                                     |     |    |     |     |     |     |    |    |    |    |
| <b>-/T</b> | key source by <b>Trend</b> only                                                     |     |    |     |     |     |     |    |    |    |    |
| <b>L/T</b> | key source by both <b>Level</b> and <b>Trend</b>                                    |     |    |     |     |     |     |    |    |    |    |
| -/-        | no key source for this pollutant                                                    |     |    |     |     |     |     |    |    |    |    |
| IE         | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |     |    |     |     |     |     |    |    |    |    |
| NE         | emission of specific pollutant <b>Not Estimated</b> (yet)                           |     |    |     |     |     |     |    |    |    |    |
| NA         | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |     |    |     |     |     |     |    |    |    |    |
| *          | no analysis done                                                                    |     |    |     |     |     |     |    |    |    |    |

## Country specifics



In 2024, NH<sub>3</sub> emissions from category 3.B (manure management) were 38.8 % from total agricultural emissions, which is equal to ~ 187.7 kt NH<sub>3</sub>. Within those emissions 42.7 % originate from cattle manure (~ 80.2 kt), 32.3 % from pig manure (ca. 60.7 kt), and 12.3 % from poultry manure (~ 23.1 kt). Calculations take into account the impact of anaerobic digestion of manure on the emissions.

NO<sub>x</sub> emissions from category 3.B (manure management) contribute only 1.6 % (~ 1.6 kt) to the total agricultural NO<sub>x</sub> emissions. They are calculated proportionally to N<sub>2</sub>O emissions, see Vos et al. (2026)<sup>1)</sup>.

NMVOC emissions from category 3.B (manure management) contributed 97.1 % (291.7 kt) from total agricultural NMVOC emissions (300.6 kt).

In 2024, manure management contributed, respectively, 61.6 % (37.2 kt), 33.3 % (11.6 kt) and 66.4 % (3.5 kt) to the total agricultural TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions (TSP: 60.4 kt, PM<sub>10</sub>: 34.7 kt, PM<sub>2.5</sub>: 5.3 kt, respectively).

## Activity data for all pollutants

The Federal Statistical Agency and the Statistical Agencies of the federal states carry out surveys in order to collect, along with other data, the head counts of animals. The results of these surveys are used for emission calculations, for details see Vos et al. (2026), Chapter 2.3<sup>2)</sup>.

The animal population figures used in the inventory are presented in Table 1. Buffaloes are included in the cattle population figures, mules and asses are included in the horse population figures (IE), see Vos et al. (2026), Chapter 2.3. In the first years after the German reunification in 1990 animal livestock decreased markedly. The head counts for cattle continued to decrease significantly until 2006/2007, followed by a more or less stable period until 2014. Since 2015 a slight decrease



occurred. In 2024, dairy cattle numbers are 56.5 % of 1990 numbers, while the total population of other cattle is at 52.3 % of 1990. Swine numbers decreased until 1995 and then increased slightly. Since 2014 a new decrease occurred which became significant between 2020 and 2022 (total swine numbers were reduced by around 18 % within two years). 2024 swine numbers are 66.6 % of 1990 numbers. The 2024 numbers of horses, sheep and goats are, respectively, at 99.6 %, 55.9 % and 183.5 % of 1990.

Figures for broilers and turkeys are showing a massive increase since 1990. Since the year 2013, there have been only minor changes of total poultry numbers. In total, 2024 poultry population figures are at 147.2 % of 1990.

Emissions of deer, rabbits, ostrich and fur-bearing animals are reported since submission 2024. The underlying animal numbers of these categories were estimated in different ways because there are no surveys which collect those animal numbers. However, the impact of those animal categories on the total emissions is small.

A detailed description of the animal numbers used can be found in Vos et al. (2026), chapter 2.3<sup>3)</sup>.

**Table 1: Population of animals, in [1,000 individuals]**

|                        | 1990     | 1995     | 2000     | 2005     | 2010     | 2015     | 2016     | 2017     | 2018     | 2019     | 2020     | 2021     | 2022     | 2023     | 2024     |
|------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| <b>dairy cattle</b>    | 6,354.6  | 5,229.4  | 4,569.8  | 4,236.4  | 4,183.1  | 4,284.6  | 4,217.7  | 4,199.0  | 4,100.9  | 4,011.7  | 3,921.4  | 3,832.7  | 3,809.7  | 3,712.8  | 3,589.4  |
| <b>other cattle</b>    | 13,133.4 | 10,660.5 | 9,968.9  | 8,800.4  | 8,628.7  | 8,350.8  | 8,248.9  | 8,082.2  | 7,848.2  | 7,627.9  | 7,380.5  | 7,206.9  | 7,187.2  | 7,123.4  | 6,871.9  |
| <b>buffalo</b>         | NO       | NO       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       |
| <b>mules and asses</b> | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       | IE       |
| <b>horses</b>          | 1,373.5  | 1,743.9  | 1,373.7  | 1,398.1  | 1,269.9  | 1,233.1  | 1,215.4  | 1,223.4  | 1,231.5  | 1,239.5  | 1,247.6  | 1,277.8  | 1,308.0  | 1,338.2  | 1,368.3  |
| <b>sheep</b>           | 3,266.1  | 2,990.7  | 2,743.3  | 2,643.1  | 2,245.0  | 1,866.9  | 1,851.0  | 1,863.2  | 1,846.0  | 1,813.6  | 1,780.3  | 1,794.8  | 1,805.7  | 1,847.6  | 1,824.5  |
| <b>goats</b>           | 90.0     | 100.0    | 140.0    | 170.0    | 149.9    | 135.9    | 138.8    | 142.8    | 146.9    | 150.9    | 154.9    | 157.5    | 160.0    | 162.6    | 165.2    |
| <b>swine</b>           | 26,502.5 | 20,387.3 | 21,767.7 | 22,742.8 | 22,244.4 | 22,978.5 | 22,761.2 | 22,920.8 | 22,019.2 | 21,625.8 | 21,622.0 | 19,728.6 | 17,692.3 | 17,525.3 | 17,642.7 |
| <b>laying hens</b>     | 53,450.5 | 47,575.8 | 48,640.0 | 43,641.6 | 41,700.5 | 50,619.3 | 51,935.5 | 52,571.1 | 53,206.6 | 53,842.1 | 54,477.6 | 54,921.5 | 55,365.4 | 55,809.3 | 56,084.2 |
| <b>broilers</b>        | 35,393.0 | 46,625.9 | 61,940.7 | 76,045.0 | 98,389.7 | 94,909.4 | 93,791.3 | 93,458.7 | 93,126.1 | 92,793.5 | 92,461.0 | 91,004.5 | 89,548.1 | 88,091.6 | 88,091.6 |
| <b>turkeys</b>         | 5,029.2  | 6,742.0  | 8,893.1  | 10,611.1 | 11,344.0 | 12,658.5 | 12,359.9 | 12,164.7 | 11,969.5 | 11,774.3 | 11,579.1 | 10,718.9 | 9,858.6  | 8,998.3  | 8,998.3  |
| <b>pullets</b>         | 17,210.8 | 16,149.2 | 17,284.1 | 16,050.9 | 14,827.0 | 13,828.3 | 12,921.8 | 12,736.3 | 12,550.7 | 12,365.1 | 12,179.6 | 12,253.0 | 12,326.5 | 12,399.9 | 12,399.9 |
| <b>ducks</b>           | 2,013.7  | 1,933.7  | 2,055.7  | 2,352.2  | 3,164.3  | 2,410.8  | 2,236.4  | 2,209.1  | 2,181.9  | 2,154.6  | 2,127.4  | 1,949.3  | 1,771.2  | 1,593.1  | 1,593.1  |
| <b>geese</b>           | 781.5    | 617.0    | 404.8    | 329.5    | 278.1    | 400.8    | 329.0    | 327.7    | 326.3    | 324.9    | 323.5    | 354.2    | 385.0    | 415.7    | 415.7    |
| <b>deer</b>            | 155.8    | 204.0    | 252.3    | 261.5    | 270.0    | 277.4    | 278.9    | 280.4    | 281.9    | 283.3    | 284.8    | 286.3    | 287.8    | 289.3    | 290.8    |
| <b>rabbits</b>         | 1,851.4  | 1,565.6  | 1,268.9  | 997.0    | 864.2    | 720.7    | 691.2    | 642.7    | 608.3    | 593.9    | 548.4    | 470.0    | 430.6    | 422.8    | 422.5    |
| <b>ostrich</b>         | NO       | 1.2      | 2.5      | 3.7      | 4.9      | 7.7      | 7.4      | 7.4      | 7.9      | 7.4      | 7.9      | 6.1      | 5.1      | 4.6      | 4.0      |
| <b>fur animals</b>     | 179.9    | 179.9    | 179.9    | 153.5    | 121.7    | 34.4     | 24.7     | 15.0     | 5.3      | 5.3      | NO       | NO       | NO       | NO       | NO       |

## Additional data

Emission calculations in accordance with a Tier 2 or Tier 3 method require data on animal performance (animal weight, weight gain, milk yield, milk protein content, milk fat content, numbers of births, numbers of eggs and weights of eggs) and on the relevant feeding details (phase feeding, feed components, protein and energy content, digestibility and feed efficiency). To subdivide officially recorded total numbers of turkeys into roosters and hens, the respective population percentages need to be known. Details on data requirements for the modelling of emissions from livestock husbandry in the German inventory can be found in Vos et al. (2026), Chapter 2<sup>4)</sup>.

Most of the data regarding feed and performance is not available from official statistics and was obtained from literature, from publications by agricultural associations, from guidelines for agricultural consulting in Germany and from expert judgments.

For 1991, 1995 and 1999, frequency distributions of feeding strategies, husbandry systems (shares of pasturing/stabling; shares of various housing methods), storage types as well as techniques of farm manure spreading were obtained with the help of the RAUMIS agricultural sector model (Regionalisiertes Agrar- und UmweltInformationssystem für Deutschland/ Regionalised agricultural and environmental information system for Germany). RAUMIS has been developed and is operated by the Institute of Rural Studies of the Thünen Institute (Federal Research Institute for Rural Areas, Forestry and Fisheries). For an introduction to RAUMIS see Weingarten (1995)<sup>5)</sup>; a detailed description is provided in Henrichsmeyer et al. (1996)<sup>6)</sup>.

RAUMIS did not model complete time series but only selected years. RAUMIS data for the years 1991, 1995, and 1999 are used in the inventory for the respective years. For 1990, the data for 1991 is adopted, for the intervening years (1992-1994 and 1996-1998) data gaps were closed by linear interpolation on district level.

For the year 2009, respective data are used that were derived from the 2010 official agricultural census and the simultaneous survey of agricultural production methods (Landwirtschaftliche Zählung 2010, Statistisches Bundesamt/ Federal Statistical Office) as well as the 2011 survey on manure application practices (Erhebung über Wirtschaftsdüngerausbringung, Statistisches Bundesamt/ Federal Statistical Office). The gaps between the latest RAUMIS model data (1999) and the first official data (2009) were closed by linear interpolation on district level. For the year 2015, data on techniques of farm manure spreading from the 2016 official agricultural census (Agrarstrukturserhebung 2016, Statistisches Bundesamt / Federal Statistical Office) are used. For the year 2019 data from the 2020 official agricultural census (Landwirtschaftszählung 2020, LW20)<sup>7)</sup> are used for housing systems, storage systems and manure spreading systems.

For 2010 to 2018 the housing and storage systems data was linearly interpolated between the censuses of 2010 and 2020. The data on manure spreading techniques was linearly interpolated between the census data from 2009 and 2015, and for 2016 to 2018 between the censuses conducted in 2016 and 2020. In addition, it was taken into account that, as of 2012, slurry spread on bare soil has to be incorporated within four hours. The data from the 2020 official agricultural census (DESTATIS, 2020) is being used for subsequent years until more current data is available<sup>8)</sup>.

For a description of the RAUMIS data, the data from official surveys and additional data from other sources see Vos et al. (2026), Chapter 2.5. Time series of frequency distributions of housing systems, storage systems and application techniques as well as the corresponding emission factors are provided in NID 2026<sup>9)</sup>, Chapter 17.3.1.

Since submission 2026 transports of manure, energy crops and digestates between NUTS 3 regions are simulated in the calculation model. This does not have major influence on the emissions of the whole country, but changes the distribution of emissions between single NUTS 3 regions. For details on the methodology, see Vos et al. (2026), Chapter 1.2<sup>10)</sup>.

## NH<sub>3</sub> and NO<sub>x</sub>

### Method

#### N in manure management

##### N excretion

In order to determine NH<sub>3</sub> and NO<sub>x</sub> emissions from manure management of a specific animal category, the individual N excretion rate must be known as well as, for NH<sub>3</sub>, the TAN content of the N excretions. Default excretion rates are provided by IPCC Guidelines and default TAN contents can be found in the EMEP/EEA Guidebook, 2023<sup>11)</sup>. However, the German agricultural emission inventory uses N mass balances to calculate the N excretions and the TAN contents of almost all reported animal categories. N mass balance calculations (see below) consider N intake with feed, N retention due to growth, N contained in milk and eggs, and N in offspring. Table 2 presents national means of N excretions and TAN contents. For methodological details and mass balance input data see Vos et al. (2026), Chapter 4.2 as well as Chapter 4.1.2<sup>12)</sup>.

For dairy cows N excretion is estimated based on milk urea content since submission 2026, for details see Vos et al. (2026) Chapter 4.1.2<sup>13)</sup>. This allows an estimation that is based on the actual feeding of the dairy cows, thus it is possible to depict the effect of feeding changes in N excretions. Milk urea contents are obtained from the agricultural information services company vit (Vereinigte Informationssysteme Tierhaltung w.V.) and directly by four state control associations, who operate a separate database. Each record includes farm-aggregated information regarding herd size, milk yield, milk urea, fat and protein contents, milking day, and racial composition of the herd. For the time between 2005 and 2022 over 10 million milk urea contents at herd-level were obtained. For the purpose of the inventory these were aggregated on district level, weighted by herd size. For the years from 1990-2004 the values of 2005 were taken, for 2023 and 2024 the values of 2022.

Table 2: National means of N excretions and TAN contents

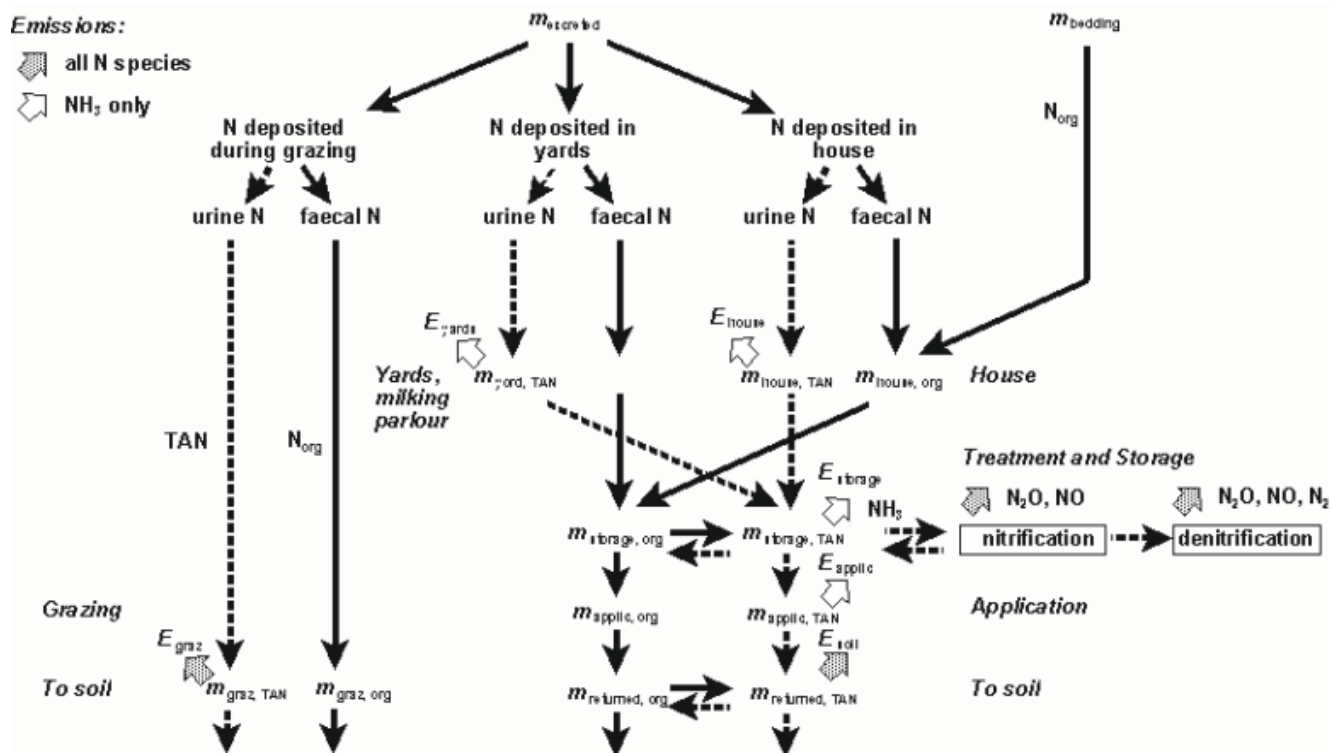
|                                                 | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|-------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>mean N excretions in kg per animal place</b> |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>dairy cattle</b>                             | 106.3 | 110.8 | 114.3 | 117.5 | 114.3 | 115.2 | 116.8 | 118.7 | 120.3 | 121.4 | 119.7 | 117.0 | 116.1 | 118.6 | 120.2 |
| <b>other cattle</b>                             | 37.9  | 39.9  | 41.3  | 41.2  | 42.1  | 42.5  | 42.5  | 42.7  | 42.9  | 43.4  | 43.7  | 43.9  | 43.9  | 44.2  | 44.4  |
| <b>horses</b>                                   | 48.2  | 48.1  | 49.0  | 48.8  | 48.8  | 54.0  | 55.0  | 56.1  | 57.1  | 58.2  | 59.2  | 59.2  | 59.2  | 59.2  | 59.2  |

|                               | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| sheep                         | 7.7   | 7.7   | 7.8   | 7.8   | 7.8   | 7.8   | 7.8   | 7.8   | 7.8   | 7.8   | 7.8   | 7.8   | 7.8   | 7.8   | 7.8   |
| goats                         | 11.0  | 11.0  | 11.0  | 11.0  | 11.0  | 11.0  | 11.0  | 11.0  | 11.0  | 11.0  | 11.0  | 11.0  | 11.0  | 11.0  | 11.0  |
| swine                         | 12.8  | 13.1  | 13.0  | 12.8  | 12.6  | 12.4  | 12.4  | 12.3  | 12.2  | 12.1  | 12.1  | 12.3  | 12.2  | 12.2  | 12.3  |
| laying hens                   | 0.81  | 0.78  | 0.76  | 0.79  | 0.86  | 0.88  | 0.89  | 0.89  | 0.89  | 0.89  | 0.90  | 0.90  | 0.90  | 0.90  | 0.91  |
| broilers                      | 0.48  | 0.37  | 0.37  | 0.36  | 0.35  | 0.40  | 0.40  | 0.40  | 0.41  | 0.40  | 0.39  | 0.39  | 0.40  | 0.41  | 0.42  |
| turkeys                       | 2.0   | 2.0   | 2.0   | 2.2   | 2.2   | 2.3   | 2.3   | 2.3   | 2.2   | 2.2   | 2.1   | 2.1   | 2.1   | 2.1   | 2.1   |
| pullets                       | 0.38  | 0.35  | 0.32  | 0.33  | 0.33  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  | 0.34  |
| ducks                         | 0.61  | 0.61  | 0.61  | 0.61  | 0.61  | 0.61  | 0.61  | 0.61  | 0.61  | 0.61  | 0.61  | 0.61  | 0.61  | 0.61  | 0.61  |
| geese                         | 0.70  | 0.70  | 0.70  | 0.70  | 0.70  | 0.70  | 0.70  | 0.70  | 0.70  | 0.70  | 0.70  | 0.70  | 0.70  | 0.70  | 0.70  |
| deer                          | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 | 16.00 |
| rabbits                       | 0.80  | 0.80  | 0.80  | 0.80  | 0.80  | 0.80  | 0.80  | 0.80  | 0.80  | 0.80  | 0.80  | 0.80  | 0.80  | 0.80  | 0.80  |
| ostrich                       | 15.60 | 15.60 | 15.60 | 15.60 | 15.60 | 15.60 | 15.60 | 15.60 | 15.60 | 15.60 | 15.60 | 15.60 | 15.60 | 15.60 | 15.60 |
| fur animals                   | 4.59  | 4.59  | 4.59  | 4.59  | 4.59  | 4.59  | 4.59  | 4.59  | 4.59  | 4.59  | 4.59  | 4.59  | 4.59  | 4.59  | 4.59  |
| <b>mean TAN contents in %</b> |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| dairy cattle                  | 51.3  | 48.9  | 47.3  | 45.9  | 44.6  | 43.7  | 43.3  | 43.4  | 42.9  | 42.3  | 41.5  | 41.1  | 41.4  | 40.5  | 39.9  |
| other cattle                  | 65.5  | 65.7  | 65.7  | 65.7  | 66.0  | 66.3  | 66.4  | 66.4  | 66.4  | 66.4  | 66.4  | 66.3  | 66.3  | 66.3  | 66.3  |
| horses                        | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  |
| sheep                         | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  |
| goats                         | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  |
| swine                         | 72.0  | 71.7  | 71.1  | 71.8  | 72.3  | 71.5  | 71.3  | 71.2  | 71.0  | 70.9  | 70.7  | 70.8  | 70.6  | 70.5  | 70.4  |
| laying hens                   | 70.2  | 69.6  | 69.0  | 69.3  | 70.0  | 70.2  | 70.1  | 70.1  | 70.2  | 70.2  | 70.1  | 70.1  | 70.2  | 70.3  | 70.2  |
| broilers                      | 60.8  | 58.9  | 56.4  | 53.5  | 50.0  | 46.9  | 46.5  | 46.1  | 45.7  | 45.2  | 44.8  | 44.8  | 44.8  | 44.8  | 44.8  |
| turkeys                       | 64.7  | 64.7  | 63.0  | 63.9  | 63.0  | 63.5  | 63.5  | 63.5  | 63.0  | 63.0  | 62.1  | 62.1  | 62.1  | 62.1  | 62.1  |
| pullets                       | 69.4  | 69.4  | 69.4  | 69.4  | 69.4  | 69.4  | 69.4  | 69.4  | 69.4  | 69.4  | 69.4  | 69.4  | 69.4  | 69.4  | 69.4  |
| ducks                         | 49.9  | 49.9  | 49.9  | 49.9  | 49.9  | 49.9  | 49.9  | 49.9  | 49.9  | 49.9  | 49.9  | 49.9  | 49.9  | 49.9  | 49.9  |
| geese                         | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  |
| deer                          | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  | 50.0  |
| rabbits                       | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  |
| ostrich                       | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  | 70.0  |
| fur animals                   | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  | 60.0  |

#### N mass flow and emission assessment

The calculation of the emissions of  $\text{NH}_3$ ,  $\text{N}_2\text{O}$ ,  $\text{NO}_x$  and  $\text{N}_2$  from German animal husbandry is based on the so-called N mass flow approach (e. g. Dämmgen and Hutchings, 2008)<sup>14)</sup>. This approach differentiates between N excreted with faeces (organic nitrogen Norg, i. e. undigested feed N) and urine (total ammoniacal nitrogen TAN, i. e. fraction of feed N metabolized). The N flow within the manure management system is treated as depicted in the figure below. This method reconciles the requirements of both the Atmospheric Emission Inventory Guidebook for  $\text{NH}_3$  emissions (EMEP/EEA, 2023)<sup>15)</sup>, and the IPCC guidelines for greenhouse gas emissions (IPCC (2006)<sup>16)</sup>. Reidy et al. (2008)<sup>17)</sup>, showed for several European countries (Germany, the Netherlands, Switzerland, United Kingdom) that their N-flow based inventory models yielded, in spite of national peculiarities, comparable results as long as standardised data sets for the input variables were used.

Not explicitly shown in the N mass flow scheme is air scrubbing in housing and anaerobic digestion of manure. These issues are separately described further below. Note that emissions from grazing and application are reported in sector 3.D.



*General scheme of N flows in animal husbandry*

*m*: mass from which emissions may occur. Narrow broken arrows: TAN (total ammoniacal nitrogen); narrow continuous arrows: organic N. The horizontal arrows denote the process of immobilisation in systems with bedding occurring in the house, and the process of mineralisation during storage, which occurs in any case. Broad arrows denote N-emissions assigned to manure management ( $E_{\text{yard}}$   $\text{NH}_3$  emissions from yards;  $E_{\text{house}}$   $\text{NH}_3$  emissions from house;  $E_{\text{storage}}$   $\text{NH}_3$ ,  $\text{N}_2\text{O}$ ,  $\text{NO}_x$  and  $\text{N}_2$  emissions from storage;  $E_{\text{applic}}$   $\text{NH}_3$  emissions during and after spreading;  $E_{\text{graz}}$   $\text{NH}_3$ ,  $\text{N}_2\text{O}$ ,  $\text{NO}_x$  and  $\text{N}_2$  emissions during and after grazing;  $E_{\text{soil}}$   $\text{N}_2\text{O}$ ,  $\text{NO}_x$  and  $\text{N}_2$  emissions from soil resulting from manure input).

The model allows tracing of the pathways of the two N fractions after excretion. The various locations where excretion may take place are considered. The partial mass flows through the livestock systems are represented.

During storage Norg can be transformed into TAN and vice versa. Both, the way and the magnitude of such transformations may be influenced by manure treatment processes like, e. g., anaerobic digestion where a considerable fraction of Norg is mineralized to TAN. For details see Vos et al. (2026), Chapter 4.2<sup>18)</sup>. Wherever NH<sub>3</sub> is emitted, its formation is related to the amount of the TAN present. N<sub>2</sub>O emissions are related to the total amount of N available (Norg + TAN). NO<sub>x</sub> emissions (i. e. NO emissions) are calculated proportionally to the N<sub>2</sub>O emissions, see section 'Emission factors'. Note that the N<sub>2</sub>O, NO<sub>x</sub> and N<sub>2</sub> emissions from the various storage systems include the respective emissions from the related housing systems.

### Air scrubber systems in swine and poultry housings

For pig and poultry production the inventory model considers the effect of air scrubbing. Data on frequencies of air scrubbing facilities and the removal efficiency are provided by KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft / Association for Technology and Structures in Agriculture) supplemented by data from the 2020 agricultural census. The average removal efficiency of  $\text{NH}_3$  is 80 % for swine and 70 % for poultry, while for TSP and  $\text{PM}_{10}$  the rates are set to 90 % and for  $\text{PM}_{2.5}$  to 70 % for both animal categories. For swine two types of air scrubbers are distinguished: systems of “first class” that remove both  $\text{NH}_3$  and particles, and “second class” systems that remove only particles reliably and have a  $\text{NH}_3$  removal efficiency of 20%.

According to KTBL, 7.6 % of all pig places were equipped with "first class" systems in 2024, another 12.6 % were equipped with "second class" systems. For poultry 0.9 % of all laying hen places and 2.5 % of all broiler places were equipped with air scrubbers that remove both NH<sub>3</sub> and particles.

The amounts of  $\text{NH}_3\text{-N}$  removed by air scrubbing are completely added to the pools of total N and TAN for landspreading. For details see Vos et al. (2026), Chapter 4.2.2<sup>19)</sup>.

## Anaerobic digestion of manure

According to IPCC (2006), anaerobic digestion of manure is treated like a particular storage type<sup>20)</sup>. In the German Inventory it comprises three sub-compartments (pre-storage, fermenter and storage of digestates). For details see Vos et al. (2026), Chapters 2.6 and 4.2.5<sup>21)</sup>. The resulting digestates are considered as liquid. Two different types of digestates storage systems are considered: gastight storage and open tank. For open tanks formation of a natural crust because of co-fermentation with energy crops is taken into account. Furthermore, the modelling of anaerobic digestion and spreading of the digestates takes into account that the amount of TAN in the digestates is higher than in untreated slurry and that the frequencies of spreading techniques differ from those for untreated slurry.

NH<sub>3</sub> and NO emissions occur from pre-storage of solid manure, from non-gastight storage of digestates and from application of digestates (NH<sub>3</sub> emissions and NO emissions from application of digested manure are reported in 3.D.a.2.a). There are no such emissions from pre-storage of slurry, from the fermenter and from gastight storage of digestates. Note that NH<sub>3</sub> and NO emissions calculated with respect to the digestion of animal manures do not comprise the contributions by co-digested energy crops. The latter are dealt with separately in 3.D.a.2.c and 3.I.

## Emission Factors

Application of the N mass flow approach requires detailed emission factors for NH<sub>3</sub>, N<sub>2</sub>O, NO<sub>x</sub> and N<sub>2</sub> describing the emissions from the various housing and storage systems.

The detailed NH<sub>3</sub> emission factors are, in general, related to the amount of TAN available at the various stages of the N flow chain. The emission factors for laying hens, broilers, pullets, ducks and turkeys are related to N. Most NH<sub>3</sub> emission factors are country-specific but some are taken from EMEP (2023). No specific NH<sub>3</sub> emission factors are known for the application of digested manure. However, due to co-fermentation with energy crops, the viscosity of digested manure resembles that of untreated cattle slurry. Hence, the emission factors for untreated cattle slurry are adopted for the application of digested manure.

For the detailed emission factors of livestock husbandry see Vos et al. (2026), Chapter 4.3<sup>22)</sup>.

The detailed emission factors for N<sub>2</sub>O, NO<sub>x</sub> and N<sub>2</sub> relate to the amount of N available which is N excreted plus, in case of solid manure systems, N input with bedding material. The N<sub>2</sub>O emission factors are taken from IPCC (2019)<sup>23)</sup>. The emission factors for NO<sub>x</sub> and N<sub>2</sub> are approximated as being proportional to the N<sub>2</sub>O emission factors, i. e. the NO-N and N<sub>2</sub> emission factors are, respectively, one-tenth and three times the value of the N<sub>2</sub>O-N emission factor, see Vos et al. (2026), chapter 4.2.4. This proportionality is also applied to anaerobic digestion of manure, where N<sub>2</sub>O emissions occur from pre-storage of solid manure and non-gastight storage of digestates with the emission factors being those used for normal storage of solid manure and the storage of untreated slurry with natural crust provided by IPCC(2019)<sup>24)</sup>. Note that the inventory model calculates NO rather than NO<sub>x</sub>. The conversion of NO emissions into NO<sub>x</sub> emissions is achieved by multiplying the NO emissions with the NO<sub>2</sub>/ NO molar weight ratio of 46/30. This relationship also holds for NO and NO<sub>x</sub> emission factors.

Table 3 shows the implied emission factors of NH<sub>3</sub> and NO<sub>x</sub> for the various animal categories (housing and storage) These emission factors normalize emissions from an animal category as the ratio of the total emission to the respective number of animals. The overall German NH<sub>3</sub> IEF for manure application is reported in section 3.D.a.2.a.

Table 3: IEF for NH<sub>3</sub> & NO<sub>x</sub> from manure management, in [kg per animal place]

|                     | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|---------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>Ammonia</b>      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| <b>dairy cattle</b> | 9.3   | 9.7   | 10.1  | 10.8  | 10.7  | 10.9  | 11.0  | 11.3  | 11.5  | 11.5  | 11.1  | 10.7  | 10.7  | 10.6  | 10.6  |
| <b>other cattle</b> | 5.7   | 5.8   | 5.9   | 6.2   | 6.6   | 6.3   | 6.2   | 6.1   | 6.1   | 6.1   | 6.1   | 6.1   | 6.1   | 6.1   | 6.1   |
| <b>horses</b>       | 13.5  | 13.5  | 13.7  | 13.7  | 13.7  | 14.8  | 15.0  | 15.3  | 15.5  | 15.7  | 16.0  | 16.0  | 16.0  | 16.0  | 16.0  |
| <b>sheep</b>        | 0.83  | 0.82  | 0.84  | 0.83  | 0.84  | 0.83  | 0.83  | 0.83  | 0.82  | 0.83  | 0.83  | 0.82  | 0.82  | 0.82  | 0.83  |
| <b>goats</b>        | 1.62  | 1.62  | 1.62  | 1.62  | 1.62  | 1.62  | 1.62  | 1.62  | 1.62  | 1.62  | 1.62  | 1.62  | 1.62  | 1.62  | 1.62  |
| <b>swine</b>        | 4.45  | 4.36  | 4.24  | 4.15  | 3.94  | 3.68  | 3.63  | 3.58  | 3.54  | 3.49  | 3.45  | 3.48  | 3.38  | 3.40  | 3.44  |
| <b>laying hens</b>  | 0.213 | 0.205 | 0.210 | 0.207 | 0.136 | 0.128 | 0.127 | 0.126 | 0.124 | 0.123 | 0.121 | 0.121 | 0.120 | 0.121 | 0.121 |
| <b>broilers</b>     | 0.143 | 0.108 | 0.104 | 0.098 | 0.087 | 0.091 | 0.089 | 0.089 | 0.088 | 0.087 | 0.084 | 0.085 | 0.082 | 0.086 | 0.087 |
| <b>turkeys</b>      | 0.797 | 0.797 | 0.800 | 0.877 | 0.833 | 0.845 | 0.845 | 0.844 | 0.835 | 0.827 | 0.771 | 0.770 | 0.764 | 0.761 | 0.767 |
| <b>pullets</b>      | 0.125 | 0.116 | 0.105 | 0.104 | 0.097 | 0.091 | 0.092 | 0.093 | 0.095 | 0.096 | 0.098 | 0.097 | 0.098 | 0.101 | 0.102 |

|                        | 1990    | 1995    | 2000    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    | 2024    |
|------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| <b>ducks</b>           | 0.193   | 0.193   | 0.193   | 0.192   | 0.190   | 0.184   | 0.183   | 0.183   | 0.185   | 0.184   | 0.187   | 0.187   | 0.183   | 0.183   | 0.183   |
| <b>geese</b>           | 0.386   | 0.385   | 0.385   | 0.384   | 0.381   | 0.375   | 0.379   | 0.379   | 0.382   | 0.382   | 0.383   | 0.383   | 0.382   | 0.381   | 0.381   |
| <b>deer</b>            | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   | 0.000   |
| <b>rabbits</b>         | 0.228   | 0.228   | 0.228   | 0.228   | 0.228   | 0.228   | 0.228   | 0.228   | 0.228   | 0.228   | 0.228   | 0.228   | 0.228   | 0.228   | 0.228   |
| <b>ostrich</b>         | 1.765   | 1.765   | 1.765   | 1.765   | 1.765   | 1.765   | 1.765   | 1.765   | 1.765   | 1.765   | 1.765   | 1.765   | 1.765   | 1.765   | 1.765   |
| <b>fur animals</b>     | 1.123   | 1.123   | 1.123   | 1.123   | 1.123   | 1.123   | 1.123   | 1.123   | 1.123   | 1.123   | 1.123   | 1.123   | 1.123   | 1.123   | 1.123   |
| <b>Nitrogen oxides</b> |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| <b>dairy cattle</b>    | 0.163   | 0.154   | 0.163   | 0.168   | 0.158   | 0.146   | 0.146   | 0.147   | 0.148   | 0.148   | 0.143   | 0.137   | 0.136   | 0.140   | 0.142   |
| <b>other cattle</b>    | 0.064   | 0.068   | 0.071   | 0.076   | 0.079   | 0.077   | 0.077   | 0.077   | 0.078   | 0.078   | 0.078   | 0.077   | 0.077   | 0.078   | 0.078   |
| <b>horses</b>          | 0.169   | 0.169   | 0.172   | 0.171   | 0.171   | 0.184   | 0.187   | 0.190   | 0.193   | 0.196   | 0.198   | 0.198   | 0.198   | 0.198   | 0.198   |
| <b>sheep</b>           | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   |
| <b>goats</b>           | 0.025   | 0.025   | 0.025   | 0.025   | 0.025   | 0.025   | 0.025   | 0.025   | 0.025   | 0.025   | 0.025   | 0.025   | 0.025   | 0.025   | 0.025   |
| <b>swine</b>           | 0.013   | 0.015   | 0.015   | 0.016   | 0.016   | 0.014   | 0.014   | 0.013   | 0.013   | 0.013   | 0.012   | 0.012   | 0.012   | 0.012   | 0.012   |
| <b>laying hens</b>     | 0.00027 | 0.00026 | 0.00026 | 0.00030 | 0.00035 | 0.00037 | 0.00036 | 0.00036 | 0.00023 | 0.00023 | 0.00024 | 0.00024 | 0.00023 | 0.00024 | 0.00024 |
| <b>broilers</b>        | 0.00016 | 0.00012 | 0.00012 | 0.00013 | 0.00014 | 0.00016 | 0.00016 | 0.00016 | 0.00011 | 0.00011 | 0.00011 | 0.00011 | 0.00011 | 0.00011 | 0.00011 |
| <b>turkeys</b>         | 0.00068 | 0.00068 | 0.00070 | 0.00085 | 0.00095 | 0.00091 | 0.00094 | 0.00094 | 0.00069 | 0.00066 | 0.00061 | 0.00061 | 0.00060 | 0.00058 | 0.00060 |
| <b>pullets</b>         | 0.00013 | 0.00012 | 0.00011 | 0.00013 | 0.00015 | 0.00014 | 0.00014 | 0.00014 | 0.00009 | 0.00009 | 0.00009 | 0.00009 | 0.00009 | 0.00010 | 0.00010 |
| <b>ducks</b>           | 0.00024 | 0.00024 | 0.00024 | 0.00025 | 0.00026 | 0.00027 | 0.00028 | 0.00027 | 0.00021 | 0.00021 | 0.00022 | 0.00022 | 0.00021 | 0.00021 | 0.00021 |
| <b>geese</b>           | 0.00025 | 0.00025 | 0.00025 | 0.00029 | 0.00032 | 0.00032 | 0.00030 | 0.00030 | 0.00023 | 0.00023 | 0.00024 | 0.00024 | 0.00023 | 0.00022 | 0.00022 |
| <b>deer</b>            | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| <b>rabbits</b>         | 0.00269 | 0.00269 | 0.00269 | 0.00269 | 0.00269 | 0.00269 | 0.00269 | 0.00269 | 0.00269 | 0.00269 | 0.00269 | 0.00269 | 0.00269 | 0.00269 | 0.00269 |
| <b>ostrich</b>         | 0.00126 | 0.00126 | 0.00126 | 0.00126 | 0.00126 | 0.00126 | 0.00126 | 0.00126 | 0.00126 | 0.00126 | 0.00126 | 0.00126 | 0.00126 | 0.00126 | 0.00126 |
| <b>fur animals</b>     | 0.01508 | 0.01508 | 0.01508 | 0.01508 | 0.01508 | 0.01508 | 0.01508 | 0.01508 | 0.01508 | 0.01508 | 0.01508 | 0.01508 | 0.01508 | 0.01508 | 0.01508 |

#### Trend discussion for Key Sources

Dairy cattle, other cattle and swine are key sources of NH<sub>3</sub> emissions from manure management.

The time series of the total NH<sub>3</sub> emissions from all three categories are predominantly driven by the development of the animal numbers, see Table 1. However, the effect of decreasing animal numbers is partly compensated by the continuously increasing animal performance. This leads to increasing N excretions per animal, see Table 2, which, in principle, is reflected by increasing implied emission factors, see Table 3. For swine the IEF is decreasing over time due to lower raw protein contents in feed and the use of air scrubbing systems that, to a high degree, remove NH<sub>3</sub> from the housings.

For NO<sub>x</sub> there are no key categories.

#### Recalculations

All timeseries of the emission inventory have completely been recalculated. Tables 4 and 5 compare the recalculated time series for NH<sub>3</sub> and NO<sub>x</sub> from 3B with the respective data of last year's submission.

For NH<sub>3</sub> there are many reasons for very different emissions compared to last year's submission. For dairy cows the new methodology to calculate N and TAN excretions (see [main page of the agricultural sector recalculation No. 3](#)) results in general in lower emissions. The upward correction of historic milk yields (**recalculation No. 4**) results in higher emissions. In combination these two recalculations result in lower emissions, especially in more recent years. The subdivision of the sows category in gilts and old sows (**recalculation No. 5**) is the main reason for lower emissions from swine.

The adjusted N excretion for horses after 2010 (**recalculation No. 6**) is the main reason for higher emissions from other animals. The addition of substrate transports to biogas plants (**recalculation No. 1**) has a smaller impact on emissions than the other recalculations. This recalculation is the main reason for the changes for emissions from other cattle and poultry but it also affects dairy cattle and swine emissions. Many of the other recalculations have much smaller effects. Overall, the changes result in lower emissions compared with last year's submission.

The total emissions of NO<sub>x</sub> for all years up to 2019 are higher and thereafter a little bit lower than those of submission 2025. The main reasons for this are the recalculations done for dairy cattle (**recalculations No. 3 and No. 4**). Up to the year 2019 the effect of the adjusted milk yields (resulting in higher emissions) is higher than the effect of the new methodology to



calculate N emissions which leads to lower N excretions especially in more recent years. All other reasons listed above regarding NH<sub>3</sub> have similar effects on NO<sub>x</sub> emissions. Further details on recalculations are described in Vos et al. (2026), Chapter 1.3<sup>25)</sup>.

Table 4: Comparison of NH<sub>3</sub> emissions [kt] with previous submission

|                                  |                            | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|----------------------------------|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>NFR-Total: NH<sub>3</sub></b> | <b>current submission</b>  | 297.22 | 250.13 | 245.22 | 244.46 | 235.19 | 231.40 | 227.54 | 226.84 | 220.30 | 215.27 | 209.68 | 199.90 | 190.21 | 188.78 | 187.67 |
|                                  | <b>previous submission</b> | 300.67 | 252.12 | 248.41 | 248.80 | 242.06 | 237.98 | 233.87 | 231.70 | 224.95 | 220.40 | 216.51 | 208.17 | 197.88 | 196.54 |        |
|                                  | <b>absolute change</b>     | -3.45  | -1.99  | -3.20  | -4.33  | -6.87  | -6.58  | -6.33  | -4.86  | -4.65  | -5.14  | -6.83  | -8.27  | -7.67  | -7.76  |        |
|                                  | <b>relative change [%]</b> | -1.15  | -0.79  | -1.29  | -1.74  | -2.84  | -2.76  | -2.71  | -2.10  | -2.07  | -2.33  | -3.15  | -3.97  | -3.88  | -3.95  |        |
| thereof: <b>Dairy cattle</b>     | <b>current submission</b>  | 58.81  | 50.52  | 46.08  | 45.56  | 44.83  | 46.63  | 46.48  | 47.61  | 46.96  | 46.11  | 43.41  | 40.83  | 40.65  | 39.50  | 38.05  |
|                                  | <b>previous submission</b> | 60.08  | 50.88  | 47.58  | 47.96  | 49.01  | 51.16  | 50.96  | 50.81  | 50.34  | 50.41  | 49.61  | 48.53  | 48.11  | 47.56  |        |
| thereof: <b>Other cattle</b>     | <b>current submission</b>  | 75.09  | 61.37  | 58.84  | 54.44  | 57.03  | 52.31  | 51.04  | 49.59  | 47.76  | 46.24  | 44.92  | 43.89  | 43.75  | 43.65  | 42.16  |
|                                  | <b>previous submission</b> | 75.09  | 61.37  | 58.84  | 54.43  | 57.07  | 52.45  | 51.18  | 49.73  | 47.86  | 46.37  | 45.09  | 44.10  | 43.95  | 43.75  |        |
| thereof: <b>Swine</b>            | <b>current submission</b>  | 118.02 | 88.90  | 92.30  | 94.41  | 87.70  | 84.59  | 82.66  | 82.07  | 78.05  | 75.42  | 74.52  | 68.60  | 59.81  | 59.50  | 60.67  |
|                                  | <b>previous submission</b> | 120.20 | 90.53  | 93.99  | 96.33  | 90.18  | 87.72  | 85.80  | 85.33  | 81.27  | 78.46  | 77.66  | 71.70  | 62.66  | 62.12  |        |
| thereof: <b>Poultry</b>          | <b>current submission</b>  | 23.31  | 22.67  | 26.15  | 28.06  | 25.82  | 27.64  | 27.13  | 26.92  | 26.51  | 26.09  | 25.03  | 24.31  | 23.25  | 22.86  | 23.06  |
|                                  | <b>previous submission</b> | 23.31  | 22.67  | 26.16  | 28.07  | 26.00  | 27.82  | 27.37  | 27.17  | 26.72  | 26.32  | 25.23  | 24.50  | 23.43  | 22.93  |        |
| thereof: <b>Other animals</b>    | <b>current submission</b>  | 22.00  | 26.67  | 21.85  | 22.00  | 19.81  | 20.24  | 20.23  | 20.64  | 21.02  | 21.42  | 21.80  | 22.27  | 22.75  | 23.27  | 23.74  |
|                                  | <b>previous submission</b> | 22.00  | 26.67  | 21.85  | 22.00  | 19.81  | 18.82  | 18.56  | 18.66  | 18.75  | 18.84  | 18.92  | 19.32  | 19.73  | 20.18  |        |

Table 5: Comparison of NO<sub>x</sub> emissions [kt] with previous submission

|                                  |                            | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|----------------------------------|----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>NFR-Total: NO<sub>x</sub></b> | <b>current submission</b>  | 2.537 | 2.211 | 2.087 | 2.062 | 1.997 | 1.891 | 1.867 | 1.854 | 1.800 | 1.762 | 1.710 | 1.633 | 1.597 | 1.607 | 2.537 |
|                                  | <b>previous submission</b> | 2.403 | 2.119 | 2.023 | 2.014 | 1.980 | 1.878 | 1.848 | 1.822 | 1.783 | 1.750 | 1.716 | 1.658 | 1.619 | 1.621 |       |
|                                  | <b>absolute change</b>     | 0.13  | 0.09  | 0.06  | 0.05  | 0.02  | 0.01  | 0.02  | 0.03  | 0.02  | 0.01  | -0.01 | -0.02 | -0.02 | -0.01 |       |
|                                  | <b>relative change [%]</b> | 5.60  | 4.35  | 3.20  | 2.38  | 0.84  | 0.67  | 1.01  | 1.77  | 0.97  | 0.65  | -0.40 | -1.48 | -1.39 | -0.86 |       |
| thereof: <b>Dairy cattle</b>     | <b>current submission</b>  | 1.036 | 0.807 | 0.743 | 0.712 | 0.660 | 0.623 | 0.618 | 0.618 | 0.608 | 0.593 | 0.562 | 0.523 | 0.519 | 0.520 | 0.508 |
|                                  | <b>previous submission</b> | 0.892 | 0.708 | 0.672 | 0.658 | 0.634 | 0.607 | 0.600 | 0.590 | 0.585 | 0.580 | 0.570 | 0.549 | 0.544 | 0.545 |       |
| thereof: <b>Other cattle</b>     | <b>current submission</b>  | 0.843 | 0.726 | 0.711 | 0.668 | 0.683 | 0.647 | 0.637 | 0.625 | 0.609 | 0.595 | 0.576 | 0.557 | 0.553 | 0.556 | 0.537 |
|                                  | <b>previous submission</b> | 0.843 | 0.726 | 0.711 | 0.668 | 0.684 | 0.652 | 0.642 | 0.630 | 0.613 | 0.600 | 0.582 | 0.565 | 0.561 | 0.558 |       |
| thereof: <b>Swine</b>            | <b>current submission</b>  | 0.351 | 0.313 | 0.326 | 0.366 | 0.358 | 0.316 | 0.308 | 0.303 | 0.286 | 0.271 | 0.266 | 0.241 | 0.208 | 0.209 | 0.213 |
|                                  | <b>previous submission</b> | 0.360 | 0.319 | 0.332 | 0.372 | 0.367 | 0.332 | 0.322 | 0.318 | 0.300 | 0.286 | 0.281 | 0.258 | 0.224 | 0.222 |       |
| thereof: <b>Poultry</b>          | <b>current submission</b>  | 0.026 | 0.025 | 0.029 | 0.035 | 0.043 | 0.048 | 0.048 | 0.048 | 0.033 | 0.032 | 0.032 | 0.032 | 0.030 | 0.030 | 0.030 |
|                                  | <b>previous submission</b> | 0.026 | 0.025 | 0.029 | 0.034 | 0.042 | 0.048 | 0.047 | 0.047 | 0.046 | 0.044 | 0.042 | 0.040 | 0.040 | 0.039 |       |

|                                  |                            | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|----------------------------------|----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| thereof:<br><b>Other animals</b> | <b>current submission</b>  | 0.282 | 0.340 | 0.279 | 0.281 | 0.253 | 0.256 | 0.256 | 0.261 | 0.265 | 0.270 | 0.275 | 0.280 | 0.286 | 0.293 | 1.249 |
|                                  | <b>previous submission</b> | 0.282 | 0.340 | 0.279 | 0.281 | 0.253 | 0.240 | 0.236 | 0.238 | 0.239 | 0.240 | 0.241 | 0.246 | 0.251 | 0.257 |       |

#### Planned improvements

No improvements are planned at present.

## NMVOC

In 2024, NMVOC emissions from manure management amount to 291.7 kt which is 97.1 % of total NMVOC emissions from the agricultural sector. 84.1 % thereof originate from cattle, 15.9 % from other animals.

#### Method

The Tier 2 methodology provided by EMEP/EEA (2023), Chapter 3.B, page 26<sup>26)</sup> was used to assess the NMVOC emissions from manure management for dairy cattle and other cattle. For all other animals the Tier 1 methodology (EMEP/EEA (2023), Chapter 3.B, page 17)<sup>27)</sup> was used. The use of the Tier 2 methodology yields NMVOC emissions which formally could be reported in the sectors 3.D.a.2.a (application of manure to soils) and 3.D.a.3 (grazing emissions).

However, to be congruent with the NMVOC emissions for other animal categories, Germany reports these emissions in the NMVOC emissions reported from manure management (3.B). For the NFR codes 3.D.a.2.a and 3.D.a.3 the key note IE is used for NMVOC emissions.

#### Activity data

Animal numbers serve as activity data, see Table 1.

#### Emission factors

For the Tier 2 methodology applied to dairy cattle and other cattle the following data was used:

- gross feed intake in MJ per year, country specific data from the annual reporting of greenhouse gas emissions, see NID 2026, Chapter 5.1.3.3<sup>28)</sup>,
- proportion  $x_{\text{house}}$  of the year the animals spend in the livestock building: country specific data, being equal to  $1 - x_{\text{graz}}$  with  $x_{\text{graz}}$  the proportion of the year spent on pasture, see NID 2026, Chapter 17.3.1<sup>29)</sup>,
- $\text{FRAC}_{\text{silage}}$ : 1 as proposed by EMEP (2023), Chapter 3.B, p. 27, since silage feeding for cattle is considered dominant in Germany
- $\text{FRAC}_{\text{silage store}}$ : 0.25 as proposed by EMEP/EEA (2023), Ch. 3.B, p. 27<sup>30)</sup> for European conditions
- $\text{EF}_{\text{NMVOC, silage feeding}}$ ,  $\text{EF}_{\text{NMVOC, house}}$ ,  $\text{EF}_{\text{NMVOC, graz}}$  are taken from EMEP/EEA (2023), Chapter 3.1, p. 31, table 3.11<sup>31)</sup> as 0.0002002, 0.0000353 and 0.0000069 kg NMVOC/MJ feed intake, respectively,
- $\text{EF}_{\text{NH}_3, \text{storage}}$ ,  $\text{EF}_{\text{NH}_3, \text{building}}$  and  $\text{EF}_{\text{NH}_3, \text{application}}$  are taken from the  $\text{NH}_3$  reporting (see above and 3.D).

For all other animal categories the Tier 1 emission factors for NMVOC were used as provided in EMEP/EEA (2023), Ch. 3.B, p. 17, Table 3.4<sup>32)</sup>. For horses the emission factors for feeding with silage was chosen, for all other animals the emission factors for feeding without silage. Due to missing country-specific emission factors or emission factors that do not correspond to the inventory's animal categories, the emission factors provided in EMEP/EEA (2023), Ch. 3.B, p. 17, Table 3.4, were used to define specific emission factors for weaners, boars, lambs, ponies/light horses and pullets, ostriches, and deer see Vos et al. (2026), Chapter 4.3.3<sup>33)</sup>.

The implied emission factors given in Table 4 relate the overall NMVOC emissions to the number of animals in each animal category. The IEFs for dairy cattle and other cattle are much higher than the EMEP/EEA Tier 1 EF, which are 17.937 kg NMVOC for dairy cattle and 8.902 kg NMVOC for other cattle. The only possible explanation for those huge differences is that the EMEP Tier2 and Tier1 methods are not consistent.



The IEFs for the other categories provided in Table 6 correspond to the EMEP Tier1 emission factors, except for horses, sheep and swine. These categories comprise subcategories with different emission factors so that their overall IEFs in Table 4 represent subpopulation-weighted national mean values.

Note that other poultry in Germany includes not only geese and ducks but also pullets. For pullets no default EF is given in the 2023 EMEP/EEA guidebook (EMEP/EEA, 2023), hence the EF of broilers has been adopted (because of similar housing). This assumption significantly lowers the overall IEF of other poultry (in Table 6 the IEFs are listed separately for each poultry category). The IEF of the sheep category is significantly lower than the EMEP/EEA Tier 1 emission factor, because for lambs the EF is assumed to be 40% lower compared to an adult sheep in accordance with the difference in N excretion between lambs and adult sheep.

Table 6: IEF for NMVOC from manure management, in [kg NMVOC per animal place]

|                     | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>dairy cattle</b> | 32.914 | 35.430 | 38.490 | 39.726 | 40.290 | 40.898 | 41.328 | 41.220 | 41.988 | 42.823 | 43.405 | 43.556 | 43.173 | 44.716 | 45.579 |
| <b>other cattle</b> | 12.400 | 12.298 | 12.406 | 12.247 | 12.207 | 11.835 | 11.763 | 11.730 | 11.703 | 11.732 | 11.791 | 11.866 | 11.848 | 11.880 | 11.905 |
| <b>horses</b>       | 6.497  | 6.491  | 6.688  | 6.660  | 6.644  | 6.646  | 6.648  | 6.651  | 6.654  | 6.657  | 6.660  | 6.659  | 6.658  | 6.657  | 6.656  |
| <b>sheep</b>        | 0.131  | 0.131  | 0.132  | 0.132  | 0.131  | 0.131  | 0.131  | 0.131  | 0.131  | 0.131  | 0.131  | 0.131  | 0.131  | 0.131  | 0.131  |
| <b>goats</b>        | 0.542  | 0.542  | 0.542  | 0.542  | 0.542  | 0.542  | 0.542  | 0.542  | 0.542  | 0.542  | 0.542  | 0.542  | 0.542  | 0.542  | 0.542  |
| <b>swine</b>        | 0.695  | 0.698  | 0.690  | 0.682  | 0.669  | 0.651  | 0.649  | 0.648  | 0.648  | 0.647  | 0.642  | 0.645  | 0.643  | 0.644  | 0.644  |
| <b>laying hens</b>  | 0.165  | 0.165  | 0.165  | 0.165  | 0.165  | 0.165  | 0.165  | 0.165  | 0.165  | 0.165  | 0.165  | 0.165  | 0.165  | 0.165  | 0.165  |
| <b>broilers</b>     | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  |
| <b>turkeys</b>      | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  |
| <b>pullets</b>      | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  | 0.108  |
| <b>ducks</b>        | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  |
| <b>geese</b>        | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  |
| <b>deer</b>         | 0.045  | 0.045  | 0.045  | 0.045  | 0.045  | 0.045  | 0.045  | 0.045  | 0.045  | 0.045  | 0.045  | 0.045  | 0.045  | 0.045  | 0.045  |
| <b>rabbits</b>      | 0.059  | 0.059  | 0.059  | 0.059  | 0.059  | 0.059  | 0.059  | 0.059  | 0.059  | 0.059  | 0.059  | 0.059  | 0.059  | 0.059  | 0.059  |
| <b>ostrich</b>      | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  | 0.489  |
| <b>fur animals</b>  | 1.941  | 1.941  | 1.941  | 1.941  | 1.941  | 1.941  | 1.941  | 1.941  | 1.941  | 1.941  | 1.941  | 1.941  | 1.941  | 1.941  | 1.941  |

### Trend discussion for Key Sources

Dairy cattle and other cattle are key sources of NMVOC emissions from manure management. The total NMVOC emissions from both animal categories strongly correlate with the animal numbers given in Table 1 (dairy cattle:  $R^2 = 0.90$ ; other cattle:  $R^2 = 0.99$ ).

### Recalculations

All timeseries of the emission inventory have completely been recalculated. Table 7 compares the recalculated time series of the NMVOC emissions from 3.B with the respective data of last year's submission. The recalculated total emissions are higher. For dairy cattle and other cattle emissions are higher due to changes of  $\text{NH}_3$  emissions which have impact on the Tier 2 methodology which is applied for cattle NMVOC emissions. For other animals there are no changes compared with the previous submission. Further details on recalculations are described in Vos et al. (2026), Chapter 1.3.

Table 7: Comparison of NMVOC emissions [kt] with previous submission

|                         |                            | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|-------------------------|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>NFR-Total: NMVOC</b> | <b>current submission</b>  | 418.62 | 362.01 | 346.77 | 325.36 | 324.20 | 325.33 | 322.01 | 318.62 | 314.16 | 311.13 | 306.95 | 300.63 | 296.10 | 296.66 | 291.74 |
|                         | <b>previous submission</b> | 415.22 | 357.45 | 342.28 | 320.98 | 320.35 | 322.59 | 318.93 | 315.55 | 311.20 | 307.95 | 303.73 | 297.43 | 293.26 | 292.11 |        |
|                         | <b>absolute change</b>     | 3.39   | 4.56   | 4.49   | 4.38   | 3.85   | 2.74   | 3.07   | 3.07   | 2.96   | 3.18   | 3.22   | 3.20   | 2.84   | 4.55   |        |
|                         | <b>relative change [%]</b> | 0.82   | 1.27   | 1.31   | 1.36   | 1.20   | 0.85   | 0.96   | 0.97   | 0.95   | 1.03   | 1.06   | 1.07   | 0.97   | 1.56   |        |

|                                  |                            | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|----------------------------------|----------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| thereof:<br><b>Dairy cattle</b>  | <b>current submission</b>  | 209.16 | 185.28 | 175.89 | 168.29 | 168.54 | 175.23 | 174.31 | 173.08 | 172.19 | 171.79 | 170.21 | 166.94 | 164.48 | 166.02 | 163.60 |
|                                  | <b>previous submission</b> | 205.77 | 180.73 | 171.39 | 163.89 | 164.40 | 171.96 | 170.78 | 169.61 | 168.80 | 168.25 | 166.61 | 163.33 | 161.27 | 161.23 |        |
| thereof:<br><b>Other cattle</b>  | <b>current submission</b>  | 162.85 | 131.10 | 123.68 | 107.78 | 105.33 | 98.83  | 97.03  | 94.80  | 91.85  | 89.49  | 87.02  | 85.52  | 85.15  | 84.63  | 81.81  |
|                                  | <b>previous submission</b> | 162.85 | 131.10 | 123.68 | 107.80 | 105.62 | 99.36  | 97.49  | 95.21  | 92.27  | 89.86  | 87.40  | 85.93  | 85.52  | 84.87  |        |
| thereof:<br><b>Other animals</b> | <b>current submission</b>  | 46.61  | 45.63  | 47.21  | 49.29  | 50.33  | 51.27  | 50.67  | 50.73  | 50.12  | 49.84  | 49.72  | 48.17  | 46.47  | 46.01  | 46.33  |
|                                  | <b>previous submission</b> | 46.61  | 45.63  | 47.21  | 49.29  | 50.33  | 51.27  | 50.67  | 50.73  | 50.12  | 49.83  | 49.72  | 48.17  | 46.47  | 46.01  |        |

## Planned improvements

No improvements are planned at present.

## Particle emissions

In 2024, TSP emissions from manure management amount to 60.4 % of total emissions from the agricultural sector. Of these emissions 23.9 % originate from cattle, 32.9 % from pigs, and 41.6 % from poultry.

34.7 % of total PM<sub>10</sub> emissions from the agricultural sector are caused by manure management, where 33.3 % originate from cattle, 15.3 % from pigs, and 47.0 % from poultry.

66.4 % of total PM<sub>2.5</sub> emissions from the agricultural sector are caused by manure management, where 76.5 % originate from cattle, 2.4 % from pigs, and 16.7 % from poultry.

## Method

EMEP/EEA (2013), Ch. 3.B, p. 26<sup>34)</sup> provided a Tier2 methodology. In the 2023 Guidebook (EMEP, 2023), this methodology has been replaced by a Tier1 methodology. However, EF for cattle derived with the EMEP/EEA 2013 Tier2 methodology remained unchanged. Therefore, the EMEP/EEA 2013<sup>35)</sup> methodology was kept for cattle. For swine the EMEP 2013 methodology was formally kept but the EMEP/EEA 2023 Tier1 EF was used both for slurry and solid based manure management systems. In case the EMEP 2023 EFs are simply rounded EMEP/EEA 2013 EFs, the unrounded EMEP/EEA 2013 EFs were kept. For rabbits the EFs from The Netherlands' inventory were adopted (Huis In't Veld et al, 2011)<sup>36)</sup>, for ostriches the EFs of goats were used. The inventory considers air scrubber systems in swine and poultry husbandry. For animal places equipped with air scrubbing the emission factors are reduced according to the removal efficiency of the air scrubber systems (90 % for TSP and PM<sub>10</sub>, 70 % for PM<sub>2.5</sub>). For details see Vos et al. (2026), Chapter 4.2.2.

## Activity data

Animal numbers serve as activity data, see Table 1.

## Emission factors

Tier 1 emission factors for TSP, PM<sub>10</sub> and PM<sub>2.5</sub> from livestock husbandry are provided in EMEP/EEA (2023), Ch. 3.B, p. 18, Table 3.5 and 55, Table A1.7. For cattle the Tier2 emission factors provided in EMEP/EEA (2013), Ch. 3.B, p. 29, Table 3-11 were used, because they differentiate between slurry and solid manure systems and were also used to develop the EMEP/EEA 2023 Tier1 emissions factors. They are also provided in EMEP/EEA (2023), Ch. 3.B, p. 53, Table A1.7.

The implied emission factors given in Table 8 relate the overall TSP and PM emissions to the number of animals in each animal category. The Guidebook does not indicate whether EFs have considered the condensable component (with or without).

Table 8: IEF for TSP, PM<sub>10</sub> & PM<sub>2.5</sub> from manure management

|                                 | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|---------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Total suspended particles (TSP) |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| dairy cattle                    | 1.2124 | 1.4016 | 1.4542 | 1.4727 | 1.4969 | 1.5360 | 1.5455 | 1.5541 | 1.5630 | 1.5721 | 1.5721 | 1.5723 | 1.5722 | 1.5723 | 1.5730 |
| other cattle                    | 0.5194 | 0.5107 | 0.5014 | 0.4903 | 0.4798 | 0.4762 | 0.4759 | 0.4756 | 0.4755 | 0.4748 | 0.4746 | 0.4750 | 0.4755 | 0.4744 | 0.4737 |
| horses                          | 0.3514 | 0.3512 | 0.3558 | 0.3552 | 0.3548 | 0.3549 | 0.3549 | 0.3550 | 0.3551 | 0.3551 | 0.3552 | 0.3552 | 0.3551 | 0.3551 | 0.3551 |
| sheep                           | 0.0484 | 0.0478 | 0.0489 | 0.0486 | 0.0489 | 0.0482 | 0.0482 | 0.0482 | 0.0480 | 0.0482 | 0.0482 | 0.0481 | 0.0478 | 0.0480 | 0.0482 |
| goats                           | 0.0914 | 0.0914 | 0.0914 | 0.0914 | 0.0914 | 0.0914 | 0.0914 | 0.0914 | 0.0914 | 0.0914 | 0.0914 | 0.0914 | 0.0914 | 0.0914 | 0.0914 |
| swine                           | 0.8260 | 0.8366 | 0.8320 | 0.8218 | 0.7928 | 0.7503 | 0.7453 | 0.7390 | 0.7316 | 0.7231 | 0.7243 | 0.7070 | 0.6881 | 0.6884 | 0.6938 |
| laying hens                     | 0.1898 | 0.1898 | 0.1890 | 0.1881 | 0.1869 | 0.1856 | 0.1853 | 0.1854 | 0.1846 | 0.1841 | 0.1838 | 0.1835 | 0.1830 | 0.1828 | 0.1826 |
| broilers                        | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0399 | 0.0397 | 0.0396 | 0.0395 | 0.0394 | 0.0394 | 0.0392 | 0.0392 | 0.0391 | 0.0391 |
| turkeys                         | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 |
| pullets                         | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 | 0.0400 |
| ducks                           | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 |
| geese                           | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 |
| deer                            | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| rabbits                         | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 |
| ostrich                         | 0.0278 | 0.0278 | 0.0278 | 0.0278 | 0.0278 | 0.0278 | 0.0278 | 0.0278 | 0.0278 | 0.0278 | 0.0278 | 0.0278 | 0.0278 | 0.0278 | 0.0278 |
| fur animals                     | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 |
| PM <sub>10</sub>                |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| dairy cattle                    | 0.5557 | 0.6426 | 0.6667 | 0.6752 | 0.6862 | 0.7042 | 0.7086 | 0.7125 | 0.7166 | 0.7208 | 0.7208 | 0.7209 | 0.7208 | 0.7209 | 0.7212 |
| other cattle                    | 0.2403 | 0.2363 | 0.2320 | 0.2267 | 0.2218 | 0.2201 | 0.2200 | 0.2199 | 0.2198 | 0.2195 | 0.2194 | 0.2196 | 0.2198 | 0.2193 | 0.2190 |
| horses                          | 0.1619 | 0.1619 | 0.1639 | 0.1636 | 0.1634 | 0.1634 | 0.1635 | 0.1635 | 0.1635 | 0.1635 | 0.1636 | 0.1636 | 0.1636 | 0.1635 | 0.1635 |
| sheep                           | 0.0194 | 0.0192 | 0.0196 | 0.0195 | 0.0196 | 0.0193 | 0.0193 | 0.0193 | 0.0192 | 0.0193 | 0.0193 | 0.0193 | 0.0192 | 0.0192 | 0.0193 |
| goats                           | 0.0368 | 0.0368 | 0.0368 | 0.0368 | 0.0368 | 0.0368 | 0.0368 | 0.0368 | 0.0368 | 0.0368 | 0.0368 | 0.0368 | 0.0368 | 0.0368 | 0.0368 |
| swine                           | 0.1241 | 0.1255 | 0.1244 | 0.1225 | 0.1173 | 0.1099 | 0.1088 | 0.1078 | 0.1068 | 0.1054 | 0.1051 | 0.1029 | 0.1001 | 0.1001 | 0.1007 |
| laying hens                     | 0.0400 | 0.0399 | 0.0398 | 0.0396 | 0.0393 | 0.0391 | 0.0390 | 0.0390 | 0.0389 | 0.0388 | 0.0387 | 0.0386 | 0.0385 | 0.0385 | 0.0384 |
| broilers                        | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0199 | 0.0198 | 0.0198 | 0.0198 | 0.0197 | 0.0197 | 0.0196 | 0.0196 | 0.0196 | 0.0195 |
| turkeys                         | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 |
| pullets                         | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |
| ducks                           | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 | 0.1400 |
| geese                           | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 | 0.2400 |
| deer                            | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| rabbits                         | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 | 0.0107 |
| ostrich                         | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 |
| fur animals                     | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 |
| PM <sub>2.5</sub>               |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| dairy cattle                    | 0.3616 | 0.4181 | 0.4338 | 0.4393 | 0.4465 | 0.4582 | 0.4610 | 0.4636 | 0.4663 | 0.4690 | 0.4690 | 0.4690 | 0.4690 | 0.4690 | 0.4693 |
| other cattle                    | 0.1574 | 0.1548 | 0.1520 | 0.1487 | 0.1456 | 0.1444 | 0.1443 | 0.1442 | 0.1442 | 0.1440 | 0.1439 | 0.1440 | 0.1442 | 0.1439 | 0.1437 |
| horses                          | 0.1027 | 0.1026 | 0.1039 | 0.1038 | 0.1036 | 0.1037 | 0.1037 | 0.1037 | 0.1037 | 0.1037 | 0.1038 | 0.1037 | 0.1037 | 0.1037 | 0.1037 |
| sheep                           | 0.0059 | 0.0059 | 0.0060 | 0.0060 | 0.0060 | 0.0059 | 0.0059 | 0.0059 | 0.0059 | 0.0059 | 0.0059 | 0.0059 | 0.0059 | 0.0059 | 0.0059 |
| goats                           | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 | 0.0112 |
| swine                           | 0.0056 | 0.0057 | 0.0056 | 0.0055 | 0.0053 | 0.0050 | 0.0050 | 0.0049 | 0.0049 | 0.0049 | 0.0048 | 0.0048 | 0.0047 | 0.0047 | 0.0047 |
| laying hens                     | 0.0030 | 0.0030 | 0.0030 | 0.0030 | 0.0030 | 0.0029 | 0.0029 | 0.0029 | 0.0029 | 0.0029 | 0.0029 | 0.0029 | 0.0029 | 0.0029 | 0.0029 |
| broilers                        | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 |
| turkeys                         | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |
| pullets                         | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 | 0.0020 |
| ducks                           | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 | 0.0180 |

|                    | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|--------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| <b>geese</b>       | 0.0320 | 0.0320 | 0.0320 | 0.0320 | 0.0320 | 0.0320 | 0.0320 | 0.0320 | 0.0320 | 0.0320 | 0.0320 | 0.0320 | 0.0320 | 0.0320 | 0.0320 |
| <b>deer</b>        | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| <b>rabbits</b>     | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 | 0.0021 |
| <b>ostrich</b>     | 0.0034 | 0.0034 | 0.0034 | 0.0034 | 0.0034 | 0.0034 | 0.0034 | 0.0034 | 0.0034 | 0.0034 | 0.0034 | 0.0034 | 0.0034 | 0.0034 | 0.0034 |
| <b>fur animals</b> | 0.0040 | 0.0040 | 0.0040 | 0.0040 | 0.0040 | 0.0040 | 0.0040 | 0.0040 | 0.0040 | 0.0040 | 0.0040 | 0.0040 | 0.0040 | 0.0040 | 0.0040 |

## Trend discussion for Key Sources

Swine and laying hens are key sources of TSP emissions from manure management. The total TSP emissions from swine mainly follow the animal numbers given in Table 1 for the earlier years of the time series. However, due to increases in places equipped with air scrubbing and different emission factors of the different housing systems of the five swine subcategories (sows (divided in gilts and old sows), weaners, fattening pigs, boars) and the varying population shares in those housing systems the  $R^2$  of the linear regression is lower than 1 (0.79). For laying hens ( $R^2 = 0.98$ ) and broilers ( $R^2 = 0.99$ ), due to the low prevalence of air scrubbing systems TSP emissions almost perfectly correlate with the animal numbers provided in Table 1.

## Recalculations

The following table 9 shows the effects of recalculations on emissions of particulate matter. Minimal differences compared with the previous submission are due to the correction of the number of animal places equipped with air scrubbers (**recalculation No. 11**), see [main page of the agricultural sector](#). Further details on recalculations are described in Vos et al. (2026), Chapter 1.3.

Table 9: Comparison of particle emissions (TSP, PM<sub>10</sub> & PM<sub>2.5</sub>) [kt] with previous submission

| TSP, PM <sub>10</sub> , PM <sub>2.5</sub> emissions from manure management, in kt |                     |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|-----------------------------------------------------------------------------------|---------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                                                                   |                     | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
| TSP                                                                               | current submission  | 50.36 | 43.31 | 44.13 | 43.37 | 42.70 | 43.91 | 43.56 | 43.53 | 42.51 | 41.85 | 41.67 | 39.64 | 37.71 | 37.32 | 37.23 |
|                                                                                   | previous submission | 50.36 | 43.31 | 44.13 | 43.37 | 42.70 | 43.91 | 43.57 | 43.54 | 42.51 | 41.80 | 41.67 | 39.63 | 37.71 | 37.32 |       |
|                                                                                   | absolute change     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.05  | 0.00  | 0.00  | 0.00  | 0.00  |       |
|                                                                                   | relative change [%] | 0.00  | 0.00  | 0.00  | 0.00  | -0.01 | -0.01 | -0.01 | 0.00  | 0.00  | 0.13  | 0.00  | 0.00  | 0.00  | 0.00  |       |
| PM <sub>10</sub>                                                                  | current submission  | 14.50 | 13.12 | 13.25 | 13.09 | 13.32 | 13.60 | 13.42 | 13.37 | 13.12 | 12.93 | 12.79 | 12.32 | 11.91 | 11.69 | 11.58 |
|                                                                                   | previous submission | 14.50 | 13.12 | 13.25 | 13.09 | 13.32 | 13.60 | 13.42 | 13.37 | 13.12 | 12.93 | 12.79 | 12.32 | 11.91 | 11.69 |       |
|                                                                                   | absolute change     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.01  | 0.00  | 0.00  | 0.00  | 0.00  |       |
|                                                                                   | relative change [%] | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.05  | 0.00  | 0.00  | 0.00  | 0.00  |       |
| PM <sub>2.5</sub>                                                                 | current submission  | 5.11  | 4.61  | 4.32  | 4.04  | 4.03  | 4.10  | 4.05  | 4.03  | 3.95  | 3.88  | 3.79  | 3.70  | 3.66  | 3.58  | 3.49  |
|                                                                                   | previous submission | 5.11  | 4.61  | 4.32  | 4.04  | 4.03  | 4.10  | 4.05  | 4.03  | 3.95  | 3.88  | 3.79  | 3.70  | 3.66  | 3.58  |       |
|                                                                                   | absolute change     | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  |       |
|                                                                                   | relative change [%] | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.00  | 0.01  | 0.00  | 0.00  | 0.00  | 0.00  |       |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

## Uncertainty

Details are described in [chapter 1.7](#).

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- <sup>16), 20)</sup> IPCC (2006): IPCC – Intergovernmental Panel on Climate Change (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry and Other Land Use., 2006
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- <sup>23), 24)</sup> IPCC (2019): IPCC – Intergovernmental Panel on Climate Change (2019): 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry and Other Land Use., 2019
- <sup>36)</sup> Huis In't Velt, J.W.H., Dousma, F., Nijboer, G.M. (2011): Gaseous Emissions and fine dust from rabbit housing systems. Livestock research Wageningen, Report 459., 2011)) [(HENRICHSMEYERETAL1996> Henrichsmeyer, W., Cypris, C., Löhe, W., Meuth, M., Isermeyer F, Heinrich, I., Schefski, A., Neander, E., Fasterding, F., Neumann, M., Nieberg, H., 1996: Entwicklung des gesamtdeutschen Agrarsektormodells RAUMIS96. Endbericht zum Kooperationsprojekt. Forschungsbericht für das BMELF (94 HS 021), Bonn/Braunschweig, 1996

### Short description

[illegible]

|            |                                                                                     |
|------------|-------------------------------------------------------------------------------------|
| <b>L/-</b> | key source by <b>Level</b> only                                                     |
| <b>-/T</b> | key source by <b>Trend</b> only                                                     |
| <b>L/T</b> | key source by both <b>Level</b> and <b>Trend</b>                                    |
| <b>-/-</b> | no key source for this pollutant                                                    |
| <b>IE</b>  | emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |
| <b>NE</b>  | emission of specific pollutant <b>Not Estimated</b> (yet)                           |
| <b>NA</b>  | specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |
| <b>*</b>   | no analysis done                                                                    |

## Country specifics



### NH<sub>3</sub> and NO<sub>x</sub>

In 2024, agricultural soils emitted 295.1 kt NH<sub>3</sub> or 61.0 % of the total agricultural NH<sub>3</sub> emissions in Germany (484.0 kt NH<sub>3</sub>). The main contributions to the total NH<sub>3</sub> emissions from agricultural soils are the application of manure (3.D.a.2.a), with 171.4 kt (58.1 %), the application of other organic N-fertilizers (3.D.a.2.c) with 57.2 kt (19.4 %), and the application of inorganic N-fertilizers (3.D.a.1) with 42.9 kt (14.5 %).

N excretions on pastures (3.D.a.3) have a share of 15.2 kt NH<sub>3</sub> (5.2 %), emissions from crop residues (3.D.a.4) are 7.1 kt NH<sub>3</sub> (2.4 %), and the application of sewage sludge (3.D.a.2.b) 1.4 kt NH<sub>3</sub> (0.5 %).

In 2024, agricultural soils were the source of 98.3 % (96.4 kt) of the total of NO<sub>x</sub> emissions in the agricultural category (98.0 kt). The NO<sub>x</sub> emissions from agricultural soils are primarily due to application of inorganic fertilizer (3.D.a.1) (40.5 kt) and manure (3.D.a.2.a) (36.1 kt). Application of other organic N-fertilizers (3.D.a.2.c) contributes 14.7 kt, 5.3 kt are due to excretions on pastures (3.D.a.3). Emissions from application of sewage sludge (3.D.a.2.b) contribute 0.4 kt.

### NMVOC

In 2024, the category of agricultural soils contributed 8.9 kt NMVOC or 2.9 % to the total agricultural NMVOC emissions in Germany (300.6 kt NMVOC). The only emission source was cultivated crops (3.D.e).

### TSP, PM<sub>10</sub> & PM<sub>2.5</sub>

In 2024, agricultural soils contributed, respectively, 38.4 % (23.2 kt), 66.7 % (23.2 kt) and 33.6 % (1.8 kt) to the total agricultural TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions (60.4 kt, 34.7 kt, 5.3 kt, respectively). The emissions are reported in category 3.D.c (Farm-level agricultural operations including storage, handling and transport of agricultural products).



### 3.D.a.1 - Inorganic N-fertilizers

The calculation of  $\text{NH}_3$  and  $\text{NO}_x$  ( $\text{NO}$ ) emissions from the application of synthetic fertilizers is described in Vos et al. (2026)<sup>1)</sup>, Chapters 5.2.1.2 and 5.2.2.2 1.

#### Activity Data

German statistics report the amounts of fertilizers sold which are assumed to equal the amounts that are applied. Since the 2021 submission, storage effects are approximated by applying a moving average to the sales data (moving centered three-year average, for the last year a weighted two-year average, which assigns 2/3 of the weight to the last year). Since the year 2022, data for the sales of urea that is stabilized with urease inhibitor is available. It cannot be published because of data-privacy issues. Therefore, the emissions are calculated and provided by the federal statistical office using the emission factors as described below. The activity data are published in aggregate for urea, urea+inhibitor and nitrogen solutions to maintain confidentiality. For details see Vos et al. (2026), Chapter 2.8<sup>2)</sup>.

Table 1: AD for the estimation of  $\text{NH}_3$  and  $\text{NO}_x$  emissions from application of synthetic fertilizers

|                                                      | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>Application of fertilizers (total)</b>            | 2,195 | 1,723 | 1,922 | 1,797 | 1,635 | 1,736 | 1,731 | 1,622 | 1,499 | 1,404 | 1,327 | 1,245 | 1,123 | 1,048 | 1,028 |
| <b>calcium ammonium nitrate</b>                      | 1,368 | 1,044 | 982   | 824   | 689   | 618   | 605   | 571   | 543   | 520   | 497   | 470   | 422   | 396   | 388   |
| <b>urea and ammonia nitrate urea solutions (AHL)</b> | 369   | 403   | 508   | 526   | 542   | 590   | 604   | 539   | 460   | 385   | 342   | 318   | 293   | 276   | 262   |
| <b>ammonium phosphates</b>                           | 85    | 55    | 66    | 55    | 64    | 84    | 82    | 77    | 65    | 64    | 58    | 51    | 41    | 36    | 38    |
| <b>other NK and NPK</b>                              | 246   | 162   | 175   | 126   | 63    | 67    | 62    | 54    | 52    | 51    | 51    | 47    | 40    | 34    | 31    |
| <b>other straight fertilizers</b>                    | 127   | 60    | 191   | 266   | 277   | 377   | 377   | 381   | 378   | 383   | 379   | 359   | 328   | 306   | 309   |

#### Methodology

$\text{NH}_3$  emissions from the application of synthetic fertilizers are calculated using the Tier 2 approach according to EMEP/EEA (2023), Ch. 3.D, pp. 16ff<sup>3)</sup>, distinguishing between various fertilizer types, see Table 2. For  $\text{NO}_x$ , the Tier 1 approach described in EMEP/EEA (2023), Ch. 3.D, p. 15 is applied.

#### Emission factors

The emission factors for  $\text{NH}_3$  depend on fertilizer type, see EMEP/EEA (2023), Ch. 3.D, p. 17., Table 2 lists the EMEP/EEA emission factors for the fertilizers used in the inventory<sup>4)</sup>. In order to reflect average German conditions, the emission factors for cool climate and a pH value lower than 7 was chosen. For urea fertilizer the German fertilizer ordinance prescribes the use of urease inhibitors or the immediate incorporation into the soil from 2020 onwards. The  $\text{NH}_3$  emission factor for urea fertilizers is therefore reduced by 70% from 2020 onwards for the immediate incorporation of urea, according to Bittman et al. (2014, Table 15)<sup>5)</sup>. For the use of urease inhibitors the emission factor for urea fertilizer is reduced by 60%. For details see Vos et al. (2026), Chapter 5.2.1.2<sup>6)</sup>.

Table 2: Synthetic fertilizers, emission factors in [kg  $\text{NH}_3$  per kg fertilizer N]

| <b>Fertilizer type</b>                 | <b>EF</b> |
|----------------------------------------|-----------|
| calcium ammonium nitrate               | 0.024     |
| ammonia nitrate urea solutions (AHL)   | 0.087     |
| urea (up to 2019)                      | 0.195     |
| urea (from 2020 with urease inhibitor) | 0.078     |
| urea (from 2020 if incorporated)       | 0.0585    |
| ammonium phosphates                    | 0.084     |
| other NK and NPK                       | 0.084     |
| other straight fertilizers             | 0.024     |



For NO<sub>x</sub>, the simpler methodology by EMEP/EEA (2023), Ch.3.D, p. 13 was used. The emission factor 0.040 from EMEP, 2023-3D, Table 3.1 has the unit of [kg N<sub>2</sub>O per kg fertilizer N] and was derived from Stehfest and Bouwman (2006)<sup>7)</sup>.

The German inventory uses the emission factor 0.012 kg NO-N per kg N derived from Stehfest and Bouwman (2006) directly<sup>8)</sup>. This is equivalent to an emission factor of 0.03943 kg NO<sub>x</sub> per kg fertilizer N (obtained by multiplying 0.012 kg NO-N per kg N with the molar weight ratio 46/14 for NO<sub>2</sub>: NO). The inventory uses the unrounded emission factor.

Table 3: Emission factor for NO<sub>x</sub> emissions from fertilizer application

| Emission factor    | kg NO-N per kg fertilizer N | kg NO <sub>x</sub> per kg fertilizer N |
|--------------------|-----------------------------|----------------------------------------|
| EF <sub>fert</sub> | 0.012                       | 0.039                                  |

## Trend discussion for Key Sources

Since 2016, fertilizer sales have fallen dramatically (by around a third). Emissions have fallen accordingly. This is even more pronounced for NH<sub>3</sub> than for NO<sub>x</sub>, as total NH<sub>3</sub> from the application of mineral fertilizers is, until the year 2019, very strongly correlated with the amount of urea applied ( $R^2 = 0.64$ ), the sales of which have decreased more than for all other mineral fertilizers. Since 2020 the negative trend is reinforced as urea fertilizer has to be either used with urease inhibitors or has to be incorporated into the soil directly, which reduces emissions.

## Recalculations

Table 4 shows the effects of recalculations on NH<sub>3</sub> and NO<sub>x</sub> emissions. The big differences for NH<sub>3</sub> emissions are due to the correction of the EMEP/EEA (2023) emission factor for straight fertilizers (**recalculation No. 2**). Concerning NO<sub>x</sub>, emissions differences only occur in 2023, resulting from applying the moving average to sales data (see activity data).

Table 4: Comparison of NH<sub>3</sub> and NO<sub>x</sub> emissions [kt] with previous submission

| NH <sub>3</sub> and NO <sub>x</sub> emissions from inorganic fertilizer application, in kt |                     |        |        |        |        |        |        |        |        |        |        |        |        |        |        |       |
|--------------------------------------------------------------------------------------------|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
|                                                                                            |                     | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024  |
| Ammonia                                                                                    | current submission  | 121.93 | 99.21  | 119.19 | 118.44 | 120.16 | 133.00 | 135.03 | 121.47 | 105.50 | 91.66  | 54.81  | 52.05  | 47.52  | 44.08  | 42.89 |
|                                                                                            | previous submission | 129.55 | 102.80 | 130.65 | 134.39 | 136.77 | 155.61 | 157.68 | 144.31 | 128.19 | 114.66 | 77.56  | 73.59  | 67.18  | 61.79  |       |
|                                                                                            | absolute change     | -7.61  | -3.59  | -11.46 | -15.96 | -16.61 | -22.61 | -22.65 | -22.84 | -22.69 | -23.01 | -22.75 | -21.54 | -19.66 | -17.71 |       |
|                                                                                            | relative change [%] | -5.88  | -3.49  | -8.77  | -11.87 | -12.14 | -14.53 | -14.36 | -15.83 | -17.70 | -20.06 | -29.33 | -29.27 | -29.27 | -28.67 |       |
| Nitrogen oxides                                                                            | current submission  | 86.53  | 67.93  | 75.77  | 70.84  | 64.48  | 68.46  | 68.24  | 63.95  | 59.11  | 55.34  | 52.31  | 49.08  | 44.29  | 41.31  | 40.55 |
|                                                                                            | previous submission | 86.53  | 67.93  | 75.77  | 70.84  | 64.48  | 68.46  | 68.24  | 63.95  | 59.11  | 55.34  | 52.31  | 49.08  | 44.29  | 40.89  |       |
|                                                                                            | absolute change     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.41   |       |
|                                                                                            | relative change [%] | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 1.01   |       |

## Planned improvements

No improvements are planned at present.

## 3.D.a.2.a - Animal manure applied to soils

In this sub-category Germany reports the NH<sub>3</sub> and NO<sub>x</sub> (NO) emissions from application of manure (including application of anaerobically digested manure). An overview is given in Vos et al. (2026), Chapters 5.2.1.2 and 5.2.2.2<sup>9)</sup>.

Germany uses the Tier2 methodology for estimating NMVOC emissions for cattle in sector 3.B (manure management). The use of this methodology yields NMVOC emissions which formally could be reported in the sectors 3.D.a.2.a and 3.D.a.3 (grazing emissions). However, to be congruent with the NMVOC emissions for other animal categories, Germany reports

these emissions in the NMVOC emissions reported from manure management (3.B). For the NFR codes 3.D.a.2.a and 3.D.a.3 the notation key IE is used for NMVOC emissions.

Activity data

The calculation of the amount of N in manure applied is based on the N mass flow approach (see 3.B). It is the total of N excreted by animals in the housing and the N imported with bedding material minus N losses by emissions of N species from housing and storage. Hence, the amount of total N includes the N contained in anaerobically digested manures to be applied to the field.

The frequencies of application techniques and incorporation times as well as the underlying data sources are described in Vos et al. (2026), Chapter 2.5. The frequencies are provided in the National Inventory Report 2026 for the German Greenhouse Gas Inventory 1990-2024 (NID 2026)<sup>10)</sup>. Available in April 2026.)), Chapter 17.3.1<sup>11)</sup>.

Table 5: AD for the estimation of NH<sub>3</sub> and NO<sub>x</sub> emissions from application of manure

| Application of manure in [kt N] |       |       |       |      |       |       |       |       |       |      |      |      |      |      |
|---------------------------------|-------|-------|-------|------|-------|-------|-------|-------|-------|------|------|------|------|------|
| 1990                            | 1995  | 2000  | 2005  | 2010 | 2015  | 2016  | 2017  | 2018  | 2019  | 2020 | 2021 | 2022 | 2023 | 2024 |
| 1,236                           | 1,088 | 1,047 | 1,009 | 996  | 1,036 | 1,032 | 1,036 | 1,020 | 1,007 | 987  | 953  | 927  | 924  | 915  |

Methodology

NH<sub>3</sub> emissions from manure application are calculated separately for each animal species in the mass flow approach by multiplying the respective TAN amount with NH<sub>3</sub> emission factors for the various manure application techniques. For details see [3-b-manure-management 3.B] and Vos et al. (2026), Chapter 5.2.1.2. For NO<sub>x</sub> emissions from manure application the inventory calculates NO-N emissions (see Vos et al. (2026), Chapter 5.2.2.2<sup>12)</sup>, that are subsequently converted into NO<sub>x</sub> emissions by multiplying with the molar weight ratio 46/14. The Tier1 approach as described in EMEP/EEA (2023), Ch. 3.D, p. 13 is used<sup>13)</sup>.

Emission factors

The following table shows the time series of the overall German NH<sub>3</sub> IEF defined as the ratio of total NH<sub>3</sub>-N emission from manure application to the total amount of N spread with manure. For NO<sub>x</sub> the same emission factor like for the application of synthetic fertilizer was used (see Table 3).

Table 6: IEF for NH<sub>3</sub>-N from application of manure

| IEF in [kg NH <sub>3</sub> -N per kg N] in applied manure |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|-----------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1990                                                      | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
| 0.216                                                     | 0.204 | 0.196 | 0.183 | 0.175 | 0.165 | 0.163 | 0.162 | 0.159 | 0.157 | 0.154 | 0.154 | 0.157 | 0.155 | 0.154 |

Trend discussion for Key Sources

Both NH<sub>3</sub> and NO<sub>x</sub> emissions from the application of animal manure are key sources. Total NO<sub>x</sub> is calculated proportionally to the total N applied with manure which decreased remarkably from 1990 to 1991 due to the decline in animal numbers following the German reunification (reduction of livestock numbers in Eastern Germany). In the 1990s and 2000s this was followed by a weakened decline in animal manure amounts. From 2010 to 2014 there was a slight increase and since then the amount of N in manure applied has been declining again, see Table 5. The NO<sub>x</sub> emissions follow these trends. For total NH<sub>3</sub> emissions there is a negative trend. This is due to the decreasing amounts of animal manure and the increasing use of application practices with lower NH<sub>3</sub> emission factors.

Recalculations

Until 2000, the total emissions of NH<sub>3</sub> from application of manure are higher than those of last year’s submission and thereafter they are lower. For NO<sub>x</sub> the changes are similar, however the change from higher to lower values takes place 20 years later.

These differences are predominantly caused by different estimates of manure N, which is applied, compared to the last submission. Many of the recalculations have an effect on this, especially the **recalculations No. 2, No. 3, No. 4, No. 5, and No. 6**. The two most important ones are **No. 3** (the new methodology to calculate N and TAN excretions of dairy cows leads to higher N excretion at the beginning and lower N excretions at the end of the time series, the percentage shares of TAN are lower for all years. The latter is responsible for the earlier change in the trend of NH<sub>3</sub> emissions) and **No. 4** (higher milk yields generally increase excretions), see [main page of the agricultural sector](#), list of recalculation reasons. Further details on recalculations are described in Vos et al. (2026), Chapter 1.3<sup>14)</sup>.

Table 7: Comparison of NH<sub>3</sub> and NO<sub>x</sub> emissions [kt] with previous submission

|                 |                     | NH <sub>3</sub> and NO <sub>x</sub> emissions from application of manure, in kt |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
|-----------------|---------------------|---------------------------------------------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
|                 |                     | 1990                                                                            | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
| Ammonia         | current submission  | 324.37                                                                          | 268.83 | 249.29 | 224.08 | 211.68 | 207.35 | 204.72 | 203.36 | 197.44 | 192.54 | 184.02 | 178.16 | 176.66 | 174.47 | 171.37 |
|                 | previous submission | 320.57                                                                          | 265.78 | 249.01 | 225.69 | 217.80 | 215.60 | 211.87 | 208.09 | 202.39 | 197.93 | 192.18 | 188.44 | 185.70 | 185.00 |        |
|                 | absolute change     | 3.79                                                                            | 3.05   | 0.28   | -1.61  | -6.12  | -8.26  | -7.15  | -4.73  | -4.95  | -5.39  | -8.17  | -10.28 | -9.04  | -10.52 |        |
|                 | relative change [%] | 1.18                                                                            | 1.15   | 0.11   | -0.71  | -2.81  | -3.83  | -3.38  | -2.27  | -2.45  | -2.72  | -4.25  | -5.45  | -4.87  | -5.69  |        |
| Nitrogen oxides | current submission  | 48.75                                                                           | 42.89  | 41.29  | 39.77  | 39.27  | 40.85  | 40.69  | 40.83  | 40.20  | 39.72  | 38.91  | 37.56  | 36.55  | 36.44  | 36.08  |
|                 | previous submission | 45.94                                                                           | 40.69  | 39.69  | 38.54  | 38.63  | 40.23  | 39.98  | 39.81  | 39.26  | 38.98  | 38.66  | 37.68  | 36.65  | 36.65  |        |
|                 | absolute change     | 2.81                                                                            | 2.20   | 1.60   | 1.23   | 0.64   | 0.62   | 0.71   | 1.02   | 0.94   | 0.74   | 0.26   | -0.13  | -0.10  | -0.21  |        |
|                 | relative change [%] | 6.11                                                                            | 5.42   | 4.04   | 3.19   | 1.65   | 1.55   | 1.77   | 2.57   | 2.40   | 1.90   | 0.67   | -0.34  | -0.27  | -0.58  |        |

## Planned improvements

No improvements are planned at present.

## 3.D.a.2.b - Sewage sludge applied to soils

The calculation of NH<sub>3</sub> and NO<sub>x</sub> (NO) emissions from application of sewage sludge is described in Vos et al. (2026), Chapters 5.2.1.2 and 5.2.2.2<sup>15)</sup>.

## Activity data

N quantities from application of sewage sludge were calculated from data of the German Environment Agency and (since 2009) from data of the Federal Statistical Office.

Table 8: AD for the estimation of NH<sub>3</sub> and NO<sub>x</sub> emissions from application of sewage sludge

| Application of sewage sludge in kt N |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|--------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 1990                                 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
| 27                                   | 35   | 33   | 27   | 26   | 19   | 19   | 14   | 13   | 16   | 14   | 12   | 12   | 10   | 10   |

## Methodology

A Tier 1 methodology is used (EMEP/EEA, 2023, 3.D, Chapter 3.3.1). NH<sub>3</sub> and NO<sub>x</sub> emissions are calculated by multiplying the amounts of N in sewage sludge applied with the respective emission factors.

## Emission factors

EMEP/EEA (2023), Chapter 3.D, Table 3-1 provides a Tier1 emission factor for NH<sub>3</sub> (0.13 kg NH<sub>3</sub> per kg N applied) emissions from application of sewage sludge. The German inventory uses the equivalent emission factor in NH<sub>3</sub>-N units which is 0.11

kg NH<sub>3</sub>-N per kg N applied (cf. the derivation of the emission factor described in the appendix of EMEP/EEA (2023), Chapter 3.D, p. 35)<sup>16)</sup>. For NO<sub>x</sub> the same emission factor like for the application of synthetic fertilizer was used (see Table 3).

## Trend discussion for Key Sources

NH<sub>3</sub> and NO<sub>x</sub> emissions from the application of sewage sludge are no key sources.

## Recalculations

There were no recalculations concerning sewage sludge except the replacement of extrapolated activity data in 2023 with data from the Federal Statistical Office. Further details on recalculations are described in Vos et al. (2026), Chapter 1.3<sup>17)</sup>.

Table 9: Comparison of NH<sub>3</sub> and NO<sub>x</sub> emissions [kt] with previous submission

| NH <sub>3</sub> and NO <sub>x</sub> emissions from application of sewage sludge, in kt |                     | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023   | 2024 |
|----------------------------------------------------------------------------------------|---------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|--------|------|
| Ammonia                                                                                | current submission  | 3.66 | 4.71 | 4.40 | 3.66 | 3.51 | 2.52 | 2.51 | 1.87 | 1.78 | 2.14 | 1.85 | 1.61 | 1.61 | 1.39   | 1.39 |
|                                                                                        | previous submission | 3.66 | 4.71 | 4.40 | 3.66 | 3.51 | 2.52 | 2.51 | 1.87 | 1.78 | 2.14 | 1.85 | 1.61 | 1.61 | 1.61   |      |
|                                                                                        | absolute change     | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -0.22  |      |
|                                                                                        | relative change [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -13.84 |      |
| Nitrogen oxides                                                                        | current submission  | 1.08 | 1.39 | 1.30 | 1.08 | 1.04 | 0.74 | 0.74 | 0.55 | 0.52 | 0.63 | 0.55 | 0.47 | 0.48 | 0.41   | 0.41 |
|                                                                                        | previous submission | 1.08 | 1.39 | 1.30 | 1.08 | 1.04 | 0.74 | 0.74 | 0.55 | 0.52 | 0.63 | 0.55 | 0.47 | 0.48 | 0.48   |      |
|                                                                                        | absolute change     | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -0.07  |      |
|                                                                                        | relative change [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | -13.84 |      |

## Planned improvements

No improvements are planned at present.

## 3.D.a.2.c - Other organic fertilizers applied to soils

This sub category contains the total of Germany's NH<sub>3</sub> and NO<sub>x</sub> (NO) emissions from application of

- residues from digested energy crops,
- residues from digested waste,
- compost from biowaste,
- compost from green waste, and
- imported animal manures.

For details see Vos et al. (2026), Chapters 5.2.1.2 and 5.2.2.2.

## Activity data

Activity data is the amount of N in residues from anaerobic digestion of energy crops and waste and of compost from biowaste and green waste when leaving storage, as well as the amount of N in imported animal manures. For energy crops this is the N contained in the energy crops when being fed into the digestion process minus the N losses by emissions of N species from the storage of the residues (see 3.I). N losses from pre-storage are negligible and there are no N losses from fermenter (see Vos et al. (2026), Chapter 5.1)<sup>18)</sup>. For residues from digested waste, compost from biowaste and compost from green waste the amount of N was derived from the waste statistics of the Federal Statistical Office (see Vos et al. (2026), Chapter 2.8)<sup>19)</sup>. For imported manure the amounts of N were derived from statistics published by CBS (Statistics

Netherlands) and RVO (Rijksdienst voor Ondernemend Nederland) The imported manure is categorized into cattle slurry, pig slurry, poultry manure, horse manure and mixed solid manure. Only imported manures from The Netherlands are taken into account, as for other countries the amounts of imported manures are unknown as are the amounts of exported manure. For details see Vos et al. (2026), Chapter 2.8<sup>20)</sup>.

Table 10: AD for the estimation of NH<sub>3</sub> and NO<sub>x</sub> emissions emissions from application of other organic fertilizers

| Application of other organic fertilizers in [kt N] |              |              |              |               |               |               |               |               |               |               |               |               |               |               |               |
|----------------------------------------------------|--------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                                                    | 1990         | 1995         | 2000         | 2005          | 2010          | 2015          | 2016          | 2017          | 2018          | 2019          | 2020          | 2021          | 2022          | 2023          | 2024          |
| Residues, digested energy crops                    | 0.05         | 0.59         | 5.12         | 43.36         | 158.69        | 289.08        | 287.80        | 283.33        | 279.45        | 279.98        | 286.48        | 281.57        | 302.37        | 293.35        | 293.35        |
| Residues, digested waste                           | 0.00         | 0.00         | 1.55         | 4.97          | 10.46         | 15.05         | 13.97         | 13.79         | 14.00         | 13.75         | 13.40         | 15.13         | 15.62         | 17.49         | 18.20         |
| Compost, biowaste                                  | 4.51         | 19.54        | 31.87        | 28.82         | 22.64         | 22.59         | 23.34         | 21.90         | 25.14         | 24.31         | 25.42         | 22.98         | 23.10         | 19.90         | 18.53         |
| Compost, greenwaste                                | 1.13         | 4.90         | 7.67         | 9.46          | 11.27         | 13.67         | 14.29         | 14.87         | 14.92         | 15.89         | 16.74         | 15.95         | 15.93         | 14.62         | 13.85         |
| Imported manure                                    | 5.19         | 19.26        | 15.56        | 21.48         | 28.15         | 28.75         | 30.26         | 27.52         | 22.17         | 21.27         | 18.14         | 15.32         | 14.24         | 16.59         | 16.51         |
| <b>TOTAL</b>                                       | <b>10.87</b> | <b>44.30</b> | <b>61.77</b> | <b>108.09</b> | <b>231.21</b> | <b>369.15</b> | <b>369.65</b> | <b>361.40</b> | <b>355.67</b> | <b>355.21</b> | <b>360.19</b> | <b>350.95</b> | <b>371.26</b> | <b>361.95</b> | <b>360.44</b> |

## Methodology

The NH<sub>3</sub> emissions are calculated the same way as the NH<sub>3</sub> emissions from application of animal manure (3.D.a.2.a). The frequencies of application techniques and incorporation times as well as the underlying data sources are provided e. g. in the NID 2025, Chapter 17.3.1. It is assumed that residues of digested waste are applied in the same way and have the same emission factors as residues from digested energy crops. For compost from biowaste and green waste it is assumed that they are applied in the same way and have the same emission factors as cattle solid manure. The amounts of TAN in the residues from digested energy crops applied are obtained from the calculations of emissions from the storage of the digested energy crops (3.I). The amounts of TAN in the residues from digested waste, compost from biowaste and compost from green waste are derived from industry data (provided by Bundesgütegemeinschaft Kompost, BGK). For the imported manures it is assumed that the different imported manure types (see above) were applied in the same way as the corresponding domestic animal manure types. Mixed manure was treated like solid manure from goats, sheep and horses. Corresponding TAN contents were derived from publications of the German federal states. As published TAN contents vary strongly, for each imported manure type the maximum of published TAN contents was assumed to prevent an underestimation of the NH<sub>3</sub> emissions. For details see Vos et al. (2026), Chapter 2.8<sup>21)</sup>.

For NO<sub>x</sub> emissions the Tier 1 approach as described in EMEP/EEA (2023), Ch.3.D, p. 13 is used<sup>22)</sup>. The inventory calculates NO emissions that are subsequently converted into NO<sub>x</sub> emissions by multiplying with the molar weight ratio 46/30.

## Emission factors

For NH<sub>3</sub> the emission factors for untreated cattle slurry were adopted for residues from digested energy crops and residues from waste. The emission factors for cattle solid manure were adopted for compost from biowaste and compost from green waste, see Vos et al. (2026), Chapters 5.2.1.2 and 5.2.2.2. For imported manures the corresponding emission factors of the same type of domestic manure were used.

For NO<sub>x</sub> the same emission factor like for the application of synthetic fertilizer was used (see Table 3).

Table 11: IEF for NH<sub>3</sub>-N emissions from application of other organic fertilizers

| IEF in kg NH <sub>3</sub> -N per kg N of other organic fertilizers |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|--------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                                                    | 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
| Residues, digested energy crops                                    | 0.182 | 0.185 | 0.184 | 0.184 | 0.186 | 0.154 | 0.152 | 0.149 | 0.145 | 0.142 | 0.139 | 0.140 | 0.140 | 0.140 | 0.140 |
| Residues, digested waste                                           | 0.000 | 0.000 | 0.192 | 0.193 | 0.193 | 0.171 | 0.164 | 0.156 | 0.163 | 0.162 | 0.163 | 0.162 | 0.160 | 0.157 | 0.159 |

|                            |              |              |              |              |              |              |              |              |              |              |              |              |              |              |              |
|----------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| <b>Compost, biowaste</b>   | 0.042        | 0.037        | 0.038        | 0.036        | 0.034        | 0.032        | 0.032        | 0.032        | 0.029        | 0.033        | 0.034        | 0.036        | 0.037        | 0.033        | 0.031        |
| <b>Compost, greenwaste</b> | 0.016        | 0.014        | 0.014        | 0.014        | 0.013        | 0.015        | 0.015        | 0.020        | 0.013        | 0.012        | 0.012        | 0.012        | 0.013        | 0.012        | 0.011        |
| <b>Imported manure</b>     | 0.209        | 0.206        | 0.202        | 0.186        | 0.173        | 0.150        | 0.145        | 0.145        | 0.151        | 0.149        | 0.145        | 0.144        | 0.145        | 0.151        | 0.149        |
| <b>TOTAL</b>               | <b>0.120</b> | <b>0.110</b> | <b>0.092</b> | <b>0.131</b> | <b>0.161</b> | <b>0.142</b> | <b>0.139</b> | <b>0.137</b> | <b>0.132</b> | <b>0.130</b> | <b>0.127</b> | <b>0.128</b> | <b>0.130</b> | <b>0.130</b> | <b>0.131</b> |

## Trend discussion for Key Sources

The application of other organic fertilizers is a key source for NH<sub>3</sub>. Emissions are dominated by the emissions from digested energy crops. They have become important since about 2005 and have risen sharply until 2013. Since then, they have changed little each year and tend to decrease slightly in the last few years. The latter is mostly due to the increasing use of application practices with lower NH<sub>3</sub> emission factors.

## Recalculations

Recalculations after 2009 are mainly due to the update of activity data. Concerning NH<sub>3</sub> emissions, small differences occur in all years. This is because the underlying spatial distribution of imported manure is different, which results in different IEFs compared to last year's submission (see [main page of the agricultural sector](#), list of recalculation **reasons No. 19 and No. 1** (for the year 2023 also **reason No. 18 and No. 20**), and Vos et al. (2026), Chapter 1.3)<sup>23)</sup>.

Table 12: Comparison of NH<sub>3</sub> and NO<sub>x</sub> emissions from application of other organic fertilizers [kt] with previous submission

| NH <sub>3</sub> and NO <sub>x</sub> emissions from application of other organic fertilizers, in kt |                            |       |      |      |       |       |       |       |       |       |       |       |       |       |       |       |
|----------------------------------------------------------------------------------------------------|----------------------------|-------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                                                                                                    |                            | 1990  | 1995 | 2000 | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
| <b>Ammonia</b>                                                                                     | <b>current submission</b>  | 1.58  | 5.90 | 6.92 | 17.15 | 45.25 | 63.68 | 62.30 | 60.02 | 57.00 | 56.01 | 55.66 | 54.60 | 58.38 | 57.13 | 57.18 |
|                                                                                                    | <b>previous submission</b> | 1.58  | 5.87 | 6.89 | 17.02 | 44.70 | 63.07 | 61.72 | 59.21 | 56.73 | 55.57 | 55.40 | 54.25 | 58.24 | 58.35 |       |
|                                                                                                    | <b>absolute change</b>     | 0.00  | 0.03 | 0.02 | 0.13  | 0.54  | 0.61  | 0.57  | 0.81  | 0.27  | 0.44  | 0.27  | 0.35  | 0.15  | -1.23 |       |
|                                                                                                    | <b>relative change [%]</b> | -0.02 | 0.56 | 0.36 | 0.74  | 1.22  | 0.97  | 0.93  | 1.36  | 0.48  | 0.79  | 0.48  | 0.64  | 0.25  | -2.10 |       |
| <b>Nitrogen oxides</b>                                                                             | <b>current submission</b>  | 0.43  | 1.75 | 2.44 | 4.26  | 9.12  | 14.55 | 14.57 | 14.25 | 14.02 | 14.01 | 14.20 | 13.84 | 14.64 | 14.27 | 14.21 |
|                                                                                                    | <b>previous submission</b> | 0.43  | 1.75 | 2.44 | 4.26  | 9.09  | 14.51 | 14.57 | 14.23 | 14.02 | 13.99 | 14.19 | 13.82 | 14.67 | 14.61 |       |
|                                                                                                    | <b>absolute change</b>     | 0.00  | 0.00 | 0.00 | 0.00  | 0.03  | 0.05  | 0.00  | 0.02  | 0.00  | 0.02  | 0.02  | 0.01  | -0.03 | -0.34 |       |
|                                                                                                    | <b>relative change [%]</b> | 0.00  | 0.00 | 0.00 | 0.00  | 0.32  | 0.33  | 0.00  | 0.16  | 0.00  | 0.13  | 0.11  | 0.10  | -0.20 | -2.31 |       |

## Planned improvements

No improvements are planned at present.

## 3.D.a.3 - Urine and dung deposited by grazing animals

The calculation of NH<sub>3</sub> and NO<sub>x</sub> (NO) emissions from N excretions on pasture is described in Vos et al. (2026), Chapters 5.2.1.1 and 5.2.2.1<sup>24)</sup>.

## Activity data

Activity data for NH<sub>3</sub> emissions during grazing is the amount of TAN excreted on pasture, while for NO<sub>x</sub> emissions it is the amount of N excreted.

The TAN excretions are derived by multiplying the share of N excretion on pastures with the N excretions and TAN contents provided in 3.B, Table 2.

Table 13: Shares of N excretions on pasture, in [%]

|                     | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>Dairy cows</b>   | 19.8 | 15.0 | 12.4 | 11.2 | 9.9  | 8.5  | 8.2  | 7.9  | 7.6  | 7.3  | 7.4  | 7.4  | 7.4  | 7.3  | 7.3  |
| <b>Other cattle</b> | 15.1 | 17.3 | 18.9 | 19.0 | 19.6 | 20.5 | 20.7 | 20.9 | 21.2 | 21.4 | 21.5 | 21.4 | 21.4 | 21.7 | 21.9 |
| <b>Sheep</b>        | 55.1 | 55.5 | 55.1 | 55.4 | 54.8 | 55.4 | 55.4 | 55.4 | 55.6 | 55.5 | 55.4 | 55.5 | 55.8 | 55.6 | 55.4 |
| <b>Goats</b>        | 34.2 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>Horses</b>       | 20.5 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>Laying hens</b>  | 0.1  | 0.1  | 0.5  | 1.0  | 1.7  | 2.3  | 2.4  | 2.3  | 2.5  | 2.6  | 2.8  | 2.7  | 2.9  | 3.0  | 3.1  |
| <b>Deer</b>         | 100  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| <b>Ostriches</b>    | 80   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

## Methodology

NH<sub>3</sub> emissions from grazing are calculated by multiplying the respective animal population (3.B, Table 1) with corresponding N excretions and relative TAN contents (3.B, Table 2) and the fraction of N excreted on pasture (Table 13). The result is multiplied with the animal specific emission factor (Table 14). NO emissions are calculated the same way with the exception that the emission factor is related to N excreted instead of TAN.

## Emission Factors

The emission factors for NH<sub>3</sub> are taken from EMEP/EEA (2023)-3B-29, Table 3.9. They relate to the amount of TAN excreted on pasture. For laying hens, deer and ostriches there are no emission factors given in this table. Germany uses for laying hens an emission factor of 0.35 kg NH<sub>3</sub>-N per kg TAN excreted, based on an expert judgement from KTBL (see Vos et al. 2026, Chapter 5.2.1.1)<sup>25)</sup>. The same EF is used by UK. It was also used for ostriches. For deer the emission factor of sheep was adopted.

Following the intention of EMEP/EEA (2023), Chapter 3.D, Table 3.1, the inventory uses for NO<sub>x</sub> the same emission factor as for the application of synthetic fertilizer (see Table 3)<sup>26)</sup>. In order to obtain NO<sub>x</sub> emissions (as NO<sub>2</sub>) the NO-N emission factor of 0.12 kg NO-N per kg N excreted is multiplied by 46/14.

Table 14: Emission factors for emissions of NH<sub>3</sub> and NO from grazing

|                     |                                                |
|---------------------|------------------------------------------------|
| <b>Dairy cows</b>   | 0.14 kg NH <sub>3</sub> -N per kg TAN excreted |
| <b>Other cattle</b> | 0.14 kg NH <sub>3</sub> -N per kg TAN excreted |
| <b>Horses</b>       | 0.35 kg NH <sub>3</sub> -N per kg TAN excreted |
| <b>Sheep, goats</b> | 0.09 kg NH <sub>3</sub> -N per kg TAN excreted |
| <b>Laying hens</b>  | 0.35 kg NH <sub>3</sub> -N per kg TAN excreted |
| <b>Deer</b>         | 0.09 kg NH <sub>3</sub> -N per kg TAN excreted |
| <b>Ostriches</b>    | 0.35 kg NH <sub>3</sub> -N per kg TAN excreted |
| <b>All animals</b>  | 0.012 kg NO-N per kg N excreted                |

## Trend discussion for Key Sources

Emissions from urine and dung deposited by grazing animals are no key sources.

## Recalculations

Until 2012, NH<sub>3</sub> grazing emissions are lower than those of last year's submission and thereafter they are higher. For NO<sub>x</sub> emissions from grazing in all years are higher than those of last year's submission. **Recalculations No. 3** (new methodology to calculate N and TAN excretions of dairy cows) and **No. 4** (higher milk yields) lead in combination to higher N excretion of dairy cows, especially at the beginning of the time series, but to lower TAN excretions for all years. Since NH<sub>3</sub> emissions are related to TAN excretion and NO<sub>x</sub> emissions are related to N excretion, this leads to lower NH<sub>3</sub> and higher NO emissions. **Recalculation No. 6** (higher N (and TAN) excretion for heavy horses as of 2011) is the reason why, after 2012,



NH<sub>3</sub> emissions are higher compared with last year's submission. Further details on recalculations are described in Vos et al. (2026), Chapter 1.3<sup>27)</sup>.

Table 15: Comparison of NH<sub>3</sub> and NO<sub>x</sub> emissions [kt] with previous submission

|                 |                     | NH <sub>3</sub> and NO <sub>x</sub> emissions from grazing, in kt |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|-----------------|---------------------|-------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                 |                     | 1990                                                              | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
| Ammonia         | current submission  | 24.50                                                             | 20.91 | 18.53 | 16.75 | 15.95 | 15.98 | 15.85 | 15.83 | 15.67 | 15.55 | 15.33 | 15.12 | 15.20 | 15.35 | 15.20 |
|                 | previous submission | 24.58                                                             | 21.15 | 18.79 | 17.00 | 16.26 | 15.94 | 15.73 | 15.56 | 15.33 | 15.19 | 15.00 | 14.85 | 14.93 | 15.09 |       |
|                 | absolute change     | -0.08                                                             | -0.24 | -0.26 | -0.25 | -0.31 | 0.04  | 0.11  | 0.27  | 0.34  | 0.36  | 0.33  | 0.26  | 0.27  | 0.25  |       |
|                 | relative change [%] | -0.32                                                             | -1.15 | -1.38 | -1.47 | -1.90 | 0.22  | 0.71  | 1.76  | 2.22  | 2.36  | 2.22  | 1.78  | 1.84  | 1.68  |       |
| Nitrogen oxides | current submission  | 9.44                                                              | 7.67  | 6.83  | 6.12  | 5.78  | 5.63  | 5.56  | 5.53  | 5.43  | 5.35  | 5.25  | 5.15  | 5.15  | 5.19  | 5.12  |
|                 | previous submission | 8.84                                                              | 7.38  | 6.66  | 6.00  | 5.72  | 5.55  | 5.47  | 5.40  | 5.30  | 5.24  | 5.17  | 5.11  | 5.11  | 5.17  |       |
|                 | absolute change     | 0.59                                                              | 0.29  | 0.17  | 0.13  | 0.06  | 0.07  | 0.08  | 0.13  | 0.13  | 0.11  | 0.08  | 0.04  | 0.04  | 0.03  |       |
|                 | relative change [%] | 6.73                                                              | 3.93  | 2.58  | 2.09  | 1.00  | 1.31  | 1.55  | 2.35  | 2.38  | 2.05  | 1.46  | 0.80  | 0.70  | 0.52  |       |

## Planned improvements

No improvements are planned at present.

## 3.D.a.4 - Crop residues applied to soil

The calculation of NH<sub>3</sub> from crop residues is described in Vos et al. (2026), Chapter 5.2.1.3. According to EMEP/EEA (2023) NH<sub>3</sub> emissions are only occurring in a significant amount from crop residues on the soil surface, which are present more than three days and have an N content of more than 0.0132 kg N per kg dry matter<sup>28)</sup>. This means that there are no NH<sub>3</sub> emissions from most crop residues of the most commonly used crops in Germany. The major source of the emissions are residues of grassland cuts.

## Activity data

The NH<sub>3</sub> emissions are calculated proportionally to the amounts of N stored in the above-ground biomass, according to EMEP/EEA (2023)<sup>29)</sup>. This requires the knowledge of the areas of cultivation, of crop yields and of the N contents of the above ground crop residues.

Table 16: AD for the estimation of NH<sub>3</sub> emissions from crop residues

| N in aboveground crop residues in kt N |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|----------------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 1990                                   | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
| 370                                    | 377  | 418  | 429  | 411  | 417  | 416  | 443  | 348  | 391  | 403  | 425  | 413  | 424  | 424  |

## Methodology

According to EMEP (2023) the NH<sub>3</sub> emissions from crop residues can be neglected when the crop residues are on the field for less than three days. Thus the first step in the emission calculation is determining which share of the crop residues of each crop are incorporated into the soil or removed in the first three days after harvesting the crop. The remaining amounts are multiplied with their respective N contents and the resulting amounts of N are then multiplied with the NH<sub>3</sub>-emission factor.



## Emission factors

According to the methodology given in EMEP/EEA (2023) the emission factor for the NH<sub>3</sub> emissions from crop residues applied to the soil is zero if the N content of the above ground crop residues is below or equal to the threshold of 0.0132 kg N per kg dry matter. In all other cases the NH<sub>3</sub> emission factor is determined using the following linear regression, see EMEP/EEA (2023)<sup>30)</sup>:

$$EF(NH_{3_x}) = \frac{(410 \times N_{above dm_x} - 5.42)}{100}$$

Where x is the according crop and N<sub>above dm</sub> is the N content of the above ground dry matter. The implied emission factors provided in the following table are defined as ratio of the total NH<sub>3</sub>-N emissions from crop residues to the total N in aboveground crop residues.

Table 17: IEF for NH<sub>3</sub>-N emissions from crop residues

| IEF in kg NH <sub>3</sub> -N per kg N in aboveground crop residues |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|--------------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1990                                                               | 1995  | 2000  | 2005  | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
| 0.019                                                              | 0.016 | 0.014 | 0.014 | 0.013 | 0.013 | 0.014 | 0.013 | 0.013 | 0.013 | 0.013 | 0.014 | 0.013 | 0.013 | 0.014 |

## Trend discussion for Key Sources

NH<sub>3</sub> emissions from crop residues are no key source.

## Recalculations

For all years, NH<sub>3</sub> emissions from crop residues are slightly higher than those of last year's submission. The main reason for this is **recalculation No. 15** (update of number of grassland cuts). Further details on recalculations are described in Vos et al. (2026), Chapter 1.3<sup>31)</sup>.

Table 18: Comparison of NH<sub>3</sub> emissions [kt] with previous submission

| NH <sub>3</sub> emissions from crop residues, in kt |                     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|-----------------------------------------------------|---------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|                                                     |                     | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
| Ammonia                                             | current submission  | 8.73 | 7.34 | 7.17 | 7.08 | 6.58 | 6.45 | 6.98 | 7.13 | 5.50 | 6.32 | 6.59 | 7.38 | 6.67 | 6.94 | 7.06 |
|                                                     | previous submission | 8.70 | 7.32 | 7.14 | 7.06 | 6.55 | 6.43 | 6.95 | 7.11 | 5.47 | 6.27 | 6.51 | 7.35 | 6.62 | 6.89 |      |
|                                                     | absolute change     | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 | 0.08 | 0.03 | 0.05 | 0.05 |      |
|                                                     | relative change [%] | 0.34 | 0.35 | 0.35 | 0.36 | 0.40 | 0.39 | 0.39 | 0.39 | 0.68 | 0.75 | 1.18 | 0.47 | 0.76 | 0.75 |      |

## Planned improvements

No improvements are planned at present.

## 3.D.c - Farm-level agricultural operations including storage, handling and transport of agricultural products

In this category Germany reports TSP, PM<sub>10</sub> and PM<sub>2.5</sub> emissions from crop production according to EMEP (2023)-3D-22. For details see Vos et al. (2026), Chapter 5.2.4<sup>32)</sup>.

## Activity data

The activity data is the total area of agricultural land (arable land, grassland and horticultural land) including areas with cover crops. This data is provided by official statistics.

Table 19: Agricultural land (including areas with cover crops), in [1000\*ha]

| 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 17,542 | 16,285 | 16,457 | 16,555 | 17,010 | 17,447 | 17,484 | 17,532 | 17,509 | 17,559 | 17,498 | 17,431 | 17,386 | 17,367 | 17,142 |

## Methodology

The Tier 2 methodology used is described in EMEP (2023)-3D-22.

## Emission factors

Emission factors given in EMEP/EEA (2023), Chapter 3.D, p. 18, Tables 3.6 and 3.8 are used<sup>33)</sup> with the exception of „Harvesting“ PM<sub>10</sub>-factors for Wheat, Rye, Barley and Oat which were taken from the Danish IIR. These Guidebook-EFs are obviously too high by a factor of 10 and were corrected in the Danish IIR.

The missing default-EFs for „other arable“ in the 2023 EMEP/EEA Guidebook were replaced with the average of the EFs of wheat, rye, barley and oat, as it was done in the Danish IIR. The PM<sub>10</sub> EFs were also used as TSP EFs. The Guidebook does not indicate whether EFs have considered the condensable component (with or without). For details on country specific numbers of agricultural crop operations see Vos et al. (2026), Chapter 5.2.4<sup>34)</sup>.

Table 20: Implied emission factors for PM emissions from agricultural soils, in [kg ha<sup>-1</sup>]

|                         | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| <b>TSP</b>              | 1.42 | 1.41 | 1.42 | 1.41 | 1.39 | 1.38 | 1.37 | 1.37 | 1.37 | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 | 1.35 |
| <b>PM<sub>10</sub></b>  | 1.42 | 1.41 | 1.42 | 1.41 | 1.39 | 1.38 | 1.37 | 1.37 | 1.37 | 1.36 | 1.36 | 1.36 | 1.36 | 1.36 | 1.35 |
| <b>PM<sub>2.5</sub></b> | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.11 | 0.10 |

### Trend discussion for Key Sources

TSP and PM<sub>10</sub> are key sources. Emissions depend on the areas covered, crop types and number of crop operations. With the exception of the numbers of soil cultivations, which is slightly decreasing, these data are relatively constant. Overall this is reflected in a slight decline of emissions in the last years.

## Recalculations

There were no recalculations. Further details on recalculations are described in Vos et al. (2026), Chapter 1.3<sup>35)</sup>.

Table 21: Comparison of particle emissions (TSP, PM<sub>10</sub> & PM<sub>2.5</sub>) [kt] with previous submission

[illegible]

|                   |                     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|-------------------|---------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| PM <sub>2.5</sub> | current submission  | 1.90 | 1.78 | 1.85 | 1.85 | 1.87 | 1.88 | 1.87 | 1.87 | 1.85 | 1.84 | 1.81 | 1.81 | 1.82 | 1.82 | 1.77 |
|                   | previous submission | 1.90 | 1.78 | 1.85 | 1.85 | 1.87 | 1.88 | 1.87 | 1.87 | 1.85 | 1.84 | 1.81 | 1.81 | 1.82 | 1.82 |      |
|                   | absolute change     | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |      |
|                   | relative change [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |      |

Planned improvements

No improvements are planned at present.

3.D.e - Cultivated crops

In this category Germany reports NMVOC emissions from crop production according to EMEP/EEA (2023), Ch. 3.D, p. 21<sup>36)</sup>. For details see Vos et al. (2026), Chapter 5.2.3<sup>37)</sup>.

Activity data

The *total area of arable land and grassland* applied as activity data is provided by official statistics.

Table 22: Arable land and grassland, in [1000 ha]

| 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 16,506 | 15,312 | 15,498 | 15,561 | 15,734 | 15,719 | 15,662 | 15,647 | 15,570 | 15,563 | 15,447 | 15,376 | 15,336 | 15,322 | 15,093 |

Methodology

The Tier 2 methodology described in EMEP/EEA (2023), Chapter 3.D, pp. 21ff is used<sup>38)</sup>.

Emission Factors

The emission factors for wheat, rye, rape and grass (15°C) given in EMEP/EEA (2023), Ch. 3.D, p. 21, Table 3.4 were used<sup>39)</sup>. For all grassland areas the grass (15°C) EF is used, for all other crops except rye and rape the EF of wheat is used.

The implied emission factors provided in the following table are defined as ratio of the total NMVOC emissions from cultivated crops to the total area given by activity data.

Table 23: IEF for NMVOC emissions from crop production, in [kg ha-1]

| 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 0.47 | 0.53 | 0.57 | 0.59 | 0.61 | 0.63 | 0.62 | 0.62 | 0.50 | 0.55 | 0.59 | 0.61 | 0.58 | 0.60 | 0.59 |

Trend discussion for Key Sources

NMVOC emissions from crop production are no key source.

Recalculations

There were no recalculations. Further details on recalculations are described in Vos et al. (2026), Chapter 1.3<sup>40)</sup>.

Table 24: Comparison of NMVOC emissions [kt] with previous submission

|  |  |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|--|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|  |  | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|--|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|

|       |                     | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|-------|---------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| NMVOC | current submission  | 7.69 | 8.19 | 8.79 | 9.17 | 9.53 | 9.91 | 9.69 | 9.74 | 7.82 | 8.56 | 9.16 | 9.44 | 8.91 | 9.23 | 8.87 |
|       | previous submission | 7.69 | 8.19 | 8.79 | 9.17 | 9.53 | 9.91 | 9.69 | 9.74 | 7.82 | 8.56 | 9.16 | 9.44 | 8.91 | 9.23 |      |
|       | absolute change     | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |      |
|       | relative change [%] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |      |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the pollutant specific recalculation tables following [chapter 9.1 - Recalculations](#).

Planned improvements



At the moment, no category-specific improvements are planned.

Uncertainty

Details are described in [chapter 1.7](#).

<sup>1)</sup> 2), 6), 9), 11), 12), 14), 15), 17), 18), 19), 20), 21), 23), 24), 25), 27), 31), 32), 34), 35), 37), 40) Vos, C., Rösemann, C., Haenel, H.-D., Dämmgen, U., Döring, U., Wulf, S., Eurich-Menden, Döhler, H., Steuer, B., Osterburg, B., Fuß, R. (2026): Calculations of gaseous and particulate emissions from German agriculture 1990 – 2024: Report on methods and data (RMD) Submission 2026. [www.eminv-agriculture.de](http://www.eminv-agriculture.de), 2026

<sup>3)</sup> 4), 13), 16), 22), 26), 28), 29), 30), 33), 36), 38), 39) EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, EEA Report No 06/2023, <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023>.; Copenhagen, 2023

<sup>5)</sup> Bittman, S., Dedina, M., Howard C.M., Oenema, O., Sutton, M.A. (2014): Options for Ammonia Mitigation. Guidance from the UNECE task Force on Reactive Nitrogen. Centre for Ecology and Hydrology, Edinburgh, UK, 2014

<sup>7), 8)</sup> Stehfest E., Bouwman L. (2006): N2O and NO emission from agricultural fields and soils under natural vegetation: summarizing available measurement data and modelling of global emissions. Nutr. Cycl. Agroecosyst. 74, 207 – 228., <https://doi.org/10.1007/s10705-006-9000-7>; 2006

<sup>10)</sup> UBA (2026): National Inventory Report (NID) 2026 for the German Greenhouse Gas Inventory 1990-2024. Dessau-Roßlau, April 2026.

## 3.D.f - Agriculture: Other (including use of pesticides)

### Country Specifics

So far, the only activity and emissions reported in 3.D.f - Agriculture: Other are the application of pesticides and the resulting emission of HCB.

### Background



Hexachlorobenzene (HCB) is one of the listed persistent organic pollutants covered by the Aarhus Protocol on Persistent Organic Pollutants from 2009, Annex III<sup>9)</sup>, the Stockholm Convention<sup>10)</sup> and Directive 2016/2284 (NECD), Annex I from 2016<sup>11)</sup>. These conventions and directives oblige parties to reduce their emissions of dioxins, furans, polycyclic aromatic hydrocarbons (PAHs) and hexachlorobenzene (HCB) below their levels in 1990.

In Germany, the application of HCB as a pesticide, in a pure form, was prohibited in 1977 and thus no HCB emissions were reported until the 2016 reporting.

However, HCB can occur as an impurity in active substances such as:

- Lindane ( $C_6H_6Cl_6$ ): Gamma-Hexachlorocyclohexane (a.k.a.  $\gamma$ -HCH)
- DCPA ( $C_{10}H_6Cl_4O_4$ ): Dimethyl-Tetrachloroterephthalate (a.k.a. Dacthal)
- PCP ( $C_6HCl_5O$ ): Pentachlorophenol (a.k.a. Santophen, Pentachlorol, Chlorophen, Chlon, Dowicide 7, Pentacon, Penwar, Sinituho, Penta)
- Atrazine ( $C_8H_{14}ClN_5$ ): 2-Chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine
- Simazine ( $C_7H_{12}ClN_5$ ): 2,4-Bis(ethylamino)-6-chloro-1,3,5-triazine
- Propazine ( $C_9H_{16}ClN_5$ ): 2,4-Bis(isopropylamino)-6-chloro-1,3,5-triazine
- PCNB ( $C_6Cl_5NO_2$ ): 1,2,3,4,5-Pentachloro-6-nitrobenzene (a.k.a. Pentachloronitrobenzol or Quintozine)
- **Chlorothalonil** ( $C_6Cl_4N_2$ ): 2,4,5,6-Tetrachlorobenzene-1,3-dicarbonitrile (short: TCPN)
- **Tefluthrin** ( $C_{17}H_{14}ClF_7O_2$ ): rac-(2,3,5,6-Tetrafluoro-4-methylphenyl)methyl (1R,3R)-2,2-dimethyl-3-[(1Z)-2-chloro-3,3,3-trifluoroprop-1-en-1-yl]cyclopropane-1-carboxylate
- **Picloram** ( $C_6H_3Cl_3N_2O_2$ ): 4-Amino-3,5,6-trichloropyridine-2-carboxylic acid (a.k.a. Tordon, Grazon)

Only Tefluthrin and Picloram are continued to be used in approved pesticides in Germany (cf. Table 1) with Tefluthrin not being emission relevant as it is applied on seed in closed storage buildings (communication by Syngenta Agro, 2015<sup>12)</sup>). In 2022, analyses were carried out for HCB contamination in the crop protection product Force 20 CS. HCB contamination could not be detected. Thus, it is not considered in the amount of reported HCB emissions.

Tabel 1: Chlorothalonil: Trade names, approval numbers and intended applications; last update September 2022

| Plant protection product | Approval number | Application for                                                                                      | no longer approved in Germany |
|--------------------------|-----------------|------------------------------------------------------------------------------------------------------|-------------------------------|
| BRAVO 500                | 043138-00       | Wheat                                                                                                | •                             |
| Sambarin                 | 033705-00       | Wheat                                                                                                | •                             |
| Pugil 75 WG              | 004486-00       | Wheat                                                                                                | •                             |
| AMISTAR Opti             | 005748-00       | Wheat, barley und rye                                                                                | •                             |
| Tattoo C                 | 005805-00       | Potatoes                                                                                             | •                             |
| CREDO                    | 006542-00       | Wheat, barley                                                                                        | •                             |
| Simbo Extra              | 004124-00       | Wheat, barley                                                                                        | •                             |
| ZAKEO Opti               | 005748-61       | Wheat, barley und rye                                                                                | •                             |
| Daconil 2787 Extra       | 023138-00       | Golf course greens, tees, and fairways, ornamental turfgrass and ornamental herbs, shrubs and trees. | •                             |

Table 2: Picloram: Trade names, approval numbers and intended applications; last update September 2022

| Plant protection product | Approval number | Application for                         |
|--------------------------|-----------------|-----------------------------------------|
| Barca 334 SL             | 008772-00       | Rapeseed (summer/winter)                |
| Belkar                   | 008778-00       | Rapeseed (winter)                       |
| Chaco                    | 00A402-00       | Rapeseed (winter)                       |
| EFFIGO                   | 005866-00       | Rapeseed (winter), maize, round cabbage |
| Gajus                    | 008943-00       | Rapeseed (winter)                       |
| Gala 334 SL              | 008772-60       | Rapeseed                                |
| GF-2545                  | 008089-00       | Rapeseed (winter)                       |
| Runway                   | 006872-00       | Rapeseed (winter)                       |

Sources: <https://psm-zulassung.bvl.bund.de/psm/jsp/>, <https://www.proplanta.de/Pflanzenschutzmittel/Liste/>

HCB has never been contained in co-formulants of approved pesticides (communication of the Federal Office of Consumer Protection and Food Safety (BVL, 2015)<sup>13)</sup>.

In the past, some applicants listed maximum HCB concentrations in technical active substances in certain lindane-containing substances. The concentrations given amounted to  $\leq 0.1$  g/kg, a level oriented to the detection limits of the analysis method used at the time. Substances conforming to that maximum concentration were approved only through 1989 or 1990 (in one case, through 1995).

Obligations to report substance quantities sold did not take effect until 1998. For the other relevant active substances, the BVL has no information on HCB as an impurity. However, publications in recent years have included data from 1977 onward (BVL 2022)<sup>14)</sup>. Therefore, data on the active ingredients atrazine, simazine, propazine, and quintozone are also available and were included in the 2023 reporting.

## Methodology

The emissions were calculated in keeping with the method proposed in the EMEP (2019)<sup>15)</sup> (3Df/3I-5, chapter 3, Tier 1 approach).

$$EM_{pest} = \sum m_{pest_i} \times EF_{pest_i}$$

To estimate the emission of HCB which is present as an impurity, an impurity factor (IF) has to be considered in the calculation:

$$EM_{pest} = \sum m_{pest_i} \times IF_{(j,i)} \times EF_{pest_i}$$

where:

- $EM_{pest}$  = total HCB emission of active substance (in [mg/a], reported in [kg/a] here),
- $m_{pest}$  = mass of individual active substance applied (in [kg/a]),
- $IF_{j,i}$  = impurity factor of the  $j^{th}$  active substance in the  $i^{th}$  active substance (in [mg/kg])
- $EF_{pest}$  = EF for individual active substance (volatile fraction of applied amount of the active substance).

A modeled emission factor is used for Germany (see description of Emission factors). According to the definition of the Tier 2 Approach <sup>16)</sup> (EMEP Guidebook 2019) the method can be described as Tier 2.

## Activity data

As activity data, domestic sales of pesticides with the active substances chlorothalonil, picloram, lindane as well as atrazine, simazine, propazine and quintozone compiled by the BVL were used (reports pursuant to § 64 of the Plant Protection Act (PflSchG, 2012) <sup>17)</sup>; (cf. Table II, domestic sales). Since 2018, domestic sales of all active substances have been published <sup>18)</sup> or <https://gis.bvl.bund.de/>.

Table 3: Domestic sales of active substances, as of 1987, in t/a

|             | <b>Chlorthalonil</b> | <b>Picloram</b> | <b>Lindane</b> | <b>Atrazine</b> | <b>Simazine</b> | <b>Propazine</b> | <b>Quintozone</b> |
|-------------|----------------------|-----------------|----------------|-----------------|-----------------|------------------|-------------------|
| <b>1987</b> | 260.2                | 0.4             | 129.1          | 2,106.2         | 176.8           |                  | 0.3               |
| <b>1988</b> | 313.9                | 0.5             | 151.8          | 2,074.6         | 210.5           |                  |                   |
| <b>1989</b> | 234.9                | 0.6             | 90.6           | 1,093.0         | 195.3           |                  |                   |
| <b>1990</b> | 317.3                |                 | 120.4          | 751.9           | 185.7           |                  |                   |
| <b>1995</b> | 55.6                 |                 | 26.2           |                 |                 |                  |                   |
| <b>1996</b> | 82.5                 |                 | 36.9           |                 |                 |                  |                   |
| <b>1997</b> | 76.0                 |                 | 29.0           |                 | 0.8             |                  |                   |
| <b>1998</b> | 16.7                 |                 |                |                 | 0.2             |                  |                   |
| <b>1999</b> | 149.9                |                 |                |                 |                 |                  |                   |
| <b>2000</b> | 109.3                |                 |                |                 |                 |                  |                   |
| <b>2005</b> | 857.2                |                 |                |                 |                 |                  |                   |
| <b>2010</b> | 620.7                | 1.9             |                |                 |                 |                  |                   |
| <b>2015</b> | 886.0                | 3.5             |                |                 |                 |                  |                   |
| <b>2016</b> | 1,148.1              | 4.3             |                |                 |                 |                  |                   |
| <b>2017</b> | 1,418.8              | 4.1             |                |                 |                 |                  |                   |
| <b>2018</b> | 860.8                | 3.9             |                |                 |                 |                  |                   |
| <b>2019</b> | 911.8                | 7.5             |                |                 |                 |                  |                   |
| <b>2020</b> | 105.2                | 9.4             |                |                 |                 |                  |                   |
| <b>2021</b> |                      | 11.3            |                |                 |                 |                  |                   |
| <b>2022</b> |                      | 13.0            |                |                 |                 |                  |                   |
| <b>2023</b> |                      | 6.1             |                |                 |                 |                  |                   |
| <b>2024</b> |                      | 10.6            |                |                 |                 |                  |                   |

## HCB Impurities

The HCB quantities are calculated in light of the maximum permitted concentrations of HCB impurities established by legal acts of the EU <sup>19)</sup> defines, for certain active substances and in connection with their approval, maximum levels of impurities that are of toxicological or ecotoxicological concern or that are of special concern due to the environmental risks they pose. Since the implementing regulation is a directly applicable law, the maximum levels are binding throughout Europe. In addition, in special cases the BVL may define maximum levels for impurities that the regulation does not cover. Conformance with such maximum levels is then included as a necessary condition for approval of relevant pesticides. The approach is a highly conservative one that probably overestimates the actual emissions.

## Chlorothalonil

Before 2006 there was no legal regulation in Germany on the maximum content of HCB in the active substance chlorothalonil. However, with the implementation of Directive 91/414/EEC <sup>20)</sup>, manufacturers had to analyse their technical active substance for possible relevant impurities and, where appropriate, indicate a maximum level. These maximum levels had to be maintained. Information about the levels specified for chlorothalonil for the years 1990 and 1999 for Germany are not known. As described in the FAO specification (2015, p. 49, <sup>21)</sup> Chlorothalonil was reviewed by IPCS (INTERNATIONAL PROGRAMME ON CHEMICAL SAFETY) in the Environmental Health Criteria (EHC) series in 1996. The limit for HCB in the FAO specification in 1998 for chlorothalonil was 0.3 g/kg and manufacturer stated in that report that the company had improved the manufacturing process (see FAO Specification, 2015, p. 51). Thus, a maximum HCB concentration of 300 mg/kg (IPCS, 1996 <sup>22)</sup>) is considered for the years 1990 until 1999 for Germany.



Directive 2005/53/EC<sup>23)</sup>, which entered into force on 1 March 2006, established a maximum permitted HCB concentration of 10 mg/kg in chlorothalonil as a technical active substance. Due to a review by the FAO 288/2005 (see FAO 2015, p.22 and p. 51) and taking into account the results of batch samples testing the impurity the max. concentration was raised again up to 0.04 g/kg. Thus, the standard was raised to 40 mg/kg in Directive 2006/76/EC<sup>24)</sup>. According to the current FAO Specifications and Evaluations for Agricultural Pesticides, Chlorothalonil (2020)<sup>25)</sup> continues to be reported at 40 mg/kg (see Table 1, p. 18).

For the years as of 2000, the specified maximum HCB concentrations in chlorothalonil differ considerably from pesticide to pesticide – in some cases despite the EU-regulation, the values differ from year to year for the same pesticide. For the year 2000, an intermediate value (170 mg/kg) was calculated by linear interpolation.

According to information from the BVL (October 2021, personal communication), the maximum content of HCB in chlorothalonil was increased from 10 to 40 mg/kg in the products “AMISTAR Opti” and “CREDO” due to subsequently applied for active substance sources. Likewise, an additional potential active substance source (production site) was also reported retroactively. For the years 2001 to 2017, the value of 40 mg/kg (for the reporting 2022) is used for the maximum content of HCB.

For the years from 2018 onwards, the information from the authorisation holders (Syngenta Agro, 2015) is used for the maximum concentration of 10 mg/kg, as only the product “AMISTAR Opti” was still on the market.

### Picloram

For picloram, a maximum concentration of 50 mg/kg has been specified for some pesticides. Relevant pesticides were introduced in Germany beginning in 2006. Picloram was added to Annex I with the Commission Directive 2008/69/EC<sup>26)</sup> and the HCB impurity is still set to 50 mg/kg (FAO, 2012<sup>27)</sup>). For 2023, the same amount as for previous years is assumed.

### Lindane

The data on lindane sales were compared by the BVL with historical data from the former GDR statistics and published since 2020 (see Table II). For the years after 1997 no data are available because the application of lindane was phased out in 1998.

For lindane, a maximum concentration of 100 mg/kg was specified for the years 1990 through 1994. For the years after 1994 a lower concentration (50 mg/kg) was assumed which is based on compiled information of Bailey (2001)<sup>28)</sup> (cf. Table III).

### Other active substances atrazine, simazine, propazine and quintozone

The BVL has no information on past or current concentrations of impurities in the active substances atrazine, simazine, propazine and quintozone that have been placed on the market. For this reason, the information on impurity levels compiled in the EMEP/EEA Guidebook 2019 is used (cf. Table III).

Table 4: Maximum concentrations of HCB impurities in relevant active substances, in mg/kg

|             | Chlorothalonil | Picloram | Lindane | Atrazine | Simazine | Propazine | Quintozone |
|-------------|----------------|----------|---------|----------|----------|-----------|------------|
| 1987-1994   | 300            | 50       | 100     | 2.5      | 1        | 1         | 500        |
| 1995-1997   | 300            | 50       | 50      | 1        | 1        | 1         | 500        |
| 1998 - 1999 | 300            | 50       | n/a     | n/a      | 1        | n/a       | n/a        |
| 2000        | 170            | 50       | n/a     | n/a      | n/a      | n/a       | n/a        |
| 2001 - 2017 | 40             | 50       | n/a     | n/a      | n/a      | n/a       | n/a        |
| 2018 - 2023 | 10             | 50       | n/a     | n/a      | n/a      | n/a       | n/a        |

In recent years, the total HCB quantities in pesticide active substances (cf. Table V) have been affected primarily by sales of chlorothalonil.

While this results from the large quantities of chlorothalonil-containing pesticides sold, it is also due to the high chlorothalonil concentrations in such pesticides and to the high permitted maximum HCB concentrations (0.3 g/kg), in chlorothalonil as a technical active substance, that applied prior to 2000. Due to the revised data, changes in HCB quantities



occur.

The maximum HCB quantity for picloram, in the period under consideration, were lower, respectively, than the relevant quantities for chlorothalonil. For this reason, fluctuations in sales of picloram have very little impact on maximum HCB quantities.

## Emission factor

The HCB emission factor was modeled by using the Pesticide Leaching Model (PELMO 3.31) which is also used for the European registration process of pesticides. The one-dimensional pesticide leaching model has been extended to predict the pesticide volatilisation after agricultural applications under field conditions (Ferrari et al., 2005<sup>29)</sup>) however, it is also able to calculate the behaviour of impurities in the products. The model was developed by the Fraunhofer Institute for Molecularbiology and Applied Ecology (IME).

Due to its volatility behaviour in the presence of water vapor even at low temperatures, ambient HCB is usually found in the vapour phase and appears to volatilize from plant and soil surfaces during the first 24 hours after application (Klein, M., 2017)<sup>30)</sup>. As a test substance chlorothalonil was used in the simulation. The simulation conditions are defined after annual applications in potatoes 14 days before harvest. A detailed description of the input parameters is available (Klein, M., 2017). It is assumed that the HCB volatilisation of the impurity in picloram is the same.

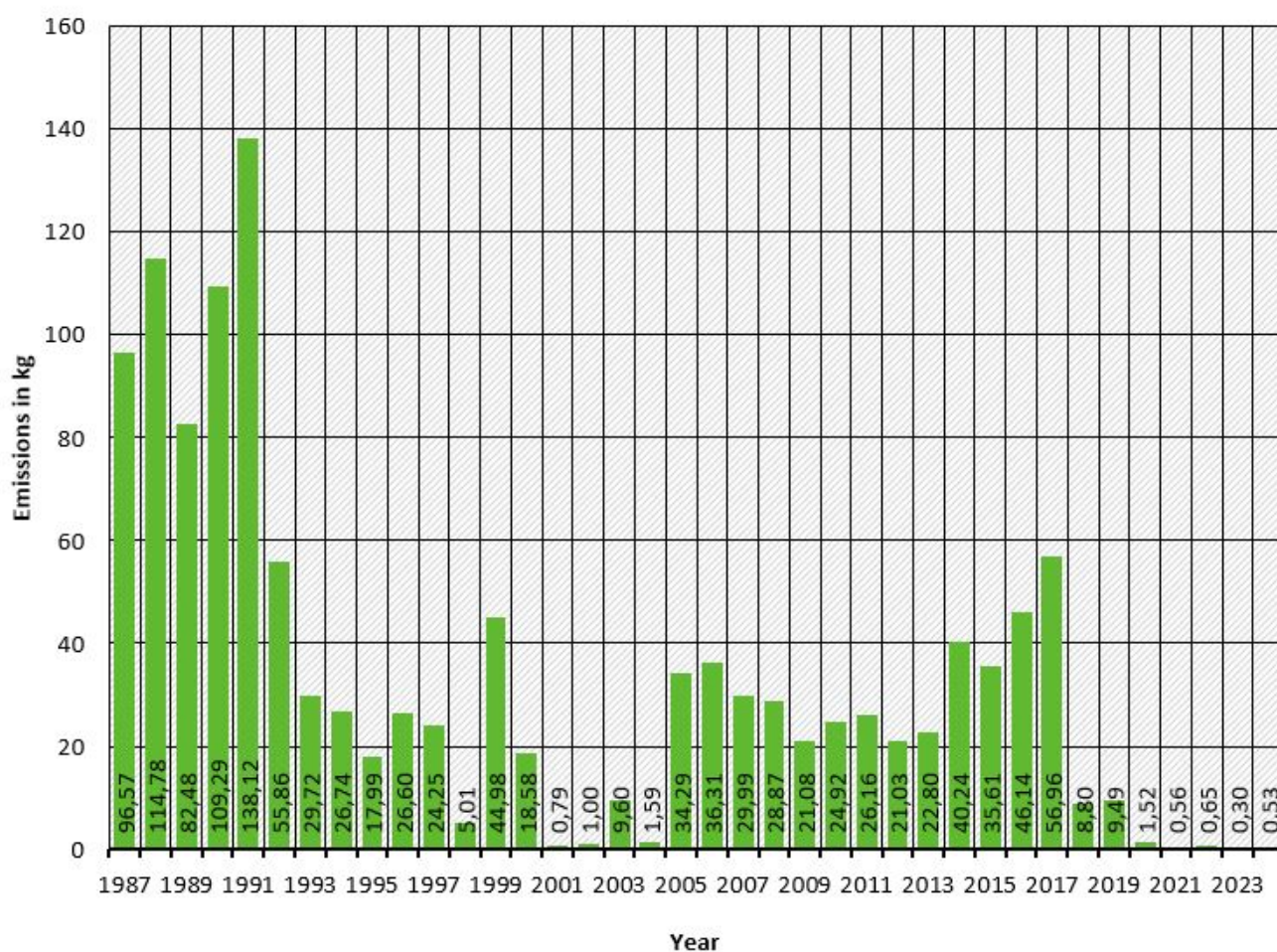
The result of the emission factor is 1 or 100% and represents a fraction that has to be multiplied with the concentration of the applied compound.

## Trend discussion for Key Sources

The following chart gives an overview of the emission trend of HCB (see Picture 1). HCB emissions were fully recalculated from 1987 onwards including atrazine, simazine, propazine and quinzoline. HCB emissions are reported in the NFR tables beginning in 1990.

HCB emissions are mainly dominated by the share of chlorothalonil. According to the BVL (2021a)<sup>31)</sup>, a possible explanation for the increase in HCB emissions from 2005 onwards would be the re-approval of "Bravo 500" in December 2004 against Septoria in wheat and then for the first time against phytophthora in potatoes. It is possible that the first "sell-out" took place in 2014, as the end of approval for "Bravo 500" was originally 30.04.2016 with a sales deadline of 30.10.2016 and a phase-out period for users until 30.10.2017. The end of the EU active substance authorisation for chlorothalonil was later extended to 31.10.2018 and again to 31.10.2019, and with it the authorisations for the plant protection products in Germany. With the Implementing Regulation (EU) 2019/677 23), the BVL revoked the last three approvals for plant protection products containing chlorothalonil on 31 October 2019<sup>32)</sup>. A sell-off period until 30 April 2020 applied. Often, in the last years before the end of the approval, the remaining stocks are brought onto the market, which leads to higher sales than in previous years. No active ingredient of chlorothalonil was sold in 2021. This means that chlorothalonil is off the market for the time being. According to the German Federal Office of Consumer Protection and Food Safety (BVL)<sup>33)</sup>, the EU authorization ([http://data.europa.eu/eli/reg\\_impl/2023/2592/oj](http://data.europa.eu/eli/reg_impl/2023/2592/oj)) for picloram has been extended beyond the end of 2023. Subsequent applications from the European Food Safety Authority (EFSA) must be submitted by December 1, 2025.

*Picture 1: Trend of HCB emissions in Germany in the sector agriculture, in kg*



Source: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were made compared to the last submission.

## Uncertainty

For the calculation of emissions consumption figures (i. e. statistical figures) are used. Therefore, a standard error of HCB content is assumed as 2.5 % for the emission inventory. The 95% confidence interval is therefore 5 %. A normal distribution is assumed.

The uncertainty for the emission factor was determined using the PELMO model. For this purpose, the applied amounts of HCB on the plant surface were calculated with a vapour pressure reduced by a factor of 10. In addition, the meteorological conditions for modelling were selected in such a way that a range of possible emission factors for different locations was distributed across Europe (from Porto, Portugal, to Jokioinen in Finland). This results in a minimum and maximum emission factor. The maximum range was 30 %; the arithmetic mean was 10 % uncertainty (personal communication, Klein, 2017). A conservative approach and thus 30 % uncertainty is chosen for the calculation of uncertainties. The BVL also prepares a quality report on the quantities sales volumes of plant protection products<sup>34)</sup>. This report was prepared in accordance with the guidelines for quality reports of the Federal Statistical Office. It describes the procedure for compiling the annual statistics on plant protection products exported plant protection products and the active substances they contain. active substances contained therein.

## Planned improvements



Currently, no source-specific improvements are planned.

<sup>9)</sup>

Aarhus Protocol on Persistent Organic Pollutants (2009), United Nation: Aarhus Protocol on Long-range Transboundary Air Pollution, Persistent Organic Pollutants, 1998 - Amendment - (on Annexes V and VII) Decision 2009. Status In force (since Dec 13, 2010), Annex III.

<sup>10)</sup>

Stockholm Convention (2001): The Stockholm Convention on Persistent Organic Pollutants, opened for signature May 23, 2001, UN Doc. UNEP/POPS/CONF/4, App. II (2001), reprinted in 40 ILM 532 (2001) [hereinafter Stockholm Convention]. The text of the convention and additional information about POPs is available online at the United Nations Environment Programme's (UNEP's) POPs website

<sup>11)</sup>

Directive 2016/2284/EU: Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC

<sup>12)</sup>

Syngenta Agro (2015), Dep. „Zulassung und Produktsicherheit“, personal communication

<sup>13)</sup>

BVL (2015) (Bundesamts für Verbraucherschutz und Lebensmittelsicherheit Braunschweig): persönliche Mitteilung der Wirkstoffdaten, 2015.

<sup>14)</sup>

BVL 2022, “ Absatz an Pflanzenschutzmitteln in der Bundesrepublik Deutschland Ergebnisse der Meldungen gemäß § 64 Pflanzenschutzgesetz für das Jahr 2017, korrig. Version von Nov 2018, Tab 3.2, [https://www.bvl.bund.de/SharedDocs/Downloads/04\\_Pflanzenschutzmittel/01\\_meldungen\\_par\\_64/meld\\_par\\_64\\_2017.pdf;jsessionid=575C3CE6FEC9CF7B81387944C90C6972.1\\_cid372?\\_\\_blob=publicationFile&v=2](https://www.bvl.bund.de/SharedDocs/Downloads/04_Pflanzenschutzmittel/01_meldungen_par_64/meld_par_64_2017.pdf;jsessionid=575C3CE6FEC9CF7B81387944C90C6972.1_cid372?__blob=publicationFile&v=2)

<sup>15)</sup>

EMEP (2019): EMEP/EEA air pollutant emission inventory guidebook – 2019, EEA Report No 13/2019, <https://www.eea.europa.eu/publications/emep-eea-guidebook-2019>.

<sup>16)</sup>

Tier 2 is similar to Tier 1 but uses more specific emission factors developed on the basis of knowledge of the types of processes and specific process conditions that apply in the country for which the inventory is being developed. Tier 2 methods are more complex, will reduce the level of uncertainty, and are considered adequate for estimating emissions for key categories.

<sup>17)</sup>

PflSchG (2012): Gesetz zur Neuordnung des Pflanzenschutzgesetzes, Bundesgesetzblatt (BGBl), Jahrgang 2012, Teil I, Nr. 7, § 64.

<sup>18)</sup>

see Excel Table “Absatzmengen an Wirkstoffen in Pflanzenschutzmitteln von 1987 bis 2023”. [https://www.bvl.bund.de/DE/Arbeitsbereiche/04\\_Pflanzenschutzmittel/01\\_Aufgaben/02\\_ZulassungPSM/03\\_PSMInlandsabsatzAusfuhr/psm\\_PSMInlandsabsatzAusfuhr\\_node.html](https://www.bvl.bund.de/DE/Arbeitsbereiche/04_Pflanzenschutzmittel/01_Aufgaben/02_ZulassungPSM/03_PSMInlandsabsatzAusfuhr/psm_PSMInlandsabsatzAusfuhr_node.html)

<sup>19)</sup>

Commission Implementing Regulation (EU) No 540/2011 ((COMMISSION IMPLEMENTING REGULATION (EU) No 540/2011 of 25 May 2011 implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards the list of approved active substances. <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32011R0541>

<sup>20)</sup>

Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the market, <https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:31991L0414>

<sup>21)</sup>

FAO (2015): FAO (Food and Agriculture Organization of the United Nations) Specifications and Evaluations for Chlorothalonil, p 51. <http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/jmps/ps-new/en/>

<sup>22)</sup>

IPCS (1996), Chlorothalonil. Environmental Health Criteria, 183. 145pp. WHO, Geneva, Switzerland. ISBN 92-4-157183-7. C12138614.7.

<sup>23)</sup>

Directive 2005/53/EC: Commission Directive 2005/53/EC of 16 September 2005 amending Council Directive 91/414/EEC to include chlorothalonil, chlorotoluron, cypermethrin, daminozide and thiophanate-methyl as active substances 2005/53/EC C.F.R. (2005).

<sup>24)</sup>

Directive 2006/76/EC: Commission Directive 2006/76/EC of 22 September 2006 amending Council Directive 91/414/EEC as regards the specification of the active substance chlorothalonil (Text with EEA relevance) 2006/76/EC C.F.R. (2006

<sup>25)</sup>

FAO (2020): FAO (Food and Agriculture Organization of the United Nations) Specifications and Evaluations for Chlorothalonil, <http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/jmps/ps-new/en/#C>

<sup>26)</sup>

Directive 2008/69/EC: Commission Directive 2008/69/EC of 1 July 2008 amending Council Directive 91/414/EEC to include clofentezine, dicamba, difenoconazole, diflubenzuron, imazaquin, lenacil, oxadiazon, picloram and pyriproxyfen as active substances 2008/69/EC C.F.R. (2008).

<sup>27)</sup>

FAO (2012): FAO (Food and Agriculture Organization of the United Nations) Specifications and Evaluations for Picloram, Table 2, p. 23. <http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/jmps/ps-new/en/>

<sup>28)</sup>

Bailey, R. E., (2001): Global hexachlorobenzene emissions. Chemosphere, 43(2), 167-182.

<sup>29)</sup>

Ferrari, F., Klein, M., Capri, E., & Trevisan, M. (2005). Prediction of pesticide volatilization with PELMO 3.31. Chemosphere, 60 (5), 705-713

<sup>30)</sup>

Klein, M. (2017), Calculation of emission factors for impurities in organic pesticides with PELMO. Personal communication. Description available, Umweltbundesamt, FG V 1.6, Emissionssituation.

<sup>31)</sup>

BVL (2021a) (Bundesamts für Verbraucherschutz und Lebensmittelsicherheit Braunschweig): persönliche Mitteilung der Wirkstoffdaten, 2021

<sup>32)</sup>

cf. BVL; 2019: BVL - Fachmeldungen - Widerruf der Zulassung von Pflanzenschutzmitteln mit dem Wirkstoff Chlorthalonil zum 31. Oktober 2019. (2019, 31. Oktober). Abgerufen am September 2021, von [https://www.bvl.bund.de/SharedDocs/Fachmeldungen/04\\_pflanzenschutzmittel/2019/2019\\_06\\_19\\_Fa\\_Widerruf\\_Chlorthalonil.html](https://www.bvl.bund.de/SharedDocs/Fachmeldungen/04_pflanzenschutzmittel/2019/2019_06_19_Fa_Widerruf_Chlorthalonil.html)

<sup>33)</sup>

BVL (2024): Personal communication (20241009) on the extension of the approval of Picloram

<sup>34)</sup>

BVL (2024b): [https://www.bvl.bund.de/SharedDocs/Downloads/04\\_Pflanzenschutzmittel/01\\_meldungen\\_par\\_64/01\\_Qualit%C3%A4tsbericht\\_AbsatzmengenPSM/Qualitätsbericht\\_AbsatzmengenPSM\\_pdf.pdf?\\_\\_blob=publicationFile&v=4](https://www.bvl.bund.de/SharedDocs/Downloads/04_Pflanzenschutzmittel/01_meldungen_par_64/01_Qualit%C3%A4tsbericht_AbsatzmengenPSM/Qualitätsbericht_AbsatzmengenPSM_pdf.pdf?__blob=publicationFile&v=4)

## 3.F - Field burning of agricultural residues

### Short description

| NFR-Code                                                                                  | Method                                       | AD | EF |
|-------------------------------------------------------------------------------------------|----------------------------------------------|----|----|
| 3.F                                                                                       | NO (no intentional field burning in Germany) |    |    |
| Method(s) applied                                                                         |                                              |    |    |
| D                                                                                         | Default                                      |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *                |    |    |
| T2                                                                                        | Tier 2*                                      |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *              |    |    |
| C                                                                                         | CORINAIR                                     |    |    |
| CS                                                                                        | Country Specific                             |    |    |
| M                                                                                         | Model                                        |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                              |    |    |
| (source for) Activity Data                                                                |                                              |    |    |
| NS                                                                                        | National Statistics                          |    |    |
| RS                                                                                        | Regional Statistics                          |    |    |
| IS                                                                                        | International Statistics                     |    |    |
| PS                                                                                        | Plant Specific                               |    |    |
| As                                                                                        | Associations, business organisations         |    |    |
| Q                                                                                         | specific Questionnaires (or surveys)         |    |    |
| M                                                                                         | Model / Modelled                             |    |    |
| C                                                                                         | Confidential                                 |    |    |
| (source for) Emission Factors                                                             |                                              |    |    |
| D                                                                                         | Default (EMEP Guidebook)                     |    |    |
| CS                                                                                        | Country Specific                             |    |    |
| PS                                                                                        | Plant Specific                               |    |    |
| M                                                                                         | Model / Modelled                             |    |    |
| C                                                                                         | Confidential                                 |    |    |

### Country specifics

Already in 1990, the first year of the emission reporting time series, the burning of crop residues had been banned by law in Germany.

Only in specific, exceptional situations (e. g. infestation by insects) permissions can be issued on municipal level.

Inquiries with several district administration offices revealed that such exceptional permissions mostly do concern forest areas rather than agricultural areas, and that there are no official statistics on those exceptions. Due to the restrictions in legislation and the information gathered from the district administration offices it is assumed that burning of agricultural areas is occurring extremely seldom and that the pertinent emissions can be neglected (NO). For more details see Vos et al. (2026)<sup>1)</sup>.

<sup>1)</sup> Vos, C., Rösemann, C., Haenel, H.-D., Dämmgen, U., Döring, U., Wulf, S., Eurich-Menden, Döhler, H., Steuer, B., Osterburg, B., Fuß, R. (2026): Calculations of gaseous and particulate emissions from German agriculture 1990 – 2024: Report on methods and data (RMD) Submission 2026. [www.eminv-agriculture.de](http://www.eminv-agriculture.de), 2026

## 3.I - Agricultural: Other

### Short description

| Category Code                                                                             | Name of Category                       | Method                                  | AD    | EF                                      |
|-------------------------------------------------------------------------------------------|----------------------------------------|-----------------------------------------|-------|-----------------------------------------|
| 3.I                                                                                       | Agriculture: other                     |                                         |       |                                         |
| consisting of / including source categories:                                              |                                        |                                         |       |                                         |
| 3.I                                                                                       | Storage of digestate from energy crops | T2 (NH <sub>3</sub> , NO <sub>x</sub> ) | Q, PS | CS (NH <sub>3</sub> , NO <sub>x</sub> ) |
| Method(s) applied                                                                         |                                        |                                         |       |                                         |
| D                                                                                         | Default                                |                                         |       |                                         |
| T1                                                                                        | Tier 1 / Simple Methodology *          |                                         |       |                                         |
| T2                                                                                        | Tier 2*                                |                                         |       |                                         |
| T3                                                                                        | Tier 3 / Detailed Methodology *        |                                         |       |                                         |
| C                                                                                         | CORINAIR                               |                                         |       |                                         |
| CS                                                                                        | Country Specific                       |                                         |       |                                         |
| M                                                                                         | Model                                  |                                         |       |                                         |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                        |                                         |       |                                         |
| (source for) Activity Data                                                                |                                        |                                         |       |                                         |
| NS                                                                                        | National Statistics                    |                                         |       |                                         |
| RS                                                                                        | Regional Statistics                    |                                         |       |                                         |
| IS                                                                                        | International Statistics               |                                         |       |                                         |
| PS                                                                                        | Plant Specific                         |                                         |       |                                         |
| As                                                                                        | Associations, business organisations   |                                         |       |                                         |
| Q                                                                                         | specific Questionnaires (or surveys)   |                                         |       |                                         |
| M                                                                                         | Model / Modelled                       |                                         |       |                                         |
| C                                                                                         | Confidential                           |                                         |       |                                         |
| (source for) Emission Factors                                                             |                                        |                                         |       |                                         |
| D                                                                                         | Default (EMEP Guidebook)               |                                         |       |                                         |
| CS                                                                                        | Country Specific                       |                                         |       |                                         |
| PS                                                                                        | Plant Specific                         |                                         |       |                                         |
| M                                                                                         | Model / Modelled                       |                                         |       |                                         |
| C                                                                                         | Confidential                           |                                         |       |                                         |

| NO <sub>x</sub> | NM VOC                                                                                       | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|-----------------|----------------------------------------------------------------------------------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| -/-             | NA                                                                                           | NA              | -/-             | NA                | NA               | NA  | NA | NA | NA           | NA   |
| <b>L/-</b>      | key source by <b>L</b> evel only                                                             |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b>      | key source by <b>T</b> rend only                                                             |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b>      | key source by both <b>L</b> evel and <b>T</b> rend                                           |                 |                 |                   |                  |     |    |    |              |      |
| -/-             | no key source for this pollutant                                                             |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b>       | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b>       | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b>       | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                 |                 |                   |                  |     |    |    |              |      |
| *               | no analysis done                                                                             |                 |                 |                   |                  |     |    |    |              |      |

### Country specifics

In 2024, NH<sub>3</sub> emissions from category 3.I (agriculture other) amounted to 0.26 % of total agricultural emissions, which is equal to ~ 1.3 kt NH<sub>3</sub>. NO<sub>x</sub> emissions from category 3.I contribute 0.07 % (~ 0.07 kt) to the total agricultural emissions. All these emissions originate from the storage of digestate from energy crops (for details on anaerobic digestion of energy crops see Vos et al. (2026), Chapter 5.1<sup>1)</sup>. The emissions resulting from the application of energy crop digestates as organic fertilizer are dealt with under 3.D.a.2.c.



## Activity Data

Time series of activity data have been provided by KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft / Association for Technology and Structures in Agriculture). From these data the amount of N in energy crops fed into anaerobic digestion was calculated.

Table 1: N amount in energy crops fed into anaerobic digestion, in [kt N]

| 1990 | 1995 | 2000 | 2005 | 2010  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  | 2023  | 2024  |
|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 0.0  | 0.6  | 5.3  | 45.1 | 163.0 | 293.7 | 292.2 | 287.4 | 283.2 | 283.2 | 289.3 | 283.8 | 304.9 | 295.3 | 295.3 |

Table 2: Distribution of gastight storage and storage in open tank of energy crop digestates, in [%]

|              | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| gastight     | 0.0  | 4.7  | 9.4  | 15.8 | 42.2 | 65.2 | 67.1 | 69.1 | 71.0 | 74.9 | 78.7 | 82.6 | 82.0 | 85.8 | 85.8 |
| non-gastight | 100  | 95.3 | 90.6 | 84.2 | 57.8 | 34.8 | 32.9 | 30.9 | 29.0 | 25.1 | 21.3 | 17.4 | 18.0 | 14.2 | 14.2 |

## Methodology

The calculation of emissions from storage of digestate from energy crops considers two different types of storage, i.e. gastight storage and open tank. The frequencies of these storage types are also provided by KTBL (see Table 2). There are no emissions of NH<sub>3</sub> and NO from gastight storage of digestate. Hence the total emissions from the storage of digestate are calculated by multiplying the amount of N in the digestate leaving the fermenter with the relative frequency of open tanks and the emission factor for open tank. The amount of N in the digestate leaving the fermenter is identical to the N amount in energy crops fed into anaerobic digestion (see Table 1) because N losses from pre-storage are negligible and there are no N losses from fermenter (see Vos et al. 2026, Chapter 5.1)<sup>2)</sup>.

## Emission factors

As no specific emission factor is known for the storage of digestion residues in open tanks, the NH<sub>3</sub> emission factor for storage of cattle slurry with crust in open tanks was adopted (0.045 kg NH<sub>3</sub> -N per kg TAN). This choice of emission factor is based on the fact that energy crops are, in general, co-fermented with animal manures (i. e. mostly slurry) and that a natural crust forms on the liquid digestates due to the relatively high dry matter content of the energy crops.

The TAN content after the digestion process is 0.56 kg TAN per kg N. The NO emission factor for storage of digestion residues in open tanks was set to 0.0005 kg NO-N per kg N.

The following table shows the resulting implied emission factors for NH<sub>3</sub> -N and NO-N. NO<sub>x</sub> emissions are related to NO-N emissions by the ratio of 46/14. This relationship also holds for NO-N and NO<sub>x</sub> emission factors.

Table 3: IEF for NH<sub>3</sub> -N and NO-N emissions from storage of digested energy crops

|                                | 1990    | 1995    | 2000    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    | 2024    |
|--------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| kg NH <sub>3</sub> -N per kg N | 0.0252  | 0.0240  | 0.0228  | 0.0212  | 0.0146  | 0.0087  | 0.0082  | 0.0078  | 0.0073  | 0.0063  | 0.0054  | 0.0044  | 0.0045  | 0.0036  | 0.0036  |
| kg NO-N per kg N               | 0.00050 | 0.00048 | 0.00045 | 0.00042 | 0.00029 | 0.00017 | 0.00016 | 0.00015 | 0.00014 | 0.00013 | 0.00011 | 0.00009 | 0.00009 | 0.00007 | 0.00007 |

## Trend discussion for Key Sources

NH<sub>3</sub> and NO<sub>x</sub> from storage of anaerobically digested energy crops are no key source.

## Recalculations

There were no recalculations except the replacement of extrapolated activity data in 2023 with data from KTBL (see [main page of the agricultural sector](#), Chapter 5 - NFR 3 - Agriculture (OVERVIEW), **recalculation No. 18**). For further details on recalculations see Vos et al. (2026), Chapter 1.3.

Table 4: Comparison of NH<sub>3</sub> and NO<sub>x</sub> emissions [kt] with previous submission

|                 | Submission          | 1990   | 1995   | 2000   | 2005   | 2010   | 2015   | 2016   | 2017   | 2018   | 2019   | 2020   | 2021   | 2022   | 2023   | 2024   |
|-----------------|---------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Ammonia         | current             | 0.0015 | 0.0180 | 0.1482 | 1.1624 | 2.8842 | 3.1074 | 2.9181 | 2.7131 | 2.5068 | 2.1785 | 1.8901 | 1.5115 | 1.6749 | 1.2796 | 1.2796 |
|                 | previous            | 0.0015 | 0.0180 | 0.1482 | 1.1624 | 2.8842 | 3.1074 | 2.9181 | 2.7131 | 2.5068 | 2.1785 | 1.8901 | 1.5115 | 1.6749 | 1.6749 |        |
|                 | absolute change     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | -0.40  |        |
|                 | relative change [%] | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | -23.60 |        |
| Nitrogen oxides | current             | 0.0001 | 0.0010 | 0.0080 | 0.0624 | 0.1548 | 0.1668 | 0.1567 | 0.1457 | 0.1346 | 0.1170 | 0.1015 | 0.0811 | 0.0899 | 0.0687 | 0.0687 |
|                 | previous            | 0.0001 | 0.0010 | 0.0080 | 0.0624 | 0.1548 | 0.1668 | 0.1567 | 0.1457 | 0.1346 | 0.1170 | 0.1015 | 0.0811 | 0.0899 | 0.0899 |        |
|                 | absolute change     | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | -0.02  |        |
|                 | relative change [%] | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | 0.00   | -23.60 |        |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

## Uncertainty

Details are described in [chapter 1.7](#).

<sup>1), 2)</sup> Vos, C., Rösemann, C., Haenel, H.-D., Dämmgen, U., Döring, U., Wulf, S., Eurich-Menden, Döhler, H., Steuer, B., Osterburg, B., Fuß, R. (2026): Calculations of gaseous and particulate emissions from German agriculture 1990 – 2024: Report on methods and data (RMD) Submission 2026. [www.eminv-agriculture.de](http://www.eminv-agriculture.de), 2026



## CHAPTER 6: NFR 5 - Waste (OVERVIEW)



Source category *NFR 5 - Waste* is not a key source. NMVOC and PM<sub>2.5</sub> emissions from Solid Waste Disposal on Land, NH<sub>3</sub> emissions from Composting and Anaerobic Digestion at biogas facilities, emissions from Cremation as well as NMVOC emissions from Domestic & Commercial and Industrial Wastewater Treatment are reported.

Germany has a large number of waste incineration plants, whose emissions are reported in *NFR 1*, because German legislation requires energy recovery. Therefore, waste is also part of the German Energy Statistic as well as the National Energy Balance.

In addition to the “classical” municipal waste incineration, there are also various types of combustion installations, like co-incineration of “replacement fuels” in conventional power plants or industrial plants. The increasing number of co-incineration plants is mainly due to the landfill ban of untreated waste in 2005 and the introduction of the emission trading scheme (ETS). Further information about the methodology of municipal waste incineration, co-incineration in public power plants and emissions from waste wood combustion is available in chapter: [1.A.1.a -Public electricity and heat production](#). Municipal waste incineration does also include clinical waste, which is not incinerated separately.

Emissions from hazardous waste incineration plants are reported in source category [1.A.2.g. viii - Stationary Combustion in Manufacturing Industries and Construction: Other Production](#) as well as co-incineration in industrial plants, whereas emissions from sewage sludge incineration are reported in source category [1.A.1.c - Manufacture of solid fuels and other energy industries](#), following the structure of the National Statistics.

In Germany, “Other Waste Incineration” (*NFR 5.C.1.b vi*) is prohibited by law, therefore, “NO” is used as notation key.

Furthermore, it should be mentioned that all emissions originating from biogas recovery are reported in source category [1.A.1.a](#), following the structure of the National Energy Balance. That covers emissions from sewage gas as well as landfill gas and biogas from biological waste treatment.

**NFR 5 consists of the following sub-categories:**

| NFR Code                                             | Name of Category                                                        | State of Reporting                                                   |
|------------------------------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------|
| <b>5.A &amp; 5.B - Biological Treatment of Waste</b> |                                                                         |                                                                      |
| <b>5.A</b>                                           | Biological Treatment of Waste: Solid Waste Disposal on Land             |                                                                      |
| <b>5.B.1</b>                                         | Biological Treatment of Waste: Composting                               |                                                                      |
| <b>5.B.2</b>                                         | Biological Treatment of Waste: Anaerobic digestion at biogas facilities |                                                                      |
| <b>5.C - Thermal Treatment of Waste</b>              |                                                                         |                                                                      |
| <b>5.C.1.a</b>                                       | Municipal Waste Incineration                                            | considered in <a href="#">1.A.1.a</a>                                |
| <b>5.C.1.b i</b>                                     | Industrial Waste Incineration                                           | considered in <a href="#">1.A.1.a</a> & <a href="#">1.A.2.g viii</a> |
| <b>5.C.1.b ii</b>                                    | Hazardous Waste Incineration                                            | considered in <a href="#">1.A.2.g viii</a>                           |
| <b>5.C.1.b iii</b>                                   | Clinical Waste Incineration                                             | considered in <a href="#">1.A.1.a</a>                                |
| <b>5.C.1.b iv</b>                                    | Sewage Sludge incineration                                              | considered in <a href="#">1.A.1.c</a>                                |
| <b>5.C.1.b v</b>                                     | Cremation                                                               |                                                                      |
| <b>5.C.1.b vi</b>                                    | Other waste incineration (please specify in the IIR)                    | NO                                                                   |
| <b>5.C.2</b>                                         | Open Burning of Waste                                                   |                                                                      |
| <b>5.D - Wastewater handling</b>                     |                                                                         |                                                                      |
| <b>5.D.1</b>                                         | Domestic & Commercial Wastewater Handling                               |                                                                      |
| <b>5.D.2</b>                                         | Industrial Wastewater Handling                                          |                                                                      |
| <b>5.D.3</b>                                         | Other Wastewater Handling                                               | NO                                                                   |
| <b>5.E - Other Waste (please specify in IIR)</b>     |                                                                         |                                                                      |
| <b>5.E.1</b>                                         | Other Waste: Mechanical-biological Treatment of Waste                   | GHG emissions only                                                   |
| <b>5.E.2</b>                                         | Other Waste: Building and Car Fires                                     |                                                                      |

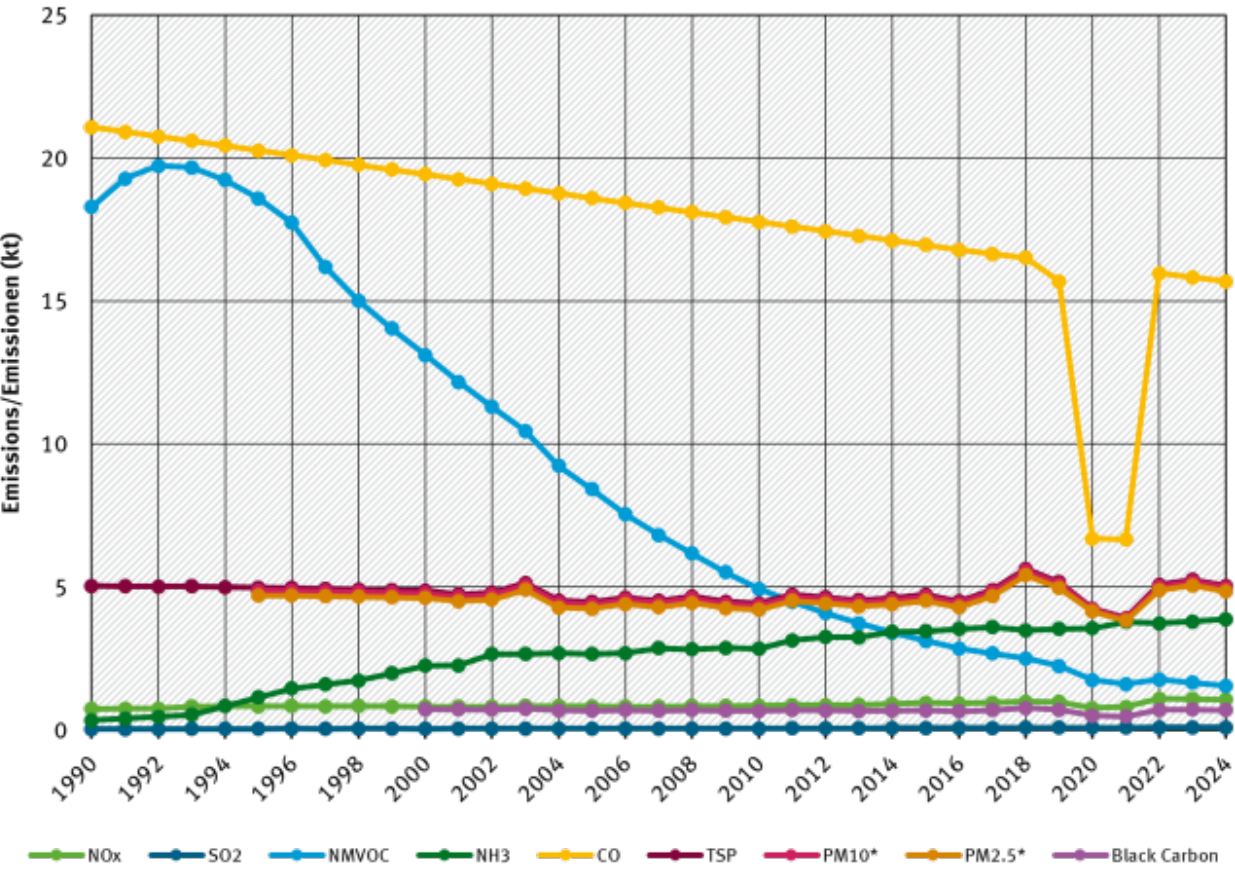
NOTE: Within category 5.C - *Waste incineration*, Germany only reports emissions from *NFR 5.C.1.b v - Cremation* and *NFR 5.C.2 bonfires etc.*. For all other sub-categories of NFR 5.C, as all waste incineration in Germany is carried out with energy recovery and in order to avoid double counting, resulting emissions are reported as *not occurring (NO)* under NFR 5.C but are included in energy sector NFR 1.

## Visual overview

Emission trends for main pollutants in *NFR 5 - Waste*:

Waste/Abfall (NFR 5)

Emissions by pollutant / Emissionen nach Schadstoff



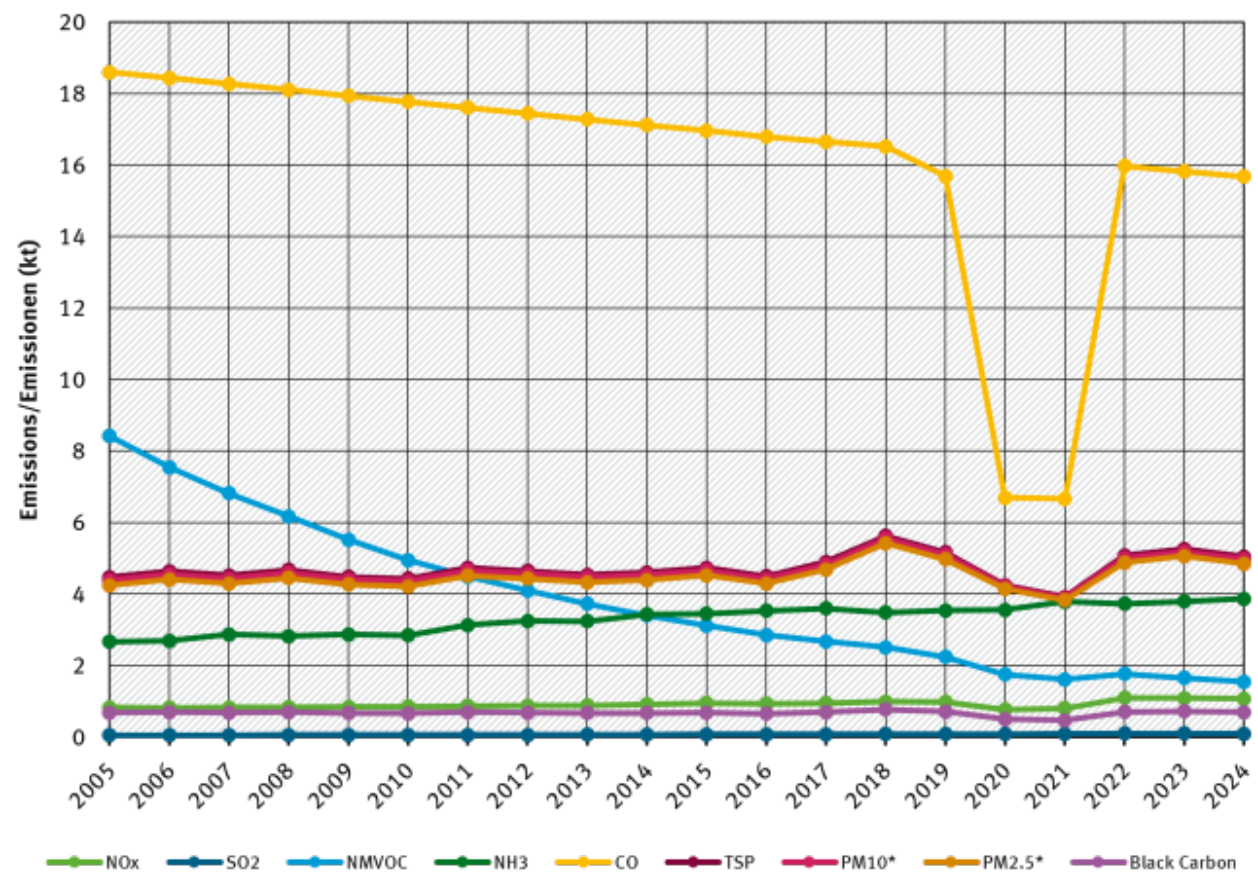
\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Emission Inventory (18.03.2026)



Waste/Abfall (NFR 5)

Emissions by pollutant / Emissionen nach Schadstoff

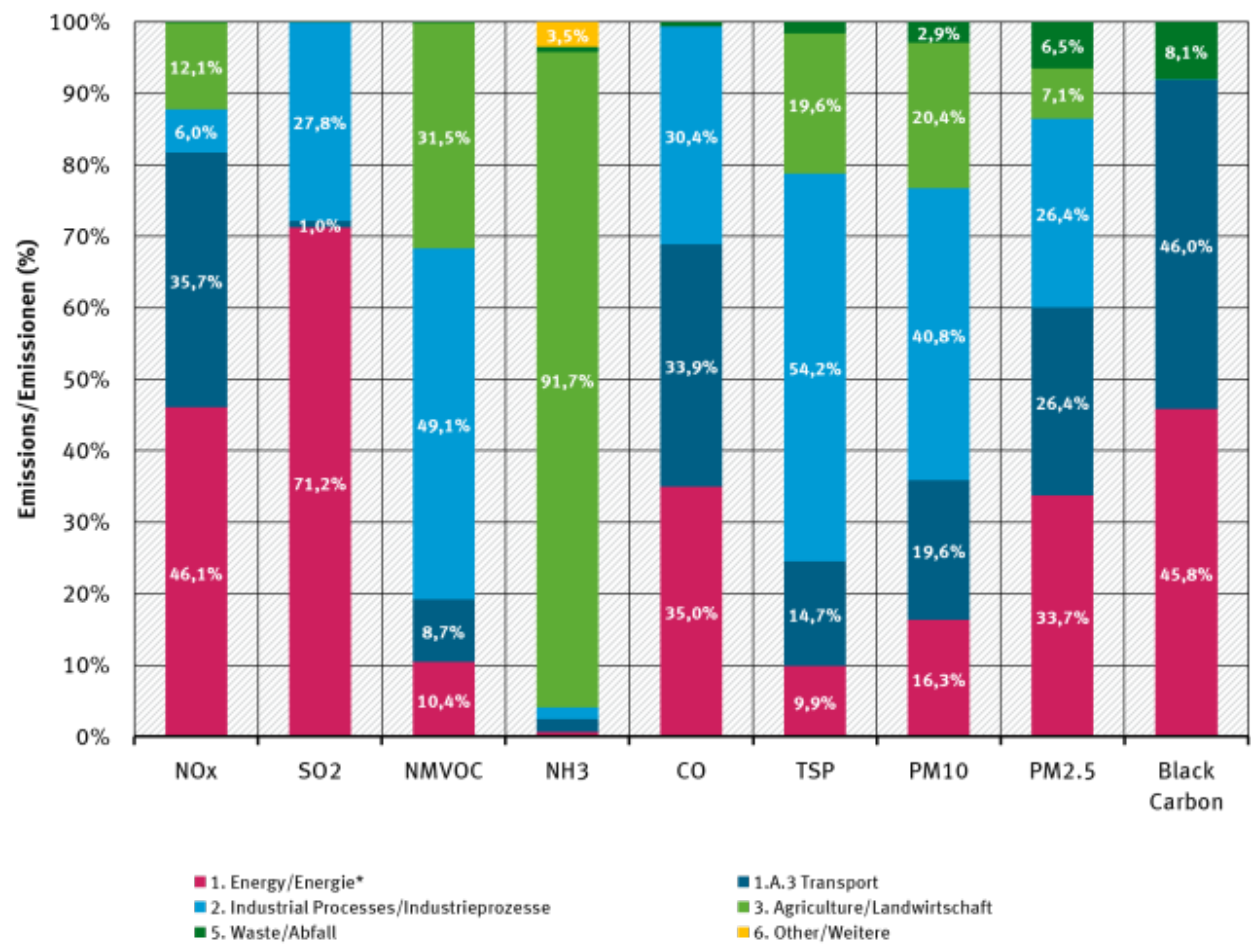


\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995 Quelle: German Emission Inventory (18.03.2026)

[Contribution of NFRs 1 to 6 to the National Totals](#)

Contribution of NFR categories to the emissions/Anteile der NFR-Kategorien an den Emissionen

2024 percentages per air pollutant / Anteile pro Luftschadstoff für 2024



\* without transport ( ohne Verkehr (1.A.3)

Quelle: German Emission Inventory (06.02.2026)

## 5.A - Biological Treatment of Waste: Solid Waste Disposal on Land

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 5.A                                                                                       | T1                                   | NS | D  |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub>                                                                               | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|-----------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA                                                                                            | -/-    | NA              | NA              | -/-               | -/-              | -/- | NA | NA | NA           | NA   |
| <b>L/-</b> key source by <b>Level</b> only                                                    |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>Trend</b> only                                                    |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>Level</b> and <b>Trend</b>                                   |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/-</b> no key source for this pollutant                                                   |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b> emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b> emission of specific pollutant <b>Not Estimated</b> (yet)                           |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b> specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |        |                 |                 |                   |                  |     |    |    |              |      |
| * no analysis done                                                                            |        |                 |                 |                   |                  |     |    |    |              |      |

In category **5.A**, NMVOC and PM<sub>2.5</sub> emissions from managed disposal in landfills are reported in accordance with review recommendation DE-5A-2017-0001. In addition to that, for the sake of completeness, PM<sub>10</sub> and TSP emissions were also reported.

In the period since 1990 (and previously, to some extent), a number of legal provisions have been issued pertaining to Germany's waste-management sector, and a number of relevant measures have been initiated. These moves have had a strong impact on trends in emissions from waste-landfilling. Relevant developments have included intensified collection of biodegradable waste from households and the commercial sector, intensified collection of other recyclable materials, such as glass, paper/cardboard, metals and plastics; separate collection of packaging and recycling of packaging. In addition, incineration of municipal waste has been expanded, and mechanical biological treatment of residual waste has been

introduced. As a result, the amounts of landfilled municipal waste decreased very sharply from 1990 to 2006, and stabilised at a low level since 2006. Today over half of municipal waste produced in Germany is collected separately and gleaned for recyclable materials (separate collection of recyclable materials and biodegradable waste). National statistical data are used (see sub-chapter “activity- data”).

In 2004, about 2.000 landfills of relevance for this category were in operation in the Federal Republic of Germany. In June 2005, in keeping with new, stricter requirements under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements (Abfallablagerungsverordnung) and the Landfill Ordinance (Deponieverordnung), nearly half of those landfills were closed. As a result, in 2017 less than 1100 landfills, divided into 5 deposition classes are still in operation.

Also, pursuant to regulations in force since June 2005, landfilling of biodegradable waste is no longer permitted - for conformance with pertinent requirements, municipal waste and other biodegradable waste must be pre-treated via thermal or mechanical-biological processes. All these measures have had strong impact on the formation of NMVOC, PM<sub>2.5</sub>, PM<sub>10</sub> and TSP so that their emissions decreased significantly since 1990.

## Methodology

For the estimation of NMVOC, Germany decided against the proposed EF of the EMEP/EEA Guidebook 2023, but instead for the Tier1 approach of the US-EPA which is reproduced in the EMEP/EEA Guidebook 2019 (Part B, 5.A, chap. 3.2.2, p. 5) <sup>1)</sup>.

According to national experts in the field, the approach of the US-EPA is more likely to produce better data, because the ratio between NMVOC (1.3 %) and CH<sub>4</sub> (98.7 %) in VOC from landfill gas is scientifically sound and assumed to be the very same in Germany. Also, already existing and published data for methane emissions from landfills, derived from the IPCC-FOD Waste Model (see NIR of Germany), can be used. However, with the NIR 2023 some of the emission parameters used to estimate methane emissions have been modified (DOC for food waste, DOC<sub>r</sub> for wood/straw, half-life time for paper and wood/straw) according to the results of research projects initiated for the improvement of the German inventory reporting (Stegmann et al, 2018; pages 172-173, table 36) <sup>2)</sup>. As a result, the methane emissions have changed considerably and thus the related NMVOC-emissions that are reported here.

Emissions for PM<sub>2.5</sub>, PM<sub>10</sub> and TSP, reported under this category, are calculated using the Tier1 approach of the EMEP/EEA Guidebook 2023, where the emission factors are 0.033, 0.219 and 0.463 [g/t] <sup>3)</sup>.

The EFs are multiplied with the total amount of solid waste (AD) treated in managed above-ground landfills, following the standard equation:

$$EM = AD * EF$$

## Activity data

From 1990 until 2017, official statistical data provided by the Federal Statistical Office are applied <sup>4)</sup>.

Data for 1991 and 1992 as well as 1994 and 1995 are not available and have been interpolated. From 2018 until today data are made available by the National Statistical Agency by means of a direct data provision on a yearly basis. These data comprise the total amount of solid waste deposited above-ground, meaning, that all mineral wastes (mineral/construction/demolition) are also included. Remaining fractions of these wastes (mineral/construction/demolition) go to underground landfills and therefore do not play a part in dust emissions.

The data are published on a yearly basis with an exception for the actual year of reporting. The activity data for the actual year of reporting are obtained, initially, by carrying the relevant data from the previous year forward, in unchanged form. In the following year, when the actual activity data for the given year becomes available, they replace the data that were carried forward. With regard to emissions from landfills, this procedure has only a very small impact on the total emissions in the relevant current report year.

## Emission factors

See “Methodology”.

## Uncertainties

The AD from Statistisches Bundesamt usually have an uncertainty of  $\pm 3\%$  whereas the uncertainties for the PMs and TSP emission factors, according to the EMEP/EEA Guidebook (Part B, 5.A, chap. 3.2.2, Table 3-1, p. 6), were estimated as:

Table 1: Uncertainty estimates of PM emission factors

|                         |              |
|-------------------------|--------------|
| <b>PM<sub>2.5</sub></b> | -99% / +385% |
| <b>PM<sub>10</sub></b>  | -99% / +379% |
| <b>TSP</b>              | -99% / +377% |

Due to the fact that for the ratio of NMVOC and CH<sub>4</sub> in VOC from landfill gas no range is given in the EMEP-Guidebook, the overall uncertainty for the emission estimation of NMVOC is estimated by expert judgement to be  $\pm 50\%$ .

## Recalculations

The waste statistics of the Federal Statistical Office are regularly published with a one-year delay - which leads to an estimation of the current reporting year. This estimate is replaced in the following year with the then current data. Since the resulting recalculation usually is very small it is not reported here.

However, in this year's reporting the correction of the deposited waste quantities is higher than usual and thus is affecting the recalculation of TSP and PMs to a higher extent than is usually the case. For this reason, the recalculation is reported here. For the sake of completeness NMVOC emissions are also reported.

Table 1: Revised 2023 NMVOC emissions, in [kt]

|                            |       |
|----------------------------|-------|
| <b>current submission</b>  | 1,037 |
| <b>previous submission</b> | 1,056 |

Table 2: Revised 2023 PM and TSP emissions, in [t]

|                            | <b>TSP</b> | <b>PM<sub>10</sub></b> | <b>PM<sub>2.5</sub></b> |
|----------------------------|------------|------------------------|-------------------------|
| <b>current submission</b>  | 15,621     | 7,389                  | 1,113                   |
| <b>previous submission</b> | 18,135     | 8,578                  | 1,293                   |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, Part B, 5.A, chapter 3.2.2, Table 3-1, page 5; Copenhagen 2019.

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/5-waste/5-a-biological-treatment-of/@download/file>

<sup>2)</sup> Stegmann et al. (2018): Stegmann, R., Heyer, K.-U., Hupe, K. (IFAS - Ingenieurbüro für Abfallwirtschaft, Hamburg) with Rettenberger, G., Schneider, R. (Ingenieurgruppe RUK GmbH, Stuttgart): Überprüfung der methodischen Grundlagen zur



Bestimmung der Methanbildung in Deponien, ISSN 1862-4804; on behalf of the Umweltbundesamt, Dessau-Roßlau 2018.

[https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/139\\_2023\\_texte\\_methanbildung\\_in\\_deponien.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/139_2023_texte_methanbildung_in_deponien.pdf)

<sup>3)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Part B, 5.A, chapter 3.2.2, Table 3-1, page 6; Copenhagen 2023.

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/5-waste/5-a-solid-waste-disposal/@download/file>

<sup>4)</sup> Destatis (2024): Federal Statistical Office (Statistisches Bundesamt - Destatis), Fachserie 19, Reihe 1: Abfallentsorgung (Waste management), Table 2.1; Wiesbaden 2024.

<https://www.destatis.de/DE/Publikationen/Thematisch/UmweltstatistischeErhebungen/Abfallwirtschaft/Abfallentsorgung.html>

## 5.B.1 - Biological Treatment of Waste: Composting

### Short description

Within NFR category **5.B.1**, ammonia (NH<sub>3</sub>) emissions from composting of organic wastes are reported.

| NFR Code                                                                                  | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 5.B.1                                                                                     | CS                                   | NS | CS |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub>                                                                                        | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|--------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA                                                                                                     | NA     | NA              | -/-             | NA                | NA               | NA  | NA | NA | NA           | NA   |
| <b>L/-</b> key source by <b>L</b> evel only                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>T</b> rend only                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend                                          |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/-</b> no key source for this pollutant                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b> emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b> emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b> specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |        |                 |                 |                   |                  |     |    |    |              |      |
| * no analysis done                                                                                     |        |                 |                 |                   |                  |     |    |    |              |      |

Separately collected organic waste (biowaste) from e.g. households, public garden and park service, food industry, restaurants, canteens and from agriculture can be treated either (i) aerobically (= composting) or (ii) anaerobically (= biogas production).

The aim of the treatment reported under this category is the production of compost, leading to the recycling of nutrients and organic matter.

The produced compost is used as fertilizer or soil improver in agriculture or horticulture and also in private gardening. In Germany about 50% of the organic waste is treated in composting plants and ammonia (NH<sub>3</sub>) is an important emission to air.

## Method

Emissions from composting are not a key source and of minor priority.

The Method in use is country specific, based on a Tier 2 approach that is in accordance with the IPCC Guidelines 2006.

## Activity Data

Official statistical data (Statistisches Bundesamt, GENESIS, Table Nr. 32111-0003 - Erhebung der Abfallentsorgung; <sup>1)</sup>) are used for the estimation.

The data are published annually with an exception for the current year of reporting. Therefore, activity data for the current year of reporting are obtained, initially, by extrapolating the trend of the last 3 years. In the following year, when the actual activity data for the given year becomes available, they replace the extrapolated data. This procedure has only a very small impact on the total emissions in the relevant current report year.

## Emission factors

The emission factor used for calculating NH<sub>3</sub> emissions is based on emission data from a research project <sup>2)</sup>. The NH<sub>3</sub>-EF is 222 g/t and used for the whole time series. The use of abatement technologies (such as biofilters) are taken into account.

## Uncertainties

The AD from Statistisches Bundesamt have an uncertainty of  $\pm 2\%$  whereas the uncertainty for the EF is -59/+130% (ibid.).

## Recalculations

When preparing the current inventory data, statistical data are only available for the previous reporting year. The current reporting year must therefore be extrapolated on the basis of the previous year. The result of this approach is revised by the correct data in the following year. For this reason, annual recalculations are required for the previous year.

Table 1: Revised biowaste activity data, in [kt]

|                     | 2023  |
|---------------------|-------|
| current submission  | 8,115 |
| previous submission | 7,948 |

Table 2: Accordingly revised NH<sub>3</sub> emissions for 2023, in [t]

|                     |       |
|---------------------|-------|
| current submission  | 1,802 |
| previous submission | 1,765 |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

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<sup>1)</sup> Statistisches Bundesamt, GENESIS, Table Nr. 32111-0003 - Erhebung der Abfallentsorgung; Wiesbaden;  
<https://www-genesis.destatis.de/genesis//online?operation=table&code=32111-0003&bypass=true&levelindex=0&levelid=1630573034654#abreadcrumb>

<sup>2)</sup> Carsten Cuhls, Birte Mähl, Joachim Clemens; gewitra Ingenieurgesellschaft für Wissenstransfer mbH: Ermittlung der Emissionssituation bei der Verwertung von Bioabfällen; im Auftrag des Umweltbundesamtes, April 2015.  
<https://www.umweltbundesamt.de/publikationen/ermittlung-der-emissionssituation-bei-der>

## 5.B.2 - Biological Treatment of Waste: Anaerobic Digestion at Biogas Facilities

### Short description

Within NFR category **5.B.2**, ammonia (NH<sub>3</sub>) emissions from the anaerobic digestion of organic waste at biogas facilities are reported.

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 5.B.2                                                                                     | CS                                   | NS | CS |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC                                                                                       | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|-----------------|----------------------------------------------------------------------------------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA              | NA                                                                                           | NA              | -/-             | NA                | NA               | NA  | NA | NA | NA           | NA   |
| <b>L/-</b>      | key source by <b>L</b> evel only                                                             |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b>      | key source by <b>T</b> rend only                                                             |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b>      | key source by both <b>L</b> evel and <b>T</b> rend                                           |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/-</b>      | no key source for this pollutant                                                             |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b>       | emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b>       | emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b>       | specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                 |                 |                   |                  |     |    |    |              |      |
| <b>*</b>        | no analysis done                                                                             |                 |                 |                   |                  |     |    |    |              |      |

Separately collected organic waste (biowaste) from e.g. households, public garden and park service, food industry, restaurants, canteens and from agriculture can be treated in two different ways: aerobically (composting) and anaerobically (biogas production).

The aim of the treatment reported under this category is the production of digestate, leading to the recycling of nutrients and organic matter.

The produced digestate is used as fertilizer or soil improver in agriculture or horticulture and also in private gardening. In Germany, about 50% of the organic waste is treated in anaerobic digestion plants and ammonia (NH<sub>3</sub>) is an important emission to air.

## Method

Emissions from anaerobic digestion at biogas facilities are not a key source and of minor priority. The Method in use is country specific, based on a Tier 2 approach that is in accordance with the IPCC Guidelines 2006.

### Activity data

Official statistical data (Statistisches Bundesamt, GENESIS, TableNr. 32111-0003 - Erhebung der Abfallentsorgung <sup>1)</sup>) and a Statistical Report on waste disposal <sup>2)</sup> are used for the estimation.

The data are published annually with an exception for the current year of reporting. Therefore, activity data for the current year of reporting are obtained, initially, by extrapolating the trend of the last 3 years. In the following year, when the actual activity data for the given year becomes available, they replace the extrapolated data. This procedure has only a very small impact on the total emissions in the relevant current report year.

### Emission factors

The emission factor used for calculating NH<sub>3</sub> emissions is based on emission data from a research project <sup>3)</sup>. The NH<sub>3</sub>-EF is 274 g/t and used for the whole time series (which is starting in 1998).

## Uncertainties

The AD from Statistisches Bundesamt have an uncertainty of  $\pm 2\%$  whereas the uncertainty for the EF is -18/+920% (ibid.).

## Recalculations

When preparing the current inventory data, statistical data are only available for the previous reporting year. The current reporting year must therefore be extrapolated on the basis of the previous year. The result of this approach is revised by the correct data in the following year. For this reason, annual recalculations are required for the previous year.

Table 1: Revised biowaste activity data, in [kt]

|                     | 2023  |
|---------------------|-------|
| current submission  | 7,262 |
| previous submission | 7,416 |

Table 2: Accordingly revised NH<sub>3</sub> emissions, in [t]

|                     | 2023  |
|---------------------|-------|
| current submission  | 1,990 |
| previous submission | 2,032 |



For **pollutant-specific information on recalculated emission estimates** for Base Year and 2023, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

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<sup>1)</sup> Statistisches Bundesamt, GENESIS, TableNr. 32111-0003 - Erhebung der Abfallentsorgung; Wiesbaden;  
<https://www-genesis.destatis.de/genesis//online?operation=table&code=32111-0003&bypass=true&levelindex=0&levelid=1630573034654#abreadcrumb>

<sup>2)</sup> Statistisches Bundesamt, Statistischer Bericht Abfallentsorgung, TableNr. 32111-12; Wiesbaden;  
[https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Abfallwirtschaft/\\_inhalt.html#sprg238672](https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Abfallwirtschaft/_inhalt.html#sprg238672)

<sup>3)</sup> Carsten Cuhls, Birte Mähl, Joachim Clemens; gewitra Ingenieurgesellschaft für Wissenstransfer mbH: Ermittlung der Emissionssituation bei der Verwertung von Bioabfällen; im Auftrag des Umweltbundesamtes, April 2015.  
<https://www.umweltbundesamt.de/publikationen/ermittlung-der-emissionssituation-bei-der>

## 5.C.1.b v - Cremation

| Category Code                                                                             | Method                               | AD | EF    |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|-------|
| 5.C.1.b.v                                                                                 | CS                                   | AS | D, CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |       |
| <b>D</b>                                                                                  | Default                              |    |       |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |       |
| <b>T2</b>                                                                                 | Tier 2*                              |    |       |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |       |
| <b>C</b>                                                                                  | CORINAIR                             |    |       |
| <b>CS</b>                                                                                 | Country Specific                     |    |       |
| <b>M</b>                                                                                  | Model                                |    |       |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |       |
| <b>(source for) Activity Data</b>                                                         |                                      |    |       |
| <b>NS</b>                                                                                 | National Statistics                  |    |       |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |       |
| <b>IS</b>                                                                                 | International Statistics             |    |       |
| <b>PS</b>                                                                                 | Plant Specific                       |    |       |
| <b>As</b>                                                                                 | Associations, business organisations |    |       |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |       |
| <b>M</b>                                                                                  | Model / Modelled                     |    |       |
| <b>C</b>                                                                                  | Confidential                         |    |       |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |       |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |       |
| <b>CS</b>                                                                                 | Country Specific                     |    |       |
| <b>PS</b>                                                                                 | Plant Specific                       |    |       |
| <b>M</b>                                                                                  | Model / Modelled                     |    |       |
| <b>C</b>                                                                                  | Confidential                         |    |       |

| NO <sub>x</sub>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO  | Pb  | Cd  | Hg  | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAH1-4 | HCB | PCBs |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|-----|-----|-----|-----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|------|
| -/-                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | -/-    | -/-             | NA              | -/-               | -/-              | -/- | NE | -/- | -/- | -/- | -/- | NE | NE | NE | NE | NE | NE | -/-    | -/-   | -/-   | NE    | -/-   | -/-    | -/- | -/-  |
| <b>L/-</b> key source by <b>Level</b> only<br><b>-/T</b> key source by <b>Trend</b> only<br><b>L/T</b> key source by both <b>Level</b> and <b>Trend</b><br><b>-/-</b> no key source for this pollutant<br><b>IE</b> emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category)<br><b>NE</b> emission of specific pollutant <b>Not Estimated</b> (yet)<br><b>NA</b> specific pollutant not emitted from this source or activity = <b>Not Applicable</b><br><b>*</b> no analysis done |        |                 |                 |                   |                  |     |    |     |     |     |     |    |    |    |    |    |    |        |       |       |       |       |        |     |      |

### Method

Emissions from cremation are not a key source and of minor priority. Since March 1997, a national legal ordinance for cremation plants nationwide is in force (27. BImSchV).

### Activity data

Activity data for this category are based on data from the statistics of the “Bundesverband Deutscher Bestatter e.V.”<sup>1)</sup>. For purposes of GHG reporting we specify cremations as masses, too. The cremation is a growing trend in funerals.

Table 1: Annual amount of cremated human bodies, in [kt]

| 1990  | 1995  | 2000  | 2005  | 2010  | 2015  | 2020  | 2024  |
|-------|-------|-------|-------|-------|-------|-------|-------|
| 13.55 | 25.32 | 26.24 | 29.22 | 34.18 | 45.88 | 56.77 | 60.97 |



| 1990                                                                                                                                   | 1995 | 2000 | 2005 | 2010 | 2015 | 2020 | 2024 |
|----------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|------|------|------|
| data source: own calculation, conversion is not described in detail here for reasons of piety, but is comparable to other publications |      |      |      |      |      |      |      |

## Emission factors

Emission factors used are default values from the EMEP/EEA air pollutant emission inventory guidebook 2023 as well as national data for POPs from the research project “POP- und Hg-Emissionen aus abfallwirtschaftlichen Anlagen” - Teilvorhaben zum Globalvorhaben „Überprüfung des Standes der Technik der Emissionen prioritärer Schadstoffe für einzelne Industriebranchen (Kleinfeuerungsanlagen und abfallwirtschaftliche Anlagen)“<sup>2)</sup>.

In 2018, the TERT noted that the German emission factor for Hg is 100 times smaller than the default value proposed in the 2016 EMEP/EEA Guidebook and the emission factors for Cd and Pb being 1,000 times smaller than the proposed default values. The EF set has now been updated.

In contrast, the country-specific emission factor for Hg was calculated on the basis of the German report on “OSPAR Recommendation 2003/4 on controlling the dispersal of mercury from crematoria” - and was revised after the finalization of the research project „Umweltrelevanz und Stand der Technik bei Einäscherungsanlagen“ (Environmental relevance and state of the art for cremation plants)<sup>3)</sup>. As part of this research project, emission measurements were carried out at six cremation routes. According to OSPAR reporting 2010/2014, approx. 90% of the plants have effective Hg mitigation technology, whereas approx. 10% are not equipped. This ratio is roughly reflected in the 2020 project report, too. Since the cremation duration is approximately one hour, the mean value per hour corresponds to the Hg load per cremation and is used accordingly for inventory calculation.

As development of state of the art, values are interpolated between 2010 and 2018 (from 0,0913 g/cremation to 0,0447 g/cremation). This time span represents a real retrofit of the crematoria.

In 2025, we carried out a complete review of the emission factor (EF) references. This work resulted in a few minor changes to the time series, but most importantly, all time points are now referenced. The emission factors for Pb and Cd have been set to default values<sup>4)</sup> due to a lack of country specific references.

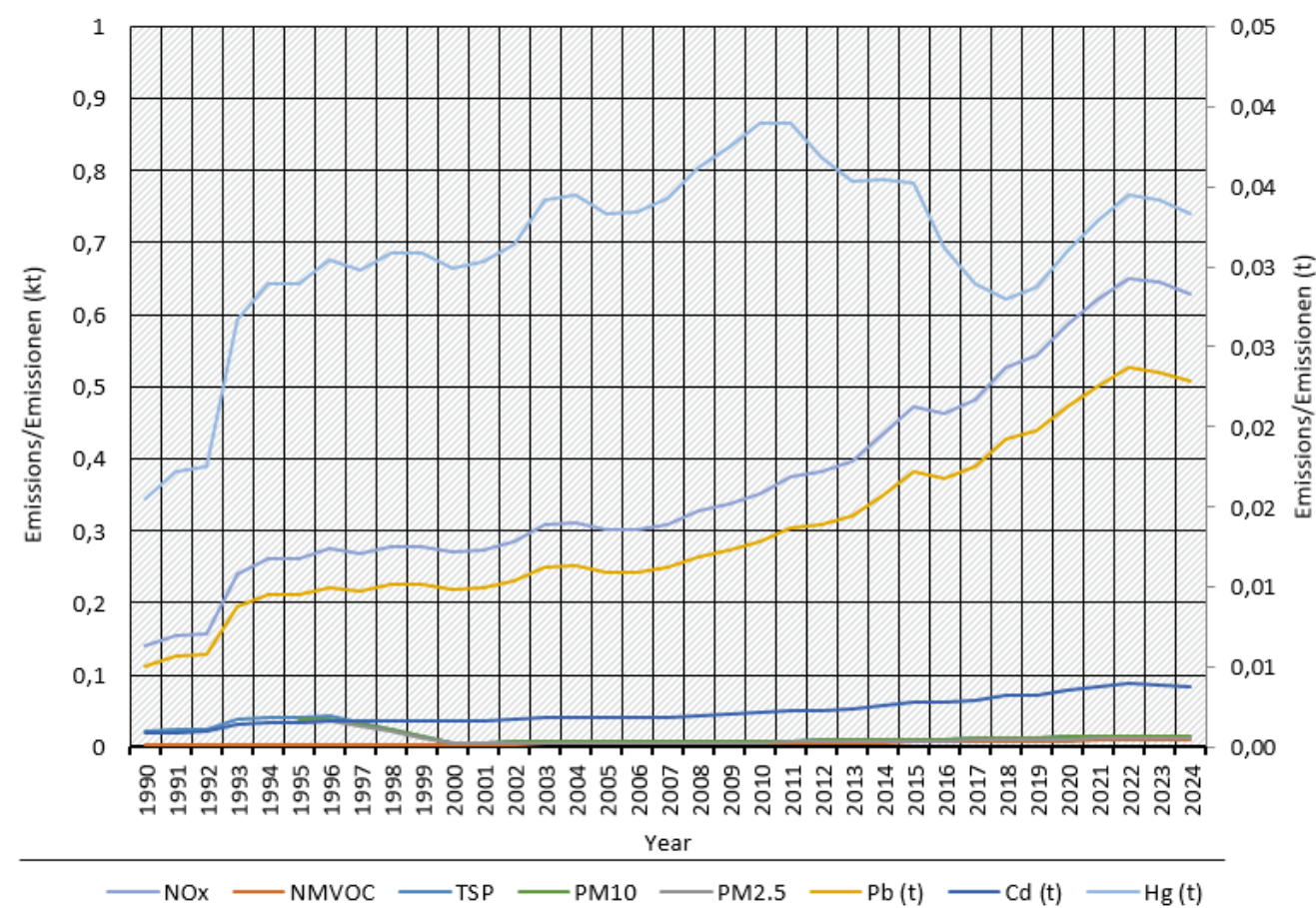
Emission factors for TSP, PM<sub>10</sub>, and PM<sub>2.5</sub> derive from the research study “Studie zur Korngrößenverteilung (PM<sub>10</sub> und PM<sub>2.5</sub>) von Staubemissionen”<sup>5)</sup>.

## Trends in emissions

Most emission trends are the result of the increasing trend of AD, partly with decreasing EF at the same time. As result even the trend for Hg emissions is decreasing for a temporary period.

Trends of Emissions of Cremation

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995  
Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

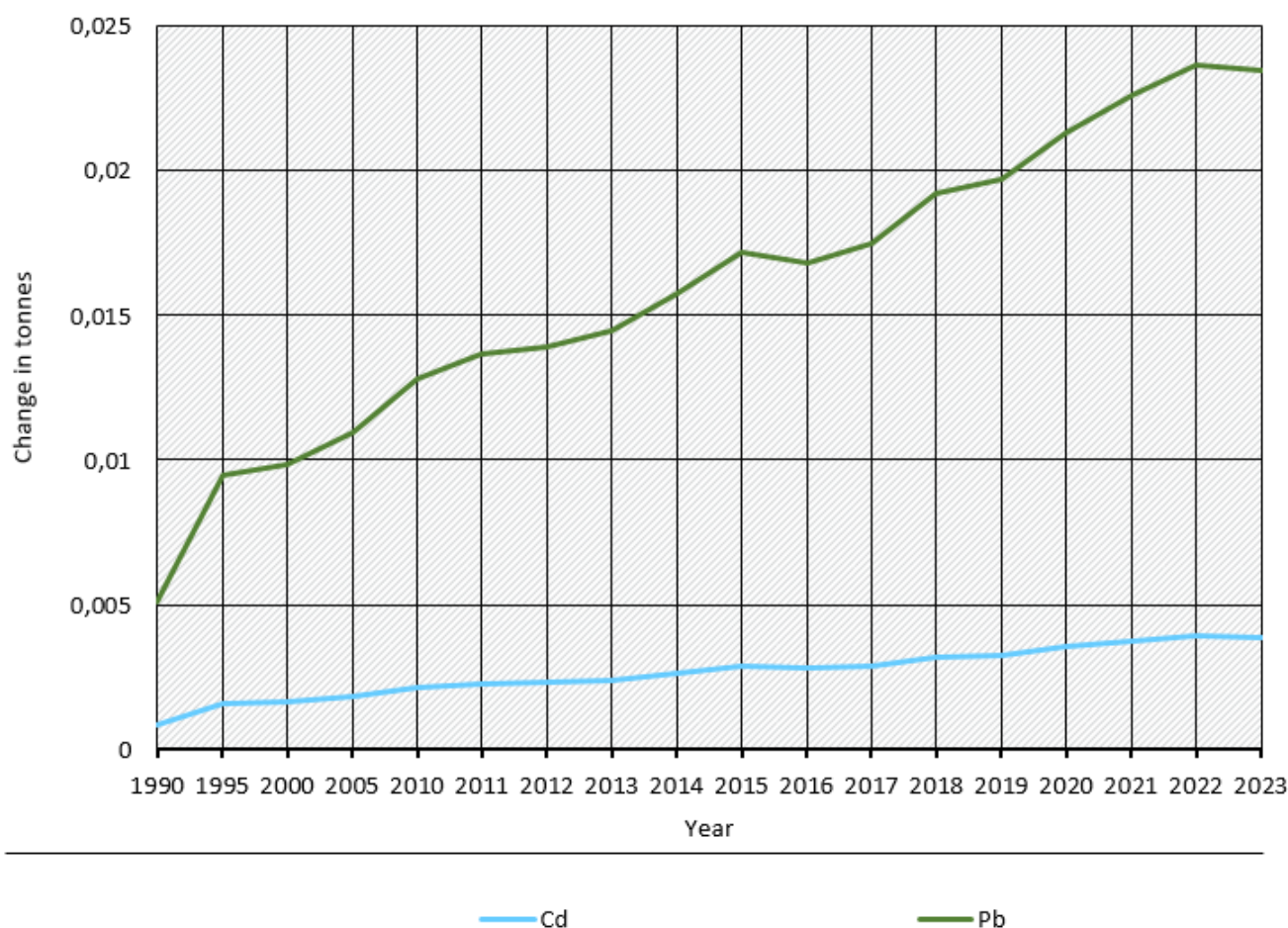
Emission trends in NFR 5.C.1.b.v

Recalculations

In addition to a number of marginal changes in the time series for several pollutants, there were significant changes in Pb and Cd. The increase over time is due to the replacement of decreasing EF with constant default values.

## Emissions in Germany in NFR category cremation

Absolute changes compared to last year's submission



Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

### Recalculations for Cremation



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

### Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> annual personal message from Stephan Neuser (contact URL: <https://www.bestatter.de/verband/allgemeines-ueber-den-bdb/>)

<sup>2)</sup> Stöcklein, Gass u. Suritsch, 2016: "POP- und Hg-Emissionen aus abfallwirtschaftlichen Anlagen", Teilvorhaben zum Globalvorhaben „Überprüfung des Standes der Technik der Emissionen prioritärer Schadstoffe für einzelne Industriebranchen (Kleinf Feuerungsanlagen und abfallwirtschaftliche Anlagen“; URL: [https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/texte\\_38\\_2016\\_pop-und\\_hg-emissionen\\_aus\\_](https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/texte_38_2016_pop-und_hg-emissionen_aus_)

[abfallwirtschaftlichen\\_anlagen.pdf](#); UBA-Texte 38/2016; im Auftrag des Umweltbundesamtes, April 2016

<sup>3)</sup> Schetter, Dr. G., Bittig, Dr. M. (2020): Schetter GmbH & Co. KG mit Köngen Institut für Energie- und Umwelttechnik e. V., Duisburg, im Auftrag des Umweltbundesamtes, FKZ 3716 53 3021 „Umweltrelevanz und Stand der Technik bei Einäscherungsanlagen“ (Environmental relevance and state of the art for cremation plants); URL:

<https://www.umweltbundesamt.de/publikationen/umweltrelevanz-stand-technik-einaescherungsanlagen>; ISSN 1862-4804, Köngen/Duisburg/Dessau-Roßlau, August 2019

<sup>4)</sup> EMEP/EEA, 2023: EMEP/EEA air pollutant emission inventory guidebook 2023, Copenhagen, 2023,

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023>

<sup>5)</sup> Dreiseidler, A., Baumbach, G., Pregger, T., Obermeier, A. (1999): Studie zur Korngrößenverteilung ( $< PM_{10}$  und  $< PM_{2,5}$ ) von Staubemissionen. UBA-Forschungsbericht 297 44 853, Umweltbundesamt Berlin (Study on particle size distribution ( $< PM_{10}$  and  $< PM_{2,5}$ ) of dust emissions)

## 5.C.2 - Open Burning of Waste

| Category Code                                                                             | Method                               | AD | EF    |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|-------|
| 5.C.2                                                                                     | CS                                   | Q  | D, CS |
| <b>Method(s) applied</b>                                                                  |                                      |    |       |
| <b>D</b>                                                                                  | Default                              |    |       |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |       |
| <b>T2</b>                                                                                 | Tier 2*                              |    |       |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |       |
| <b>C</b>                                                                                  | CORINAIR                             |    |       |
| <b>CS</b>                                                                                 | Country Specific                     |    |       |
| <b>M</b>                                                                                  | Model                                |    |       |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |       |
| <b>(source for) Activity Data</b>                                                         |                                      |    |       |
| <b>NS</b>                                                                                 | National Statistics                  |    |       |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |       |
| <b>IS</b>                                                                                 | International Statistics             |    |       |
| <b>PS</b>                                                                                 | Plant Specific                       |    |       |
| <b>As</b>                                                                                 | Associations, business organisations |    |       |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |       |
| <b>M</b>                                                                                  | Model / Modelled                     |    |       |
| <b>C</b>                                                                                  | Confidential                         |    |       |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |       |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |       |
| <b>CS</b>                                                                                 | Country Specific                     |    |       |
| <b>PS</b>                                                                                 | Plant Specific                       |    |       |
| <b>M</b>                                                                                  | Model / Modelled                     |    |       |
| <b>C</b>                                                                                  | Confidential                         |    |       |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub>                                                                               | PM <sub>10</sub> | TSP | BC  | CO  | Pb  | Cd  | Hg | As | Cr  | Cu  | Ni  | Se  | Zn  | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCB | PCB |
|-----------------|--------|-----------------|-----------------|-------------------------------------------------------------------------------------------------|------------------|-----|-----|-----|-----|-----|----|----|-----|-----|-----|-----|-----|--------|-------|-------|-------|-------|------|-----|-----|
| -/-             | -/-    | -/-             | NE              | -/-                                                                                             | -/-              | -/- | -/- | -/- | -/- | -/- | NE | NE | -/- | -/- | -/- | -/- | -/- | -/-    | -/-   | -/-   | -/-   | -/-   | -/-  | NE  | NE  |
|                 |        |                 |                 | L/- key source by <b>Level</b> only                                                             |                  |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | -/T key source by <b>T</b> rend only                                                            |                  |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | L/T key source by both <b>Level</b> and <b>T</b> rend                                           |                  |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | -/- no key source for this pollutant                                                            |                  |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | IE emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |                  |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | NE emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |                  |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | NA specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |                  |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | * no analysis done                                                                              |                  |     |     |     |     |     |    |    |     |     |     |     |     |        |       |       |       |       |      |     |     |

Within NFR sub-category 5.C.2 - Open Burning of Waste, the German emissions inventory provides only emissions from allowed bonfires and from other wooden materials burnt outdoors. Emissions from bonfires are key source for PM<sub>2.5</sub> and PM<sub>10</sub>, but in principle of minor priority due to discontinuous appearance.

Please see chapter regarding farming/plantation waste: [3.F - Field burning of agricultural residues](#) - this is banned by law in Germany. So there is no gap of reporting.

Emissions from open burning of wood and green waste for traditional purposes, so-called bonfires such as Easter fires, are reported model-based. In addition to biogenic carbon dioxide, emissions of NO<sub>x</sub>, SO<sub>2</sub>, CO, NMVOC, particulate matter (PM<sub>2.5</sub>, PM<sub>10</sub> and TSP), Polycyclic Aromatic Hydrocarbons (PAHs) and Heavy Metals are covered so far.

### Method

For developing of a estimation frame a survey regarding the number of such bonfires was carried out by an expert work <sup>1)</sup>.



As the result, questionnaires from municipalities and statistical projections for Germany for the year 2016 were checked. The project has shown a declining trend since 1990. On the basis of expert judgement, a further reduction of emissions in the future is expected.

As discussed on Review 2020 regarding all relevant sources: A comparison shows that the volume of bonfires is significantly higher than the volume of campfires. In terms of number, however, the two types of fires are similar. Due to the large fluctuations of the minimum/maximum values, the median was proposed in study.

In our view, the estimation of bonfires emissions is conservative and complete.

## Activity data

Activity data for this category are based on data from a step by step calculation: After the evaluation of the questionnaires an extrapolation of the volume and the number of bonfires was made for Germany. For the years since 2019, it became visible that, in addition to the model-based continuous decrease in activities, special aspects must be taken into account: Because of the restrictions on public activities during the pandemic, modeling of less traditional events was searched for.

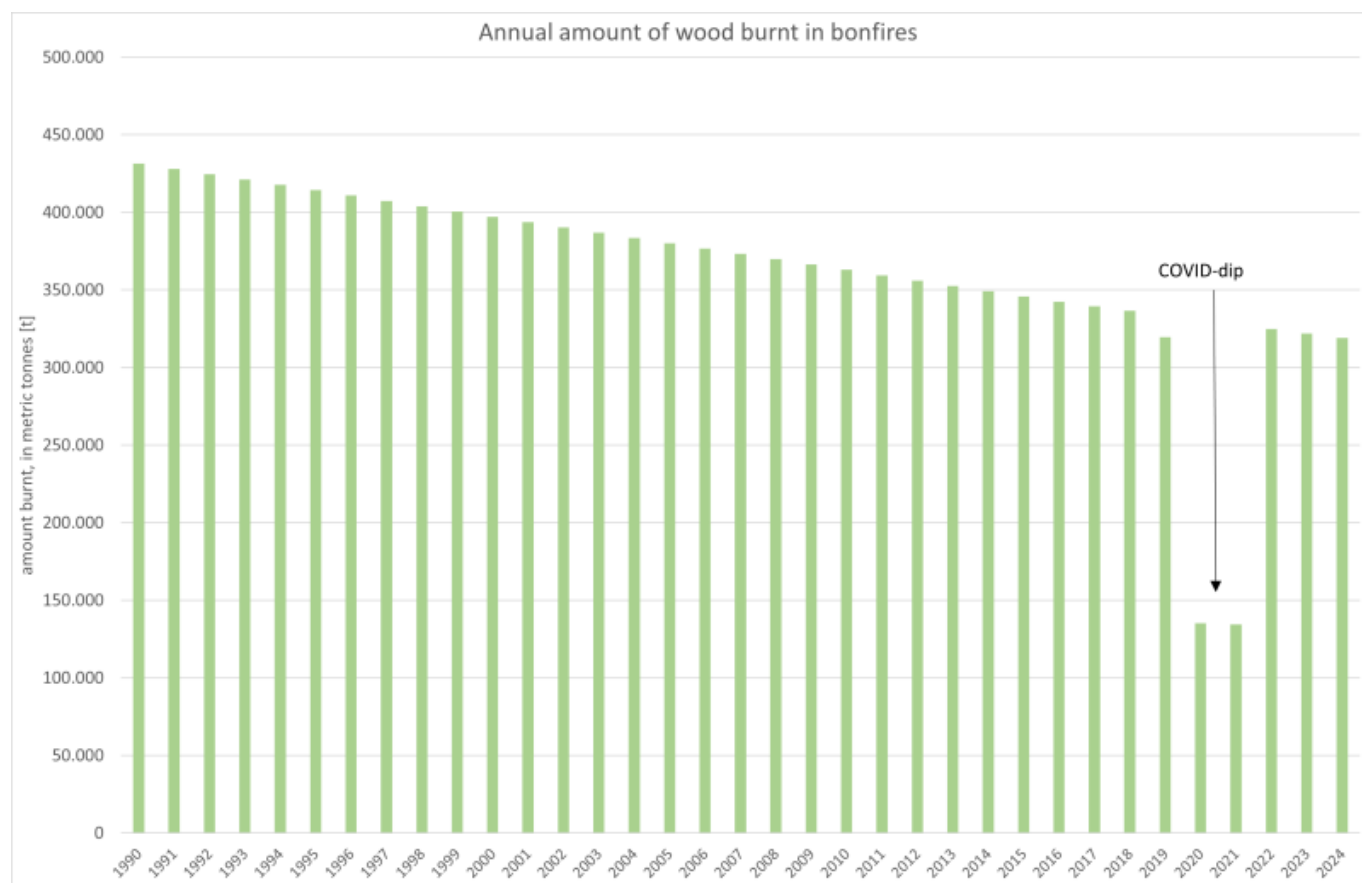
Two types of fires were already classified in the expert project: camp fires in the more private sector and, most importantly, Easter Fires in the more public sector. The calculations are now considered separately and the camp fires are modeled with a continued steady decline.

Here, Easter fires follow an approach based on a general percentage decrease of ~0.9% per year. Apart from this general approach, 2019 shows an additional 5 percentage points decrease due to a exceptionally high risk for forest fires that lead to a ban on open fires. Furthermore for 2020 and 2021, an additional 60 percent decrease was modeled due to cancellations for pandemic response (no 100% collapse due to local exceptions and follow-up events). For all years as of 2022 no such additional restrictions were modelled with the trend returning to the path left after 2018.

The following values are the result of evaluation:

Table 1: Total annual mass of bonfires, in metric tonnes [t]

| 1990    | 1995    | 2000    | 2005    | 2010    | 2015    | 2016    | 2017    | 2018    | 2019    | 2020    | 2021    | 2022    | 2023    | 2024    |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 431,394 | 414,275 | 397,157 | 380,038 | 362,919 | 345,800 | 342,376 | 339,466 | 336,556 | 319,531 | 135,170 | 134,297 | 324,915 | 322,005 | 319,094 |



## Emission factors

As discussed on Review 2020 regarding EF used and referenced: We use different EF from different references suitable for the burning of wooden wastes. We consider both fresh wood (garden and park waste) and dry wood (without coatings etc.). We have tried to find relevant parallels, for example because of the burning of fresh wood with regard to forest fires.

However, the majority of emission factors is derived from the EMEP/EEA Guidebook 2023 for 5.C.2, evaluated and corrected in use, as shown in the following table:

Table 2: Emission factors applied for emissions from bonfires

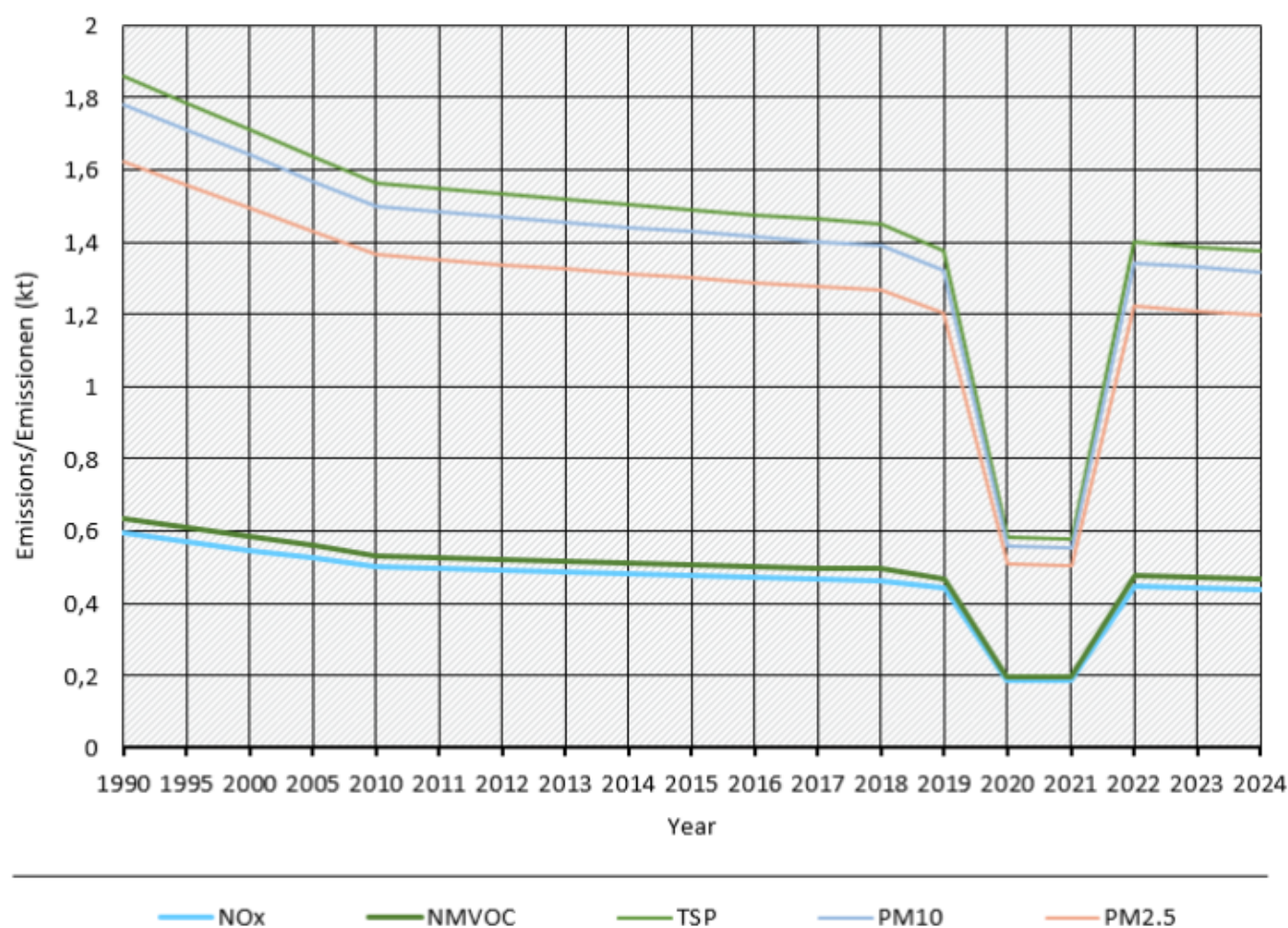
|                         | value | unit | Current reference                                                                                                                                                                                                                                                                |
|-------------------------|-------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO</b>               | 48.8  | kg/t | EMEP/EEA Guidebook 2023, Chapter 5.C.2 Open burning of waste, table 3-2: Tier 2 emission factors for source category 5.C.2 Small-scale waste burning, forest residues <sup>2)</sup>                                                                                              |
| <b>NO<sub>x</sub></b>   | 1.38  | kg/t |                                                                                                                                                                                                                                                                                  |
| <b>SO<sub>2</sub></b>   | 0.03  | kg/t |                                                                                                                                                                                                                                                                                  |
| <b>NM VOC</b>           | 1.47  | kg/t |                                                                                                                                                                                                                                                                                  |
| <b>TSP</b>              | 4.31  | kg/t |                                                                                                                                                                                                                                                                                  |
| <b>PM<sub>10</sub></b>  | 4.13  | kg/t |                                                                                                                                                                                                                                                                                  |
| <b>PM<sub>2.5</sub></b> | 3.76  | kg/t |                                                                                                                                                                                                                                                                                  |
| <b>BC</b>               | 1.05  | kg/t | EMEP/EEA Guidebook 2023, Chapter 5.C.2 Open burning of waste, table 3-2: f-BC = 28% of PM <sub>2.5</sub> <sup>3)</sup>                                                                                                                                                           |
| <b>PCDD/F</b>           | 10.0  | µg/t | EMEP/EEA Guidebook 2023, Chapter 5.C.2 Open burning of waste, table 3-1 - Tier 1 emission factors for source category 5.C.2 Small-scale waste burning <sup>4)</sup>                                                                                                              |
| <b>PAH</b>              | 3.39  | g/t  | sum of single compounds                                                                                                                                                                                                                                                          |
| <b>B[a]P</b>            | 1.3   | g/t  | IIR Ireland: EFs are referenced to a former research project called 'Use of charcoal, tobacco etc.', a literature research, which is only available via the UBA library and in German. The EFs are relating to wood burning as it was documented in Ireland's IIR. <sup>5)</sup> |
| <b>B[b]F</b>            | 1.5   | g/t  |                                                                                                                                                                                                                                                                                  |
| <b>B[k]F</b>            | 0.5   | g/t  |                                                                                                                                                                                                                                                                                  |
| <b>I[... ]P</b>         | 0.09  | g/t  |                                                                                                                                                                                                                                                                                  |
| <b>Pb</b>               | 0.32  | g/t  | EMEP/EEA Guidebook 2023, Chapter 5.C.2 Open burning of waste, table 3-2: Tier 2 emission factors for source category 5.C.2 Small-scale waste burning, forest residues <sup>6)</sup>                                                                                              |
| <b>Cd</b>               | 0.13  | g/t  |                                                                                                                                                                                                                                                                                  |

## Trends in emissions

With no annual emission factors (no emission reduction measures implemented or to be expected), emission development correspond to the trend of activity data. Accordingly, 2020 and 2021 show a strong decrease for all covered pollutants due to the Covid pandemic and the restrictions on public life visible such as locally organized traditional bonfires (Easter or solstice fires etc.).

## Trends of Emissions in Germany in NFR-category Bonfires

Emissions by pollutant / Emissionen nach Schadstoff



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

### Emission trends of bonfires

## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> Wagner, J. & Steinmetzer, S., 2018: INTECUS GmbH Abfallwirtschaft und umweltintegratives Management: Erhebung der Größen und Zusammensetzung von Brauchtu- und Lagerfeuern durch kommunale Befragungen;



[https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2018-02-19\\_texte\\_11-2018\\_lager-brauchtu-msfeuer.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2018-02-19_texte_11-2018_lager-brauchtu-msfeuer.pdf); UBA-Texte 11/2018, Dessau-Roßlau, 2018

<sup>2), 3), 4), 6)</sup> EMEP/EEA, 2023: EMEP/EEA air pollutant emission inventory guidebook 2023; 5.C.2 Open burning of waste, <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/5-waste/5-c-2-open-burning/@@download/file>, EEA, Copenhagen, 2023

## 5.D.1 - Domestic & Commercial Wastewater Handling

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 5.D.1                                                                                     | T1                                   | NS | D  |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub>                                                                               | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|-----------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA                                                                                            | -/-    | NA              | NA              | NA                | NA               | NA  | NA | NA | NA           | NA   |
| <b>L/-</b> key source by <b>Level</b> only                                                    |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>Trend</b> only                                                    |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>Level</b> and <b>Trend</b>                                   |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/-</b> no key source for this pollutant                                                   |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b> emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b> emission of specific pollutant <b>Not Estimated</b> (yet)                           |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b> specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>*</b> no analysis done                                                                     |        |                 |                 |                   |                  |     |    |    |              |      |

In category **5.D.1**, NMVOC emissions from domestic and commercial wastewater handling are reported. The domestic section is covered by wastewaters of municipal origin (large centralised plants; ranging from 1,000 up to >100,000 resident values). The commercial section is covered by industrial and commercial wastewaters, co-treated in municipal wwt-plants.

According to national experts, dry toilets (including latrines) do not play a role in sewage treatment in Germany because they are not in compliance with the legislation and thus do not constitute a procedure of orderly wastewater disposal. Due to that reason NH<sub>3</sub> emissions cannot be estimated and the notation key is set to NA.

§ 55 of the German water resources act (german: Wasserhaushaltsgesetz, WHG) demands the assuring of the general wellbeing in order of the wastewater disposal (german: gemeinwohlverträgliche Abwasserentsorgung). To ensure this requirement the water regarding laws of the several federal states of Germany (e.g. § 46 Abs. 1 WG BW; Art. 34 BayWG) obligate to the transfer of wastewater from the citizen to the public authorities or to assigned companies (german:

Überlassungspflicht). The details are described in municipal bylaws which for the most cases obligate to the connection to the municipal wastewater infrastructure (german: Anschluss- und Benutzungszwang). Exceptions are possible but most likely realised in form of septic tanks or drainless cesspools.

We assume that if there are very little exceptions for dry-toilets on a municipal level, that those are demanded to be separating toilets, as urine and faeces would be collected separately. Because of the necessary contact between urine and faeces to build ammonia from urea (contained in urine) by hydrolysis through urease (enzyme, contained in faeces) and the assumed very little number of exceptions, there are no assessable emissions of ammonia.

The superior federal law (WHG) described above was redesigned and implemented in its current form in the year 2009 following the reform of federalism (german: Föderalismusreform) and to implement requirements from the 2000/60/EC Water Framework Directive. The regulation has been described by the laws of the federal states before this time but latest with the implementation of the requirements of the 91/271/EEC directive concerning urban waste water treatment (e.g. BayROKAbwV).

## Method

Emissions reported under this category are calculated using the Tier1 approach of the EMEP/EEA Guidebook 2023, where the emission factor (EF) is 15 mg/m<sup>3</sup> wastewater (Part B, 5.D, chap. 3.2.2, Table 3-1, p. 7 <sup>1)</sup>). This EF is multiplied with the total amount of wastewater (AD) treated in domestic and commercial wwt-plants, following the equation:

$$EM_{NMVOC} = AD \times EF \text{ (} \textit{ibid.}, \textit{chap.3.2.1} \text{)}$$

## Activity data

Total volumes of treated municipal wastewater are derived by the German statistical agency (until reporting year 2021 Statistisches Bundesamt, Fachserie 19, Reihe 2.1.2 <sup>2)</sup> and from reporting year 2022 onward, Statistischer Bericht - Erhebung der öffentlichen Abwasserbehandlung <sup>3)</sup>). The data source is published on a three-year basis with new data only for the respective year of the update. The availability of the data starts in 1991 with an exception for the following update, which was for 1995. Missing data are inter- or extrapolated.

## Emission factors

See method

## Uncertainties

The AD from Statistisches Bundesamt have an uncertainty of  $\pm 3\%$  (normal distribution) whereas the uncertainty for the EF, due to its range (5/50 mg/m<sup>3</sup>), is -70 / +210 % and the distribution lognormal.

## Recalculations

Recalculations had to be executed for the years 2020 – 2023 because of new statistical data for 2022. Therefore, it was necessary to replace data that had formerly been extrapolated. Data for 2020 and 2021 are now interpolated and data for 2023 and 2024 are extrapolated. The amount of total wastewater reported for 2022 is smaller than the formerly extrapolated value. Therefore, the amount of the reported emissions for the years 2020-2023 are slightly decreasing.

|                  | Unit              |           | 2020          | 2021          | 2022          | 2023          |
|------------------|-------------------|-----------|---------------|---------------|---------------|---------------|
| Total Wastewater | [m <sup>3</sup> ] | Subm 2026 | 8,808,439,667 | 8,568,937,333 | 8,329,435,000 | 8,089,932,667 |
|                  |                   | Subm 2025 | 8,870,238,667 | 8,692,535,333 | 8,514,832,000 | 8,337,128,667 |
| NMVOC emitted    | [kt]              | Subm 2026 | 0.132         | 0.129         | 0.125         | 0.121         |
|                  |                   | Subm 2025 | 0.133         | 0.130         | 0.128         | 0.125         |



For **pollutant-specific information on recalculated emission estimates** for Base Year and 2023, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

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<sup>1)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; Part B, Chapter 5.D Wastewater handling; page 7, 3.2.2 - Default emission factors, Table 3-1; Copenhagen 2023.

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/5-waste/5-d-wastewater-handling/@@download/file>

<sup>2)</sup> Statistisches Bundesamt; Fachserie 19: Reihe 2.1.2

<sup>3)</sup> Statistisches Bundesamt; Statistischer Bericht - Erhebung der öffentlichen Abwasserbehandlung; Table 32213-08; [https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Wasserwirtschaft/Publikationen/Downloads-Wasserwirtschaft/statistischer-bericht-abwasser-oeffentlich-2190212229005.xlsx?\\_\\_blob=publicationFile&v=4](https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/Wasserwirtschaft/Publikationen/Downloads-Wasserwirtschaft/statistischer-bericht-abwasser-oeffentlich-2190212229005.xlsx?__blob=publicationFile&v=4)

## 5.D.2 - Industrial Wastewater Handling

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 5.D.2                                                                                     | T1                                   | NS | D  |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub>                                                                                        | NMVOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|--------------------------------------------------------------------------------------------------------|-------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA                                                                                                     | -/-   | NA              | NA              | NA                | NA               | NA  | NA | NA | NA           | NA   |
| <b>L/-</b> key source by <b>L</b> evel only                                                            |       |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>T</b> rend only                                                            |       |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend                                          |       |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/-</b> no key source for this pollutant                                                            |       |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b> emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |       |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b> emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |       |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b> specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |       |                 |                 |                   |                  |     |    |    |              |      |
| * no analysis done                                                                                     |       |                 |                 |                   |                  |     |    |    |              |      |

In category **5.D.2**, **NMVOC emissions** from industrial wastewater handling are reported. The industrial section is covered by wastewaters from industrial processes. Main sectors are chemical industries, iron & steel industries, power generation, Food sector, Paper & Cardboard-production and "Other"-Industrial processes.

### Method

Emissions reported under this category are calculated using the Tier 1 approach of the EMEP/EEA Guidebook 2023, where the emission factor (EF) is 15 mg/m<sup>3</sup> wastewater (Part B, 5.D, chap. 3.2.2, Table 3-1, p. 7 <sup>1)</sup>). This EF is multiplied with the total amount of wastewater (AD) treated in industrial wwt-plants, following the equation:

$$EM_{NMVOC} = AD \times EF \text{ (} \textit{ibid.}, \textit{chap.3.2.1} \text{)}$$

## Activity data

Total volumes of treated industrial wastewater are derived by the German statistical agency (Statistisches Bundesamt, Umweltnutzung und Wirtschaft. Tabellen zu den Umweltökonomischen Gesamtrechnungen. Teil 4: Wassereinsatz, Abwasser. Table 7.7 <sup>2)</sup>). The availability of the data starts in 1991 with new data for every following year, until 2001. Until then the data source is published on a three-year basis with new data only for the respective year of the update. Missing data are interpolated. Since the Wastewaterstatistic has not been updated since 2016, the data for Chemical Industry and Paper&Cardboard has been extrapolated until 2017 on the basis of an expert judgment, assuming for the Chemical Industry a yearly reduction of 1% and for Paper&Cardboard of 1,5%. For the remaining industries expert-judgement concluded that constant values since 2016 are deemed to be most probable.

## Emission factors

See method.

It should be noted that the described default emission factor was collected in Turkey for municipal wastewater treatment plants under specific climatic conditions in developing countries. The wastewater characteristics of the considered industries sometimes differ significantly from municipal wastewater.

## Uncertainties

The AD from Statistisches Bundesamt have an uncertainty of  $\pm 3\%$  (normal distribution) whereas the uncertainty for the EF, due to its range (5/50 mg/m<sup>3</sup>), is -70 / +210 % and the distribution lognormal.

## Recalculations

Recalculations were not necessary.



For **pollutant-specific information on recalculated emission estimates** for Base Year and 2023, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

## Planned improvements



At the moment, no category-specific improvements are planned.

<sup>1)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023; Part B, Chapter 5.D Wastewater handling; page 7, 3.2.2 - Default emission factors, Table 3-1; Copenhagen 2023.  
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/5-waste/5-d-wastewater-handling/@download/file>

<sup>2)</sup> Statistisches Bundesamt, Umweltnutzung und Wirtschaft. Tabellen zu den Umweltökonomischen Gesamtrechnungen. Teil 4: Wassereinsatz, Abwasser. Table 7.7

### 5.E - Other Waste (please specify in IIR)

Under NFR category **5.E - Other Waste**, Germany so far reports greenhouse gas emissions from the mechanical biological treatment (MBT) of waste as well as air-pollutant emissions from building and car fires.

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 5.E - Other Waste                                                                         | see sub-category details             |    |    |
| consisting of / including source categories:                                              |                                      |    |    |
| 5.E.1 - Mechanical Biological Treatment (MBT)                                             | NA (GHG emissions only)              |    |    |
| 5.E.2 - Building and Car Fires                                                            | D                                    | NS | D  |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub>                                                                      | PM <sub>10</sub> | TSP | BC  | CO | Pb  | Cd  | Hg  | As  | Cr  | Cu  | Ni | Se | Zn | PCDD/F | B(a)P | B(b)F | B(k)F | I(x)P | PAHs | HCB | PCB |
|-----------------|--------|-----------------|-----------------|----------------------------------------------------------------------------------------|------------------|-----|-----|----|-----|-----|-----|-----|-----|-----|----|----|----|--------|-------|-------|-------|-------|------|-----|-----|
| NE              | NE     | NE              | NE              | L/-                                                                                    | L/-              | -/- | L/- | NE | -/- | -/- | -/- | -/- | -/- | -/- | NE | NE | NE | L/-    | NE    | NE    | NE    | NE    | NE   | NE  | NE  |
|                 |        |                 |                 | L/- key source by <b>Level</b> only                                                    |                  |     |     |    |     |     |     |     |     |     |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | -/T key source by <b>Trend</b> only                                                    |                  |     |     |    |     |     |     |     |     |     |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | L/T key source by both <b>Level</b> and <b>Trend</b>                                   |                  |     |     |    |     |     |     |     |     |     |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | -/- no key source for this pollutant                                                   |                  |     |     |    |     |     |     |     |     |     |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | IE emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |                  |     |     |    |     |     |     |     |     |     |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | NE emission of specific pollutant <b>Not Estimated</b> (yet)                           |                  |     |     |    |     |     |     |     |     |     |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | NA specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |                  |     |     |    |     |     |     |     |     |     |    |    |    |        |       |       |       |       |      |     |     |
|                 |        |                 |                 | * no analysis done                                                                     |                  |     |     |    |     |     |     |     |     |     |    |    |    |        |       |       |       |       |      |     |     |

# 5.E.1 - Other Waste: Mechanical-biological Treatment of Waste

## Short description

Under NFR category 5.E.1 - Other Waste: Mechanical-biological Treatment of Waste, Germany only reports greenhouse gas emissions from the mechanical biological treatment (MBT) of waste.

| NFR Code | Name of Category                                      | Method | AD    | EF                                                    | Key Category |
|----------|-------------------------------------------------------|--------|-------|-------------------------------------------------------|--------------|
| 5.E.1    | Other Waste: Mechanical-biological Treatment of Waste | NA     | 5.E.1 | Other Waste: Mechanical-biological Treatment of Waste | NA           |



## 5.E.2 - Other Waste: Building and Car Fires

### Short description



For key source information please see the [Overview-chapter 5.E](#).

Within NFR 5.E.2 - Other Waste: Building and Car Fires, emissions from building and car fires are reported.

### Method

With a method for estimation the AD developed within a research project <sup>1)</sup>, and after publication of Tier2-EF within the EEA-Guidebook 2019 <sup>2)</sup>, a country-specific method was implemented and further developed so that now a full-scale-approach for all Buildings and the cars as well as an estimation for waste container fires can be conducted.

However, in all cases, only accidental fires are mentioned (including acts of vandalism).

### Activity data

Official population statistics for Germany are applied as primary activity data.

From these statistical input data, the number of fires is estimated via the following steps:

- specific values for number of fires per 1,000 inhabitants,
- differentiated according to building,
- vehicle and container fires,
- Determination of the number of relevant fires per year in Germany in total,
- Differentiation of the fires according to building and vehicle fires,
- Differentiation of fires according to fire scale,
- Differentiation of building fires by building category,
- Conversion of different fires per year to full-scale fires per year - see additional description,
- Transfer of the results on the number of fires in the form of number of full-scale fires per year differentiated by fire categories.

In order to apply the emission factors available from the EMEP/EEA Guidebook, the annual number of building fires is differentiated for detached and undetached, apartment and industrial buildings.

Table 1: Estimated shares per building category, for recent years

| detached houses | undetached houses | appartement buildings | industrial buildings |
|-----------------|-------------------|-----------------------|----------------------|
| 53%             | 13%               | 13%                   | 20%                  |

#### Description of Conversion to full-scale fires per year

During Review 2023 TERT asked for to more information of method zu fires' conversion, that is given following:

As other inventory compilers weighting factors were applied for each category in order to determine the number of full-scale fires. The idea is to assume that the default EF stands for complete burning of objects, but in real in most cases fires are extinguished as soon as possible.

Table 2: Percental shares of burnt combustible material per type of fire

| type of fire            | % of burnt combustible material |
|-------------------------|---------------------------------|
| Building fire, small a) | 5                               |

| type of fire              | % of burnt combustible material |
|---------------------------|---------------------------------|
| Building fire, small b)   | 30                              |
| Building fire, medium     | 75                              |
| Building fire, major      | 100                             |
| Car fires, small          | 5                               |
| Car fires, medium         | 30                              |
| Car fires, major          | 100                             |
| Container fires, standard | 50                              |

Germany uses the following information on EFs: It can be derived from the given information and references on building fires that EFs are given for full-scale fires <sup>3)</sup>. We have no country specific information, but the other approaches seem to be suitable for our situation, too.

Table 3: Estimated number of full-scale fires, per category, per 1,000 inhabitants, for recent years

| detached houses | undetached houses | appartement buildings | industrial buildings | cars/ vehicles | containers |
|-----------------|-------------------|-----------------------|----------------------|----------------|------------|
| 0.23            | 0.06              | 0.06                  | 0.09                 | 0.21           | 0.06       |

As results we calculate with with the following range of data:

Table 4: Estimated number of full-scale fires per year, per category, range over time

| detached houses | undetached houses | appartement buildings | industrial buildings | cars/ vehicles  | containers    |
|-----------------|-------------------|-----------------------|----------------------|-----------------|---------------|
| 15,700 - 17,000 | 4,100 - 5,300     | 4,200 - 4,700         | 6,500 - 6,600        | 15,000 - 15,400 | 4,100 - 4,200 |

## Emission Factors

For most pollutants, tier2 default values from the EMEP/EEA air pollutant emission inventory guidebook 2029 (as 2016), Chapter 5.E - Other waste, tables 3-2 to 3-6 are applied <sup>4)</sup>.

Due to lack of emissions factors for black carbon we assume the following analogy: BC = 10% of the default-EF for PM<sub>2.5</sub> as provided in Table 3-40, Tier2 emission factor for conventional stoves, wood and similar wood waste.

Regarding containers we use figures from Table 6.22 - Emission factors building fires as provided in the Danish IIR 2019 <sup>5)</sup>.

In contrast to building fires and in accordance to the emission factor values provided in the EMEP/EEA Guidebook, no additional differentiation e.g. of vehicle categories is implemented.

## Verification

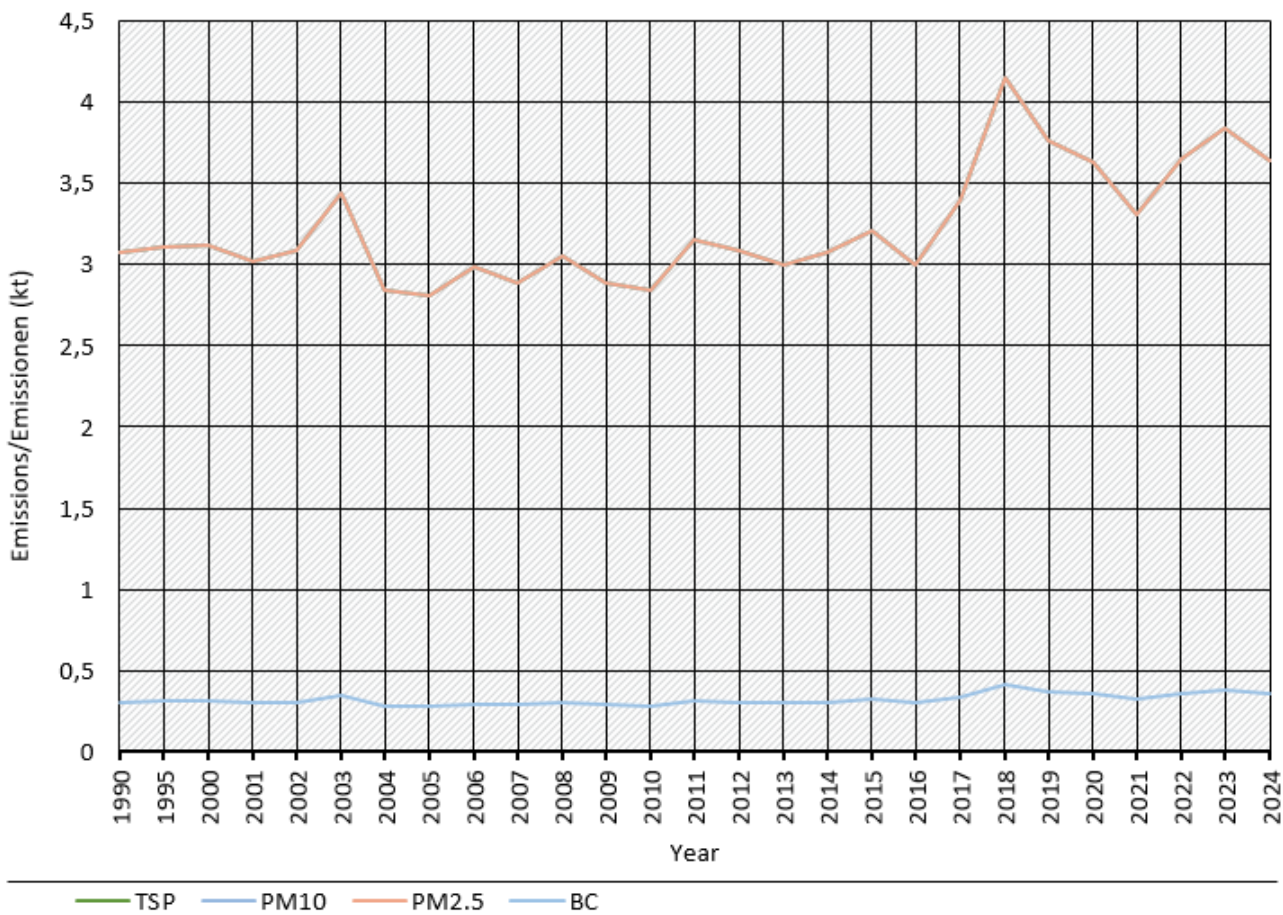
For verification purposes, a consultant has checked the Informative Inventory Reports (IIRs) of other countries. In the IIRs of Denmark and Iceland it is additionally stated that the emission factors refer to so-called "full-scale fires" and therefore the activity data (i.e. the number of fires) must be converted to so-called full-scale equivalent fires.

## Trends in emissions

All trends in emissions correspond to trends of AD. No rising trends are to identify, but a jump in 2003 due to many forest fires. Forest fires are part of the total fire AD and affect so the calculation in general, but here figures without forest fires are shown only:

Trends of Emissions in Germany from accidental fires

Emissions of particles, three fractions overlapped



\* Base Year for PM = 1995 / Basisjahr für Feinstäube (PM) ist 1995

Quelle: German Environment Agency, National inventory for the German reporting on atmospheric emissions since 1990, (03/2026)

Emission trends in NFR 5.E.2

Recalculations

Recalculations were necessary due to minor change of population figure of 2023.



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

Planned improvements



At the moment, it is planned to estimate emissions of fossil carbon dioxide based on results of a research project <sup>6)</sup>.

<sup>1)</sup> Project leader Site: [https://oekopol.de/en/archiv-en/?doc=EN\\_720](https://oekopol.de/en/archiv-en/?doc=EN_720), Publication in prep. as Umweltbundesamt 2021: Research-ID 3717411050, "Wissenschaftlich-methodische Grundlagen der Inventarverbesserung zur Umsetzung der Hinweise aus den Inventarüberprüfungen 2016 und 2017"

<sup>2)</sup>

<https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/5-waste/5-e-other-waste/view>

<sup>3)</sup> See IIR of Denmark and of Norway

<sup>4)</sup> EMEP/EEA, 2019: EMEP/EEA air pollutant emission inventory guidebook 2019; Chapter 5.E Other waste, <https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/5-waste/5-e-other-waste/@download/file>, Copenhagen, 2023

<sup>5)</sup> Nielsen, O.-K., Plejdrup, M.S., Winther, M., Mikkelsen, M.H., Nielsen, M., Gyldenkerne, S., Fauser, P., Albrechtsen, R., Hjelgaard, K.H., Bruun, H.G. & Thomsen, M. 2019. Annual Danish Informative Inventory Report to UNECE. Emission inventories from the base year of the protocols to year 2017. Aarhus University, DCE – Danish Centre for Environment and Energy, 549 pp. Scientific Report No. 313; <http://dce2.au.dk/pub/SR313.pdf>; 2019

<sup>6)</sup> <https://www.umweltbundesamt.de/publikationen/relevanz-fossiler-brandguter-bei-brandereignissen>, Publication of Umweltbundesamt 2026

# CHAPTER 7: NFR 6 - Other (anthropogenic) emission sources

| Category Code                               | Name of category                                    | Method             | AD | EF | Key Category |
|---------------------------------------------|-----------------------------------------------------|--------------------|----|----|--------------|
| 6                                           | Other Sources                                       | see sub-categories |    |    |              |
| consisting of / including source categories |                                                     |                    |    |    |              |
| 6.A.1                                       | Ammonia emissions from human sweating and breathing | T1                 | NS | D  |              |
| 6.A.2                                       | Ammonia emissions from pets                         | T1                 | NS | D  |              |
|                                             |                                                     |                    |    |    |              |

## 6 - Other Sources

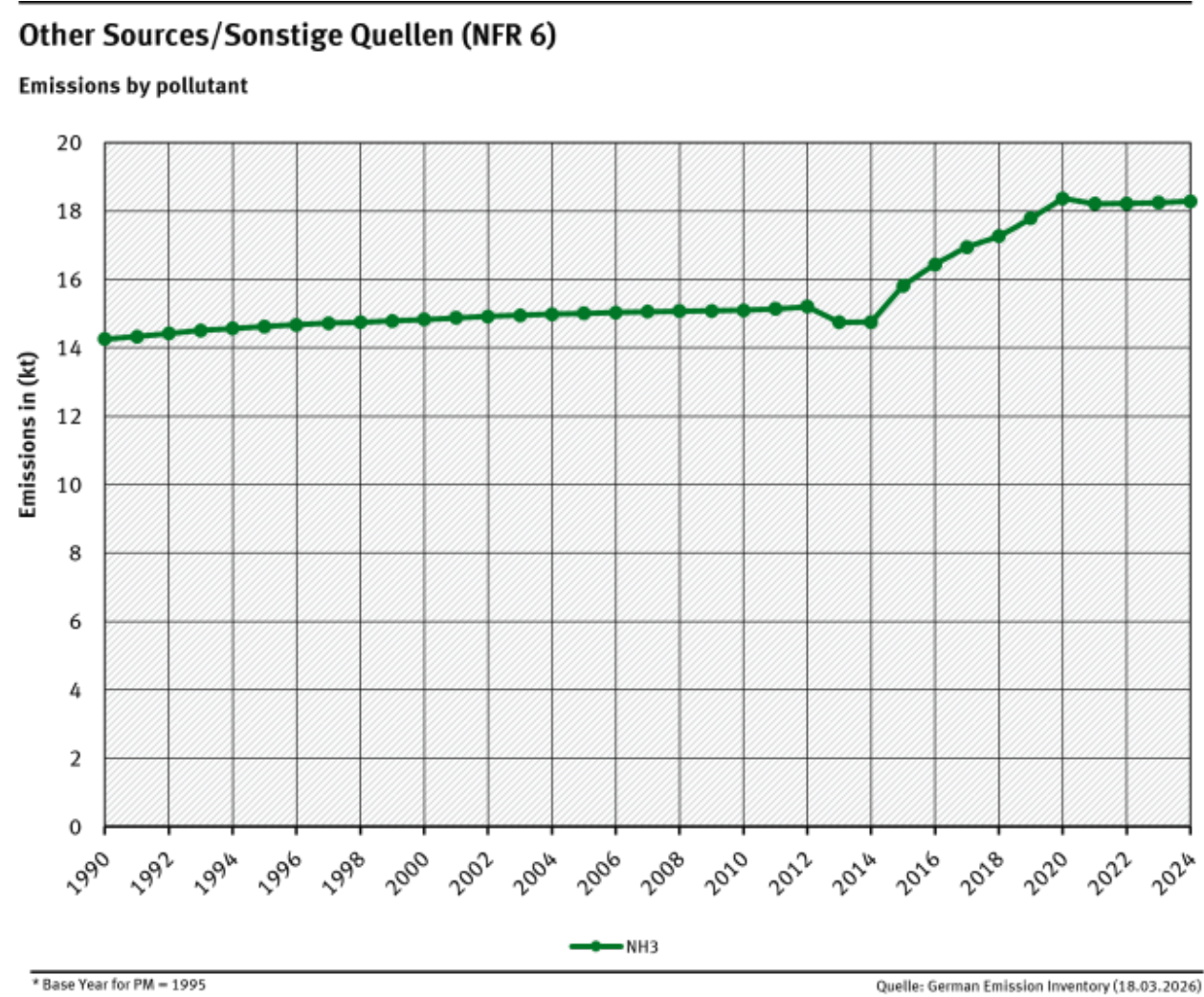
Within **NFR 6 - Other Sources**, activities and resulting emissions are taken into account that cannot be related to any of the other NFR categories.

For the time being, the two activities or emission sources taken into account here are human breathing (respiration) and sweating (transpiration) as well as domestic animals (pets).

| NFR code | NFR name                                   |
|----------|--------------------------------------------|
| 6.A.1    | Emissions from human re- and transpiration |
| 6.A.2    | Ammonia emissions from pets                |

### Overview

Emission trends for main pollutants in *NFR 6 - Other Sources*:



[Contribution of NFRs 1 to 6 to the National Totals, for 2024](#)



Contribution of NFR categories to the emissions/Anteile der NFR-Kategorien an den Emissionen

2024 percentages per air pollutant / Anteile pro Luftschadstoff für 2024



\* without transport ( ohne Verkehr (1.A.3)

Quelle: German Emission Inventory (06.02.2026)

## 6.A.1 - Ammonia emissions from human respiration and transpiration

### Short description

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 6.A.1                                                                                     | T1                                   | NS | D  |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub>                                                                               | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|-----------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA                                                                                            | NA     | NA              | -/-             | NA                | NA               | NA  | NA | NA | NA           | NA   |
| <b>L/-</b> key source by <b>Level</b> only                                                    |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>Trend</b> only                                                    |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>Level</b> and <b>Trend</b>                                   |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/-</b> no key source for this pollutant                                                   |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b> emission of specific pollutant <b>Included Elsewhere</b> (i.e. in another category) |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b> emission of specific pollutant <b>Not Estimated</b> (yet)                           |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b> specific pollutant not emitted from this source or activity = <b>Not Applicable</b> |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>*</b> no analysis done                                                                     |        |                 |                 |                   |                  |     |    |    |              |      |

In addition to animal-related excretion, nitrogen (N) is also introduced into the environment through human consumption of food and later disposed of.

Although nitrogen is released into the wastewater system as urine, mainly, physiological processes such as sweating and respiration also release nitrogen as ammonia.

### Methodology

The calculation of ammonia emissions in this area is made for the first time and is based on the methodological description of Visschendijk et al. (2022)<sup>1)</sup>.

For the complete time series, the emissions are calculated as follows:



$$EM = AD_{(population)} \times EF_{(kg\ EM\ per\ inhabitant)}$$

### Activity data

The number of inhabitants in Germany is derived from the Federal Statistical Office of Germany (DESTATIS) on an annual basis.

The number of people living in Germany by end of June of a specific year is taken as activity data. As of June 2023, 82,7 million people lived in Germany.

The following table shows the population figures over time.

Table 1: Population figures in Germany, as of 1990

|             |            |
|-------------|------------|
| <b>1990</b> | 79,753,227 |
| <b>1995</b> | 81,307,715 |
| <b>2000</b> | 81,456,617 |
| <b>2005</b> | 81,336,663 |
| <b>2010</b> | 80,284,071 |
| <b>2015</b> | 82,175,684 |
| 2016        | 82,521,653 |
| 2017        | 82,792,351 |
| 2018        | 83,019,213 |
| 2019        | 83,166,711 |
| <b>2020</b> | 83,155,031 |
| 2021        | 83,237,124 |
| 2022        | 83,118,501 |
| 2023        | 83,456,045 |
| <b>2024</b> | 83,577,140 |

### Emission factor

For the calculation of ammonia emissions in this category, the highest of the emission factors given in Sutton et al. (2000)<sup>2)</sup> are used, resulting in a total emission factor of 0.0826 kg NH<sub>3</sub>-N per person per year (according to the assumptions sum of 74.88 (sweating) and 7.7 (breathing) grams NH<sub>3</sub>-N per person per year, respectively).

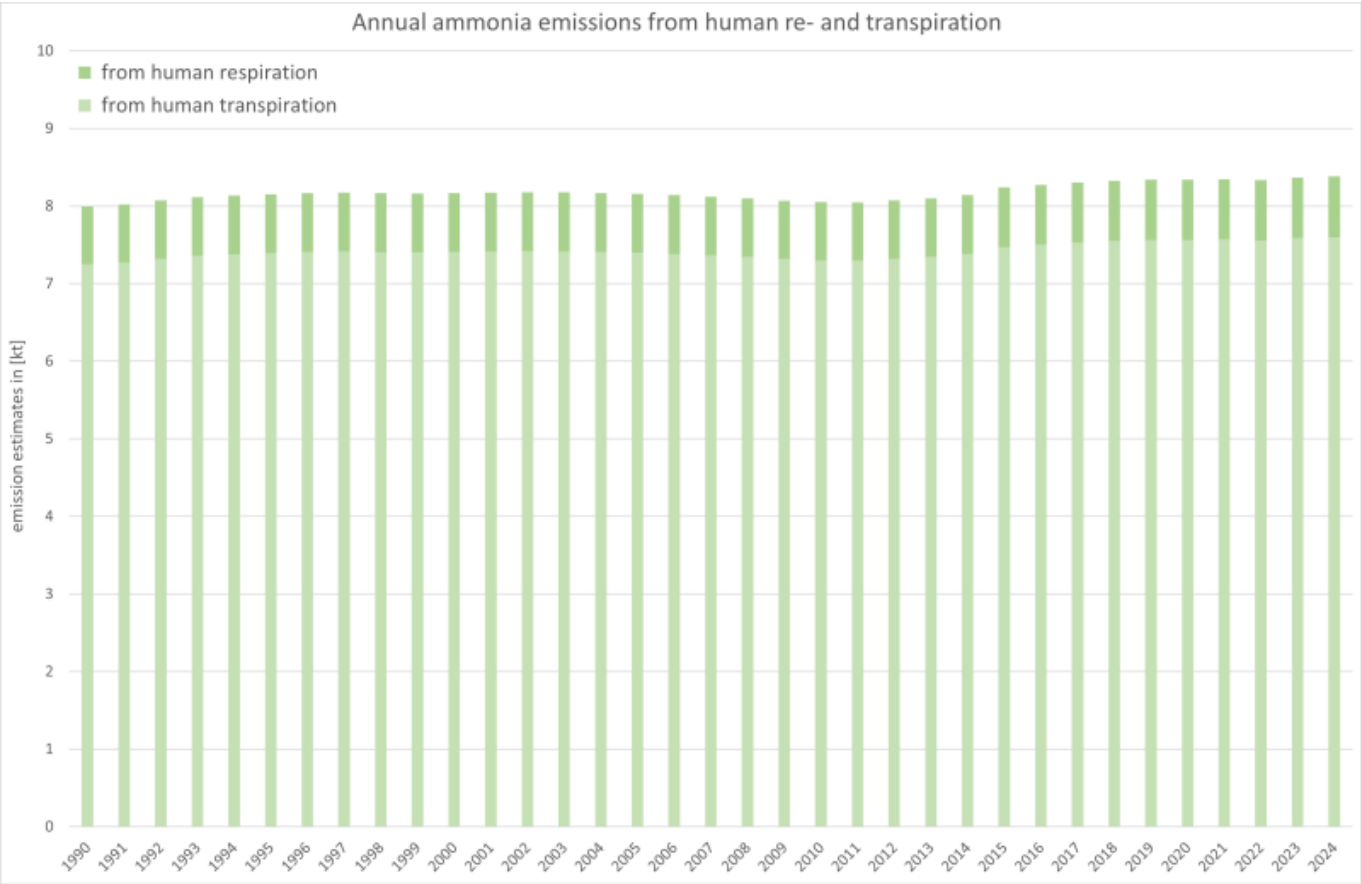
Here, to avoid underestimating of emissions, the higher EFs were applied.

The amount was converted to the amount of ammonia using the stoichiometric factor of 17/14.

### Emission Trend

The average value over the last decade is 8.3 kt NH<sub>3</sub> / year, so this category is not a major source of regional NH<sub>3</sub> emissions.

The following figure shows the emission trend as of 1990:



Recalculations

Recalculated emission estimates result from revised activity data for 2022 and 2023:

Table 2: Revised total population

|                     | 2022       | 2023       |
|---------------------|------------|------------|
| current submission  | 83,118,501 | 83,456,045 |
| previous submission | 82,711,282 | 82,711,282 |
| absolute change     | 407,219    | 744,763    |
| relative change     | 0.49%      | 0.90%      |



For **pollutant-specific information on recalculated emission estimates for Base Year and 2023**, please see the recalculation tables following [chapter 9.1 - Recalculations](#).

Uncertainties

Activity data obtained from the Federal Statistical Office of Germany (DESTATIS) usually have an uncertainty of  $\pm 3\%$ .

As emission factors vary between different data sources and the amount of ammonia volatilized is based on an assumption, uncertainties for the emission factors are expected to be relatively high.

Hence the overall uncertainty for the emission estimation of  $\text{NH}_3$  is estimated by expert judgement to be  $\pm 95\%$ .

Planned Improvement





At the moment, no source-specific improvements are planned.

- 
- <sup>1)</sup> Visschedijk, A.J.H., Meesters, J.A.J., Nijkamp, M.M., Koch, W.W.R., Jansen, B.I., Dröge, R. (2022): Methods used for the Dutch Emission Inventory. Product usage by consumers, construction and services. RIVM Report 2022-0003. chapter 19; <https://rivm.openrepository.com/bitstream/handle/10029/625730/2022-0003.pdf?sequence=1&isAllowed=y>, RIVM - National Institute for Public Health and the Environment Ministry of Health, Welfare and Sport, Bilthoven, 2022
- <sup>2)</sup> Sutton, M.A., Dragosits, U., Tang, Y.S., Fowler, D. (2000): Ammonia emissions from non-agricultural sources in the UK, Atmospheric Environment, Volume 34, Issue 6, 2000, Pages 855-869, ISSN 1352-2310, [https://doi.org/10.1016/S1352-2310\(99\)00362-3](https://doi.org/10.1016/S1352-2310(99)00362-3). (<https://www.sciencedirect.com/science/article/pii/S1352231099003623>); January 2000

## 6.A.2 - Ammonia emissions from pets

### Short description

In addition to non-agricultural sources of ammonia (NH<sub>3</sub>), this chapter discusses emissions from domestic animals (pets).

This emission source is taken into account for the first time with the current submission and with dogs and cats as the only two groups of pets covered so far.

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 6.A.2                                                                                     | T1                                   | NS | D  |
| Method(s) applied                                                                         |                                      |    |    |
| D                                                                                         | Default                              |    |    |
| T1                                                                                        | Tier 1 / Simple Methodology *        |    |    |
| T2                                                                                        | Tier 2*                              |    |    |
| T3                                                                                        | Tier 3 / Detailed Methodology *      |    |    |
| C                                                                                         | CORINAIR                             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| M                                                                                         | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| (source for) Activity Data                                                                |                                      |    |    |
| NS                                                                                        | National Statistics                  |    |    |
| RS                                                                                        | Regional Statistics                  |    |    |
| IS                                                                                        | International Statistics             |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| As                                                                                        | Associations, business organisations |    |    |
| Q                                                                                         | specific Questionnaires (or surveys) |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |
| (source for) Emission Factors                                                             |                                      |    |    |
| D                                                                                         | Default (EMEP Guidebook)             |    |    |
| CS                                                                                        | Country Specific                     |    |    |
| PS                                                                                        | Plant Specific                       |    |    |
| M                                                                                         | Model / Modelled                     |    |    |
| C                                                                                         | Confidential                         |    |    |

| NO <sub>x</sub>                                                                                        | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|--------------------------------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| NA                                                                                                     | NA     | NA              | -/-             | NA                | NA               | NA  | NA | NA | NA           | NA   |
| <b>L/-</b> key source by <b>L</b> evel only                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/T</b> key source by <b>T</b> rend only                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>L/T</b> key source by both <b>L</b> evel and <b>T</b> rend                                          |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>-/-</b> no key source for this pollutant                                                            |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>IE</b> emission of specific pollutant <b>I</b> ncluded <b>E</b> lsewhere (i.e. in another category) |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NE</b> emission of specific pollutant <b>N</b> ot <b>E</b> stimated (yet)                           |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>NA</b> specific pollutant not emitted from this source or activity = <b>N</b> ot <b>A</b> pplicable |        |                 |                 |                   |                  |     |    |    |              |      |
| <b>*</b> no analysis done                                                                              |        |                 |                 |                   |                  |     |    |    |              |      |

### Methodology

Ammonia emissions from pets have been calculated for the first time in submission 2024 and are based on the methodological description of Sutton et al. (2000)<sup>1)</sup> and the EMEP/EEA Guidebook 2023<sup>2)</sup>. For the complete time series, the emissions are calculated as follows:

$$EM = AD_{(number\ of\ pets)} \times EF_{(kg\ ammonia\ per\ animal\ and\ year)}$$

## Activity data

As there are no official statistics on pets in Germany, data from repeated representative surveys of 5,000 to 7,000 households conducted on behalf of the German Pet Food Association (Industrieverband Heimtierbedarf e.V., IVH, and the Zentralverband Zoologischer Fachbetriebe Deutschlands e.V., ZZF) <sup>3)</sup> for the period 2012-2023 are applied.

The latest EMEP EEA Guidebook refers to European statistics. The figures for 2021 and 2022 are consistent with those in the publication mentioned above and according to the 2023 Guidebook only the main categories cats (39% by animal category) and dogs (27% by animal category) were considered.

Time series for the main categories of pets are obtained by the numbers of the survey for the years 2012 to 2023. Data for 1990 are estimated retrospectively using the number of households (see also <https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Haushalte-Familien/Tabellen/1-3-privathaushalte-neuer-zeitvergleich.html>) and the trend between 1991 and 2013 (+13.9%) is accounted for as a baseline for 1990 animal numbers.

The data for 1990 and 2012 are used to gapfill the missing animal numbers by linear interpolation.

The following table shows the estimated pet population over time:

Table 1: Animal numbers in 10<sup>6</sup>, as of 1990

|             | Cats  | Dogs  |
|-------------|-------|-------|
| <b>1990</b> | 10.80 | 6.50  |
| <b>1995</b> | 11.16 | 6.71  |
| <b>2000</b> | 11.50 | 6.92  |
| <b>2005</b> | 11.83 | 7.12  |
| <b>2010</b> | 12.17 | 7.32  |
| <b>2015</b> | 12.90 | 7.90  |
| 2016        | 13.40 | 8.60  |
| 2017        | 13.70 | 9.20  |
| 2018        | 14.80 | 9.40  |
| 2019        | 14.70 | 10.10 |
| <b>2020</b> | 15.70 | 10.70 |
| 2021        | 16.70 | 10.30 |
| 2022        | 15.20 | 10.60 |
| 2023        | 15.70 | 10.50 |
| <b>2024</b> | 15.90 | 10.50 |

## Emission factors

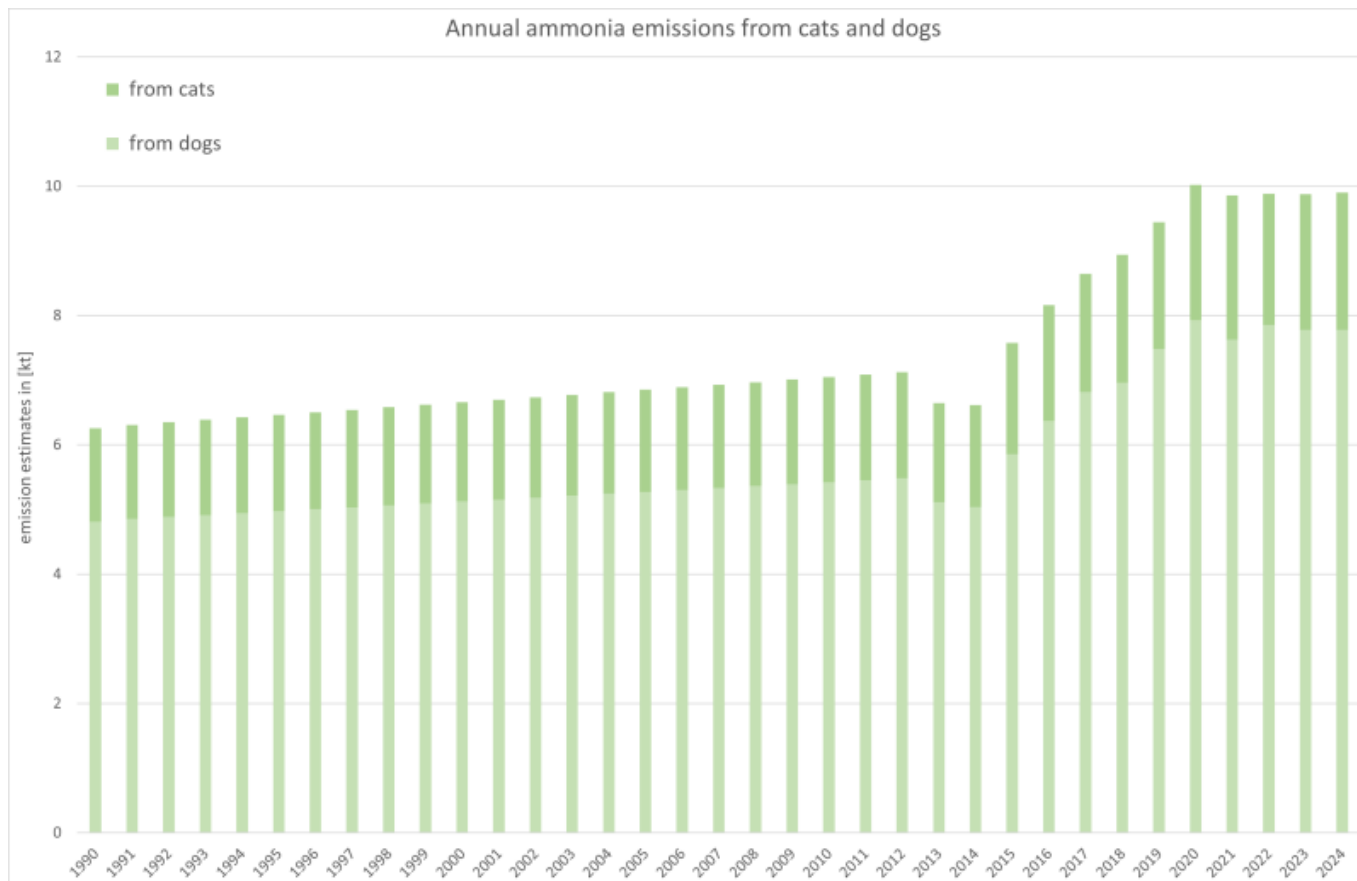
For the calculation of ammonia emissions in this category, the mean (best estimate) of the emission factors given in Sutton et al. (2000) <sup>4)</sup> are used:

- $EF_{\text{cats}}: 0.11 \text{ kg NH}_3\text{-N animal}^{-1} \text{ year}^{-1}$
- $EF_{\text{dogs}}: 0.61 \text{ kg NH}_3\text{-N animal}^{-1} \text{ year}^{-1}$

The emission factors were converted to the amount of ammonia using the stoichiometric factor of 17/14.

## Emission Trend

The following figure shows the development of emissions for the pet-categories dogs ( $EM_{\text{dog}}$ ) and cats ( $EM_{\text{cat}}$ ) as of 1990:



In recent years, an increasing trend can be observed, resulting in a mean value (between 2020 to 2023) of 9.9 kt NH<sub>3</sub>/a or 2 % of total national ammonia emissions reported for 2023. Especially since the Corona year 2020, more people have acquired pets such as dogs.

## Recalculations



With **activity data and emission factors remaining unaltered**, no recalculations occur against the previous submission.

## Uncertainties

For pets the uncertainty of the animal numbers is assumed to be 5% (standard error), and hence 10% for half the 95% confidence interval, with normal distribution.

There is no information on the uncertainty of the emission factors. However, as EF vary between different sources and the amount of ammonia volatilized is based on an assumption, EF uncertainties are expected to be relatively high. Therefore, an uncertainty of 50% for half the 95-percent confidence-interval (normal distribution) is assumed.

## Planned Improvement



At the moment, no source-specific improvements are planned.

<sup>1), 4)</sup> Sutton, M.A., Dragosits, U., Tang, Y.S., Fowler, D. (2000): Ammonia emissions from non-agricultural sources in the UK,

- Atmospheric Environment, Volume 34, Issue 6, 2000, Pages 855-869, ISSN 1352-2310, [https://doi.org/10.1016/S1352-2310\(99\)00362-3](https://doi.org/10.1016/S1352-2310(99)00362-3). (<https://www.sciencedirect.com/science/article/pii/S1352231099003623>); January 2000
- <sup>2)</sup> EMEP/EEA (2023): EMEP/EEA Guidebook 2023, Chapter 6, <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/6-other-sources/6-a-other-2023/view>, Copenhagen, 2023
- <sup>3)</sup> IVH & ZZF (2024): Industrierverband Heimtierbedarf e.V. (IVH) and the Zentralverband Zoologischer Fachbetriebe Deutschlands e.V. (ZZF); <https://web.archive.org/web/20240922112326/https://www.ivh-online.de/der-verband/daten-fakten/anzahl-der-heimtiere-in-deutschland.html>, 2024

## CHAPTER 8: NFR 11 - Natural emission sources

| Category Code                               | Name of category      | Method                   | AD | EF |
|---------------------------------------------|-----------------------|--------------------------|----|----|
| 11                                          | Natural Sources       | see sub-categories       |    |    |
| consisting of / including source categories |                       |                          |    |    |
| 11.A                                        | Volcanoes             | not occurring in Germany |    |    |
| 11.B                                        | Forest Fires          | CS, T2                   | CS | D  |
| 11.C                                        | Other Natural Sources | see sub-categories       |    |    |



## 11.B - Forest Fires

### Short Description

In Germany's forests, prescribed burning is not applied. Therefore, all forest fires are categorized as wildfires (including emissions from forest fires occurring naturally or caused by humans).

As NFR 11.B is a memo item category, emissions reported here are not accounted for in the National Totals.

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| 11.B                                                                                      | CS, T2, T1                           | CS | D  |
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub>                                                              | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC  | CO  | Heavy Metals | POPs |
|------------------------------------------------------------------------------|--------|-----------------|-----------------|-------------------|------------------|-----|-----|-----|--------------|------|
| -/-                                                                          | -/-    | -/-             | -/-             | -/-               | -/-              | -/- | -/- | -/- | NA           | NA   |
| This memo item source category is not included in the key category analysis. |        |                 |                 |                   |                  |     |     |     |              |      |

### Methodology

For calculating the emissions of wildfires a country specific Tier2 approach was used. The mass of carbon emitted M(C) was calculated using the adapted equation follows the methodology of Seiler and Crutzen (1980)<sup>11</sup>.



$$M_C = 0.45 \times A \times B \times \beta$$

where:

0.45 = average fraction of carbon in fuel wood;

A = forest area burnt in [m<sup>2</sup>];

B = mean above-ground biomass of fuel material per unit area in [kg/m<sup>2</sup>];

$\beta$  = burning efficiency (fraction burnt) of the above-ground biomass.

The data on forest areas burnt for the period 1990 to 2024 have been taken from the German forest fire statistic <sup>2)</sup> managed by the Federal Agency for Agriculture and Food. The mean above-ground biomass of fuel material was determined from the pools above ground biomass, dead wood and litter. The mean above-ground biomass and dead wood biomass was derived for each year by linear extrapolation and interpolation between the

- German National Forest Inventories of 1987, 2002, 2012, 2022 (Bundeswaldinventuren 1987, 2002, 2012, 2022),
- [the inventory study 2008](#) and,
- [the carbon inventory 2017](#).

Biomass of Litter was derived for each year by linear interpolation between 1990 and 2006 and extrapolation from 2007 based on the two Forest soil inventories BZE I <sup>3)</sup> and BZE II Wald (2006) <sup>4)</sup>.

Pursuant to König (2007) <sup>5)</sup>, 80% of the forest fires in Germany are surface fires and 20% crown fires. In accordance to the IPCC Good Practice Guidance for LULUCF (2003) a burning efficiency of 0.15 was used for surface fires and an efficiency of 0.45 was used for crown fires.

The emissions for the pollutants were calculated by multiplying the mass of carbon with the respective emission factors from (EMEP/EEA, 2023), Chapter 11.B - Forest Fires, Table 3-3 Emission ratios for biomass fires, expressed relative to the carbon emitted as CO<sub>2</sub> (based upon recommendations of Andreae, 1991) <sup>6)</sup>.

For the calculation of particulate emissions (TSP, PM<sub>10</sub> and PM<sub>2.5</sub>) the burnt biomass was multiplied with the respective emission factors from (EMEP/EEA, 2023), Chapter 11.B - Forest Fires, Table 3-5: Tier 2 emission factors for source category 11.B Forest fires, temperate forest <sup>7)</sup>. Those particulate emission factors have been estimated by averaging the emission factors from the US Environmental Protection Agency (USEPA, 1996) <sup>8)</sup> methodology, since no better information is available. Those emission factors are assumed to be the same for all types of forest.

The Guidebook does not indicate whether EFs have considered the condensable component (with or without).

### Activity data

The data on forest areas burnt for the period 1990 to 2024 are based on the German forest fire statistic (BLE, 2025) managed by the Federal Agency for Agriculture and Food.

Table 1: Area of forest burnt from 1990 until the latest reporting year, in [ha]

| 1990  | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018  | 2019  | 2020 | 2021 | 2022  | 2023  | 2024 |
|-------|------|------|------|------|------|------|------|------|------|------|------|-------|-------|------|------|-------|-------|------|
| 1,606 | 592  | 581  | 183  | 522  | 214  | 269  | 199  | 120  | 526  | 283  | 395  | 2,349 | 2,711 | 368  | 148  | 3,058 | 1,240 | 334  |

### Emission factors

For the year 2024 the following estimated emission factors were applied:

Table 2: Emission factors applied for 2024

|                   | EF <sub>2024</sub> |
|-------------------|--------------------|
| NO <sub>x</sub>   | 145.24             |
| CO                | 5180.10            |
| NMVOC             | 457.49             |
| SO <sub>x</sub>   | 35.03              |
| NH <sub>3</sub>   | 39.21              |
| TSP               | 823.01             |
| PM <sub>10</sub>  | 532.53             |
| PM <sub>2.5</sub> | 435.71             |
| BC                | 39.21              |

In addition, a single but large-scale fire which occurred in September 2018, is taken into account here. As an exceptionally large amount of CO<sub>2</sub> was released during this event, a detailed description of the circumstances can be found in the National Inventory Report 2020 for the German Greenhouse Gas Inventory 1990-2018 (NIR 2020), Chapter 6.8.2.5 <sup>9)</sup>.

The burned area of the drained moor used as a military facility covered 1,221 ha. The fire was extensively investigated and documented by the Federal Office for Infrastructure, Environmental Protection and Services of the German Armed Forces. The emissions are calculated according to IPCC GL (2006), chapter 2, form 2.27 <sup>10)</sup>.

The product  $M_b \times C_f$  is set to 336 t d.m. ha<sup>-1</sup> according to Table 2.6 and equation 2.7, 2013 IPCC Wetlands Supplement (IPCC (2013)) <sup>11)</sup>, i.e. it is assumed that the moor was completely drained during the fire.



- $M_b$  = mass of fuel available for combustion, tonnes ha<sup>-1</sup> (i.e. mass of dry organic soil fuel)
- $C_f$  = combustion factor, dimensionless

For calculating CO emissions, the EF according to Table 2.7, 2013 IPCC Wetlands Supplement 207 g (kg dm)<sup>-1</sup>, is taken into account, resulting in 85 kt CO.

### Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

### Planned Improvement



At the moment, no source-specific improvements are planned.

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<https://link.springer.com/content/pdf/10.1007/BF00137988.pdf>; <https://doi.org/10.1007/BF00137988>; 1980
- <sup>2)</sup> BLE, 2025: Waldbrandstatistik der Bundesrepublik Deutschland für das Jahr 2024, 19 p.,  
<https://www.bmel-statistik.de/forst-holz/waldbrandstatistik>; Bundesanstalt für Landwirtschaft und Ernährung, Bonn, Juli 2025
- <sup>3)</sup> Wolff, B. & Riek, W. (1997): Deutscher Waldbodenbericht 1996 - Ergebnisse der bundesweiten Bodenzustandserhebung in Wald (BZE) 1987 - 1993. editor: Bundesministerium für Ernährung, Landwirtschaft und Forsten, Bd. 1 u. 2., 144 p.,  
<https://web.archive.org/web/20230308011726/https://www.bmel-statistik.de/fileadmin/daten/FHB-0320205-1996.pdf>, Bonn, 1997
- <sup>4)</sup> Wellbrock, N., Aydin, C.-T., Block, J., Bussian, B., Deckert, M., Diekmann, O., Evers, J., Fetzner, K. D., Gauer, J., Gehrman, J., Kölling, C., König, N., Liesebach, M., Marin, J., Meiwes, K. J., Milbert, G., Raben, G., Riek, W., Schäfer, W., Schwerhoff, J., Ullrich, T., Utermann, J., Volz, H.-A., Weigel, A. & Wolff, B. (2006): Bodenzustandserhebung im Wald (BZE II) Arbeitsanleitung für die Außenaufnahmen. Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, 413 p.;  
<https://www.bmel.de/DE/themen/wald/wald-in-deutschland/bodenzustandserhebung.html>, Berlin, 2006
- <sup>5)</sup> König, H.-C., 2007: Waldbrandschutz - Kompendium für Forst und Feuerwehr. 1. Fachverlag Matthias Grimm, 197 p.; Berlin, 2007
- <sup>6, 7)</sup> EMEP/EEA, 2023: EMEP/EEA air pollutant emission inventory guidebook 2023, Chapter 11.B Forest fires;  
<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/11-natural-sources/11-b-forest-fires/@download/file>; Copenhagen, 2023
- <sup>8)</sup> USEPA, 1996: Compilation of Air Pollutant Emission Factors Vol.1. Stationary, Point and Area Sources. Report AP-42, fifth edition,  
[https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors-stationary-sources&ved=2ahUKEwIF-6qL2MmTAXWCA9sEHR\\_IJ2cQFnoECCQQAQ&usq=AOvVaw2\\_elOMvtyiZjFrGgLsi6hH](https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors-stationary-sources&ved=2ahUKEwIF-6qL2MmTAXWCA9sEHR_IJ2cQFnoECCQQAQ&usq=AOvVaw2_elOMvtyiZjFrGgLsi6hH), 1996
- <sup>9)</sup> Umweltbundesamt (2020): NIR 2020: National Inventory Report 2020 for the German Greenhouse Gas Inventory 1990-2018; German Environment Agency (Umweltbundesamt – UBA),  
<https://www.umweltbundesamt.de/publikationen/berichterstattung-unter-der-klimarahmenkonvention-5>; Dessau-Roßlau, April 2020
- <sup>10)</sup> Eggleston S., Buendia L., Miwa K., Ngara T., Tanabe K. (2006): IPCC Guidelines (2006), chapter 2, form 2.27 ((IPCC (Intergovernmental Panel on Climate Change) (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use.; IEA/OECD, IPCC National Greenhouse Gas Inventories Programme, Technical Support Unit, Hayama, Kanagawa, Japan. <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>, 2006
- <sup>11)</sup> Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G.: 2013 Supplement to the IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands.; IPCC (Intergovernmental Panel on Climate Change); <http://www.ipcc-nggip.iges.or.jp/public/wetlands/index.html>, October 2013

## 11.C - Other Natural Sources

### Short description

Within **NFR 11.C - Other Natural Sources: Other**, natural activities and resulting emissions other than volcanoes (11.A) and forest fires (11.B) are to be taken into account.

The 2023 EMEP/EEA Guidebook distinguishes the following emission sub-categories of **NFR 11.C - Natural Sources: Other**:

| <b>NFR 11.C sub-categories</b>                                         |
|------------------------------------------------------------------------|
| Other natural sources: Non-managed & managed forests                   |
| Other natural sources: Natural grassland and other vegetation          |
| Other natural sources: Wetlands and waters                             |
| Other natural sources: Animals                                         |
| Other natural sources: Geological seepage                              |
| Other natural sources: Forest & grassland soils                        |
| <a href="#">Other natural sources: Lightning</a>                       |
| Other natural sources: Changes in forest and other woody biomass stock |
| Other natural sources: Forest and grassland conversion                 |
| Other natural sources: Abandonment of managed land                     |
| Other natural sources: CO <sub>2</sub> from or removal into soil       |
| Other natural sources: Other                                           |

However, for the time being, from the natural sources listed above, only emissions from lightning is taken into account in the German emissions inventory.

NOTE: As NFR 11.C is a memo item category, emissions reported here are not accounted for in the National Totals.

### Other natural sources: Lightning

For the time being, the only natural emission source reported within NFR 11.C is lightning.

| <b>Category Code</b> | <b>Method</b> | <b>AD</b> | <b>EF</b> |
|----------------------|---------------|-----------|-----------|
| 11.C                 | T1            | NS        | D         |

| Category Code                                                                             | Method                               | AD | EF |
|-------------------------------------------------------------------------------------------|--------------------------------------|----|----|
| <b>Method(s) applied</b>                                                                  |                                      |    |    |
| <b>D</b>                                                                                  | Default                              |    |    |
| <b>T1</b>                                                                                 | Tier 1 / Simple Methodology *        |    |    |
| <b>T2</b>                                                                                 | Tier 2*                              |    |    |
| <b>T3</b>                                                                                 | Tier 3 / Detailed Methodology *      |    |    |
| <b>C</b>                                                                                  | CORINAIR                             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>M</b>                                                                                  | Model                                |    |    |
| * as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters. |                                      |    |    |
| <b>(source for) Activity Data</b>                                                         |                                      |    |    |
| <b>NS</b>                                                                                 | National Statistics                  |    |    |
| <b>RS</b>                                                                                 | Regional Statistics                  |    |    |
| <b>IS</b>                                                                                 | International Statistics             |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>As</b>                                                                                 | Associations, business organisations |    |    |
| <b>Q</b>                                                                                  | specific Questionnaires (or surveys) |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |
| <b>(source for) Emission Factors</b>                                                      |                                      |    |    |
| <b>D</b>                                                                                  | Default (EMEP Guidebook)             |    |    |
| <b>CS</b>                                                                                 | Country Specific                     |    |    |
| <b>PS</b>                                                                                 | Plant Specific                       |    |    |
| <b>M</b>                                                                                  | Model / Modelled                     |    |    |
| <b>C</b>                                                                                  | Confidential                         |    |    |

| NO <sub>x</sub> | NM VOC | SO <sub>2</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Heavy Metals | POPs |
|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|--------------|------|
| -/-             | NA     | NA              | NA              | NA                | NA               | NA  | NA | NA | NA           | NA   |

*This memo item source category is not included in the key category analysis.*

Lightning (and corona discharge) during thunderstorm events cause atmospheric chemical reactions to take place at high voltages and high temperatures. These reactions cause the production of NO<sub>x</sub> in the atmosphere.

## Methodology

The calculation of NO<sub>x</sub> emissions from lightning uses strike counts from the German weather service and default emission factors from the 2023 EMEP/EEA guidebook <sup>1)</sup>.

For the complete time series, the emissions are calculated as follows:

$$EM = AD_{(number\ of\ lightning\ strikes)} \times EF_{(kg\ emission\ per\ strike)}$$

## Activity data

The number of lightning strikes in Germany is taken from a commercial system called “BLIDS” run by Siemens. The data has been cross-referenced with information from the German weather service. Consistent strike count data is available from 1992 onward and has been back-populated to cover the full time series since 1990. The following table shows the strike figures over time.

Table 1: Annual number of lightning strikes in Germany, as 1990, in [1,000 strikes]

| 1990 | 1995 | 2000  | 2005 | 2010 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|------|------|-------|------|------|------|------|------|------|------|------|------|------|------|------|
| 443  | 394  | 1,026 | 802  | 589  | 550  | 432  | 443  | 446  | 329  | 399  | 512  | 242  | 316  | 210  |

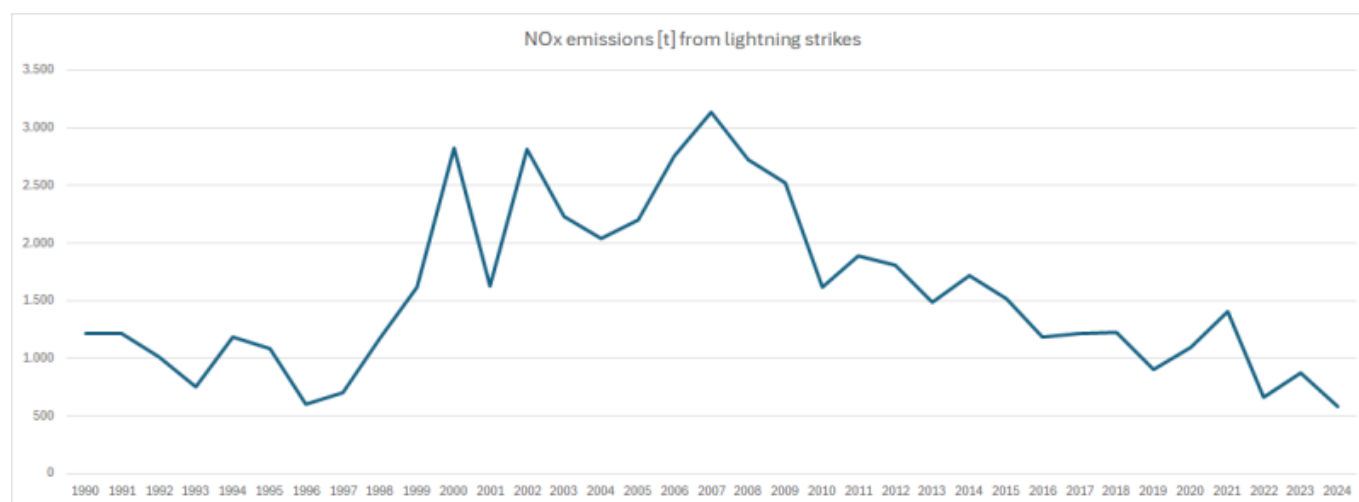
## Emission factor(s)

For the calculation of emissions in this category, the Guidebook emission factor of 2.75 kg NO<sub>x</sub> per strike is used.

## Emission Trend

The emission value is solely dependent on the strike count and varies between 1 to 3 kilotons of NO<sub>x</sub> per year.

Figure 1: NFR 11.C, NO<sub>x</sub> emissions from lightning



## Recalculations



With **activity data and emission factors remaining unrevised**, no recalculations were carried out compared to the previous submission.

## Uncertainties

The AD from BLIDS does have a low uncertainty of  $\pm 3\%$ . The uncertainties for the emission factors are estimated to be relatively high, being a default value. Hence the overall uncertainty for the emission estimation of NO<sub>x</sub> from lightning is qualified estimated by expert judgement to be high (>50%).

## Planned Improvement



At the moment, no source-specific improvements are planned.

<sup>1)</sup> EMEP/EEA 2023: EMEP/EEA air pollutant emission inventory guidebook 2023, URL: <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/11-natural-sources/11-c-other-natural-sources-6/view>, Copenhagen, 2023



|                                 |                 |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NO <sub>x</sub> | NM VOC | SO <sub>x</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## CHAPTER 9.1 - Recalculations



Generally, improvement of the emission inventory is an ongoing task and triggers recalculations for all source categories and pollutants frequently.



Further information regarding recalculations (especially due to changes in methods or activity data) can be found in the corresponding chapters of the **National Inventory Document 2026** (NID 2026) <sup>1)</sup>.

### Possible reasons for Recalculations

Due to the ever ongoing efforts to improve the inventory, more or less broad recalculations become necessary with each new submission.

#### Possible reasons for recalculations are

- **new** (sub-)categories to be included in the inventory or re-allocation of existing sub-categories within the inventory
- **data** (activity data & emission factors) for certain (sub-)categories **available for the first time**
- **change of data sources** (for activity data and emissions)
- use of **new emission factors** (due to: inquest, research projects, expert judgement etc.)
- **improvement of methods** used for calculating emissions
- **outcome of ongoing review** activities under both UN FCCC and UN ECE
- etc.

**All these changes can effect *specific years* of the inventory as well as the *entire time series*, leading to more or less significant changes within the emission trends.**

### Declaration of Recalculations

Under UN FCCC reporting, parties have to comment any recalculations in any year leading to differences between latest and current submission for a given year or the time period or series. Thereby, highest attention is given to recalculations within



base year and the most current year of the latest submission:

### Recalculations in Base Year data

- mostly rather small but of highest importance
- mostly due to changed methods or emission factors used for entire time series
- impact on basis of any evaluation

### Recalculations in data of current year of the latest submission

- mostly because of **corrected activity data** (especially in Energy Production) from finalized Energy Balances
- also due to changed methods, emission factors, or data sources used
- impact on the amount of emission reduction reported in latest submission

**Under UN ECE, within the IIR**, Germany focusses on recalculations in values reported for **1990** for all MAIN POLLUTANTS, HEAVY METALS and POPS, **1995** for PM<sub>2.5</sub> and PM<sub>10</sub> and **2000** for BLACK CARBON (BC), and the **last year of the previous submission**, providing the **quantity** (in absolute numbers and in %) of change for any recalculated emission **and the reasons** for the recalculations carried out

## Recalculations in current submission

Table 1: Overview of impact of recalculations on the level of National Totals (For more detailed information please mouseclick the pollutant.)

| for reporting year:                                     |      | BASE YEAR <sup>1</sup> |             |        |         | 2023        |             |        |        |
|---------------------------------------------------------|------|------------------------|-------------|--------|---------|-------------|-------------|--------|--------|
|                                                         |      | prev. subm.            | curr. subm. | ±      | ± %     | prev. subm. | curr. subm. | ±      | ± %    |
| <b>Main pollutants</b>                                  |      |                        |             |        |         |             |             |        |        |
| <b>NEC</b>                                              |      |                        |             |        |         |             |             |        |        |
| Nitrogen Oxides - NO <sub>x</sub> (as NO <sub>2</sub> ) | [kt] | 2,846.04               | 2,849.57    | 3.54   | 0.12%   | 844.88      | 841.23      | -3.65  | -0.43% |
| Non-Methane VOC - NMVOC                                 | [kt] | 3,953.69               | 3,941.76    | -11.9  | -0.30%  | 974.82      | 968.05      | -6.77  | -0.69% |
| Sulphur Oxides - SO <sub>x</sub> (as SO <sub>2</sub> )  | [kt] | 5,460.81               | 5,460.81    | 0.00   | 0.00%   | 216.62      | 210.47      | -6.15  | -2.84% |
| Ammonia - NH <sub>3</sub>                               | [kt] | 834.48                 | 827.15      | -7.32  | -0.88%  | 569.00      | 531.54      | -37.5  | -6.58% |
| <b>Particulate Matter</b>                               |      |                        |             |        |         |             |             |        |        |
| Particles <2.5µm - PM <sub>2.5</sub>                    | [kt] | 199.77                 | 197.47      | -2.30  | -1.15%  | 77.47       | 77.91       | 0.44   | 0.57%  |
| Particles <10µm - PM <sub>10</sub>                      | [kt] | 337.92                 | 334.41      | -3.51  | -1.04%  | 181.55      | 183.76      | 2.21   | 1.22%  |
| Total Suspended Particles - TSP                         | [kt] | 2,015.59               | 2,015.25    | -0.34  | -0.02%  | 333.54      | 334.83      | 1.29   | 0.39%  |
| Black Carbon - BC                                       | [kt] | 39.20                  | 39.01       | -0.18  | -0.46%  | 9.36        | 9.27        | -0.09  | -0.91% |
| <b>Other</b>                                            |      |                        |             |        |         |             |             |        |        |
| Carbon Monoxide - CO                                    | [kt] | 13,320.53              | 13,319.31   | -1.22  | -0.009% | 2,409.34    | 2,339.64    | -69.7  | -2.89% |
| <b>Heavy Metals</b>                                     |      |                        |             |        |         |             |             |        |        |
| <b>Priority HM</b>                                      |      |                        |             |        |         |             |             |        |        |
| Lead - Pb                                               | [t]  | 1,899.27               | 1,921.37    | 22.10  | 1.16%   | 151.08      | 173.15      | 22.1   | 14.6%  |
| Cadmium - Cd                                            | [t]  | 29.10                  | 29.19       | 0.09   | 0.29%   | 9.36        | 9.43        | 0.07   | 0.75%  |
| Mercury - Hg                                            | [t]  | 35.53                  | 35.53       | 0.00   | 0.00%   | 5.43        | 5.42        | -0.009 | -0.17% |
| <b>Other HM</b>                                         |      |                        |             |        |         |             |             |        |        |
| Arsenic - As                                            | [t]  | 85.92                  | 86.16       | 0.25   | 0.29%   | 5.05        | 5.28        | 0.22   | 4.45%  |
| Chrome - Cr                                             | [t]  | 165.69                 | 174.06      | 8.37   | 5.05%   | 65.59       | 74.34       | 8.75   | 13.3%  |
| Copper - Cu                                             | [t]  | 619.88                 | 804.80      | 184.92 | 29.83%  | 584.30      | 782.79      | 198    | 34.0%  |
| Nickel - Ni                                             | [t]  | 332.75                 | 333.95      | 1.21   | 0.36%   | 123.07      | 127.74      | 4.67   | 3.79%  |
| Selenium - Se                                           | [t]  | 5.73                   | 5.82        | 0.09   | 1.55%   | 2.68        | 2.76        | 0.08   | 3.03%  |
| Zinc - Zn                                               | [t]  | 474.15                 | 511.59      | 37.43  | 7.89%   | 284.64      | 319.57      | 34.9   | 12.3%  |
| <b>Persistent Organic Pollutants - POPs</b>             |      |                        |             |        |         |             |             |        |        |
| Dioxines & Furanes - PCDD/F                             | [g]  | 805.10                 | 805.10      | 0.00   | 0.00%   | 110.98      | 110.74      | -0.24  | -0.22% |
| <b>Polycyclic Organic Hydrocarbons - PAHs</b>           |      |                        |             |        |         |             |             |        |        |
| Benzo(a)pyrene - B[a]P                                  | [t]  | 26.99                  | 27.03       | 0.04   | 0.15%   | 15.66       | 15.57       | -0.09  | -0.55% |
| Benzo(b)fluoranthene - B[b]F                            | [t]  | 35.83                  | 36.71       | 0.87   | 2.44%   | 22.72       | 22.46       | -0.26  | -1.15% |

|                                            |      |          |          |      |       |        |        |       |        |
|--------------------------------------------|------|----------|----------|------|-------|--------|--------|-------|--------|
| Benzo(k)fluoranthene - B[k]F               | [t]  | 16.26    | 17.10    | 0.84 | 5.14% | 10.35  | 10.38  | 0.03  | 0.25%  |
| Indeno(1,2,3-c,d)pyrene - I[1,2,3-c,d]P    | [t]  | 23.03    | 23.22    | 0.19 | 0.83% | 15.05  | 14.88  | -0.17 | -1.16% |
| Polycyclic Aromatic Hydrocarbons - PAH 1-4 | [t]  | 115.67   | 117.61   | 1.94 | 1.68% | 67.13  | 66.60  | -0.53 | -0.79% |
| <b>Other POPs</b>                          |      |          |          |      |       |        |        |       |        |
| Hexachlorobenzene - HCB                    | [kg] | 2,900.52 | 2,900.52 | 0.00 | 0.00% | 3.85   | 3.85   | 0.00  | -0.12% |
| Polychlorinated Biphenyls - PCBs           | [kg] | 1,735.78 | 1,735.78 | 0.00 | 0.00% | 203.80 | 206.48 | 2.68  | 1.31%  |

<sup>1</sup>: Base Year of reporting: 1990; excemptions: PM<sub>2.5</sub> and PM<sub>10</sub>: 1995 and BC: 2000

## Overview of reasons for recalculations against Submission 2025

(main changes only, without claim to completeness)

### 1. revision of (primary) activity data

- 1.A together with 2.C.1: routine revision of National Energy Balances 2003 to 2022 <sup>2)</sup> & finalisation of National Energy Balance 2023 <sup>3)</sup>

### 2. update or revision of entire model

- 1.A.3.a: routine revision of TREMOD Aviation (TREMOD AV) <sup>4)</sup>
- 1.A.3.b: routine revision of TREMOD <sup>5)</sup>
- 1.A.2.g vii, 1.A.4.a ii, 1.A.4.b ii and 1.A.4.c ii: routine revision of TREMOD Mobile Machinery (TREMOD MM) <sup>6)</sup>
- 1.A.3.d: routine revision of E.M.M.A. model maintained by BSH <sup>7)</sup>

### 3. newly implemented activity and/or emission factors

- 2.B.10.b: newly implemented AD and EF based on available results from research project on VOC
- 2.C.3: newly implemented EF for B[b]F, B[k]F and I[x]P, also resulting in a strong increase of PAH1-4 emissions
- 2.D.3.c: newly implemented EF for PM (2023 EMEP/EEA Guidebook default)

### 4. revision of emission factors

- 1.A.3.b v i & v ii: update to emission factor information as provided in the 2025 Update release of Chapter 1.A.3.b v i & v ii of the EMEP/EEA Guidebook 2023 <sup>8)</sup>
- 5.C.1.b v: use of 2023 EMEP/EEA Guidebook default-EF for Pb and Cd

### 5. re-allocation of activity data and/or emissions

- 

### 6. as an outcome of the ongoing review activities under both UNFCCC and UNECE

- 2.D.3.c: newly implemented EF for PM (GB Default)

<sup>2)</sup> AGEb (2025a): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; [https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?\\_jahresbereich-bilanz=2021-2030](https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?_jahresbereich-bilanz=2021-2030), (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>3)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>4)</sup> Allekotte et al. (2025): TREMOD Aviation (TREMOD AV) - Revision des Modells zur Berechnung des Flugverkehrs (TREMOD-AV). Heidelberg, Berlin: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH & Öko-Institut e.V., Berlin & Heidelberg, 2025.

<sup>5)</sup> Knörr et al. (2025a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, im Auftrag des Umweltbundesamtes, Heidelberg [u.a.]: Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, Heidelberg & Berlin, 2025.

<sup>6)</sup> Knörr et al. (2025b): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: ifeu Institute for Energy and Environmental Research

(Institut für Energie- und Umweltforschung Heidelberg gGmbH, ifeu): Aktualisierung des Modells TREMOD-Mobile Machinery (TREMOM) 2025, Heidelberg, 2025.

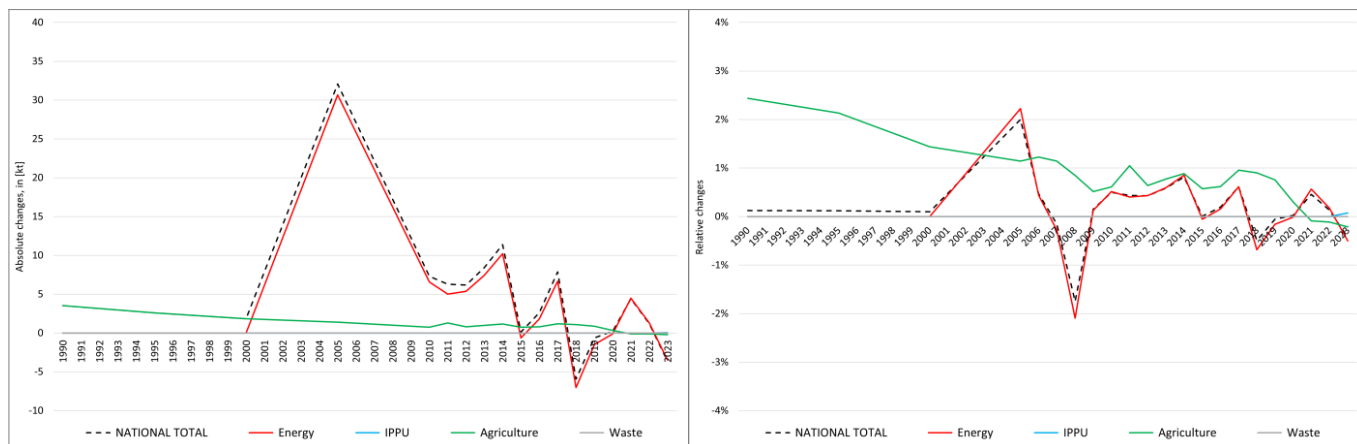
<sup>7)</sup> Deichnik (2025): Aktualisierung und Revision des Modells zur Berechnung der spezifischen Verbräuche und Emissionen des von Deutschland ausgehenden Seeverkehrs; Federal Maritime and Hydrographic Agency (BSH - Bundesamt für Seeschifffahrt und Hydrographie Hamburg); on behalf of the Umweltbundesamt, Hamburg / Dessau-Roßlau, 2025.

<sup>8)</sup>

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-vi>

| pollutant-specific data: |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |
|--------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|
|                          | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P |

## Recalculations - Nitrogen Oxides



The marginal changes within the **National Total** reported for **1990 (+3.54 kt or +0.12 %)** result from changes in **NFR 3 (+3.54 kt or +2.44 %)**. Additional but antagonistic changes in NFRs 1.A.2.g vii and 1.A.4.c ii do not affect the National Total.

The most significant percental change occurs for **NFR 3.B.1.a with plus 16.2 %**.

Table 1: Changes of emission estimates 1990

|                            | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                         |
|----------------------------|-----------------|-----------------|-------------|--------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 | absolute    | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>2,846.04</b> | <b>2,849.57</b> | <b>3.54</b> | <b>0.12%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>2,599.34</b> | <b>2,599.34</b> | <b>0.00</b> | <b>0.00%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 34.654          | 34.657          | 0.003       | 0.01%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 10.439          | 10.437          | -0.002      | -0.02%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>100.73</b>   | <b>100.73</b>   | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 3 - Agriculture</b> | <b>145.23</b>   | <b>148.77</b>   | <b>3.54</b> | <b>2.44%</b> | <b>sub-category chapters</b>      |
| 3.B.1.a                    | 0.89            | 1.04            | 0.14        | 16.16%       | <a href="#">here</a>              |
| 3.B.3                      | 0.36            | 0.35            | -0.01       | -2.68%       | <a href="#">here</a>              |
| 3.D.a.2.a                  | 45.94           | 48.75           | 2.81        | 6.11%        | <a href="#">here</a>              |
| 3.D.a.3                    | 8.84            | 9.44            | 0.59        | 6.73%        | <a href="#">here</a>              |
| <b>NFR 5 - Waste</b>       | <b>0.74</b>     | <b>0.74</b>     | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |              |                                   |

The small changes within the **National Total** reported for **2023 (-3.65 kt or -0.43 %)** are dominated by **revisions throughout NFR 1** with the most significant *absolute* change occurring for **NFR 1.A.4.c ii with minus 4.58 kt** together with less significant revisions **throughout NFRs 2 and 3**.

Here, the most significant *percental* change occurs for **NFR 1.A.2.g vii with plus 34.4 %**.

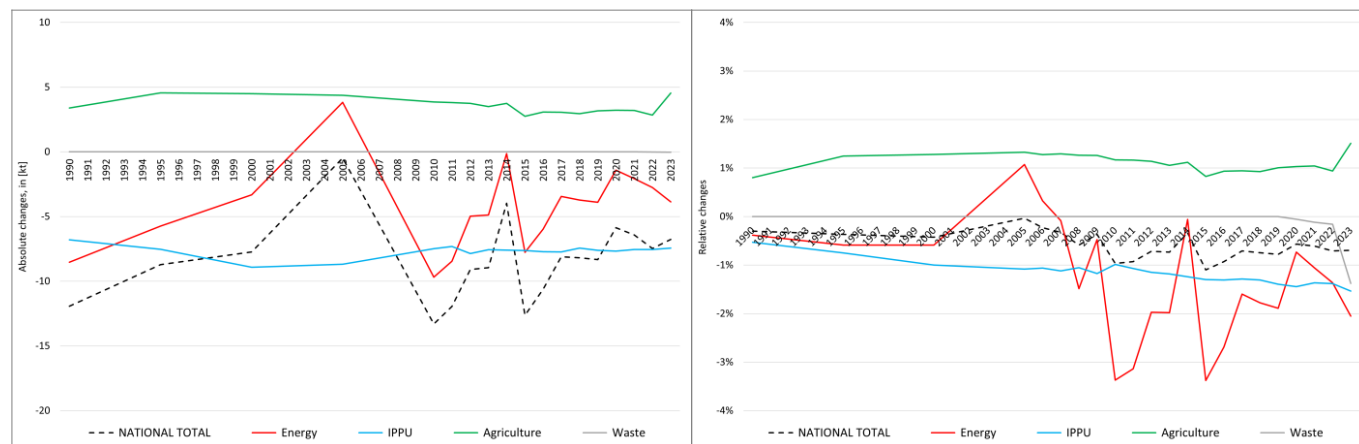
Table 2: Changes of emission estimates 2023

|                       | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|-----------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector            | [kt]            |                 | absolute     | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>844.88</b>   | <b>841.23</b>   | <b>-3.65</b> | <b>-0.43%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>695.05</b>   | <b>691.57</b>   | <b>-3.48</b> | <b>-0.50%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 168.11          | 169.59          | 1.48         | 0.88%         | <a href="#">here</a>              |

|                            | Submission 2025 | Submission 2026 | Difference   |                                   | Reasoning                    |
|----------------------------|-----------------|-----------------|--------------|-----------------------------------|------------------------------|
| NFR Sector                 | [kt]            |                 | relative     | see description and reasoning in: |                              |
| <b>NATIONAL TOTAL</b>      | <b>844.88</b>   | <b>841.23</b>   | <b>-3.65</b> | <b>-0.43%</b>                     | <b>sub-category chapters</b> |
| <b>NFR 1 - Energy</b>      | <b>695.05</b>   | <b>691.57</b>   | <b>-3.48</b> | <b>-0.50%</b>                     | <b>sub-category chapters</b> |
| 1.A.1.b                    | 14.34           | 14.24           | -0.10        | -0.69%                            | <a href="#">here</a>         |
| 1.A.1.c                    | 10.84           | 11.58           | 0.74         | 6.79%                             | <a href="#">here</a>         |
| 1.A.2.a                    | 3.86            | 3.90            | 0.04         | 0.93%                             | <a href="#">here</a>         |
| 1.A.2.b                    | 0.944           | 0.939           | -0.004       | -0.47%                            | <a href="#">here</a>         |
| 1.A.2.e                    | 0.23            | 0.19            | -0.05        | -19.84%                           | <a href="#">here</a>         |
| 1.A.2.g vii                | 5.15            | 6.92            | 1.77         | 34.37%                            | <a href="#">here</a>         |
| 1.A.2.g viii               | 59.41           | 58.18           | -1.24        | -2.08%                            | <a href="#">here</a>         |
| 1.A.3.b i                  | 169.24          | 169.07          | -0.16        | -0.10%                            | <a href="#">here</a>         |
| 1.A.3.b ii                 | 41.34           | 40.92           | -0.42        | -1.02%                            | <a href="#">here</a>         |
| 1.A.3.b iii                | 59.99           | 59.53           | -0.47        | -0.78%                            | <a href="#">here</a>         |
| 1.A.3.b iv                 | 1.18            | 1.17            | -0.01        | -0.85%                            | <a href="#">here</a>         |
| 1.A.3.c                    | 7.358           | 7.360           | 0.002        | 0.03%                             | <a href="#">here</a>         |
| 1.A.3.d ii                 | 19.69           | 19.20           | -0.49        | -2.49%                            | <a href="#">here</a>         |
| 1.A.4.a i                  | 17.74           | 17.00           | -0.74        | -4.16%                            | <a href="#">here</a>         |
| 1.A.4.a ii                 | 5.45            | 5.95            | 0.51         | 9.29%                             | <a href="#">here</a>         |
| 1.A.4.b i                  | 53.69           | 53.84           | 0.14         | 0.27%                             | <a href="#">here</a>         |
| 1.A.4.b ii                 | 0.40            | 0.38            | -0.02        | -4.81%                            | <a href="#">here</a>         |
| 1.A.4.c i                  | 7.575           | 7.578           | 0.003        | 0.04%                             | <a href="#">here</a>         |
| 1.A.4.c ii                 | 32.43           | 27.85           | -4.58        | -14.13%                           | <a href="#">here</a>         |
| 1.A.5.a                    | 0.248           | 0.252           | 0.004        | 1.52%                             | <a href="#">here</a>         |
| 1.A.5.b                    | 2.80            | 2.88            | 0.07         | 2.59%                             | <a href="#">here</a>         |
| 1.B.1.b                    | 0.23            | 0.29            | 0.05         | 23.38%                            | <a href="#">here</a>         |
| 1.B.2.a iv                 | 0.652           | 0.651           | -0.002       | -0.26%                            |                              |
| 1.B.2.c                    | 0.306           | 0.303           | -0.003       | -1.04%                            |                              |
| <b>NFR 2 - IPPU</b>        | <b>49.23</b>    | <b>49.27</b>    | <b>0.04</b>  | <b>0.07%</b>                      | <b>sub-category chapters</b> |
| 2.A.3                      | 9.91            | 9.95            | 0.03         | 0.33%                             | <a href="#">here</a>         |
| 2.C.1                      | 18.520          | 18.522          | 0.003        | 0.02%                             | <a href="#">here</a>         |
| 2.G                        | 0.18754         | 0.18757         | 0.00003      | 0.01%                             | <a href="#">here</a>         |
| <b>NFR 3 - Agriculture</b> | <b>99.51</b>    | <b>99.30</b>    | <b>-0.21</b> | <b>-0.21%</b>                     | <b>sub-category chapters</b> |
| 3.B.1.a                    | 0.545           | 0.520           | -0.02        | -4.54%                            | <a href="#">here</a>         |
| 3.B.1.b                    | 0.558           | 0.556           | -0.003       | -0.47%                            | <a href="#">here</a>         |
| 3.B.3                      | 0.22            | 0.21            | -0.01        | -6.09%                            | <a href="#">here</a>         |
| 3.B.4.e                    | 0.23            | 0.27            | 0.04         | 15.85%                            | <a href="#">here</a>         |
| 3.B.4.g i                  | 0.017           | 0.013           | -0.004       | -24.25%                           | <a href="#">here</a>         |
| 3.B.4.g ii                 | 0.013           | 0.010           | -0.003       | -23.09%                           | <a href="#">here</a>         |
| 3.B.4.g iii                | 0.007           | 0.005           | -0.002       | -25.27%                           | <a href="#">here</a>         |
| 3.B.4.g iv                 | 0.0020          | 0.0016          | -0.0004      | -18.73%                           | <a href="#">here</a>         |
| 3.D.a.1                    | 40.89           | 41.31           | 0.41         | 1.01%                             | <a href="#">here</a>         |
| 3.D.a.2.a                  | 36.65           | 36.44           | -0.21        | -0.58%                            | <a href="#">here</a>         |
| 3.D.a.2.b                  | 0.476           | 0.410           | -0.07        | -13.84%                           | <a href="#">here</a>         |
| 3.D.a.2.c                  | 14.61           | 14.27           | -0.34        | -2.31%                            | <a href="#">here</a>         |
| 3.D.a.3                    | 5.17            | 5.19            | 0.03         | 0.52%                             | <a href="#">here</a>         |
| 3.I                        | 0.09            | 0.07            | -0.02        | -23.60%                           | <a href="#">here</a>         |
| <b>NFR 5 - Waste</b>       | <b>1.09</b>     | <b>1.09</b>     | <b>0.00</b>  | <b>0.00%</b>                      |                              |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |              |                                   |                              |

|                                 |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |       |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|-------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDDF | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|-------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Non-Methane Volatile Organic Compounds



The changes within the **National Total** reported for **1990 (-12 kt or -0.30 %)** are dominated by three revisions in NFR sub-categories **1.B.2.a v** (-8.52 kt), **2.B.10.b** (-6.80 kt) and **3.B.1.a** (+3.39 kt), with the strongest percental change occurring for **2.B.10.b** with minus 84 %.

Table 1: Changes in emission estimates for 1990

|                            | Submission 2025 | Submission 2026 | Difference    |               | Reasoning                         |
|----------------------------|-----------------|-----------------|---------------|---------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 |               | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>3,953.69</b> | <b>3,941.76</b> | <b>-11.93</b> | <b>-0.30%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>2,220.86</b> | <b>2,212.34</b> | <b>-8.52</b>  | <b>-0.38%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 7.15001         | 7.15003         | 0.00002       | 0.0003%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 2.0624          | 2.0619          | -0.0004       | -0.02%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 34.986          | 34.985          | -0.001        | -0.004%       | <a href="#">here</a>              |
| 1.B.2.a v                  | 88.91           | 80.39           | -8.52         | -9.58%        |                                   |
| <b>NFR 2 - IPPU</b>        | <b>1,291.63</b> | <b>1,284.83</b> | <b>-6.80</b>  | <b>-0.53%</b> | <b>sub-category chapters</b>      |
| 2.B.10.b                   | 8.09            | 1.29            | -6.80         | -84.05%       | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>422.91</b>   | <b>426.31</b>   | <b>3.39</b>   | <b>0.80%</b>  | <b>sub-category chapters</b>      |
| 3.B.1.a                    | 205.77          | 209.16          | 3.39          | 1.65%         | <a href="#">here</a>              |
| <b>NFR 5 - Waste</b>       | <b>18.28</b>    | <b>18.28</b>    | <b>0.00</b>   | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |               |               |                                   |

The changes within the **National Total** reported for **2023 (-6.77 kt or -0.69 %)** are dominated by revisions in NFR sub-categories **1.A.4.c ii** (-2.85 kt), **2.B.10.b** (-7.41 kt) and **3.B.1.a** (+4.80 kt) with the strongest percental change occurring for **2.B.10.b** with minus 92 %.

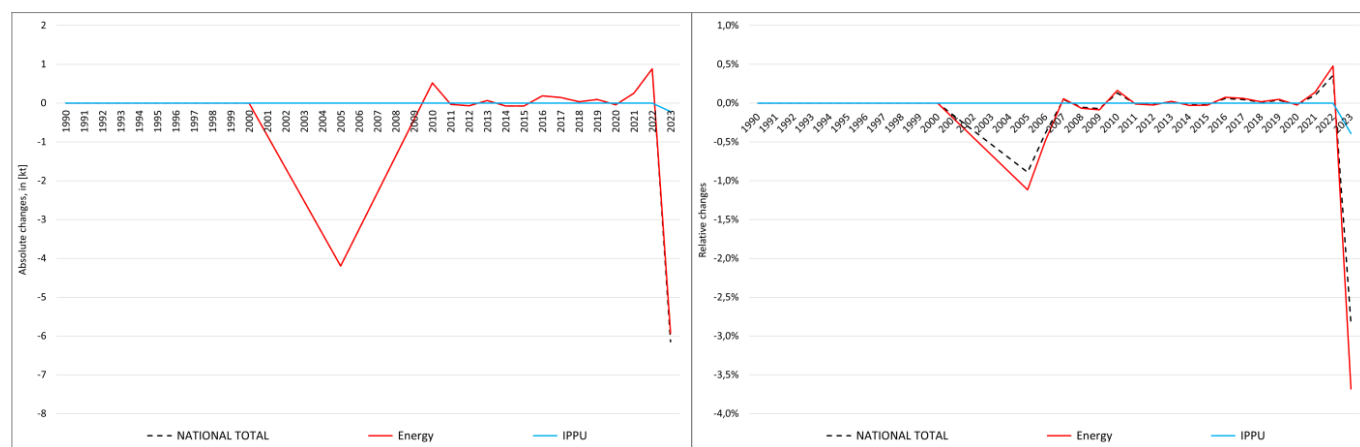
Table 2: Changes in emission estimates for 2023

|                       | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|-----------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector            | [kt]            |                 |              | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>974.82</b>   | <b>968.05</b>   | <b>-6.77</b> | <b>-0.69%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>188.48</b>   | <b>184.61</b>   | <b>-3.87</b> | <b>-2.05%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 6.03            | 6.26            | 0.23         | 3.79%         | <a href="#">here</a>              |
| 1.A.1.b               | 0.90            | 0.87            | -0.02        | -2.61%        | <a href="#">here</a>              |
| 1.A.1.c               | 0.32            | 0.34            | 0.02         | 6.08%         | <a href="#">here</a>              |

|                            | Submission 2025 | Submission 2026 | Difference    |               | Reasoning                         |
|----------------------------|-----------------|-----------------|---------------|---------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 | relative      |               | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>974.82</b>   | <b>968.05</b>   | <b>-6.77</b>  | <b>-0.69%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>188.48</b>   | <b>184.61</b>   | <b>-3.87</b>  | <b>-2.05%</b> | <b>sub-category chapters</b>      |
| 1.A.2.a                    | 0.245           | 0.247           | 0.003         | 1.16%         | <a href="#">here</a>              |
| 1.A.2.b                    | 0.077           | 0.075           | -0.001        | -1.71%        | <a href="#">here</a>              |
| 1.A.2.e                    | 0.028           | 0.023           | -0.005        | -18.10%       | <a href="#">here</a>              |
| 1.A.2.g vii                | 4.00            | 3.23            | -0.78         | -19.45%       | <a href="#">here</a>              |
| 1.A.2.g viii               | 5.28            | 5.21            | -0.07         | -1.24%        | <a href="#">here</a>              |
| 1.A.3.a ii(i)              | 0.2184          | 0.2188          | 0.0003        | 0.15%         | <a href="#">here</a>              |
| 1.A.3.b i                  | 40.95           | 40.90           | -0.04         | -0.10%        | <a href="#">here</a>              |
| 1.A.3.b ii                 | 1.41            | 1.40            | -0.01         | -1.02%        | <a href="#">here</a>              |
| 1.A.3.b iii                | 1.990           | 1.991           | 0.001         | 0.04%         | <a href="#">here</a>              |
| 1.A.3.b iv                 | 11.75           | 11.65           | -0.10         | -0.83%        | <a href="#">here</a>              |
| 1.A.3.b v                  | 24.84           | 24.62           | -0.22         | -0.88%        | <a href="#">here</a>              |
| 1.A.3.c                    | 0.3666          | 0.3666          | 0.0001        | 0.01%         | <a href="#">here</a>              |
| 1.A.3.d ii                 | 1.47            | 1.44            | -0.03         | -2.08%        | <a href="#">here</a>              |
| 1.A.4.a i                  | 3.80            | 3.70            | -0.09         | -2.48%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.576           | 0.624           | 0.05          | 8.22%         | <a href="#">here</a>              |
| 1.A.4.b i                  | 32.00           | 31.90           | -0.10         | -0.31%        | <a href="#">here</a>              |
| 1.A.4.b ii                 | 7.849           | 7.470           | -0.38         | -4.83%        | <a href="#">here</a>              |
| 1.A.4.c i                  | 0.833           | 0.831           | -0.001        | -0.15%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 13.23           | 10.38           | -2.85         | -21.58%       | <a href="#">here</a>              |
| 1.A.5.a                    | 0.08            | 0.09            | 0.01          | 6.79%         | <a href="#">here</a>              |
| 1.A.5.b                    | 1.46            | 1.49            | 0.03          | 2.12%         | <a href="#">here</a>              |
| 1.B.2.a i                  | 5.27            | 5.28            | 0.01          | 0.15%         |                                   |
| 1.B.2.a iv                 | 2.938           | 2.936           | -0.002        | -0.05%        |                                   |
| 1.B.2.a v                  | 16.79           | 17.32           | 0.53          | 3.15%         |                                   |
| 1.B.2.b                    | 2.25            | 2.22            | -0.03         | -1.14%        |                                   |
| 1.B.2.c                    | 0.292           | 0.288           | -0.003        | -1.18%        |                                   |
| <b>NFR 2 - IPPU</b>        | <b>483.32</b>   | <b>475.89</b>   | <b>-7.43</b>  | <b>-1.54%</b> | <b>sub-category chapters</b>      |
| 2.A.3                      | 0.434           | <b>0.431</b>    | <b>-0.003</b> | <b>-0.69%</b> | <a href="#">here</a>              |
| 2.B.10.b                   | 8.04            | 0.63            | -7.41         | -92.12%       | <a href="#">here</a>              |
| 2.I                        | 3.65            | 3.64            | -0.02         | -0.46%        | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>301.35</b>   | <b>305.89</b>   | <b>4.55</b>   | <b>1.51%</b>  | <b>sub-category chapters</b>      |
| 3.B.1.a                    | 161.23          | 166.02          | 4.80          | 2.97%         | <a href="#">here</a>              |
| 3.B.1.b                    | 84.87           | 84.63           | -0.25         | -0.29%        | <a href="#">here</a>              |
| 3.B.4.h                    | 0.0404          | 0.0402          | -0.0002       | -0.59%        | <a href="#">here</a>              |
| <b>NFR 5 - Waste</b>       | <b>1.68</b>     | <b>1.65</b>     | <b>-0.02</b>  | <b>-1.38%</b> | <b>sub-category chapters</b>      |
| 5.A                        | 1.056           | 1.037           | -0.02         | -1.84%        | <a href="#">here</a>              |
| 5.D.1                      | 0.13            | 0.12            | 0.00          | -2.97%        | <a href="#">here</a>              |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |               |               |                                   |

|                                 |                 |                   |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |       |       |       |       |       |        |     |     |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NO <sub>x</sub> | NM <sub>VOC</sub> | SO <sub>x</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDDF | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Sulphur Oxides



The **National Total** reported for **1990** remains unaffected by negligibly small changes within three sub-categories of NFR 1 and, thus, unaltered compared to the previous submission.

Table 1: Changes in emission estimates for 1990

| NFR Sector                 | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                                               |
|----------------------------|-----------------|-----------------|-------------|--------------|---------------------------------------------------------|
|                            | [kt]            |                 |             | relative     |                                                         |
| <b>NATIONAL TOTAL</b>      | <b>5,460.81</b> | <b>5,460.81</b> | <b>0.00</b> | <b>0.00%</b> | see description and reasoning in: sub-category chapters |
| <b>NFR 1 - Energy</b>      | <b>5,284.38</b> | <b>5,284.38</b> | <b>0.00</b> | <b>0.00%</b> | sub-category chapters                                   |
| 1.A.2.g vii                | 2.6625          | 2.6627          | 0.0002      | 0.01%        | <a href="#">here</a>                                    |
| 1.A.4.a ii                 | 0.5342          | 0.5341          | -0.0001     | -0.03%       | <a href="#">here</a>                                    |
| 1.A.4.c ii                 | 5.75770         | 5.75766         | -0.00005    | -0.001%      | <a href="#">here</a>                                    |
| <b>NFR 2 - IPPU</b>        | <b>176.39</b>   | <b>176.39</b>   | <b>0.00</b> | <b>0.00%</b> |                                                         |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |             |              |                                                         |
| <b>NFR 5 - Waste</b>       | <b>0.03</b>     | <b>0.03</b>     | <b>0.00</b> | <b>0.00%</b> |                                                         |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |              |                                                         |

Changes in the **National Total** reported for **2023** ( **-6.15 kt or -2.84 %**) are dominated by interconnected revisions in NFR sub-categories **1.A.1.b** (-1.84 kt), **1.A.2.g viii** (-2.22 kt), and **1.A.4.b i** (-1.15 kt), together with a variety of more or less significant changes throughout NFRs 1 and 2.

The most significant percental change occurs for **NFR 1.A.5.a** with minus **48.14 %**.

Table 2: Changes in emission estimates for 2023

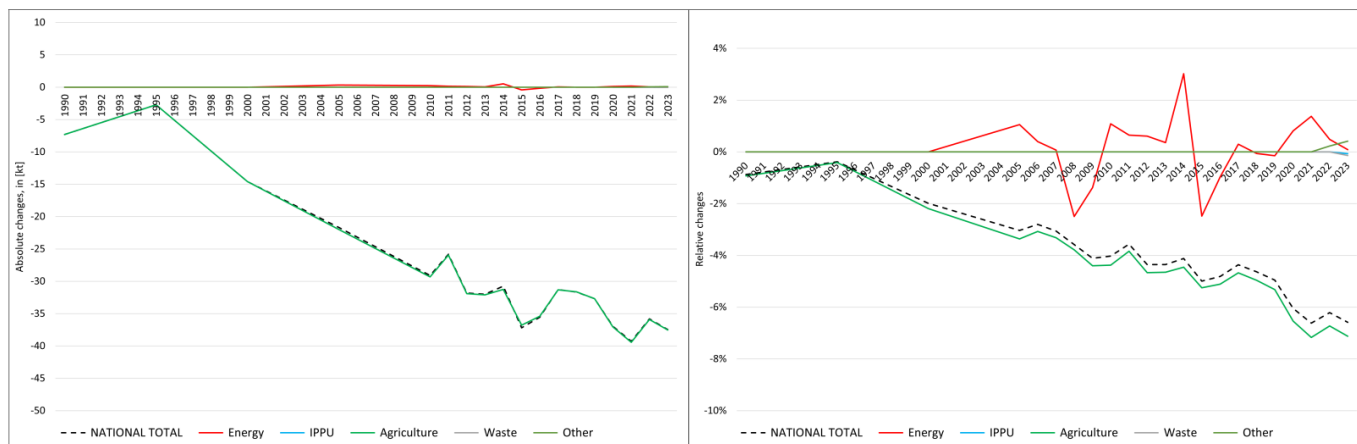
| NFR Sector            | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                                               |
|-----------------------|-----------------|-----------------|--------------|---------------|---------------------------------------------------------|
|                       | [kt]            |                 |              | relative      |                                                         |
| <b>NATIONAL TOTAL</b> | <b>216.62</b>   | <b>210.47</b>   | <b>-6.15</b> | <b>-2.84%</b> | see description and reasoning in: sub-category chapters |
| <b>NFR 1 - Energy</b> | <b>161.04</b>   | <b>155.11</b>   | <b>-5.93</b> | <b>-3.68%</b> | sub-category chapters                                   |
| 1.A.1.a               | 69.01           | 68.62           | -0.39        | -0.56%        | <a href="#">here</a>                                    |
| 1.A.1.b               | 42.43           | 40.59           | -1.84        | -4.34%        | <a href="#">here</a>                                    |
| 1.A.1.c               | 5.25            | 5.45            | 0.21         | 3.94%         | <a href="#">here</a>                                    |
| 1.A.2.a               | 4.62            | 4.37            | -0.26        | -5.57%        | <a href="#">here</a>                                    |
| 1.A.2.b               | 0.397           | 0.408           | 0.01         | 2.88%         | <a href="#">here</a>                                    |
| 1.A.2.e               | 0.91            | 0.71            | -0.20        | -21.85%       | <a href="#">here</a>                                    |
| 1.A.2.g vii           | 0.010           | 0.013           | 0.003        | 25.08%        | <a href="#">here</a>                                    |



|                            | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|----------------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 | relative     |               | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>216.62</b>   | <b>210.47</b>   | <b>-6.15</b> | <b>-2.84%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>161.04</b>   | <b>155.11</b>   | <b>-5.93</b> | <b>-3.68%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g viii               | 16.05           | 13.92           | -2.12        | -13.22%       | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.4763          | 0.4756          | -0.0007      | -0.14%        | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.0663          | 0.0656          | -0.0007      | -1.00%        | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.2039          | 0.2025          | -0.0014      | -0.70%        | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.0062          | 0.0061          | -0.0001      | -0.84%        | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.310           | 0.308           | -0.002       | -0.56%        | <a href="#">here</a>              |
| 1.A.4.a i                  | 1.73            | 1.47            | -0.26        | -14.99%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.003           | 0.004           | 0.001        | 19.26%        | <a href="#">here</a>              |
| 1.A.4.b i                  | 11.39           | 10.24           | -1.15        | -10.08%       | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.0013          | 0.0012          | -0.0001      | -4.82%        | <a href="#">here</a>              |
| 1.A.4.c i                  | 2.02            | 1.94            | -0.08        | -3.73%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.032           | 0.028           | -0.004       | -12.81%       | <a href="#">here</a>              |
| 1.A.5.a                    | 0.028           | 0.015           | -0.014       | -48.14%       | <a href="#">here</a>              |
| 1.A.5.b                    | 0.022           | 0.024           | 0.002        | 10.78%        | <a href="#">here</a>              |
| 1.B.1.b                    | 0.70            | 0.87            | 0.17         | 24.48%        | <a href="#">here</a>              |
| 1.B.2.a iv                 | 3.83            | 3.82            | -0.01        | -0.27%        |                                   |
| 1.B.2.c                    | 0.76            | 0.75            | -0.01        | -0.99%        |                                   |
| <b>NFR 2 - IPPU</b>        | <b>55.48</b>    | <b>55.26</b>    | <b>-0.22</b> | <b>-0.39%</b> | <b>sub-category chapters</b>      |
| 2.A.3                      | 7.00            | 6.95            | -0.05        | -0.70%        | <a href="#">here</a>              |
| 2.B.6                      | 0.72            | 0.55            | -0.17        | -23.48%       | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |              |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.10</b>     | <b>0.10</b>     | <b>0.00</b>  | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |              |               |                                   |

| pollutant-specific data: |     |        |     |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|--------------------------|-----|--------|-----|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
|                          | NOx | NM VOC | SOx | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |

## Recalculations - Ammonia



The small changes within the **National Total** reported for **1990 (-7.32 kt or -0.88 %)** are dominated by revisions in sub-categories of **NFR 3** (-7.32 kt) together with less significant changes throughout NFRs 1 and 3.

The most significant percental change occurs for NFR **3.D.a.1** with minus **5.88 %**.

Table 1: Changes in emission estimates for 1990

|                            | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|----------------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 | absolute     | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>834.48</b>   | <b>827.15</b>   | <b>-7.32</b> | <b>-0.88%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>15.89</b>    | <b>15.89</b>    | <b>0.00</b>  | <b>0.00%</b>  | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.005513        | 0.005514        | 0.000001     | 0.01%         | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.0016202       | 0.0016199       | -0.0000003   | -0.02%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.0115413       | 0.0115411       | -0.0000001   | -0.001%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>14.68</b>    | <b>14.68</b>    | <b>0.00</b>  | <b>0.00%</b>  |                                   |
| <b>NFR 3 - Agriculture</b> | <b>789.32</b>   | <b>782.00</b>   | <b>-7.32</b> | <b>-0.93%</b> | <b>sub-category chapters</b>      |
| 3.B.1.a                    | 60.08           | 58.81           | -1.27        | -2.11%        | <a href="#">here</a>              |
| 3.B.3                      | 120.20          | 118.02          | -2.18        | -1.82%        | <a href="#">here</a>              |
| 3.D.a.1                    | 129.55          | 121.93          | -7.61        | -5.88%        | <a href="#">here</a>              |
| 3.D.a.2.a                  | 320.57          | 324.37          | 3.79         | 1.18%         | <a href="#">here</a>              |
| 3.D.a.2.c                  | 1.5789          | 1.5785          | -0.0004      | -0.02%        | <a href="#">here</a>              |
| 3.D.a.3                    | 24.58           | 24.50           | -0.08        | -0.32%        | <a href="#">here</a>              |
| 3.D.a.4                    | 8.70            | 8.73            | 0.03         | 0.34%         | <a href="#">here</a>              |
| <b>NFR 5 - Waste</b>       | <b>0.34</b>     | <b>0.34</b>     | <b>0.00</b>  | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>14.25</b>    | <b>14.25</b>    | <b>0.00</b>  | <b>0.00%</b>  |                                   |

The strong changes within the **National Total** reported for **2023 (-37.46 kt or -6.58 %)** result mainly from revisions throughout **NFR 3** (-37.53 kt) together with less significant changes throughout NFRs 1, 2, and 5.

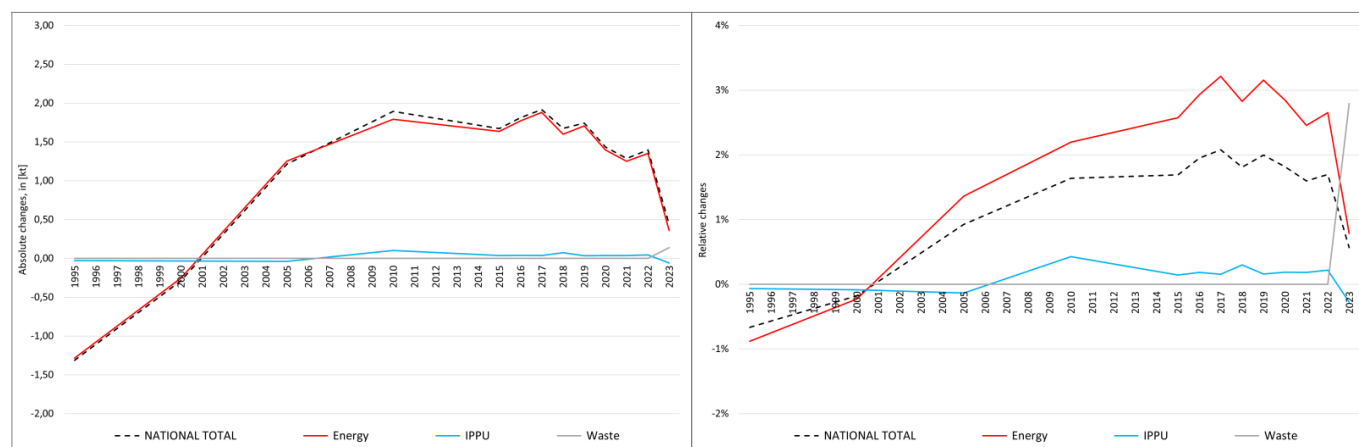
The most significant percental changes occur for NFR sub-categories **1.A.2.g vii** with **plus 30.2 %** and **3.D.a.1** with **minus 28.7 %**.

Table 2: Changes in emission estimates for 2023

|                            | Submission 2025 | Submission 2026 | Difference    |               | Reasoning                         |
|----------------------------|-----------------|-----------------|---------------|---------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 | relative      |               | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>569.00</b>   | <b>531.54</b>   | <b>-37.46</b> | <b>-6.58%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>12.70</b>    | <b>12.71</b>    | <b>0.01</b>   | <b>0.08%</b>  | <b>sub-category chapters</b>      |
| 1.A.1.a                    | 0.5772          | 0.5771          | -0.0001       | -0.02%        | <a href="#">here</a>              |
| 1.A.1.b                    | 0.589           | 0.577           | -0.01         | -1.98%        | <a href="#">here</a>              |
| 1.A.1.c                    | 0.022           | 0.024           | 0.002         | 6.75%         | <a href="#">here</a>              |
| 1.A.2.a                    | 0.1011          | 0.1008          | -0.0003       | -0.31%        | <a href="#">here</a>              |
| 1.A.2.b                    | 0.0072          | 0.0067          | -0.0005       | -7.54%        | <a href="#">here</a>              |
| 1.A.2.e                    | 0.0024          | 0.0019          | -0.0005       | -21.14%       | <a href="#">here</a>              |
| 1.A.2.f                    | 0.0201          | 0.0202          | 0.0001        | 0.36%         | <a href="#">here</a>              |
| 1.A.2.g vii                | 0.0043          | 0.0056          | 0.0013        | 30.20%        | <a href="#">here</a>              |
| 1.A.2.g viii               | 0.352           | 0.367           | 0.015         | 4.23%         | <a href="#">here</a>              |
| 1.A.3.b i                  | 8.344           | 8.333           | -0.01         | -0.13%        | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.288           | 0.285           | -0.002        | -0.78%        | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.672           | 0.663           | -0.01         | -1.30%        | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.0192          | 0.0190          | -0.0002       | -0.84%        | <a href="#">here</a>              |
| 1.A.3.c                    | 0.007104        | 0.007106        | 0.000002      | 0.02%         | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.0049          | 0.0048          | 0.00          | -2.20%        | <a href="#">here</a>              |
| 1.A.4.a i                  | 0.20            | 0.19            | -0.01         | -5.41%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.0015          | 0.0018          | 0.0003        | 18.06%        | <a href="#">here</a>              |
| 1.A.4.b i                  | 1.27            | 1.31            | 0.03          | 2.62%         | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.000322        | 0.000306        | -0.000015     | -4.81%        | <a href="#">here</a>              |
| 1.A.4.c i                  | 0.052           | 0.057           | 0.01          | 9.83%         | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.014           | 0.012           | -0.002        | -12.37%       | <a href="#">here</a>              |
| 1.A.5.a                    | 0.00679         | 0.00682         | 0.00002       | 0.35%         | <a href="#">here</a>              |
| 1.A.5.b                    | 0.023           | 0.025           | 0.002         | 7.94%         | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>7.389</b>    | <b>7.384</b>    | <b>-0.005</b> | <b>-0.07%</b> | <b>sub-category chapters</b>      |
| 2.A.3                      | 0.836           | 0.831           | -0.005        | -0.60%        | <a href="#">here</a>              |
| 2.G                        | 0.5299          | 0.5300          | 0.0001        | 0.02%         | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>526.95</b>   | <b>489.42</b>   | <b>-37.53</b> | <b>-7.12%</b> | <b>sub-category chapters</b>      |
| 3.B.1.a                    | 47.56           | 39.50           | -8.05         | -16.93%       | <a href="#">here</a>              |
| 3.B.1.b                    | 43.75           | 43.65           | -0.10         | -0.22%        | <a href="#">here</a>              |
| 3.B.3                      | 62.12           | 59.50           | -2.62         | -4.21%        | <a href="#">here</a>              |
| 3.B.4.e                    | 18.29           | 21.38           | 3.09          | 16.89%        | <a href="#">here</a>              |
| 3.B.4.g i                  | 6.77            | 6.74            | -0.03         | -0.44%        | <a href="#">here</a>              |
| 3.B.4.g ii                 | 7.67            | 7.57            | -0.11         | -1.41%        | <a href="#">here</a>              |
| 3.B.4.g iii                | 6.86            | 6.85            | -0.01         | -0.17%        | <a href="#">here</a>              |
| 3.B.4.g iv                 | 1.63            | 1.70            | 0.07          | 4.50%         | <a href="#">here</a>              |
| 3.D.a.1                    | 61.79           | 44.08           | -17.71        | -28.67%       | <a href="#">here</a>              |
| 3.D.a.2.a                  | 185.00          | 174.47          | -10.52        | -5.69%        | <a href="#">here</a>              |
| 3.D.a.2.b                  | 1.61            | 1.39            | -0.22         | -13.84%       | <a href="#">here</a>              |
| 3.D.a.2.c                  | 58.35           | 57.13           | -1.23         | -2.10%        | <a href="#">here</a>              |
| 3.D.a.3                    | 15.09           | 15.35           | 0.25          | 1.68%         | <a href="#">here</a>              |
| 3.D.a.4                    | 6.89            | 6.94            | 0.05          | 0.75%         | <a href="#">here</a>              |
| 3.I                        | 1.67            | 1.28            | -0.40         | -23.60%       | <a href="#">here</a>              |
| <b>NFR 5 - Waste</b>       | <b>3.797</b>    | <b>3.791</b>    | <b>-0.005</b> | <b>-0.14%</b> | <b>sub-category chapters</b>      |
| 5.B.1                      | 1.765           | 1.802           | 0.037         | 2.10%         | <a href="#">here</a>              |
| 5.B.2                      | 2.032           | 1.990           | -0.042        | -2.08%        | <a href="#">here</a>              |
| <b>NFR 6 - Other</b>       | <b>18.17</b>    | <b>18.24</b>    | <b>0.07</b>   | <b>0.41%</b>  | <b>sub-category chapters</b>      |
| 6.A                        | 18.17           | 18.24           | 0.07          | 0.41%         |                                   |

|                                 |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Particulate Matter <2.5µm



The small changes within the **National Total** reported for **1995 (-1.31 kt or -0.66 %)** are dominated by revisions in NFR sub-categories **1.A.3.b vi (+1.55 kt)** and **1.A.3.d ii (-2.71 kt)** together with a variety of less significant revisions throughout NFRs 1 and 2. In addition, for NFR 2.D.3.c, particulate matter emissions are reported for the first time.

The most significant percental change occurs for **1.A.4.c iii with -81.53%**.

Table 1: Changes of emission estimates 1995

|                            | Submission 2025 | Submission 2026 | Difference    |               | Reasoning                         |
|----------------------------|-----------------|-----------------|---------------|---------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 | absolute      | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>197.47</b>   | <b>196.16</b>   | <b>-1.31</b>  | <b>-0.66%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>145.68</b>   | <b>144.40</b>   | <b>-1.28</b>  | <b>-0.88%</b> | <b>sub-category chapters</b>      |
| 1.A.3.b vi                 | 6.00            | 7.54            | 1.55          | 25.82%        | <a href="#">here</a>              |
| 1.A.3.b vii                | 3.39            | 3.43            | 0.04          | 1.11%         | <a href="#">here</a>              |
| 1.A.3.d ii                 | 4.70            | 1.99            | -2.71         | -57.73%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.62626         | 0.62612         | -0.00014      | -0.02%        | <a href="#">here</a>              |
| 1.A.4.c iii                | 0.07            | 0.01            | -0.06         | -81.53%       | <a href="#">here</a>              |
| 1.A.5.b                    | 1.15            | 1.05            | -0.10         | -8.38%        | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>40.687</b>   | <b>40.660</b>   | <b>-0.027</b> | <b>-0.07%</b> | <b>sub-category chapters</b>      |
| 2.D.3.c                    | NE              | 0.048           | 0.048         |               | <a href="#">here</a>              |
| 2.I                        | 1.048           | 0.974           | -0.075        | -7.14%        | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>6.39</b>     | <b>6.39</b>     | <b>0.00</b>   | <b>0.00%</b>  |                                   |
| <b>NFR 5 - Waste</b>       | <b>4.71</b>     | <b>4.71</b>     | <b>0.00</b>   | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |               |               |                                   |

The small changes within the **National Total** reported for **2023 (+0.44 kt or +0.57 %)** are dominated by revisions in NFR sub-categories **1.A.3.b vi (+1.19 kt)** and **1.A.4.c ii (-0.52 kt)** together with a variety of less significant revisions throughout NFRs 1 and 2. In addition, for NFR 2.D.3.c, particulate matter emissions are reported for the first time.

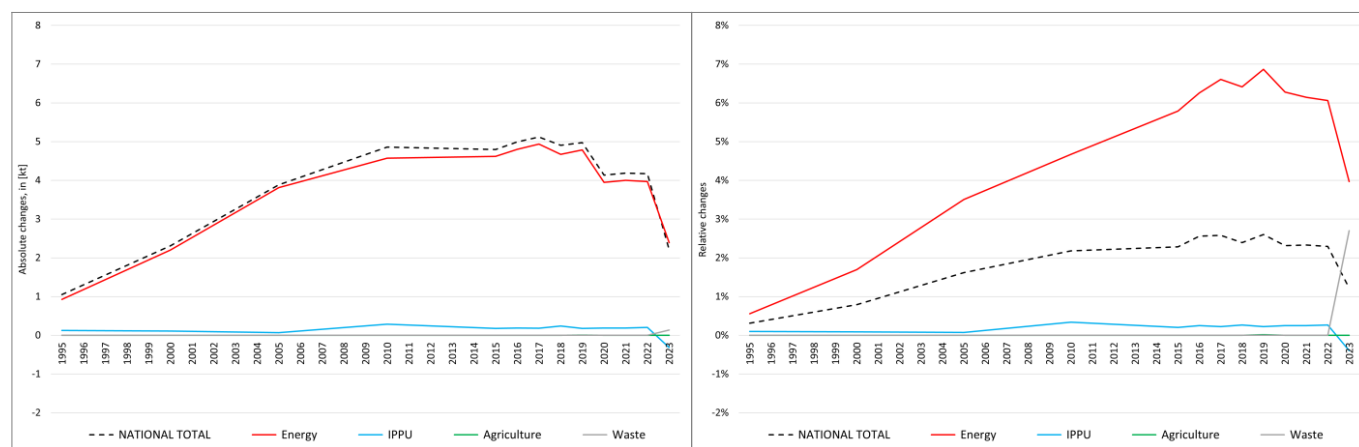
The most significant percental change occurs for **1.A.4.a ii with -37.3%**.

Table 2: Changes of emission estimates 2023

|                            | Submission 2025 | Submission 2026 | Difference     |               | Reasoning                         |
|----------------------------|-----------------|-----------------|----------------|---------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 |                | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>77.47</b>    | <b>77.91</b>    | <b>0.44</b>    | <b>0.57%</b>  | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>45.81</b>    | <b>46.17</b>    | <b>0.36</b>    | <b>0.79%</b>  | <b>sub-category chapters</b>      |
| 1.A.1.a                    | 3.13            | 3.16            | 0.03           | 1.03%         | <a href="#">here</a>              |
| 1.A.1.b                    | 0.59            | 0.57            | -0.02          | -3.86%        | <a href="#">here</a>              |
| 1.A.1.c                    | 0.23            | 0.24            | 0.01           | 4.40%         | <a href="#">here</a>              |
| 1.A.2.a                    | 0.073           | 0.068           | -0.006         | -8.03%        | <a href="#">here</a>              |
| 1.A.2.g vii                | 0.27            | 0.36            | 0.09           | 31.97%        | <a href="#">here</a>              |
| 1.A.2.g viii               | 1.83            | 1.81            | -0.03          | -1.45%        | <a href="#">here</a>              |
| 1.A.3.a ii(i)              | 0.01151         | 0.01152         | 0.00001        | 0.12%         | <a href="#">here</a>              |
| 1.A.3.b i                  | 1.708           | 1.705           | -0.003         | -0.20%        | <a href="#">here</a>              |
| 1.A.3.b ii                 | 1.19            | 1.18            | -0.01          | -1.00%        | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.848           | 0.847           | -0.001         | -0.10%        | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.864           | 0.857           | -0.007         | -0.83%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 7.53            | 8.71            | <u>1.19</u>    | 15.77%        | <a href="#">here</a>              |
| 1.A.3.b vii                | 4.187           | 4.008           | -0.18          | -4.28%        | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.70            | 0.66            | -0.05          | -6.61%        | <a href="#">here</a>              |
| 1.A.4.a i                  | 2.127           | 2.002           | -0.125         | -5.87%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.105           | 0.145           | 0.039          | <u>37.33%</u> | <a href="#">here</a>              |
| 1.A.4.b i                  | 13.97           | 13.93           | -0.04          | -0.29%        | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.104           | 0.099           | -0.005         | -4.71%        | <a href="#">here</a>              |
| 1.A.4.c i                  | 0.458           | 0.457           | -0.001         | -0.26%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 3.49            | 2.97            | <u>-0.52</u>   | -14.90%       | <a href="#">here</a>              |
| 1.A.4.c iii                | 0.009           | 0.008           | -0.001         | -6.54%        | <a href="#">here</a>              |
| 1.A.5.a                    | 0.042           | 0.045           | 0.004          | 8.89%         | <a href="#">here</a>              |
| 1.A.5.b                    | 0.081           | 0.086           | 0.005          | 6.64%         | <a href="#">here</a>              |
| 1.B.1.b                    | 0.199           | 0.191           | -0.008         | -3.85%        | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>21.34</b>    | <b>21.28</b>    | <b>-0.06</b>   | <b>-0.28%</b> | <b>sub-category chapters</b>      |
| 2.A.3                      | 0.042           | 0.042           | 0.00           | -0.53%        | <a href="#">here</a>              |
| 2.A.5.a                    | 1.83            | 1.71            | -0.11          | -6.18%        | <a href="#">here</a>              |
| 2.C.1                      | 2.0978          | 2.0980          | 0.0001         | 0.01%         | <a href="#">here</a>              |
| 2.C.2                      | 0.0008          | 0.0008          | 0.00           | 1.72%         | <a href="#">here</a>              |
| 2.D.3.c                    | NE              | <u>0.03</u>     | 0.03           |               | <a href="#">here</a>              |
| 2.G                        | 3.50            | 3.51            | 0.01           | 0.15%         | <a href="#">here</a>              |
| 2.I                        | 0.621           | 0.618           | -0.003         | -0.46%        | <a href="#">here</a>              |
| 2.L                        | 10.10           | 10.13           | 0.03           | 0.25%         | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>5.40627</b>  | <b>5.40626</b>  | <b>0.00</b>    | <b>0.00%</b>  |                                   |
| <b>NFR 5 - Waste</b>       | <b>4.92122</b>  | <b>5.05862</b>  | <b>0.13740</b> | <b>2.79%</b>  | <b>sub-category chapters</b>      |
| 5.A                        | 0.00129         | 0.00111         | -0.00018       | -13.86%       | <a href="#">here</a>              |
| 5.E                        | 3.69669         | 3.83427         | 0.13758        | 3.72%         | <a href="#">here</a>              |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |                |               |                                   |

|                                 |     |        |     |     |       |             |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|-------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | <b>PM10</b> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----|--------|-----|-----|-------|-------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Particulate Matter <10µm



The small changes within the **National Total** reported for **1995 (-1.31 kt or -0.66 %)** are dominated by revisions in NFR sub-categories **1.A.3.b vi (+3.95 kt)** and **1.A.3.d ii (-2.94 kt)** together with a variety of less significant revisions throughout NFRs 1 and 2. In addition, for NFR 2.D.3.c, particulate matter emissions are reported for the first time.

The most significant percental change occurs for **1.A.4.c iii with -81.63%**.

Table 1: Changes of emission estimates 1995

|                            | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                         |
|----------------------------|-----------------|-----------------|-------------|--------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 | absolute    | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>334.41</b>   | <b>335.46</b>   | <b>1.05</b> | <b>0.31%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>165.74</b>   | <b>166.67</b>   | <b>0.93</b> | <b>0.56%</b> | <b>sub-category chapters</b>      |
| 1.A.3.b vi                 | 11.11           | 15.06           | 3.95        | 35.58%       | <a href="#">here</a>              |
| 1.A.3.b vii                | 6.27            | 6.35            | 0.08        | 1.35%        | <a href="#">here</a>              |
| 1.A.3.d ii                 | 4.98            | 2.04            | -2.94       | -59.05%      | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.626           | 0.626           | 0.00        | -0.02%       | <a href="#">here</a>              |
| 1.A.4.c iii                | 0.078           | 0.014           | -0.064      | -81.63%      | <a href="#">here</a>              |
| 1.A.5.b                    | 1.16            | 1.06            | -0.10       | -8.99%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>127.68</b>   | <b>127.81</b>   | <b>0.13</b> | <b>0.10%</b> | <b>sub-category chapters</b>      |
| 2.D.3.c                    | NE              | 0.24            | 0.24        |              | <a href="#">here</a>              |
| 2.I                        | 1.58            | 1.47            | -0.11       | -7.14%       | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>36.10</b>    | <b>36.10</b>    | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 5 - Waste</b>       | <b>4.88</b>     | <b>4.88</b>     | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |              |                                   |

The changes within the **National Total** reported for **2023 (+2.21 kt or +1.22 %)** are dominated by a revision in NFR sub-category **1.A.3.b vi (+3.38 kt)** together with a variety of revisions throughout NFRs 1, 2, and 5. In addition, for NFR 2.D.3.c, particulate matter emissions are reported for the first time.

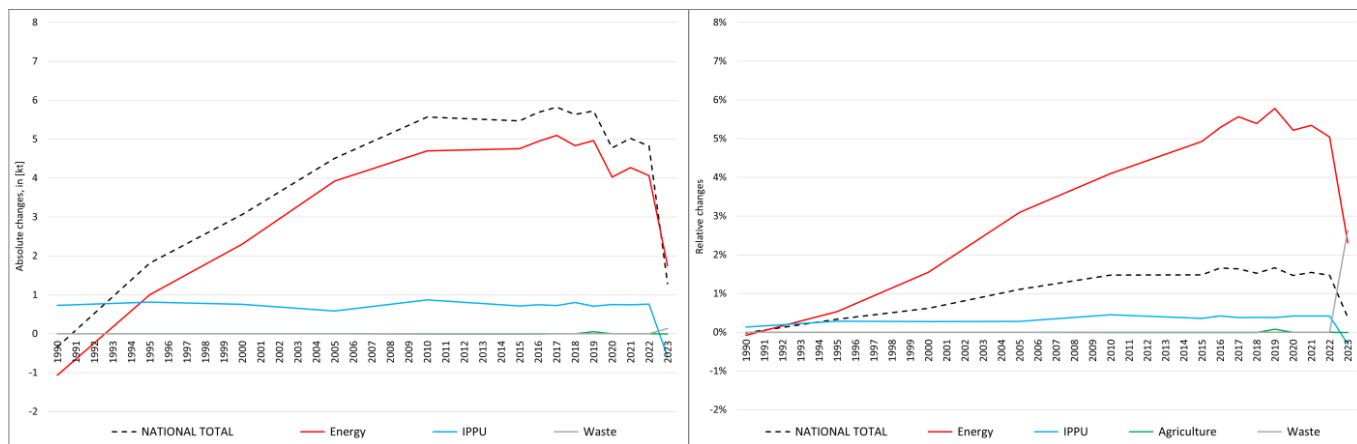
The most significant percental change occurs for **NFR 1.A.4.a ii with +37.3 %**

Table 2: Changes of emission estimates 2023

|                            | Submission 2025 | Submission 2026 | Difference    |                                   | Reasoning                    |
|----------------------------|-----------------|-----------------|---------------|-----------------------------------|------------------------------|
| NFR Sector                 | [kt]            |                 | relative      | see description and reasoning in: |                              |
| <b>NATIONAL TOTAL</b>      | <b>181.55</b>   | <b>183.76</b>   | <b>2.21</b>   | <b>1.22%</b>                      | <b>sub-category chapters</b> |
| <b>NFR 1 - Energy</b>      | <b>60.29</b>    | <b>62.68</b>    | <b>2.39</b>   | <b>3.97%</b>                      | <b>sub-category chapters</b> |
| 1.A.1.a                    | 3.36            | 3.40            | 0.04          | 1.07%                             | <a href="#">here</a>         |
| 1.A.1.b                    | 0.67            | 0.64            | -0.03         | -3.89%                            | <a href="#">here</a>         |
| 1.A.1.c                    | 0.25            | 0.26            | 0.01          | 4.60%                             | <a href="#">here</a>         |
| 1.A.2.a                    | 0.074           | 0.068           | -0.006        | -8.00%                            | <a href="#">here</a>         |
| 1.A.2.g vii                | 0.27            | 0.36            | 0.09          | 31.97%                            | <a href="#">here</a>         |
| 1.A.2.g viii               | 2.05            | 2.03            | -0.03         | -1.40%                            | <a href="#">here</a>         |
| 1.A.3.a ii(i)              | 0.01151         | 0.01152         | 0.00001       | 0.12%                             | <a href="#">here</a>         |
| 1.A.3.b i                  | 1.708           | 1.705           | -0.003        | -0.20%                            | <a href="#">here</a>         |
| 1.A.3.b ii                 | 1.190           | 1.178           | -0.01         | -1.00%                            | <a href="#">here</a>         |
| 1.A.3.b iii                | 0.848           | 0.847           | -0.001        | -0.10%                            | <a href="#">here</a>         |
| 1.A.3.b iv                 | 0.864           | 0.857           | -0.007        | -0.83%                            | <a href="#">here</a>         |
| 1.A.3.b vi                 | 13.95           | 17.33           | <u>3.38</u>   | 24.25%                            | <a href="#">here</a>         |
| 1.A.3.b vii                | 7.74            | 7.42            | -0.32         | -4.07%                            | <a href="#">here</a>         |
| 1.A.3.d ii                 | 0.74            | 0.69            | -0.05         | -6.84%                            | <a href="#">here</a>         |
| 1.A.4.a i                  | 2.36            | 2.22            | -0.14         | -5.85%                            | <a href="#">here</a>         |
| 1.A.4.a ii                 | 0.11            | 0.14            | 0.04          | <u>37.33%</u>                     | <a href="#">here</a>         |
| 1.A.4.b i                  | 14.70           | 14.65           | -0.04         | -0.29%                            | <a href="#">here</a>         |
| 1.A.4.b ii                 | 0.104           | 0.099           | -0.005        | -4.71%                            | <a href="#">here</a>         |
| 1.A.4.c i                  | 0.477           | 0.476           | -0.001        | -0.25%                            | <a href="#">here</a>         |
| 1.A.4.c ii                 | 3.49            | 2.97            | -0.52         | -14.90%                           | <a href="#">here</a>         |
| 1.A.4.c iii                | 0.009           | 0.009           | -0.001        | -6.54%                            | <a href="#">here</a>         |
| 1.A.5.a                    | 0.045           | 0.049           | 0.004         | 8.67%                             | <a href="#">here</a>         |
| 1.A.5.b                    | 0.08            | 0.09            | 0.01          | 6.59%                             | <a href="#">here</a>         |
| 1.B.1.b                    | 0.29            | 0.28            | -0.01         | -4.59%                            | <a href="#">here</a>         |
| <b>NFR 2 - IPPU</b>        | <b>80.83</b>    | <b>80.51</b>    | <b>-0.32</b>  | <b>-0.39%</b>                     | <b>sub-category chapters</b> |
| 2.A.3                      | 0.0714          | 0.0711          | -0.0003       | -0.48%                            | <a href="#">here</a>         |
| 2.A.5.a                    | 11.73           | 11.20           | -0.53         | -4.51%                            | <a href="#">here</a>         |
| 2.C.1                      | 3.7223          | 3.7226          | 0.0002        | 0.01%                             | <a href="#">here</a>         |
| 2.C.2                      | 0.00328         | 0.00334         | 0.00006       | 1.72%                             | <a href="#">here</a>         |
| 2.D.3.c                    | NE              | <u>0.13</u>     | 0.13          |                                   | <a href="#">here</a>         |
| 2.G                        | 3.773           | 3.779           | 0.005         | 0.14%                             | <a href="#">here</a>         |
| 2.I                        | 0.938           | 0.934           | -0.004        | -0.46%                            | <a href="#">here</a>         |
| 2.L                        | 44.95           | 45.02           | 0.08          | 0.17%                             | <a href="#">here</a>         |
| <b>NFR 3 - Agriculture</b> | <b>35.38</b>    | <b>35.38</b>    | <b>0.00</b>   | <b>0.00%</b>                      |                              |
| <b>NFR 5 - Waste</b>       | <b>5.0508</b>   | <b>5.1872</b>   | <b>0.1364</b> | <b>2.70%</b>                      | <b>sub-category chapters</b> |
| 5.A                        | 0.0086          | 0.0074          | -0.0012       | -13.86%                           | <a href="#">here</a>         |
| 5.E                        | 3.6967          | 3.8343          | 0.1376        | 3.72%                             | <a href="#">here</a>         |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |               |                                   |                              |

|                                 |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCb | PCB |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Total Suspended Particles (TSP)



The marginal changes within the **National Total** reported for **1990 (-0.34 kt or -0.02 %)** are dominated by two opposing revision in NFRs sub-categories **1.A.3.b vi (+3.56 kt)** and **1.A.3.d ii (-4.45 kt)** together with less significant revisions in NFRs 1 and 3. Here, TSP emissions from **2.D.3.c (0.73 kt)** are reported for the first time.

The strongest percental changes occur for NFRs **1.A.4.c iii with -83 %** and **1.A.3.d ii with minus 62 %**.

Table 1: Changes in emission estimates for 1990

|                            | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|----------------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 | absolute     | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>2,015.59</b> | <b>2,015.25</b> | <b>-0.34</b> | <b>-0.02%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>1,391.90</b> | <b>1,390.84</b> | <b>-1.07</b> | <b>-0.08%</b> | <b>sub-category chapters</b>      |
| 1.A.3.b vi                 | 12.67           | 16.23           | 3.56         | 28.09%        | <a href="#">here</a>              |
| 1.A.3.b vii                | 10.80           | 10.88           | 0.09         | 0.79%         | <a href="#">here</a>              |
| 1.A.3.d ii                 | 7.17            | 2.71            | -4.45        | -62.14%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 1.30            | 1.30            | 0.00         | -0.03%        | <a href="#">here</a>              |
| 1.A.4.c iii                | 0.11            | 0.02            | -0.09        | -83.13%       | <a href="#">here</a>              |
| 1.A.5.b                    | 2.82            | 2.65            | -0.17        | -5.87%        | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>543.41</b>   | <b>544.14</b>   | <b>0.73</b>  | <b>0.13%</b>  | <b>sub-category chapters</b>      |
| 2.D.3.c                    | NE              | 0.73            | 0.73         |               | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>75.24</b>    | <b>75.24</b>    | <b>0.00</b>  | <b>0.00%</b>  | <b>sub-category chapters</b>      |
| <b>NFR 5 - Waste</b>       | <b>5.04</b>     | <b>5.04</b>     | <b>0.00</b>  | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |              |               |                                   |

The rather small changes within the **National Total** reported for **2023 (+1.29 kt or +0.39 %)** are dominated by revisions in NFR sub-categories **1.A.3.b vi (+3.10 kt)** and **2.A.5.a (-1.35 kt)** together with less significant revisions in NFRs 1, 2 and 3.

Here, TSP emissions from **2.D.3.c (0.53 kt)** are reported for the first time.

The strongest percental changes occur for NFRs **1.A.4.a ii with plus 37 %** and **1.A.2.g vii with plus 32 %**.

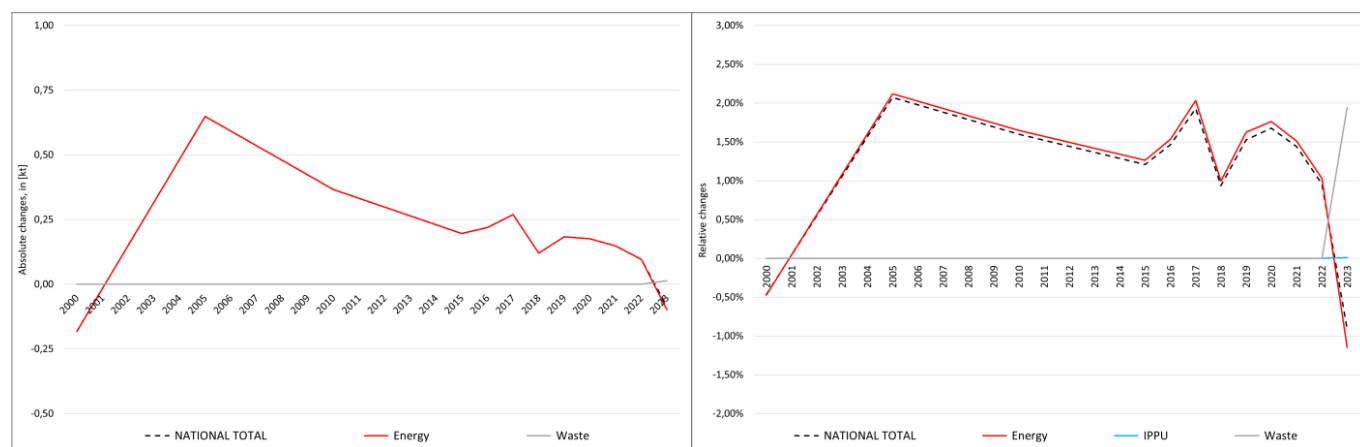
Table 2: Changes in emission estimates for 2023



|                            | Submission 2025 | Submission 2026 | Difference    |                                   | Reasoning                    |
|----------------------------|-----------------|-----------------|---------------|-----------------------------------|------------------------------|
| NFR Sector                 | [kt]            |                 | relative      | see description and reasoning in: |                              |
| <b>NATIONAL TOTAL</b>      | <b>333.541</b>  | <b>334.831</b>  | <b>1.29</b>   | <b>0.39%</b>                      | <b>sub-category chapters</b> |
| <b>NFR 1 - Energy</b>      | <b>75.429</b>   | <b>77.173</b>   | <b>1.74</b>   | <b>2.31%</b>                      | <b>sub-category chapters</b> |
| 1.A.1.a                    | 3.57            | 3.61            | 0.04          | 1.11%                             | <a href="#">here</a>         |
| 1.A.1.b                    | 0.74            | 0.71            | -0.03         | -3.92%                            | <a href="#">here</a>         |
| 1.A.1.c                    | 0.3615          | 0.3814          | 0.02          | 5.51%                             | <a href="#">here</a>         |
| 1.A.2.a                    | 0.074           | 0.068           | -0.01         | -7.96%                            | <a href="#">here</a>         |
| 1.A.2.g vii                | 0.27            | 0.36            | 0.09          | 31.97%                            | <a href="#">here</a>         |
| 1.A.2.g viii               | 2.27            | 2.24            | -0.03         | -1.41%                            | <a href="#">here</a>         |
| 1.A.3.a ii(i)              | 0.01183         | 0.01186         | 0.00002       | 0.18%                             | <a href="#">here</a>         |
| 1.A.3.b i                  | 1.708           | 1.705           | -0.003        | -0.20%                            | <a href="#">here</a>         |
| 1.A.3.b ii                 | 1.190           | 1.178           | -0.01         | -1.00%                            | <a href="#">here</a>         |
| 1.A.3.b iii                | 0.848           | 0.847           | -0.001        | -0.10%                            | <a href="#">here</a>         |
| 1.A.3.b iv                 | 0.864           | 0.857           | -0.007        | -0.83%                            | <a href="#">here</a>         |
| 1.A.3.b vi                 | 18.47           | 21.57           | 3.10          | 16.81%                            | <a href="#">here</a>         |
| 1.A.3.b vii                | 15.51           | 14.84           | -0.66         | -4.28%                            | <a href="#">here</a>         |
| 1.A.3.d ii                 | 0.7380          | 0.6875          | -0.05         | -6.84%                            | <a href="#">here</a>         |
| 1.A.4.a i                  | 2.46            | 2.32            | -0.14         | -5.75%                            | <a href="#">here</a>         |
| 1.A.4.a ii                 | 0.105           | 0.145           | 0.04          | 37.33%                            | <a href="#">here</a>         |
| 1.A.4.b i                  | 15.02           | 14.97           | -0.04         | -0.30%                            | <a href="#">here</a>         |
| 1.A.4.b ii                 | 0.104           | 0.099           | -0.005        | -4.71%                            | <a href="#">here</a>         |
| 1.A.4.c i                  | 0.488           | 0.487           | -0.001        | -0.25%                            | <a href="#">here</a>         |
| 1.A.4.c ii                 | 3.49            | 2.97            | -0.52         | -14.90%                           | <a href="#">here</a>         |
| 1.A.4.c iii                | 0.0092          | 0.0086          | -0.0006       | -6.54%                            | <a href="#">here</a>         |
| 1.A.5.a                    | 0.047           | 0.051           | 0.004         | 8.68%                             | <a href="#">here</a>         |
| 1.A.5.b                    | 0.08            | 0.09            | 0.01          | 6.59%                             | <a href="#">here</a>         |
| 1.B.1.b                    | 0.56            | 0.52            | -0.04         | -6.83%                            | <a href="#">here</a>         |
| <b>NFR 2 - IPPU</b>        | <b>191.98</b>   | <b>191.39</b>   | <b>-0.59</b>  | <b>-0.31%</b>                     | <b>sub-category chapters</b> |
| 2.A.3                      | 0.33            | 0.33            | 0.00          | -0.14%                            | <a href="#">here</a>         |
| 2.A.5.a                    | 34.87           | 33.53           | -1.35         | -3.87%                            | <a href="#">here</a>         |
| 2.C.2                      | 0.0051          | 0.0052          | 0.0001        | 1.72%                             | <a href="#">here</a>         |
| 2.D.3.c                    | NE              | 0.53            | 0.53          |                                   | <a href="#">here</a>         |
| 2.G                        | 3.77            | 3.78            | 0.01          | 0.14%                             | <a href="#">here</a>         |
| 2.I                        | 1.22            | 1.21            | -0.01         | -0.46%                            | <a href="#">here</a>         |
| 2.L                        | 98.46           | 98.69           | 0.23          | 0.23%                             | <a href="#">here</a>         |
| <b>NFR 3 - Agriculture</b> | <b>61.016</b>   | <b>61.014</b>   | <b>-0.002</b> | <b>-0.003%</b>                    | <b>sub-category chapters</b> |
| 3.B.3                      | 12.066          | 12.065          | -0.002        | -0.01%                            | <a href="#">here</a>         |
| <b>NFR 5 - Waste</b>       | <b>5.12</b>     | <b>5.25</b>     | <b>0.135</b>  | <b>2.64%</b>                      | <b>sub-category chapters</b> |
| 5.A                        | 0.018           | 0.016           | -0.003        | -13.86%                           | <a href="#">here</a>         |
| 5.E                        | 3.70            | 3.83            | 0.138         | 3.72%                             | <a href="#">here</a>         |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |               |                                   |                              |

|                                 |                 |                   |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |       |       |       |       |       |        |     |     |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NO <sub>x</sub> | NM <sub>VOC</sub> | SO <sub>x</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDDF | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Black Carbon (BC)



The small changes within the **National Total** reported for **2000 (-0.18 kt or -0.46 %)** result from a **variety of revisions in NFRs 1 and 5** with the biggest change occurring for NFR sub-category **1.A.3.d** with **-0.41 kt**. In addition, for NFR 1.A.3.b vii, BC emissions are reported for the first time.

The most significant percental change occurs for **NFR 1.A.4.c iii** with **-96 %**.

Table 1: Changes of emission estimates 2000

|                            | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|----------------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 |              | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>39.20</b>    | <b>39.01</b>    | <b>-0.18</b> | <b>-0.46%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>38.45</b>    | <b>38.27</b>    | <b>-0.18</b> | <b>-0.47%</b> | <b>sub-category chapters</b>      |
| 1.A.3.b vi                 | 1.62            | 1.73            | 0.11         | 6.57%         | <a href="#">here</a>              |
| 1.A.3.b vii                | NE              | <u>0.15</u>     | 0.15         |               | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.74            | 0.33            | <u>-0.41</u> | -55.17%       | <a href="#">here</a>              |
| 1.A.4.c iii                | 0.01            | 0.00            | -0.01        | -95.76%       | <a href="#">here</a>              |
| 1.A.5.b                    | 0.14837         | 0.13262         | -0.02        | -10.61%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>0.02</b>     | <b>0.02</b>     | <b>0.00</b>  | <b>0.00%</b>  |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |              |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.73</b>     | <b>0.73</b>     | <b>0.00</b>  | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |              |               |                                   |

The small changes within the **National Total** reported for **2023 (-0.09 kt or -0.91 %)** result from a **variety of revisions in NFRs 1 and 5** with the biggest change occurring for NFR sub-category **1.A.4.c ii** with **-0.29 kt**. In addition, for NFR 1.A.3.b vii, BC emissions are reported for the first time.

The most significant percental change occurs for **NFR 1.A.4.c iii** with **-85.5 %**.

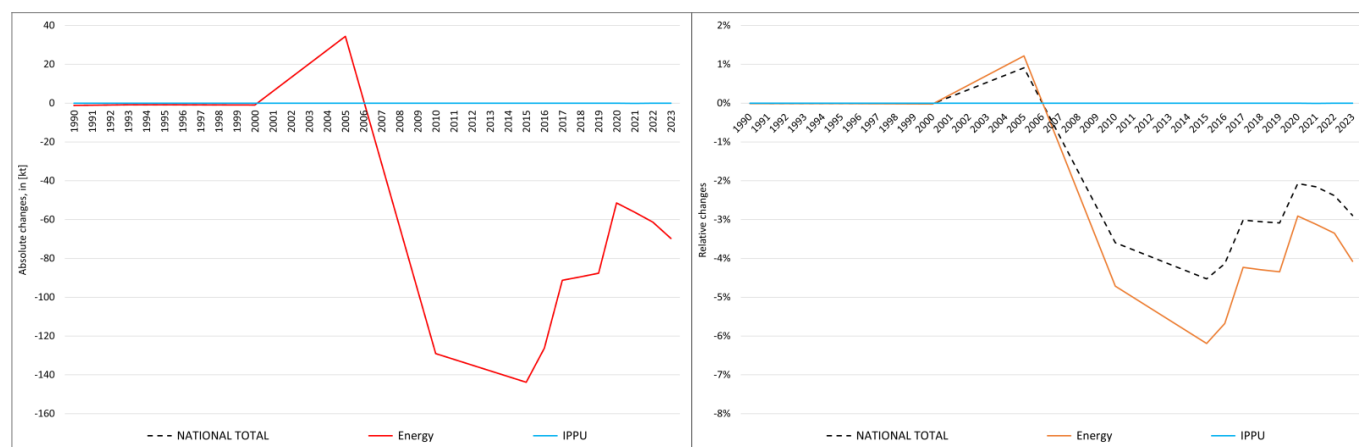
Table 2: Changes of emission estimates 2023

|                       | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|-----------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector            | [kt]            |                 |              | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>9.36</b>     | <b>9.27</b>     | <b>-0.09</b> | <b>-0.91%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>8.64</b>     | <b>8.54</b>     | <b>-0.10</b> | <b>-1.15%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 0.0252          | 0.0253          | 0.0001       | 0.54%         | <a href="#">here</a>              |
| 1.A.1.b               | 0.0347          | 0.0333          | -0.0014      | -4.04%        | <a href="#">here</a>              |
| 1.A.1.c               | 0.00033         | 0.00036         | 0.00004      | 11.42%        | <a href="#">here</a>              |

|                            | Submission 2025   | Submission 2026   | Difference      |               | Reasoning                         |
|----------------------------|-------------------|-------------------|-----------------|---------------|-----------------------------------|
| NFR Sector                 | [kt]              |                   |                 | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>9.36</b>       | <b>9.27</b>       | <b>-0.09</b>    | <b>-0.91%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>8.64</b>       | <b>8.54</b>       | <b>-0.10</b>    | <b>-1.15%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.18              | 0.24              | 0.07            | 38.02%        | <a href="#">here</a>              |
| 1.A.2.g viii               | 0.029             | 0.027             | -0.002          | -5.51%        | <a href="#">here</a>              |
| 1.A.3.a i(i)               | 0.02766           | 0.02766           | 0.00            | 0.00%         | <a href="#">here</a>              |
| 1.A.3.a ii(i)              | 0.005327          | 0.005329          | 0.000002        | 0.04%         | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.813             | 0.826             | 0.013           | 1.55%         | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.624             | 0.618             | -0.006          | -0.97%        | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.3804            | 0.3817            | 0.0013          | 0.35%         | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.154             | 0.153             | -0.001          | -0.83%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 1.849             | 1.836             | -0.013          | -0.73%        | <a href="#">here</a>              |
| 1.A.3.b vii                | NE                | 0.16              | 0.16            |               | <a href="#">here</a>              |
| 1.A.3.c                    | 0.07963           | 0.07965           | 0.00002         | 0.02%         | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.209             | 0.205             | -0.004          | -1.88%        | <a href="#">here</a>              |
| 1.A.4.a i                  | 0.55              | 0.51              | -0.04           | -7.41%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.08              | 0.11              | 0.03            | 38.34%        | <a href="#">here</a>              |
| 1.A.4.b i                  | 1.320             | 1.316             | -0.005          | -0.35%        | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.0052            | 0.0050            | -0.0002         | -4.71%        | <a href="#">here</a>              |
| 1.A.4.c i                  | 0.085             | 0.085             | 0.00            | 0.00%         | <a href="#">here</a>              |
| 1.A.4.c ii                 | 2.11              | 1.82              | -0.29           | -13.95%       | <a href="#">here</a>              |
| 1.A.4.c iii                | 0.0027            | 0.0004            | -0.0023         | -85.48%       | <a href="#">here</a>              |
| 1.A.5.a                    | 0.012             | 0.013             | 0.001           | 8.43%         | <a href="#">here</a>              |
| 1.A.5.b                    | 0.038             | 0.039             | 0.001           | 3.85%         | <a href="#">here</a>              |
| 1.B.1.b                    | 0.016374          | 0.016377          | 0.000003        | 0.02%         | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>0.01009710</b> | <b>0.01009821</b> | <b>0.000001</b> | <b>0.01%</b>  | <b>sub-category chapters</b>      |
| 2.G                        | 0.00737347        | 0.00737458        | 0.000001        | 0.02%         | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>         |                   |                 |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.71</b>       | <b>0.72</b>       | <b>0.01</b>     | <b>1.94%</b>  | <b>sub-category chapters</b>      |
| 5.E                        | 0.37              | 0.38              | 0.01            | 3.72%         | <a href="#">here</a>              |
| <b>NFR 6 - Other</b>       | <b>NA</b>         |                   |                 |               |                                   |

|                                 |                 |                   |                 |                 |                   |                  |     |    |           |    |    |    |    |    |    |    |    |    |                   |       |       |       |       |        |     |     |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|-----------|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NO <sub>x</sub> | NM <sub>VOC</sub> | SO <sub>x</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | <b>CO</b> | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD <sub>F</sub> | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|-----------|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Carbon monoxide (CO)



The marginal changes in the **National Total** reported for **1990 (-1.22 kt or -0.01 %)** are dominated by a revisions in NFR sub-category **1.A.3.d ii with -1.15 kt**.

However, the strongest percental change occurs for NFR **1.A.4.c iii with minus 52 %**.

Table 1: Changes in emission estimates for 1990

|                            | Submission 2025  | Submission 2026  | Difference   |               | Reasoning                         |
|----------------------------|------------------|------------------|--------------|---------------|-----------------------------------|
| NFR Sector                 | [kt]             |                  | absolute     | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>13,320.53</b> | <b>13,319.31</b> | <b>-1.22</b> | <b>-0.01%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>12,050.69</b> | <b>12,049.47</b> | <b>-1.22</b> | <b>-0.01%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 73.97            | 73.98            | 0.01         | 0.01%         | <a href="#">here</a>              |
| 1.A.3.d ii                 | 21.53            | 20.39            | -1.15        | -5.32%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 6.05             | 6.05             | 0.00         | -0.03%        | <a href="#">here</a>              |
| 1.A.4.c iii                | 0.04             | 0.02             | -0.02        | -51.89%       | <a href="#">here</a>              |
| 1.A.5.b                    | 116.99           | 116.93           | -0.06        | -0.05%        | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>1,248.77</b>  | <b>1,248.77</b>  | <b>0.00</b>  | <b>0.00%</b>  |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>        |                  |              |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>21.08</b>     | <b>21.08</b>     | <b>0.00</b>  | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>        |                  |              |               |                                   |

The far more significant changes in the **National Total** reported for **2023 (-69.7 kt or 2.89 %)** are dominated by revisions within NFR sub-categories **1.A.2.g vii (-43 kt)** and **1.A.4.c ii (-16 kt)**.

In contrast, the most significant percental change occurs for NFR **1.A.4.c iii with minus 47 %**.

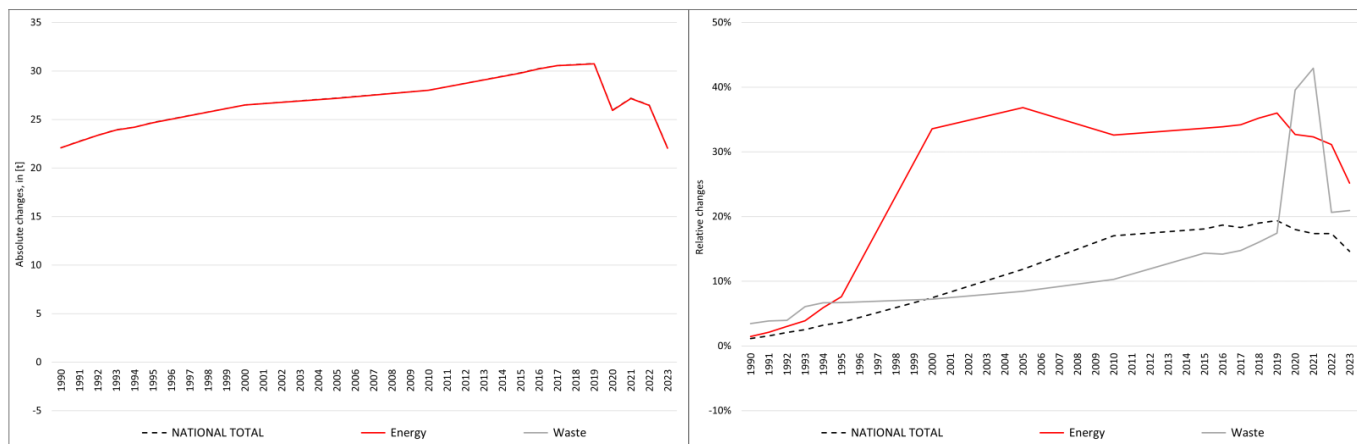
Table 2: Changes in emission estimates for 2023

|                       | Submission 2025 | Submission 2026 | Difference    |               | Reasoning                         |
|-----------------------|-----------------|-----------------|---------------|---------------|-----------------------------------|
| NFR Sector            | [kt]            |                 | absolute      | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>2,409.34</b> | <b>2,339.64</b> | <b>-69.70</b> | <b>-2.89%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>1,709.75</b> | <b>1,640.05</b> | <b>-69.70</b> | <b>-4.08%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 81.78           | 81.78           | 0.01          | 0.01%         | <a href="#">here</a>              |
| 1.A.1.b               | 1.45            | 1.54            | 0.09          | 6.17%         | <a href="#">here</a>              |
| 1.A.1.c               | 10.37           | 10.85           | 0.48          | 4.62%         | <a href="#">here</a>              |
| 1.A.2.a               | 30.97           | 30.73           | -0.24         | -0.78%        | <a href="#">here</a>              |

|                            | Submission 2025 | Submission 2026 | Difference     |                 | Reasoning                         |
|----------------------------|-----------------|-----------------|----------------|-----------------|-----------------------------------|
| NFR Sector                 | [kt]            |                 | relative       |                 | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>2,409.34</b> | <b>2,339.64</b> | <b>-69.70</b>  | <b>-2.89%</b>   | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>1,709.75</b> | <b>1,640.05</b> | <b>-69.70</b>  | <b>-4.08%</b>   | <b>sub-category chapters</b>      |
| 1.A.2.b                    | 0.1391          | 0.1388          | -0.0003        | -0.20%          | <a href="#">here</a>              |
| 1.A.2.e                    | 0.091           | 0.072           | -0.02          | -20.64%         | <a href="#">here</a>              |
| 1.A.2.f                    | 1.04            | 1.00            | -0.04          | -3.95%          | <a href="#">here</a>              |
| 1.A.2.g vii                | 180.53          | 137.46          | <u>-43.07</u>  | -23.86%         | <a href="#">here</a>              |
| 1.A.2.g viii               | 15.60           | 15.16           | -0.45          | -2.86%          | <a href="#">here</a>              |
| 1.A.3.a ii(i)              | 1.89            | 1.90            | 0.01           | 0.43%           | <a href="#">here</a>              |
| 1.A.3.b i                  | 661.63          | 660.65          | -0.98          | -0.15%          | <a href="#">here</a>              |
| 1.A.3.b ii                 | 38.47           | 38.32           | -0.15          | -0.39%          | <a href="#">here</a>              |
| 1.A.3.b iii                | 23.89           | 23.82           | -0.07          | -0.29%          | <a href="#">here</a>              |
| 1.A.3.b iv                 | 53.25           | 52.80           | -0.45          | -0.85%          | <a href="#">here</a>              |
| 1.A.3.c                    | 1.0962          | 1.0963          | 0.0002         | 0.02%           | <a href="#">here</a>              |
| 1.A.3.d ii                 | 6.95            | 6.04            | -0.91          | -13.14%         | <a href="#">here</a>              |
| 1.A.4.a i                  | 52.48           | 49.13           | -3.35          | -6.39%          | <a href="#">here</a>              |
| 1.A.4.a ii                 | 1.20            | 1.49            | 0.29           | 24.44%          | <a href="#">here</a>              |
| 1.A.4.b i                  | 358.50          | 357.39          | -1.11          | -0.31%          | <a href="#">here</a>              |
| 1.A.4.b ii                 | 82.65           | 78.65           | -4.00          | -4.84%          | <a href="#">here</a>              |
| 1.A.4.c i                  | 15.25           | 15.24           | -0.01          | -0.08%          | <a href="#">here</a>              |
| 1.A.4.c ii                 | 73.13           | 57.23           | <u>-15.89</u>  | -21.73%         | <a href="#">here</a>              |
| 1.A.4.c iii                | 0.02            | 0.01            | -0.01          | <u>-46.98%</u>  | <a href="#">here</a>              |
| 1.A.5.a                    | 1.358           | 1.464           | 0.11           | 7.82%           | <a href="#">here</a>              |
| 1.A.5.b                    | 10.471          | 10.561          | 0.09           | 0.86%           | <a href="#">here</a>              |
| 1.B.2.a iv                 | 0.322           | 0.321           | -0.001         | -0.26%          |                                   |
| 1.B.2.c                    | 0.096           | 0.095           | -0.001         | -1.09%          |                                   |
| <b>NFR 2 - IPPU</b>        | <b>683.7734</b> | <b>683.7749</b> | <b>0.00150</b> | <b>0.00022%</b> | <b>sub-category chapters</b>      |
| 2.A.3                      | 0.4671          | 0.4669          | -0.00019       | -0.04%          | <a href="#">here</a>              |
| 2.G                        | 11.423          | 11.425          | 0.00169        | 0.01%           | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |                |                 |                                   |
| <b>NFR 5 - Waste</b>       | <b>15.82</b>    | <b>15.82</b>    | <b>0.00</b>    | <b>0.00%</b>    |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |                |                 |                                   |

| pollutant-specific data: |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |
|--------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|
|                          | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P |

## Recalculations - Lead (Pb)



The remarkably strong changes in the **National Total** reported for **1990 (+22.1 kt or +1.16 %)** result almost entirely from a revision in NFR sub-category **1.A.3.b vi with +22.09 t**.

However, the by far strongest percental change occurs for NFR **5.C.1.b v with plus 161,190 %**

Table 1: Changes of emission estimates 1990

|                            | Submission 2025 | Submission 2026 | Difference   |              | Reasoning                         |
|----------------------------|-----------------|-----------------|--------------|--------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |              | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>1,899.27</b> | <b>1,921.37</b> | <b>22.10</b> | <b>1.16%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>1,499.08</b> | <b>1,521.17</b> | <b>22.09</b> | <b>1.47%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 2.0891          | 2.0894          | 0.0003       | 0.02%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 33.05           | 55.15           | 22.09        | 66.84%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.00007793      | 0.00007791      | -0.00000002  | -0.03%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 4.5502          | 4.5499          | -0.0003      | -0.01%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>400.05</b>   | <b>400.05</b>   | <b>0.00</b>  | <b>0.00%</b> |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |              |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.147</b>    | <b>0.152</b>    | <b>0.005</b> | <b>3.45%</b> | <b>sub-category chapters</b>      |
| 5.C.1.b v                  | 0.000003        | 0.005080        | 0.005076     | 161,190%     | <a href="#">here</a>              |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |              |              |                                   |

The remarkably strong changes in the **National Total** reported for **2023 (+22.1 kt or +14.6 %)** result almost entirely from a revision in NFR sub-category **1.A.3.b vi with +23.7 t**.

However, the by far strongest percental change occurs for NFR **5.C.1.b v with plus 161,190 %**

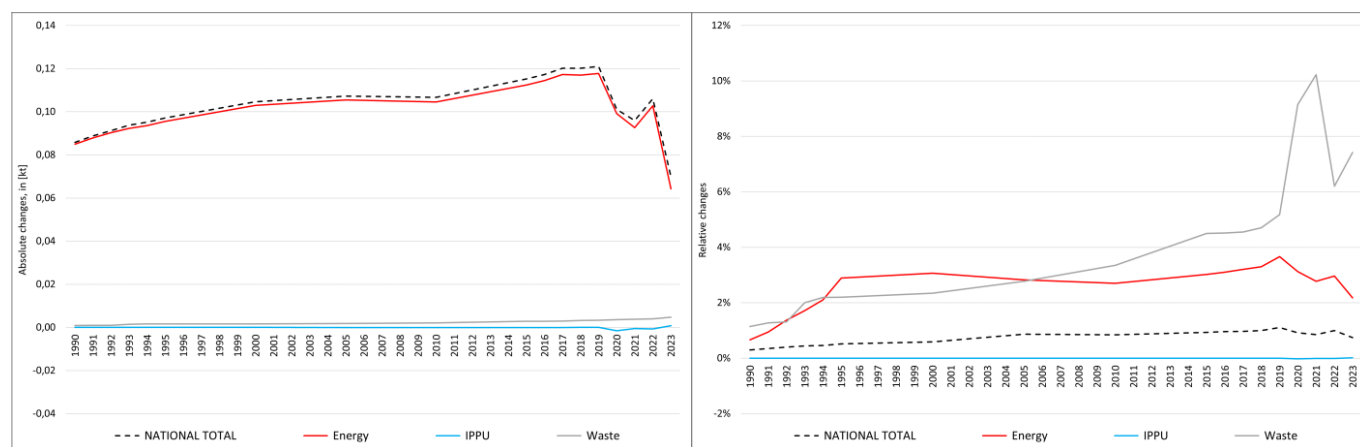
Table 2: Changes of emission estimates 2023

|                       | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|-----------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector            | [t]             |                 |              | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>151.08</b>   | <b>173.15</b>   | <b>22.08</b> | <b>14.61%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>87.61</b>    | <b>109.67</b>   | <b>22.06</b> | <b>25.18%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 5.59            | 5.59            | 0.01         | 0.14%         | <a href="#">here</a>              |
| 1.A.1.b               | 5.66            | 5.74            | 0.08         | 1.45%         | <a href="#">here</a>              |
| 1.A.1.c               | 0.069           | 0.078           | 0.01         | 13.57%        | <a href="#">here</a>              |
| 1.A.2.g vii           | 0.00048         | 0.00053         | 0.00005      | 9.38%         | <a href="#">here</a>              |

|                            | Submission 2025 | Submission 2026 | Difference        |                | Reasoning                         |
|----------------------------|-----------------|-----------------|-------------------|----------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |                   | relative       | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>151.08</b>   | <b>173.15</b>   | <b>22.08</b>      | <b>14.61%</b>  | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>87.61</b>    | <b>109.67</b>   | <b>22.06</b>      | <b>25.18%</b>  | <b>sub-category chapters</b>      |
| 1.A.2.g viii               | 0.43            | 0.39            | -0.04             | -9.11%         | <a href="#">here</a>              |
| 1.A.3.a i(i)               | 0.00405         | 0.00415         | 0.00009           | 2.34%          | <a href="#">here</a>              |
| 1.A.3.a ii(i)              | 0.205           | 0.209           | 0.005             | 2.34%          | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.0324          | 0.0323          | -0.0001           | -0.16%         | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.00230         | 0.00227         | -0.00002          | -1.02%         | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.0064          | 0.0063          | -0.0001           | -0.79%         | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.00061         | 0.00060         | -0.00001          | -0.84%         | <a href="#">here</a>              |
| 1.A.3.b vi                 | 48.16           | 71.87           | 23.70             | 49.22%         | <a href="#">here</a>              |
| 1.A.3.b vii                | 0.062           | 0.059           | -0.004            | -6.33%         | <a href="#">here</a>              |
| 1.A.3.c                    | 0.087013        | 0.087009        | -0.000005         | -0.01%         | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.037           | 0.036           | -0.001            | -1.76%         | <a href="#">here</a>              |
| 1.A.4.a i                  | 22.98           | 21.29           | -1.69             | -7.37%         | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.00005         | 0.00007         | 0.00002           | 38.53%         | <a href="#">here</a>              |
| 1.A.4.b i                  | 4.22            | 4.21            | -0.01             | -0.31%         | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.00014         | 0.00013         | -0.00001          | -4.81%         | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.00112         | 0.00096         | -0.00016          | -14.09%        | <a href="#">here</a>              |
| 1.A.5.b                    | 0.000492        | 0.000491        | -0.000001         | -0.28%         | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>63.3475</b>  | <b>63.3448</b>  | <b>-0.0027163</b> | <b>-0.004%</b> | <b>sub-category chapters</b>      |
| 2.A.3                      | 0.5897          | 0.5870          | -0.0027221        | -0.46%         | <a href="#">here</a>              |
| 2.G                        | 0.0014634       | 0.0014691       | 0.0000057         | 0.39%          | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |                   |                |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.11376</b>  | <b>0.13759</b>  | <b>0.02383</b>    | <b>20.95%</b>  | <b>sub-category chapters</b>      |
| 5.C.1.b v                  | 0.00001         | 0.02344         | 0.02343           | 161,190%       | <a href="#">here</a>              |
| 5.E                        | 0.01070         | 0.01110         | 0.00040           | 3.72%          | <a href="#">here</a>              |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |                   |                |                                   |

|                                 |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCb | PCB |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Cadmium (Cd)



The rather small changes within the **National Total** reported for **1990 (+0.09 t or + 0.29 %)** result almost entirely from a revision in **NFR sub-category 1.A.3.b vi** with **+0.08 t**.

However, the by far strongest percental change occurs for **NFR 5.C.1.b v** with **plus 160,827 %**.

Table 1: Changes of emission estimates 1990

|                            | Submission 2025 | Submission 2026 | Difference      |              | Reasoning                         |
|----------------------------|-----------------|-----------------|-----------------|--------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |                 | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>29.10</b>    | <b>29.19</b>    | <b>0.09</b>     | <b>0.29%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>12.76</b>    | <b>12.84</b>    | <b>0.08</b>     | <b>0.67%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.000045234     | 0.000045238     | 0.000000004     | 0.01%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 0.15            | 0.23            | 0.08            | 57.26%       | <a href="#">here</a>              |
| 1.A.3.b vii                | 0.0022136       | 0.0022131       | -0.0000005      | -0.02%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.000007793     | 0.000007791     | -0.000000002    | -0.03%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.0065754       | 0.0065750       | -0.0000005      | -0.01%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>16.27</b>    | <b>16.27</b>    | <b>0.00</b>     | <b>0.00%</b> |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |                 |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.074027</b> | <b>0.074874</b> | <b>0.000846</b> | <b>1.14%</b> | <b>sub-category chapters</b>      |
| 5.C.1.b v                  | 0.000001        | 0.000847        | 0.000846        | 160,827%     | <a href="#">here</a>              |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |                 |              |                                   |

The small changes within the **National Total** reported for **2023 (+0.07 t or +0.75 %)** result from a **variety of revisions throughout NFRs 1, 2 and 5** dominated by revised emission estimates for NFR sub-category **1.A.3.b vi** with **+0.09 t**.

However, the by far strongest percental change occurs for **NFR 5.C.1.b v** with **plus 160,827 %**.

Table 2: Changes of emission estimates 2023

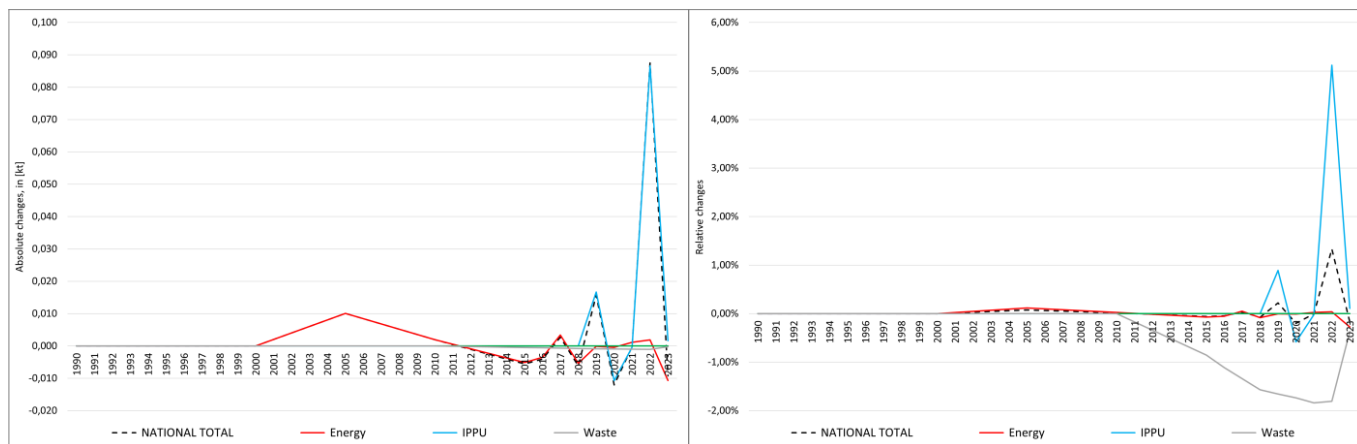
|                       | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                         |
|-----------------------|-----------------|-----------------|-------------|--------------|-----------------------------------|
| NFR Sector            | [t]             |                 |             | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>9.36</b>     | <b>9.43</b>     | <b>0.07</b> | <b>0.75%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>2.95</b>     | <b>3.02</b>     | <b>0.06</b> | <b>2.18%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 0.5937          | 0.5943          | 0.0006      | 0.11%        | <a href="#">here</a>              |
| 1.A.1.b               | 1.2391          | 1.2387          | -0.0004     | -0.03%       | <a href="#">here</a>              |
| 1.A.1.c               | 0.008           | 0.009           | 0.001       | 13.57%       | <a href="#">here</a>              |



|                            | Submission 2025  | Submission 2026  | Difference      |              | Reasoning                         |
|----------------------------|------------------|------------------|-----------------|--------------|-----------------------------------|
| NFR Sector                 | [t]              |                  |                 | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>9.36</b>      | <b>9.43</b>      | <b>0.07</b>     | <b>0.75%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>2.95</b>      | <b>3.02</b>      | <b>0.06</b>     | <b>2.18%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.000054         | 0.000057         | 0.000003        | 5.86%        | <a href="#">here</a>              |
| 1.A.2.g viii               | 0.093            | 0.088            | -0.005          | -5.22%       | <a href="#">here</a>              |
| 1.A.3.a i(i)               | 0.00000000196    | 0.00000000201    | 0.00000000005   | 2.34%        | <a href="#">here</a>              |
| 1.A.3.a ii(i)              | 0.0000000099     | 0.000000101      | 0.000000002     | 2.34%        | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.003907         | 0.003901         | -0.000006       | -0.16%       | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.000243         | 0.000241         | -0.000002       | -1.02%       | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.000656         | 0.000651         | -0.000005       | -0.79%       | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.0000763        | 0.0000757        | -0.0000006      | -0.84%       | <a href="#">here</a>              |
| 1.A.3.b vi                 | 0.22             | 0.31             | 0.09            | 41.70%       | <a href="#">here</a>              |
| 1.A.3.b vii                | 0.0032           | 0.0030           | -0.0002         | -6.34%       | <a href="#">here</a>              |
| 1.A.3.c                    | 0.003639         | 0.003638         | -0.000001       | -0.02%       | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.0043           | 0.0041           | -0.0001         | -2.65%       | <a href="#">here</a>              |
| 1.A.4.a i                  | 0.249            | 0.231            | -0.02           | -7.33%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.000005         | 0.000007         | 0.000002        | 38.53%       | <a href="#">here</a>              |
| 1.A.4.b i                  | 0.521            | 0.519            | -0.002          | -0.35%       | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.00138          | 0.00132          | -0.00007        | -4.72%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.007            | 0.005            | -0.002          | -24.52%      | <a href="#">here</a>              |
| 1.A.5.b                    | 0.0000418        | 0.0000416        | -0.0000002      | -0.41%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>6.3417002</b> | <b>6.3425150</b> | <b>0.000815</b> | <b>0.01%</b> | <b>sub-category chapters</b>      |
| 2.A.3                      | 0.015641         | 0.015562         | -0.000079       | -0.51%       | <a href="#">here</a>              |
| 2.G                        | 0.74417675       | 0.74507085       | 0.0008941       | 0.12%        | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>        |                  |                 |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.06346</b>   | <b>0.06817</b>   | <b>0.00471</b>  | <b>7.42%</b> | <b>sub-category chapters</b>      |
| 5.C.1.b v                  | 0.000002         | 0.003907         | 0.003905        | 160,827%     | <a href="#">here</a>              |
| 5.E                        | 0.021601         | 0.022405         | 0.000804        | 3.72%        | <a href="#">here</a>              |
| <b>NFR 6 - Other</b>       | <b>NA</b>        |                  |                 |              |                                   |

|                                 |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCb | PCB |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Mercury (Hg)



With no reportable changes within the **National Total** reported for **1990**, the only notable but canceling changes occur for NFRs **1.A.2.g vii**, **1.A.4.a ii** and **1.A.4.c ii**.

Table 1: Changes of emission estimates 1990

| NFR Sector                 | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                                               |
|----------------------------|-----------------|-----------------|-------------|--------------|---------------------------------------------------------|
|                            | [t]             |                 |             | relative     |                                                         |
| <b>NATIONAL TOTAL</b>      | <b>35.53</b>    | <b>35.53</b>    | <b>0.00</b> | <b>0.00%</b> | see description and reasoning in: sub-category chapters |
| <b>NFR 1 - Energy</b>      | <b>26.46</b>    | <b>26.46</b>    | <b>0.00</b> | <b>0.00%</b> | sub-category chapters                                   |
| 1.A.2.g vii                | 0.0043872       | 0.0043875       | 0.0000003   | 0.01%        | <a href="#">here</a>                                    |
| 1.A.4.a ii                 | 0.0008260       | 0.0008258       | -0.0000002  | -0.03%       | <a href="#">here</a>                                    |
| 1.A.4.c ii                 | 0.0094791       | 0.0094790       | -0.0000001  | -0.001%      | <a href="#">here</a>                                    |
| <b>NFR 2 - IPPU</b>        | <b>9.03</b>     | <b>9.03</b>     | <b>0.00</b> | <b>0.00%</b> |                                                         |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |             |              |                                                         |
| <b>NFR 5 - Waste</b>       | <b>0.03</b>     | <b>0.03</b>     | <b>0.00</b> | <b>0.00%</b> |                                                         |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |              |                                                         |

The small changes within the **National Total** reported for **2023 (-0.009 t or -0.17 %)** result from a **variety of revisions throughout NFRs 1, 2 and 5**.

The most significant percental change occurs in **NFR 1.A.4.a ii with plus 38.5 %**.

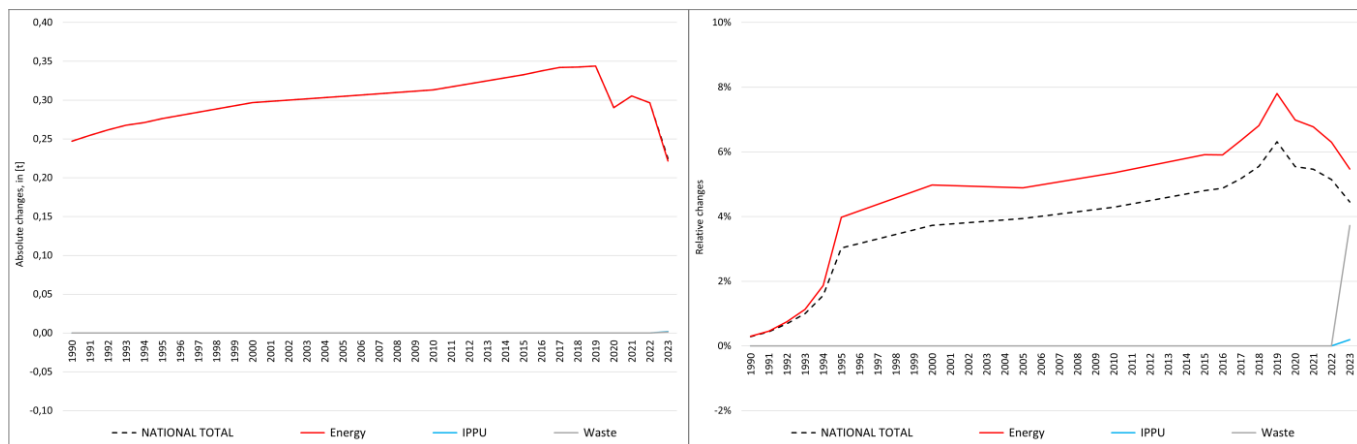
Table 2: Changes of emission estimates 2023

| NFR Sector            | Submission 2025 | Submission 2026 | Difference    |               | Reasoning                                               |
|-----------------------|-----------------|-----------------|---------------|---------------|---------------------------------------------------------|
|                       | [t]             |                 |               | relative      |                                                         |
| <b>NATIONAL TOTAL</b> | <b>5.430</b>    | <b>5.421</b>    | <b>-0.009</b> | <b>-0.17%</b> | see description and reasoning in: sub-category chapters |
| <b>NFR 1 - Energy</b> | <b>3.89</b>     | <b>3.88</b>     | <b>-0.011</b> | <b>-0.27%</b> | sub-category chapters                                   |
| 1.A.1.a               | 2.65            | 2.65            | 0.002         | 0.08%         | <a href="#">here</a>                                    |
| 1.A.1.b               | 0.2263          | 0.2265          | 0.0002        | 0.09%         | <a href="#">here</a>                                    |
| 1.A.1.c               | 0.091           | 0.100           | 0.010         | 10.55%        | <a href="#">here</a>                                    |
| 1.A.2.g vii           | 0.0039          | 0.0047          | 0.0008        | 19.25%        | <a href="#">here</a>                                    |
| 1.A.2.g viii          | 0.24            | 0.22            | -0.02         | -7.93%        | <a href="#">here</a>                                    |
| 1.A.3.a i(i)          | 0.000000085     | 0.000000087     | 0.000000002   | 2.34%         | <a href="#">here</a>                                    |
| 1.A.3.a ii(i)         | 0.0000043       | 0.0000044       | 0.0000001     | 2.34%         | <a href="#">here</a>                                    |
| 1.A.3.b i             | 0.2110          | 0.2107          | -0.0003       | -0.16%        | <a href="#">here</a>                                    |

|                            | Submission 2025 | Submission 2026 | Difference      |                                   | Reasoning                    |
|----------------------------|-----------------|-----------------|-----------------|-----------------------------------|------------------------------|
| NFR Sector                 | [t]             |                 | relative        | see description and reasoning in: |                              |
| <b>NATIONAL TOTAL</b>      | <b>5.430</b>    | <b>5.421</b>    | <b>-0.009</b>   | <b>-0.17%</b>                     | <b>sub-category chapters</b> |
| <b>NFR 1 - Energy</b>      | <b>3.89</b>     | <b>3.88</b>     | <b>-0.011</b>   | <b>-0.27%</b>                     | <b>sub-category chapters</b> |
| 1.A.3.b ii                 | 0.0228          | 0.0226          | -0.0002         | -1.02%                            | <a href="#">here</a>         |
| 1.A.3.b iii                | 0.0678          | 0.0673          | -0.001          | -0.79%                            | <a href="#">here</a>         |
| 1.A.3.b iv                 | 0.00332         | 0.00329         | -0.00003        | -0.84%                            | <a href="#">here</a>         |
| 1.A.3.d ii                 | 0.00687         | 0.00680         | -0.00007        | -0.99%                            | <a href="#">here</a>         |
| 1.A.4.a i                  | 0.0576          | 0.0542          | -0.003          | -5.87%                            | <a href="#">here</a>         |
| 1.A.4.a ii                 | 0.0005          | 0.0007          | 0.0002          | 38.53%                            | <a href="#">here</a>         |
| 1.A.4.b i                  | 0.2667          | 0.2663          | -0.0003         | -0.12%                            | <a href="#">here</a>         |
| 1.A.4.b ii                 | 0.00070         | 0.00067         | -0.00003        | -4.82%                            | <a href="#">here</a>         |
| 1.A.4.c ii                 | 0.0108          | 0.0094          | -0.0014         | -13.05%                           | <a href="#">here</a>         |
| 1.A.5.a                    | 0.00053         | 0.00056         | 0.00003         | 5.07%                             | <a href="#">here</a>         |
| 1.A.5.b                    | 0.00057         | 0.00056         | -0.00001        | -1.37%                            | <a href="#">here</a>         |
| 1.B.1.b                    | 0.013           | 0.015           | 0.002           | 15.38%                            | <a href="#">here</a>         |
| 1.B.2.a i                  | 0.00188         | 0.00190         | 0.00002         | 1.01%                             |                              |
| <b>NFR 2 - IPPU</b>        | <b>1.483564</b> | <b>1.485167</b> | <b>0.001603</b> | <b>0.11%</b>                      | <b>sub-category chapters</b> |
| 2.A.2                      | 0.012788        | 0.012791        | 0.000003        | 0.02%                             | <a href="#">here</a>         |
| 2.B.10.a                   | 0.026400        | 0.028000        | 0.001600        | 6.06%                             | <a href="#">here</a>         |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |                 |                                   |                              |
| <b>NFR 5 - Waste</b>       | <b>0.0567</b>   | <b>0.0565</b>   | <b>-0.0002</b>  | <b>-0.37%</b>                     | <b>sub-category chapters</b> |
| 5.C.1.b v                  | 0.0351          | 0.0341          | -0.0010         | -2.89%                            | <a href="#">here</a>         |
| 5.E                        | 0.0216          | 0.0224          | 0.0008          | 3.72%                             | <a href="#">here</a>         |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |                 |                                   |                              |

|                                 |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Arsenic (As)



With the marginal changes in NFRs **1.A.2.g vii**, **1.A.4.a ii** and **1.A.4.c ii** canceling each other out, the changes within the **National Total** reported for **1990 (+0.25 t or +0.29 %)** result entirely from a revision in **NFR 1.A.3.b vi with +0.25 t**, also resembling the strongest percental change with **+65.1 %**.

Table 1: Changes of emission estimates for 1990

|                            | Submission 2025 | Submission 2026 | Difference   |              | Reasoning                         |
|----------------------------|-----------------|-----------------|--------------|--------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |              | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>85.92</b>    | <b>86.16</b>    | <b>0.25</b>  | <b>0.29%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>82.37</b>    | <b>82.61</b>    | <b>0.25</b>  | <b>0.30%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.000087208     | 0.000087215     | 0.000000007  | 0.01%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 0.38            | 0.63            | 0.25         | 65.10%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.000015586     | 0.000015581     | -0.000000004 | -0.03%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.000188308     | 0.000188305     | -0.000000003 | -0.001%      | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>3.52</b>     | <b>3.52</b>     | <b>0.00</b>  | <b>0.00%</b> |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |              |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.03</b>     | <b>0.03</b>     | <b>0.00</b>  | <b>0.00%</b> |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |              |              |                                   |

The changes within the **National Total** reported for **2022 (+0.18 t or +3.19 %)** are dominated by a revision in NFR sub-category **1.A.1.b with plus 0.18 t** together with a variety of revisions throughout NFRs 1, 2 and 5.

Here, the most significant percental change occurs in **NFR 1.A.1.b with plus 18.6 %**.

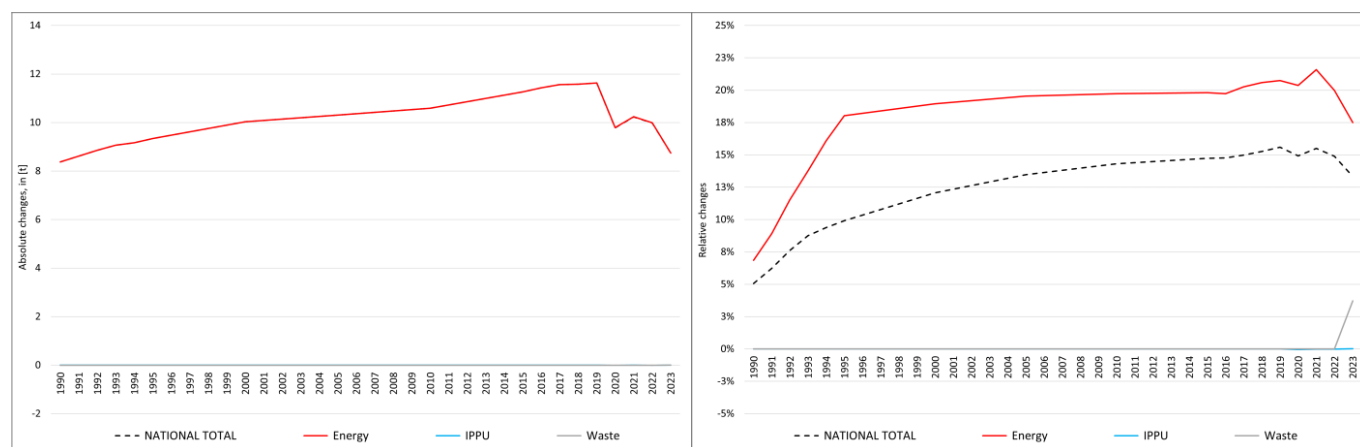
Table 2: Changes of emission estimates for 2023

|                       | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                         |
|-----------------------|-----------------|-----------------|-------------|--------------|-----------------------------------|
| NFR Sector            | [t]             |                 |             | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>5.05</b>     | <b>5.28</b>     | <b>0.22</b> | <b>4.45%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>4.06</b>     | <b>4.28</b>     | <b>0.22</b> | <b>5.47%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 1.64            | 1.64            | 0.002       | 0.14%        | <a href="#">here</a>              |
| 1.A.1.b               | 0.99            | 1.00            | 0.01        | 1.31%        | <a href="#">here</a>              |
| 1.A.1.c               | 0.0054          | 0.0061          | 0.0007      | 13.56%       | <a href="#">here</a>              |
| 1.A.2.g vii           | 0.00009         | 0.00010         | 0.00001     | 10.39%       | <a href="#">here</a>              |
| 1.A.2.g viii          | 0.153           | 0.137           | -0.017      | -10.89%      | <a href="#">here</a>              |

|                            | Submission 2025 | Submission 2026 | Difference    |              | Reasoning                         |
|----------------------------|-----------------|-----------------|---------------|--------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |               | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>5.05</b>     | <b>5.28</b>     | <b>0.22</b>   | <b>4.45%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>4.06</b>     | <b>4.28</b>     | <b>0.22</b>   | <b>5.47%</b> | <b>sub-category chapters</b>      |
| 1.A.3.a i(i)               | 0.0000000029    | 0.0000000030    | 0.0000000001  | 2.34%        | <a href="#">here</a>              |
| 1.A.3.a ii(i)              | 0.000000149     | 0.000000152     | 0.000000003   | 2.34%        | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.00616         | 0.00615         | -0.00001      | -0.16%       | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.000453        | 0.000448        | -0.000005     | -1.02%       | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.00127         | 0.00126         | -0.00001      | -0.79%       | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.0001145       | 0.0001135       | -0.0000010    | -0.84%       | <a href="#">here</a>              |
| 1.A.3.b vi                 | 0.55            | 0.82            | 0.26          | 47.85%       | <a href="#">here</a>              |
| 1.A.3.b vii                | 0.040           | 0.037           | -0.003        | -6.33%       | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.011393        | 0.010823        | -0.0006       | -5.00%       | <a href="#">here</a>              |
| 1.A.4.a i                  | 0.53            | 0.49            | -0.04         | -7.39%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.000010        | 0.000014        | 0.000004      | 38.53%       | <a href="#">here</a>              |
| 1.A.4.b i                  | 0.12233         | 0.12216         | -0.00017      | -0.14%       | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.000024        | 0.000023        | -0.000001     | -4.82%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.00021         | 0.00018         | -0.00003      | -13.56%      | <a href="#">here</a>              |
| 1.A.5.b                    | 0.0001414       | 0.0001412       | -0.0000003    | -0.19%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>0.963</b>    | <b>0.965</b>    | <b>0.002</b>  | <b>0.19%</b> | <b>sub-category chapters</b>      |
| 2.A.3                      | 0.178           | 0.180           | 0.002         | 1.04%        | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |               |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.0343</b>   | <b>0.0356</b>   | <b>0.0013</b> | <b>3.72%</b> | <b>sub-category chapters</b>      |
| 5.E                        | 0.0343          | 0.0356          | 0.0013        | 3.72%        | <a href="#">here</a>              |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |               |              |                                   |

|                                 |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Chromium (Cr)



With the marginal changes in NFRs **1.A.2.g vii**, **1.A.4.a ii** and **1.A.4.c ii** canceling each other out, the remarkable changes within the **National Total** reported for **1990 (+8.37 t or +5 %)** result entirely from a revision in **NFR 1.A.3.b vi** with **+8.37 t**, also resembling the strongest percental change with **+68 %**.

Table 1: Changes of emission estimates for 1990

|                            | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                         |
|----------------------------|-----------------|-----------------|-------------|--------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |             | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>165.69</b>   | <b>174.06</b>   | <b>8.37</b> | <b>5.05%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>122.29</b>   | <b>130.66</b>   | <b>8.37</b> | <b>6.85%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.0067865       | 0.0067870       | 0.0000005   | 0.01%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 12.30           | 20.67           | 8.37        | 68.09%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.0013248       | 0.0013244       | -0.0000004  | -0.03%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.041945        | 0.041943        | -0.000002   | -0.005%      | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>3.52</b>     | <b>3.52</b>     | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |             |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.03</b>     | <b>0.03</b>     | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |              |                                   |

The significant changes within the **National Total** reported for **2023 (+8.75 t or +13.33 %)** are by far dominated by a revision in NFR sub-category **1.A.3.b vi** with **+9 t**, also resembling the strongest percental change with **+50 %**.

In addition, emission estimates were revised for a variety of sub-categories throughout NFRs 1, 2 and 5.

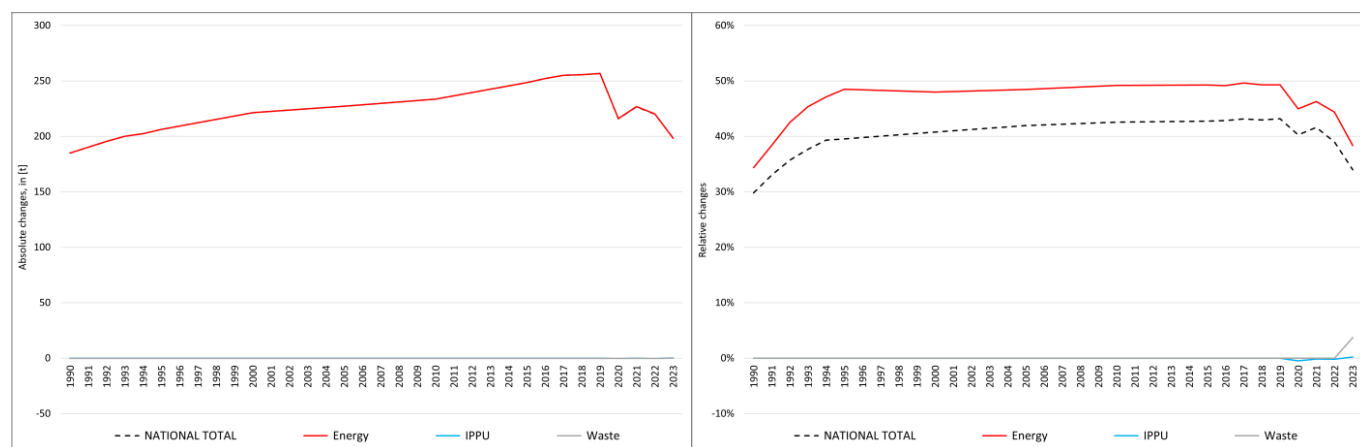
Table 2: Changes of emission estimates for 2023

|                       | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|-----------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector            | [t]             |                 |              | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>65.59</b>    | <b>74.34</b>    | <b>8.746</b> | <b>13.33%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>49.95</b>    | <b>58.69</b>    | <b>8.742</b> | <b>17.50%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 3.11            | 3.11            | 0.004        | 0.13%         | <a href="#">here</a>              |
| 1.A.1.b               | 1.43            | 1.45            | 0.020        | 1.37%         | <a href="#">here</a>              |
| 1.A.1.c               | 0.041           | 0.047           | 0.006        | 13.60%        | <a href="#">here</a>              |
| 1.A.2.g vii           | 0.0053          | 0.0068          | 0.0015       | 28.08%        | <a href="#">here</a>              |
| 1.A.2.g viii          | 0.18            | 0.16            | -0.02        | -9.08%        | <a href="#">here</a>              |
| 1.A.3.a i(i)          | 0.000000062     | 0.000000063     | 0.000000001  | 2.34%         | <a href="#">here</a>              |

|                            | Submission 2025 | Submission 2026 | Difference      |               | Reasoning                         |
|----------------------------|-----------------|-----------------|-----------------|---------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |                 | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>65.59</b>    | <b>74.34</b>    | <b>8.746</b>    | <b>13.33%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>49.95</b>    | <b>58.69</b>    | <b>8.742</b>    | <b>17.50%</b> | <b>sub-category chapters</b>      |
| 1.A.3.a ii(i)              | 0.00000312      | 0.00000320      | 0.00000007      | 2.34%         | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.2155          | 0.2152          | -0.0003         | -0.16%        | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.0351          | 0.0347          | -0.0004         | -1.02%        | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.109           | 0.108           | -0.001          | -0.79%        | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.00240         | 0.00238         | -0.00002        | -0.84%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 17.92           | 26.92           | 9.00            | 50.19%        | <a href="#">here</a>              |
| 1.A.3.b vii                | 1.10            | 1.03            | -0.07           | -6.33%        | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.025           | 0.024           | -0.001          | -4.34%        | <a href="#">here</a>              |
| 1.A.4.a i                  | 2.41            | 2.23            | -0.18           | -7.40%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.0009          | 0.0012          | 0.0003          | 38.53%        | <a href="#">here</a>              |
| 1.A.4.b i                  | 2.71            | 2.70            | -0.009          | -0.35%        | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.0063          | 0.0060          | -0.0003         | -4.73%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.044           | 0.035           | -0.009          | -20.10%       | <a href="#">here</a>              |
| 1.A.5.b                    | 0.000534        | 0.000528        | -0.000006       | -1.12%        | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>15.616</b>   | <b>15.619</b>   | <b>0.002922</b> | <b>0.02%</b>  | <b>sub-category chapters</b>      |
| 2.A.3                      | 0.090           | 0.090           | -0.000502       | -0.56%        | <a href="#">here</a>              |
| 2.G                        | 0.873           | 0.876           | 0.003424        | 0.39%         | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |                 |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.033</b>    | <b>0.034</b>    | <b>0.001</b>    | <b>3.72%</b>  | <b>sub-category chapters</b>      |
| 5.E                        | 0.033           | 0.034           | 0.001           | 3.72%         | <a href="#">here</a>              |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |                 |               |                                   |

|                                 |     |        |     |     |       |      |     |    |    |    |    |    |    |    |           |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|-----------|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | <b>Cu</b> | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|-----------|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Copper (Cu)



With the marginal changes in NFRs **1.A.2.g vii**, **1.A.4.a ii** and **1.A.4.c ii** canceling each other out, the fundamental changes within the **National Total** reported for **1990 (+185 t or +30 %)** result entirely from a revision in **NFR 1.A.3.b vi**, also resembling the strongest percental change with **+69 %**.

Table 1: Changes of emission estimates for 1990

|                            | Submission 2025 | Submission 2026 | Difference    |               | Reasoning                         |
|----------------------------|-----------------|-----------------|---------------|---------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |               | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>619.88</b>   | <b>804.80</b>   | <b>184.92</b> | <b>29.83%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>538.01</b>   | <b>722.93</b>   | <b>184.92</b> | <b>34.37%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.0045599       | 0.0045603       | 0.0000003     | 0.01%         | <a href="#">here</a>              |
| 1.A.3.b vi                 | 269.69          | 454.60          | 184.92        | 68.57%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.0008884       | 0.0008881       | -0.0000002    | -0.03%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 1.11506         | 1.11498         | -0.00008      | -0.01%        | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>3.52</b>     | <b>3.52</b>     | <b>0.00</b>   | <b>0.00%</b>  |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |               |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.03</b>     | <b>0.03</b>     | <b>0.00</b>   | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |               |               |                                   |

The fundamental changes within the **National Total** reported for **2023 (+198.5 t or 34 %)** result almost entirely from a revision in NFR sub-category **1.A.3.b vi (+198.8 t or +50.6 %)**.

In addition, emission estimates were revised for a variety of sub-categories throughout NFRs 1, 2 and 5.

Table 2: Changes of emission estimates for 2023

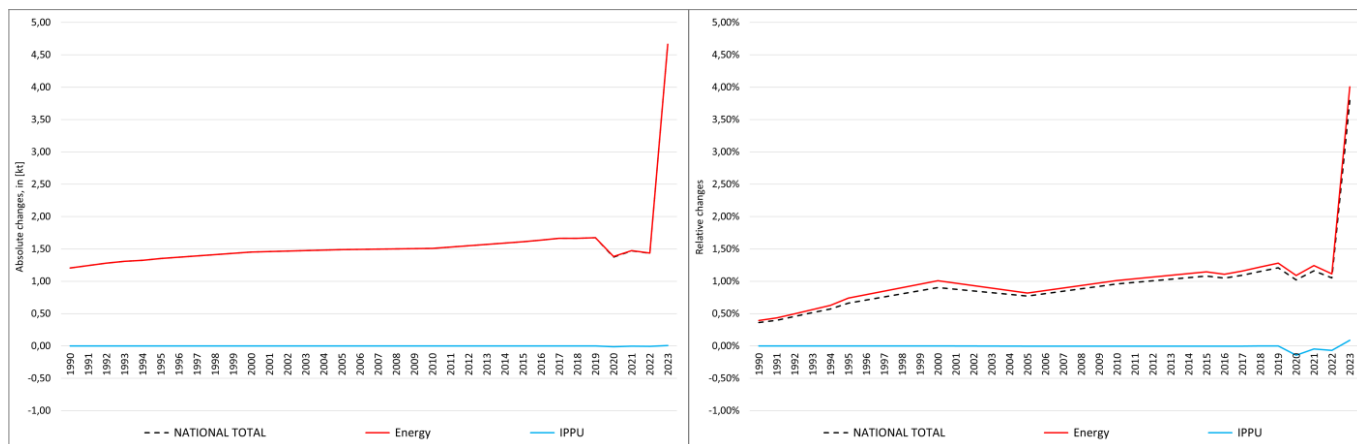
|                       | Submission 2025 | Submission 2026 | Difference    |               | Reasoning                         |
|-----------------------|-----------------|-----------------|---------------|---------------|-----------------------------------|
| NFR Sector            | [t]             |                 |               | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>584.30</b>   | <b>782.79</b>   | <b>198.49</b> | <b>33.97%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>517.19</b>   | <b>715.55</b>   | <b>198.35</b> | <b>38.35%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 5.526           | 5.532           | 0.006         | 0.11%         | <a href="#">here</a>              |
| 1.A.1.b               | 4.38            | 4.43            | 0.06          | 1.31%         | <a href="#">here</a>              |
| 1.A.1.c               | 0.05            | 0.06            | 0.01          | 13.58%        | <a href="#">here</a>              |
| 1.A.2.g vii           | 0.004           | 0.005           | 0.001         | 27.51%        | <a href="#">here</a>              |
| 1.A.2.g viii          | 0.26            | 0.23            | -0.03         | -11.27%       | <a href="#">here</a>              |
| 1.A.3.a i(i)          | 0.000000044     | 0.000000045     | 0.000000001   | 2.34%         | <a href="#">here</a>              |



|                     | Submission 2025 | Submission 2026 | Difference |          | Reasoning                         |
|---------------------|-----------------|-----------------|------------|----------|-----------------------------------|
| NFR Sector          | [t]             |                 |            | relative | see description and reasoning in: |
| NATIONAL TOTAL      | 584.30          | 782.79          | 198.49     | 33.97%   | sub-category chapters             |
| NFR 1 - Energy      | 517.19          | 715.55          | 198.35     | 38.35%   | sub-category chapters             |
| 1.A.3.a ii(i)       | 0.00000223      | 0.00000228      | 0.00000005 | 2.34%    | <a href="#">here</a>              |
| 1.A.3.b i           | 0.1489          | 0.1487          | -0.0002    | -0.16%   | <a href="#">here</a>              |
| 1.A.3.b ii          | 0.02357         | 0.02333         | -0.00024   | -1.02%   | <a href="#">here</a>              |
| 1.A.3.b iii         | 0.073           | 0.072           | -0.001     | -0.79%   | <a href="#">here</a>              |
| 1.A.3.b iv          | 0.00171         | 0.00170         | -0.00001   | -0.84%   | <a href="#">here</a>              |
| 1.A.3.b vi          | 393.06          | 591.83          | 198.77     | 50.57%   | <a href="#">here</a>              |
| 1.A.3.b vii         | 0.037           | 0.035           | -0.002     | -6.33%   | <a href="#">here</a>              |
| 1.A.3.d ii          | 0.56            | 0.54            | -0.02      | -3.10%   | <a href="#">here</a>              |
| 1.A.4.a i           | 2.03            | 1.88            | -0.15      | -7.41%   | <a href="#">here</a>              |
| 1.A.4.a ii          | 0.0006          | 0.0008          | 0.0002     | 38.53%   | <a href="#">here</a>              |
| 1.A.4.b i           | 2.24            | 2.23            | -0.01      | -0.36%   | <a href="#">here</a>              |
| 1.A.4.b ii          | 0.23            | 0.22            | -0.01      | -4.72%   | <a href="#">here</a>              |
| 1.A.4.c i           | 0.083           | 0.083           | 0.000      | 0.00%    | <a href="#">here</a>              |
| 1.A.4.c ii          | 1.11            | 0.84            | -0.27      | -24.58%  | <a href="#">here</a>              |
| 1.A.5.b             | 0.003032        | 0.003028        | -0.000004  | -0.14%   | <a href="#">here</a>              |
| NFR 2 - IPPU        | 67.02497        | 67.16360        | 0.13863    | 0.21%    | sub-category chapters             |
| 2.A.3               | 0.05693         | 0.05676         | -0.00018   | -0.31%   | <a href="#">here</a>              |
| 2.G                 | 50.50853        | 50.64734        | 0.13881    | 0.27%    | <a href="#">here</a>              |
| NFR 3 - Agriculture | NA              |                 |            |          |                                   |
| NFR 5 - Waste       | 0.08            | 0.08            | 0.003      | 3.72%    | sub-category chapters             |
| 5.E                 | 0.08            | 0.08            | 0.003      | 3.72%    | <a href="#">here</a>              |
| NFR 6 - Other       | NA              |                 |            |          |                                   |

|                                 |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Nickel (Ni)



With the marginal changes in NFRs **1.A.2.g vii**, **1.A.4.a ii** and **1.A.4.c ii** canceling each other out, the small changes within the **National Total** reported for **1990 (+1.21 t or +0.36 %)** result entirely from a revision in **NFR 1.A.3.b vi**, also resembling the strongest percental change with **+63 %**.

Table 1: Changes of emission estimates for 1990

|                            | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                         |
|----------------------------|-----------------|-----------------|-------------|--------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |             | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>332.75</b>   | <b>333.95</b>   | <b>1.21</b> | <b>0.36%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>305.13</b>   | <b>306.34</b>   | <b>1.21</b> | <b>0.40%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.00022985      | 0.00022988      | 0.00000002  | 0.01%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 1.91            | 3.12            | 1.21        | 63.03%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.00003117      | 0.00003116      | -0.00000001 | -0.03%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.045797        | 0.045794        | -0.000003   | -0.01%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>3.52</b>     | <b>3.52</b>     | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |             |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.03</b>     | <b>0.03</b>     | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |              |                                   |

The remarkable changes within the **National Total** reported for **2023 (+4.67 t or +3.79 %)** are dominated by a revision in NFR sub-category **1.A.3.b vi with +1.29 t (+46.2 %)** together with a variety of smaller revisions throughout NFRs 1 and 2.

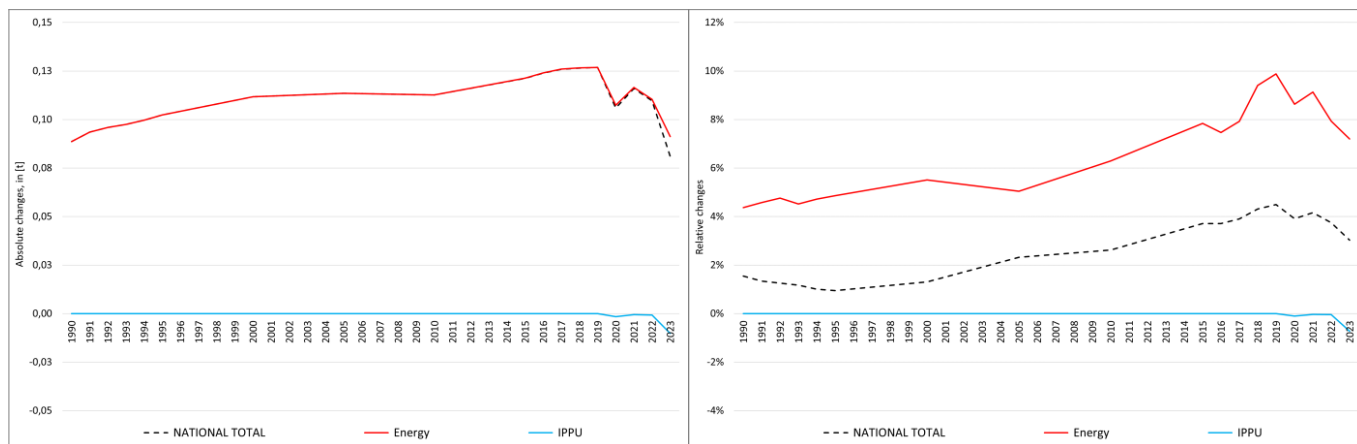
Table 2: Changes of emission estimates for 2023

|                       | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                         |
|-----------------------|-----------------|-----------------|-------------|--------------|-----------------------------------|
| NFR Sector            | [t]             |                 |             | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>123.07</b>   | <b>127.74</b>   | <b>4.67</b> | <b>3.79%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>116.43</b>   | <b>121.10</b>   | <b>4.66</b> | <b>4.00%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 2.757           | 2.761           | 0.004       | 0.15%        | <a href="#">here</a>              |
| 1.A.1.b               | 66.5            | 70.0            | 3.52        | 5.29%        | <a href="#">here</a>              |
| 1.A.1.c               | 0.0267          | 0.0304          | 0.0036      | 13.55%       | <a href="#">here</a>              |
| 1.A.2.g vii           | 0.00042         | 0.00038         | -0.00004    | -9.18%       | <a href="#">here</a>              |
| 1.A.2.g viii          | 1.76            | 1.69            | -0.07       | -3.93%       | <a href="#">here</a>              |
| 1.A.3.a i(i)          | 0.000000226     | 0.000000231     | 0.000000005 | 2.34%        | <a href="#">here</a>              |
| 1.A.3.a ii(i)         | 0.00000114      | 0.00000117      | 0.00000003  | 2.34%        | <a href="#">here</a>              |

|                            | Submission 2025 | Submission 2026 | Difference      |              | Reasoning                         |
|----------------------------|-----------------|-----------------|-----------------|--------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |                 | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>123.07</b>   | <b>127.74</b>   | <b>4.67</b>     | <b>3.79%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>116.43</b>   | <b>121.10</b>   | <b>4.66</b>     | <b>4.00%</b> | <b>sub-category chapters</b>      |
| 1.A.3.b i                  | 0.03965         | 0.03958         | -0.00007        | -0.16%       | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.00125         | 0.00124         | -0.00001        | -1.02%       | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.00258         | 0.00256         | -0.00002        | -0.79%       | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.000876        | 0.000869        | -0.000007       | -0.84%       | <a href="#">here</a>              |
| 1.A.3.b vi                 | 2.79            | 4.08            | 1.29            | 46.22%       | <a href="#">here</a>              |
| 1.A.3.b vii                | 0.58            | 0.54            | -0.04           | -6.33%       | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.39            | 0.36            | -0.03           | -7.07%       | <a href="#">here</a>              |
| 1.A.4.a i                  | 0.060           | 0.057           | -0.004          | -6.22%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.000020        | 0.000028        | 0.000008        | 38.53%       | <a href="#">here</a>              |
| 1.A.4.b i                  | 0.4356          | 0.4343          | -0.0013         | -0.29%       | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.0097          | 0.0093          | -0.0005         | -4.72%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.046           | 0.034           | -0.011          | -24.59%      | <a href="#">here</a>              |
| 1.A.5.b                    | 0.003259        | 0.003257        | -0.000002       | -0.06%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>6.639079</b> | <b>6.644912</b> | <b>0.005833</b> | <b>0.09%</b> | <b>sub-category chapters</b>      |
| 2.A.3                      | 0.037146        | 0.037252        | 0.000106        | 0.29%        | <a href="#">here</a>              |
| 2.G                        | 1.717740        | 1.723467        | 0.005727        | 0.33%        | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |                 |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>NA</b>       |                 |                 |              |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |                 |              |                                   |

|                                 |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Selenium (Se)



With the marginal changes in NFRs **1.A.2.g vii**, **1.A.4.a ii** and **1.A.4.c ii** canceling each other out, the changes within the **National Total** reported for **1990 (+0.09 t or +1.55 %)** result entirely from a revision in **NFR 1.A.3.b vi**, also resembling the strongest percental change with **+38 %**.

Table 1: Changes of emission estimates for 1990

|                            | Submission 2025 | Submission 2026 | Difference   |              | Reasoning                         |
|----------------------------|-----------------|-----------------|--------------|--------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |              | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>5.73</b>     | <b>5.82</b>     | <b>0.09</b>  | <b>1.55%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>2.03</b>     | <b>2.12</b>     | <b>0.09</b>  | <b>4.37%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.00008395      | 0.00008395      | 0.00000001   | 0.01%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 0.24            | 0.32            | 0.09         | 37.56%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.000015586     | 0.000015581     | -0.000000004 | -0.03%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.0066308       | 0.0066303       | -0.00000005  | -0.01%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>3.52</b>     | <b>3.52</b>     | <b>0.00</b>  | <b>0.00%</b> |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |              |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.03</b>     | <b>0.03</b>     | <b>0.00</b>  | <b>0.00%</b> |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |              |              |                                   |

The changes within the **National Total** reported for **2023 (+0.08 t or +3.03 %)** are dominated by a revision in **NFR 1.A.3.b vi with +0.09 t (+38 %)**.

However, the **strongest percental change** occurs for **NFR 1.A.4.a ii with +38.5 %**.

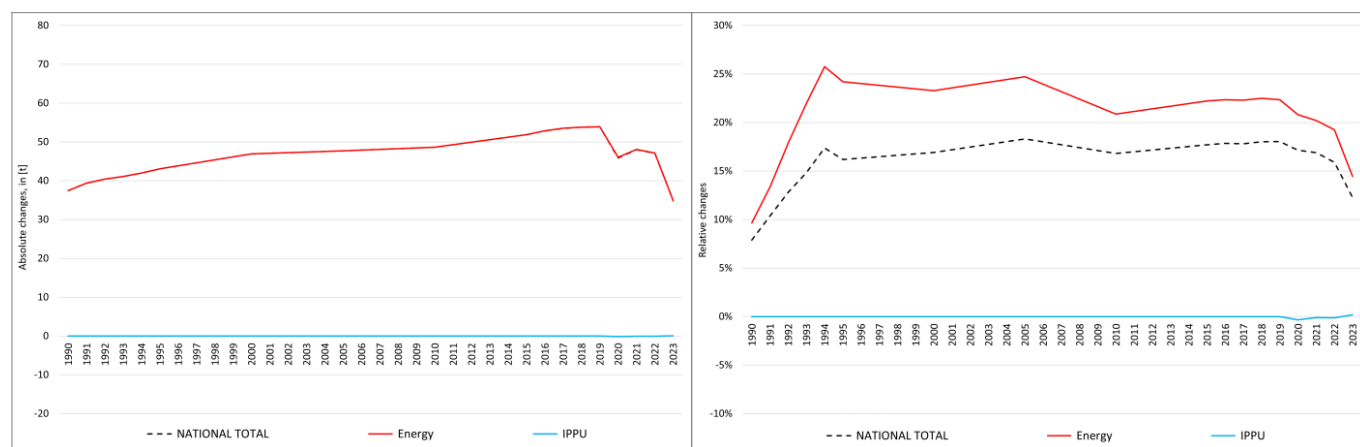
Table 2: Changes of emission estimates for 2023

|                       | Submission 2025 | Submission 2026 | Difference    |              | Reasoning                         |
|-----------------------|-----------------|-----------------|---------------|--------------|-----------------------------------|
| NFR Sector            | [t]             |                 |               | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>2.68</b>     | <b>2.76</b>     | <b>0.08</b>   | <b>3.03%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>1.27</b>     | <b>1.36</b>     | <b>0.09</b>   | <b>7.20%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 0.0638          | 0.0640          | 0.0002        | 0.29%        | <a href="#">here</a>              |
| 1.A.1.b               | 0.809           | 0.814           | 0.005         | 0.68%        | <a href="#">here</a>              |
| 1.A.2.g vii           | 0.000079        | 0.000093        | 0.000013      | 16.50%       | <a href="#">here</a>              |
| 1.A.2.g viii          | 0.012           | 0.011           | -0.002        | -15.25%      | <a href="#">here</a>              |
| 1.A.3.a i(i)          | 0.00000000196   | 0.00000000201   | 0.00000000005 | 2.34%        | <a href="#">here</a>              |

|                            | Submission 2025 | Submission 2026 | Difference    |               | Reasoning                         |
|----------------------------|-----------------|-----------------|---------------|---------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |               | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>2.68</b>     | <b>2.76</b>     | <b>0.08</b>   | <b>3.03%</b>  | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>1.27</b>     | <b>1.36</b>     | <b>0.09</b>   | <b>7.20%</b>  | <b>sub-category chapters</b>      |
| 1.A.3.a ii(i)              | 0.000000099     | 0.000000101     | 0.000000002   | 2.34%         | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.00455         | 0.00454         | -0.00001      | -0.16%        | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.000433        | 0.000429        | -0.000004     | -1.02%        | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.00127         | 0.00126         | -0.00001      | -0.79%        | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.0000763       | 0.0000757       | -0.0000006    | -0.84%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 0.34            | 0.43            | 0.09          | 26.13%        | <a href="#">here</a>              |
| 1.A.3.c                    | 0.0023388       | 0.0023380       | -0.0000009    | -0.04%        | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.0220          | 0.0217          | -0.0003       | -1.24%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.000010        | 0.000014        | 0.000004      | 38.53%        | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.00138         | 0.00131         | -0.00006      | -4.72%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.007           | 0.005           | -0.002        | -24.34%       | <a href="#">here</a>              |
| 1.A.5.b                    | 0.0003250       | 0.0003248       | -0.0000002    | -0.05%        | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>1.409</b>    | <b>1.399</b>    | <b>-0.010</b> | <b>-0.72%</b> | <b>sub-category chapters</b>      |
| 2.A.3                      | 1.202           | 1.191           | -0.011        | -0.91%        | <a href="#">here</a>              |
| 2.G                        | 0.206           | 0.207           | 0.001         | 0.39%         | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |               |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>NA</b>       |                 |               |               |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |               |               |                                   |

|                                 |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCb | PCB |
|---------------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Zinc (Zn)



With the marginal changes in NFRs **1.A.2.g vii**, **1.A.4.a ii** and **1.A.4.c ii** canceling each other out, the remarkable changes within the **National Total** reported for **1990 (+37.4 t or +7.89 %)** result entirely from a revision in **NFR 1.A.3.b vi**, also resembling the strongest percental change with **+40 %**.

Table 1: Changes of emission estimates for 1990

|                            | Submission 2025 | Submission 2026 | Difference   |              | Reasoning                         |
|----------------------------|-----------------|-----------------|--------------|--------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |              | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>474.15</b>   | <b>511.59</b>   | <b>37.43</b> | <b>7.89%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>387.46</b>   | <b>424.90</b>   | <b>37.43</b> | <b>9.66%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.015013        | 0.015014        | 0.000001     | 0.01%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 94.21           | 131.64          | 37.43        | 39.74%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.002805        | 0.002805        | -0.000001    | -0.03%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.67198         | 0.67193         | -0.00005     | -0.01%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>3.52</b>     | <b>3.52</b>     | <b>0.00</b>  | <b>0.00%</b> |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |              |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.03</b>     | <b>0.03</b>     | <b>0.00</b>  | <b>0.00%</b> |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |              |              |                                   |

The substantial changes within the **National Total** reported for **2023 (+35 t or +12.3 %)** are dominated by a revision in **NFR 1.A.3.b vi with +38 t (+27.9 %)**.

However, the **strongest percental change** occurs for **NFR 1.A.4.a ii with +38.5 %**.

Table 2: Changes of emission estimates for 2023

|                       | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|-----------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector            | [t]             |                 |              | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>284.64</b>   | <b>319.57</b>   | <b>34.93</b> | <b>12.27%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>241.49</b>   | <b>276.34</b>   | <b>34.85</b> | <b>14.43%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 3.853           | 3.857           | 0.003        | 0.09%         | <a href="#">here</a>              |
| 1.A.1.b               | 3.48            | 3.53            | 0.05         | 1.38%         | <a href="#">here</a>              |
| 1.A.1.c               | 0.029           | 0.033           | 0.004        | 13.67%        | <a href="#">here</a>              |
| 1.A.2.g vii           | 0.014           | 0.016           | 0.002        | 17.74%        | <a href="#">here</a>              |
| 1.A.2.g viii          | 0.36            | 0.30            | -0.06        | -15.31%       | <a href="#">here</a>              |
| 1.A.3.a i(i)          | 0.00000032      | 0.00000033      | 0.00000001   | 2.34%         | <a href="#">here</a>              |

|                            | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|----------------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |              | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>284.64</b>   | <b>319.57</b>   | <b>34.93</b> | <b>12.27%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>241.49</b>   | <b>276.34</b>   | <b>34.85</b> | <b>14.43%</b> | <b>sub-category chapters</b>      |
| 1.A.3.a ii(i)              | 0.0000164       | 0.0000167       | 0.0000004    | 2.34%         | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.772           | 0.771           | -0.001       | -0.16%        | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.078           | 0.077           | -0.001       | -1.02%        | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.230           | 0.228           | -0.002       | -0.79%        | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.0126          | 0.0125          | -0.0001      | -0.84%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 136.65          | 174.71          | <u>38.07</u> | 27.86%        | <a href="#">here</a>              |
| 1.A.3.b vii                | 1.3109          | 1.2279          | -0.08        | -6.33%        | <a href="#">here</a>              |
| 1.A.3.c                    | 0.2400          | 0.2399          | -0.0001      | -0.04%        | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.46            | 0.45            | -0.01        | -2.32%        | <a href="#">here</a>              |
| 1.A.4.a i                  | 37.04           | 34.29           | <u>-2.75</u> | -7.42%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.0018          | 0.0025          | 0.0007       | <u>38.53%</u> | <a href="#">here</a>              |
| 1.A.4.b i                  | 54.84           | 54.64           | -0.20        | -0.37%        | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.14            | 0.13            | -0.01        | -4.72%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.67            | 0.51            | -0.16        | -24.06%       | <a href="#">here</a>              |
| 1.A.5.b                    | 0.00555         | 0.00552         | -0.00003     | -0.53%        | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>43.15</b>    | <b>43.23</b>    | <b>0.08</b>  | <b>0.19%</b>  | <b>sub-category chapters</b>      |
| 2.G                        | 29.23           | 29.31           | 0.08         | 0.27%         | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |              |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>NA</b>       |                 |              |               |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |              |               |                                   |

|                                 |                 |                   |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |                   |       |       |       |       |        |                 |                 |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|-------|-------|--------|-----------------|-----------------|
| <b>pollutant-specific data:</b> | NO <sub>x</sub> | NM <sub>VOC</sub> | SO <sub>x</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD <sub>F</sub> | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HC <sub>B</sub> | PC <sub>B</sub> |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|-------|-------|--------|-----------------|-----------------|

## Recalculations - Dioxines & Furanes (PCDD/F)

With no reportable changes within the **National Total** reported for **1990**, the only notable revisions occur for NFRs **1.A.2.g vii**, **1.A.4.a ii** and **1.A.4.c ii** with mutually canceling absolute changes.

Table 1: Changes of emission estimates 1990

|                            | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                         |
|----------------------------|-----------------|-----------------|-------------|--------------|-----------------------------------|
| NFR Sector                 | [g]             |                 |             | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>805.10</b>   | <b>805.10</b>   | <b>0.00</b> | <b>0.00%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>522.76</b>   | <b>522.76</b>   | <b>0.00</b> | <b>0.00%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.057803        | 0.057807        | 0.000004    | 0.01%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.010847        | 0.010844        | -0.000003   | -0.03%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.294356        | 0.294343        | -0.000013   | -0.00005%    | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>242.10</b>   | <b>242.10</b>   | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |             |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>40.25</b>    | <b>40.25</b>    | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |              |                                   |

The marginal changes within the **National Total** reported for **2023 (-0.24 g or -0.22 %)** are dominated by revisions in NFR sub-categories **1.A.4.a i** with **-1.70 g** and **5.E** with **+1.55 g** together with a variety of less significant revisions throughout NFR 1.

The most significant percental change occurs in NFR **1.A.4.a i** with **plus 38.5 %**.

Table 2: Changes of emission estimates 2023

|                       | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|-----------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector            | [g]             |                 |              | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>110.98</b>   | <b>110.74</b>   | <b>-0.24</b> | <b>-0.22%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>50.44</b>    | <b>48.65</b>    | <b>-1.79</b> | <b>-3.55%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 3.46            | 3.45            | -0.01        | -0.25%        | <a href="#">here</a>              |
| 1.A.1.b               | 0.0138          | 0.0141          | 0.0003       | 2.40%         | <a href="#">here</a>              |
| 1.A.1.c               | 0.048           | 0.049           | 0.002        | 3.41%         | <a href="#">here</a>              |
| 1.A.2.a               | 0.0231          | 0.0230          | -0.0001      | -0.31%        | <a href="#">here</a>              |
| 1.A.2.g vii           | 0.05            | 0.06            | 0.01         | 18.56%        | <a href="#">here</a>              |
| 1.A.2.g viii          | 0.94            | 0.92            | -0.02        | -2.36%        | <a href="#">here</a>              |
| 1.A.3.b i             | 4.59            | 4.63            | 0.04         | 0.92%         | <a href="#">here</a>              |
| 1.A.3.b ii            | 0.49060         | 0.49064         | 0.00004      | 0.01%         | <a href="#">here</a>              |
| 1.A.3.b iii           | 0.180           | 0.179           | -0.001       | -0.69%        | <a href="#">here</a>              |
| 1.A.3.b iv            | 0.2470          | 0.2475          | 0.0005       | 0.20%         | <a href="#">here</a>              |
| 1.A.3.c               | 0.022842        | 0.022840        | -0.000002    | -0.01%        | <a href="#">here</a>              |
| 1.A.3.d ii            | 1.68            | 1.64            | -0.04        | -2.49%        | <a href="#">here</a>              |
| 1.A.4.a i             | 23.07           | 21.37           | <b>-1.70</b> | <b>-7.36%</b> | <a href="#">here</a>              |
| 1.A.4.a ii            | 0.007           | 0.010           | 0.003        | <b>38.53%</b> | <a href="#">here</a>              |
| 1.A.4.b i             | 13.54           | 13.51           | -0.03        | -0.24%        | <a href="#">here</a>              |
| 1.A.4.b ii            | 0.052           | 0.050           | -0.002       | -4.69%        | <a href="#">here</a>              |
| 1.A.4.c i             | 1.47            | 1.47            | 0.003        | 0.23%         | <a href="#">here</a>              |
| 1.A.4.c ii            | 0.31            | 0.25            | -0.06        | -19.38%       | <a href="#">here</a>              |
| 1.A.5.a               | 0.18            | 0.20            | 0.02         | 9.37%         | <a href="#">here</a>              |
| 1.A.5.b               | 0.0191          | 0.0190          | -0.0001      | -0.56%        | <a href="#">here</a>              |
| 1.B.1.b               | 0.01672         | 0.01673         | 0.00001      | 0.09%         | <a href="#">here</a>              |



|                            | Submission 2025   | Submission 2026   | Difference       |                 | Reasoning                                |
|----------------------------|-------------------|-------------------|------------------|-----------------|------------------------------------------|
| <b>NFR Sector</b>          | <b>[g]</b>        |                   |                  | <b>relative</b> | <b>see description and reasoning in:</b> |
| <b>NATIONAL TOTAL</b>      | <b>110.98</b>     | <b>110.74</b>     | <b>-0.24</b>     | <b>-0.22%</b>   | <b>sub-category chapters</b>             |
| <b>NFR 1 - Energy</b>      | <b>50.44</b>      | <b>48.65</b>      | <b>-1.79</b>     | <b>-3.55%</b>   | <b>sub-category chapters</b>             |
| <b>NFR 2 - IPPU</b>        | <b>15.5978808</b> | <b>15.5978823</b> | <b>0.0000015</b> | <b>0.00001%</b> | <b>sub-category chapters</b>             |
| 2.G                        | 0.009943          | 0.009945          | 0.0000015        | 0.02%           | <a href="#">here</a>                     |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>         |                   |                  |                 |                                          |
| <b>NFR 5 - Waste</b>       | <b>44.94</b>      | <b>46.48</b>      | <b>1.55</b>      | <b>3.45%</b>    | <b>sub-category chapters</b>             |
| 5.E                        | 41.63             | 43.18             | <u>1.55</u>      | 3.72%           | <a href="#">here</a>                     |
| <b>NFR 6 - Other</b>       | <b>NA</b>         |                   |                  |                 |                                          |

|                                 |                 |                   |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |                   |       |       |       |       |        |     |     |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NO <sub>x</sub> | NM <sub>VOC</sub> | SO <sub>x</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD <sub>F</sub> | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Benzo[a]Pyrene

The small changes within the **National Total** reported for **1990 (+0.04 t or +0.15 %)** result from a variety of **revisions in sub-categories of NFR 1.A.3.b** together with negligibly small and **canceling revisions in NFRs 1.A.2.g vii, 1.A.4.a ii and 1.A.4.c ii**.

Here, the strongest percental changes occur for NFRs **1.A.3.b vi with plus 59.5 %** and **1.A.3.b ii with plus 46 %**.

Table 1: Changes of emission estimates 1990

|                            | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                         |
|----------------------------|-----------------|-----------------|-------------|--------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |             | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>26.99</b>    | <b>27.03</b>    | <b>0.04</b> | <b>0.15%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>25.47</b>    | <b>25.51</b>    | <b>0.04</b> | <b>0.16%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.024532        | 0.024534        | 0.000002    | 0.01%        | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.29            | 0.33            | 0.04        | 12.45%       | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.015           | 0.023           | 0.007       | 45.97%       | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.052           | 0.037           | -0.015      | -29.14%      | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.0043          | 0.0037          | -0.0006     | -13.96%      | <a href="#">here</a>              |
| 1.A.3.b vi                 | 0.02            | 0.04            | 0.01        | 59.53%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.004688        | 0.004687        | -0.000001   | -0.03%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.0530687       | 0.0530682       | -0.0000006  | -0.001%      | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>0.96</b>     | <b>0.96</b>     | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |             |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.56</b>     | <b>0.56</b>     | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |              |                                   |

The small changes within the **National Total** reported for **2023 (-0.09 t or -0.55 %)** result from a variety of more or less significant revisions throughout NFRs 1 and 2, with the dominating revisions for NFR sub-categories **1.A.3.b i (+0.14 t)** and **1.A.4.a i (-0.17 t)**

However, the most significant percental changes occur in NFRs **1.A.3.b vi with +48 %** and **1.A.3.b i with +38 %**.

Table 2: Changes of emission estimates 2023

|                       | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|-----------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector            | [t]             |                 |              | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>15.66</b>    | <b>15.57</b>    | <b>-0.09</b> | <b>-0.55%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>15.20</b>    | <b>15.11</b>    | <b>-0.09</b> | <b>-0.57%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 0.0375          | 0.0379          | 0.0004       | 1.18%         | <a href="#">here</a>              |
| 1.A.1.b               | 0.00290         | 0.00300         | 0.00010      | 3.56%         | <a href="#">here</a>              |
| 1.A.1.c               | 0.000683        | 0.000686        | 0.000003     | 0.44%         | <a href="#">here</a>              |
| 1.A.2.a               | 0.0001155       | 0.0001152       | -0.0000004   | -0.31%        | <a href="#">here</a>              |
| 1.A.2.g vii           | 0.021           | 0.026           | 0.005        | 21.92%        | <a href="#">here</a>              |
| 1.A.2.g viii          | 0.0211          | 0.0204          | -0.0007      | -3.11%        | <a href="#">here</a>              |
| 1.A.3.a i(i)          | 0.000000054     | 0.000000055     | 0.000000001  | 2.34%         | <a href="#">here</a>              |
| 1.A.3.a ii(i)         | 0.00000273      | 0.00000279      | 0.00000006   | 2.34%         | <a href="#">here</a>              |
| 1.A.3.b i             | 0.38            | 0.52            | 0.14         | 38.51%        | <a href="#">here</a>              |
| 1.A.3.b ii            | 0.06            | 0.03            | -0.03        | -46.28%       | <a href="#">here</a>              |
| 1.A.3.b iii           | 0.07            | 0.06            | -0.01        | -11.80%       | <a href="#">here</a>              |
| 1.A.3.b iv            | 0.0032          | 0.0030          | -0.0002      | -7.62%        | <a href="#">here</a>              |
| 1.A.3.b vi            | 0.03            | 0.05            | 0.02         | 48.02%        | <a href="#">here</a>              |

|                     | Submission 2025 | Submission 2026 | Difference |          | Reasoning                         |
|---------------------|-----------------|-----------------|------------|----------|-----------------------------------|
| NFR Sector          | [t]             |                 |            | relative | see description and reasoning in: |
| NATIONAL TOTAL      | 15.66           | 15.57           | -0.09      | -0.55%   | sub-category chapters             |
| NFR 1 - Energy      | 15.20           | 15.11           | -0.09      | -0.57%   | sub-category chapters             |
| 1.A.3.c             | 0.0076495       | 0.0076490       | -0.0000006 | -0.01%   | <a href="#">here</a>              |
| 1.A.3.d ii          | 0.0126          | 0.0123          | -0.0003    | -2.49%   | <a href="#">here</a>              |
| 1.A.4.a i           | 2.24            | 2.07            | -0.17      | -7.41%   | <a href="#">here</a>              |
| 1.A.4.a ii          | 0.003           | 0.004           | 0.001      | 38.32%   | <a href="#">here</a>              |
| 1.A.4.b i           | 12.045          | 12.003          | -0.042     | -0.35%   | <a href="#">here</a>              |
| 1.A.4.b ii          | 0.00324         | 0.00308         | -0.00016   | -4.82%   | <a href="#">here</a>              |
| 1.A.4.c i           | 0.140           | 0.140           | 0.000      | 0.00%    | <a href="#">here</a>              |
| 1.A.4.c ii          | 0.061           | 0.053           | -0.008     | -12.94%  | <a href="#">here</a>              |
| 1.A.5.a             | 0.018           | 0.020           | 0.002      | 9.39%    | <a href="#">here</a>              |
| 1.A.5.b             | 0.00231         | 0.00228         | -0.00004   | -1.56%   | <a href="#">here</a>              |
| 1.B.1.b             | 0.040132        | 0.040134        | 0.000002   | 0.01%    | <a href="#">here</a>              |
| NFR 2 - IPPU        | 0.0419447       | 0.0419479       | 0.0000032  | 0.01%    | sub-category chapters             |
| 2.G                 | 0.0212988       | 0.0213020       | 0.0000032  | 0.02%    | <a href="#">here</a>              |
| NFR 3 - Agriculture | NA              |                 |            |          |                                   |
| NFR 5 - Waste       | 0.42            | 0.42            | 0.00       | 0.00%    |                                   |
| NFR 6 - Other       | NA              |                 |            |          |                                   |

|                                 |                 |                   |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |                   |       |              |       |       |        |                 |                 |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|--------------|-------|-------|--------|-----------------|-----------------|
| <b>pollutant-specific data:</b> | NO <sub>x</sub> | NM <sub>VOC</sub> | SO <sub>x</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD <sub>F</sub> | B[a]P | <b>B[b]F</b> | B[k]F | I[x]P | PAH1-4 | HC <sub>B</sub> | PC <sub>B</sub> |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|--------------|-------|-------|--------|-----------------|-----------------|

## Recalculations - Benzo[b]Fluoranthene

The changes within the **National Total** reported for **1990 (+0.87 t or +2.44 %)** result almost entirely from newly implemented emission estimates for **NFR sub-category 2.C.3, increasing the emissions from NFR 2 by nearly 2,000%**. Furthermore, a variety of revisions have been carried out throughout NFR 1.

Table 1: Changes of emission estimates 1990

|                            | Submission 2025 | Submission 2026 | Difference  |               | Reasoning                         |
|----------------------------|-----------------|-----------------|-------------|---------------|-----------------------------------|
| NFR Sector                 | [t]             |                 | relative    |               | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>35.83</b>    | <b>36.71</b>    | <b>0.87</b> | <b>2.44%</b>  | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>35.14</b>    | <b>35.15</b>    | <b>0.01</b> | <b>0.02%</b>  | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.040017        | 0.040020        | 0.000003    | 0.01%         | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.37            | 0.48            | 0.11        | 29.62%        | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.02            | 0.03            | 0.01        | 62.57%        | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.31            | 0.22            | -0.09       | -28.95%       | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.0048          | 0.0046          | -0.0002     | -5.17%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 0.03            | 0.00            | -0.02       | -86.00%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.007793        | 0.007791        | -0.000002   | -0.03%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.086554        | 0.086553        | -0.000001   | -0.001%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>0.04</b>     | <b>0.91</b>     | <b>0.87</b> | <b>1,962%</b> | <b>sub-category chapters</b>      |
| 2.C.3                      | NE              | <u>0.87</u>     | <u>0.87</u> |               | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |             |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.65</b>     | <b>0.65</b>     | <b>0.00</b> | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |               |                                   |

The changes within the **National Total** reported for **2023 (-0.26 t or -1.15 %)** result from a variety of more or less significant revisions throughout NFR 1. In addition, for **NFR sub-category 2.C.3**, B[b]F emissions are being reported for the first time.

However, the most significant percental change occurs in NFR **1.A.3.b vi with minus -87.5 %**.

Table 2: Changes of emission estimates 2023

|                       | Submission 2025 | Submission 2026 | Difference   |                | Reasoning                         |
|-----------------------|-----------------|-----------------|--------------|----------------|-----------------------------------|
| NFR Sector            | [t]             |                 | relative     |                | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>22.72</b>    | <b>22.46</b>    | <b>-0.26</b> | <b>-1.15%</b>  | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>22.21</b>    | <b>21.95</b>    | <b>-0.26</b> | <b>-1.18%</b>  | <b>sub-category chapters</b>      |
| 1.A.2.g vii           | 0.03            | 0.04            | 0.01         | 27.39%         | <a href="#">here</a>              |
| 1.A.3.a i(i)          | 0.000000078     | 0.000000079     | 0.000000002  | 2.34%          | <a href="#">here</a>              |
| 1.A.3.a ii(i)         | 0.0000039       | 0.0000040       | 0.0000001    | 2.34%          | <a href="#">here</a>              |
| 1.A.3.b i             | 0.43            | 0.59            | <u>0.16</u>  | 36.90%         | <a href="#">here</a>              |
| 1.A.3.b ii            | 0.067           | 0.033           | -0.034       | -50.80%        | <a href="#">here</a>              |
| 1.A.3.b iii           | 0.394           | 0.348           | -0.046       | -11.60%        | <a href="#">here</a>              |
| 1.A.3.b iv            | 0.0036          | 0.0034          | -0.0002      | -5.43%         | <a href="#">here</a>              |
| 1.A.3.b vi            | 0.039           | 0.005           | -0.034       | <b>-87.53%</b> | <a href="#">here</a>              |
| 1.A.3.c               | 0.012683        | 0.012682        | -0.000001    | -0.01%         | <a href="#">here</a>              |
| 1.A.3.d ii            | 0.0210          | 0.0205          | -0.0005      | -2.49%         | <a href="#">here</a>              |
| 1.A.4.a i             | 3.27            | 3.03            | <u>-0.24</u> | -7.41%         | <a href="#">here</a>              |
| 1.A.4.a ii            | 0.005           | 0.007           | 0.002        | 38.53%         | <a href="#">here</a>              |
| 1.A.4.b i             | 17.55           | 17.49           | -0.06        | -0.36%         | <a href="#">here</a>              |
| 1.A.4.b ii            | 0.0032          | 0.0031          | -0.0002      | -4.82%         | <a href="#">here</a>              |

|                            | Submission 2025 | Submission 2026 | Difference       |               | Reasoning                         |
|----------------------------|-----------------|-----------------|------------------|---------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |                  | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>22.72</b>    | <b>22.46</b>    | <b>-0.26</b>     | <b>-1.15%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>22.21</b>    | <b>21.95</b>    | <b>-0.26</b>     | <b>-1.18%</b> | <b>sub-category chapters</b>      |
| 1.A.4.c ii                 | 0.10            | 0.09            | -0.01            | -12.72%       | <a href="#">here</a>              |
| 1.A.5.a                    | 0.0264          | 0.0289          | 0.0025           | 9.39%         | <a href="#">here</a>              |
| 1.A.5.b                    | 0.00252         | 0.00249         | -0.00004         | -1.49%        | <a href="#">here</a>              |
| 1.B.1.b                    | 0.049960        | 0.049963        | 0.000003         | 0.01%         | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>0.025913</b> | <b>0.026239</b> | <b>0.0003265</b> | <b>1.26%</b>  | <b>sub-category chapters</b>      |
| 2.C.3                      | NE              | 0.0003225       | 0.0003225        |               | <a href="#">here</a>              |
| 2.G                        | 0.025913        | 0.025916        | 0.0000039        | 0.02%         | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |                  |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.48</b>     | <b>0.48</b>     | <b>0.00</b>      | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |                  |               |                                   |

|                                 |                 |                   |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |                   |       |       |              |       |        |                 |                 |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|--------------|-------|--------|-----------------|-----------------|
| <b>pollutant-specific data:</b> | NO <sub>x</sub> | NM <sub>VOC</sub> | SO <sub>x</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD <sub>F</sub> | B[a]P | B[b]F | <b>B[k]F</b> | I[x]P | PAH1-4 | HC <sub>B</sub> | PC <sub>B</sub> |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|--------------|-------|--------|-----------------|-----------------|

## Recalculations - Benzo[k]Fluoranthene

The changes within the **National Total** reported for **1990 (+0.87 t or +2.44 %)** result almost entirely from newly implemented emission estimates for **NFR sub-category 2.C.3, increasing the emissions from NFR 2 by nearly 2,000%**. Furthermore, a variety of revisions have been carried out throughout NFR 1.

Table 1: Changes of emission estimates 1990

|                            | Submission 2025 | Submission 2026 | Difference  |               | Reasoning                         |
|----------------------------|-----------------|-----------------|-------------|---------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |             | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>35.83</b>    | <b>36.71</b>    | <b>0.87</b> | <b>2.44%</b>  | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>35.14</b>    | <b>35.15</b>    | <b>0.01</b> | <b>0.02%</b>  | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.040017        | 0.040020        | 0.000003    | 0.01%         | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.37            | 0.48            | 0.11        | 29.62%        | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.02            | 0.03            | 0.01        | 62.57%        | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.31            | 0.22            | -0.09       | -28.95%       | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.0048          | 0.0046          | -0.0002     | -5.17%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 0.03            | 0.00            | -0.02       | -86.00%       | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.007793        | 0.007791        | -0.000002   | -0.03%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.086554        | 0.086553        | -0.000001   | -0.001%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>0.04</b>     | <b>0.91</b>     | <b>0.87</b> | <b>1,962%</b> | <b>sub-category chapters</b>      |
| 2.C.3                      | NE              | <u>0.87</u>     | <u>0.87</u> |               | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |             |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.65</b>     | <b>0.65</b>     | <b>0.00</b> | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |               |                                   |

The small changes within the **National Total** reported for **2023 (+0.03 t or +0.25 %)** result from a variety of revisions throughout NFRs 1 and 2. In addition, for **NFR sub-categories 1.A.3.b vi and 2.C.3**, B[k]F emissions are being reported for the first time.

However, the most significant percental change occurs in NFR **1.A.3.b i with plus 103.7 %**.

Table 2: Changes of emission estimates 2023

|                       | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                         |
|-----------------------|-----------------|-----------------|-------------|--------------|-----------------------------------|
| NFR Sector            | [t]             |                 |             | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>10.35</b>    | <b>10.38</b>    | <b>0.03</b> | <b>0.25%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>10.16</b>    | <b>10.19</b>    | <b>0.03</b> | <b>0.25%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii           | 0.018           | 0.025           | 0.007       | 36.67%       | <a href="#">here</a>              |
| 1.A.3.a i(i)          | 0.000000038     | 0.000000039     | 0.000000001 | 2.34%        | <a href="#">here</a>              |
| 1.A.3.a ii(i)         | 0.00000193      | 0.00000198      | 0.00000005  | 2.34%        | <a href="#">here</a>              |
| 1.A.3.b i             | 0.22            | 0.45            | 0.23        | 103.70%      | <a href="#">here</a>              |
| 1.A.3.b ii            | 0.035           | 0.012           | -0.02       | -67.04%      | <a href="#">here</a>              |
| 1.A.3.b iii           | 0.44            | 0.39            | -0.05       | -11.57%      | <a href="#">here</a>              |
| 1.A.3.b iv            | 0.0026          | 0.0024          | -0.0002     | -7.91%       | <a href="#">here</a>              |
| 1.A.3.b vi            | NE              | <u>0.007</u>    | 0.007       |              | <a href="#">here</a>              |
| 1.A.3.c               | 0.009           | 0.006           | -0.003      | -31.11%      | <a href="#">here</a>              |
| 1.A.3.d ii            | 0.0145          | 0.0141          | -0.0004     | -2.49%       | <a href="#">here</a>              |
| 1.A.4.a i             | 1.45            | 1.34            | -0.11       | -7.41%       | <a href="#">here</a>              |
| 1.A.4.a ii            | 0.004           | 0.005           | 0.001       | 38.35%       | <a href="#">here</a>              |
| 1.A.4.b i             | 7.78            | 7.75            | -0.03       | -0.35%       | <a href="#">here</a>              |
| 1.A.4.b ii            | 0.00032         | 0.00030         | -0.00002    | -4.82%       | <a href="#">here</a>              |

|                            | Submission 2025  | Submission 2026  | Difference       |              | Reasoning                         |
|----------------------------|------------------|------------------|------------------|--------------|-----------------------------------|
| NFR Sector                 | [t]              |                  |                  | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>10.35</b>     | <b>10.38</b>     | <b>0.03</b>      | <b>0.25%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>10.16</b>     | <b>10.19</b>     | <b>0.03</b>      | <b>0.25%</b> | <b>sub-category chapters</b>      |
| 1.A.4.c ii                 | 0.067            | 0.058            | -0.008           | -12.42%      | <a href="#">here</a>              |
| 1.A.5.a                    | 0.012            | 0.013            | 0.001            | 9.39%        | <a href="#">here</a>              |
| 1.A.5.b                    | 0.00056          | 0.00055          | -0.00001         | -1.06%       | <a href="#">here</a>              |
| 1.B.1.b                    | 0.0253894        | 0.0253909        | 0.0000015        | 0.01%        | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>0.0259125</b> | <b>0.0262390</b> | <b>0.0003265</b> | <b>1.26%</b> | <b>sub-category chapters</b>      |
| 2.C.3                      | NE               | <u>0.0003225</u> | 0.0003225        |              | <a href="#">here</a>              |
| 2.G                        | 0.0259125        | 0.0259164        | 0.0000039        | 0.02%        | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>        |                  |                  |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.16</b>      | <b>0.16</b>      | <b>0.00</b>      | <b>0.00%</b> |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>        |                  |                  |              |                                   |

|                                 |                 |                   |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |                   |       |       |       |       |        |                 |                 |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|-------|-------|--------|-----------------|-----------------|
| <b>pollutant-specific data:</b> | NO <sub>x</sub> | NM <sub>VOC</sub> | SO <sub>x</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD <sub>F</sub> | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HC <sub>B</sub> | PC <sub>B</sub> |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|-------|-------|--------|-----------------|-----------------|

## Recalculations - Indeno[1,2,3-c,d]Pyrene

The small changes within the **National Total** reported for **1990 (+0.19 t or +0.83 %)** result from a variety of revisions have been carried out throughout NFR 1 together with newly implemented emission estimates for **NFR sub-category 2.C.3, increasing the emissions from NFR 2 by nearly 160%**.

Table 1: Changes of emission estimates 1990

|                            | Submission 2025 | Submission 2026 | Difference  |              | Reasoning                         |
|----------------------------|-----------------|-----------------|-------------|--------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |             | relative     | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>23.03</b>    | <b>23.22</b>    | <b>0.19</b> | <b>0.83%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>22.92</b>    | <b>23.00</b>    | <b>0.08</b> | <b>0.34%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.0064068       | 0.0064072       | 0.0000005   | 0.01%        | <a href="#">here</a>              |
| 1.A.3.b i                  | 0.39            | 0.50            | 0.11        | 28.12%       | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.018           | 0.025           | 0.007       | 40.18%       | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.08            | 0.06            | -0.02       | -28.84%      | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.0052          | 0.0050          | -0.0002     | -3.59%       | <a href="#">here</a>              |
| 1.A.3.c                    | 0.007           | 0.005           | -0.002      | -31.01%      | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.0012434       | 0.0012430       | -0.0000003  | -0.03%       | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.0138588       | 0.0138586       | -0.0000001  | -0.001%      | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>0.07</b>     | <b>0.18</b>     | <b>0.11</b> | <b>158%</b>  | <b>sub-category chapters</b>      |
| 2.C.3                      | NE              | 0.11            | 0.11        |              | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |             |              |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.04</b>     | <b>0.04</b>     | <b>0.00</b> | <b>0.00%</b> |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |              |                                   |

The significant changes within the **National Total** reported for **2022 (+1.28 t or +4.92 %)** are dominated by revisions in NFR sub-categories **1.A.4.b i with +1.39 t** and **1.A.4.a i with -0.11 t** together with a variety of small revisions throughout NFR 1.

However, the most significant percental change occurs in NFR **1.A.4.a ii with minus 16 %**.

Table 2: Changes of emission estimates 2023

|                       | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|-----------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector            | [t]             |                 |              | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>15.05</b>    | <b>14.88</b>    | <b>-0.17</b> | <b>-1.16%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>14.98</b>    | <b>14.81</b>    | <b>-0.17</b> | <b>-1.16%</b> | <b>sub-category chapters</b>      |
| 1.A.2.g vii           | 0.0053          | 0.0066          | 0.0013       | 23.90%        | <a href="#">here</a>              |
| 1.A.3.a i(i)          | 0.000000087     | 0.000000089     | 0.000000002  | 2.34%         | <a href="#">here</a>              |
| 1.A.3.a ii(i)         | 0.0000044       | 0.0000045       | 0.0000001    | 2.34%         | <a href="#">here</a>              |
| 1.A.3.b i             | 0.43            | 0.52            | 0.09         | 20.63%        | <a href="#">here</a>              |
| 1.A.3.b ii            | 0.06            | 0.04            | -0.03        | -40.83%       | <a href="#">here</a>              |
| 1.A.3.b iii           | 0.10            | 0.09            | -0.01        | -11.46%       | <a href="#">here</a>              |
| 1.A.3.b iv            | 0.0039          | 0.0037          | -0.0002      | -5.22%        | <a href="#">here</a>              |
| 1.A.3.b vi            | 0.019           | NE              | -0.019       | -100%         | <a href="#">here</a>              |
| 1.A.3.c               | 0.0020          | 0.0014          | -0.0006      | -31.02%       | <a href="#">here</a>              |
| 1.A.3.d ii            | 0.00332         | 0.00324         | -0.00008     | -2.49%        | <a href="#">here</a>              |
| 1.A.4.a i             | 2.22            | 2.05            | -0.16        | -7.41%        | <a href="#">here</a>              |
| 1.A.4.a ii            | 0.0008          | 0.0011          | 0.0003       | 37.73%        | <a href="#">here</a>              |
| 1.A.4.b i             | 11.947          | 11.905          | -0.04        | -0.35%        | <a href="#">here</a>              |
| 1.A.4.b ii            | 0.00072         | 0.00069         | -0.00003     | -4.82%        | <a href="#">here</a>              |



|                     | Submission 2025 | Submission 2026 | Difference |          | Reasoning                         |
|---------------------|-----------------|-----------------|------------|----------|-----------------------------------|
| NFR Sector          | [t]             |                 |            | relative | see description and reasoning in: |
| NATIONAL TOTAL      | 15.05           | 14.88           | -0.17      | -1.16%   | sub-category chapters             |
| NFR 1 - Energy      | 14.98           | 14.81           | -0.17      | -1.16%   | sub-category chapters             |
| 1.A.4.c ii          | 0.016           | 0.014           | -0.002     | -12.85%  | <a href="#">here</a>              |
| 1.A.5.a             | 0.018           | 0.020           | 0.002      | 9.39%    | <a href="#">here</a>              |
| 1.A.5.b             | 0.00053         | 0.00052         | -0.00001   | -1.54%   | <a href="#">here</a>              |
| 1.B.1.b             | 0.017199        | 0.017200        | 0.000001   | 0.01%    | <a href="#">here</a>              |
| NFR 2 - IPPU        | 0.04169268      | 0.04174068      | 0.00004800 | 0.12%    | sub-category chapters             |
| 2.C.3               | NE              | 0.0000417       | 0.0000417  |          | <a href="#">here</a>              |
| 2.G                 | 0.04169268      | 0.04169897      | 0.00000629 | 0.02%    | <a href="#">here</a>              |
| NFR 3 - Agriculture | NA              |                 |            |          |                                   |
| NFR 5 - Waste       | 0.03            | 0.03            | 0.00       | 0.00%    |                                   |
| NFR 6 - Other       | NA              |                 |            |          |                                   |

|                                 |                 |        |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |        |       |       |       |       |        |     |     |
|---------------------------------|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|
| <b>pollutant-specific data:</b> | NO <sub>x</sub> | NM VOC | SO <sub>x</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | HCB | PCB |
|---------------------------------|-----------------|--------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|-------|-------|-------|--------|-----|-----|

## Recalculations - Polyaromatic Hydrocarbons 1 to 4

The rather remarkable changes within the **National Total** reported for **1990 (+1.94 t or +1.68 %)** are dominated by newly implemented emission estimates for B[b]F, B[k]F and I[x]P from **NFR sub-category 2.C.3**, increasing the PAH emissions from this specific source by **more than 200 %**. Furthermore, a variety of often opposing **revisions** occurs for sub-categories **throughout NFR 1**.

Table 1: Changes of emission estimates 1990

|                            | Submission 2025 | Submission 2026 | Difference  |               | Reasoning                         |
|----------------------------|-----------------|-----------------|-------------|---------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |             | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>115.67</b>   | <b>117.61</b>   | <b>1.94</b> | <b>1.68%</b>  | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>102.40</b>   | <b>102.50</b>   | <b>0.09</b> | <b>0.09%</b>  | <b>sub-category chapters</b>      |
| 1.A.2.g vii                | 0.097716        | 0.097723        | 0.000007    | 0.01%         | <a href="#">here</a>              |
| 1.A.3.b i                  | 1.24            | 1.56            | 0.32        | 25.62%        | <a href="#">here</a>              |
| 1.A.3.b ii                 | 0.06            | 0.10            | 0.04        | 62.72%        | <a href="#">here</a>              |
| 1.A.3.b iii                | 0.80            | 0.57            | -0.23       | -28.93%       | <a href="#">here</a>              |
| 1.A.3.b iv                 | 0.018           | 0.016           | -0.002      | -9.08%        | <a href="#">here</a>              |
| 1.A.3.b vi                 | 0.06            | 0.04            | -0.02       | -28.25%       | <a href="#">here</a>              |
| 1.A.3.c                    | 0.29            | 0.28            | -0.01       | -4.08%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.01910         | 0.01909         | -0.00001    | -0.03%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.211353        | 0.211351        | -0.000002   | -0.001%       | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>11.81</b>    | <b>13.65</b>    | <b>1.85</b> | <b>15.65%</b> | <b>sub-category chapters</b>      |
| 2.C.3                      | 0.90            | 2.75            | 1.85        | 206%          | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |             |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>1.46</b>     | <b>1.46</b>     | <b>0.00</b> | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |               |                                   |

The significant changes within the **National Total** reported for **2022 (+1.28 t or +4.92 %)** are dominated by revisions in NFR sub-categories **1.A.4.b i with +1.39 t** and **1.A.4.a i with -0.11 t** together with a variety of small revisions throughout NFR 1.

However, the most significant percental change occurs in NFR **1.A.4.a ii with minus 16 %**.

Table 2: Changes of emission estimates 2023

|                       | Submission 2025 | Submission 2026 | Difference   |               | Reasoning                         |
|-----------------------|-----------------|-----------------|--------------|---------------|-----------------------------------|
| NFR Sector            | [t]             |                 |              | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b> | <b>67.13</b>    | <b>66.60</b>    | <b>-0.53</b> | <b>-0.79%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b> | <b>63.04</b>    | <b>62.51</b>    | <b>-0.53</b> | <b>-0.85%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a               | 0.03745         | 0.03790         | 0.00044      | 1.18%         | <a href="#">here</a>              |
| 1.A.1.b               | 0.00290         | 0.00300         | 0.00010      | 3.56%         | <a href="#">here</a>              |
| 1.A.1.c               | 0.000683        | 0.000686        | 0.000003     | 0.44%         | <a href="#">here</a>              |
| 1.A.2.a               | 0.000325        | 0.000324        | -0.000001    | -0.27%        |                                   |
| 1.A.2.g vii           | 0.08            | 0.10            | 0.02         | 27.87%        | <a href="#">here</a>              |
| 1.A.2.g viii          | 0.51            | 0.47            | -0.04        | -7.23%        | <a href="#">here</a>              |
| 1.A.3.a i(i)          | 0.00000026      | 0.00000026      | 0.00000001   | 2.34%         | <a href="#">here</a>              |
| 1.A.3.a ii(i)         | 0.0000130       | 0.0000133       | 0.0000003    | 2.34%         | <a href="#">here</a>              |
| 1.A.3.b i             | 1.453           | 2.074           | 0.62         | 42.70%        | <a href="#">here</a>              |
| 1.A.3.b ii            | 0.230           | 0.117           | -0.11        | -49.25%       | <a href="#">here</a>              |
| 1.A.3.b iii           | 1.00            | 0.88            | -0.12        | -11.59%       | <a href="#">here</a>              |
| 1.A.3.b iv            | 0.013           | 0.012           | -0.001       | -6.38%        | <a href="#">here</a>              |

|                            | Submission 2025 | Submission 2026 | Difference      |               | Reasoning                         |
|----------------------------|-----------------|-----------------|-----------------|---------------|-----------------------------------|
| NFR Sector                 | [t]             |                 |                 | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>67.13</b>    | <b>66.60</b>    | <b>-0.53</b>    | <b>-0.79%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>63.04</b>    | <b>62.51</b>    | <b>-0.53</b>    | <b>-0.85%</b> | <b>sub-category chapters</b>      |
| 1.A.3.b vi                 | 0.09            | 0.06            | -0.03           | -34.04%       | <a href="#">here</a>              |
| 1.A.3.c                    | 0.031           | 0.028           | -0.003          | -10.72%       | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.051           | 0.050           | -0.001          | -2.49%        | <a href="#">here</a>              |
| 1.A.4.a i                  | 9.17            | 8.49            | -0.68           | -7.41%        | <a href="#">here</a>              |
| 1.A.4.a ii                 | 0.013           | 0.017           | 0.005           | 38.37%        | <a href="#">here</a>              |
| 1.A.4.b i                  | 49.32           | 49.15           | -0.17           | -0.35%        | <a href="#">here</a>              |
| 1.A.4.b ii                 | 0.0075          | 0.0071          | -0.0004         | -4.82%        | <a href="#">here</a>              |
| 1.A.4.c ii                 | 0.24            | 0.21            | -0.03           | -12.70%       | <a href="#">here</a>              |
| 1.A.5.a                    | 0.074           | 0.081           | 0.007           | 9.39%         | <a href="#">here</a>              |
| 1.A.5.b                    | 0.0059          | 0.0058          | -0.0001         | -1.48%        | <a href="#">here</a>              |
| 1.B.1.b                    | 0.13268         | 0.13269         | 0.00001         | 0.01%         | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>2.999367</b> | <b>3.000071</b> | <b>0.000704</b> | <b>0.02%</b>  | <b>sub-category chapters</b>      |
| 2.C.3                      | 0.000334        | 0.001021        | 0.000687        | 206%          | <a href="#">here</a>              |
| 2.G                        | 0.1148164       | 0.1148338       | 0.0000173       | 0.02%         | <a href="#">here</a>              |
| <b>NFR 3 - Agriculture</b> | <b>NA</b>       |                 |                 |               |                                   |
| <b>NFR 5 - Waste</b>       | <b>1.09</b>     | <b>1.09</b>     | <b>0.00</b>     | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |                 |               |                                   |

|                                 |                 |                   |                 |                 |                   |                  |     |    |    |    |    |    |    |    |    |    |    |    |                   |       |       |       |       |        |            |     |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|-------|-------|--------|------------|-----|
| <b>pollutant-specific data:</b> | NO <sub>x</sub> | NM <sub>VOC</sub> | SO <sub>x</sub> | NH <sub>3</sub> | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD <sub>F</sub> | B[a]P | B[b]F | B[k]F | I[x]P | PAH1-4 | <b>HCB</b> | PCB |
|---------------------------------|-----------------|-------------------|-----------------|-----------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|----|-------------------|-------|-------|-------|-------|--------|------------|-----|

## Recalculations - Hexachlorobenzene (HCB)

Compared to the previous submission, the **National Total** reported for **1990** remains **unaltered**.

Table 1: Changes of emission estimates 1990

|                            | Submission 2025 | Submission 2026 | Difference  |              |
|----------------------------|-----------------|-----------------|-------------|--------------|
| NFR Sector                 | [kg]            |                 |             | relative     |
| <b>NATIONAL TOTAL</b>      | <b>2,900.52</b> | <b>2,900.52</b> | <b>0.00</b> | <b>0.00%</b> |
| <b>NFR 1 - Energy</b>      | <b>4.80</b>     | <b>4.80</b>     | <b>0.00</b> | <b>0.00%</b> |
| <b>NFR 2 - IPPU</b>        | <b>2,786.42</b> | <b>2,786.42</b> | <b>0.00</b> | <b>0.00%</b> |
| <b>NFR 3 - Agriculture</b> | <b>109.29</b>   | <b>109.29</b>   | <b>0.00</b> | <b>0.00%</b> |
| <b>NFR 5 - Waste</b>       | <b>0.01</b>     | <b>0.01</b>     | <b>0.00</b> | <b>0.00%</b> |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |             |              |

The marginally small changes within the **National Total** reported for **2023 (-0.005 kg or -0.12 %)** result from a variety of small revisions throughout NFR 1 and with the most significant percental change occurring in NFR **1.A.2.g viii with minus 16.3 %**.

Table 2: Changes of emission estimates 2023

|                            | Submission 2025 | Submission 2026 | Difference    |               | Reasoning                         |
|----------------------------|-----------------|-----------------|---------------|---------------|-----------------------------------|
| NFR Sector                 | [kg]            |                 |               | relative      | see description and reasoning in: |
| <b>NATIONAL TOTAL</b>      | <b>3.85</b>     | <b>3.85</b>     | <b>-0.005</b> | <b>-0.12%</b> | <b>sub-category chapters</b>      |
| <b>NFR 1 - Energy</b>      | <b>2.27</b>     | <b>2.27</b>     | <b>-0.005</b> | <b>-0.21%</b> | <b>sub-category chapters</b>      |
| 1.A.1.a                    | 1.11            | 1.11            | 0.007         | 0.66%         | <a href="#">here</a>              |
| 1.A.2.g viii               | 0.014           | 0.012           | -0.002        | -16.27%       | <a href="#">here</a>              |
| 1.A.3.d ii                 | 0.037           | 0.036           | -0.001        | -2.73%        | <a href="#">here</a>              |
| 1.A.4.a i                  | 0.067           | 0.062           | -0.005        | -7.37%        | <a href="#">here</a>              |
| 1.A.4.b i                  | 1.043           | 1.039           | -0.004        | -0.37%        | <a href="#">here</a>              |
| 1.A.5.a                    | 0.00050         | 0.00054         | 0.00005       | 9.75%         | <a href="#">here</a>              |
| <b>NFR 2 - IPPU</b>        | <b>1.25</b>     | <b>1.25</b>     | <b>0.00</b>   | <b>0.00%</b>  |                                   |
| <b>NFR 3 - Agriculture</b> | <b>0.30</b>     | <b>0.30</b>     | <b>0.00</b>   | <b>0.00%</b>  |                                   |
| <b>NFR 5 - Waste</b>       | <b>0.03</b>     | <b>0.03</b>     | <b>0.00</b>   | <b>0.00%</b>  |                                   |
| <b>NFR 6 - Other</b>       | <b>NA</b>       |                 |               |               |                                   |

|                          |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |
|--------------------------|-----|--------|-----|-----|-------|------|-----|----|----|----|----|----|----|----|----|----|----|----|--------|-------|
| pollutant-specific data: |     |        |     |     |       |      |     |    |    |    |    |    |    |    |    |    |    |    |        |       |
|                          | NOx | NM VOC | SOx | NH3 | PM2.5 | PM10 | TSP | BC | CO | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn | PCDD/F | B[a]P |

## Recalculations - Polychlorinated Biphenyls (PCBs)

Compared to the previous submission, the **National Total** reported for **1990** remains **unaltered**.

Table 1: Changes of emission estimates 1990

|                     | Submission 2025 | Submission 2026 | Difference |       |
|---------------------|-----------------|-----------------|------------|-------|
| NFR Sector          | [kg]            |                 | relative   |       |
| NATIONAL TOTAL      | 1,735.78        | 1,735.78        | 0.00       | 0.00% |
| NFR 1 - Energy      | 588.96          | 588.96          | 0.00       | 0.00% |
| NFR 2 - IPPU        | 1,146.82        | 1,146.82        | 0.00       | 0.00% |
| NFR 3 - Agriculture | NA              |                 |            |       |
| NFR 5 - Waste       | 0.0000005       | 0.0000005       | 0.0000000  | 0.00% |
| NFR 6 - Other       | NA              |                 |            |       |

The changes within the **National Total** reported for **2023 (+2.68 kg or +1.31 %)** are dominated by changes in NFR sub-category **1.A.2.g viii** (+2.2 kg) together with a variety of small revisions throughout NFR 1.

Table 2: Changes of emission estimates 2023

|                     | Submission 2025 | Submission 2026 | Difference |        | Reasoning                         |
|---------------------|-----------------|-----------------|------------|--------|-----------------------------------|
| NFR Sector          | [kg]            |                 | relative   |        | see description and reasoning in: |
| NATIONAL TOTAL      | 203.80          | 206.48          | 2.68       | 1.31%  | sub-category chapters             |
| NFR 1 - Energy      | 139.15          | 141.82          | 2.68       | 1.92%  | sub-category chapters             |
| 1.A.1.a             | 97.93           | 98.71           | 0.78       | 0.80%  | <a href="#">here</a>              |
| 1.A.2.g viii        | 16.95           | 19.15           | 2.20       | 13.01% | <a href="#">here</a>              |
| 1.A.3.b i           | 0.00105         | 0.00106         | 0.00001    | 0.92%  | <a href="#">here</a>              |
| 1.A.3.b ii          | 0.00010566      | 0.00010567      | 0.00000001 | 0.01%  | <a href="#">here</a>              |
| 1.A.3.b iii         | 0.0000355       | 0.0000352       | -0.0000002 | -0.69% | <a href="#">here</a>              |
| 1.A.3.b iv          | 0.0001169       | 0.0001171       | 0.0000002  | 0.20%  | <a href="#">here</a>              |
| 1.A.3.d ii          | 0.082           | 0.081           | -0.001     | -1.02% | <a href="#">here</a>              |
| 1.A.4.a i           | 4.28            | 3.96            | -0.32      | -7.46% | <a href="#">here</a>              |
| 1.A.4.b i           | 19.49           | 19.50           | 0.01       | 0.05%  | <a href="#">here</a>              |
| 1.A.5.a             | 0.032           | 0.035           | 0.003      | 9.11%  | <a href="#">here</a>              |
| NFR 2 - IPPU        | 64.66           | 64.66           | 0.00       | 0.00%  |                                   |
| NFR 3 - Agriculture | NA              |                 |            |        |                                   |
| NFR 5 - Waste       | 0.0000024       | 0.0000025       | 0.0000001  | 3.90%  | sub-category chapters             |
| 5.C.1.b v           | 0.0000024       | 0.0000025       | 0.0000001  | 3.90%  | <a href="#">here</a>              |
| NFR 6 - Other       | NA              |                 |            |        |                                   |

## CHAPTER 9.2 - Improvements

### Improvements since last Submission



The following table provides an overview of the main improvements introduced with the current NFR and IIR submission and their affect on the **TACCC** principles for **T**ransparency, **A**ccuracy, **C**onsistency, **C**ompleteness, and **C**omparability.

|                                                                                        |                                                                                                                                                | improvement of: |          |             |              |               | result of |
|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|----------|-------------|--------------|---------------|-----------|
| What?                                                                                  | Where?                                                                                                                                         | Transparency    | Accuracy | Consistency | Completeness | Comparability | review?   |
| IMPROVEMENTS SPECIFIC TO GERMANY'S EMISSIONS INVENTORY (as provided in the NFR tables) |                                                                                                                                                |                 |          |             |              |               |           |
| newly implemented emission sources (!)                                                 |                                                                                                                                                |                 |          |             | x            | x             |           |
| newly implemented emission estimates (replacing 'NE')                                  | BC from 1.A.3.b vii; TSP, PM <sub>10</sub> and PM <sub>2.5</sub> from 2.D.3.c                                                                  |                 |          |             | x            | x             |           |
| re-allocation of activity data and/or emissions                                        |                                                                                                                                                |                 |          |             |              |               |           |
| upgrade of tier approach                                                               | PM from 1.A.3.b vi: upgrade to tier2 (EMEP/EEA Guidebook 2023, Update 2025)                                                                    | x               | x        |             |              | x             |           |
| adoption of EF from:                                                                   |                                                                                                                                                |                 |          |             |              |               |           |
| (i) the latest EMEP/EEA Guidebook (ongoing)                                            | BC & PM from maritime navigation: EF for PM and BC based in (Scipper, 2021), as provided in the related chapter of the 2023 EMEP/EEA Guidebook |                 |          |             |              | x             |           |
| (ii) the IPCC Refinement (2019)                                                        |                                                                                                                                                |                 |          |             |              |               |           |
| (iii) research projects                                                                |                                                                                                                                                |                 |          |             |              |               |           |
| IMPROVEMENTS SPECIFIC TO THE IIR                                                       |                                                                                                                                                |                 |          |             |              |               |           |
| (i) in-depth revision of chapter                                                       |                                                                                                                                                | x               |          | x           |              |               | x         |
| (ii) new chapter/annex                                                                 |                                                                                                                                                |                 |          |             |              |               |           |

|                                            |                                                                                                                                                            |   |  |  |  |   |  |
|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--|--|--|---|--|
| (iii) provision of original inventory data | <a href="#">Appendix 2.4</a> : derivation of tier2 EF for PAH from 1.A.3.b i-iv; <a href="#">1.A.3.c- Railways</a> : derivation of tier1 EF for PAH and HM | x |  |  |  | x |  |
|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--|--|--|---|--|

## Improvements planned for future submissions

Possible improvement issues that have been identified so far and will be checked in the future are given below:

### **OVER-ALL INVENTORY (all source categories)**

- To prioritise improvements on the basis of the results of the uncertainty analysis, it is planned to determine uncertainty analysis at source category level.

### **stationary fuel combustion:**

- 1.A.1.a: evaluation of measurement data on POPs and heavy metal in large combustion plants
- 1.A.1.b: revision of SO<sub>2</sub> emission factors
- further improvements of PAH Emission factors for small combustion plants

### **mobile fuel combustion:**

- 1.A.3.b vi + vii: update of emission factors for abrasive emissions from tyres and brakes (via research project), with special focus on Euro7 standard; possible implementation into TREMOD
- 1.A.3.c: validation and revision of approach for abrasive emissions from railways; possible implementation into TREMOD
- navigation & shipping (1.A.3.d i, 1.A.3.d ii, 1.A.4.c iii and 1.A.5.b): implementation of specific PAH tier1 default emission factors from EMEP/EEA Guidebook 2023 (see Appendix 2.4 for [Maritime and inland vessels](#) as well as [specific information on NFR 1.A.3.d](#))

### **industrial processes:**

- iron and steel production: assessment of the use of default emission factors to complete PAH emission reporting.
- copper production: completeness of HM reporting

## Investigated Review Findings

### **NECD 2025**

| Aspect                                    | Sector       | First identified in | Finding summary                                                                                  | Observation           | Implemented? | Official Comment for IIR                                                        |
|-------------------------------------------|--------------|---------------------|--------------------------------------------------------------------------------------------------|-----------------------|--------------|---------------------------------------------------------------------------------|
| Accuracy Transparency pre-2023 GB Finding | 1.A.3.d ii   | 2025                | lack of transparency regarding the use of default PAH emission factors from 1.A.3.c and 1.A.3.b. | DE-1A3dii-2025-0001   | no           | see above (improvements planned for future submissions: mobile fuel combustion) |
| Accuracy Transparency                     | 1.A.3.d i(i) | 2023                | lack of transparency regarding the rather high PM emission factors applied                       | DE-1A3di(i)-2023-0002 | yes          | EF revised within underlying model (see <a href="#">here</a> )                  |
| Transparency                              | 1.A.3.c      | 2025                | lack of transparency regarding the source of emission factors.                                   | DE-1A3c-2025-0002     | resolved     |                                                                                 |

| Aspect                           | Sector  | First identified in | Finding summary                                                                       | Observation       | Implemented? | Official Comment for IIR                                                                                       |
|----------------------------------|---------|---------------------|---------------------------------------------------------------------------------------|-------------------|--------------|----------------------------------------------------------------------------------------------------------------|
| Transparency pre-2023 GB Finding | 1.A.3.b | 2025                | lack of transparency regarding the trend and sources of default POP emission factors. | DE-1A3b-2025-0001 | yes          | default-EF updated to latest version of EMEP/EEA Guidebook 2023 (Update 2025) (see also <a href="#">here</a> ) |

## NECD 2024

| Aspect       | Sector   | First identified in | Finding summary                                                              | Observation           | Implemented? | Official Comment for IIR                                                                                                                                                                                               |
|--------------|----------|---------------------|------------------------------------------------------------------------------|-----------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Completeness | 2D3c     | 2022                | notation key 'NA' (not applicable) provided for particulate matter emissions | DE-2D3c-2022-0001     | yes          | The research project is ongoing. For the current submission we changed the notation keys to 'NE' and will report on further progress made implementing this improvement in future IIR submissions <a href="#">here</a> |
| Accuracy     | 1A3di(i) | 2023                | check PM2.5 implied emission factor                                          | DE-1A3di(i)-2023-0002 | no           |                                                                                                                                                                                                                        |
| Transparency | 2D3a     | 2023                | improve discription of domestic solvent use                                  | DE-2D3a-2023-0001     | no           |                                                                                                                                                                                                                        |
| Accuracy     | 2D3e     | 2023                | investigate the possibility of using surrogate data                          | DE-2D3e-2023-0001     | no           |                                                                                                                                                                                                                        |

## CLRTAP 2024

| Aspect       | Sector | First identified in | Finding summary                                                                                                                                                                                            | Observation    | Implemented? | Comment |
|--------------|--------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------|---------|
| Completeness | 2D3a   | 2024                | allocate NMVOC emissions related to pesticides use to SNAP 060604 (other other), describe emission factors in the next submission                                                                          | DE-2024-2D3a-1 | no           |         |
| Completeness | 2D3a   | 2024                | find AD source for hand sanitizers or transparently describe the issue of hand sanitizer use in more detail including evidence that (also during the pandemic) hand sanitizers are fully included in 2D3a. | DE-2024-2D3a-2 | no           |         |
| Consistency  | 2D3e   | 2024                | merge the two time-series by using the methods provided for this purpose                                                                                                                                   | DE-2024-2D3e-1 | no           |         |
| Consistency  | 2D3f   | 2024                | improve trend explanation                                                                                                                                                                                  | DE-2024-2D3f-1 | no           |         |
| Consistency  | 2D3g   | 2024                | merge the two time-series by using the methods provided for this purpose                                                                                                                                   | DE-2024-2D3g-1 | no           |         |
| Consistency  | 2D3h   | 2024                | improve trend explanation                                                                                                                                                                                  | DE-2024-2D3h-1 | no           |         |
| Transparency | 2D3a   | 2024                | provide further information on methodology and evolution of EF over time for the different categories considered and how the impact of regulations has been determined                                     | DE-2024-2D3a-3 | no           |         |
| Transparency | 2D3d   | 2024                | provide further information on methodology and evolution of EF and AD over time for the different sub-activities considered and how the impact of regulations has been determined                          | DE-2024-2D3d-2 | no           |         |
| Transparency | 2D3e   | 2024                | provide further information on methodology and evolution of EF and AD over time and how the impact of regulations has been determined                                                                      | DE-2024-2D3e-2 | no           |         |



| Aspect       | Sector | First identified in | Finding summary                                                                                                                                                                                                    | Observation    | Implemented? | Comment |
|--------------|--------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------|---------|
| Transparency | 2D3f   | 2024                | provide further information on methodology and evolution of EF and AD over time and how the impact of regulations has been determined                                                                              | DE-2024-2D3f-2 | no           |         |
| Transparency | 2D3g   | 2024                | provide further information on methodology and evolution of EF and AD over time and how the impact of regulations has been determined                                                                              | DE-2024-2D3g-2 | no           |         |
| Transparency | 2D3h   | 2024                | provide further information on methodology and evolution of EF and AD over time and how the impact of regulations has been determined. - use the official procedure to provide confidential information to the ERT | DE-2024-2D3h-2 | no           |         |
| Transparency | 2D3i   | 2024                | provide further information on methodology and evolution of EF and AD over time and how the impact of regulations has been determined                                                                              | DE-2024-2D3i-1 | no           |         |
| Consistency  | 2D3e   | 2024                | consider this issue when implementing the recommendation for question DE-2024-2D3e-1                                                                                                                               | DE-2024-2D3e-3 | no           |         |
| Consistency  | 2D3d   | 2024                | merge the two time-series in one unique consistent series by using methods to resolve data gap and merge two series                                                                                                | DE-2024-2D3d-1 | no           |         |

**NECD 2023**

| Aspect                 | Sector   | First identified in | Finding summary                                                                                                                                                                                                                                                                                                                                                                         | Observation                   | Implemented?                                                          | Official Comment for IIR                                                                                                                                                                                                                 |
|------------------------|----------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (lack of) Transparency | 2C4      | 2022                | Lack of transparency regarding the use of notation keys does not match IIR description                                                                                                                                                                                                                                                                                                  | DE-2-2022-0002;DE-2-2022-0002 | Partly                                                                |                                                                                                                                                                                                                                          |
|                        | 2D3      | 2023                | Check Notation keys                                                                                                                                                                                                                                                                                                                                                                     | DE-2D-2023-0001               | No                                                                    |                                                                                                                                                                                                                                          |
|                        | 2D3a     | 2023                | Improve discription of domestic solvent use                                                                                                                                                                                                                                                                                                                                             | DE-2D3a-2023-0001             | partly                                                                |                                                                                                                                                                                                                                          |
|                        | 2D3i     | 2023                | consider allocation of NMVOC from lubricants, concrete additives, and plant protectives to NFR 2.G and provide information for not calculating the emission from use of shoes, and clarification about reporting NMVOC from lubricants and cooling lubricants                                                                                                                           | DE-2D3i-2023-0001             | Yes except the allocation of concrete additives and plant protectives |                                                                                                                                                                                                                                          |
|                        | 3Da2c    | 2023                | harmonise description of conversion of NO <sub>x</sub> EFs throughout all Chapters for 3.D Agricultural soils in the IIR                                                                                                                                                                                                                                                                | DE-3Da2c-2023-0001            | Yes                                                                   |                                                                                                                                                                                                                                          |
|                        | 3Dc      | 2023                | correct tier level for 3.D.c provided in the IIR                                                                                                                                                                                                                                                                                                                                        | DE-3Dc-2023-0001              | No                                                                    | tier corrected to T2                                                                                                                                                                                                                     |
|                        | 5E       | 2023                | Include the information (weighting factors applied for each type of buildings/car fires in order to derive the number of full-scale fires justification that the default emission factors refer to full-scale burning) and complete the description with detailed activity data split by type of fire (small medium major) and category of buildings including the sources of the data. | DE-5E-2023-0001               | Yes                                                                   | Germany has improved transparency regarding the methodological description. About the conversion of different types of fires to full-scale fires and about the activity data split by type of fire now there is more information in IIR. |
|                        | 2A5a     | 2023                | Include an explanation for how the share of the emissions from saltmining has been determined                                                                                                                                                                                                                                                                                           | DE-2A5a-2023-0001             | Yes                                                                   | Germany has included an explanation of the determination in IIR and has added an informative graph.                                                                                                                                      |
| Accuracy               | 1A3di(i) | 2023                | check PM <sub>2.5</sub> implied emission factor                                                                                                                                                                                                                                                                                                                                         | DE-1A3di(i)-2023-0002         | No                                                                    |                                                                                                                                                                                                                                          |
|                        | 2D3e     | 2023                | investigate the possibility of using surrogate data                                                                                                                                                                                                                                                                                                                                     | DE-2D3e-2023-0001             | No                                                                    |                                                                                                                                                                                                                                          |

| Aspect       | Sector | First identified in | Finding summary                                                                                                                                                            | Observation                         | Implemented? | Official Comment for IIR                                                                                                                                        |
|--------------|--------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Completeness | 2D3c   | 2022                | For particulate matter Germany did not provide estimates and was using the notation key 'NA' (not applicable) in its NFR                                                   | DE-2D3c-2022-0001;DE-2D3c-2022-0001 | Yes          | The research is ongoing now we have changed the notation keys to NE. Germany will report on the progress made implementing this improvement in IIR submissions. |
|              | 3B     | 2022                | Other animals not reported                                                                                                                                                 | DE-3B4h-2022-0001;DE-3B4h-2022-0001 | Yes          | Will be implemented in Submission 2024                                                                                                                          |
|              | 5A     | 2023                | estimate PM emissions from all mineral waste handled (including backfilling) or provide a justification in the IIR that the estimate includes all relevant emissions       | DE-5A-2023-0001                     | Yes          |                                                                                                                                                                 |
| Consistency  | 3B4gi  | 2023                | Correct inconsistencies in the timeseries and to include explanations of any fluctuations with clear references to other documents and corresponding statements            | Germany-2023-3B-4                   | No           |                                                                                                                                                                 |
|              | 3B4gii | 2023                | Correct inconsistencies in the timeseries and include explanations of any fluctuations with clear references to other documents and corresponding statements in it the IIR | Germany-2023-3B-5                   | Yes          | Germany will add the link to chimney sweeps statistic in the next IIR submission.                                                                               |

**CLRTAP 2023**

| Aspect                 | Sector         | First identified in | Finding summary                                                                                                                                                                                                          | Observation       | Implemented? | Comment                                                                           |
|------------------------|----------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|--------------|-----------------------------------------------------------------------------------|
| (lack of) Transparency | 3F             | 2023                | Include information and the correct reference to Roseman et al. (2023) in the IIR                                                                                                                                        | Germany-2023-3F-1 | No           | Updated Publication is now correctly referenced as Vos et al. 2024                |
|                        | KCA            | 2023                | Includes information on available the linked background files on the quantitative KCA level and trend assessment in its IIR                                                                                              | Germany-2023-0-1  | Yes          |                                                                                   |
|                        | 3B2\3B4d\3B4e  | 2023                | Add in the improvement plan a year in which the CLRTAP recommendation was implemented to include a clear reference to the chapters of the NIR and other documents and to link the previous IIRs in the relevant chapters | Germany-2023-3B-2 | No           |                                                                                   |
|                        | 3b1a\3B3\3B4gi | 2023                | include the provided justifications of fluctuations in emissions and changes in the calculations in its IIR and to add in the improvement plan the year in which the recommendation was implemented                      | Germany-2023-3B-3 | No           |                                                                                   |
| Consistency            | 3B4gi          | 2023                | correct inconsistencies in the timeseries and to include explanations of any fluctuations with clear references to other documents and corresponding statements                                                          | Germany-2023-3B-4 | No           |                                                                                   |
|                        | 3B4gii         | 2023                | Correct inconsistencies in the timeseries and include explanations of any fluctuations with clear references to other documents and corresponding statements in it the IIR                                               | Germany-2023-3B-5 | Yes          |                                                                                   |
| Completeness           | 3B4h           | 2023                | Continue the effort in calculating emissions from the category Other animals and include more detailed information on the manner of the gathering activity data for this category                                        | Germany 2023-3B-1 | No           | Emissions from other animals (deer ostrich rabbits fur-bearing animals) included. |

NECD 2022

| Aspect                 | Sector  | First identified in | Finding summary                                                                                                                         | Observation          | Implemented? | Comment                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------|---------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------|----------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (lack of) Transparency | 1A5b    | 2022                | Lack of transparency regarding the NO <sub>x</sub> emissions outlier in 2005 compared to 2000-2010 emissions                            | DE-1A5b-2022-0001    | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 1A5b    | 2022                | Lack of transparency regarding the PM <sub>2.5</sub> emissions outlier in 2005 compared to 2000-2010 emissions                          | DE-1A5b-2022-0002    | Partly       |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 2C4     | 2022                | Lack of transparency regarding the use of notation keys does not match IIR description                                                  | DE-2-2022-0002       | Partly       |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 2G      | 2022                | Lack of transparency regarding the drop in the emissions in 2020 from the previous rather steady trend                                  | DE-2G-2022-0001      | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 2J      | 2022                | Lack of transparency regarding the use of notation keys because the notation keys 'NA' and 'NE' do not match the explanation in the IIR | DE-2J-2022-0001      | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 2K      | 2022                | Lack of transparency on the use of these notation keys and the explanation provided in the IIR                                          | DE-2K-2022-0001      | No           |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 3D      | 2022                | Lack of transparency regarding activity data reported in the NFR tables for years 1990-2020                                             | DE-3D-2022-0001      | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Consistency            | 1A4ciii | 2018                |                                                                                                                                         | DE-1A4ciii-2018-0001 | No           | As described in the relevant IIR chapter activity data for maritime navigation including fishing is estimated bottom-up in a country-specific model and based on ship movement data. From that perspective jumps in fuel consumption cannot be explained by errors in statistics but are assumed to represent reality in respect to the amounts of fuels used by fishing vessels operating from German harbours. |

| Aspect       | Sector | First identified in | Finding summary                                                                                                                                                                    | Observation        | Implemented? | Comment                                                                                                                                                                                                                                               |
|--------------|--------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Completeness | 2D3c   | 2022                | For particulate matter Germany did not provide estimates and was using the notation key 'NA' (not applicable) in its NFR                                                           | DE-2D3c-2022-0001  | Yes          | The research is ongoing now we have changed the notation keys to NE. Germany will report on the progress made implementing this improvement in IIR submissions.                                                                                       |
|              | 2H1    | 2022                | Germany reports 'IE' for all pollutants under NFR 1.A.2.d assuming that the fuel-related emissions are allocated under 2.H.1. However, for BC and CO the notation key 'NE' is used | DE-2H1-2022-0002   | Yes          | We have improved the IIR documentation of the allocation of all emissions from the pulp and paper industry and included an explanation of the management of process related sulphur and ammonia emissions for pulping processes occurring in Germany. |
|              | 3B     | 2022                | Other animals not reported                                                                                                                                                         | DE-3B4h-2022-0001  | Yes          | Will be implemented in Submission 2024                                                                                                                                                                                                                |
|              | 3Da2a  | 2022                | Use of notation key for NMVOC while emissions are expected                                                                                                                         | DE-3Da2a-2022-0001 | Yes          |                                                                                                                                                                                                                                                       |
|              | 5D1    | 2022                | Lack of transparency regarding dry toilets (including latrines)                                                                                                                    | DE-5-2022-0001     | No           |                                                                                                                                                                                                                                                       |
| Accuracy     | 3Dc    | 2022                | Farm-Level Agricultural Operations should be reported using Tier 2 or higher                                                                                                       | DE-3Dc-2022-0001   | Yes          |                                                                                                                                                                                                                                                       |

**CLRTAP 2022**

| Aspect                 | Sector | First identified in | Finding summary                                                                                                                                  | Observation        | Implemented? | Comment                                                                                                                                                                |
|------------------------|--------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (lack of) Transparency | 1A4bi  | 2022                | Document the description of the activity date in more detail including information from the chimney sweeps statistic in the next IIR submission. | § 10 (CLRTAP 2022) | No           | Germany will add the link to chimney sweeps statistic in the next IIR submission.                                                                                      |
|                        | 1A4bi  | 2022                | Provide a complete and clear documentation on the splitting of appliance types are in the next IIR submission.                                   | § 12 (CLRTAP 2022) | Partly       | Germany will check possible further information and report the results in future IIR submission.                                                                       |
|                        | 1A4bi  | 2022                | Include information on the measurement standards and equipment used to determine the emission factors.                                           | § 14 (CLRTAP 2022) | No           | Germany will check possible further information and report the results in future IIR submission. Nevertheless information about the status is already included in IIR. |
|                        | 1A4bi  | 2022                | Include the information provided during the review on the approach to the so-called user impact                                                  | § 17 (CLRTAP 2022) | No           | Germany will look at the development of the Guidebook and then will consider changes.                                                                                  |
|                        | 1A4bi  | 2022                | Include further information on the age distribution of the vehicle fleet and more information about the traffic condition.                       | § 25 (CLRTAP 2022) |              |                                                                                                                                                                        |
| Completeness           | 1A4bi  | 2022                | Further investigate for each biomass and coal PM emission factor whether or not condensables are included.                                       | § 18 (CLRTAP 2022) | No           | Germany will look at the development of the Guidebook and then will consider changes.                                                                                  |

## NECD 2021

| Aspect  | Sector | First identified in | Finding summary            | Observation          | Implemented? | Comment |
|---------|--------|---------------------|----------------------------|----------------------|--------------|---------|
| General | LPS    | 2021                | Update to the 2019 dataset | DE-LPS-GEN-2021-0002 | No           |         |

| Aspect                 | Sector                | First identified in | Finding summary                                                     | Observation          | Implemented? | Comment                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------|-----------------------|---------------------|---------------------------------------------------------------------|----------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (lack of) Transparency | 1A1a\1A2gviii\1A4\1B1 | 2021                | Clearly reference EFs used for HCB and BC                           | DE-1A1a-2021-0001    | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 1A2b                  | 2021                | Update notation key used for BC emission                            | DE-1A2b-2021-0001    | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 1A2e                  | 2021                | Update notation key for BC and check allocation                     | DE-1A2e-2021-0001    | Yes          | The notation key for 1.A.2.e is changed and a description of the allocation of the emissions is included in the IIR 2022.                                                                                                                                                                                                                                                                                        |
|                        | 1A4bii                | 2021                | Update IIR description                                              | DE-1A4bii-2021-0001  | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 1A3ei                 | 2021                | Explicitly state why PM <sub>2.5</sub> is equal to PM <sub>10</sub> | DE-1A3ei-2021-0001   | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 5                     | 2021                | Update to the latest Guidebook where needed                         | DE-5-2021-0001       | Yes          | Citation has been updated to the latest GB version - no changes in EF needed. Only for 5C2 some changes in EF is planned.                                                                                                                                                                                                                                                                                        |
| Consistency            | 1A4ciii               | 2018                | Large increase in AD from 2015 to 2016                              | DE-1A4ciii-2018-0001 | No           | As described in the relevant IIR chapter activity data for maritime navigation including fishing is estimated bottom-up in a country-specific model and based on ship movement data. From that perspective jumps in fuel consumption cannot be explained by errors in statistics but are assumed to represent reality in respect to the amounts of fuels used by fishing vessels operating from German harbours. |
|                        | 1A4cii                | 2018                | Inconsistent AD values NFR vs. IIR                                  | DE-1A4cii-2018-0001  | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 1A1b                  | 2021                | Resolve time series issue for BC                                    | DE-1A1b-2021-0001    | No           |                                                                                                                                                                                                                                                                                                                                                                                                                  |



| Aspect        | Sector | First identified in | Finding summary                                       | Observation          | Implemented? | Comment                                                                                                                |
|---------------|--------|---------------------|-------------------------------------------------------|----------------------|--------------|------------------------------------------------------------------------------------------------------------------------|
| Completeness  | 2D3g   | 2018                | Report PAHs from 2.D.3.g Chemical Products            | DE-2D3g-2018-0001    | Yes          |                                                                                                                        |
|               | LPS    | 2020                | Add missing pollutants: PAHs, PCBs, PM <sub>2.5</sub> | DE-LPS-GEN-2020-0001 | Yes          | Since these pollutants are not in the ePRTR dataset Germany cannot report them.                                        |
|               | 1A2a   | 2021                | Report BC emissions                                   | DE-1A2a-2021-0002    | No           |                                                                                                                        |
|               | 1A2a   | 2021                | Include BC emissions                                  | DE-1A2a-2021-0001    | Yes          |                                                                                                                        |
|               | 1A5a   | 2021                | Include BC emissions                                  | DE-1A5a-2021-0001    | Yes          |                                                                                                                        |
|               | 2A3    | 2021                | Include BC emissions                                  | DE-2A3-2021-0001     | Yes          | The notation key for BC is changed from 'NA' to 'NE' and a justification for this notation key is included in the IIR. |
|               | LPS    | 2021                | Include PCDD/F emissions                              | DE-LPS-GEN-2021-0001 | No           |                                                                                                                        |
|               | GRID   | 2021                | Include NOx emissions from shipping                   | DE-GRID-G-2021-0001  | Yes          |                                                                                                                        |
| Comparability | 1B1b   | 2021                | Update PAH reporting                                  | DE-1B1b-2021-0001    | Yes          | Revised emission factors developed according to suggestions in review.                                                 |
|               | 2A1    | 2021                | Update PAH reporting                                  | DE-2A1-2021-0001     | Yes          | Details of the methodology used for BaP and for PAH-1-4 estimation are explained in IIR 2022.                          |
|               | 2C1    | 2021                | Update PAH reporting                                  | DE-2C1-2021-0001     | Yes          |                                                                                                                        |
|               | 2C3    | 2021                | Update PAH reporting                                  | DE-2C3-2021-0001     | partly       |                                                                                                                        |
| Accuracy      | 1A2f   | 2021                | Move CO emission calculation to a higher tier         | DE-1A2f-2021-0003    | Yes          |                                                                                                                        |

## NECD 2020

| Aspect  | Sector | First identified in | Finding summary                                      | Observation          | Implemented? | Comment |
|---------|--------|---------------------|------------------------------------------------------|----------------------|--------------|---------|
| General | LPS    | 2020                | Improve consistency with the latest ePRTR reporting. | DE-LPS-GEN-2020-0002 | Yes          |         |

| Aspect                 | Sector  | First identified in | Finding summary                                                                                                 | Observation          | Implemented? | Comment                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------|---------|---------------------|-----------------------------------------------------------------------------------------------------------------|----------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (lack of) Transparency | 3I      | 2020                | Improve the transparency of the calculations used for NO emissions from storage of digestate from energy crops. | DE-3I-2020-0001      | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 2C7a    | 2020                | Improve Transparency for Cd and Pb emissions from copper production                                             | DE-2C7a-2020-0001    | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | LPS     | 2020                | Reallocate livestock emissions from GNFR L_AgriOther to K_AgriLivestock                                         | DE-LPS-K-2020-0001   | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Consistency            | 1A4cii  | 2018                | IEF Cd trend since 2007 erratic                                                                                 | DE-1A4cii-2018-0001  | Partly       | As described in the relevant IIR chapter activity data for maritime navigation including fishing is estimated bottom-up in a country-specific model and based on ship movement data. From that perspective jumps in fuel consumption cannot be explained by errors in statistics but are assumed to represent reality in respect to the amounts of fuels used by fishing vessels operating from German harbours. |
|                        | 1A4ciii | 2018                | Large increase in AD from 2015 to 2016                                                                          | DE-1A4ciii-2018-0001 | No           | Metal and PCDD/F emissions are not considered as fugitive. If IE would be used nevertheless one can assume there are such fugitives. Germany suggest to keep the notation key NA.                                                                                                                                                                                                                                |

| Aspect       | Sector | First identified in | Finding summary                                                                    | Observation                       | Implemented? | Comment                                                                                                      |
|--------------|--------|---------------------|------------------------------------------------------------------------------------|-----------------------------------|--------------|--------------------------------------------------------------------------------------------------------------|
| Completeness | 2B6    | 2017                | Include the NOx emissions in the next submission.                                  | DE-2B6-2017-0001;DE-2B6-2018-0001 | Yes          |                                                                                                              |
|              | 2D3g   | 2018                | Report PAHs from 2D3g Chemical Products                                            | DE-2D3g-2018-0001                 | Yes          |                                                                                                              |
|              | 2C1    | 2018                | Potential under-estimate of emissions of HCB                                       | DE-2C1-2018-0001                  | Yes          | Implemented in submission 2021 using the default emission factor from the 2019 EMEP/EEA Guidebook.           |
|              | 5D2    | 2019                | NMVOC emissions missing although default EFs exist                                 | DE-5D2-2019-0001                  | Yes          | Industrial wastewater NMVOC emissions were implemented and are part of the 2021 reporting.                   |
|              | 2D3a   | 2019                | Emissions of Hg not estimated                                                      | DE-2D3a-2019-0001                 | Yes          |                                                                                                              |
|              | LPS    | 2020                | Add missing pollutants PAHs PCBs PM2.5                                             | DE-LPS-GEN-2020-0001              | Yes          | Since these pollutants are not in the ePRTR dataset Germany cannot report them.                              |
|              | GRID   | 2020                | Add gridded emissions of Cd Pb Hg PCDD/F PAHs HCB PCBs to reporting                | DE-GRID-GEN-2020-0001             | Yes          |                                                                                                              |
| Accuracy     | 2D3a   | 2018                | Rationale for not estimating emissions in category 2D3a and notation key selection | DE-2D3a-2018-0001                 | Yes          | Germany is in the process of evaluating data to calculate emissions of Hg from the use of fluorescent tubes. |
|              | LPS    | 2020                | Check emission data for facility "Heyne & Penke Verpackungen GmbH"                 | DE-LPS-E-2020-0001                | Yes          |                                                                                                              |

| Aspect | Sector | First identified in | Finding summary                                                           | Observation          | Implemented? | Comment                                                                                                                                                                                                                                                    |
|--------|--------|---------------------|---------------------------------------------------------------------------|----------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| QA/QC  | LPS    | 2020                | Improve coordinates given check for collisions                            | DE-LPS-GEN-2020-0004 | No           |                                                                                                                                                                                                                                                            |
|        | LPS    | 2020                | Make sure each point source reported has unique key build from attributes | DE-LPS-GEN-2020-0003 | No           | Germany checked this issue and does not see any reason to change the data. It is unclear why LPS name GNFR and stack height should function as a key alternative in particular because the table already provides the ePRTR ID as an unique and valid key. |

## NECD 2019

| Aspect                 | Sector  | First identified in | Finding summary                                                                                                                                                           | Observation                       | Implemented? | Comment                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------|---------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (lack of) Transparency | 1A1     | 2017                | Presents its NH3 EF for stationary combustion in the next submission of its IIR justify the use of these and compare these against the values in 2016 EMEP/EEA Guidebook. | DE-1A1-2017-0001;DE-1A1-2018-0001 | Yes          | A comparison with default values is not possible.                                                                                                                                                                                                                                                                                                                                                                |
| Consistency            | 1A4cii  | 2018                | IEF Cd trend since 2007 erratic                                                                                                                                           | DE-1A4cii-2018-0001               | Partly       | As the National Energy Balances 2003 to 2020 have been revised by the Working Group on Energy Balances (AGEB) in advance of the 2024 submission this erratic trend has been resolved.                                                                                                                                                                                                                            |
|                        | 1A4ciii | 2018                | Large increase in AD from 2015 to 2016                                                                                                                                    | DE-1A4ciii-2018-0001              | No           | As described in the relevant IIR chapter activity data for maritime navigation including fishing is estimated bottom-up in a country-specific model and based on ship movement data. From that perspective jumps in fuel consumption cannot be explained by errors in statistics but are assumed to represent reality in respect to the amounts of fuels used by fishing vessels operating from German harbours. |
|                        | 1A4bii  | 2019                | Significant fluctuations in fuel consumption over the time series                                                                                                         | DE-1A4bii-2019-0001               | Yes          | As the National Energy Balances 2003 to 2020 have been revised by the Working Group on Energy Balances (AGEB) in advance of the 2024 submission this erratic trend has been resolved.                                                                                                                                                                                                                            |

| Aspect        | Sector | First identified in | Finding summary                                                                                                                                                       | Observation                         | Implemented? | Comment                                                                                                                                                                                                                                                                                                  |
|---------------|--------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Completeness  | 2B3    | 2017                | Include the NOx emissions in the next submission preferably using a country specific method to account for the specific technologies and abatement equipment applied. | DE-2B3-2017-0001;DE-2B3-2018-0001   | Yes          |                                                                                                                                                                                                                                                                                                          |
|               | 2B6    | 2017                | Include the NOx emissions in the next submission.                                                                                                                     | DE-2B6-2017-0001;DE-2B6-2018-0001   | Yes          |                                                                                                                                                                                                                                                                                                          |
|               | 5A     | 2017                | Include NMVOC and PM2.5 emissions from 5A in its next submission.                                                                                                     | DE-5A-2017-0001;DE-5A-2018-0001     | Yes          | Implemented in 2020 reporting. Although only the reporting of NMVOC and PM2.5 emissions was requested Germany decided to additionally report PM10 and TSP.                                                                                                                                               |
|               | 2D3g   | 2018                | Report PAHs from 2D3g Chemical Products                                                                                                                               | DE-2D3g-2018-0001                   | Yes          |                                                                                                                                                                                                                                                                                                          |
|               | 2C1    | 2018                | Potential under-estimate of emissions of HCB                                                                                                                          | DE-2C1-2018-0001                    | Yes          | Implemented in submission 2021 using the default emission factor from the 2019 EMEP/EEA Guidebook.                                                                                                                                                                                                       |
|               | 5D2    | 2019                | NMVOC emissions missing although default EFs exist                                                                                                                    | DE-5D2-2019-0001                    | Yes          | Industrial wastewater NMVOC emissions were implemented and are part of the 2021 reporting.                                                                                                                                                                                                               |
|               | 1A2a   | 2019                | NE reported for Cadmium although a default EF is available                                                                                                            | DE-1A2a-2019-0001                   | Yes          |                                                                                                                                                                                                                                                                                                          |
|               | 1A2b   | 2019                | NE reported for some pollutants although default EFs are available                                                                                                    | DE-1A2b-2019-0002                   | Yes          |                                                                                                                                                                                                                                                                                                          |
|               | 1A2b   | 2019                | NA is reported for HCB 1990                                                                                                                                           | DE-1A2b-2019-0001                   | Yes          | Germany carefully checked all possible additional sources for HCB in this sector. This includes the BREF documents as well as other literature. There was no indication for any missing emission found. The emission factors in the Guidebook are only applicable to processes not occurring in Germany. |
|               | 1A3b   | 2019                | PCB emissions missing for all years although default emission factors are available                                                                                   | DE-1A3b-2019-0001                   | Yes          | Emissions calculated based on default EF                                                                                                                                                                                                                                                                 |
|               | 1A3c   | 2019                | Update notation key from NE to NA                                                                                                                                     | DE-1A3c-2019-0001                   | Yes          |                                                                                                                                                                                                                                                                                                          |
|               | 2D3a   | 2019                | Emissions of Hg not estimated                                                                                                                                         | DE-2D3a-2019-0001                   | Yes          |                                                                                                                                                                                                                                                                                                          |
|               | 5C2    | 2019                | Emission are not estimated for PCDD/F Pb and Cd although default EFs are available                                                                                    | DE-5C2-2019-0001                    | Yes          | Default-EF used emissions reported.                                                                                                                                                                                                                                                                      |
| Comparability | 1A4ai  | 2019                | Implied EFs PAHs and PCDD/F are outliers compared to other member states                                                                                              | DE-1A4ai-2019-0001                  | No           |                                                                                                                                                                                                                                                                                                          |
| Accuracy      | 1A1a   | 2017                | Include the revised estimate of activity data and emissions for biogas in its next submission.                                                                        | DE-1A1a-2017-0003;DE-1A1a-2018-0001 | Partly       | Implemented in 2020 submission                                                                                                                                                                                                                                                                           |
|               | 2D3a   | 2018                | Rationale for not estimating emissions in category 2D3a and notation key selection                                                                                    | DE-2D3a-2018-0001                   | Yes          | Germany is in the process of evaluating data to calculate emissions of Hg from the use of fluorescent tubes.                                                                                                                                                                                             |
|               | 3B     | 2019                | Tier 1 method used for key category                                                                                                                                   | DE-3B-2019-0001                     | Yes          | Implemented in 2020 reporting                                                                                                                                                                                                                                                                            |

| Aspect                 | Sector  | First identified in | Finding summary                                                                                                                                                           | Observation                                            | Implemented? | Comment                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------|---------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (lack of) Transparency | 1A1     | 2017                | Presents its NH3 EF for stationary combustion in the next submission of its IIR justify the use of these and compare these against the values in 2016 EMEP/EEA Guidebook. | DE-1A1-2017-0001;DE-1A1-2018-0001                      | Yes          | A comparison with default values is not possible.                                                                                                                                                                                                                                                                                                                                                                |
|                        | 1A1b    | 2014                | Include the country specific EFs for combustion in refineries in the relating chapter of its IIR to improve transparency.                                                 | § 55 (CLRTAP 2014);DE-1A1b-2017-0001;DE-1A1b-2018-0001 | Yes          | The emission factors continue to be under revision. New emission factors will be included in the IIR following the use of results of a finished project.                                                                                                                                                                                                                                                         |
|                        | 2D3d    | 2017                | Include explanation on recalculation to 1994 in the next submission.                                                                                                      | DE-2D3d-2017-0001;DE-2D3d-2018-0001                    | Yes          | Was reported with the submission 2019.                                                                                                                                                                                                                                                                                                                                                                           |
|                        | 1A3bi   | 2018                | Incorrect notation keys for activity data                                                                                                                                 | DE-1A3bi-2018-0002                                     | Yes          | notation keys replaced by activity data values                                                                                                                                                                                                                                                                                                                                                                   |
|                        | 1A3bv   | 2018                | Incorrect notation keys for HCB and PCB emissions                                                                                                                         | DE-1A3bv-2018-0001                                     | Yes          | 'NE' replaced by 'NA' as suggested by the TERT                                                                                                                                                                                                                                                                                                                                                                   |
| Consistency            | 1A4cii  | 2018                | IEF Cd trend since 2007 erratic                                                                                                                                           | DE-1A4cii-2018-0001                                    | Partly       | As the National Energy Balances 2003 to 2020 have been revised by the Working Group on Energy Balances (AGEB) in advance of the 2024 submission this erratic trend has been resolved.                                                                                                                                                                                                                            |
|                        | 1A4ciii | 2018                | Large increase in AD from 2015 to 2016                                                                                                                                    | DE-1A4ciii-2018-0001                                   | No           | As described in the relevant IIR chapter activity data for maritime navigation including fishing is estimated bottom-up in a country-specific model and based on ship movement data. From that perspective jumps in fuel consumption cannot be explained by errors in statistics but are assumed to represent reality in respect to the amounts of fuels used by fishing vessels operating from German harbours. |
|                        | 1A4cii  | 2018                | Inconsistent AD values NFR vs. IIR                                                                                                                                        | DE-1A4cii-2018-0001                                    | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |

| Aspect        | Sector | First identified in | Finding summary                                                                                                                                                                                       | Observation                         | Implemented? | Comment                                                                                                                                                                                                                                                                                           |
|---------------|--------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Completeness  | 2B3    | 2017                | Include the NOx emissions in the next submission preferably using a country specific method to account for the specific technologies and abatement equipment applied.                                 | DE-2B3-2017-0001;DE-2B3-2018-0001   | Yes          |                                                                                                                                                                                                                                                                                                   |
|               | 2B6    | 2017                | Include the NOx emissions in the next submission.                                                                                                                                                     | DE-2B6-2017-0001;DE-2B6-2018-0001   | Yes          |                                                                                                                                                                                                                                                                                                   |
|               | 2C3    | 2017                | Include NOx from aluminium production in the next submission to improve completeness and comparability.                                                                                               | DE-2C3-2017-0001;DE-2C3-2018-0002   | Yes          | Germany carefully assessed the situation regarding this issue and concluded that no substantial NOx emission are to be expected from this source. But in order to avoid an underestimation Germany implemented the default EF of the emission guidebook 2019.                                     |
|               | 5A     | 2017                | Include NMVOC and PM2.5 emissions from 5A in its next submission.                                                                                                                                     | DE-5A-2017-0001;DE-5A-2018-0001     | Yes          | Implemented in 2020 reporting. Although only the reporting of NMVOC and PM2.5 emissions was requested Germany decided to additionally report PM10 and TSP.                                                                                                                                        |
|               | 5D     | 2017                | Include the estimation of NMVOC emissions from wastewater treatment plant in its next submission.                                                                                                     | DE-5D-2017-0001;DE-5D-2018-0001     | Yes          |                                                                                                                                                                                                                                                                                                   |
|               | 2D3g   | 2018                | Report PAHs from 2D3g Chemical Products                                                                                                                                                               | DE-2D3g-2018-0001                   | Yes          |                                                                                                                                                                                                                                                                                                   |
|               | 1B2aiv | 2018                | Potential under-estimate of emissions of Hg Cd PCDD/F                                                                                                                                                 | DE-1B2aiv-2018-0001                 | Yes          | Metal and PCDD/F emissions are not considered as fugitive. If IE would be used nevertheless one can assume there are such fugitives. Germany suggest to keep the notation key NA.                                                                                                                 |
|               | 2C1    | 2018                | Potential under-estimate of emissions of HCB                                                                                                                                                          | DE-2C1-2018-0001                    | Yes          | Data acquisition for the resolution of this issue will be implemented in the framework of a research project updating several emission factors. The effort is scheduled to start in 2021 and will take about 3 years. Until then the default emission factor from the EMEP/EEA Guidebook is used. |
|               | 2C3    | 2018                | Potential under-estimate of emissions of HCB                                                                                                                                                          | DE-2C3-2018-0001                    | Yes          | Implemented in submission 2019 using the default emission factor of the 2016 EMEP/EEA Guidebook                                                                                                                                                                                                   |
| Comparability | 5C     | 2018                | Hg EF is 100 times smaller than the default value proposed in the 2016 EMEP/EEA Guidebook and the Cd and Pb EF are 1000 times smaller than the default values proposed in the 2016 EMEP/EEA Guidebook | DE-5-2018-0001                      | No           | References to research Projects of CS-EF added                                                                                                                                                                                                                                                    |
| Accuracy      | 1A1a   | 2017                | Include the revised estimate of activity data and emissions for biogas in its next submission.                                                                                                        | DE-1A1a-2017-0003;DE-1A1a-2018-0001 | Partly       | Implemented in 2020 submission                                                                                                                                                                                                                                                                    |
|               | 2D3a   | 2018                | Rationale for not estimating emissions in category 2D3a and notation key selection                                                                                                                    | DE-2D3a-2018-0001                   | Yes          | Germany is in the process of evaluating data to calculate emissions of Hg from the use of fluorescent tubes.                                                                                                                                                                                      |

## NECD 2017

| Aspect                 | Sector   | First identified in | Finding summary                                                                                                                                                                                                                                                                                  | Observation                                            | Implemented? | Comment                                                                                                                                                                                                                                                       |
|------------------------|----------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (lack of) Transparency | 1A1      | 2017                | Presents its NH3 EF for stationary combustion in the next submission of its IIR justify the use of these and compare these against the values in 2016 EMEP/EEA Guidebook.                                                                                                                        | DE-1A1-2017-0001;DE-1A1-2018-0001                      | Yes          | A comparison with default values is not possible.                                                                                                                                                                                                             |
|                        | 1A1a     | 2017                | Improves the transparency of its IIR regarding PM2.5 shares used for each fuel (solid fuels (coal and lignite) and gaseous fuels but also biomass if relevant).                                                                                                                                  | DE-1A1a-2017-0001                                      | No           |                                                                                                                                                                                                                                                               |
|                        | 1A1b     | 2014                | Include the country specific EFs for combustion in refineries in the relating chapter of its IIR to improve transparency.                                                                                                                                                                        | § 55 (CLRTAP 2014);DE-1A1b-2017-0001;DE-1A1b-2018-0001 | Yes          | The emission factors continue to be under revision. New emission factors will be included in the IIR following the use of results of a finished project.                                                                                                      |
|                        | 1A2gviii | 2017                | Improve the transparency of the IIR to explain its assumptions on the PM2.5 fraction used for each fuel and particularly for liquid fuels biomass and other fuels.                                                                                                                               | DE-1A2gviii-2017-0001                                  | Yes          |                                                                                                                                                                                                                                                               |
|                        | 2A1      | 2017                | Include the explanation and rationale for using two sets of activity data to be included in the IIR for the next submission.                                                                                                                                                                     | DE-2A1-2017-0001                                       | Yes          |                                                                                                                                                                                                                                                               |
|                        | 2C       | 2017                | Update the SO2 emission factors for 2C5 2C6 and 2C7a for the next submission to reflect the individual production activities and to include more transparent information on primary vs. secondary production of lead zinc and copper in the IIR.                                                 | DE-2C-2017-0001                                        | Yes          |                                                                                                                                                                                                                                                               |
|                        | 2D3d     | 2017                | Include explanation on recalculation to 1994 in the next submission.                                                                                                                                                                                                                             | DE-2D3d-2017-0001;DE-2D3d-2018-0001                    | Yes          | Was reported with the submission 2019.                                                                                                                                                                                                                        |
|                        | 3B       | 2017                | Include the information for the proportional of NO-N and N2 and the reference in the IIR to improve transparency.                                                                                                                                                                                | DE-3B-2017-0002                                        | Yes          |                                                                                                                                                                                                                                                               |
|                        | 3B2      | 2017                | Mention that NFR 3B2 includes lambs and also explain the lower EF NMVOC used for lambs. Furthermore the TERT recommend that Germany in IIR mentioned that pullets are included in NFR 3B4giv other poultry.                                                                                      | DE-3B2-2017-0004                                       | Yes          |                                                                                                                                                                                                                                                               |
| Consistency            | 3F       | 2017                | Include more information in the IIR for the next submission referring to the specific law and clarifying from which year the ban came into force. Furthermore it is recommended to inform whether there are derogations for field burning under certain circumstances or for certain crop types. | DE-3F-2017-0001                                        | Yes          |                                                                                                                                                                                                                                                               |
|                        | 1A2      | 2017                | Use the right notation keys in the NFR tables for its next submissions. (1A2 Stationary Combustion in Manufacturing Industries and Construction PM2.5 2005-2015)                                                                                                                                 | DE-1A2-2017-0001                                       | Yes          |                                                                                                                                                                                                                                                               |
| Completeness           | 5E       | 2010                | Although the Guidebook has methods for car and house fires in Chapter 6 it may be more transparent to include these in Chapter 7 as Chapter 6D is more focused on compost and sludge. The ERT encourages Germany to consider including some of these emissions in the next submissions.          | § 116 (CLRTAP 2010);§139 (CLRTAP 2014);DE-5A-2017-0003 | Partly       |                                                                                                                                                                                                                                                               |
|                        | 2B10a    | 2017                | Investigate whether flaring occurs in relation to carbide production e.g. by contacting the single producer of carbide.                                                                                                                                                                          | DE-2B10a-2017-0002                                     | Yes          | Flaring is a common destruction technic in chemical industry. But no information exists to assign flaring quantities to a single installation.                                                                                                                |
|                        | 2B3      | 2017                | Include the NOx emissions in the next submission preferably using a country specific method to account for the specific technologies and abatement equipment applied.                                                                                                                            | DE-2B3-2017-0001;DE-2B3-2018-0001                      | Yes          |                                                                                                                                                                                                                                                               |
|                        | 2B6      | 2017                | Include the NOx emissions in the next submission.                                                                                                                                                                                                                                                | DE-2B6-2017-0001;DE-2B6-2018-0001                      | Yes          |                                                                                                                                                                                                                                                               |
|                        | 2C3      | 2017                | Include NOx from aluminium production in the next submission to improve completeness and comparability.                                                                                                                                                                                          | DE-2C3-2017-0001;DE-2C3-2018-0002                      | Yes          | Germany carefully assessed the situation regarding this issue and concluded that no substantial NOx emission are to be expected from this source. But in order to avoid an underestimation Germany implemented the default EF of the emission guidebook 2019. |
|                        | 3D1bii   | 2017                | Include the emission from sewage sludge applied to agricultural soils in the next submission.                                                                                                                                                                                                    | DE-3Da2b-2017-0001                                     | Yes          |                                                                                                                                                                                                                                                               |
|                        | 5A       | 2017                | Include NMVOC and PM2.5 emissions from 5A in its next submission.                                                                                                                                                                                                                                | DE-5A-2017-0001;DE-5A-2018-0001                        | Yes          | Implemented in 2020 reporting. Although only the reporting of NMVOC and PM2.5 emissions was requested Germany decided to additionally report PM10 and TSP.                                                                                                    |
|                        | 5D       | 2017                | Include the estimation of NMVOC emissions from wastewater treatment plant in its next submission.                                                                                                                                                                                                | DE-5D-2017-0001;DE-5D-2018-0001                        | Yes          |                                                                                                                                                                                                                                                               |



| Aspect        | Sector | First identified in | Finding summary                                                                                                | Observation                         | Implemented? | Comment                        |
|---------------|--------|---------------------|----------------------------------------------------------------------------------------------------------------|-------------------------------------|--------------|--------------------------------|
| Comparability | 3D1a   | 2017                | Use the updated emission factors available in the 2016 EMEP/EEA Guidebook (Table 3.2) for the next submission. | DE-3Da1-2017-0001                   | Yes          |                                |
| Accuracy      | 1A1a   | 2017                | Include the revised estimate of activity data and emissions for biogas in its next submission.                 | DE-1A1a-2017-0003;DE-1A1a-2018-0001 | Partly       | Implemented in 2020 submission |

## CLRTAP 2014

| Aspect                 | Sector   | First identified in | Finding summary                                                                                                                                                                                                                                              | Observation                                            | Implemented? | Comment                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------------------|----------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| General                |          | 2010                | Provide a PDF version of the IIR for offline use and to better facilitate the review process                                                                                                                                                                 | § 6 9 11 28 (CLRTAP 2010);§ 17 (CLRTAP 2014)           | Yes          | The German IIR is basically created in the form and structure of a wiki and is published as such. A parallel publication in the form of a continuous text document is currently not planned. However the inventory compiler routinely creates a PDF copy of the finished report particularly for documentation purposes - which can be made available upon request and if necessary for example during a review. |
|                        |          | 2014                | Use the results of the KCA to prioritise improvements in the inventory                                                                                                                                                                                       | § 14 (CLRTAP 2014)                                     | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
| (lack of) Transparency | 3B       | 2014                | Explain the variation in activity data for goats in the IIR.                                                                                                                                                                                                 | § 120 (CLRTAP 2014)                                    | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 2D3      | 2014                | The methodology described in the IIR for solvent and other product use is found to be not transparent. Provide detail on all 37 subcategories including activity data and emission factors.                                                                  | § 18 96 97 98 (CLRTAP 2014)                            | Yes          | The transparency for the solvents used and products used sector in the IIR was much improved in the submission 2016.                                                                                                                                                                                                                                                                                             |
|                        |          | 2010                | Inaccuracies were found in the use of notation keys and it is recommended to justify the use of notation keys in the IIR for each particular sector.                                                                                                         | § 38 (CLRTAP 2010);§ 19 (CLRTAP 2014)                  | Yes          | Information tables for NE & IE were added to the completeness chapter of the current IIR.                                                                                                                                                                                                                                                                                                                        |
|                        |          | 2014                | Provide more detailed to explain emission trends e.g. annual fluctuations and discontinuities of emissions.                                                                                                                                                  | § 21 78 (CLRTAP 2014)                                  | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        |          | 2014                | Extend the use of a bibliography for some subsectors to all sectors in the IIR.                                                                                                                                                                              | § 77 (CLRTAP 2014)                                     | No           | The amount of recurring references is very small within most source categories. And the total number of references per page is usually quite low. So directly linking to the documents seems like a good way to make sources available to the readers.                                                                                                                                                           |
|                        | 1A1b     | 2014                | Include the country specific EFs for combustion in refineries in the relating chapter of its IIR to improve transparency.                                                                                                                                    | § 55 (CLRTAP 2014);DE-1A1b-2017-0001;DE-1A1b-2018-0001 | Yes          | The emission factors continue to be under revision. New emission factors will be included in the IIR following the use of results of a finished project.                                                                                                                                                                                                                                                         |
|                        | 1A3b     | 2010                | Explain in more detail the emission calculation for road transport not only by saying that HBEFA and TREMOD are used but giving more information including an overview of emission factors in the next versions of the IIR.                                  | § 65 (CLRTAP 2010);§ 72 (CLRTAP 2014)                  | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 1B2d     | 2014                | Report in the IIR on what basis emissions from geothermal energy extraction are considered negligible.                                                                                                                                                       | § 59 (CLRTAP 2014)                                     | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 3B       | 2014                | Provide additional information in the IIR especially related to: TAN contents distributions of housing and storage facilities (e.g. for the first and last reporting year) slurry storage systems and the spreading systems applied corresponding EFs.       | § 117 (CLRTAP 2014)                                    | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 5A\5B\5C | 2010                | Since all incineration is reported under energy add information about the methodology used for different types of waste incineration under NFR 1. In NFR 6C use the notation key "IE" instead of "NO" and to explain the use of the notation key in the IIR. | § 103 110 111 112 (CLRTAP 2010);§ 136 (CLRTAP 2014)    | Yes          | Information on methods used for estimation of energy-related is reported in NFR 1. Germany considers NO to be correct and explains the situation in its IIR. Cremation estimation is explained now.                                                                                                                                                                                                              |

| Aspect      | Sector  | First identified in | Finding summary                                                                                                                                                                                                                                                               | Observation                            | Implemented? | Comment                                                                                                                                                                                                                                                         |
|-------------|---------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Consistency | 2       | 2014                | Ensure time series consistency of TSP emissions between 1990 and later years and clearly explain in the IIR where and why consistent reporting is not possible.                                                                                                               | § 80 (CLRTAP 2014)                     | Yes          |                                                                                                                                                                                                                                                                 |
|             | 1A1\1A2 | 2010                | In the IIR in the "Short description" for 1A1 and 1A2 Germany presents a tier 2 or 3 approach. However during the review Germany indicated that only the tier 2 approach was used. This needs correction in the IIR (was agreed by Germany to do this)                        | § 47 (CLRTAP 2010); § 54 (CLRTAP 2014) | Yes          |                                                                                                                                                                                                                                                                 |
|             | 2A1\2A2 | 2014                | A time series inconsistency is found which relates to a different reporting structure before 2000. It is recommended to explore the feasibility of harmonizing the methodology.                                                                                               | § 93 (CLRTAP 2014)                     | Yes          |                                                                                                                                                                                                                                                                 |
|             | 2D3     | 2014                | Provide emissions for 1990-2005 at a disaggregated level similar to later years if possible. If not explain why for the earlier period emissions have been estimated at a more aggregated level. Also clearly document in the case of IE where emissions have been allocated. | § 100 101 (CLRTAP 2014)                | Yes          | The manufacturing industry was the most important branch of the GDR economy. The transformation of the markets and the disappearance of large state-owned enterprises in the course of the German unity led to a dramatic change in the eastern part of Germany |
|             | 3B      | 2014                | The ERT encourages Germany to further improve the consistency of the time series of NH3 for manure management. In chapter 4 of the EMEP/EEA Guidebook 2013 specific methods are provided.                                                                                     | § 110 (CLRTAP 2014)                    | Yes          |                                                                                                                                                                                                                                                                 |
|             | 3B      | 2014                | Sheep animal numbers show a step change due to a different reporting time. This should be corrected for and described in the IIR as appropriate.                                                                                                                              | § 119 (CLRTAP 2014)                    | Yes          |                                                                                                                                                                                                                                                                 |
|             | 3B      | 2014                | Check and explain the variation in activity data for horses in the IIR.                                                                                                                                                                                                       | § 121 (CLRTAP 2014)                    | Yes          |                                                                                                                                                                                                                                                                 |
|             | 3B      | 2014                | Explain how the change in farm practices or the implementation of mitigation measures has affected the time series in the IIR in order to facilitate the assessment of emission trends.                                                                                       | § 111 (CLRTAP 2014)                    | Yes          |                                                                                                                                                                                                                                                                 |
|             | 3B      | 2014                | Explain in the IIR why the NH3 EF for dairy cattle decreased from 2011 to 2012.                                                                                                                                                                                               | § 122 (CLRTAP 2014)                    | Yes          |                                                                                                                                                                                                                                                                 |
|             | 3B      | 2014                | Explain in the IIR why the NH3 EF for swine decreased from 1993 to 1994.                                                                                                                                                                                                      | § 123 (CLRTAP 2014)                    | Yes          |                                                                                                                                                                                                                                                                 |
|             | 3B      | 2014                | Explain in the IIR why the NH3 EF significant changes for different poultry subsectors in the 2000s.                                                                                                                                                                          | § 124 (CLRTAP 2014)                    | No           |                                                                                                                                                                                                                                                                 |

| Aspect        | Sector              | First identified in | Finding summary                                                                                                                                                                                                                                                                                        | Observation                                            | Implemented? | Comment                                                                                                                                                                                                 |
|---------------|---------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Completeness  |                     | 2010                | Emissions prior to 1990 are not reported.                                                                                                                                                                                                                                                              | § 27 (CLRTAP 2010);§ 24 (CLRTAP 2014)                  | Yes          | Little information is available due to the split of Germany into two nations. Some overview data has been added to the IIR.                                                                             |
|               |                     | 2014                | LPS data were not reported.                                                                                                                                                                                                                                                                            | § 10 (CLRTAP 2014)                                     | Yes          |                                                                                                                                                                                                         |
|               |                     | 2014                | A key category analysis (KCA) was missing for the base years (1990 or 2000 for PM) of the pollutants.                                                                                                                                                                                                  | § 13 (CLRTAP 2014)                                     | Yes          |                                                                                                                                                                                                         |
|               | 5E                  | 2010                | Although the Guidebook has methods for car and house fires in Chapter 6 it may be more transparent to include these in Chapter 7 as Chapter 6D is more focused on compost and sludge. The ERT encourages Germany to consider including some of these emissions in the next submissions.                | § 116 (CLRTAP 2010);§139 (CLRTAP 2014);DE-SA-2017-0003 | Partly       |                                                                                                                                                                                                         |
|               | 1A4a\1A4c\1A5a      | 2014                | HM and POP currently not reported since no consistent dataset is available (partly country specific partly Guidebook). The recommendation is to describe the issue in the IIR and until it is solved use the Guidebook emission factors despite their recognized uncertainty rather than reporting NE. | § 57 (CLRTAP 2014)                                     | Yes          | Implemented for 1A4ai and 1A4ci                                                                                                                                                                         |
|               | 1A3ai(i)\1A3aii(i)  | 2014                | Heavy metal emissions are currently not estimated. The ERT recommends that the Party estimates these emissions using the methodology in the EMEP/EEA Guidebook.                                                                                                                                        | § 62 (CLRTAP 2014)                                     | Yes          |                                                                                                                                                                                                         |
|               | 1A3biv\1A4bii       | 2014                | PM10 and PM2.5 emissions are reported as "NE". The ERT recommends that Germany completes the inventory by estimating these emissions.                                                                                                                                                                  | § 63 (CLRTAP 2014)                                     | Yes          |                                                                                                                                                                                                         |
|               | 1A3bv               | 2014                | Evaporative emissions from running losses (i.e. vapour generated in the fuel tank during vehicle operation) were missing because not considered in the TREMOD model. The ERT recommends to include these in the inventory.                                                                             | § 73 (CLRTAP 2014)                                     | Yes          | This issue has not yet been looked into as other model revisions especially regarding a follow-up of 'diesel gate' appear much more relevant tying up all resources.                                    |
|               | 1A3dii              | 2014                | Pb and Hg emissions are currently not estimated. The ERT recommends that the Party considers the emission factors available in the Guidebook.                                                                                                                                                          | § 64 (CLRTAP 2014)                                     | Yes          |                                                                                                                                                                                                         |
|               | 5A\5D               | 2014                | Improves the completeness of the inventory by estimating emissions from solid waste disposal and wastewater handling.                                                                                                                                                                                  | § 127 (CLRTAP 2014)                                    | Yes          | Solid waste emissions implemented since 2020 reporting. Domestic wastewater emissions implemented since 2018 reporting. Industrial wastewater emissions implemented since 2021 reporting.               |
|               | 5A\5C\5D            | 2010                | The inventory regarding Waste is currently not complete with missing estimates for several source categories.                                                                                                                                                                                          | § 102 (CLRTAP 2010);§ 134 135 (CLRTAP 2014)            | Yes          | Industrial wastewater emissions implemented since 2021 reporting. Solid waste emissions implemented since 2020 reporting. Domestic wastewater emissions implemented since 2018 reporting. 5.C completed |
| Comparability | 1A4bii\1A4cii       | 2014                | Implied NOx emission factors are at the high end of the range when compared with a selected group of countries (AT BE DK ES FI FR GB IE IT NL NO). The ERT recommends that the Party reviews the emission factors for these two sources and includes an explanation for this issue in the IIR.         | § 66 (CLRTAP 2014)                                     | Yes          | This minor issue has not yet been checked. The inventory compiler will look into this as soon as resources allow.                                                                                       |
|               | 1A2a\1A4a\1A4c\1A5a | 2014                | Notation key NE is used for (many) heavy metals despite the availability of EFs in the EMEP/EEA Guidebook. If all HM emissions from iron & steel are reported in 2C1 the notation key should be IE.                                                                                                    | § 56 (CLRTAP 2014)                                     | Yes          | Implemented for 1A4ai and 1A4ci                                                                                                                                                                         |

| Aspect   | Sector      | First identified in | Finding summary                                                                                                                                                                                                                                                                                                                   | Observation                                               | Implemented? | Comment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------|-------------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Accuracy |             | 2010                | Implement a (qualitative and quantitative) uncertainty analysis and use the results to prioritize improvements to the inventory                                                                                                                                                                                                   | § 20 24 (CLRTAP 2010);§ 32 44e 85 (CLRTAP 2014)           | Partly       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|          |             | 2014                | Include a chapter in the IIR with for each source category the foreseen improvements for the inventory                                                                                                                                                                                                                            | § 34 (CLRTAP 2014)                                        | Partly       | Included for most categories                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|          | 1A3bvi      | 2014                | This source is a key category for Pb and the ERT has noted that the emission factor for brake wear used by Germany was higher than the maximum range quoted by the 2013 Guidebook. Germany is recommended to review the EF explain where it is coming from in the IIR and potentially revise to bring in line with the Guidebook. | § 74 (CLRTAP 2014)                                        | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|          | 1A3dii\1A5b | 2014                | Review the methodology for national navigation by distinguishing between coastal and inland shipping based on an ongoing research project as well as explicitly include emissions from military activities.                                                                                                                       | § 75 76 (CLRTAP 2014)                                     | Yes          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|          | 2A1         | 2010                | Cement production is a key source for Hg HCB and for NOx PM10 and PAH but Tier 1 is used. The ERT encourages Germany to use plant-specific data collected as part of the LCPD IPPC and E-PRTR to develop a tier 2 or 3 methodology in the near future and to document these in its IIR.                                           | § 79 (CLRTAP 2010);§ 88 (CLRTAP 2014)                     | Yes          | plant-specific data approach is not planned                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|          | 2D3         | 2014                | Increase the use of information from individual installations that make a high contribution to the key categories such as car assembly sites and big printing installations.                                                                                                                                                      | § 104 (CLRTAP 2014)                                       | Yes          | Emissions caused by the use of solvents and solvent-based products are reported in the relevant source groups. In our methodology we also include the application of solvent-based products in large installations such as those used in automotive series production or large printing systems. The emission data of defined individual plants are thus included in the calculation but cannot be shown and published individually for reasons of confidentiality and data protection. |
|          | 3B          | 2014                | Describe the efforts taken to verify / validate the emission model in the IIR.                                                                                                                                                                                                                                                    | § 118 (CLRTAP 2014)                                       | No           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| QA/QC    |             | 2010                | Fully implement the QA/QC system for the air pollutant emission inventory. If possible implement a unified QA/QC system for reporting to CLRTAP and UNFCCC.                                                                                                                                                                       | § 21 24 62 74 88 105 (CLRTAP 2010);§ 37 44f (CLRTAP 2014) | No           | Ongoing discussion                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|          |             | 2010                | Widen the use of the existing QA/QC system used for the set of activity data as well as the methods and emission factors for GHGs for the needs of CLRTAP/NECD inventories and providing further details on its implementation in the IIR (general and sectoral descriptions).                                                    | § 33 40 (CLRTAP 2010);§ 16 69 84 87 103 105 (CLRTAP 2014) | No           | Ongoing discussion                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|          |             | 2014                | Include information on verification and validation of the inventory in the IIR.                                                                                                                                                                                                                                                   | § 38 (CLRTAP 2014)                                        | Yes          | Ongoing discussion                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

## CLRTAP 2010

| Aspect  | Sector | First identified in | Finding summary                                                                              | Observation                                 | Implemented? | Comment                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------|--------|---------------------|----------------------------------------------------------------------------------------------|---------------------------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| General |        | 2010                | Provide a PDF version of the IIR for offline use and to better facilitate the review process | § 6 9 11 28 (CLRTAP 2010);§ 17 (CLRTAP2014) | Yes          | The German IIR is basically created in the form and structure of a wiki and is published as such. A parallel publication in the form of a continuous text document is currently not planned. However the inventory compiler routinely creates a PDF copy of the finished report particularly for documentation purposes - which can be made available upon request and if necessary for example during a review. |

| Aspect                 | Sector       | First identified in | Finding summary                                                                                                                                                                                                                                                                                                                                                                           | Observation                                         | Implemented? | Comment                                                                                                                                                                                             |
|------------------------|--------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (lack of) Transparency |              | 2010                | Inaccuracies were found in the use of notation keys and it is recommended to justify the use of notation keys in the IIR for each particular sector.                                                                                                                                                                                                                                      | § 38 (CLRTAP 2010);§ 19 (CLRTAP 2014)               | Yes          | Information tables for NE & IE were added to the completeness chapter of the current IIR.                                                                                                           |
|                        |              | 2010                | Provide more detailed information on the rationale for recalculations at a sectoral level to complement the information already provided in the recalculation tables per pollutant.                                                                                                                                                                                                       | § 30 43 90 107 (CLRTAP 2010)                        | Partly       |                                                                                                                                                                                                     |
|                        | 1A2a\1A2b\2C | 2010                | For iron & steel there is a mix of reporting under 1A2a (PM & CO) 2C1 (NOx SOx VOC NH3) and "NE" (HMs and POPs). For non ferrous metals similar issues are observed. The recommendation is to explain the rationale for reporting in different source categories as well the rationale for NEs. NE reporting should be avoided as much as possible e.g. by applying Guidebook Tier 1 EFs. | § 48 49 (CLRTAP 2010)                               | Yes          | The reporting in the different source categories is explained in the IIR.                                                                                                                           |
|                        | 1A2gviii     | 2010                | The ERT recommends that Germany include details of the units of AD used in its estimations as this was not always the case.                                                                                                                                                                                                                                                               | § 51 (CLRTAP 2010)                                  | Yes          |                                                                                                                                                                                                     |
|                        | 1A3b         | 2010                | Explain in more detail the emission calculation for road transport not only by saying that HBEFA and TREMOD are used but giving more information including an overview of emission factors in the next versions of the IIR.                                                                                                                                                               | § 65 (CLRTAP 2010);§ 72 (CLRTAP 2014)               | Yes          |                                                                                                                                                                                                     |
|                        | 1A4          | 2010                | Provide more detail on the emission factors used including their applicability for the different years and sub-categories of the time series. Find EFs to estimate emissions for heavy metals (for example: using tier 1 in the EMEP Guidebook inventories in other countries).                                                                                                           | § 52 (CLRTAP 2010)                                  | Yes          |                                                                                                                                                                                                     |
|                        | 3B           | 2010                | The ERT recommends including in the IIR information on the complete time series of the activity data description of emission drivers recalculations and improvements for the agriculture sector.                                                                                                                                                                                          | § 86 94 (CLRTAP 2010)                               | Yes          |                                                                                                                                                                                                     |
|                        | 5A\5B\5C     | 2010                | Since all incineration is reported under energy add information about the methodology used for different types of waste incineration under NFR 1. In NFR 6C use the notation key "IE" instead of "NO" and to explain the use of the notation key in the IIR.                                                                                                                              | § 103 110 111 112 (CLRTAP 2010);§ 136 (CLRTAP 2014) | Yes          | Information on methods used for estimation of energy-related is reported in NFR 1. Germany considers NO to be correct and explains the situation in its IIR. Cremation estimation is explained now. |
| Consistency            | 1A1\1A2      | 2010                | In the IIR in the "Short description" for 1A1 and 1A2 Germany presents a tier 2 or 3 approach. However during the review Germany indicated that only the tier 2 approach was used. This needs correction in the IIR (was agreed by Germany to do this)                                                                                                                                    | § 47 (CLRTAP 2010);§ 54 (CLRTAP 2014)               | Yes          |                                                                                                                                                                                                     |
|                        | 1A5          | 2010                | The IIR says Tier 1 method is used for 1A5 but it is actually Tier 2/3. This should be corrected in the IIR.                                                                                                                                                                                                                                                                              | § 53 (CLRTAP 2010)                                  | Yes          |                                                                                                                                                                                                     |
|                        | 3B           | 2010                | The activity data (animal numbers) is coming from various sources and some corrections are being done. It is recommended that Germany includes a table in the IIR showing the livestock numbers from different sources and the type of elaboration/correction that has been done.                                                                                                         | § 94 (CLRTAP 2010)                                  | Yes          |                                                                                                                                                                                                     |

| Aspect        | Sector             | First identified in | Finding summary                                                                                                                                                                                                                                                                                                                                                                            | Observation                                            | Implemented? | Comment                                                                                                                                                                                                 |
|---------------|--------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Completeness  |                    | 2010                | Emissions prior to 1990 are not reported.                                                                                                                                                                                                                                                                                                                                                  | § 27 (CLRTAP 2010);§ 24 (CLRTAP 2014)                  | Yes          | Little information is available due to the split of Germany into two nations. Some overview data has been added to the IIR.                                                                             |
|               | 1A2a\1A2b\1A4\1B1a | 2010                | Some emissions are not estimated for some pollutants: heavy metals and POPs for 1A2a particulates heavy metals and POPs for 1A2b heavy metals for 1A4 and NMVOC for 1B1a. The ERT recommends Germany to use the Guidebook default EFs if no other method is available.                                                                                                                     | § 36 (CLRTAP 2010)                                     | Yes          |                                                                                                                                                                                                         |
|               | 5E                 | 2010                | Although the Guidebook has methods for car and house fires in Chapter 6 it may be more transparent to include these in Chapter 7 as Chapter 6D is more focused on compost and sludge. The ERT encourages Germany to consider including some of these emissions in the next submissions.                                                                                                    | § 116 (CLRTAP 2010);§139 (CLRTAP 2014);DE-5A-2017-0003 | Partly       |                                                                                                                                                                                                         |
|               | 6                  | 2010                | Consider currently missing sources: NH3 emissions from Cats and Dogs from Zoo animals and human ammonia emissions etc.                                                                                                                                                                                                                                                                     | § 116 (CLRTAP 2010)                                    | Partly       | Car and house fires have been included for quite a while now (5E). Human NH3 emissions are considered in 6A. Pets will be considered in sub2024.                                                        |
|               | 1A3a               | 2010                | NH3 reported as NE. Recommendation to investigate the emissions or report as NO if emissions do not occur.                                                                                                                                                                                                                                                                                 | § 68 (CLRTAP 2010)                                     | Yes          | The notation key 'NE' is used only for ammonia from aviation gasoline (as recommended in the 2016 EMEP Guidebook). For jet kerosene emissions are estimated.                                            |
|               | 1B1a               | 2010                | In 2010 "NE" is indicated for particulates and "NA" for NMVOC but the Guidebook has EFs. It is recommended that Germany identifies the type of coal mining using the EFs from the EMEP Guidebook or other references to estimate emissions for this sector. In 2014 NMVOC was reported as NE and the ERT recommends Germany to describe why NE is reported (emissions assumed negligible). | § 54 (CLRTAP 2010)                                     | Yes          |                                                                                                                                                                                                         |
|               | 2C1                | 2010                | Include emissions for dioxins and heavy metals based on new research project.                                                                                                                                                                                                                                                                                                              | § 80 81 (CLRTAP 2010)                                  | Yes          |                                                                                                                                                                                                         |
|               | 3D                 | 2010                | The ERT encourages Germany to estimate PM10 and PM2.5 emissions for 3D in future submissions following the EMEP/EEA Guidebook recommendations.                                                                                                                                                                                                                                             | § 98 (CLRTAP 2010)                                     | Yes          |                                                                                                                                                                                                         |
|               | 5A\5C\5D           | 2010                | The inventory regarding Waste is currently not complete with missing estimates for several source categories.                                                                                                                                                                                                                                                                              | § 102 (CLRTAP 2010);§ 134 135 (CLRTAP 2014)            | Yes          | Industrial wastewater emissions implemented since 2021 reporting. Solid waste emissions implemented since 2020 reporting. Domestic wastewater emissions implemented since 2018 reporting. 5.C completed |
| Comparability | 1A4aii             | 2010                | Emissions for main pollutants were reported as IE. The ERT encourages the Party to investigate further statistical resources for missing estimates in this sector and include a progress report within the next IIR.                                                                                                                                                                       | § 67 (CLRTAP 2010)                                     | Yes          |                                                                                                                                                                                                         |
|               | 1A2\2              | 2010                | Germany reports emissions from sugar production in source category 2D2. It is recommended to report these emissions under 1A2e and include a more detailed description of the sub-categories the methodology used the source of activity data the source of EFs and consistency across the time series (1990-2008).                                                                        | § 50 (CLRTAP 2010)                                     | Yes          | Reporting of NMVOC and PM emissions from sugar production in 2H2 (used to be 2D2) is correct according to the Inventory Guidebook 2016.                                                                 |
|               | 1A3di(ii)\1A4cii   | 2010                | Emissions reported as IE. The ERT encourages Germany to make separate emission estimates for these sectors in future IIR reports and in the meantime a separate summary table of all categories (fully or partially reported as IE) and where they have been moved would be beneficial.                                                                                                    | § 69 (CLRTAP 2010)                                     | Yes          |                                                                                                                                                                                                         |

| Aspect   | Sector      | First identified in | Finding summary                                                                                                                                                                                                                                                                         | Observation                                                | Implemented? | Comment                                                                           |
|----------|-------------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|--------------|-----------------------------------------------------------------------------------|
| Accuracy |             | 2010                | Implement a (qualitative and quantitative) uncertainty analysis and use the results to prioritize improvements to the inventory                                                                                                                                                         | § 20 24 (CLRTAP 2010); § 32 44e 85 (CLRTAP 2014)           | Partly       |                                                                                   |
|          | 1A1b\1A1c\2 | 2010                | Improvement from Tier 2 to Tier 3 using plant-specific data for some industrial processes including cement production as well as for large combustion plants (e.g. 1A1b 1A1c)                                                                                                           | § 19 41 45 46 (CLRTAP 2010)                                | Yes          | Included for large combustion plants no plant-specific data for cement production |
|          | 2A1         | 2010                | Cement production is a key source for Hg HCB and for NOx PM10 and PAH but Tier 1 is used. The ERT encourages Germany to use plant-specific data collected as part of the LCPD IPPC and E-PRTR to develop a tier 2 or 3 methodology in the near future and to document these in its IIR. | § 79 (CLRTAP 2010); § 88 (CLRTAP 2014)                     | Yes          | plant-specific data approach is not planned                                       |
|          | 2L          | 2010                | Include results of ongoing research project to improve from Tier 1 to higher Tier methodology.                                                                                                                                                                                          | § 82 83 (CLRTAP 2010)                                      | Yes          |                                                                                   |
|          | 3B          | 2010                | There were errors in the calculation of N excretion rates it is recommended that Germany corrects this.                                                                                                                                                                                 | § 97 (CLRTAP 2010)                                         | Yes          |                                                                                   |
| QA/QC    |             | 2010                | Fully implement the QA/QC system for the air pollutant emission inventory. If possible implement a unified QA/QC system for reporting to CLRTAP and UNFCCC.                                                                                                                             | § 21 24 62 74 88 105 (CLRTAP 2010); § 37 44f (CLRTAP 2014) | No           | Ongoing discussion                                                                |
|          |             | 2010                | Widen the use of the existing QA/QC system used for the set of activity data as well as the methods and emission factors for GHGs for the needs of CLRTAP/NECD inventories and providing further details on its implementation in the IIR (general and sectoral descriptions).          | § 33 40 (CLRTAP 2010); § 16 69 84 87 103 105 (CLRTAP 2014) | No           | Ongoing discussion                                                                |



**PLEASE NOTE THAT PROJECTIONS ARE REPORTED ONLY BIANNUALLY AND THAT, THEREFORE, THE FOLLOWING INFORMATION HAS BEEN SUBMITTED ALREADY WITH THE 2025 SUBMISSION AND WILL BE UPDATED AGAIN WITH THE 2027 SUBMISSION.**

# CHAPTER 10: Reported Projections 2025 - Overview

In May 2019, Germany published its first National Air Pollution Control Programme ([NAPCP 2019](#)) under the revised NEC directive (EU) 2016/2284. According to Article 6 (3) of the Directive, the NAPCP must be reported in an updated version at least every four years. In this context, Germany published a draft NAPCP on June 7<sup>th</sup>, 2023. Corresponding emission projections were reported to the central data repository of the European Environment Agency (EEA) on May 2<sup>nd</sup>, 2023 under the CLRTAP and the NEC directive, presenting both the “with measures” (WM) and the “with additional measures” (WAM) preliminary scenarios as defined in the draft NAPCP 2023 mentioned above. The second German National Air Pollution Control Programme ([NAPCP 2023](#)) was passed by the federal government and published in May 2024, consistent with the previously reported projections. According to Article 8 (6) of the EU Directive 2016/2284, these projections must be updated and reported every two years. Emission projections under the CLRTAP are fully aligned with the reporting presented in the context of the NEC directive.

Updated emission projections were reported on March 14<sup>th</sup>, 2025 under the ([CLRTAP](#)) and the ([NEC directive](#)), presenting both the “with measures” (WM) and the “with additional measures” (WAM) scenarios. The IIR 2025 projections chapter describes all assumptions and methodology of those emission projections.

Projections reported in 2025 are based on emission inventory submission 2024 (see Table 1). In addition, because of relevant recalculations in ammonia emissions of the agricultural sector (NFR 3) within emission inventory submission 2025 (see [Chapter 8.1 - Recalculations](#)), a second dataset was submitted containing only ammonia emission projections in the “with measures” (WM) scenario based on emission inventory submission 2025 under otherwise identical assumptions (see Table 2).

Based on the NEC & CLRTAP Inventory Submission 2024, the results can be summarized as follows:

Table 1: Overview results of projections 2025 (based on NEC & CLRTAP Inventory Submission 2024)

|                                              | NO <sub>x</sub> | SO <sub>2</sub> | NMVOC      | NH <sub>3</sub> | PM <sub>2.5</sub> |
|----------------------------------------------|-----------------|-----------------|------------|-----------------|-------------------|
| <b>NATIONAL TOTAL</b> 2005 (Submission 2024) | 1,478 kt        | 472 kt          | 1,167 kt   | 627 kt          | 133 kt            |
| <b>NATIONAL TOTAL</b> 2022 (Submission 2024) | 841 kt          | 255 kt          | 747 kt     | 512 kt          | 84 kt             |
| Reduction Commitment 2020                    | -39 %           | -21 %           | -13 %      | -5 %            | -26 %             |
| Reduction Reported 2022                      | -43 %           | -46 %           | -36 %      | -18 %           | -37 %             |
| <b>NEC-Compliance</b>                        | <b>Yes</b>      | <b>Yes</b>      | <b>Yes</b> | <b>Yes</b>      | <b>Yes</b>        |
| Reduction Commitment 2030                    | -65 %           | -58 %           | -28 %      | -29 %           | -43 %             |
| Reduction Commitment 2030                    | 517 kt          | 198 kt          | 840 kt     | 445 kt          | 76 kt             |
| Projected Emissions 2030 WM                  | -66 %           | -71 %           | -35 %      | -31 %           | -43 %             |
| <b>NEC-Compliance WM</b>                     | <b>Yes</b>      | <b>Yes</b>      | <b>Yes</b> | <b>Yes</b>      | <b>Yes</b>        |
| Projected Emissions 2030 WAM                 | -66 %           | -71 %           | -35 %      | -31 %           | -44 %             |
| <b>NEC-Compliance WAM</b>                    | <b>Yes</b>      | <b>Yes</b>      | <b>Yes</b> | <b>Yes</b>      | <b>Yes</b>        |

Notes: This table does not include NO<sub>x</sub> and NMVOC emissions from agriculture (NFR 3.B and 3.D) as they are excluded for compliance checking according to Article 4 (3) of the NEC directive. Projected emissions and historic data are based on submission 2024. All values have been rounded to integer numbers. The calculation for determining the reduction commitment took place with the exact values in 2005. The rounding can lead to slight deviations.

Based on the NEC & CLRTAP Inventory Submission 2025, the recalculated results for ammonia can be summarized as follows:

Table 2: Recalculated projections 2025 for NH<sub>3</sub> (ammonia), (based on NEC & CLRTAP Inventory Submission 2025)

|                                              | NH <sub>3</sub> |
|----------------------------------------------|-----------------|
| <b>NATIONAL TOTAL</b> 2005 (Submission 2025) | 714 kt          |
| <b>NATIONAL TOTAL</b> 2023 (Submission 2025) | 569 kt          |



|                             |                       |
|-----------------------------|-----------------------|
|                             | <b>NH<sub>3</sub></b> |
| Reduction Commitment 2020   | -5%                   |
| Reduction Reported 2023     | -20%                  |
| <b>NEC-Compliance</b>       | <b>Yes</b>            |
| Reduction Commitment 2030   | -29%                  |
| Reduction Commitment 2030   | 507 kt                |
| Projected Emissions 2030 WM | -33%                  |
| <b>NEC-Compliance WM</b>    | <b>Yes</b>            |

# Introduction

## Context

Reliable data on historic emissions are key to the political process and to decisions on abatement technology promotion. However, future emission paths also do have the power to shed a new light on these discussions. Therefore, greenhouse gases (GHG) and air pollutants are inventoried and projected in the same database system using the same structure of detailed time series.

For the National Air Pollution Control Programme, a new database within this system was created in 2018 that is basically a copy of the German inventory database. In addition, multiple scenarios are taken into account, sketching development of activity data and emission factors up to 2040 and beyond. The system features integrated assessment for both greenhouse gases (GHG) and air pollutants. In particular, existing projections for GHG can be applied to air pollution contexts. The database used also allow for the flexible combination of distinct scenarios for specific sectors and source categories to add up to a complete projection of the inventory. Furthermore, reduction potentials of mitigation measures can be modelled in detail and quantified directly in the database. The projection database is fully operational and used as the common basis for reporting on emission projections under NEC directive and CLRTAP reporting obligations

## Policies

For the past years, climate change and greenhouse gas (GHG) emissions have been an important issue in society and politics. GHG emission inventories have seen a lot of attention as a consequence. However, there have also been a couple of air pollution related headlines, including “diesel gate” and particulate matter concentrations caused by residential wood burning. In Germany, these discussions have led to a number of legislative projects and new regulations which have the power to significantly change emission levels. Thus, projections generally show a further decline in emissions. Some main policy drivers are listed and contextualized below:

- Energy
  - Phase-out of coal use for energy production until 2038 with significant reductions before 2030 (last modified for lignite burning power plants on December 2<sup>nd</sup>, 2023, see (KVBG, Annex 2))
  - increasing prices in the Emissions Trading System (EU-ETS1)
  - transfer of the national Emissions Trading System (n-ETS) into the Emissions Trading System for buildings, Transport and other sectors (EU-ETS 2)
  - the EU Carbon Border Adjustment Mechanism (CBAM)
  - increasing capacity and production of renewable energy (e. g. modified Renewable Energy Sources Act from 2023 (EEG 2023))
  - new regulations with stricter emission limit values for some installation types (e. g. modified 13<sup>th</sup> BImSchV from 2021, modified 17<sup>th</sup> BImSchV from 2024, LCP BREF 2021, WGC BREF 2023)
- Transport
  - new vehicle regulations (e. g. Emission Performance Regulation (EU) 2019/631 <sup>1)</sup>, Euro 7 Regulation (EU) 2024/1257 <sup>2)</sup>
  - increasing share of electric vehicles, increasing shift to public transport
- Agriculture
  - Amendments of the “Düngeverordnung” (fertiliser ordinance) in 2017 and 2020 as well as other legislative and incentive measures to reduce fertiliser use, increase the nitrogen use efficiency and increase the share of low emission application techniques.

<sup>1)</sup> (EU) 2019/631: Regulation (EU) 2019/631 of the European Parliament and of the Council of 17 April 2019 setting CO<sub>2</sub> emission performance standards for new passenger cars and for new light commercial vehicles, and repealing Regulations (EC) No 443/2009 and (EU) No 510/2011 (recast); <http://data.europa.eu/eli/reg/2019/631/oj>

<sup>2)</sup> (EU) 2024/1257: Regulation (EU) 2024/1257 of the European Parliament and of the Council of 24 April 2024 on type-approval of motor vehicles and engines and of systems, components and separate technical units intended for such vehicles, with respect to their emissions and battery durability (Euro 7), amending Regulation (EU) 2018/858 of the European Parliament and of the Council and repealing Regulations (EC) No 715/2007 and (EC) No 595/2009 of the European Parliament and of the Council, Commission Regulation (EU) No 582/2011, Commission Regulation (EU) 2017/1151, Commission Regulation (EU) 2017/2400 and Commission Implementing Regulation (EU) 2022/1362; <http://data.europa.eu/eli/reg/2024/1257/oj>



Results - Overview

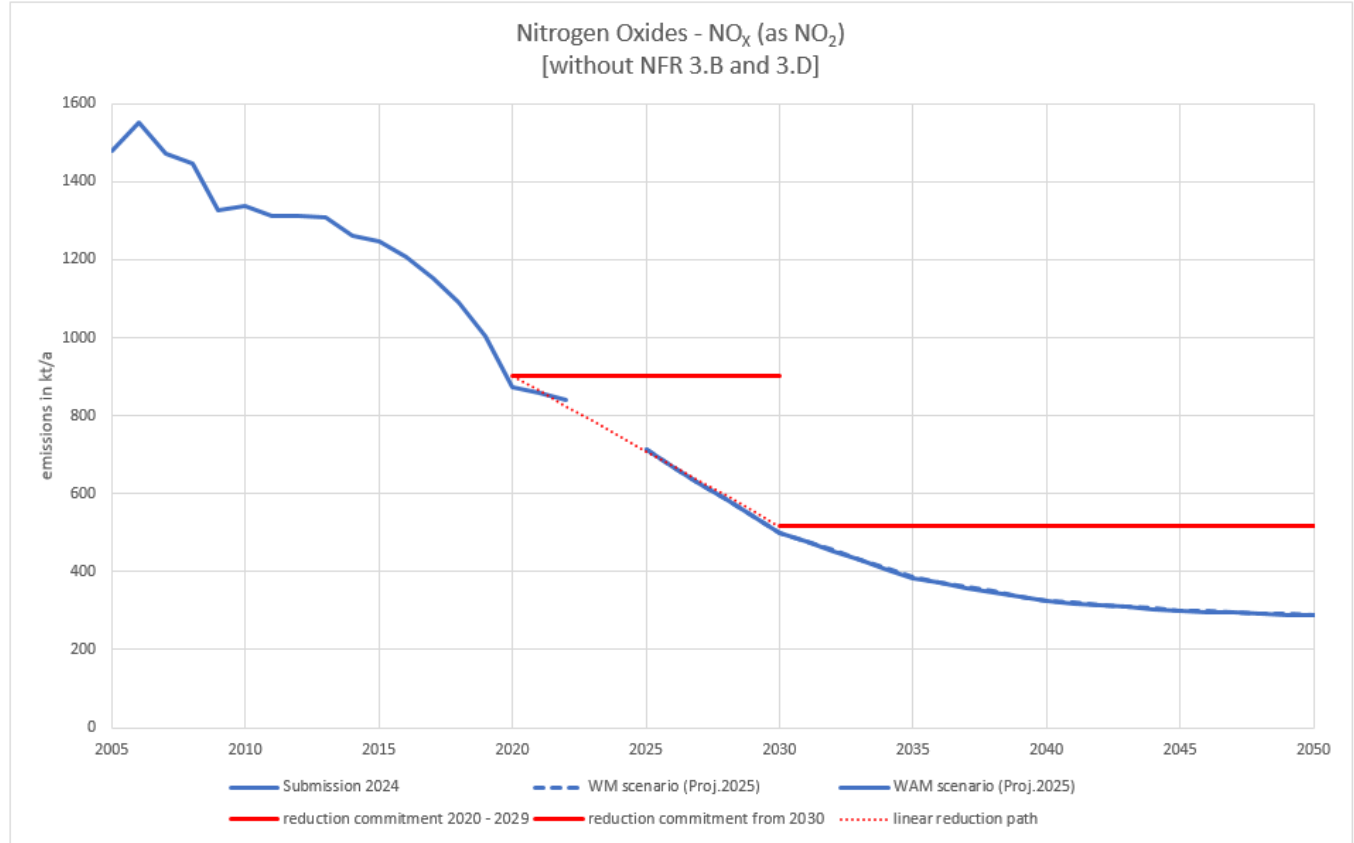
Modelling different scenarios in our database, we finally calculated the following numbers for Germany's emissions in 2030:

Table 3: Overview of projected 2030 emissions

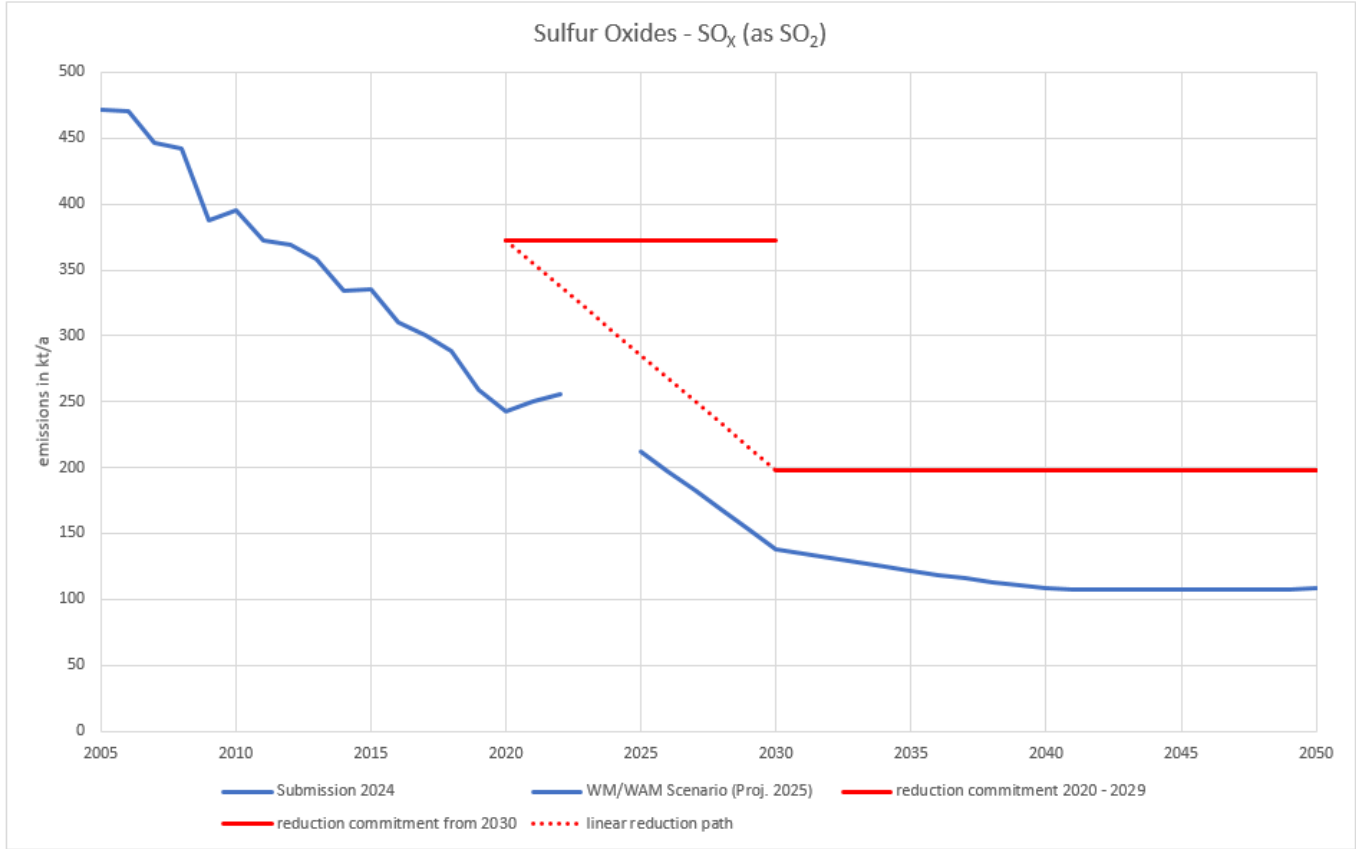
| Projections for the year 2030                                                                                               | NO <sub>x</sub> | SO <sub>2</sub> | NMVOC    | NH <sub>3</sub> | PM <sub>2.5</sub> |
|-----------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|----------|-----------------|-------------------|
| With measures                                                                                                               | 500.9 kt        | 138.4 kt        | 763.8 kt | 434.2 kt        | 75.4 kt           |
| Amendment of the emission limits of the Ecodesign Regulations (EU) 2015/1185 <sup>1)</sup> and (EU) 2015/1189 <sup>2)</sup> |                 |                 |          |                 | -0.8 kt           |
| [optional] Amendment of 13 <sup>th</sup> BImSchV <sup>3)</sup>                                                              |                 |                 |          |                 |                   |
| With additional measures                                                                                                    | 500.9 kt        | 138.4 kt        | 763.8 kt | 434.2 kt        | 74.6 kt           |

With these numbers, Germany will meet its reduction commitments for all pollutants in 2030 in both scenarios.

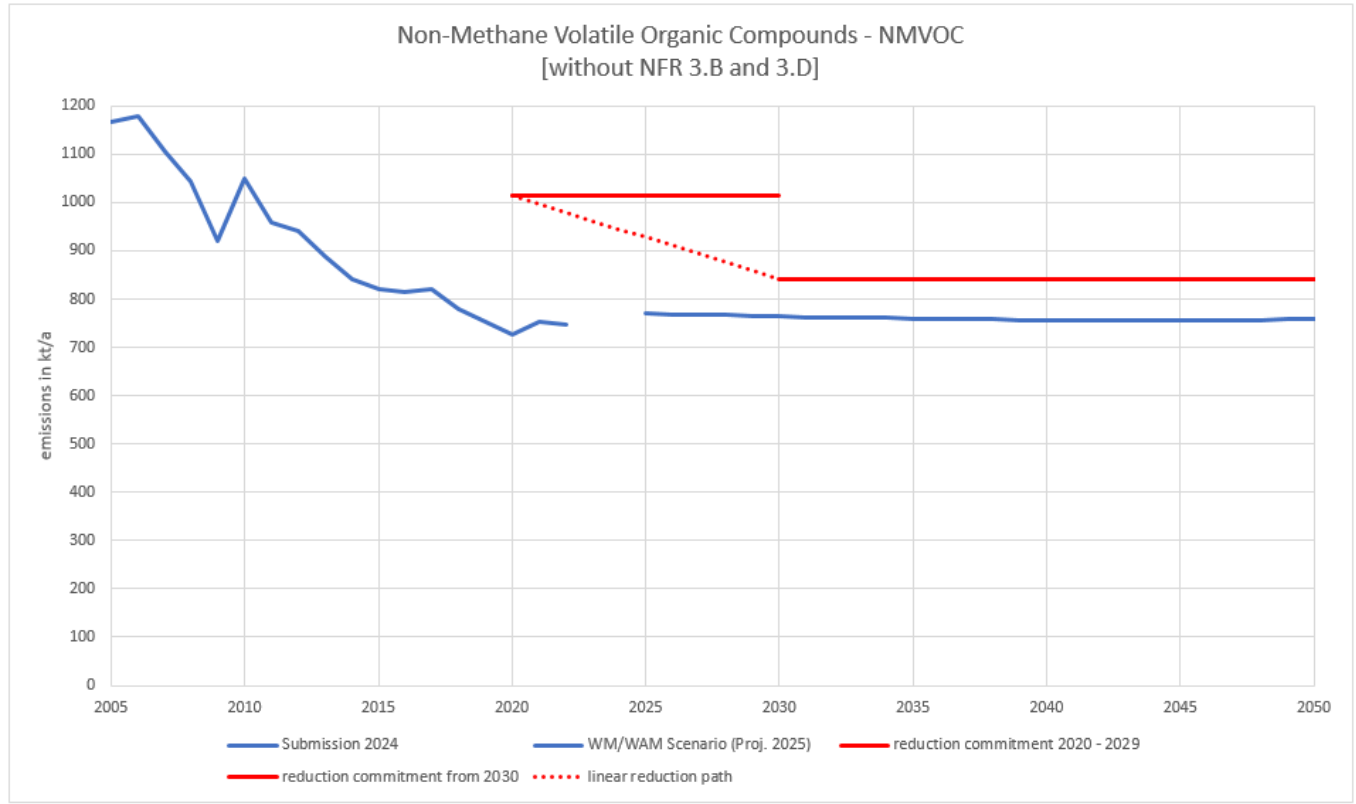
The following figures show the developments for each pollutant in the WM and WAM scenarios (WAM only for NO<sub>x</sub> and PM<sub>2.5</sub> as there are no differences between both scenarios for all other pollutants). In addition, the reduction commitments for 2020 to 2029 and from 2030 onwards as well as the indicative linear reduction path are shown. Please note that projected emissions were only calculated for the years 2025, 2030, 2035, 2040, 2045 and 2050. A linear reduction in the years between cannot be assumed, but is shown in the graphs just for illustrative reasons.



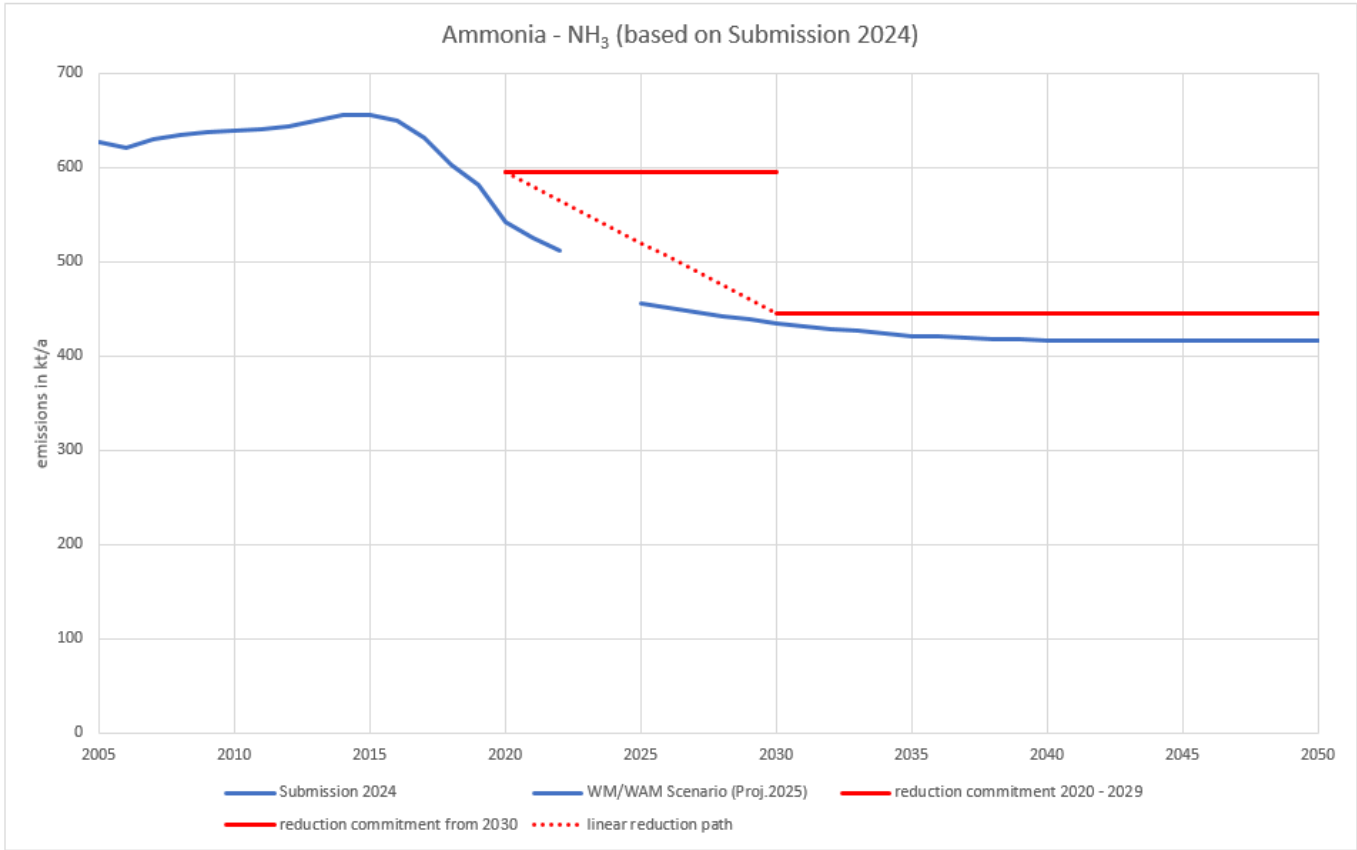
Please note that projected emissions were only calculated for the years 2025, 2030, 2035, 2040, 2045 and 2050. A linear reduction in the years between cannot be assumed but is shown in the graphs just for illustrative reasons.



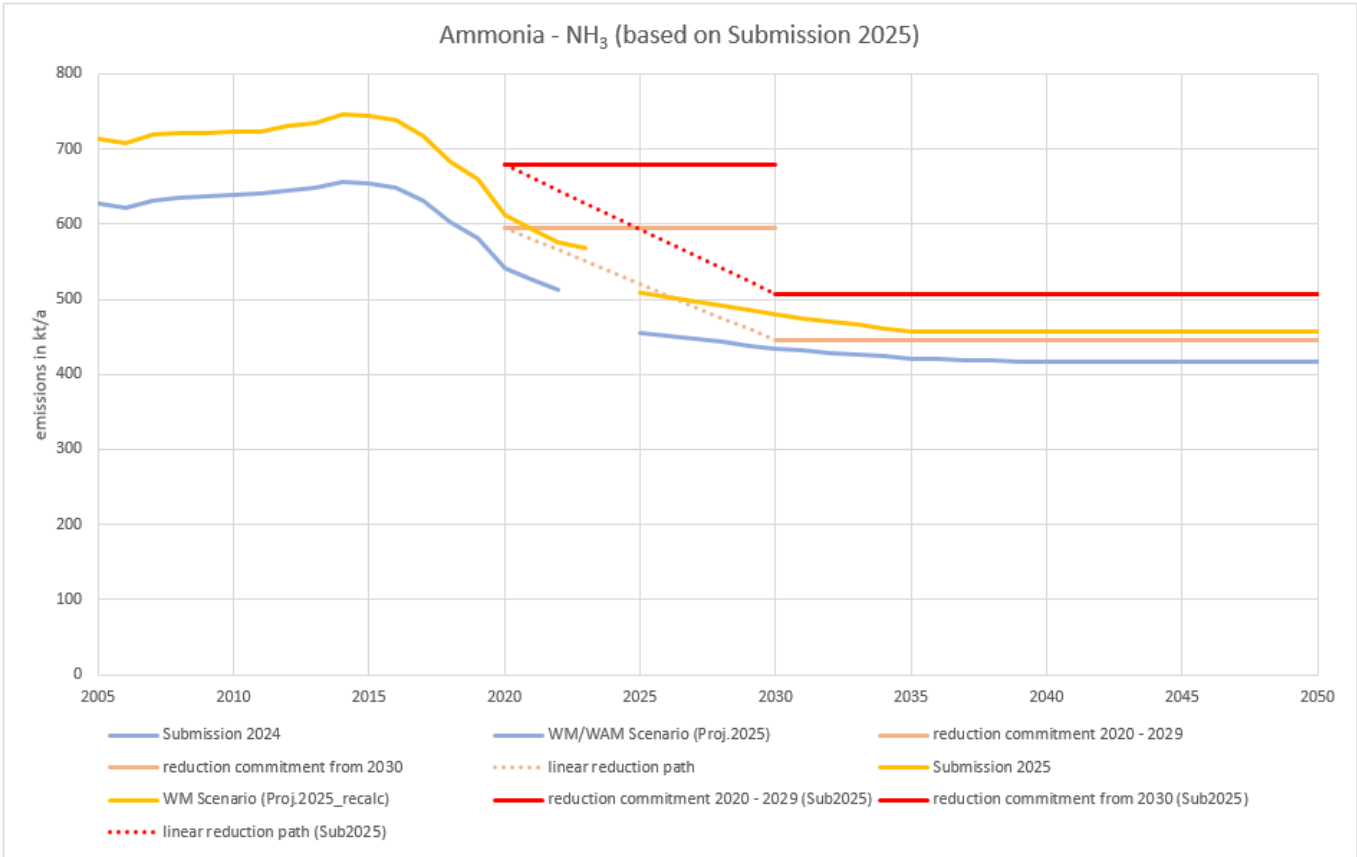
Please note that projected emissions were only calculated for the years 2025, 2030, 2035, 2040, 2045 and 2050. A linear reduction in the years between cannot be assumed but is shown in the graphs just for illustrative reasons.



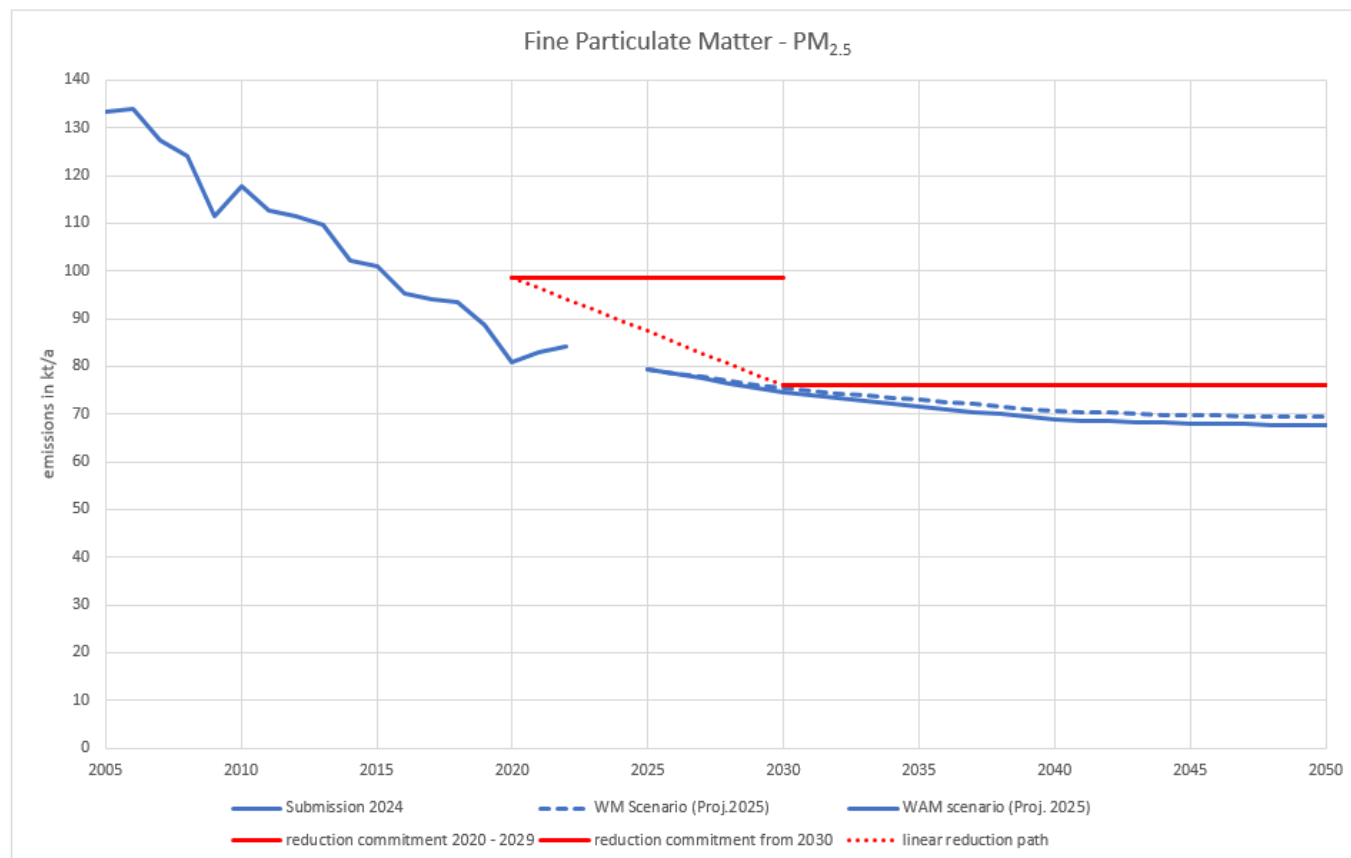
Please note that projected emissions were only calculated for the years 2025, 2030, 2035, 2040, 2045 and 2050. A linear reduction in the years between cannot be assumed but is shown in the graphs just for illustrative reasons.



Please note that projected emissions were only calculated for the years 2025, 2030, 2035, 2040, 2045 and 2050. A linear reduction in the years between cannot be assumed but is shown in the graphs just for illustrative reasons.



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Please note that projected emissions were only calculated for the years 2025, 2030, 2035, 2040, 2045 and 2050. A linear reduction in the years between cannot be assumed but is shown in the graphs just for illustrative reasons.

<sup>1)</sup> (EU) 2015/1185: Commission Regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel local space heaters; <http://data.europa.eu/eli/reg/2015/1185/oj>

<sup>2)</sup> (EU) 2015/1189: Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel boilers; <https://eur-lex.europa.eu/eli/reg/2015/1189/oj>

<sup>3)</sup> Thirteenth Ordinance on the Implementation of the Federal Immission Control Act (Ordinance on Large Combustion Plants and Gas Turbine Plants – 13. BImSchV) [https://www.gesetze-im-internet.de/bimschv\\_13\\_2021/](https://www.gesetze-im-internet.de/bimschv_13_2021/)

## Calculation documentation

In general, data basis of the emission projections calculation was the inventory submission 2024 with all the included processing of the emission data. Only for ammonia also a calculation based on inventory submission 2025 under otherwise identical assumptions was carried out.

For its national emission projections, Germany takes into account projected activity data for GHG projections and category-specific reports on air pollution emission factor development in the future. For all sectors, emission scenarios were developed in the greatest possible consistency with the latest available energy and greenhouse gas emission scenario for Germany, which was at the time of preparation of the emission projections for reporting in 2025 the MMS (WEM, with existing measures scenario) of 'Treibhausgas-Projektionen 2024 für Deutschland'<sup>1)</sup> published in mid-2024. This is also consistent with the current NECPR-reporting according to art. 17 of regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action. However, reporting of updated GHG emission projections in 2025 according to art. 18 of regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action could not be reflected for the current air pollutant emission projections, except for ammonia (reported in a separate file).

In the scenario "with measures" (WM), for the majority of the emission sources in the sectors 1.A.1 (energy industry), 1.A.2 (manufacturing industry), 1.A.4 (other combustion systems), 1.A.5 (military), 1.B (diffuse emissions from fuels), 2 (industrial processes) and 5 (waste and wastewater treatment) projected development of the activity rates is based on the with existing measures scenario (MMS=WEM) of the 'Treibhausgas-Projektion 2024 für Deutschland'. The MMS of the 2024 GHG emission projections for Germany includes all climate protection-relevant measures and instruments adopted by July 31, 2023.

In contrast to this comprehensive projection of activity data, transport emissions are calculated using the TREMOD model ("Transport Emission Model"). To estimate the future development of transport-related energy consumption and emissions, a trend scenario up to 2050 was developed, which is updated annually. Version 6.53 of TREMOD formed the basis for the current emission projections (see Allekotte et al., 2024<sup>2)</sup>). Therefore, road transport measures from the WAM scenario of the German NAPCP 2023<sup>3)</sup>, including the expansion of the truck toll system and a package of measures to promote electromobility, which have since been implemented, become part of the trend scenario. Beyond the trend scenario, findings from ongoing work for the upcoming HBEFA 5.1 update (Handbook of Emission Factors for Road Transport<sup>4)</sup>), such as an increase in the implied emission factors for trucks and coaches with Euro V and VI due to defective or manipulated exhaust aftertreatment systems were considered<sup>5)</sup> in the current WM scenario. In addition, the introduction of Euro 7 on the basis of Regulation (EU) 2024/1257 was considered in the WM scenario, leading to further decline of implied emission factors of the fleet, especially beyond 2030. Those additional assumptions are documented in Allekotte et al. (2025)<sup>6)</sup>. Furthermore, assumptions about emissions from road abrasion as well as tyre and brake wear from electrically driven mileage were included according to EMEP/EEA air pollutant emission inventory guidebook 2023<sup>7)</sup>. In order to reflect the Euro 7 Regulation also regarding particle emissions from tyre and brake wear the emission factors of the historical emissions were further adjusted for the emission projections.

The projection for the agricultural sector (NFR 3) was created by the Thünen Institute (TI) using the py-GAS-EM reporting model twofold, once based on the inventory submission 2024 and the MMS (WEM, with existing measures) of the "Treibhausgas-Projektionen 2024 für Deutschland" and once based on the current inventory submission 2025 and the MMS (WEM, with existing measures) of the "Treibhausgas-Projektionen 2025 für Deutschland"<sup>8)</sup>. For both projections, the most important input data for the calculation of the agricultural emissions (animal numbers, animal performance, mineral fertilizer use) were derived for the first time using the CAPRI model, based on the current Thünen-Baseline 2024-2034 (2024)<sup>9)</sup>. Further assumptions for the sector agriculture were assumed as in the WM scenario of the German NAPCP 2023 and are described below for the year 2030.

For dairy cows, the proportion of cows kept in tied housing systems was reduced by 50 % compared to 2020 (weakened trend projection). In the past, the decline in tied housing systems has not had the same impact on the decline in the number of dairy cows in Germany. It is assumed that this will not be the case in the future either. For other cattle, tied housing systems will also be reduced by 50 % compared to 2020.

Due to the further implementation of the German Fertiliser Ordinance, strip application on cultivated fields (since 2020) and grassland (from 2025) as well as immediate incorporation on uncultivated farmland after no more than one hour (from 2025) is becoming mandatory. On cultivated fields, the current proportions of broadcast application were redistributed to trailing hose application. On grassland, 80 % of the current proportions of broadcast application were redistributed to trailing shoe application and 20 % to trailing hose application. This roughly corresponds to today's ratio of trailing hose and trailing shoe on grassland.

The proportion of the share of liquid manure spread using injection and slot technology was extrapolated based on the increasing trend between 2010 and 2020.



The use of manure in biogas plants is statically updated based on the year 2023. The use of energy crops in biogas plants was assumed to be declining, as described in the Thünen Baseline 2024-2034. This corresponds to a reduction in the amount of energy crops used in 2030 compared to 2023 of around 61 % based on the nitrogen contained (and to a reduction of 80 % for the projection year 2035).

With the assumptions described above, a significant reduction of ammonia emissions compared to the current annual emissions will be achieved by 2030. For the WM projection based on inventory submission 2025 a buffer of roughly 16 kt results for 2030 (for the current WM projection based on inventory submission 2024 there would be no buffer without the further assumptions described below).

In addition, potential emission reductions as a result of the new version of the first general administrative regulation for the Federal Immission Control Act (Technical Instructions for Air Pollution Control - TA Luft)<sup>10)</sup>, which came into force on December 1<sup>st</sup>, 2021, were evaluated. These bring about a reduction effect of a further 11.8 kt of ammonia in 2030. In total, this results in a buffer of roughly 28 kt in the current WM scenario based on inventory submission 2025 for complying with the reduction obligation for ammonia in 2030 (or roughly 11 kt in the current WM projection based on inventory submission 2024). The assumed reduction effects through the TA-Luft are divided into three sub-areas.

- For farms falling in the category 'G' (according to Annex 1 of the 4<sup>th</sup> BImSchV for keeping or rearing of sows, fattening pigs, piglets, laying hens, pullets and broilers) it was assumed that the current status of air scrubber systems for pigs remains constant (with a reduction performance of 80 %) and that the current status for poultry increases slightly (with a reduction performance of 70 %). For almost the entire remaining stock of the respective animal category in G-systems, it was assumed that 40 % of the emissions in the barn are reduced by further system-integrated measures. This can be achieved, for example, with a less effective air scrubber system or other technical measures in animal housing. These assumptions are conservative since they only reflect the minimum requirements with regard to emission reductions according to the current legal situation and implementation practice. The TA Luft prescribes the cleaning of the exhaust air as state of the art for new systems. This also applies to existing systems – with various transitional periods – unless retrofitting is not proportionate or technically possible. In this case, other mitigation measures must be implemented. Alternatively, the TA Luft enables the use of quality-assured housing facilities that demonstrably serve animal welfare and, if designed appropriately (e.g. animal-friendly, emission-optimized outdoor climate stable), at the same time achieve relevant emission reductions that are quantitatively specified in the TA Luft. It is currently not possible to reliably estimate what proportion of the existing systems can be retrofitted with air scrubbing systems and what proportion of the new construction or replacement construction will take the form of quality-assured, animal-friendly and emission-optimized husbandry systems. Therefore, for the entire (heterogeneous) group, only the minimum achievable reductions when implementing the legal requirements were initially assumed in the sense of a conservative total analysis.
- For 30 % of the animal stocks falling into the category 'V' (according to Annex 1 of the 4<sup>th</sup> BImSchV for keeping or rearing of sows, fattening pigs, piglets, laying hens, pullets and broilers), it was assumed that these reduce emissions by 40 % through system-integrated measures in animal housing. As explained above, this is also a conservative assumption (e.g. with regard to retrofitting and the new construction of animal-friendly husbandry systems) in order not to overestimate the emission reduction.
- For 80 % of the slurry from G and V systems, it was assumed that in 2030 they would be stored covered at least with foil or comparable technology.

The NMVOC emissions from NFR sector 2.D.3, which includes emissions resulting from the use of solvents and solvent-containing products, as well as their manufacturing, are not calculated using activity rates and emission factors within the inventory. Instead, a separate model developed and expanded steadily over the past 15 years primarily by the Institute for Environmental Strategies (Ökopool GmbH) is utilized to calculate these emissions, and the results are imported into the inventory database. This model also provides emission projections based on economic forecasts specific to certain branches of industry. These economic projections were last updated for the emissions projections reported in 2023 using the Prognos report (2019) titled "Deutschland Report 2025 | 2035 | 2045". The methodology for updating the NMVOC inventory and projections is detailed in Zimmermann and Memelink (2023<sup>11)</sup>).

In a more recent project, Zimmermann et al. (2025<sup>12)</sup>) conducted a comprehensive review of the previous methods used for projecting NMVOC emissions in the sectors of printing (NFR 2.D.3.h) and coating applications (NFR 2.D.3.d). They developed new projection methods for the years 2025 to 2050. The updates made for the individual SNAP codes can be summarised as follows:

SNAP 60101 demonstrated a clear correlation with automobile production. A forecast for production in Germany has been established based on EU production forecasts and used in the emission projections. For SNAP 60102, emissions showed a correlation with vehicle fleet size from 2015 onward. Forecast data on the vehicle population was taken from the study (Adolf et al., 2014<sup>13)</sup>) and used for the projection. SNAP 60103 showed that employee numbers and annual construction output correlated with emissions from 2018 on. Projections have been implemented using data from BMAS (2021<sup>14)</sup>) and the

Prognos report (2019). For SNAP 60104, a correction factor to the “population development” indicator has been applied to update projections. SNAP 60105 showed a significant correlation with the completion of commercial buildings. Due to the lack of specific forecasts for this indicator, automotive production data (from SNAP 60101) has been used as an alternative. SNAP 60106 faced challenges in identifying suitable indices for emissions. A weak correlation with boat and shipbuilding turnover has been noted and additional corrections to enhance projection accuracy have been applied. In the case of SNAP 60107, no meaningful correlations were established, prompting to create emission projections based on trend extrapolations. Future investigations into specific SNAP areas will yield better methodologies. SNAP 60108 required careful analysis of several sub-areas. No correlation of the emissions to economic (or other) variables could be determined for several sub-areas, which is why some of the emissions were updated using trend progression. In the future, it may be useful to take a closer look at the individual areas of the SNAP code that are particularly relevant to emissions and the developments taking place in these areas to identify suitable alternative approaches for creating projections. No correlation could be established between SNAP 60109 and the indices used to date. However, with the “Other expenditure, inflation-adjusted” index, an alternative suitable forecast index could be used for the projection.

SNAP 60403 showed a high correlation with relevant economic indices and emissions. However, the available and previously used forecast for the “wood, paper and printing” sector is more highly aggregated and, in turn, hardly appears suitable for projections for the sub-sector. It was therefore decided to fall back on forecasts of employment trends. The employment figures also showed a high correlation with emissions in the retrospective analysis.

Despite the existing uncertainties and obstacles related to the creation of NMVOC emission projections, the quality of the projections for the SNAP codes mentioned above has been significantly improved by Zimmermann et al. (2025). In the past, indices were often used to create projections without a clear correlation to emissions. Now, more suitable parameters have been identified and utilized wherever possible. In other instances, trend extrapolations have been made based on historical emission data. Additionally, assumptions about technological developments have been incorporated. For future projections, an equally thorough review and update of the relevant NFR sectors that were not included in the current analysis is planned to ensure comprehensive coverage. In this regard, for the entire sector of 2.D.3 consultations with industry experts will be continued and deepened. The results of Zimmermann et al. (2025) will be regularly re-evaluated using new emission data and statistics to validate or adapt the projection preparation process.

Starting from these activity data set as a basis, future emission factors for air pollutants were modelled for each of the policies and measures individually. For each measure, the relevant emissions factors were identified and the existing historic time series in the database was extended to 2025, 2030, 2035, 2040, 2045 and 2050. Then, the future activity data for those years were multiplied with the modelled emission factors to derive projected emissions. This approach allows detailed calculations of mitigations attributable to each measure.

## General assumptions

The emission inventory aims to record the true emissions of all German emission sources. For emission projections the future emission sources are often not yet existing and true emissions cannot be measured already. Emission projections for power plants, for example, are therefore estimated using regulatory limit values. Because emission limit values in the 13<sup>th</sup> BImSchV and in the accompanying BAT conclusions are usually given in mg/Nm<sup>3</sup>, a conversion into kg/TJ is necessary to multiply emission factors with activity rates (fuel use). Table 4 shows an example of the conversion factors for NO<sub>x</sub> (Rentz et al., 2002)<sup>1)</sup> which are used to convert mg/Nm<sup>3</sup> into kg/TJ for the regulations under consideration. For each relevant pollutant, a fuel-specific conversion factor is given, taking into account the reference oxygen content in percent.

Table 4: Fuel-specific conversion factors for air pollutants according to Rentz et al. (2002)

| Pollutant       | Fuel                          | Reference oxygen content 3 % | Reference oxygen content 6 % | Reference oxygen content 11 % | Reference oxygen content 15 % |
|-----------------|-------------------------------|------------------------------|------------------------------|-------------------------------|-------------------------------|
| NO <sub>x</sub> | Hard coal                     |                              | 2.75                         |                               |                               |
|                 | Lignite                       | 2.88                         | 2.40                         | 1.60                          |                               |
|                 | Heavy fuel oil                | 3.39                         |                              |                               |                               |
|                 | Light heating oil             | 3.49                         |                              |                               |                               |
|                 | Natural gas                   | 3.57                         |                              |                               |                               |
|                 | Natural gas (gas turbines)    | 3.45                         |                              | 1.15                          | 1.15                          |
|                 | Heavy fuel oil (gas turbines) | 3.53                         |                              | 1.18                          | 1.18                          |

1)

<https://www.umweltbundesamt.de/publikationen/technischer-anhang-der-treibhausgas-projektionen>

2)

<https://www.umweltbundesamt.de/publikationen/aktualisierung-tremodtremod-mm-ermittlung-der>

3)

<https://iir.umweltbundesamt.de/2023/general/projections/wam-scenario>

4)

<https://www.hbefa.net/>

5)

[https://ermes-group.eu/sites/default/files/2024-12/1.2\\_Hausberger.pdf](https://ermes-group.eu/sites/default/files/2024-12/1.2_Hausberger.pdf)

6)

not yet published, (Link will be added as soon as the report is published.)

7)

<https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023>

8)

see chapter 6 for agriculture:

<https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/projektionen-2025-zentrale-annahmen.pdf>

9)

[https://literatur.thuenen.de/digbib\\_extern/dn068888.pdf](https://literatur.thuenen.de/digbib_extern/dn068888.pdf)

10)

[http://www.verwaltungsvorschriften-im-internet.de/bsvwvbund\\_18082021\\_IGI25025005.htm](http://www.verwaltungsvorschriften-im-internet.de/bsvwvbund_18082021_IGI25025005.htm)

11)

<https://www.umweltbundesamt.de/publikationen/aktualisierung-des-deutschen-inventars-fuer-nmvoc-0>

12)

<https://www.umweltbundesamt.de/publikationen/nmvoc-projektionen>

13)

[https://www.prognos.com/sites/default/files/2021-01/140900\\_prognos\\_shell\\_studie\\_pkw-szenarien2040.pdf](https://www.prognos.com/sites/default/files/2021-01/140900_prognos_shell_studie_pkw-szenarien2040.pdf)

14)

[https://www.bmas.de/SharedDocs/Downloads/DE/Publikationen/Forschungsberichte/fb526-3-aktualisierte-bmas-prognose-digitalisierte-arbeitswelt.pdf?\\_\\_blob=publicationFile&v=2](https://www.bmas.de/SharedDocs/Downloads/DE/Publikationen/Forschungsberichte/fb526-3-aktualisierte-bmas-prognose-digitalisierte-arbeitswelt.pdf?__blob=publicationFile&v=2)

15)

Rentz, O., Karl, U., Peter. H. (2002): Determination and evaluation of emission factors for combustion installations in Germany for the years 1995, 2000 and 2010, on behalf of the German Environment Agency (UBA), Project-Nr.299 43 142.

**Measures that have already been implemented or measures whose implementation has been decided are assigned to the WM scenario.**

**Reductions in large combustion plants through implementation of the 13<sup>th</sup> and 17<sup>th</sup> BImSchV as well as minimum requirements of recent BAT conclusions:**

Measures for large combustion plants (LCP) that have already been implemented through the 13<sup>th</sup> and 17<sup>th</sup> BImSchV or do have future reduction effects from the existing regulations as well as minimum requirements of recent BAT conclusions are considered in the WM scenario. The amendment of the 17<sup>th</sup> BImSchV, part of the WAM scenario of the NAPCP 2023, has been implemented on 13<sup>th</sup> February 2024 and future mitigation potential is estimated in the current WM scenario.

The measures affect time series of NFR sectors under 1.A.1 and 1.A.2 and lead to a reduction in the emission factors. Potential mitigation effects emerge from BAT conclusions according to Directive 2010/75/EU (amended by Directive (EU) 2024/1785). If the current inventory submission 2024 shows that the emissions in the time series are already below the upper ends of the specified emission ranges and thus the statutory maximum limit values will be fulfilled, these will be updated unchanged. In the case of time series above the upper range, the maximum permitted annual limit values are used as a result of the measure in the sense of a conservative estimation and the emission factors of the pollutants for each source group are recalculated.

The calculations always follow the same procedure. Important elements are the specific limit values of the 13<sup>th</sup> and 17<sup>th</sup> BImSchV as well as the distribution of the plants according to their rated thermal input (RTI) in megawatts (MW). In addition, it is assumed that all new and existing plants correspond at least to the standard of the upper range of the associated BAT conclusions. The lower emission factor out of both calculations is then compared with the reference value. If the recalculated emission factor of the source category under consideration is greater than the current reference value, the reference value from the 2024 submission will be updated unchanged. If the reference value is higher, the new value is set and projected<sup>1)</sup>.

According to expert estimates, the plant inventory is split as in Table 5 according to the RTI (in MW). These (cumulative) proportions are necessary for the calculation of the mean values in relation to the upper range of limit values for each source category and pollutant.

**Table 5: Proportionate inventory of LCPs according to their power range**

| RTI in MW | Proportion |
|-----------|------------|
| <100      | 4.5 %      |
| 100-300   | 14.5 %     |
| 300-1000  | 68 %       |
| >1000     | 13 %       |

The limit values of LCP are set according to their power ranges. The table shows the estimated proportion of LCP in Germany in relation to the RTI provided.

**Example 1**

The concrete procedure is illustrated using the example of NO<sub>x</sub> emissions from the use of raw lignite as fuel for heat generation in public district heating plants.

The specific BAT-associated emission levels for lignite can be found in Commission Implementing Decision (EU) 2017/1442 BAT 20. With a reference oxygen of 6%, the plants are differentiated according to size and specified with the emission levels in mg/Nm<sup>3</sup>. The upper end of the emission levels is interpreted as a maximum limit value and converted into kg/TJ using the specific conversion factor of 2.40 (see Table 4). The calculated maximum limit value is therefore averaged for each plant size, taking into account the number of plants, and thus, the estimated value for the necessary NO<sub>x</sub> emission factor for compliance with the maximum limit value is calculated in accordance with the BAT conclusions. The necessary data can be found in Table 6. This shows the plants subdivision according to their RTI with the assigned maximum limit values as annual averages in mg/Nm<sup>3</sup> and kg/TJ.

**Table 6: Emission limit values (annual averages) when using raw lignite in existing plants**

| Plant size according to RTI in MW | max limit value in mg/m <sup>3</sup> | max limit value in kg/TJ | Proportion |
|-----------------------------------|--------------------------------------|--------------------------|------------|
| <100                              | 270                                  | 112.70                   | 4.5 %      |
| 100-300                           | 180                                  | 75.13                    | 14.5 %     |
| >300                              | 175                                  | 73.04                    | 81 %       |

The LCP emission limit values for the use of raw lignite are regulated in (EU) 2017/1442 BAT 20. There are separate limit values for each RTI of the plant. The upper range is shown here as a limit value for existing plants as annual averages in mg/Nm<sup>3</sup> and kg/TJ.

The implied emission factor is calculated as follows:

$$EF_{\text{lignite}} = 112.70 \frac{\text{kg}}{\text{TJ}} \cdot 4.5\% + 75.13 \frac{\text{kg}}{\text{TJ}} \cdot 14.5\% + 73.04 \frac{\text{kg}}{\text{TJ}} \cdot 81\% = 75.13 \frac{\text{kg}}{\text{TJ}}$$

The comparison with the current submission 2024 shows that the calculated emission factor (75.13 kg/TJ) is lower than that of the reference value from 2022 (76.8 kg/TJ). Thus from 2025 onwards the emission factor will be replaced by the new value and used for the projection.

This procedure is analogous for the evaluation of all source groups and pollutants.

### Example 2

According to the Commission Implementing Decision (EU) 2017/1442 of 31<sup>st</sup> July 2017 on Conclusions on Best Available Techniques (BAT) according to Directive 2010/75/EU of the European Parliament and of the Council for large combustion plants, the maximum permissible pollutant emission for NO<sub>x</sub> while using heavy fuel oil in plants <100 MW is 270 mg/Nm<sup>3</sup> and in plants >100 MW is 110 mg/Nm<sup>3</sup> as yearly average for existing plants with more than 1,500 operating hours per year (BAT 28).

13<sup>th</sup> BImSchV in the version of 2021 sets limit values for NO<sub>x</sub> as 270 ng/Nm<sup>3</sup> in plants <100 MW with more than 1500 operating hours per year and 400 mg/Nm<sup>3</sup> in plants <100 MW with less than 1,500 operating hours per year. For existing plants >100 MW 270 mg/Nm<sup>3</sup> and for new plants >100 MW 110 mg/Nm<sup>3</sup> are set. The values are converted into kg/TJ according to the specific flue gas volume of heavy fuel oil (Table 4).

Assuming a 50% share of plants within each size class, lacking specific data, from 2030 onwards a projected implied NO<sub>x</sub> emission factor of 58.0 kg/TJ results after conversion as indicated in the following equation:

$$EF_{\text{heavy fuel oil}} = \left(400 \frac{\text{mg}}{\text{Nm}^3} \div 3.39\right) \cdot 4.5\% \cdot 0.5 + \left(270 \frac{\text{mg}}{\text{Nm}^3} \div 3.39\right) \cdot 4.5\% \cdot 0.5 + \left(270 \frac{\text{mg}}{\text{Nm}^3} \div 3.39\right) \cdot 95.5\% \cdot 0.5 + \left(110 \frac{\text{mg}}{\text{Nm}^3} \div 3.39\right) \cdot 95.5\% \cdot 0.5 = 58.0 \frac{\text{kg}}{\text{TJ}}$$

Thus, the maximum emission quantity is applicable law and is below the inventory emission factor for the reference year 2022 under conservative assumptions and therefore assigned to the WM scenario for 2030 and beyond. The emission factor for 2025 was linearly interpolated between 2022 and 2030.

### Special features of the evaluation of the emission factors

When using liquid fuels (specified in the database as “other mineral oil products”) in LCP, the specific conversion factor of 3.39 (see Table 4) is used for the assessment of NO<sub>x</sub> emissions, analogous to heavy fuel oil.

When calculating the potential SO<sub>2</sub> emissions from source group “Mitverbrennung in öffentlichen Fernheizwerken” and “Mitverbrennung in öffentlichen Kraftwerken” for other liquid fuels, a clear distinction is made in the 17<sup>th</sup> BImSchV between existing plants and new plants. The implied emission limit value of existing plants is 78.44 kg/TJ. It is assumed that by 2040 all plants will correspond to the latest technology and will therefore from 2040 onwards retain at least the limit value for new plants, estimated at 61.81 kg/TJ.

### Reduction in large combustion plants burning lignite through the coal phase-out:

The German Coal Power Generation Termination Act (“Kohleverstromungsbeendigungsgesetz”) from August 2020, last modified in December 2023, stipulates to gradually phase out coal power plants burning lignite until 31<sup>st</sup> December 2038, in the Rhenish coalfields until 31<sup>st</sup> March 2030.

However, the electricity market simulation assumes a market-driven coal exit until 2031. As a result, there is no further mitigation potential of an accelerated coal phase-out, as estimated in the WAM scenario of the NAPCP 2023. Projection of the activity rates was taken from the WEM scenario (MMS) of the “Treibhausgas-Projektionen 2024 für Deutschland” and disaggregated to the German lignite mining districts within the project as shown in Table 7.

Table 7: Primary energy use for lignite in LCP (>50 MW) according to the WEM scenario of the “Treibhausgas-Projektionen 2024 für Deutschland” in the years 2022 to 2040

| District        | Primary Energy Use<br>2022 | Primary Energy Use<br>2025 | Primary Energy<br>Use 2030 | Primary Energy<br>Use 2035 | Primary Energy<br>Use 2040 |
|-----------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
|                 | in TJ                      | in TJ                      | in TJ                      | in TJ                      | in TJ                      |
| Lausitz         | 365,425                    | 272,958                    | 0                          | 0                          | 0                          |
| Central Germany | 176,494                    | 160,652                    | 1,885                      | 0                          | 0                          |
| Rhineland       | 521,039                    | 283,443                    | 6,028                      | 0                          | 0                          |
| <b>Total</b>    | <b>1,062,958</b>           | <b>717,053</b>             | <b>7,913</b>               | <b>0</b>                   | <b>0</b>                   |

Emission factors of public heating and thermal power plants for NO<sub>x</sub> are therefore reassessed. When calculating the NO<sub>x</sub> emission factors as a result of the phase-out, the districts of Central Germany, Lausitz and Rhineland are considered separately. The individual districts will be subdivided into their existing power plants.

For each power plant, the total activity rate and the emission factors for NO<sub>x</sub> for the years 2004 to 2017 in TJ or kg/TJ according to the 2020 submission are adopted as data basis. In order to take into account fluctuations in the emission factors, the emission factors are averaged per plant over the last years, in which no new blocks went into operation (e.g. Block R of Boxberg IV in the Lausitz district started continuous operation in 2012). In addition, the mean value for all power plants in a district is calculated for the formation of the implied emission factor by weighting according to their activity rates. Hence, each district is assigned a current implied emission factor. With the shutdown of the last block of a power plant, this plant is considered to be shut down and from this point in time it is no longer included in the calculation of the implied emission factor of a specific district.

### Reduction in small combustion installations through the 1<sup>st</sup> BImSchV and funding programmes:

The amendment of the Building Energy Act (Gebäudeenergiegesetz – GEG) of 16<sup>th</sup> October 2023 was assumed to further incentivise the use of solid biomass for heat generation in the building sector. Hence, potential increase in PM emissions was estimated in the WAM scenario of the NAPCP 2023. Estimation of the potential effects of the GEG was incorporated in the WEM scenario (MMS) of the “Treibhausgas-Projektionen 2024 für Deutschland” and is therefore part of the current WM scenario.

On the other hand, reductions of dust emission factors from small combustion installations are assumed in the NFR sectors 1.A.4 and 1.A.5 through the implementation of the 1<sup>st</sup> BImSchV flanked by several funding programmes, last the “Bundesförderung effiziente Gebäude” (BEG)<sup>2)</sup>. The calculation of the future emission factors is based on the projection of the “Energiewende” scenario (EWS) from Tebert et al. (2016)<sup>1)</sup>, while the current underlying projection is containing a greater use of solid biomass in 2030 than the EWS. The developments in the area of small combustion installations, in particular the development of fuel use and the existing plant inventory, are difficult to assess and emission calculation is fraught with uncertainties. According to expert assessments, with an increase of solid biomass use, the implied emission factor will further decrease as the share of newer and cleaner installations will go up.

Based on the inventory, a distinction is only made between households (“Haushalte” (HH)) and commerce, trade, services (“Gewerbe, Handel, Dienstleistungen” (GHD)), but the calculation of the emissions factors is further sub-divided in several installation type categories of local space heaters and solid fuel boilers, with different emission limit values set by the 1<sup>st</sup> BImSchV and additional funding requirements changing from time to time. Resulting emission factors for TSP (total suspended particles) used in the WM scenario are shown in Table 8.

Table 8: TSP emission factors in small combustion installations for solid biomass in the WM scenario

| sub-sector                             | 2022 in kg/TJ | 2025 in kg/TJ | 2030 in kg/TJ | 2040 in kg/TJ | 2050 in kg/TJ |
|----------------------------------------|---------------|---------------|---------------|---------------|---------------|
| <b>households (HH)</b>                 | 59.5          |               |               |               |               |
| 1 <sup>st</sup> BImSchV + funding      |               | 47.2          | 44.7          | 39.4          | 39.4          |
| <b>commerce, trade, services (GHD)</b> | 37.4          |               |               |               |               |
| 1 <sup>st</sup> BImSchV + funding      |               | 26.8          | 25.4          | 22.7          | 22.7          |

For calculation of PM<sub>2.5</sub> and PM<sub>10</sub> emission factors, specific shares per installation type category were used. For 2030 the proportions of PM<sub>10</sub> and PM<sub>2.5</sub> in TSP (total suspended particles) are given in Table 9.

Table 9: Proportions of PM<sub>10</sub> and PM<sub>2.5</sub> in TSP in 2030 for solid biomass small combustion installations

| sub-sector                             | PM <sub>10</sub> /TSP in % | PM <sub>2.5</sub> /TSP in % |
|----------------------------------------|----------------------------|-----------------------------|
| <b>households (HH)</b>                 | 95                         | 88                          |
| <b>commerce, trade, services (GHD)</b> | 98                         | 93                          |

### Reduction in industrial processes through low-dust filter technology in sinter plants:

The assumed potential for reducing dust emissions from sinter plants is taken from the final report of the UBA project LUFT 2030 (Jörß et al., 2014)<sup>2)</sup>, where measure P 009 results in dust emissions of less than 10 mg/Nm<sup>3</sup> due to better filter technology, which was assumed to correspond to 66.7 g dust per ton sinter. The affected time series are assigned to the NFR sector 2.C.1. According to the LUFT 2030 project, this technology also causes new split factors for the calculation of PM<sub>2.5</sub> and PM<sub>10</sub>.

The emission factor for PM<sub>10</sub> is calculated by dividing the emission factor for dust by the split factor for PM<sub>10</sub> (0.9). Consequently, the emission factor for PM<sub>2.5</sub> is calculated by dividing the emission factor for dust by the split factor for PM<sub>2.5</sub>.

(0.84).

The calculated emission factors are assumed to be fully achieved in practice in the year 2030 and are used for the WM scenario.

### Reduction in medium combustion plants through implementation of the 44<sup>th</sup> BImSchV:

Medium combustion plants (MCP), including gas turbines and combustion engine plants are regulated by the national 44<sup>th</sup> BImSchV, which implemented the MCP directive (EU) 2015/2193 into national law and entered into force in June 2019, and are therefore part of the WM scenario. The underlying limit values of the emission calculation are taken from the 44<sup>th</sup> BImSchV. The measure leads to a reduction in the emission factors of the affected time series in several NFR sectors under 1.A.

The data basis for the calculation is the submission 2024. The source categories are reassessed separately according to the pollutants and the relevant fuel inputs. The expected average years in service plants are taken into account (see Table 11) as well as a distinction between old and new plants and the rated thermal input (RTI) of the plants in MW (see Table 10). Table 10 shows the plant split for various fuels taking into account the RTI.

Table 10: Proportional plant split of the MCP according to fuel consumption and RTI

| Plant split according to fuel consumption | RTI in MW | Proportion |
|-------------------------------------------|-----------|------------|
| <b>Biomass</b>                            | 1-5       | 11 %       |
|                                           | 5-20      | 30 %       |
|                                           | 20-50     | 59 %       |
| <b>Lignite</b>                            | 1-20      | 95.8 %     |
|                                           | 20-50     | 4.2 %      |
| <b>Hard coal</b>                          | 1-20      | 90.2 %     |
|                                           | 20-50     | 9.8 %      |
| <b>Heavy fuel</b>                         | 5-20      | 68.0 %     |
|                                           | 20-50     | 32.0 %     |

The limit values of the MCP are specified in the 44<sup>th</sup> BImSchV according to their performance ranges. The table shows the estimated proportion of MCP in Germany in relation to the RTI provided and the fuel input used.

Table 11: Expected service life of MCP according to type of plant, pollutant and fuel use

|                                                           | Expected average service life |
|-----------------------------------------------------------|-------------------------------|
| <b>Combustion plants - solid fuels</b>                    | 20 years                      |
| <b>Combustion plants - liquid and gaseous fuels</b>       | 15 years                      |
| <b>gas and steam turbines (GuD) and gas turbines (GT)</b> | 22 years                      |
| <b>internal combustion engines - biogas</b>               | 5 years                       |
| <b>internal combustion engines - other fuels</b>          | 10 years                      |

The new emission factors are always calculated according to the same pattern. The limit values of the 44<sup>th</sup> BImSchV are weighted for each RTI range of the plants and calculated for old and new plants. Assuming that a constant rate of existing plants, depending on the assumed average lifetime, is renewed or upgraded annually, the weighting of the limit values for new plants for the projections in 2025, 2030, 2035, 2040, 2045 and 2050 is increased or, depending on the expected average lifetime of the plant category, only the limit values for new plants are taken into account.

If the current emission factor from the 2022 submission undercuts the calculated value, the current reference value is kept for the projection because it is already below the 44<sup>th</sup> BImSchV and thus complies with the limit values. The recalculated values for the time series, reflecting the maximum permitted limit values, are assigned to time series in all other cases where the current emission factor is above the 44<sup>th</sup> BImSchV.

#### Example:

The exact procedure is exemplified by the NO<sub>x</sub> emission factors when using other solid biomass (than wood) as fuel. The procedure is in principle the same for all pollutants and fuels.

The basis for the calculation is the maximum annual average amount of NO<sub>x</sub> emissions per cubic meter permitted in the 44<sup>th</sup> BImSchV §10 (4) and (15) when using other solid biomass (than wood) as fuel (Table 12). After conversion with the specific conversion factor for lignite, assumed as similar to other solid biomass, of 2.39 (see Table 4), the limit values for old and new plants are available in kg/TJ. Table 12 shows the NO<sub>x</sub> limit values as annual average for solid biomass according to the RTI range for old and new plants in mg/Nm<sup>3</sup> and kg/TJ.



Table 12: NO<sub>x</sub> limit values for other solid biomass (than wood) in MCP according to the RTI for old and new plants

| Fuel                            | Plant    | NO <sub>x</sub> limit value according to 44 <sup>th</sup> BImSchV in mg/Nm <sup>3</sup> |     |     | NO <sub>x</sub> limit value in kg/TJ |       |       |
|---------------------------------|----------|-----------------------------------------------------------------------------------------|-----|-----|--------------------------------------|-------|-------|
|                                 |          | RTI in MW                                                                               |     |     | RTI in MW                            |       |       |
|                                 |          | 1-5                                                                                     | >5  | >20 | 1-5                                  | >5    | >20   |
| other solid biomass (than wood) | existing | 600                                                                                     |     | 370 | 250.4                                |       | 154.4 |
| other solid biomass (than wood) | new      | 370                                                                                     | 300 | 200 | 154.4                                | 125.2 | 83.5  |

Limit values for solid biomass in MCP for old and new plants according to the 44th BImSchV in mg/Nm<sup>3</sup> and kg/TJ.

It is assumed that the average service life of the plants is 20 years (Table 11). In addition, it is assumed that a constant annual renewal of the plant will be implemented after the 44<sup>th</sup> BImSchV comes into force in 2019 and that the limit values for new plants getting greater weight each year.

According to the assumption in 2025 (6 years after the regulation came into force) there is a proportion of 6/20 which fulfil the requirements of new plants and 14/20 which adhere to the limit values of existing plants. In 2030, eleven years after the 44<sup>th</sup> BImSchV was introduced, the proportion of new plants is 11/20 compared to 9/20 existing plants. After 16 years in 2035, the limit value for new plants is included in the calculation with 16/20. From 2040 only the limit value for new plants is assumed, as it is 21 years after the 44<sup>th</sup> BImSchV has entered into force.

Taking into account the plants proportions per size measured in RTI in WM (Table 10), a new emission factor of 166.8 kg/TJ for 2025 results, as shown in (3).

$$(3) \text{ emission factor (other solid biomass than wood in 2025)} = 14/20 * \{(11 \% + 30 \%) * 250.4 \text{ kg/TJ} + 59 * 154.4 \text{ kg/TJ}\} + 6/20 * \{11 \% * 154.4 \text{ kg/TJ} + 30 \% * 125.2 \text{ kg/TJ} + 59 \% * 83.5 \text{ kg/TJ}\} = 166.8 \text{ kg/TJ}.$$

Since the maximum reference value from the 2024 submission for the year 2022 (137.5 kg/TJ) is already below the calculated limit, it will be kept constant for the year 2025. For 2030 as well, as the calculated limit of 144.3 kg / TJ in 2030 is still above the reference emission factor in 2022. The procedure for calculating the emission factor in 2035 is identical and is shown in (4).

$$(4) \text{ emission factor (other solid biomass than wood in 2035)} = 4/20 * \{(11 \% + 30 \%) * 250.4 \text{ kg/TJ} + 59 \% * 154.4 \text{ kg/TJ}\} + 16/20 * \{11 \% * 154.4 \text{ kg/TJ} + 30 \% * 125.2 \text{ kg/TJ} + 59 \% * 83.5 \text{ kg/TJ}\} = 121.8 \text{ kg/TJ}$$

In 2035 the newly calculated limit value will be below the reference value, so that the calculated one is assumed as the new implied NO<sub>x</sub> emission factor.

#### Special Feature:

When calculating the NO<sub>x</sub> emission factors for using lignite and hard coal as fuel, the plant split is only differentiated according to the RTI of less than 20 MW and greater than 20 MW. The limit values given in the 44<sup>th</sup> BImSchV are differentiated according to 1-5 MW, 5-20 MW and more than 20 MW.

As a result, the assumption was made that the plant split between 1-5 MW and 5-20 MW in equal proportions would be valued with a factor of 0.5.

According to the 44<sup>th</sup> BImSchV § 16, the emission limit values for combustion engines will only apply from 1<sup>st</sup> of January 2025 on, so that the assumption of the partial renewal of plants will only apply from 2025 on. As a result, the reference values from the 2022 submission will be kept constant for 2025 and calculation of implied emission factors considering the limit values for new plants starts from the year 2025.

<sup>1)</sup> Tebert et al. (2016): Tebert, C., Volz, F., Töfke, K. (2016): Development and update of emission factors for the National Inventory regarding small and medium-size combustion plants of households and small consumers, on behalf of the Umweltbundesamt, Project-Nr. 3712 42 313 2

<sup>2)</sup> Jörß et al. (2014): Jörß, W., Emele, L., Scheffler, M., Cook, V., Theloke, J., Thiruchittampalam, B., Dünnebeil, F., Knörr, W., Heidt, C., Jozwicka, M., Kuenen, J.J.P., Denier van der Gon, H.A.C., Visschedijk, A.J.H., van Gijlswijk, R.N., Osterburg, B., Laggner, B., Stern, R., Handke, V. (2014): Luftqualität 2020/2030: Weiterentwicklung von Prognosen für Luftschadstoffe



unter Berücksichtigung von Klimastrategien, on behalf of the Umweltbundesamt, Project-Nr. 3710 43 219, UBA-Texte 35/2014, <https://www.umweltbundesamt.de/publikationen/luftqualitaet-20202030-weiterentwicklung-von>; ISSN 1862-4804, Dessau-Roßlau, July 2014

<sup>1)</sup>

Methodology and calculations for large combustion plants are based on Jakobs, H., Schneider, C., Handke, V. (2019): NEC-Richtlinie: Weiterentwicklung von Prognosen für Luftschadstoffe für nationale Luftreinhalteprogramme, Project-Number FKZ 3716512020, on behalf of the German Environment Agency (UBA).

<sup>2)</sup>

<https://www.energiewechsel.de/KAENEF/Redaktion/DE/FAQ/FAQ-Uebersicht/Richtlinien/bundesfoerderung-fuer-effiziente-gebaeude-beg.html>

## Additional measures that have not yet been implemented are assigned to the WAM scenario

### Optional amendment of the 13<sup>th</sup> BImSchV

The German Federal Government declared in its current NAPCP 2023, that an optional amendment of the 13<sup>th</sup> BImSchV will be considered for solid (other than coal), liquid and biogenic fuels in case there is non-compliance with the reduction commitment for NO<sub>x</sub> projected. Because it is very difficult to define all solid (other than coal), liquid and biogenic fuel uses in installations falling under 13<sup>th</sup> BImSchV in the inventory database, as there is often not only one single fuel used in those installations or complex calculations for an overall emission limit value of all installations falling under one facility (e. g. for refineries) are necessary, only for three exemplary categories of installations a hypothetical NO<sub>x</sub> mitigation potential was quantified. This follows a conservative approach and does not anticipate any political decision. Thus, in the updated WAM scenario reported in 2025 mitigation potential is only assumed for 2035 at the earliest.

- **potential NO<sub>x</sub> reduction in pulp and paper production through an optional amendment of the 13<sup>th</sup> BImSchV:**

According to the existing 13<sup>th</sup> BImSchV (as of 2021), different maximum amounts of NO<sub>x</sub> emissions are permitted according to the production process (sulphate and sulphite process) and the size of the plant (measured in RTI in MW) in pulp and paper production (NFR sector 2.H.1).

It is assumed for the sulfite process that all plants located in Germany are operated with an RTI of 50-300 MW. A maximum emission factor of 300 mg/Nm<sup>3</sup> for all plants according to the 13<sup>th</sup> BImSchV is assumed for the further calculation of the reduction potential. The NO<sub>x</sub> emission factor for the sulfite process was taken over from the 2024 submission in the year 2010, which is 2 kg/t. The new emission factor results from the historic emission factor (2 kg/t) and the maximum emission value proposed for the optional amendment (85 mg/Nm<sup>3</sup>) divided by the calculated mean value of the currently applicable law (300 mg/Nm<sup>3</sup>). This results in an emission factor of 0.57 kg/t for 2035 onwards as shown in (5).

$$(5) \text{ implied NO}_x \text{ emission factor (sulfite process)} = (2 \text{ kg/t} * 85 \text{ mg/Nm}^3) / 300 \text{ mg/Nm}^3 = 0.57 \text{ kg/t}$$

In the field of the sulfate process (also known as kraft process) a weighted maximum average emission factor according to the limit values of the 13<sup>th</sup> BImSchV was assumed as shown in equation (6).

$$(6) \text{ implied NO}_x \text{ emission factor (sulfate process)} = 0.36 * 250 \text{ mg/Nm}^3 + 0.64 * 200 \text{ mg/Nm}^3 = 217.78 \text{ mg/N}^3$$

The implied emission factor for the sulphate process was taken over from the 2024 submission in the year 2010. The new emission factor results from dividing the 2010 emission factor and the maximum emission value proposed for the optional amendment of the 13<sup>th</sup> BImSchV by the calculated mean value of the currently applicable law. This results in an emission factor of 0.68 kg/t for 2035 onwards as shown in equation (7).

$$(7) \text{ implied NO}_x \text{ emission factor (sulfate process)} = (1.75 \text{ kg/t} * 85 \text{ mg/Nm}^3) / 217.78 \text{ mg/Nm}^3 = 0.68 \text{ kg/t}$$

- **potential NO<sub>x</sub> reduction in refineries through an optional amendment of the 13<sup>th</sup> BImSchV:**

An optional amendment of the 13<sup>th</sup> BImSchV would lead to emission reductions in the area of refineries and is assigned to the WAM scenario. It causes a reduction in the emission factors in the affected time series of the NFR sector 1.A.1.b. A distinction must be made between refinery plants and the fuel input used by them. For plants using crude oil (naphtha), light heating oil or other petroleum products, the proposed NO<sub>x</sub> limit value is set to 85 mg/Nm<sup>3</sup> and adopted as the future maximum emission level. Some refineries in Germany get permission by applying a so-called bell rule, whereby individual parts of the plant are allowed to exceed fuel specific limit values, if the facility in total for all installations and used fuels complies with an average limit value calculated with the help of a so-called bell curve.

For plants where a future limit value of 85 mg NO<sub>x</sub>/Nm<sup>3</sup> is assumed, conversion factors based on specific flue gas volumes for heavy fuel oil or light heating oil (Table 4) were used to convert to kg NO<sub>x</sub>/TJ, shown in equation (8) for the example of refinery underfiring in LCP with light heating oil as fuel.

$$(8) \text{ implied NO}_x \text{ emission factor (refinery underfiring with light heating oil)} = 85 \text{ mg/Nm}^3 / 3.49 = 24.4 \text{ kg/TJ}$$

This results in future NO<sub>x</sub> emission factors of 24.4 kg/TJ for light heating oil and 25.1 kg/TJ for other petroleum products from 2035 onwards.

For all plants that are assumed to use permission by applying the so-called bell rule, the potential effect of integrating a NO<sub>x</sub> limit value of 85 mg/Nm<sup>3</sup> for a part of the fuels used in such plants was quantified by estimating a relative reduction. Therefore, it was assumed that the current mean emission factor for one exemplary refinery permitted by using the so-called bell rule is 274.75 mg/Nm<sup>3</sup>. The application of the proposed future limit value for all solid (other than coal), liquid and biogenic fuels used in this plant will lead to a mean emission factor of this specific refinery of 189.75 mg/Nm<sup>3</sup>. This results in a relative reduction of 69 percent, as shown in equation (9)

$$(9) \text{ percentage NO}_x \text{ emission reduction (specific refinery)} = 1 - (189.75 \text{ mg/Nm}^3 / 274.75 \text{ mg/Nm}^3) = 0.69$$

This exemplary relative reduction was then assumed to apply for all refineries permitted by using the so-called bell rule from 2035 onwards. Therefore, the current emission factor in the inventory out of submission 2024 is multiplied with this relative reduction. As an example, the resulting emission factor applied from 2035 onwards for refinery underfiring with heavy fuel oil is shown in equation (10).

$$(10) \text{ NO}_x \text{ emission (refinery underfiring with heavy fuel oil)} = 118 \text{ kg/TJ} * (1 - 0.69) = 36.5 \text{ kg/TJ}$$

- **potential NO<sub>x</sub> reductions in other large combustion plants through an optional amendment of the 13<sup>th</sup> BImSchV:**

Emissions from other LCPs, which emerge from the energy balances and cannot be clearly assigned to a specific fuel use or fuel mix, but also show a reduction potential by an optional amendment of the 13<sup>th</sup> BImSchV are assigned to the NFR sectors 1.A.1.a, 1.A.1.c and 1.A.2.g.viii and a potential reduction in the NO<sub>x</sub> emission factors was estimated.

The NO<sub>x</sub> emission factors for all non-gaseous materials other than coal for electricity and heat generation are considered and the maximum emission value for NO<sub>x</sub> is assumed to be 85 mg/Nm<sup>3</sup> from 2035 onwards. According to the 13<sup>th</sup> BImSchV, only plants with more than 1,500 operating hours per year are taken into account for which the proposed limit value of 85 mg NO<sub>x</sub>/Nm<sup>3</sup> applies. Table 13 shows the estimated relative and absolute plant split of the LCP according to their annual operating time assuming an equal fuel use distribution.

Table 13: Estimated relative and absolute plant split of LCP according to annual operating hours

| operation time | RTI in MW | proportion |
|----------------|-----------|------------|
| < 1500 h/a     | 46573     | 17.8 %     |
| > 1500 h/a     | 214990    | 82.2 %     |
| total          | 261563    | 100 %      |

First, the limit value of 85 mg/Nm<sup>3</sup> is converted into kg/TJ using the fuel specific conversion factor (Table 4). The new emission factor results from the sum of the reduction for the 82.2 per cent of the fuel use with an operating time of more than 1500 h/a and the unchanged value from the 2024 submission for the 17.8 per cent of the fuel use with less than 1500 h/a operating time, that is assumed to be not effected by an optional amendment of the 13<sup>th</sup> BImSchV.

The calculation is shown using the example of the source category of electricity generation in large public power plants using heavy fuel oil (reference value in 2022: 43.5 kg/TJ) in (11), whereby the procedure is analogous for all other source categories.

$$(11) \text{ NO}_x \text{ emission factor (electricity generation in public power plants with heavy fuel oil)} = (85 \text{ mg/Nm}^3 / 3.39) * 82.2 \% + 43.5 \text{ kg/TJ} * 17.8 \% = 28.4 \text{ kg/TJ}$$

### **Emission reduction in small combustion installations by amending the emission limits of the Ecodesign Regulations (EU) 2015/1185 and (EU) 2015/1189:**

Through amendment of the Commission regulation (EU) 2015/1189 with regard to ecodesign requirements for solid fuel boilers, it was assumed that requirements for placing on the market and putting into service solid biomass boilers regarding emissions of particulate matter will be set at 2.5 mg/m<sup>3</sup> TSP from 2027 (measured according to VDI 2066 Sheet 1, May 2021 edition and based on 13 % reference oxygen content).

Through amendment of the Commission regulation (EU) 2015/1185 with regard to ecodesign requirements for solid fuel local

space heaters, it was assumed that requirements for placing on the market and putting into service solid biomass local space heaters regarding emissions of particulate matter will be set at 20 mg/m<sup>3</sup> TSP from 2029 (measured according to VDI 2066 Sheet 1, May 2021 edition and based on 13 % reference oxygen content).

Considering these assumptions and the projected use of solid biomass in small combustion installations in the current WM scenario, a potential emission reduction of 0.8 kt PM<sub>2.5</sub> in 2030, of 1.3 kt in 2035 and of 1.8 kt in 2040 was quantified in the current WAM scenario. The absolute emission mitigation potential in 2030 and onwards very much depends on the projected biomass use as well as the year, when the proposed amendment will apply for new installations. The higher the use of solid biomass in the building sector is projected, the higher the mitigation potential of the proposed amendment of the Ecodesign requirements will be. Less stricter requirements regarding particle emissions in national policies (e. g. funding programmes) will increase the projected emissions in the WM scenario and thus, will also basically increase the mitigation potential of the proposed amendment of the EU ecodesign regulations.

Apart from that, an ambitious EU-wide regulation of PM emissions of small combustion installations will help a lot to comply with the PM<sub>2.5</sub> limit values of the new Ambient Air Quality Directive (EU) 2024/2881<sup>1)</sup> as well as the average exposure reduction obligation for PM<sub>2.5</sub>. Otherwise, the use of solid biomass might have to be banned in certain areas or at least temporarily restricted.

### **Additional reduction in agriculture compared to the German NAPCP 2023:**

For the emission projections submission 2025, in contrast to the emission projections submission 2023 as well as to the German NAPCP 2023, no further mitigation potential has been reported in the current WAM scenario regarding additional measures in the agricultural sector (NFR 3). The support measure to increase the co-fermentation of slurry in biogas production to further reduce GHG emissions of the agricultural sector has been stopped in 2024, and currently there is no other concrete measure under preparation. In addition, the support measure was not very effective due to low adoption rates in the first years until 2024. Therefore, no increase in co-digested slurry is expected above the assumptions in the WM scenario until 2030, and thus no increase of NH<sub>3</sub> emissions from digestates. Without an expected increase of emissions, and on the background of a buffer of roughly 11 (based on inventory submission 2024) respectively 28 kt NH<sub>3</sub> (based on inventory submission 2025) in the current WM scenario in the year 2030, no additional measures are necessary, and no specific WAM for NH<sub>3</sub> is calculated. The assumptions on co-fermentation of slurry in biogas production for the projections on greenhouse gas emissions (submission 2025) are documented in "Treibhausgas-Projektionen 2025 für Deutschland"<sup>2)</sup>.

In addition, the amount of ammonia emissions from the previous year will be checked annually in the future. This should be carried out for ammonia emissions from agriculture as part of the previous year's estimate of greenhouse gas emissions in accordance with Section 5 Paragraph 1 of the Federal Climate Protection Act. The previous year's estimate is based on current statistics on important activity data for the previous year (livestock, N-mineral fertiliser sales) and must be submitted annually by March 15<sup>th</sup>. If the ammonia emissions of the previous year's estimate are above the linear target path according to NEC Directive (EU) 2016/2284, the BMEL, in consultation with the BMUV, will develop a bundle of agricultural measures, that will assure compliance with the linear target path as soon as possible. Because of uncertainties in the emission projections a minimum gap of 10 kt is agreed. If the previous year's estimate in the following year has again a gap of 10 kt or more, the bundle of agricultural measures enters into force immediately.

<sup>1)</sup>

<http://data.europa.eu/eli/dir/2024/2881/oj>

<sup>2)</sup>

see table 116, pages 115-116,

[https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/projektionen\\_2025-instrumentenpapier\\_korr\\_2.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/projektionen_2025-instrumentenpapier_korr_2.pdf)

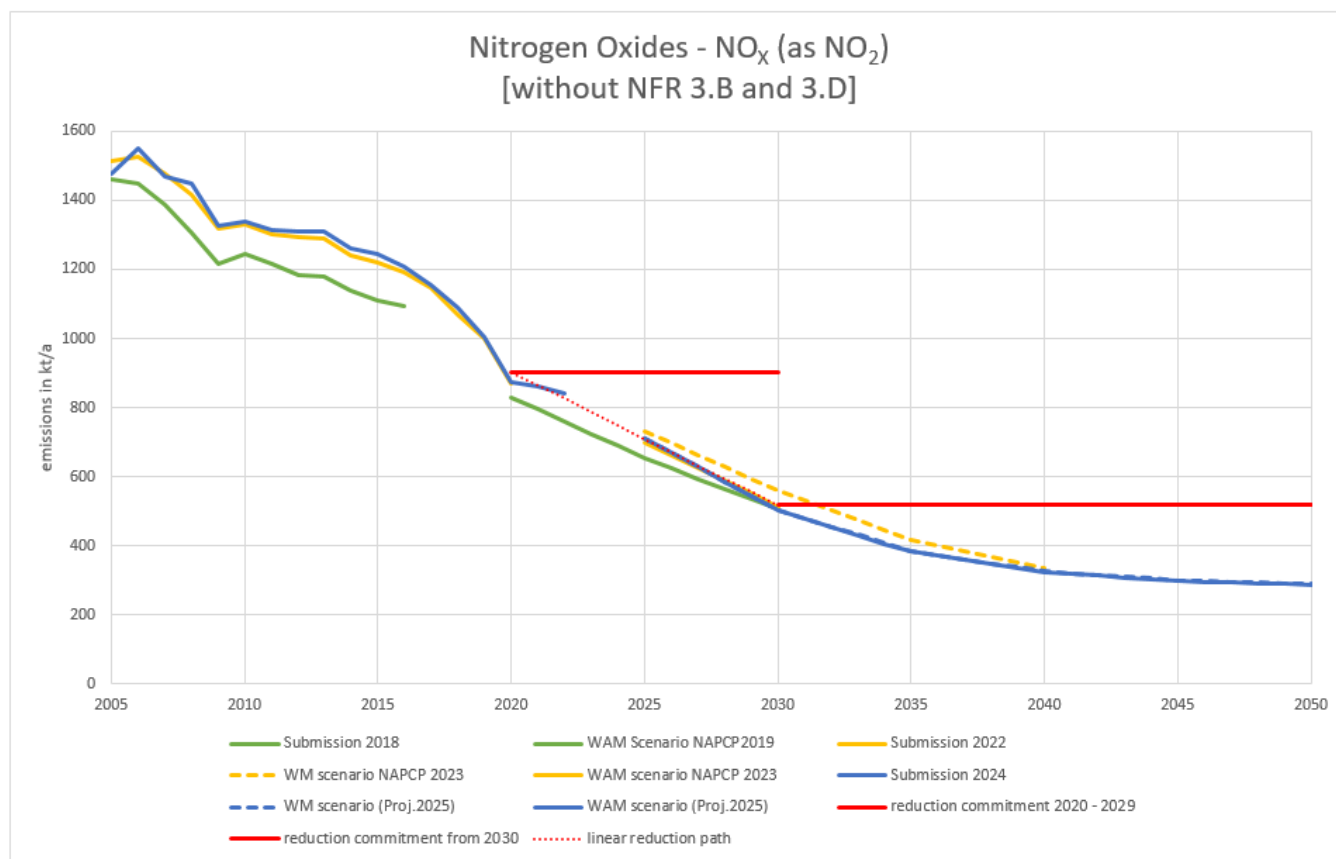
## Recalculations

Due to recalculations in each underlying emission inventory submission, all calculations of emission reduction potentials in the WM and WAM scenario of the respective projection are regularly updated. Furthermore, additional measures that had been included in the WAM scenario in the previous projection can become part of the WM scenario in the current projection, as they were put into force in the meantime (e. g. amendment of the 17<sup>th</sup> BImSchV). In addition, updated GHG emission projections using most recent projections of economic and other parameters result in a new projection of activity rates that needs to be considered for updating the emission projections of air pollutants. For the regular update of the projections under NEC-Directive (EU) 2016/2284, in between the regular update of the National Air Pollution Control Programme every four years, remaining measures in the WAM scenario of the current NAPCP stay and their mitigation potential is reassessed, unless they were dropped by the current federal government. The last is the case for the package of additional agricultural measures in the WAM scenario of the German NAPCP 2023. Thus, it was not reassessed for the current projections.

For each pollutant the following figures show the differences between inventory submissions 2018, 2022 and 2024 for historic emissions as well as the differences between the WAM emission projections reported in 2019 (consistent with the NAPCP 2019), the WM and WAM scenario reported in 2023 (consistent with the NAPCP 2023) and the current WM and WAM scenario reported in 2025. For each pollutant a brief explanation of the most relevant reasons for the occurring differences compared to the previous reporting is given. For explanation of the differences between reporting in 2023 as well as the NAPCP 2023 reported in 2024 and 2021 please see IIR 2024<sup>1)</sup> and for the differences between reporting in 2021 and 2019 please see the IIR of the 2021 reporting<sup>2)</sup>.

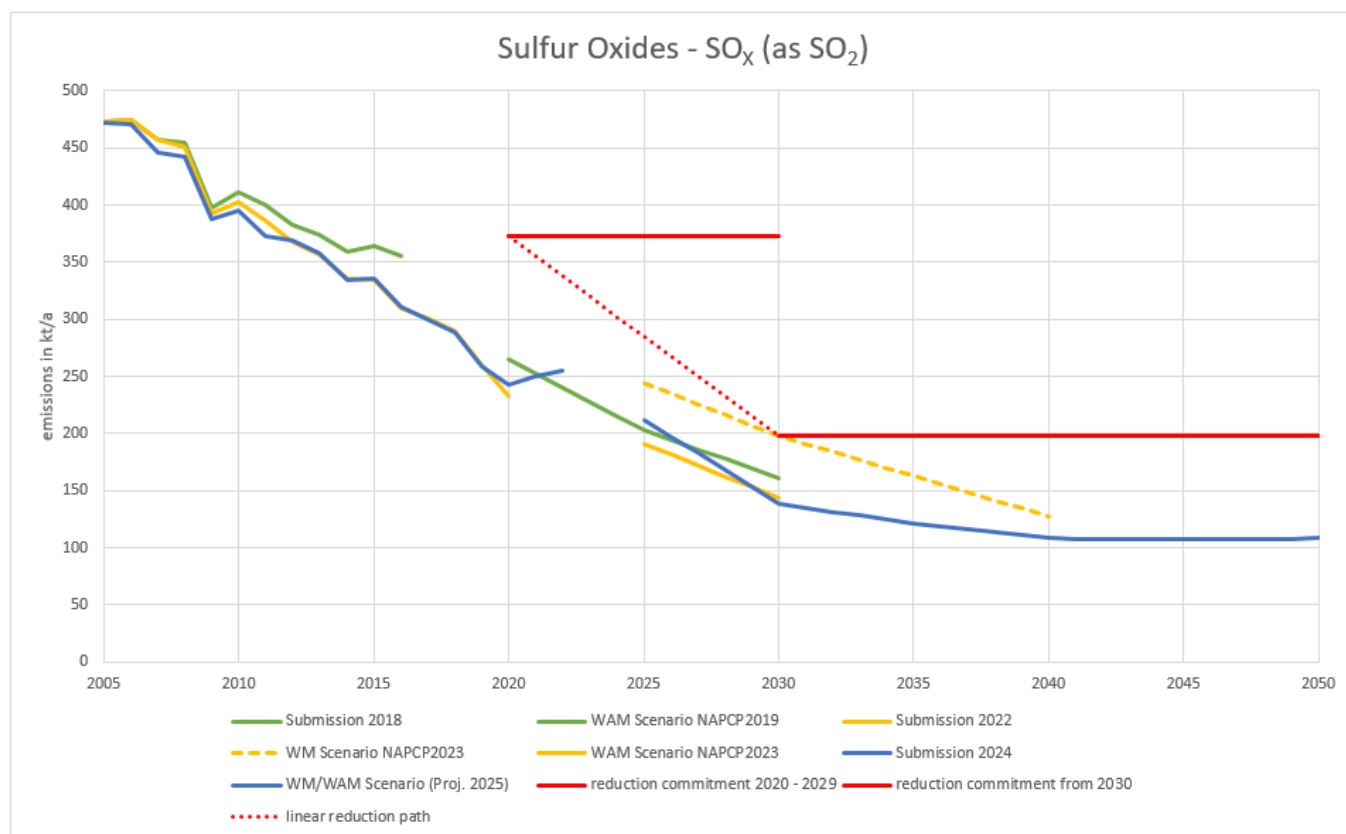
In general, there is not much change in the current projection for **NO<sub>x</sub>**, that needs further explanation. Apart from the recalculations in the inventory since submission 2018, explaining most of the differences in 2025 between the NAPCP 2019 projection and the more current projections, there are two relevant reasons for differences between the current WM projection and the previous WM projection of the NAPCP 2023:

- The coal phase-out until 2030 is now included in the WM projection. To some extent because of legislation that did take place in the meantime and to some extent because of updated assumptions on price development of fuels, prices at the energy market as well as for CO<sub>2</sub>-prices, making especially the power generation from lignite in the remaining capacities less and less economical.
- Second, most measures from the road transport package of the NAPCP 2023 are now part of the WM scenario as they entered into force in the meantime (e. g. amended truck toll, Euro 7 legislation). There is neither further increase of the share of electrically driven mileage for passenger cars nor further increase of the number of passenger cars in the fleet assumed beyond the WM scenario (for description of assumptions in the road transport sector in the current WM scenario see [calculation documentation](#) and referred publications).

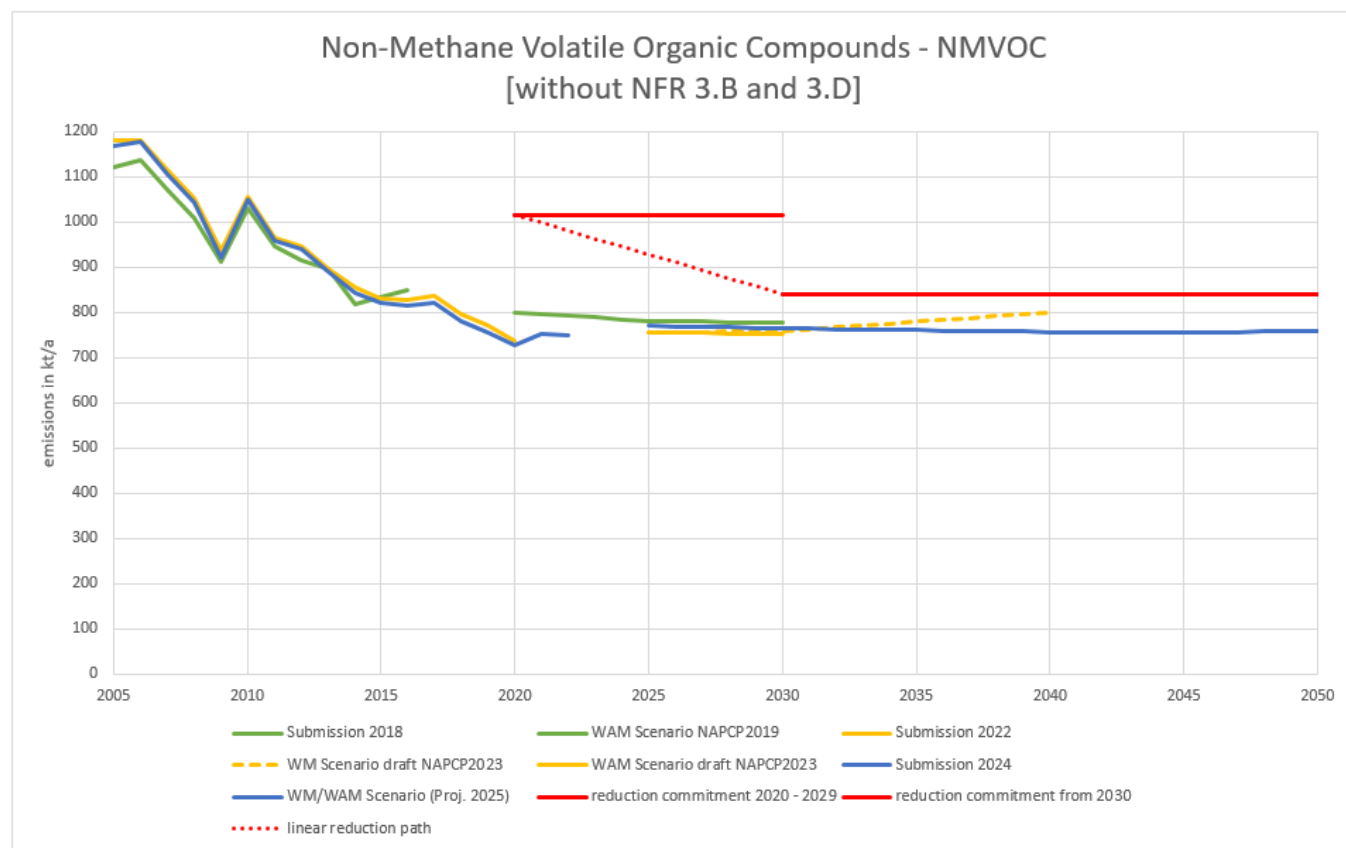


There is also not much change in the current projection for **SO<sub>x</sub>**, that needs further explanation. There is only one relevant reason for differences between the current WM projection and the previous WM projection of the NAPCP 2023:

- The coal phase-out until 2030 is now included in the WM projection. To some extent because of legislation that did take place in the meantime and to some extent because of updated assumptions on price development of fuels, prices at the energy market as well as for CO<sub>2</sub>-prices, making especially the power generation from lignite in the remaining capacities less and less economical. In the WM scenario of the NAPCP 2023 this was assumed to take place until 2038 (see description of the previous WM scenario in the IIR 2024).

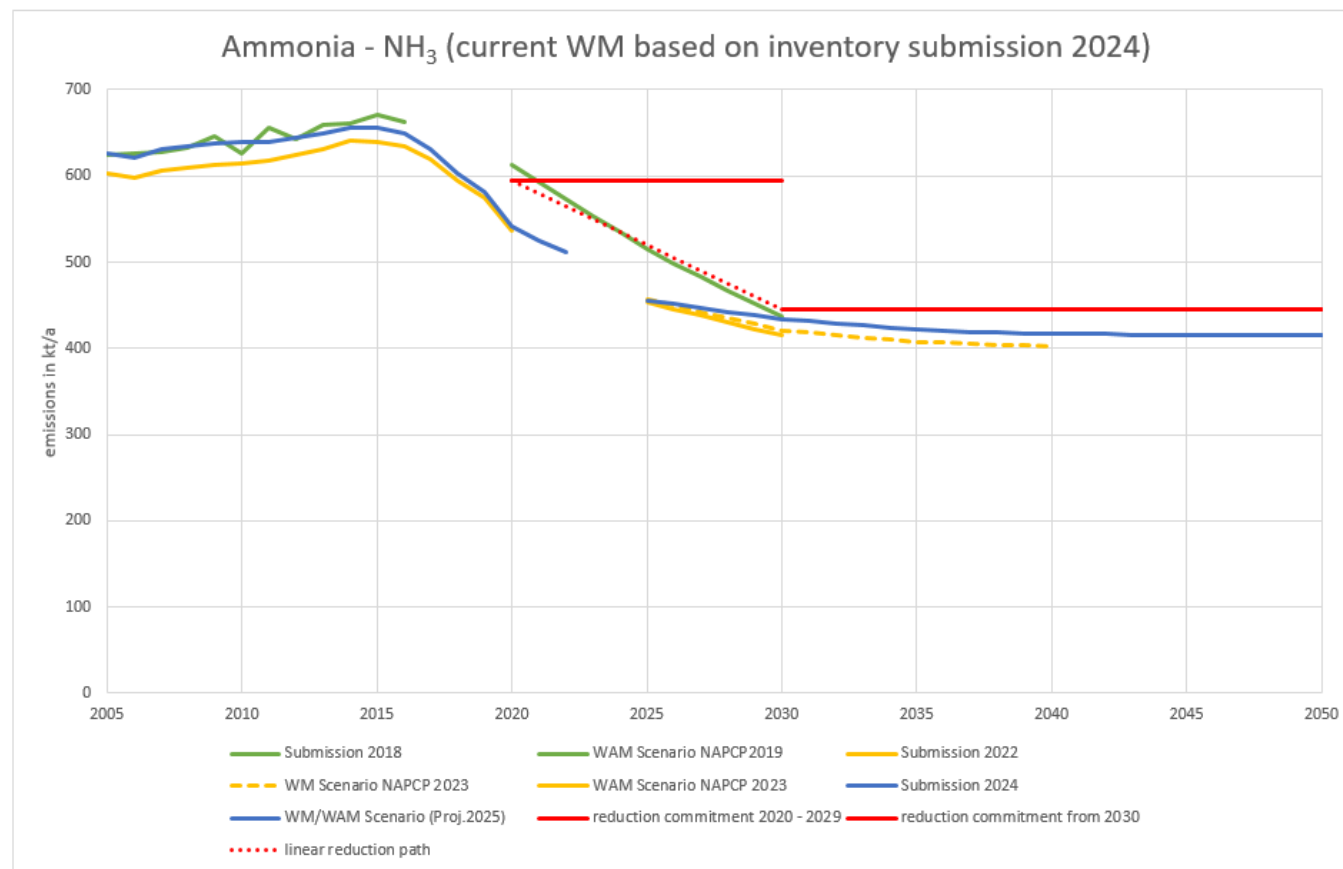


**NM VOC** emission projections are strongly influenced by economic projections. Updates on these are therefore causing changes in NM VOC emission projections. The deviating trend of the current WM projection against the previous WM projection of the NAPCP 2023 is explained in the chapter [calculation documentation](#). However, the latest historic emissions in 2022 are already below the current WM projection for 2025 to 2050, which is caused by decreases over all sectors.

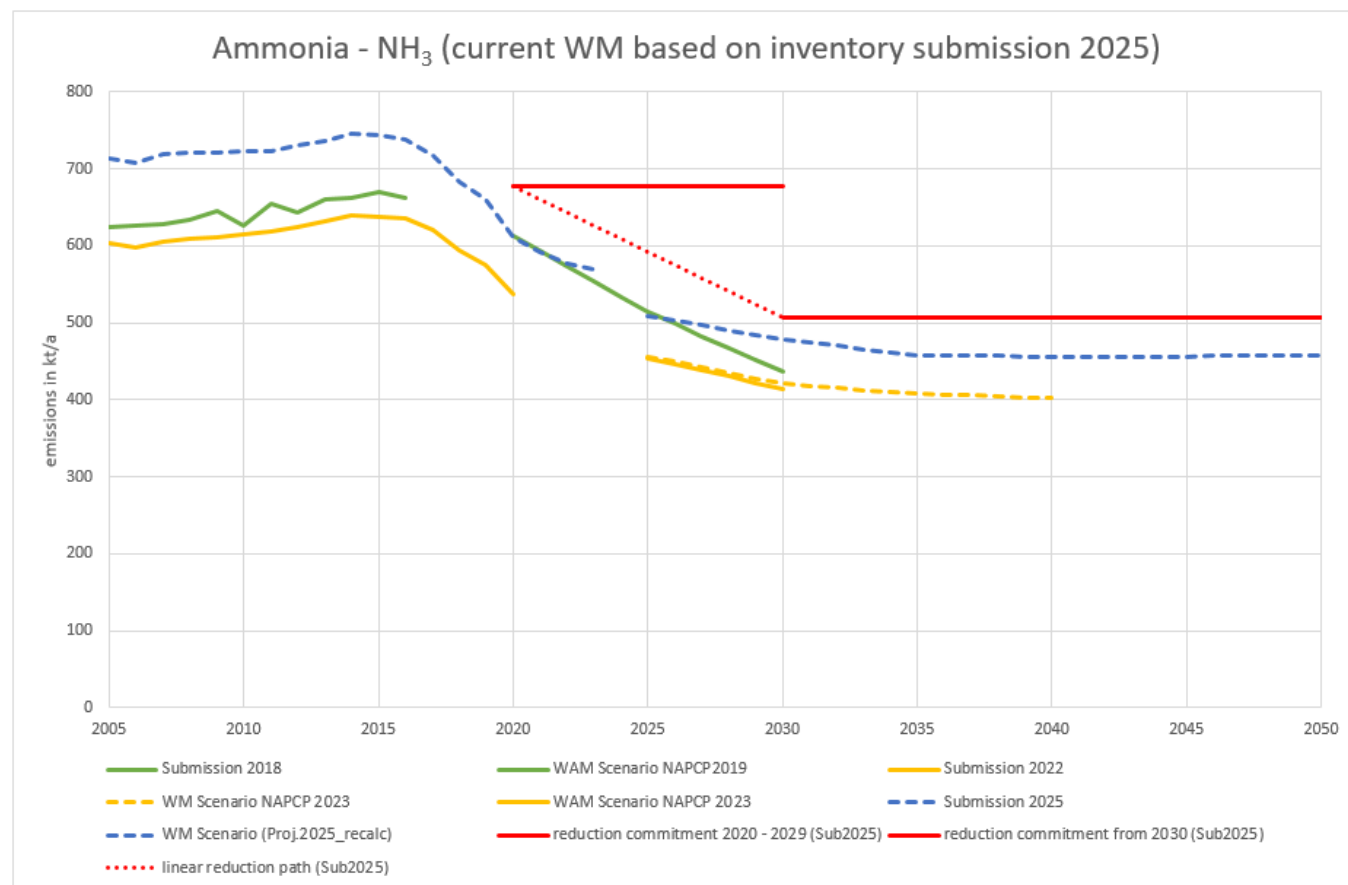


For ammonia (**NH<sub>3</sub>**) two comparisons to previous projections are shown as two WM projections were submitted under NEC-Directive & CLRTAP in 2025, one based on inventory submission 2024 and the other one based on inventory submission

2025 under otherwise identical assumptions. In both cases, from submission 2021 onwards a methodological change in emission calculations for inorganic fertilisers is leading to less variation from one year to another<sup>3)</sup>. Apart from that, current WM projection based on inventory submission 2024 is slightly above the previous WM and WAM scenarios of the NAPCP 2023 in 2030 and beyond as there are slight changes in the assumptions on animal numbers and thus, in the amount of manure and inorganic fertilisers applied. The current WM projection based on inventory submission 2025 is significantly higher, due to recalculations in the inventory. The main reason for higher emissions are adjusted emission factors for various inorganic fertilisers according to the latest EMEP/EEA air pollutant emission inventory guidebook 2023. Development of historic emissions and projections in the current WM scenario (in both variations) is not parallel, as the amount of fertilisers is multiplied with the emission factors and therefore difference in resulting emissions is not linear.

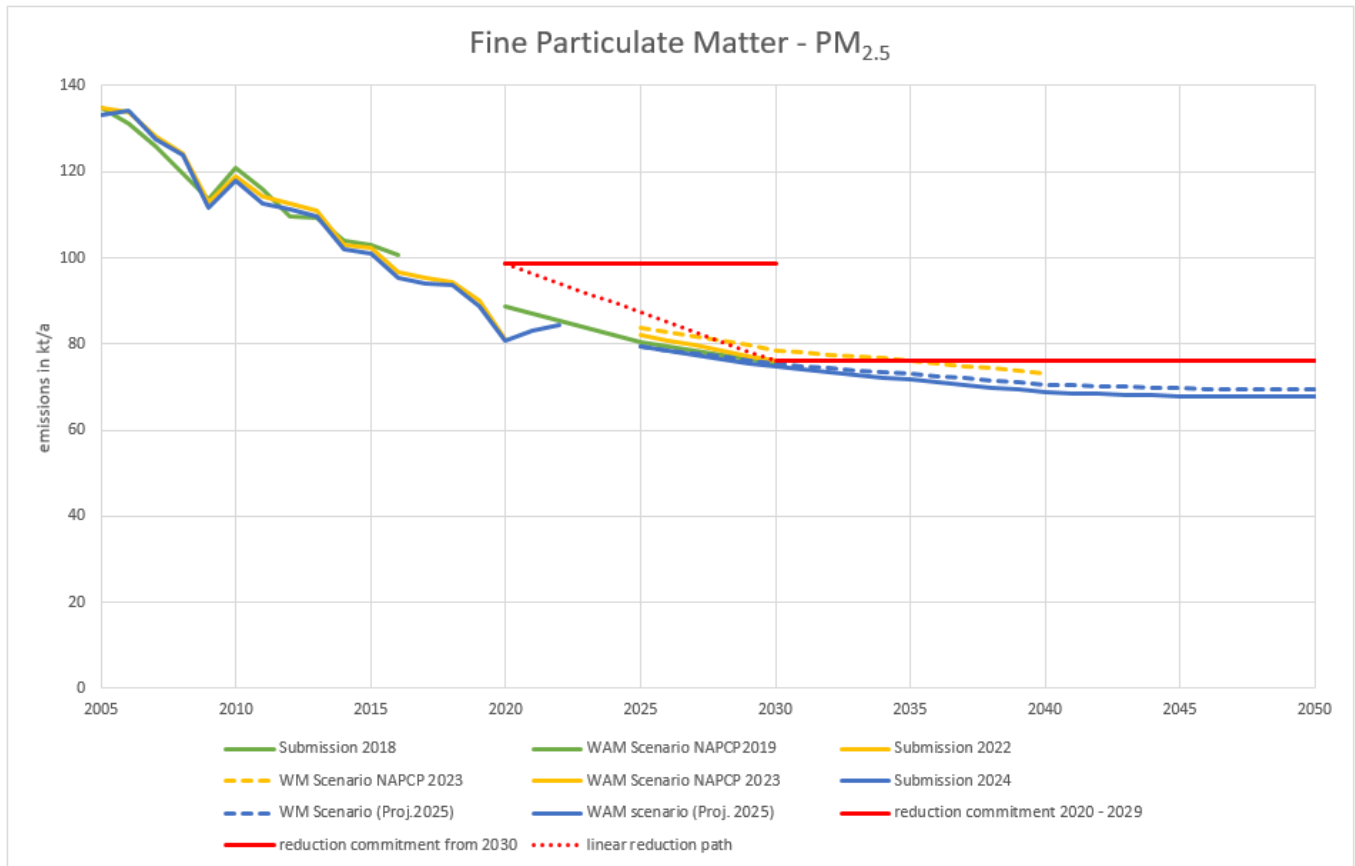






**PM<sub>2.5</sub>** projections are mostly consistent over the various projection reportings. However, the projection of the NAPCP 1999 and later projections are containing mutually compensating assumptions. The WAM scenario of the NAPCP 2019 had assumed a much higher coal use as well as a much lower use of solid biomass in 2030 than the following projections, leading to an almost congruent estimate of the projected national PM<sub>2.5</sub> total. Thus, the WM scenario of the NAPCP 2023 lies above all other displayed scenarios, because of higher biomass use than in the WAM scenario of the NAPCP 2019 (and also than in the current WM and WAM scenarios) in combination with a lower coal use than in the NAPCP 2019.

However, the assumed coal use in the current WM scenario is almost phased out until 2030 (see description in the [WM scenario](#)) in combination with an assumed use of solid biomass that is lower than in the NAPCP 2023 but higher than in the NAPCP 2019. That the WAM scenario of the NAPCP 2023 is also slightly above the current WM projection in the year 2025 is mostly due to a previously projected sharper increase in the use of solid biomass in the building sector than under updated assumptions. Apart from these differing assumptions of coal use in the energy and industry sector and the use of solid biomass in the building sector as well as in the energy and industry sector, also updated assumptions in the road transport sector have a mitigation effect (e. g. Euro 7 regulation introducing limit values for tyre and brake wear). With less biomass in the current WM scenario than in the NAPCP 2023 also the mitigation potential of the revision of the Ecodesign directives for solid fuel boilers and solid fuel local space heaters in the current [WAM scenario](#) is slightly lower than in the previous WAM scenario of the NAPCP 2023.



1)

<https://iir.umweltbundesamt.de/2024/general/projections/recalculations>

2)

<https://iir.umweltbundesamt.de/2021/general/projections/recalculations>

3)

for further explanation see: <https://iir.umweltbundesamt.de/2021/general/recalculations/ammonia>



**PLEASE NOTE THAT INFORMATION ON LARGE POINT SOURCES ARE REPORTED ONLY EVERY FOUR YEARS AND THAT, THEREFORE, THE FOLLOWING INFORMATION HAS BEEN SUBMITTED ALREADY WITH THE 2025 SUBMISSION AND WILL BE UPDATED AGAIN WITH THE 2029 SUBMISSION.**

## CHAPTER 11.1: Large Point Sources (LPS)

### Background

Germany, alongside with the European Union (EU) and EU Member States, has signed the *UN-ECE PRTR Protocol*, whereby Germany commits to establish and operate a national Pollutant Release and Transfer Register (PRTR) for public information. *The E-PRTR Regulation (European Regulation (EC) No 166/2006)* and the *German PRTR Act (SchadRegProtAG)* provide the legal basis for this fact. If pollutant threshold values or waste quantities specified in the E-PRTR Ordinance are exceeded, releases of pollutants to air, water and soil, shipments with wastewater, and disposal of hazardous and non-hazardous wastes from certain industrial activities have to be reported annually for the PRTR. <sup>1)</sup>

Since December 31, 2016, the new *NEC Directive (2016/2284/EU)* on the reduction of the national emissions of certain atmospheric pollutants came into force, replacing the *Directive (2001/81/EC)* on National Emission Ceilings. The new *NEC Directive (2016/2284/EU)* requires EU Member States to achieve new reduction targets from 2030, which in addition to the previously regulated air pollutants SO<sub>2</sub>, NO<sub>x</sub>, NMVOC and NH<sub>3</sub>, also include reduction targets for particulate matter (PM<sub>2.5</sub>) for the first time. This means that the new directive imposes significantly extended reporting obligations on the EU Member States. For the first time, EU Member States are required to create emission inventories for particulate matter, heavy metals and POPs. The inventories must also include emission projections. Furthermore, emissions from large point sources must be reported and emission data must be spatially itemized.

For the first time in 2017 and then every four years, EU Member States must report spatially distributed emissions (raster data) with a resolution of 0.1° x 0.1° (longitude-latitude). Large point sources (LPS) must be reported every 4 years, starting in 2017. Reporting is mandatory for agro-industrial and industrial activities whose annual emissions exceed certain thresholds, which correspond to those for emissions reporting under *the E-PRTR Regulation (European Regulation (EC) No 166/2006)*. <sup>2)</sup>

Annex IV of the Directive indicates, that the Member States shall prepare emission inventories “in accordance with the methodologies recognized by the Parties to the *LRTAP Convention (EMEP reporting guidelines)*” and “shall base their reporting on the *Air Pollutant Emissions Inventory (EMEP/EUA Guidelines)* referred to in the Convention.” *The reporting guidelines (UNECE 2015)* define large point sources as follows:

“Large point sources (LPS) are defined as facilities whose combined emissions, within the limited identifiable area of the site premises, exceed the pollutant emission thresholds identified in table 1 below.” <sup>3)</sup>

The associated Table 1 identifies thresholds, consistent with those identified in the E-PRTR Regulation (2016), for the following pollutants:

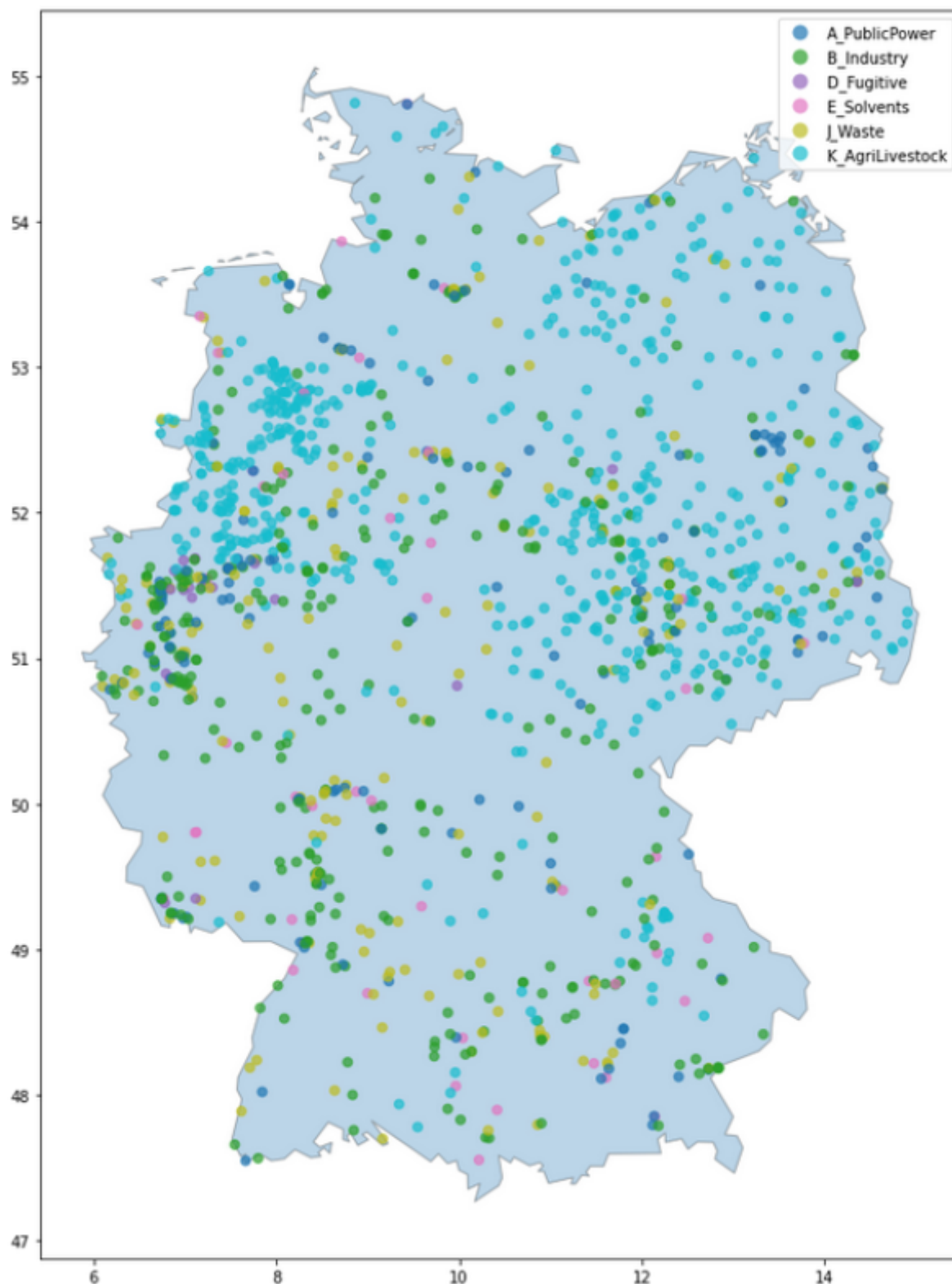
- Sulfur dioxide (SO<sub>2</sub>)
- Nitrogen Oxide (NO<sub>x</sub>)
- Carbon Monoxide (CO)
- Non-Methane Volatile Organic Compounds (NMVOC)
- Ammonia (NH<sub>3</sub>)
- Particulate Matter ≤2.5µm (PM<sub>2.5</sub>)
- Particulate Matter ≤10µm (PM<sub>10</sub>)
- Lead and compounds (Pb)
- Cadmium and compounds (Cd)
- Mercury and compounds (Hg)
- Polycyclic Aromatic Hydrocarbons (PAHs)
- PCDD & PCDF (Polychlorinated Dibenzo-Dioxins and -Furans)(as Teq)
- Hexachlorobenzene (HCB)
- Polychlorinated Biphenyls (PCBs)

## Reporting

Germany provided its point source data under the LRTAP convention for the first time in 2017. In principle, the German LPS data submission is mainly a copy of the ePRTR data available on both the [national](#) and [European websites](#). However, as some additional information is missing in the ePRTR dataset, such as stack heights, which are not available at the federal level, some gap filling is needed and explained below.

The most recent provision of large point source data, submitted in 2025, is using the 2023 ePRTR data.

Figure 1: **Large point sources for different GNFR sectors for Germany for the year 2023**



Source of data: <https://cdr.eionet.europa.eu/de/un/clrtap/lps/envaan4gq>

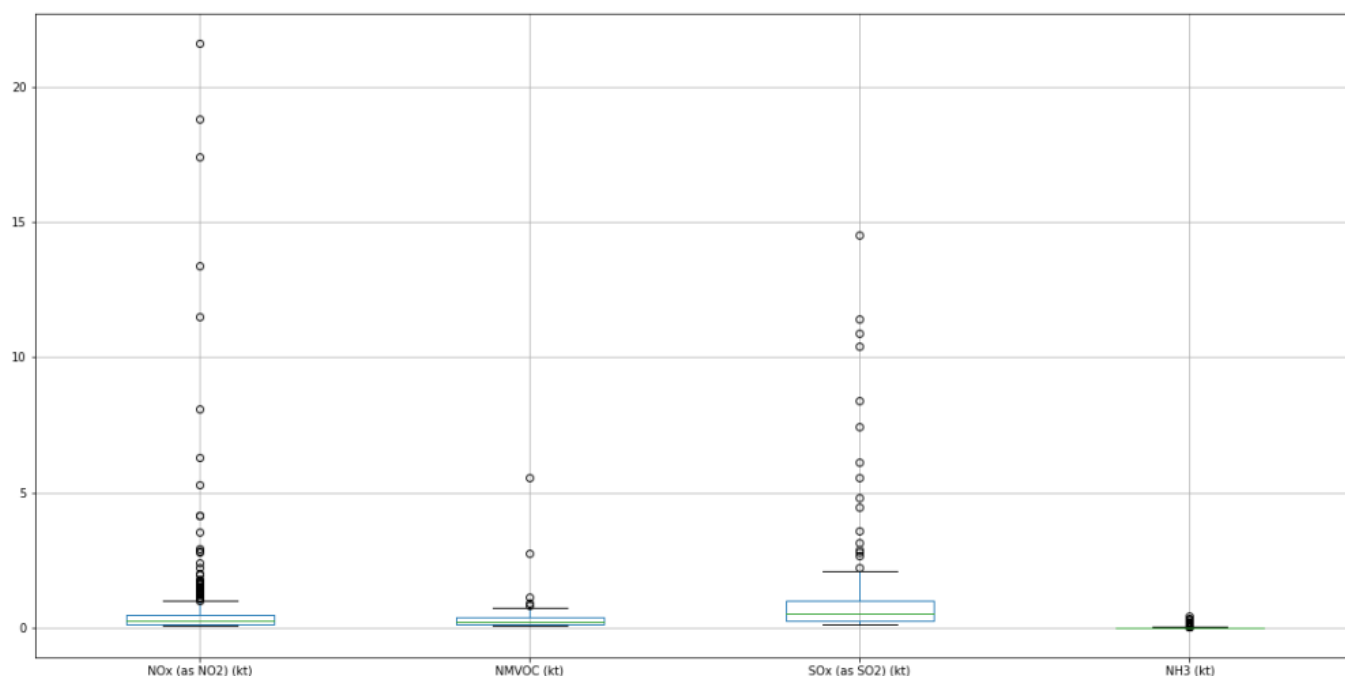
## Methodology

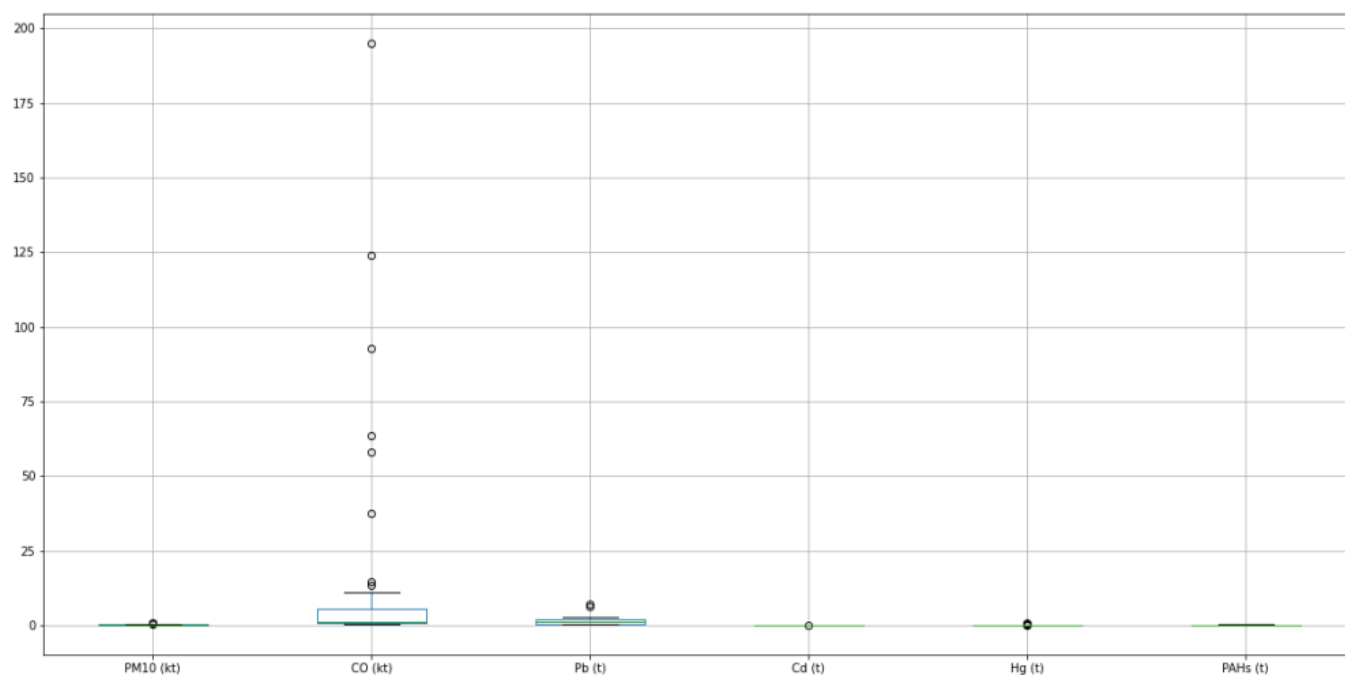
### Quality checks

Various quality checks of the data were carried out before submission. The data from the ePRTR database was cleaned, processed and missing data was added. Then, the data was transferred into a suitable format (Excel template under LRTAP convention). Before the data could be transformed into the appropriate format for submission, several data preconditions were determined. Furthermore, data quality checks were performed. Below is a list of the quality checks that have been performed.

- Calculation of the sum of LPS emissions and comparison with the NFR tables
- Unit mistakes checks
- Outlier checks
- Verification of missing information in the data (such as ID's, stack heights, GNFR, coordinates, etc.)
- Checking whether the coordinates are within Germany
- Checking whether there are duplicates in the coordinates

For example, all point sources identified as outliers in the box plots below were checked individually to be correct:





### GNFR codes and stack heights

The ePRTR dataset includes most of the information needed for LPS reporting. However, both GNFR sectors and stack heights are not included. These point source meta data are instead derived from the PRTR activities given and by researching some important point sources individually. In general, GNFR membership and stack height class have been added according to Table 1 below (mainly based on the Environmental Research Plan of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety)<sup>4)</sup>.

Table 1: Stack heights and further information related to the GNFR sectors

| Activity code from ePRTR | ePRTR description                                                                                                                                                   | GNFR          | Stack height class |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|--------------------|
| 1.a                      | Mineral oil and gas refineries                                                                                                                                      | B_Industry    | 4                  |
| 1.b                      | Installations for gasification and liquefaction                                                                                                                     | B_Industry    | 4                  |
| 1.c                      | Thermal power stations and other combustion installations (>50 MW)                                                                                                  | A_PublicPower | 5                  |
| 1.d                      | Coke ovens                                                                                                                                                          | B_Industry    | 5                  |
| 1.e                      | Coal rolling mills                                                                                                                                                  | B_Industry    | 5                  |
| 1.f                      | Installations for the manufacture of coal products and solid smokeless fuel                                                                                         | D_Fugitive    | 4                  |
| 2                        | Production and processing of metals                                                                                                                                 | B_Industry    | 5                  |
| 2.a                      | Metal ore roasting or sintering installations                                                                                                                       | B_Industry    | 5                  |
| 2.b                      | Installations for the production of pig iron or steel inc. continuous casting                                                                                       | B_Industry    | 5                  |
| 2.c                      | Installations for the processing of ferrous metals                                                                                                                  | B_Industry    | 5                  |
| 2.c.i                    | Installations for the processing of ferrous metals: (i) hot-rolling mills                                                                                           | B_Industry    | 5                  |
| 2.c.ii                   | Installations for the production of pig iron or steel and processing of ferrous metals (hot-rolling mills and smitheries with hammers)                              | B_Industry    | 5                  |
| 2.d                      | Ferrous metal foundries                                                                                                                                             | B_Industry    | 2                  |
| 2.e                      | Installations for non-ferrous metals                                                                                                                                | B_Industry    | 2                  |
| 2.e.i                    | Installations for the production of non-ferrous crude metals from ore, concentrates or secondary raw materials by metallurgical, chemical or electrolytic processes | B_Industry    | 2                  |
| 2.e.ii                   | Installations for the smelting, including the alloying, of non-ferrous metals, including recovered products (refining, foundry casting, etc.)                       | B_Industry    | 2                  |
| 2.f                      | Installations for surface treatment of metals and plastic materials using an electrolytic or chemical process                                                       | B_Industry    | 1                  |
| 3.a                      | Underground mining and related operations; Opencast mining and quarrying                                                                                            | D_Fugitive    | 1                  |
| 3.b                      | Opencast mining and quarrying                                                                                                                                       | D_Fugitive    | 1                  |
| 3.c                      | Installations for the production (see below)                                                                                                                        | B_Industry    | 2                  |
| 3.c.i                    | Installations for the production of: (i) cement clinker in rotary kilns, (iii) cement clinker or lime in other furnaces                                             | B_Industry    | 2                  |

| Activity code from ePRTR | ePRTR description                                                                                                                                                                    | GNFR       | Stack height class |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|--------------------|
| 3.c.ii                   | Installations for the production of: (ii) lime in rotary kilns, (iii) cement clinker or lime in other furnaces                                                                       | B_Industry | 2                  |
| 3.c.iii                  | Installations for the production of: (i) cement clinker in rotary kilns, (iii) cement clinker or lime in other furnaces                                                              | B_Industry | 2                  |
| 3.d                      | Installations for the production of asbestos and the manufacture of asbestos-based products                                                                                          | B_Industry | 2                  |
| 3.e                      | Installations for the manufacture of glass, incl. glass fibre                                                                                                                        | B_Industry | 2                  |
| 3.f                      | Installations for melting mineral substances, incl. the production of mineral fibres                                                                                                 | B_Industry | 2                  |
| 3.g                      | Installations for the manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain                               | B_Industry | 2                  |
| 4.a                      | Chemical installations for the production on an industrial scale of basic organic chemicals                                                                                          | B_Industry | 1                  |
| 4.a.i                    | Chemical installations for the production on an industrial scale of basic organic chemicals: simple hydrocarbons (linear or cyclic, saturated or unsaturated, aliphatic or aromatic) | B_Industry | 1                  |
| 4.a.ii                   | Chemical installations for the production on an industrial scale of basic organic chemicals: oxygen-containing hydrocarbons                                                          | B_Industry | 1                  |
| 4.a.iii                  | Chemical installations for the production on an industrial scale of basic organic chemicals: sulphurous hydrocarbons                                                                 | B_Industry | 1                  |
| 4.a.iv                   | Chemical installations for the production on an industrial scale of basic organic chemicals: nitrogenous hydrocarbons                                                                | B_Industry | 1                  |
| 4.a.ix                   | Chemical installations for the production on an industrial scale of basic organic chemicals: synthetic rubbers                                                                       | B_Industry | 1                  |
| 4.a.vi                   | Chemical installations for the production on an industrial scale of basic organic chemicals: halogenic hydrocarbons                                                                  | B_Industry | 1                  |
| 4.a.vii                  | Chemical installations for the production on an industrial scale of basic organic chemicals: organometallic compounds                                                                | B_Industry | 1                  |
| 4.a.viii                 | Chemical installations for the production on an industrial scale of basic organic chemicals: basic plastic material (polymers, syntetic fibers and cellulose-based fibers)           | B_Industry | 1                  |
| 4.a.x                    | Chemical installations for the production on an industrial scale of basic organic chemicals: dyes and pigments                                                                       | B_Industry | 1                  |
| 4.a.xi                   | Chemical installations for the production on an industrial scale of basic organic chemicals: surface-active agents and surfactants                                                   | B_Industry | 1                  |
| 4.b                      | Chemical installations for the production on an industrial scale of basic inorganic chemicals                                                                                        | B_Industry | 1                  |
| 4.b.i                    | Chemical installations for the production on an industrial scale of basic inorganic chemicals: gases                                                                                 | B_Industry | 1                  |
| 4.b.ii                   | Chemical installations for the production on an industrial scale of basic inorganic chemicals: acids                                                                                 | B_Industry | 1                  |
| 4.b.iii                  | Chemical installations for the production on an industrial scale of basic inorganic chemicals: bases                                                                                 | B_Industry | 1                  |
| 4.b.iv                   | Chemical installations for the production on an industrial scale of basic inorganic chemicals: salts                                                                                 | B_Industry | 1                  |
| 4.b.v                    | Chemical installations for the production on an industrial scale of basic inorganic chemicals: non-metals, metal-oxides or other inorganic compounds                                 | B_Industry | 1                  |
| 4.c                      | Chemical installations for the production on an industrial scale of fertilisers                                                                                                      | B_Industry | 1                  |
| 4.d                      | Installations using a chemical or biological process for the production on an industrial scale of basic plant health products and of biocides                                        | B_Industry | 1                  |
| 4.e                      | Installations using a chemical or biological process for the production on an industrial scale of basic pharmaceutical products                                                      | B_Industry | 1                  |
| 4.f                      | Installations for the production on an industrial scale of explosives and pyrotechnic products                                                                                       | B_Industry | 1                  |
| 5.a                      | Installations for the disposal or recovery of hazardous waste                                                                                                                        | J_Waste    | 3                  |
| 5.b                      | Installations for the incineration of non-hazardous waste                                                                                                                            | J_Waste    | 2                  |
| 5.c                      | Installations for the disposal of non-hazardous waste                                                                                                                                | J_Waste    | 1                  |
| 5.d                      | Landfills                                                                                                                                                                            | J_Waste    | 1                  |
| 5.e                      | Installations for the disposal or recycling of animal carcasses and animal waste                                                                                                     | J_Waste    | 2                  |

| Activity code from ePRTR | ePRTR description                                                                                                               | GNFR            | Stack height class |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------|--------------------|
| 5.f                      | Urban waste-water treatment plants                                                                                              | J_Waste         | 1                  |
| 5.g                      | Independently operated industrial wastewater treatment plants                                                                   | J_Waste         | 1                  |
| 6                        | Paper and wood producing plants                                                                                                 | B_Industry      | 2                  |
| 6.a                      | Industrial plants for the production of pulp from timber or similar fibrous materials                                           | B_Industry      | 2                  |
| 6.b                      | Industrial plants for the production of paper and board and other primary wood products                                         | B_Industry      | 2                  |
| 6.c                      | Industrial plants for the preservation of wood and wood products with chemicals                                                 | E_Solvents      | 2                  |
| 7.a                      | Installations for the intensive rearing of poultry or pigs                                                                      | K_AgriLivestock | 1                  |
| 7.a.i                    | Installations for the intensive rearing of poultry or pigs: with 40 000 places for poultry                                      | K_AgriLivestock | 1                  |
| 7.a.ii                   | Installations for the intensive rearing of poultry or pigs: with 2 000 places for production pigs (over 30 kg)                  | K_AgriLivestock | 1                  |
| 7.a.iii                  | Installations for the intensive rearing of poultry or pigs: with 750 places for sows                                            | K_AgriLivestock | 1                  |
| 8.a                      | Slaughterhouses                                                                                                                 | B_Industry      | 1                  |
| 8.b                      | Treatment and processing intended for the production of food and beverage products                                              | B_Industry      | 1                  |
| 8.b.i                    | Treatment and processesing intended for the production of food and beverage products from: animal raw materials other than milk | B_Industry      | 1                  |
| 8.b.ii                   | Treatment and processesing intended for the production of food and beverage products from: vegetable raw materials              | B_Industry      | 1                  |
| 8.c                      | Treatment and processing of milk                                                                                                | B_Industry      | 1                  |
| 9.a                      | Plants for the pre-treatment (operations such as washing, bleaching, mercerisation) or dyeing of fibres or textiles             | E_Solvents      | 1                  |
| 9.b                      | Plants for the tanning of hides and skins                                                                                       | E_Solvents      | 1                  |
| 9.c                      | Installations for the surface treatment of substances, objects or products using organic solvents                               | E_Solvents      | 1                  |
| 9.d                      | Installations for the production of carbon (hard-burnt coal) or electrographite by means of incineration or graphitisation      | B_Industry      | 2                  |
| 9.e                      | Installations for the building of, and painting or removal of paint from ships                                                  | E_Solvents      | 1                  |

## References

- <sup>1)</sup> Pollutants of the PRTR - Situation in Germany - Reporting years 2007 - 2022, Umweltbundesamt, 2024 [External Link](#)
- <sup>2), 3), 4)</sup> Analyse der novellierten NEC-Richtlinie bezüglich der erweiterten Anforderungen an die Berichterstattung von Schadstoffemissionen in die Luft - Umweltforschungsplan des Bundesministeriums für Umwelt, Naturschutz, Bau und Reaktorsicherheit, im Auftrag des Umweltbundesamtes, 2019 [External Link](#)





**PLEASE NOTE THAT GRIDDED EMISSIONS DATA ARE REPORTED ONLY EVERY FOUR YEARS AND THAT, THEREFORE, THE FOLLOWING INFORMATION HAS BEEN SUBMITTED ALREADY WITH THE 2025 SUBMISSION AND WILL BE UPDATED AGAIN WITH THE 2029 SUBMISSION.**

## CHAPTER 11.2: Gridded Data

Information on the spatial distribution of emissions is important to answer a number of questions in the field of air quality monitoring. Emission data is used to model the dispersion of air pollutants or to visualize the structure of the spatial distribution of emissions. These models show if abatement strategies were successful. For this reason, an ESRI ArcGIS based software has been developed which allows the UBA, independently and on the basis of information generally available, to regularly generate regionalized emission datasets for the complete area of the Federal Republic of Germany.

The following pollutants are currently considered: NO<sub>x</sub>, NH<sub>3</sub>, SO<sub>2</sub>, CO, NMVOC, particles (PM<sub>2.5</sub>, PM<sub>10</sub>, TSP, and BC) and Heavy Metals (HM), POPs (PAHs, HCB, PCBs, PCDD/F - dioxins/furans).

### Methodology

- The Gridding Emission Tool for ArcGIS (GRETA) contains a complete set of the required data per base year. This includes emissions, distribution parameters, geometric datasets as well as the necessary definitions and allocation tables.
- The emission data could be distributed using the energy-balanced principle (fuel sold) or inland principle (fuel used). The energy-balanced principle (fuel sold) is used for the official reporting of spatial distributed emissions for Germany.
- The geometric and statistical data, which is used for the spatial distribution, is available for different base years (1990–2023). For example, the traffic network and annual mileage data is updated in a 5-year cycle. Land use / land cover datasets (CORINE Land Cover) are used for different reference years. From 2000 onwards, information about point sources is available from the German PRTR or the EPER. For the earlier years 1990 and 1995, information from point sources was transferred from EPER data of the year 2001 and their emissions were scaled accordingly.
- For each NFR sector, the spatial distribution of the national emissions is determined using distribution parameters, and if possible, as point sources (PQ) and line sources (LQ). The remaining emissions are spatially assigned to distribution parameters on district level and further, considering land cover data, on area level (FQ).

The calculation can be carried out for different arbitrary grid widths and different coordinate reference systems. In Greta, only the national totals are currently distributed. The memo items are not considered yet.

The software and methodology is documented in detail and complies with high standards as to its flexibility and extensibility (see detailed description [Gridding Tool](#)). The following description is taken from the summary of the report “ArcGIS basierte Lösung zur detaillierten, deutschlandweiten Verteilung (Gridding) nationaler Emissionsjahreswerte auf Basis des Inventars zur Emissionsberichterstattung”. p.224 presented by Schneider et al. in 2016 <sup>1)</sup>

Figure 1: **Overview of the method for spatial distribution of national emissions**

|                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                       |                                                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>emissions for a specific year (f.e. 2010)</b> <ul style="list-style-type: none"> <li>- national emissions (NFR)</li> <li>- PRTR-emissions</li> <li>- TREMOD-emissions (road, rail, shipping, aviation)</li> </ul>                                                   | <b>distribution parameter</b> <ul style="list-style-type: none"> <li>for spatial allocation of national emissions</li> <li>- per administrative unit</li> <li>- per point/line/area source</li> </ul> | <b>definitions, allocation tables</b> <ul style="list-style-type: none"> <li>- NFR-sectors</li> <li>- pollutants</li> <li>- NFR – GNFR – SNAP</li> <li>- vertical emission heights</li> <li>- ...</li> </ul> |
| <b>set boundary conditions</b> <ul style="list-style-type: none"> <li>- consideration of PRTR emissions and TREMOD emissions</li> <li>- traffic emissions: inland or energy balance method</li> <li>- vertical emission height levels</li> <li>- pollutants</li> </ul> |                                                                                                                                                                                                       |                                                                                                                                                                                                              |
| <b>plausibility check PRTR emissions &lt; national emissions per main group</b>                                                                                                                                                                                        |                                                                                                                                                                                                       |                                                                                                                                                                                                              |
| <b>subtraction of PRTR emissions from national emissions</b>                                                                                                                                                                                                           |                                                                                                                                                                                                       |                                                                                                                                                                                                              |
| <b>assign distribution parameter per NFR-sector</b>                                                                                                                                                                                                                    |                                                                                                                                                                                                       |                                                                                                                                                                                                              |
| spatial distribution of emissions to <b>point</b> and <b>line</b> sources, as far as possible                                                                                                                                                                          |                                                                                                                                                                                                       |                                                                                                                                                                                                              |
| distribution of the remaining emissions to administrative units and <b>area</b> sources (land cover data)                                                                                                                                                              |                                                                                                                                                                                                       |                                                                                                                                                                                                              |
| <b>gridding</b> of the emissions per point, line and areas source (any raster size and coordinate reference system)                                                                                                                                                    |                                                                                                                                                                                                       |                                                                                                                                                                                                              |
| <b>data export</b> <ul style="list-style-type: none"> <li>- choice of nomenclature for export: NFR, GNFR, SNAP</li> <li>- choice of export format</li> </ul>                                                                                                           |                                                                                                                                                                                                       |                                                                                                                                                                                                              |

Significant factors for spatial distribution of national emissions are the so-called distribution parameters. These are characterized in the context of the Gridding Tool as follows:

- A distribution parameter represents a function that fully distributes a total number of emissions (e.g. national emissions Germany) to a specific amount of regional objects.
- The spatial distribution of national emissions is being performed per NFR sector;
- More complex distribution parameters distribute the emissions, for example, to different spatial object classes or by considering a further differentiation of the total emissions.
- For each NFR sector emissions are spatially distributed over one or more distribution parameters. For this purpose it has to be determined which part of the emissions is to be distributed over which distribution parameter.

Distribution parameters are used for allocation of national emissions, spatially as accurately as possible, to individual point, line or area sources depending on the source group. The location of a point source is given clearly by coordinates; typical line sources are, for example, streets, which can consist of many sections. As surface sources such areas are defined in which from many small sources emissions are released, for example, emissions from small combustion plants in built-up areas. A substantial database for distribution of national emissions in the sectors 'energy supply' and 'industry' are the emissions of individual sites or plants from the PRTR database. In addition, for example, also emissions of air traffic are allocated to point sources by location of the airports, whereas in the case of larger airports an additional local distribution is considered. Emissions from road traffic, rail traffic and inland water navigation are spatially assigned to line sources. The respective route networks consist of individual sections. To each of these network segments (line source) a share of the national emissions is assigned.

The spatial distribution of the emissions that are not distributed to point sources or line sources, is carried out in two steps on area sources. In the first step, these emissions are distributed by means of suitable distribution parameters to the district level. In the second step a more accurate spatial allocation of emissions using land cover data is carried out within the districts. Per NFR sector the areas of the relevant land use classes are chosen and only to these areas emissions are allocated.

Here, emphasis can also be placed on different CLC groups, e. g. the land-cover class 'residential areas' could get a higher rating than land-cover class 'residential areas loose'. As a result, the previously at district level distributed national

emissions are now spatially localized to the relevant land-cover areas within the districts. Aim of the spatial distribution of emissions is the compilation of emissions in a defined grid. For this, the emissions, spatially distributed to individual point, line and area sources, are assigned to the grid cells of the selected grid in a further step. After determination of the coordinate reference system and grid size of the raster, the share of each emission source (point / line / area source) per grid cell is determined. The summation of the emissions of all source shares lying within a grid cell leads to the total of emissions of the grid cell. The spatial distribution of emissions is not only limited to horizontal distribution, but also includes distribution to vertical height levels. Therefore, it was necessary to assign to each source category or to each NFR sector an average characteristic emission height above ground.



For further description of the distribution parameters, please refer to

distribution parameters

Further and more recent Greta improvements are described in additional reports (German only): Pelzer et al. (2018)<sup>2)</sup>, Pelzer et al. (2021)<sup>3)</sup>, and Pelzer et al. (2024)<sup>4)</sup>.

## Distribution Parameters

### Determination of Distribution Parameters

The PRTR database of UBA (PRTR = Pollutant Release and Transfer Register; [Thru.de](https://thru.de)) represents an important data source for the spatial distribution of national emissions. The emissions contained in this database are on hand as point source emissions and are considered as such for the spatial allocation in the Gridding Tool. Furthermore, it was established in agreement with the UBA that the data of the digital landscape models Germany of the Federal Agency of Cartography and Geodesy (BKG) are used as essential data sources. In detail, these are as follows:

- administrative boundaries (district boundaries, municipal boundaries)
- road network
- streaming water network
- rail network
- location of airports
- land-cover differentiated by classes.

As another relevant data source for spatial allocation of emissions that are not assigned by point or line sources, the Corine Land Cover (CLC) data set was stipulated. These data are differentiated in 43 land cover classes. For the usage within the scope of the Gridding Tool these have been merged to 6 CLC groups. Apart from these essential geometric base data sets, further information and data were used for deriving the final distribution parameters. These are, for example, data at district level as to the number of inhabitants or number of employees per business division. The aim was to use per NFR sector those data on the spatial distribution that reflect well the spatial structure of the emission distribution. This also includes typical (effective) vertical heights of sources per NFR sector.

## Source categories

### Energy and Industry

For the Gridding Tool a methodology has been developed considering PRTR emissions in the spatial distribution of national emissions. Here, the PRTR emissions are first subtracted at a national level from the national emissions. The share of emissions, which is covered by the PRTR emissions, is spatially assigned by the location of PRTR point sources. To avoid negative national residual emissions, this calculation must be made on an aggregated level. For this, the following main groups were defined:

- main group A (energy sector PRTR 1)
- main group B (industrial sectors, PRTR sectors 2,3,4,5,6,8,9)
- main group C (intensive livestock production and aquaculture, PRTR industry 7).

The NFR sectors for which part of the emissions are spatially allocated by means of the PRTR point sources belong to the source groups of energy supply, industry, agriculture and sewage / waste disposal. For the hereby affected NFR sectors, the national (residual) emissions are distributed in a first step by suitable distribution parameters on district level. The distribution parameters are predominantly based on statistical data on numbers of employees in the various sectors and departments of industry. Within the districts, the emissions are distributed via land cover class CLC121 (Industrial and Commercial Units) to the level of area sources.

## **Other Non-industrial Combustion Plants**

The emissions from non-industrial combustion plants (private households, other small consumers, military, agriculture, etc.) are completely spatially distributed over area sources. For this source group, distribution parameters are mainly based on statistical data at district level. The spatial distribution of emissions from small combustion plants of households was carried out via a more complex distribution function since the national emissions are differentiated into the four sub-categories of oil, gas, wood and other solid fuel combustion plants. Then the emissions per energy source are distributed using different distribution parameters to the district respectively community levels. Within the districts (for wood firing within the communities) emissions are again distributed over the relevant CLC classes to the level of the area sources.

## **Traffic or Transport**

For the traffic or transport sector (road, rail, shipping, aviation), at UBA emissions are being determined by means of the TREMOD model. These data are available in a more differentiated way than they are shown per NFR sector in national emissions. Therefore, suitable additional information from TREMOD for the spatial distribution is considered in the Gridding Tool.

For the spatial distribution of national emissions of aviation, in addition to the national totals, additional TREMOD emission data for the 26 largest German airports are available. These emissions are spatially allocated directly to their position. For the remaining smaller airports, airfields and landing sites in Germany, the national residual emissions from aviation, which are not listed in the TREMOD data separately for each airport, are spatially distributed over the number of flight movements per airport. The location of airports is known as a point source. In addition, for the 15 largest (international) airports in Germany the landing and departure sectors were digitized as funnel-shaped three-dimensional sources. This allows a much differentiated spatial distribution of the emissions to local (three-dimensional) sources for these airports.

Emissions of the source group Road Traffic are composed of exhaust emissions, emissions from abrasion (tires, brakes, roads) and emissions due to fuel evaporation. The exhaust and abrasive emissions from road traffic are fully distributed over line sources, since a digital geometric data basis exists for all roads. The distribution parameter for spatial distribution of emissions is derived from data on mileage per route section. For this purpose, data was processed from different data sources. The evaporative emissions are spatially distributed over area sources to the built-up areas.

For rail traffic, emissions resulting from both the operation of diesel engines as well as the abrasion caused by both electrically and diesel-powered trains are taken into account. The distribution of these emissions is carried out entirely on line sources based on the rail network with the section-related emissions of the DB Umwelt AG significant being an important data base for the derivation of the distribution parameters.

As described for railways, emissions from national navigation (shipping) are completely spatially distributed on line sources, too. For this purpose, the digital routing network of watercourses as well as the distribution parameters derived from emission data from TREMOD are being applied.

## **Offroad / Mobile Machinery**

This source group includes emissions released by off-road vehicles and mobile machinery (e.g. in the building and construction industry, forestry and agriculture) and by the use of mobile devices and machines in households. Emissions from these sources are allocated as area sources completely. The distribution parameters are mainly based on statistical data at district level.

## **Solvents and other Product Use**

Emissions that are released by application of solvent-based and other products in the private sector as well as in industrial and other sectors, are fully distributed as area sources. The distribution parameters are predominantly based on statistical

data at district level, e.g. employees in economic departments of G-U (Trade and Services) or inhabitants.

## Agriculture

Emissions from agriculture consist of the emissions arising from animal husbandry (e.g. cows, pigsetc.), and emissions that occur during agricultural activity on arable land and pastures.

An important data source for spatial distribution is the data of the Thünen Institute, which annually determines the emissions from agriculture at district level for Germany. In addition, emissions from stables that underlay reporting obligations are reported in the PRTR database. They only cover a small proportion of national emissions in agriculture. Therefore, a synthetic stable point source dataset was derived from the German Land Cover dataset (LBM-DE) to distribute the stable (and storage) emissions directly to the stables as point source (PQ). In the past these emissions were distributed to agricultural areas (FQ). To derive the distribution parameters used in the Gridding Tool for the affected NFR sectors, the data of the Thünen Institute, from the PRTR database and synthetic stable point source dataset were considered.

## Other NFR Sectors

There are some more NFR sectors, e.g. 1.A.4.c iii (national fishing), 1.B.2a v (distribution of oil products) and 1.A.3.e i (pipeline compressors), which do not belong to the source groups already described. The distribution parameters for these sectors are based on different data; emissions are predominantly spatially distributed as area sources.

## Recalculations / Improvements

The Gridding tool GRETA is constantly being further developed.

- Update of base years (PRTR, emission data, statistical data, etc.),
- QA/QC procedures,
- Distribution of new pollutants TSP, BC, HM, POP (PAH, HCB, PCB, PCDD/PCDF (dioxins/ furans),
- Using synthetic stable point sources (derived from national land cover data) to distribute stable (and storage) emissions to point sources,
- For the earlier years 1990 and 1995, information from point sources was transferred from EPER data of the year 2001 and their emissions were scaled accordingly.

## Results with the EMEP grid

The results are available via the Central Data Repository CDR maintained by the [EEA/EIONET](#). In 2019, the calculation tools for the gridding data were updated. In 2025, new data were stored on the CDR for the years 1990, 1995, 2000, 2005, 2010, 2015, 2019 and 2023.

The spatial resolution of reported emissions changed from a 50 x 50 km<sup>2</sup> EMEP to a 0.1° x 0.1° long-lat grid in a geographic coordinate system (WGS84). The change should improve the monitoring quality. The new EMEP domain covers the geographic area between 30°N-82°N latitude and 30°W-90°E longitude. More information about the grid development is available under EMEP grid.

In 2025, the EMEP grid, covering only the landmass of Germany, was extended to cover the domain of the baltic and north sea where emissions of the sector national navigation (1.A.3.d ii) are reported.

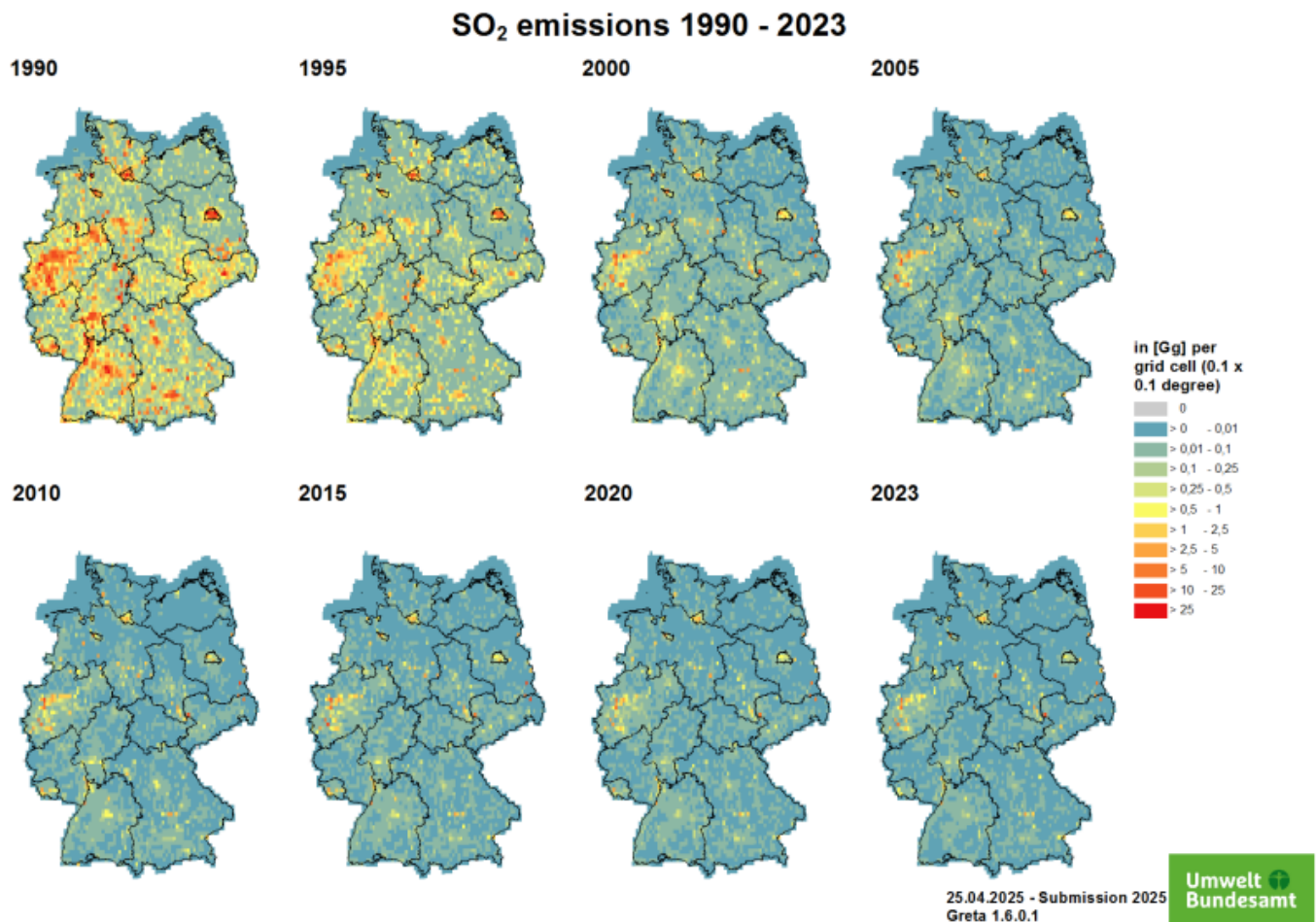
## Maps

**Acidification, eutrophication and Ground-level Ozone pollutants: Sulphur (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), ammonia (NH<sub>3</sub>) and volatile organic compounds (VOCs).**

The significant emission reduction history can be visualized with the following grid maps for the years 1990, 1995, 2000, 2005, 2010, 2015, 2019 and 2023. From 2000 onwards, information about point sources is available from the German PRTR or the EPER. For the earlier years 1990 and 1995, information from point sources were transferred from EPER data of the

year 2001 and their emissions were scaled accordingly. By presenting the spatial distribution of emissions, the emission hotspots can be precisely identified for all pollutants. In general, these are located in the German cities (e.g. Berlin, Munich or Hamburg) or the conurbations (district of the Rhine-Ruhr area).

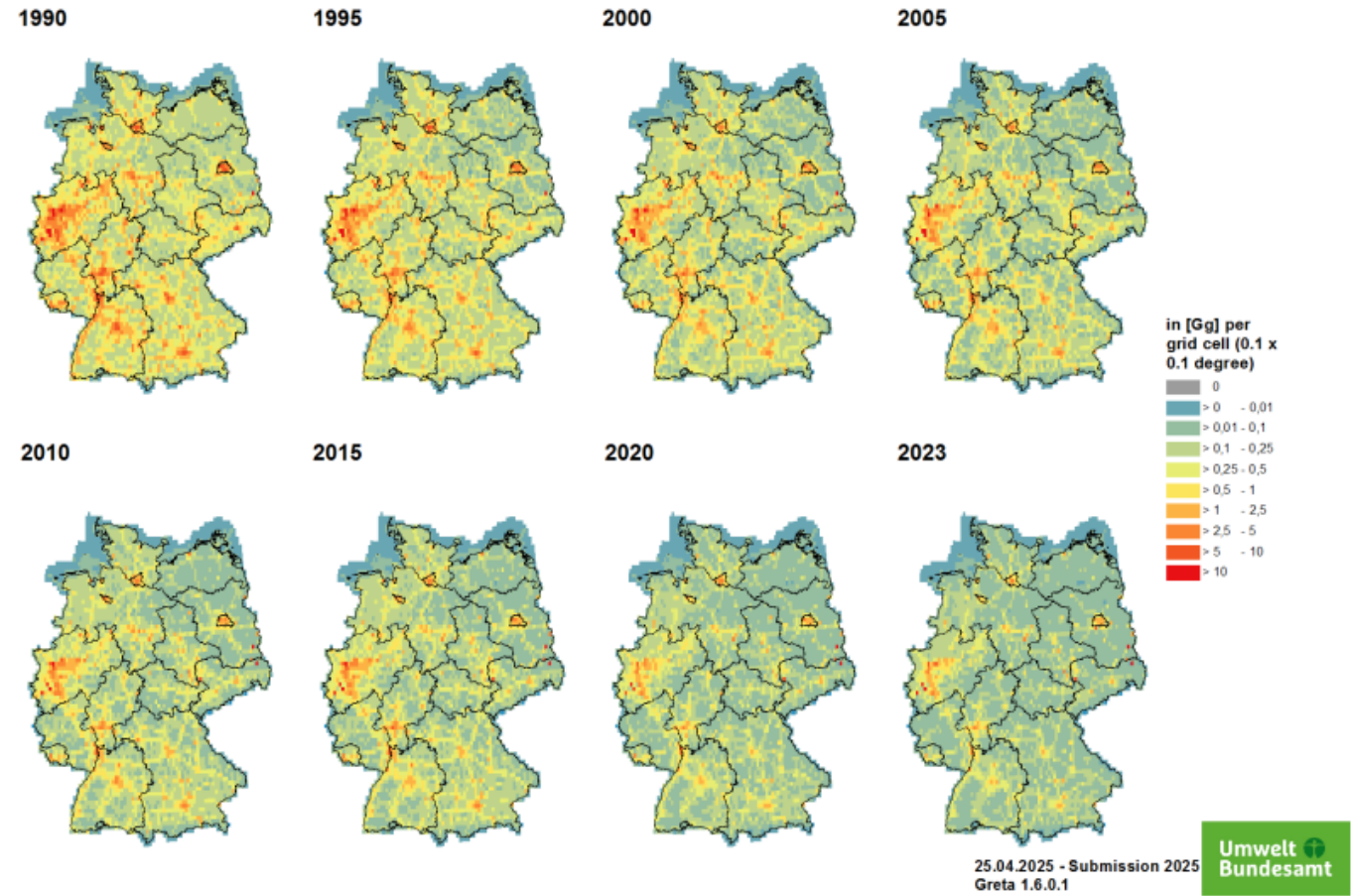
The reduction measures of SO<sub>2</sub> emissions are a success story in itself. In the early 1970s, the use of flue gas desulphurization plants in coal-fired power plants and later brown coal power plants led to a significant SO<sub>2</sub> decrease in the air. Since the 1990s, this reduction process has been further advanced by the use of low-sulfur fuels, so that today only a few areas are contaminated with SO<sub>2</sub>.



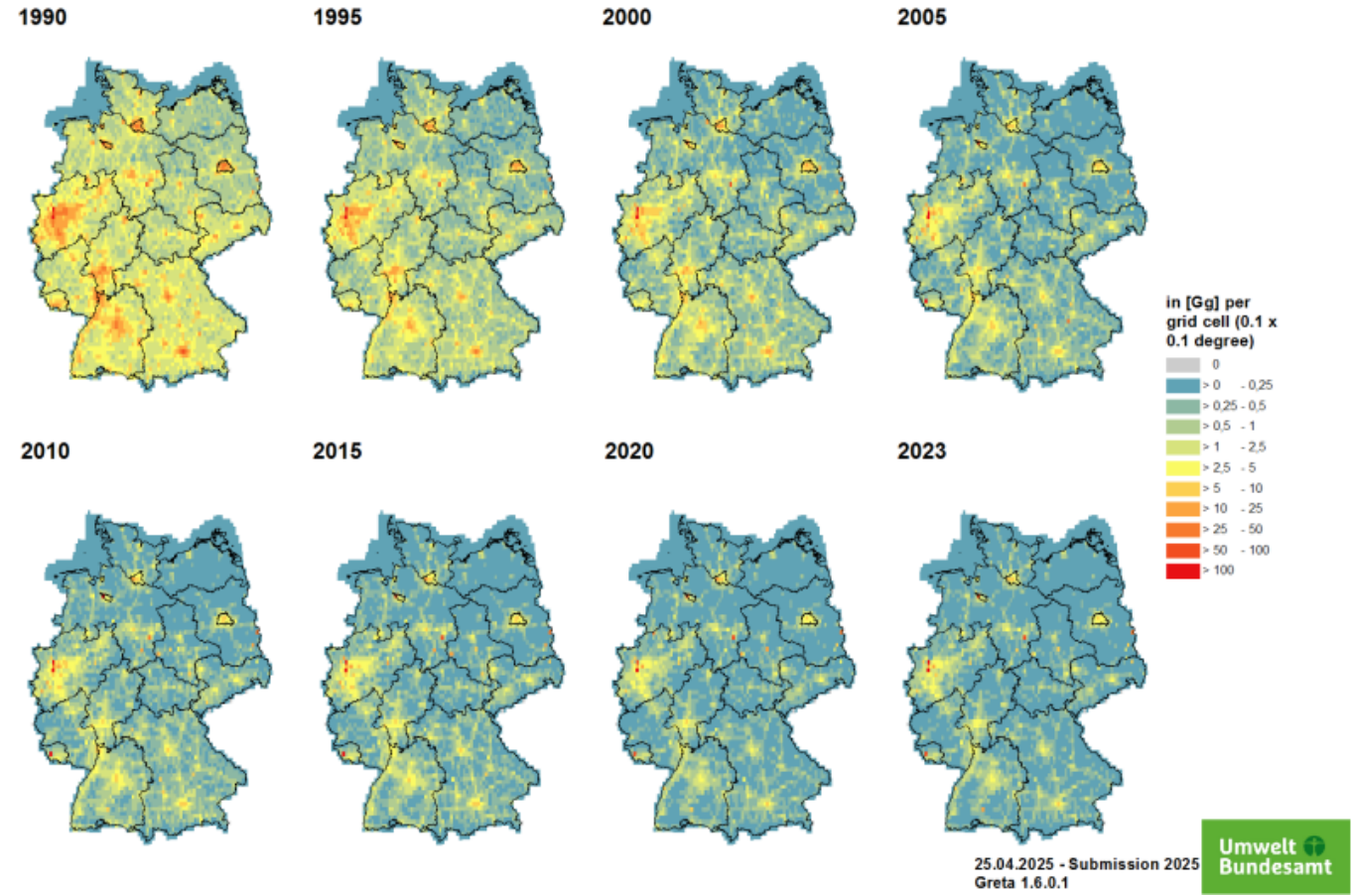
NO<sub>x</sub> and CO emissions are not only generated in the energy but also in the transport sector. This is easily recognisable from the motorway structure.



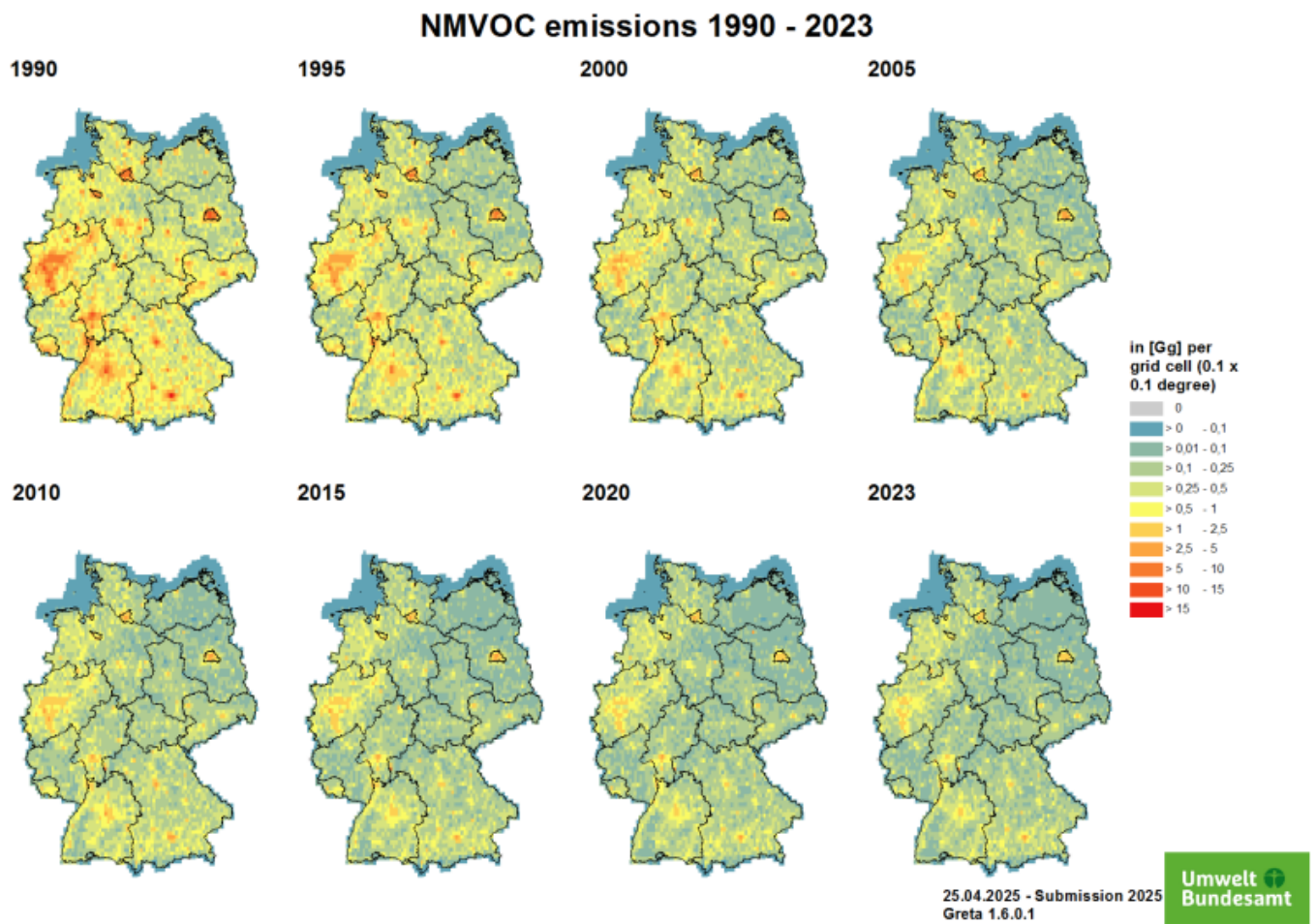
NO<sub>x</sub> emissions 1990 - 2023



CO emissions 1990 - 2023



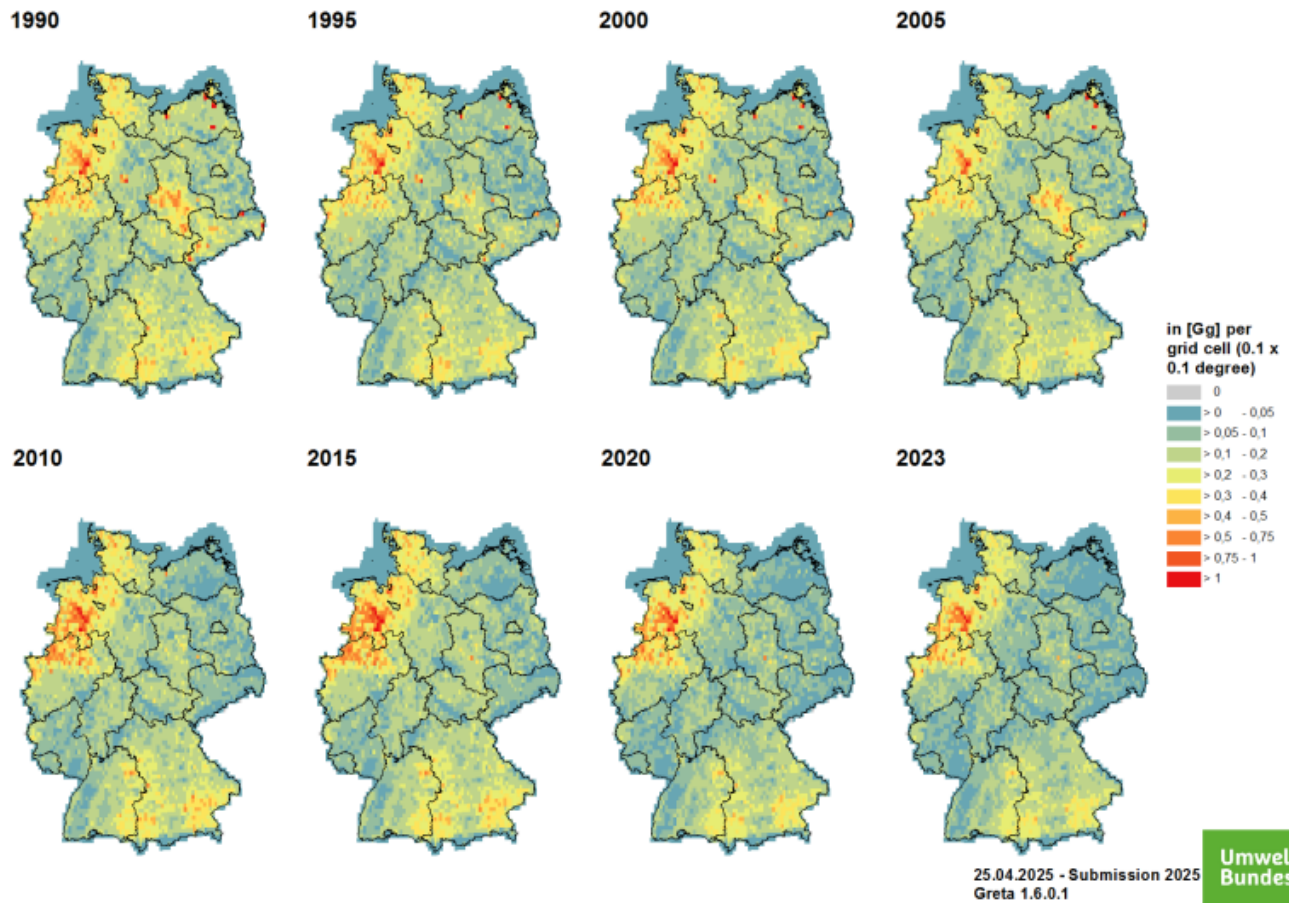
The main emitters of NMVOC are the industrial process sector and agriculture. The latter is mainly assigned to area and not to point sources.



Compared to the above mentioned air pollutants, drastic reduction of ammonia emissions did not occur in the last decades and abatement measures are still a political issue. The highest ammonia emissions occur in rural areas, especially in the north-west of Germany. The emissions from intensive livestock farming (point sources) are clearly visible in the graphics.

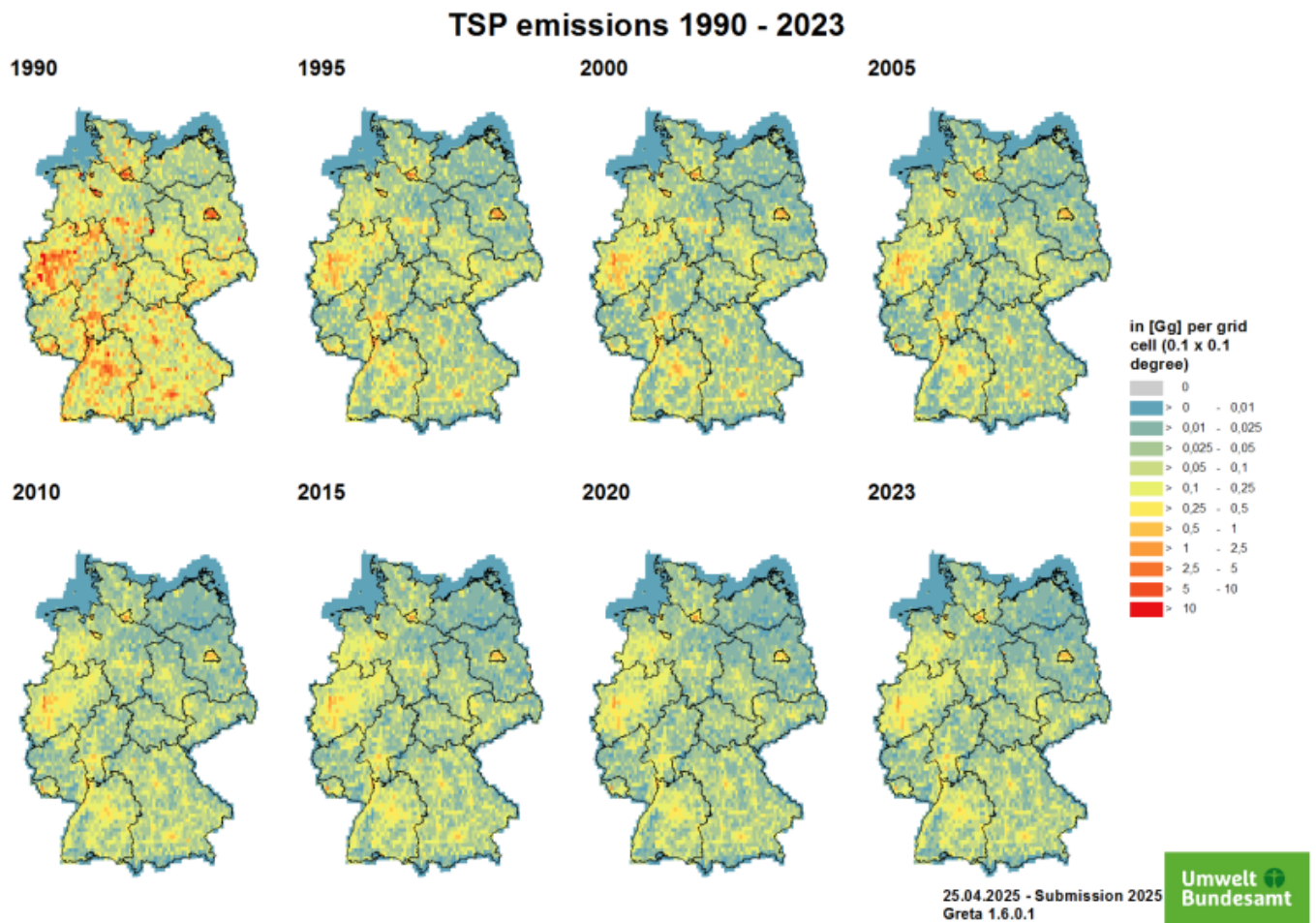


### NH<sub>3</sub> emissions 1990 - 2023

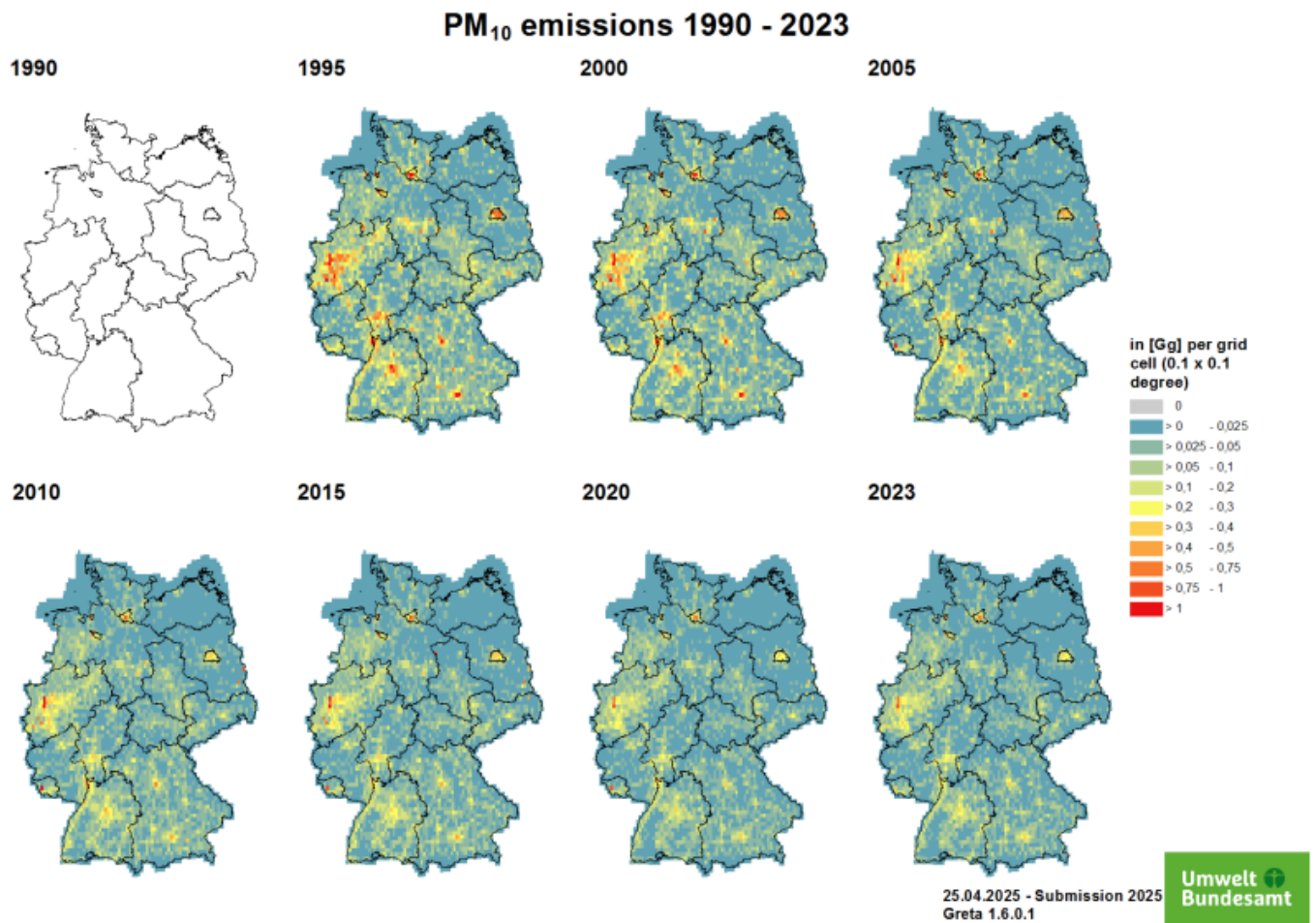


### Particle and Fine Particle Emissions

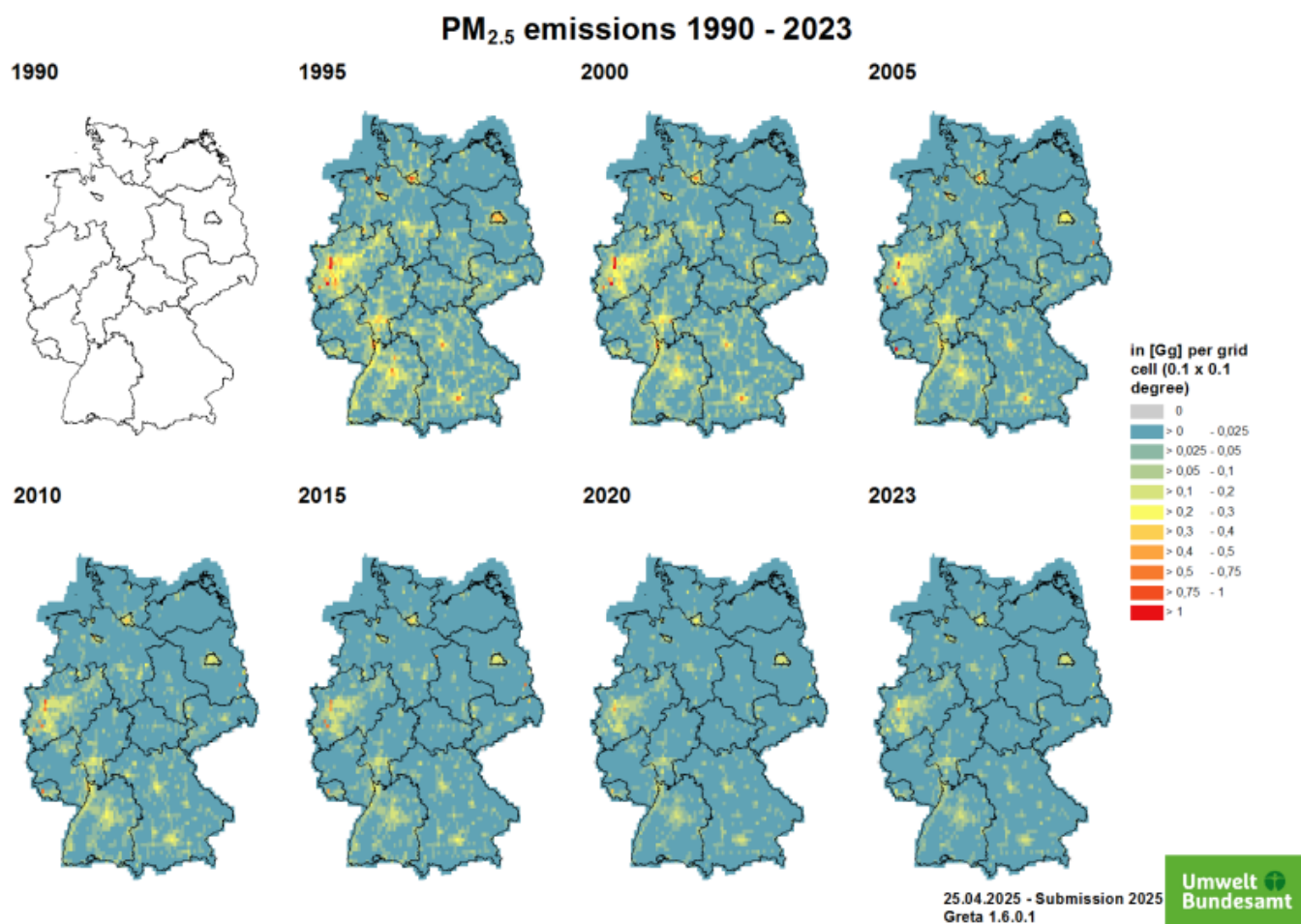
Corresponding to the SO<sub>2</sub> emissions, total suspended particles (TSP) in general could be reduced by additional built-in filters in power plants as well as in vehicles.



With a decision of the Member States in 2006,  $PM_{10}$ ,  $PM_{2.5}$  and Black Carbon emissions for the years before 2000 are not mandatory in the reporting. In the 1990s, the sampling and analysis of particulate matter differed widely and a comparability was therefore not given. For this reason, the data was only scaled back to 1995.



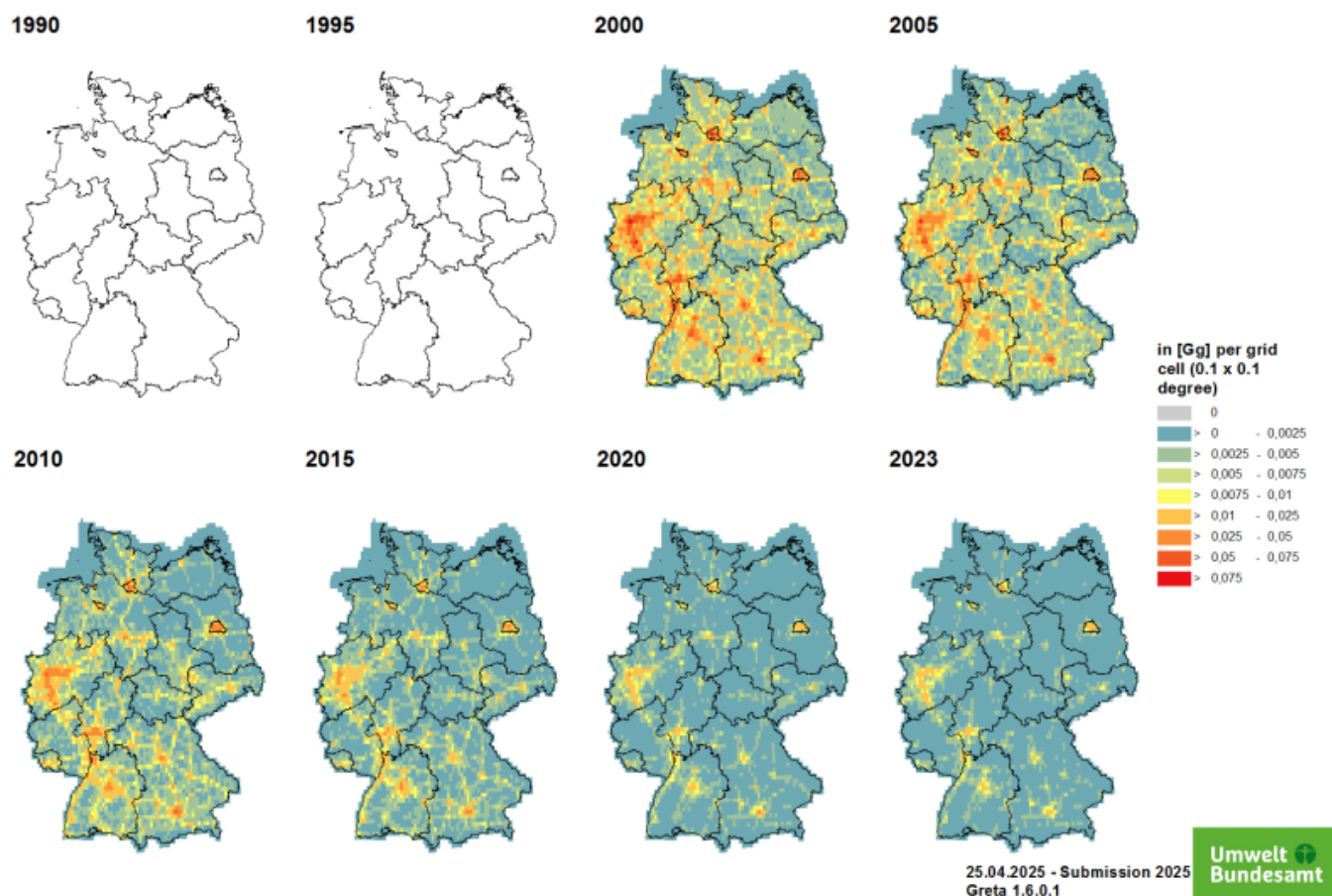
For PM<sub>2.5</sub> and TSP, the point source emissions are calculated using the emission ratio between PM<sub>10</sub> and TSP / PM<sub>2.5</sub> sector by sector.



In addition to the other particle emissions, the black carbon emissions were also spatially distributed.



## BC emissions 1990 - 2023



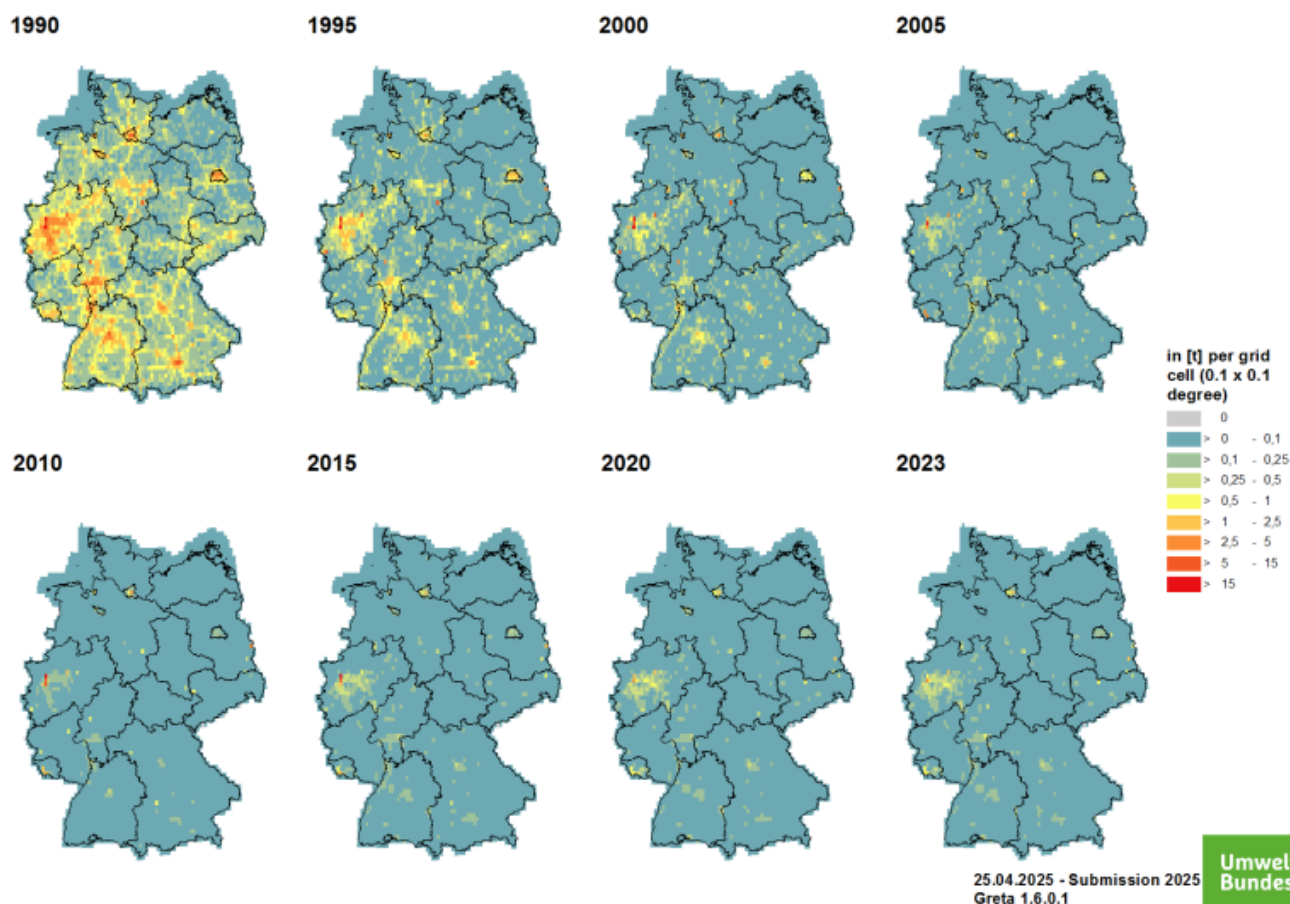
## Emissions of Heavy Metals (HM)

### Lead Emissions

Lead (Pb)-containing compounds are released in particular during combustion processes of coal and fuels. The main emitter here is the transport sector. Due to the toxic effect of these lead aerosols, leaded regular petrol (additive with lead tetraethyl) was banned in West Germany as early as 1988, the ban on leaded premium petrol followed in 1996. The European Union banned leaded petrol on 1 January 2000. Today, part of the Pb emissions still come from the automobile tyre and brake wear sector. This trend can be easily seen in the maps. The distribution parameter is analogous to road exhaust (NFR 1.A.3.b i-iv), the distribution parameter is vehicle mileage.

Another source of emissions is the metal processing industry - iron and steel. The distribution parameter is partially covered by the PRTR point sources; rest: by number of employees per district (metal production and processing).

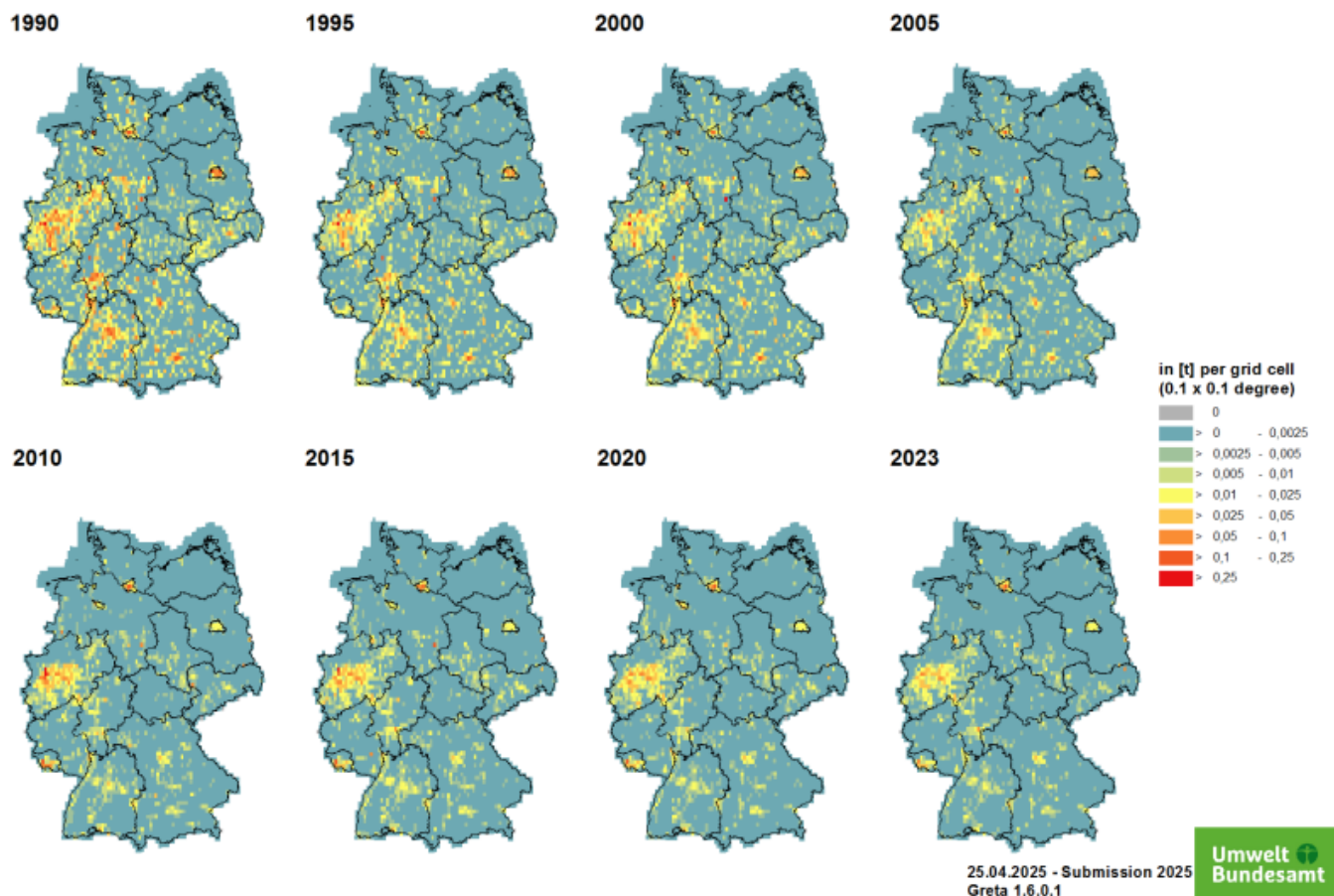
### Pb emissions 1990 - 2023



### Cadmium Emissions

Cadmium (Cd) is one of the most toxic metals and substances for humans and the environment. The metal occurs in the body as a trace element and is incorporated through food. It is found in tobacco smoke, PVC and plastic and paint pigments. In the chemical industry, cadmium is a by-product of the extraction of zinc, lead or copper. The most important emission sources in Germany are the sectors of the metal processing industry - iron and steel, and copper production. It is also emitted by petroleum refineries and coal and oil combustion. For the latter, it can be captured via appropriate particle filters and thus reduced. For the dominant emission sources, the distribution is partially covered by PRTR point sources; the rest: by number of employees per district (metal production and processing).

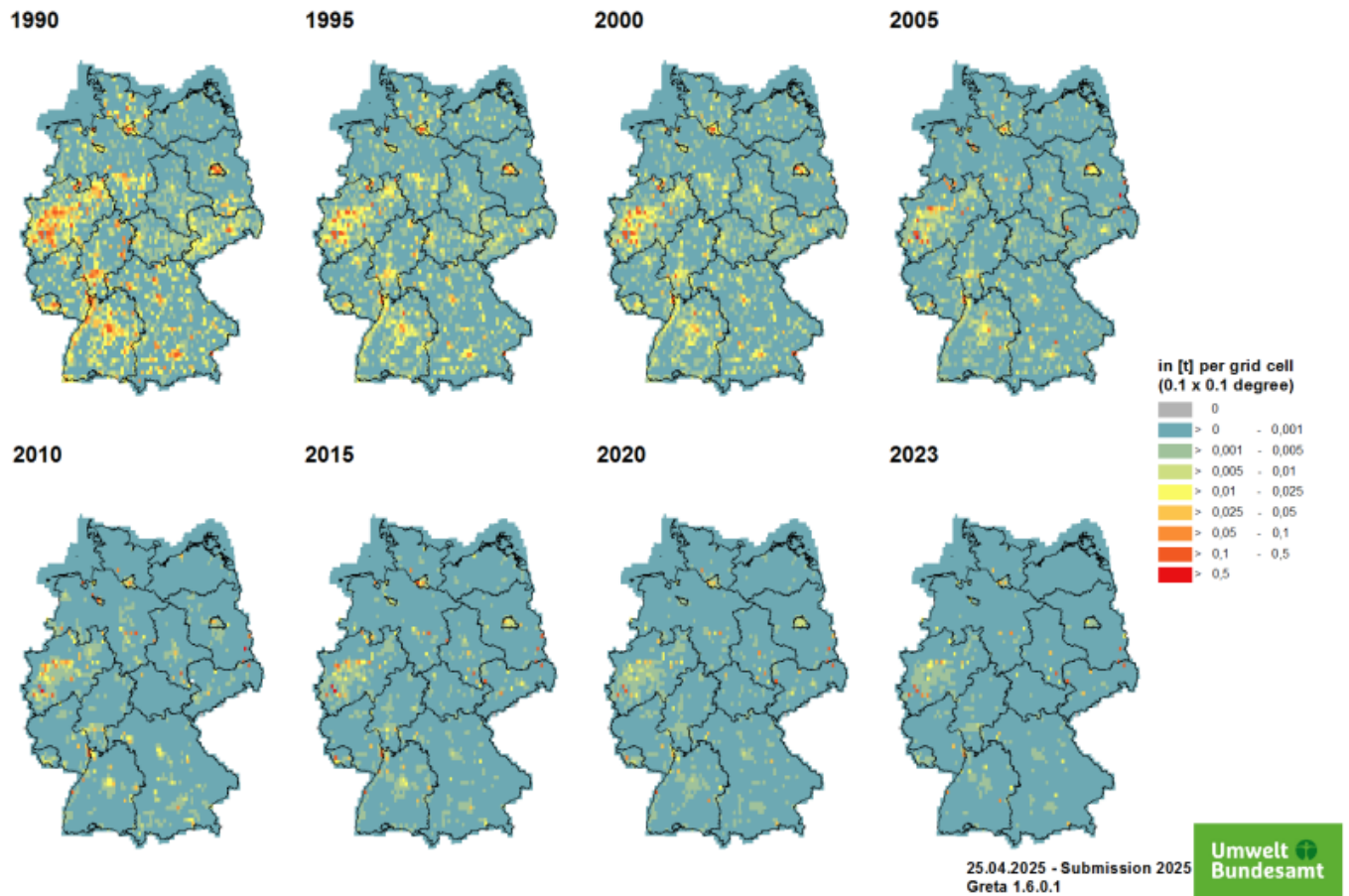
### Cd emissions 1990 - 2023



### Mercury Emissions

Mercury (Hg) belongs to the group of heavy metals that occur both naturally (e.g. volcanic eruptions) and through industrial processes (e.g. mining, burning coal or heating oil) in the environment. A distinction is made between elemental (metallic) mercury (Hg<sub>0</sub>), inorganic mercury (iHg) and organic mercury compounds such as methylmercury (MeHg). It is mostly emitted bound to fine particles. It is mainly released during energy production from fossil fuels such as coal, oil and natural gas, and during metal-producing processes such as iron and steel production. The spatial distribution is made for energy supply via PRTR point sources (the rest: number of other power plants (<25 MW electric) for public supply per district).

## Hg emissions 1990 - 2023

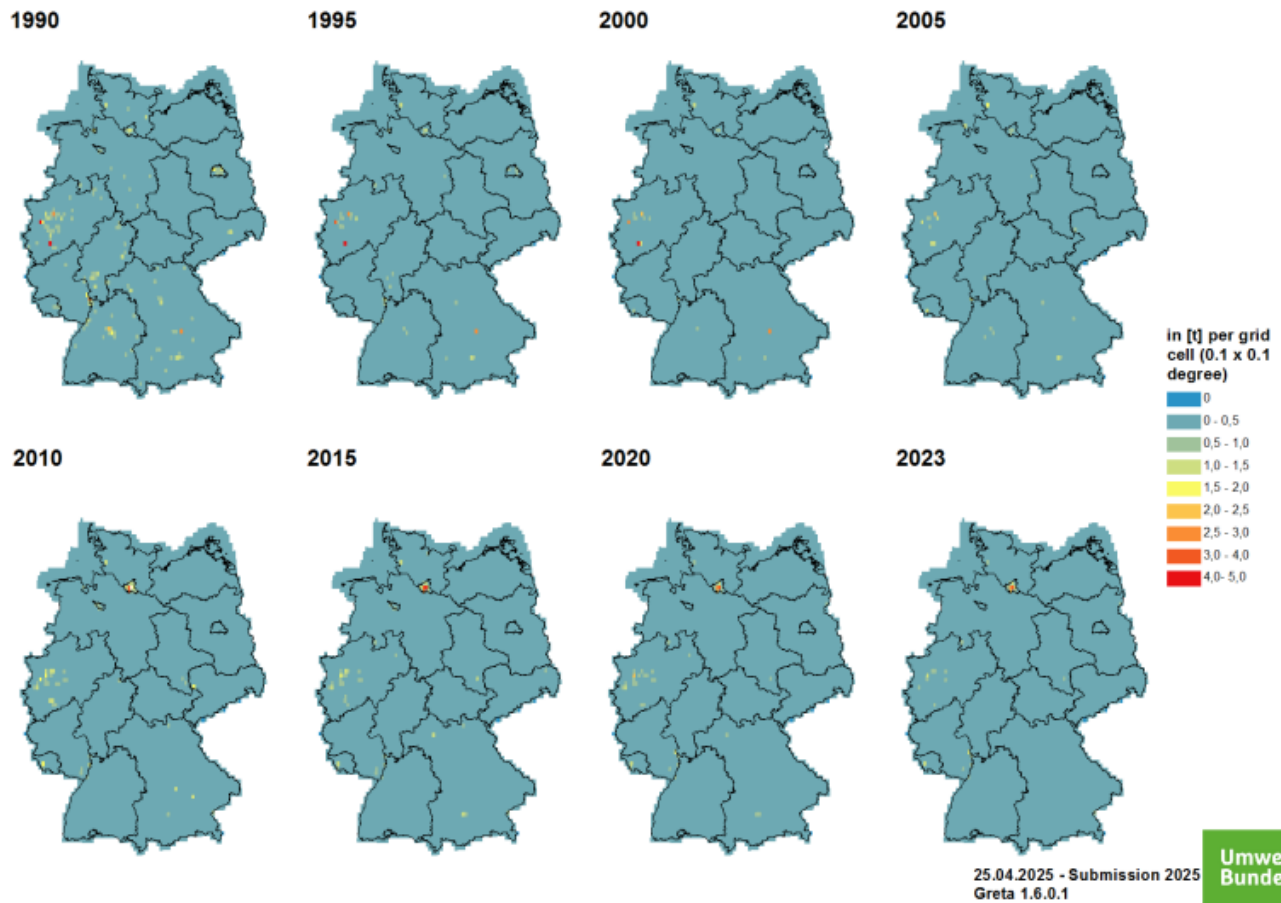


### Nickel Emissions

Nickel (Ni) is a carcinogen and allergen. The main sources for Ni emissions in Germany are combustion processes of fossil fuels and the production of Ni containing alloys. The spatial distribution of Ni emissions from energy production and industrial activity is conducted as described above.



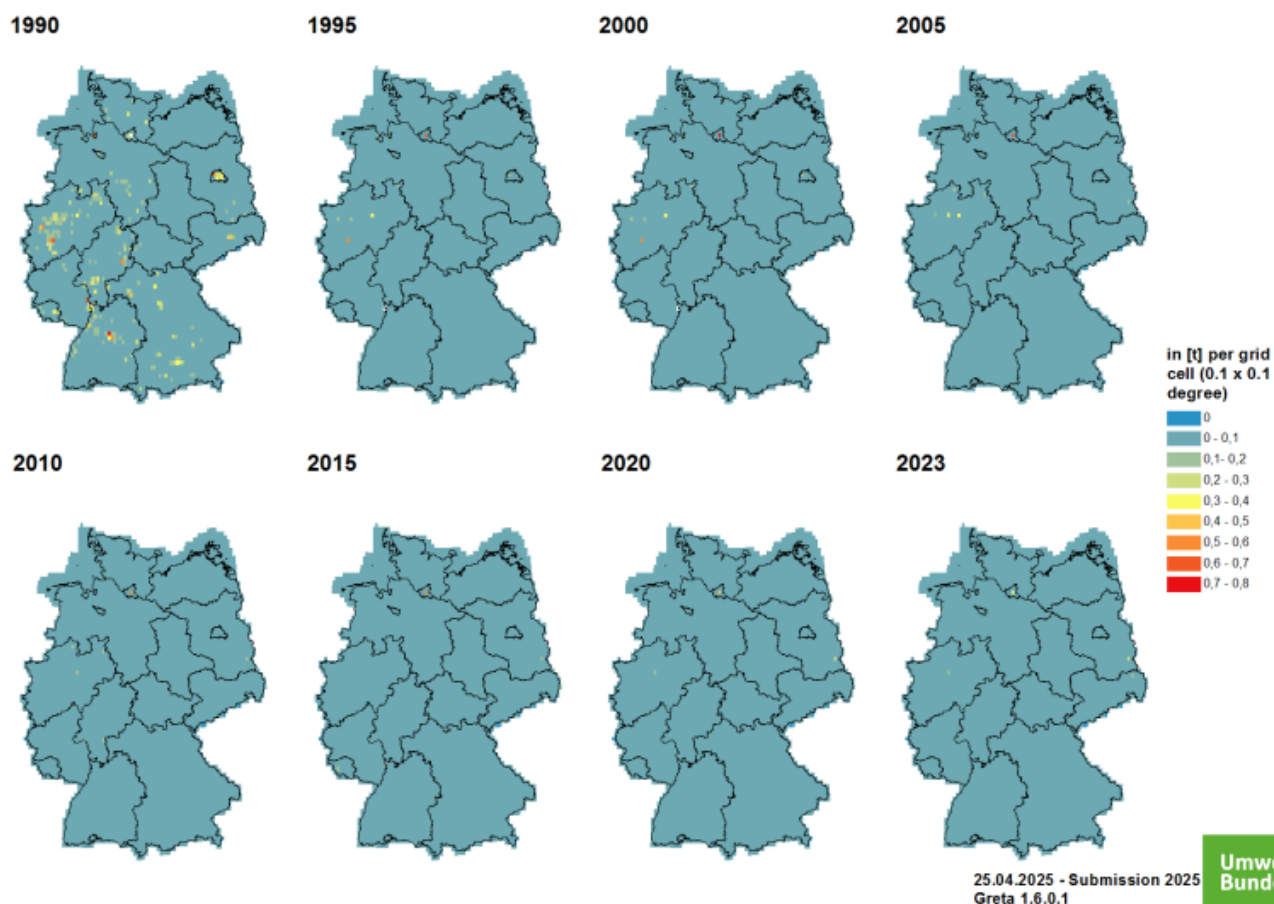
## Ni emissions 1990 - 2023



### Arsenic Emissions

Arsenic (As) is a highly toxic and carcinogenic metalloiod. In the environment, two oxidation states are most common, +3 and +5, were the first one has the highest toxic potential. Analogous to other anthropogenic metal emissions in Germany, As is released mostly during energy production from fossil fuels, especially coal, and during metal-producing processes. The spatial distribution of As emissions from energy production and industrial activity is conducted as described above.

### As emissions 1990 - 2023

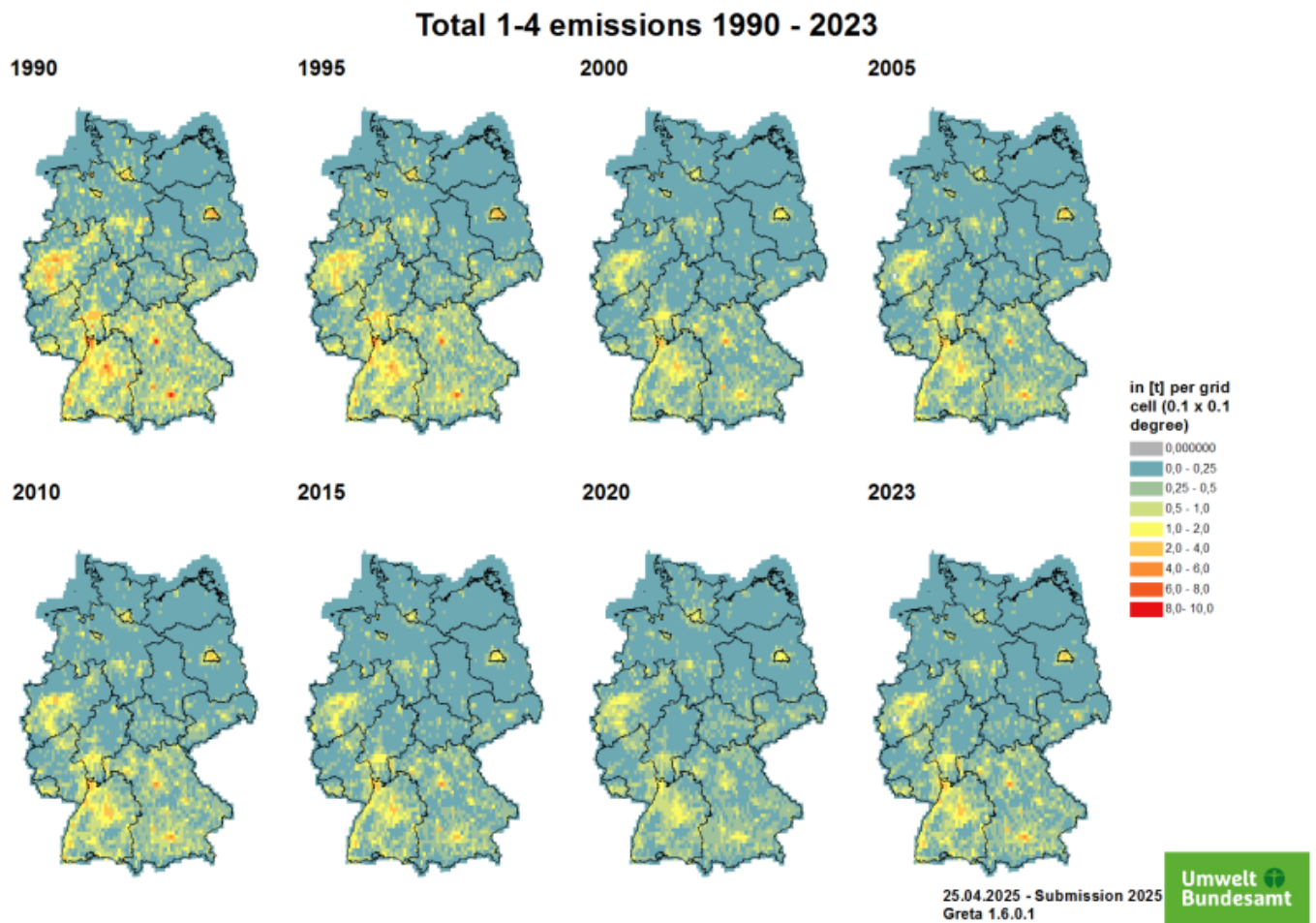


### Emissions of persistent organic pollutants (POP)

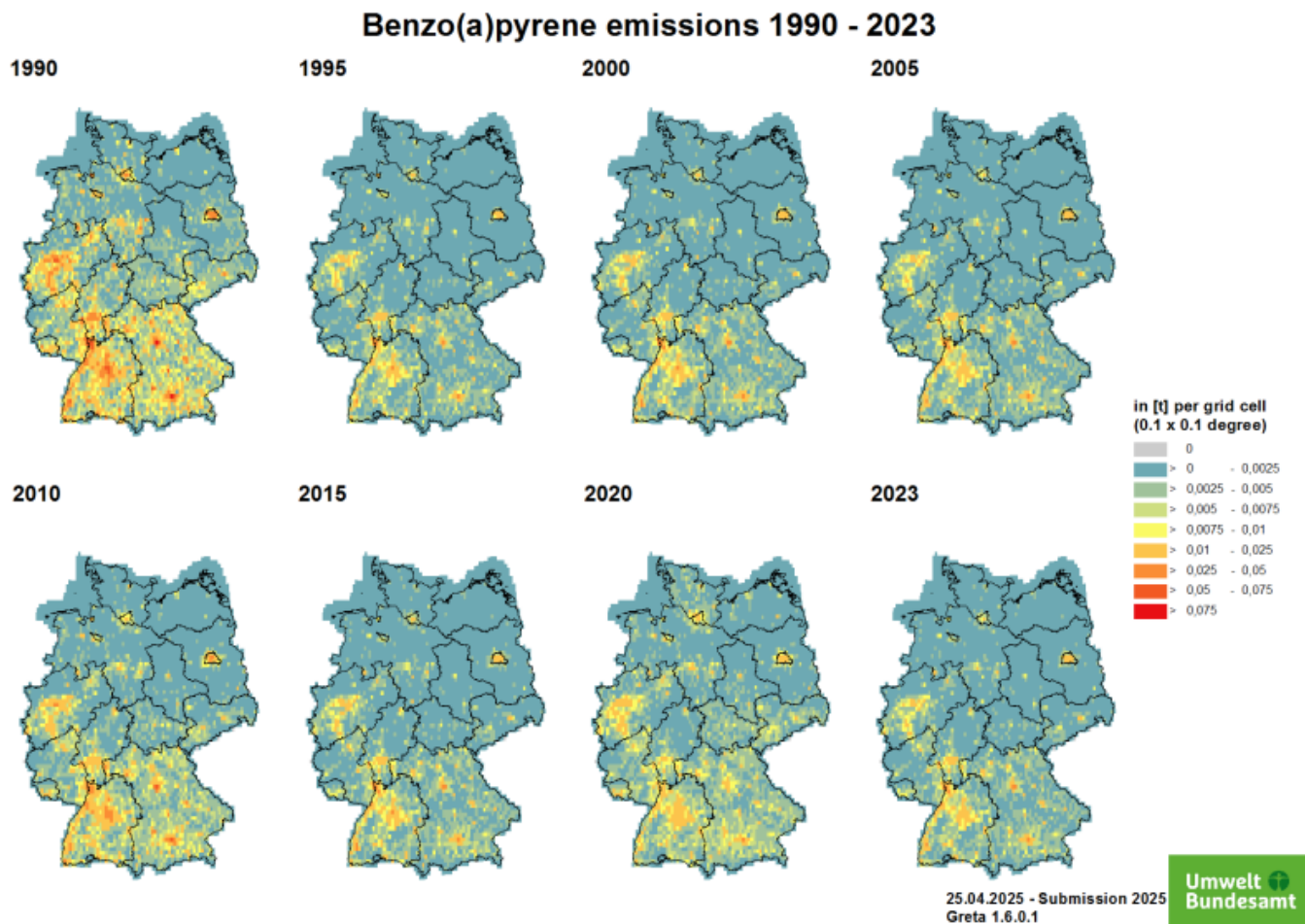
Data on POP emissions have a higher uncertainty compared to air pollutants such as SO<sub>2</sub>, CO or NO<sub>x</sub>. Therefore, the following maps should only be considered as estimates. It should be noted that the emission amounts are significantly different in magnitude from those of the air pollutants mentioned above.

#### Polycyclic aromatic Hydrocarbons and Benzo(a)pyrene

PAHs are formed during the incomplete combustion of organic material (e.g. coal, heating oil, fuel, wood, tobacco, forest fires). The dominant sources of PAHs in the environment are thus from human activity: wood-burning and combustion of other biofuels. The dominating source is the residential sector - Stationary. The spatial distribution is therefore mainly covered by distribution according to energy carriers (national).



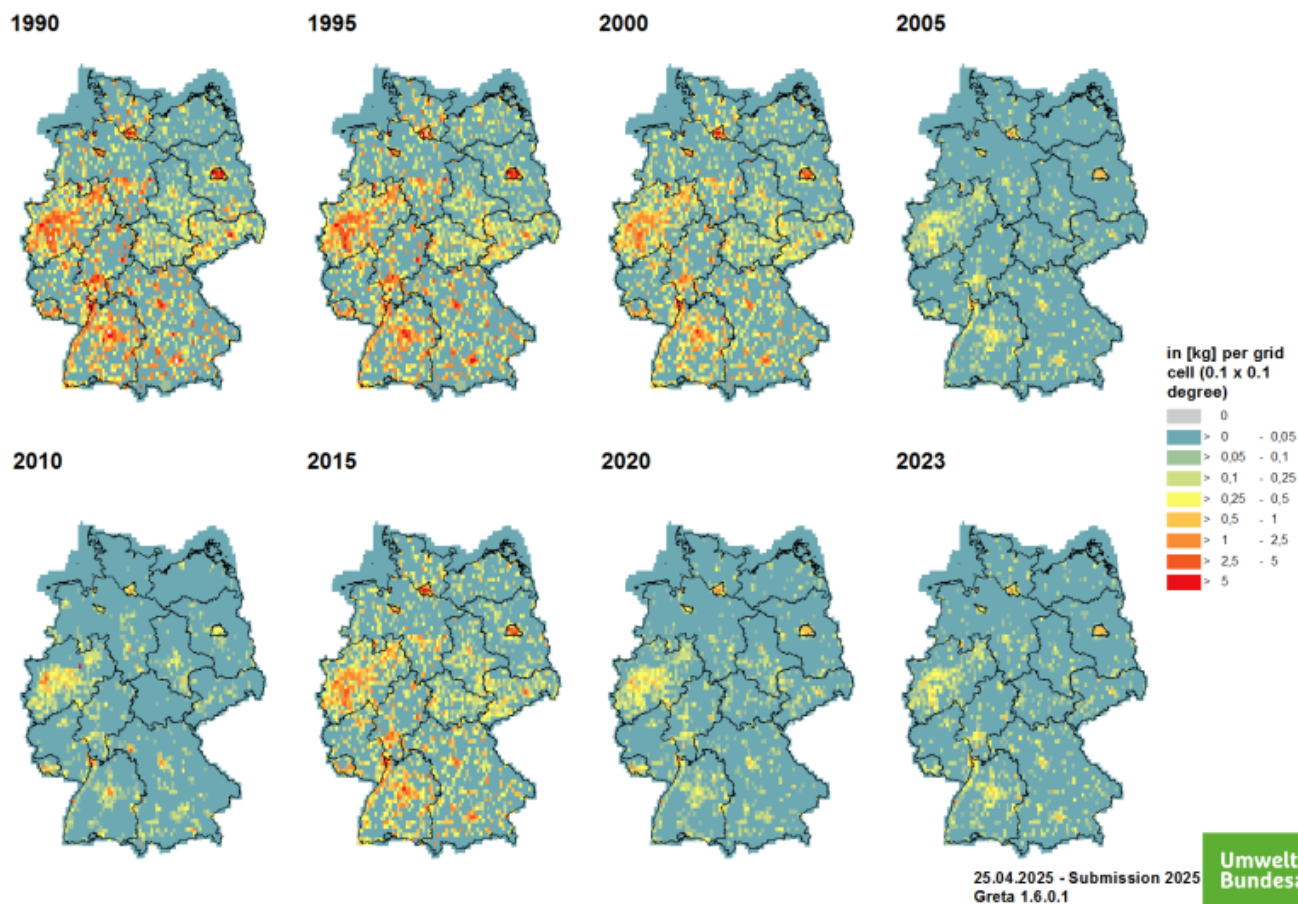
Benzo(a)pyrene is considered an indicator substance of polycyclic aromatic hydrocarbons. For this reason, more measurement data and further information are available than for other POPs. In the determination of environmental pollution by this group of substances, benzo[a]pyrene is usually used as a reference.



#### Polychlorinated biphenyls (PCB)

PCBs are classified as industrial chemicals and were used in various applications in pure form or as additives until the restrictions and bans came into force. Due to their properties (thermal stability, low water absorption and non-flammability), they were used in insulating oils in transformers, capacitors, additive to joint sealants and anti-corrosion coatings. The maps show the magnitude of HCB emissions in kilograms. The key sources are the sectors Public Power, Iron & Steel, and Residential - Stationary. The spatial distribution is therefore mainly covered by PRTR Point Sources (PS).

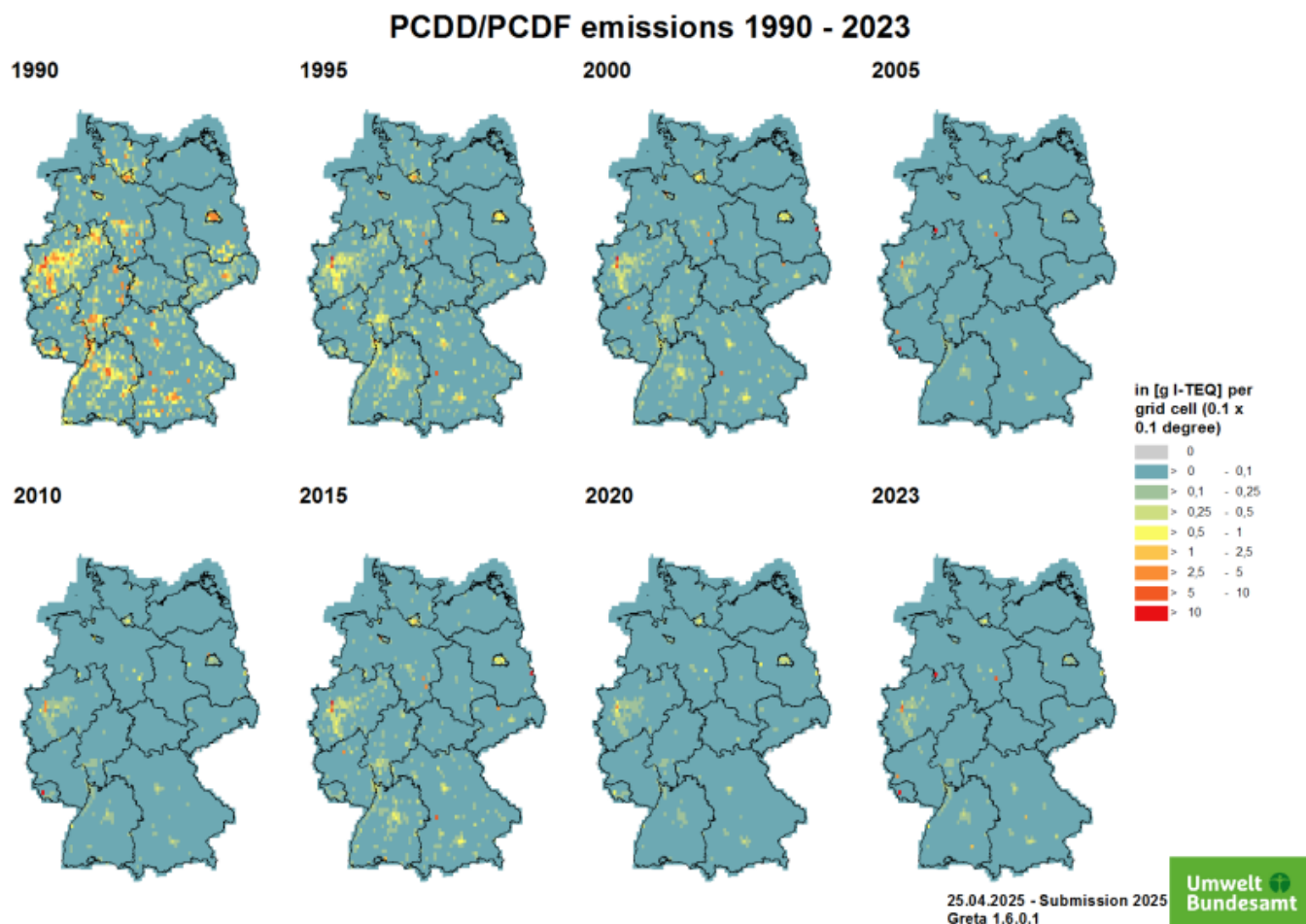
### PCB emissions 1990 - 2023



### PCDD/PCDF

Emissions of dioxins and furans are formed as by-products in a variety of thermal processes, in the production of organochlorine chemicals, or in any oxidation reactions of hydrocarbon compounds in the presence of chlorine compounds. The magnitude of dioxins emissions is presented in the g I-TEQ range (toxic equivalence, TEQ) in the maps. The major key sources are the Residential - stationary combustion (1.A.4.b i), Other Waste: Building and Car Fires (5.E.2), and Metal Industrie - Iron and Steel (2.C.1). The spatial distribution is partially covered by information of PRTR point sources and for the residential sector according to energy carriers.





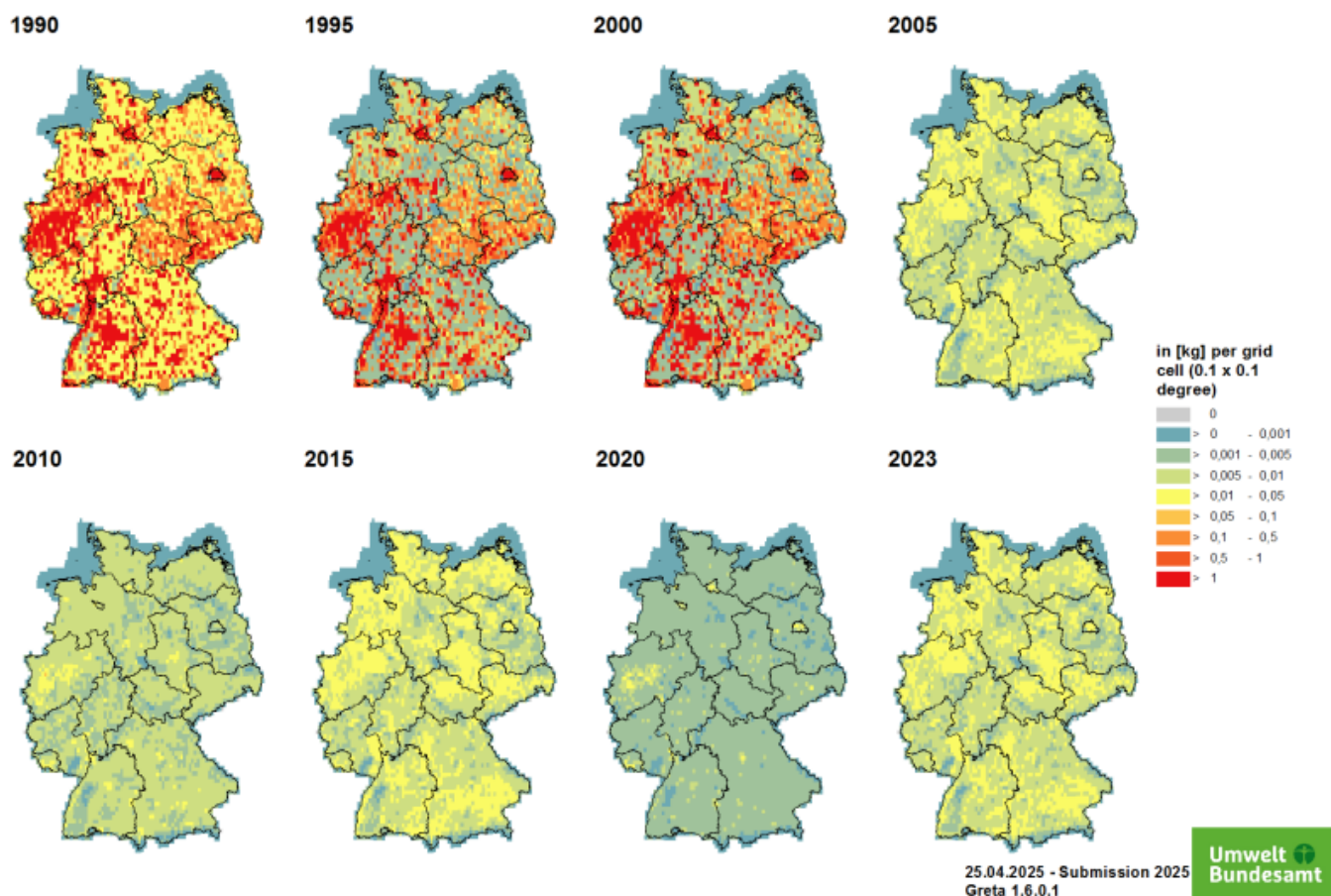
#### Hexachlorobenzene Emissions

Hexachlorobenzene (HCB) is a chemical substance that can also be formed as a by-product in the manufacture of chlorine compounds. It can also be released through incomplete combustion processes and leaching from landfills. The maps show the magnitude of HCB emissions in kilograms.

In the maps, the two main emission sources - production of secondary aluminium and application of pesticides in agriculture - as well as the emission trend are clearly visible. Degassing operations in refining plants of secondary aluminium production can produce HCB. The use of hexachloroethane has been prohibited by law in Germany since 2002, which eliminates the source of HCB. The emission distribution is partly covered by reports from the PRTR, the remaining emissions are calculated using number of employees per district in metal production and processing. More information is described under [2.C.3 - Aluminium Production](#).

In agriculture, HCB has not been used as a pure substance for a long time, as it has been banned since 1977. However, some pesticides that are still approved contain impurities that can arise during the manufacturing process. These agents are used to combat fungal infestations, particularly in cereal crops. Emissions from this sector are distributed over the agricultural area. However, this distribution is subject to great uncertainties, as the application is carried out depending on the mould infestation and the need for action. More information is described under [3.D.f - Agriculture other including use of pesticides](#).

## HCB emissions 1990 - 2023



<sup>1)</sup> Schneider et al. (2016): Schneider, Chr., Pelzer, M., Toenges-Schuller, N., Nacken, M., and Niederau, A.: ArcGIS basierte Lösung zur detaillierten, deutschlandweiten Verteilung (Gridding) nationaler Emissionsjahreswerte auf Basis des Inventars zur Emissionsberichterstattung. UBA Texte 71/2016, p.224;

[https://www.umweltbundesamt.de/sites/default/files/medien/1968/publikationen/2016-11-09\\_griddingtool\\_greta\\_langfassung\\_final.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/1968/publikationen/2016-11-09_griddingtool_greta_langfassung_final.pdf); ISSN 1862-4804; AVISO GmbH on order of the Umweltbundesamt; Dessau-Roßlau, November 2016

<sup>2)</sup> Pelzer et al. (2018): Michael Pelzer, M., Schneider, Chr., Gallus, E. and Toenges-Schuller, N.: Gridding Emission Tool for ArcGIS (GRETA): Weiterentwicklungen und Erweiterung des Stoffspektrums - documentation regarding GRETA-AddIn version 1.1.2.2:

[https://iir.umweltbundesamt.de/2025/\\_media/general/gridded\\_data/2019\\_01\\_14\\_doku\\_greta\\_erweiterung2018\\_190114.pdf](https://iir.umweltbundesamt.de/2025/_media/general/gridded_data/2019_01_14_doku_greta_erweiterung2018_190114.pdf), AVISO GmbH on order of the Umweltbundesamt, October 2018, Aachen

<sup>3)</sup> Pelzer et al. (2021): Michael Pelzer, M., Schneider, Chr., Gallus, E. and Toenges-Schuller, N.: Gridding Emission Tool for ArcGIS (GRETA): Weiterentwicklungen - GRETA-AddIn Version: 1.1.4.2; ArcGIS 10.8:

[https://iir.umweltbundesamt.de/2025/\\_media/general/gridded\\_data/2021\\_05\\_17\\_doku\\_greta\\_erweiterung\\_210517.pdf](https://iir.umweltbundesamt.de/2025/_media/general/gridded_data/2021_05_17_doku_greta_erweiterung_210517.pdf); AVISO GmbH on order of the Umweltbundesamt, May 2021, Aachen

<sup>4)</sup> Pelzer et al. (2024): Michael Pelzer, M., Toenges-Schuller, N. and Schneider, Chr.: Weiterentwicklungen 2023/2024: documentation as of 20.6.2024, GRETA-AddIn Version: 1.5.4.3; ArcGIS 10.8.2;

[https://iir.umweltbundesamt.de/2025/\\_media/general/gridded\\_data/2024\\_06\\_20\\_doku\\_greta\\_weiterentwicklung\\_2023\\_2024.pdf](https://iir.umweltbundesamt.de/2025/_media/general/gridded_data/2024_06_20_doku_greta_weiterentwicklung_2023_2024.pdf); AVISO GmbH on order of the Umweltbundesamt, June 2024, Aachen

## CHAPTER 12: Adjustments and Emissions Reduction Commitments



For its 2026 submission, Germany again fulfils its obligations regarding emission mitigation for all regulated pollutants and does not need to employ any adjustments.



The last adjustment applications date back to Germany's 2021 NEC submission. For more information, please refer to the information provided in the corresponding chapter of the 2021 IRR:

<https://iir.umweltbundesamt.de/2021/general/adjustments/start>



# Appendices to the German Informative Inventory Report

|                                                                                                                |
|----------------------------------------------------------------------------------------------------------------|
| <b>Appendix 1</b> - <a href="#">Key Category Analysis (KCA)</a>                                                |
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| <i>Appendix 2.1</i> - <a href="#">Reporting of PM emissions</a>                                                |
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| <b>Appendix 3</b> - <a href="#">Further Elaboration of Completeness</a>                                        |
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# Appendix 1 - Key Category Analysis



All information is given in [Chapter 1.5 - Key Sources](#).

# Appendix 2 - Detailed Methodological Descriptions

The following sub-chapters of Appendix 2 provide additional methodological descriptions for individual source categories (where relevant and not provided in the related NFR sub-chapter) as well as for the entire inventory.

So far, appendix 2 provides additional methodological information on:

|                                                                                                         |
|---------------------------------------------------------------------------------------------------------|
| Appendix 2.1 - <a href="#">Reporting of PM emissions</a>                                                |
| Appendix 2.2 - <a href="#">Road Transport</a>                                                           |
| Appendix 2.3 - <a href="#">Heavy Metal (HM) exhaust emissions from mobile sources</a>                   |
| Appendix 2.4 - <a href="#">Persistent Organic Pollutant (POP) exhaust emissions from mobile sources</a> |
| to be continued...                                                                                      |

## Appendix 2.1 - Reporting of PM emissions

The condensable fraction of particulate matter (PM<sub>2.5</sub>) is documented for all activities in the emissions database. A documentation entry has been created for each time series, indicating the following options for condensable particulate matter:

- Yes (measured/determined), the condensable fraction of PM<sub>2.5</sub> was measured and is included in the emission values
- No, the condensable fraction has not been determined and is not included in the emission values
- NA (no condensable PM<sub>2.5</sub> is generated in the process)
- Unknown, the condensable fraction for PM<sub>2.5</sub> is unknown and could be zero

Below is an excerpt from the database, showing the aforementioned documentation entries by source category.



NFR categories with no reported activity or PM<sub>2.5</sub> emissions are excluded here.

| NFR Source Category   |                                                              | Yes                   | Not Applicable                                                  | No                     | Unknown | Total      |
|-----------------------|--------------------------------------------------------------|-----------------------|-----------------------------------------------------------------|------------------------|---------|------------|
|                       |                                                              | (measured/determined) | (no condensable PM <sub>2.5</sub> are generated in the process) | (potentially possible) |         |            |
| <b>NFR 1 - Energy</b> |                                                              |                       |                                                                 |                        |         |            |
| 1A1ai                 | Electricity Generation                                       | -                     | -                                                               | 111                    | -       | <b>111</b> |
| 1A1aii                | Heat Plants                                                  | -                     | -                                                               | 38                     | -       | <b>38</b>  |
| 1A1b                  | Petroleum Refining                                           | -                     | -                                                               | 32                     | -       | <b>32</b>  |
| 1A1ci                 | Manufacture of Solid Fuels                                   | -                     | -                                                               | 39                     | -       | <b>39</b>  |
| 1A1ciii               | Other Energy Industries                                      | -                     | -                                                               | 3                      | -       | <b>3</b>   |
| 1A1civ                | Other Manufacture of Solid Fuels and Other Energy Industries | -                     | -                                                               | 16                     | -       | <b>16</b>  |
| 1A2a                  | Iron and Steel                                               | -                     | -                                                               | 21                     | -       | <b>21</b>  |
| 1A2gvii               | Off-road Vehicles and Other Machinery                        | 4                     | -                                                               | -                      | -       | <b>4</b>   |
| 1A2gviii              | Other                                                        | -                     | -                                                               | 104                    | -       | <b>104</b> |
| 1A3ai(i)              | International Aviation LTO (civil)                           | -                     | -                                                               | -                      | 2       | <b>2</b>   |
| 1A3ai(ii)             | International Aviation Cruise (civil)                        | -                     | -                                                               | -                      | 2       | <b>2</b>   |
| 1A3aii(i)             | Domestic Aviation LTO (civil)                                | -                     | -                                                               | -                      | 2       | <b>2</b>   |
| 1A3aii(ii)            | Domestic Aviation Cruise (civil)                             | -                     | -                                                               | -                      | 2       | <b>2</b>   |
| 1A3bi                 | Road Transport: Passenger Cars                               | 154                   | -                                                               | -                      | -       | <b>154</b> |
| 1A3bii                | Road Transport: Light duty vehicles                          | 138                   | -                                                               | -                      | -       | <b>138</b> |
| 1A3biii               | Road Transport: Heavy duty vehicles and buses                | 136                   | -                                                               | -                      | -       | <b>136</b> |
| 1A3biv                | Road Transport: Mopeds and Motorcycles                       | 56                    | -                                                               | -                      | -       | <b>56</b>  |
| 1A3bvi                | Road Transport: Automobile tyre and brake wear               | -                     | 24                                                              | -                      | -       | <b>24</b>  |
| 1A3bvii               | Road Transport: Automobile road abrasion                     | -                     | 12                                                              | -                      | -       | <b>12</b>  |
| 1A3c                  | Rail Transport                                               | 11                    | -                                                               | 1                      | -       | <b>12</b>  |
| 1A3di(i)              | International Maritime Navigation                            | -                     | -                                                               | -                      | 3       | <b>3</b>   |
| 1A3dii                | National Navigation (shipping)                               | 8                     | -                                                               | 1                      | 1       | <b>10</b>  |
| 1A3ei                 | Pipeline Transport                                           | -                     | -                                                               | 4                      | -       | <b>4</b>   |
| 1A4ai                 | Commercial/Institutional: Stationary                         | -                     | -                                                               | 29                     | -       | <b>29</b>  |
| 1A4aii                | Commercial/Institutional: Mobile                             | 3                     | -                                                               | -                      | -       | <b>3</b>   |
| 1A4bi                 | Residential: Stationary                                      | -                     | -                                                               | 15                     | -       | <b>15</b>  |
| 1A4bii                | Residential: Household and Gardening (mobile)                | -                     | -                                                               | 4                      | 4       | <b>8</b>   |

| NFR Source Category        |                                                                      | Yes | Not Applicable | No | Unknown | Total     |
|----------------------------|----------------------------------------------------------------------|-----|----------------|----|---------|-----------|
| 1A4ci                      | Agriculture/Forestry/Fishing: Stationary                             | -   | -              | 16 | -       | <b>16</b> |
| 1A4cii                     | Agriculture/Forestry/Fishing: Off-road Vehicles and other Machinery  | 6   | -              | -  | -       | <b>6</b>  |
| 1A4ciii                    | Agriculture/Forestry/Fishing: National Fishing                       | -   | -              | -  | 4       | <b>4</b>  |
| 1A5a                       | Other Stationary (including military)                                | -   | -              | 10 | -       | <b>10</b> |
| 1A5b                       | Other Mobile (including military, land based and recreational boats) | -   | -              | 8  | 1       | <b>9</b>  |
| 1B1a2i                     | Mining Activities                                                    | -   | 1              | -  | -       | <b>1</b>  |
| 1B1b                       | Solid Fuel Transformation                                            | -   | 6              | 2  | -       | <b>8</b>  |
| 1B2c2ii                    | Gas                                                                  | -   | -              | 1  | -       | <b>1</b>  |
| <b>NFR 2 - Industry</b>    |                                                                      |     |                |    |         |           |
| 2A1                        | Cement Production                                                    | -   | -              | 1  | -       | <b>1</b>  |
| 2A2                        | Lime Production                                                      | -   | -              | -  | 2       | <b>2</b>  |
| 2A3                        | Glass Production                                                     | 6   | -              | -  | -       | <b>6</b>  |
| 2A4a                       | Ceramics                                                             | -   | -              | -  | 15      | <b>15</b> |
| 2A5a                       | Quarrying and Mining of Minerals other than Coal                     | -   | 4              | -  | -       | <b>4</b>  |
| 2A5b                       | Construction and Demolition                                          | -   | 5              | -  | -       | <b>5</b>  |
| 2B5b                       | Calcium Carbide                                                      | -   | -              | -  | 1       | <b>1</b>  |
| 2B8f                       | Carbon Black                                                         | -   | -              | -  | 1       | <b>1</b>  |
| 2B10a                      | Hydrogen Production (CRT) / Chemical Industry: Other (NFR)           | -   | -              | -  | 1       | <b>1</b>  |
| 2C1a                       | Steel                                                                | -   | -              | -  | 4       | <b>4</b>  |
| 2C1b                       | Pig Iron                                                             | -   | -              | -  | 1       | <b>1</b>  |
| 2C1d                       | Sinter                                                               | -   | -              | -  | 1       | <b>1</b>  |
| 2C1f                       | Other Iron and Steel Production                                      | -   | -              | -  | 1       | <b>1</b>  |
| 2C2                        | Ferroalloys Production                                               | -   | -              | -  | 1       | <b>1</b>  |
| 2C3a                       | By-Product Emissions                                                 | -   | -              | -  | 2       | <b>2</b>  |
| 2C5                        | Lead Production                                                      | -   | -              | -  | 2       | <b>2</b>  |
| 2C6                        | Zinc Production                                                      | -   | -              | -  | 2       | <b>2</b>  |
| 2C7a                       | Rare Earth Production (CRT) / Copper Production (NFR)                | -   | -              | -  | 2       | <b>2</b>  |
| 2C7c                       | Other Metal Production                                               | -   | -              | -  | 1       | <b>1</b>  |
| 2D3b                       | Road Paving with Asphalt                                             | -   | -              | -  | 1       | <b>1</b>  |
| 2G4                        | Further Product Manufacture and Use                                  | 3   | -              | -  | 1       | <b>4</b>  |
| 2H1                        | Pulp and Paper Industry                                              | -   | -              | 2  | -       | <b>2</b>  |
| 2H2                        | Food and Beverages Industry                                          | -   | -              | -  | 2       | <b>2</b>  |
| 2I                         | Wood Processing                                                      | -   | 1              | -  | -       | <b>1</b>  |
| 2L                         | Handling of Bulk Products                                            | -   | 1              | -  | 89      | <b>90</b> |
| <b>NFR 3 - Agriculture</b> |                                                                      |     |                |    |         |           |
| 3B1a                       | Dairy Cattle                                                         | -   | 1              | -  | -       | <b>1</b>  |
| 3B1b                       | Non-dairy Cattle                                                     | -   | 6              | -  | -       | <b>6</b>  |
| 3B2                        | Sheep                                                                | -   | 1              | -  | -       | <b>1</b>  |
| 3B3                        | Swine                                                                | -   | 4              | -  | -       | <b>4</b>  |
| 3B4c                       | Deer                                                                 | -   | 1              | -  | -       | <b>1</b>  |
| 3B4d                       | Goats                                                                | -   | 1              | -  | -       | <b>1</b>  |
| 3B4e                       | Horses                                                               | -   | 1              | -  | -       | <b>1</b>  |
| 3B4gi                      | Laying Hens                                                          | -   | 1              | -  | -       | <b>1</b>  |
| 3B4gii                     | Broilers                                                             | -   | 1              | -  | -       | <b>1</b>  |
| 3B4giii                    | Turkeys                                                              | -   | 1              | -  | -       | <b>1</b>  |
| 3B4giv                     | Other Poultry                                                        | -   | 3              | -  | -       | <b>3</b>  |
| 3B4h                       | Other Animals                                                        | -   | 3              | -  | -       | <b>3</b>  |

| NFR Source Category             |                                                                                            | Yes        | Not Applicable | No         | Unknown    | Total        |
|---------------------------------|--------------------------------------------------------------------------------------------|------------|----------------|------------|------------|--------------|
| 3D3                             | Farm-level Agricultural Operations incl. Storage, Handling and Transport of Agri. Products | -          | 1              | -          | -          | 1            |
| <b>NFR 5 - Waste</b>            |                                                                                            |            |                |            |            |              |
| 5A1                             | Managed Waste Disposal Sites                                                               | -          | 1              | -          | -          | 1            |
| 5C1aii5                         | Other Waste                                                                                | -          | -              | 1          | -          | 1            |
| 5C2aii                          | Other Biogenic Waste                                                                       | -          | -              | -          | 1          | 1            |
| 5E                              | Other Waste                                                                                | -          | -              | -          | 6          | 6            |
| <b>NFR 11 - Natural Sources</b> |                                                                                            |            |                |            |            |              |
| 11B                             | Forest Fires                                                                               | -          | -              | -          | 1          | 1            |
| <b>SUM</b>                      |                                                                                            | <b>525</b> | <b>80</b>      | <b>459</b> | <b>159</b> | <b>1.223</b> |

## Appendix 2.2 - Additional information: Emissions from road transport

### Derivation of activity data

#### Cross-check with Energy Balance

The Energy Balance is also used to model transport-quantity structures in TREMOD. For example, the German Economic Institute (DIW) carries out a fuel-consumption calculation in order to derive total mileage travelled (DIW, 2002). Some of the results of the calculation, for automobile transports, are entered into TREMOD. The DIW uses a fuel-consumption calculation in order to determine total domestic mileage; TREMOD uses some other sources and assumptions to estimate total domestic mileage – especially for goods transports (cf. the detailed description in (Knörr, W., Höpfner, U., & Lambrecht, U. (2002))<sup>1)</sup>. This estimate also takes the basic figures of the Energy Balance into account.

On the other hand, due to the many dependencies and uncertainties in the model, and to the basic data that must be taken into account, no feasible means is available for comparing mileage and energy consumption, for each year and each vehicle layer, in such a manner that the results yield the Energy Balance sum and the mileage and average energy consumption figures in the time series are plausible. For this reason, the TREMOD results for the fuel consumption are corrected, at the end of the process, in such a manner that the total for each reference year corresponds to the relevant figure in the Energy Balance.

Since TREMOD calculates fuel consumption in tonnes, the results first have to be converted into terajoule [TJ]. For this purpose the net calorific values of the Working Group on Energy Balances (AGEB) are used.

Table 1: Net calorific values for gasoline and diesel oil, in kJ/kg

|                                                                                                            | GASOLINE | DIESEL |
|------------------------------------------------------------------------------------------------------------|----------|--------|
| 1990-2000                                                                                                  | 43,543   | 42,959 |
| 2005                                                                                                       |          | 42,959 |
| 2010                                                                                                       |          | 42,961 |
| 2015                                                                                                       |          | 42,694 |
| 2016                                                                                                       |          | 42,648 |
| 2017                                                                                                       |          | 42,695 |
| 2018                                                                                                       |          | 42,889 |
| 2019                                                                                                       |          | 42,691 |
| 2020                                                                                                       |          | 42,973 |
| 2021                                                                                                       |          | 42,666 |
| 2022                                                                                                       |          | 42,722 |
| 2023                                                                                                       |          | 42,774 |
| 2024                                                                                                       |          | 42,852 |
| Source: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen) <sup>2)</sup> <sup>3)</sup> |          |        |

The correction factors are derived in TREMOD separately for the various vehicle categories, as follows:

- Firstly, a correction factor for gasoline is derived from the calculated petrol consumption for all vehicle categories and from petrol sales pursuant to the Energy Balance.
- The correction factor for gasoline is then also used to bring fuel consumption of vehicles with diesel engines, among automobiles and other vehicles  $\leq 3.5$  t (light duty vehicles (LDV), and of motor homes and motorcycles (MC)), in line with the Energy Balance.
- The difference between the corrected diesel-fuel consumption of automobiles and of other vehicles  $\leq 3.5$  t and the Energy Balance is then allocated to heavy duty vehicles and busses.
- The correction factor for heavy duty vehicles and busses is then calculated from their energy consumption, as calculated in accordance with the domestic principle, and the pertinent difference, as calculated for this group, from the Energy Balance.

Table 2: Correction factors for adjustment of TREMOD estimates to the National Energy Balance

|                                                      | GASOLINE FUELS | DIESEL FUELS |          |
|------------------------------------------------------|----------------|--------------|----------|
|                                                      | PC, LDV, M2W   | PC, LDV      | HDV, Bus |
| 1990                                                 | 1.086          | 1.086        | 0.983    |
| 1995                                                 | 1.046          | 1.046        | 0.931    |
| 2000                                                 | 0.995          | 0.995        | 0.957    |
| 2005                                                 | 0.947          | 0.947        | 0.779    |
| 2010                                                 | 0.870          | 0.870        | 0.877    |
| 2015                                                 | 0.891          | 0.891        | 0.889    |
| 2016                                                 | 0.901          | 0.901        | 0.871    |
| 2017                                                 | 0.904          | 0.904        | 0.892    |
| 2018                                                 | 0.876          | 0.876        | 0.857    |
| 2019                                                 | 0.874          | 0.874        | 0.872    |
| 2020                                                 | 0.910          | 0.910        | 0.902    |
| 2021                                                 | 0.906          | 0.906        | 0.852    |
| 2022                                                 | 0.929          | 0.929        | 0.836    |
| 2023                                                 | 0.917          | 0.917        | 0.826    |
| 2024                                                 | 0.920          | 0.920        | 0.801    |
| Source: TREMOD (Knörr, et al. (2025a)) <sup>4)</sup> |                |              |          |

### Allocation of biofuels, petroleum and LPG to the structural elements

The Energy Balance lists data for biofuels, petroleum and LPG for the transport sector. For purposes of importing into the CSE, the results for these fuels are derived as follows:

- Biodiesel is allocated to all structural elements with diesel engines, in keeping with their percentage shares of consumption of conventional diesel fuel.
- Bioethanol is allocated to all structural elements with gasoline engines, in keeping with their percentage shares of consumption of conventional gasoline.
- Petroleum is allocated to busses on roads outside of municipalities – and, thus, to the structural elements SV - BUS - KOAO and SV - BUS - MTAO – in keeping with their percentage shares of consumption of conventional diesel fuel.
- LPG is allocated to conventional automobiles, with petrol engines, on municipal roads (CSE nomenclature: SV - PKWO - KOIO).

### Activity data for evaporation

The activity data for evaporation emissions is set as total gasoline consumption, on municipal roads, pursuant to TREMOD; the corresponding figure for mopeds is the total consumption. The values corrected for the Energy Balance are used.

### Motor-vehicle-fleet data

For western Germany from 1990 through 1993, and for Germany as a whole as of 1994, car ownership was calculated on the basis of the officially published ownership and new registration statistics of the Federal Motor Transport Authority (KBA). The car ownership analysis for East Germany in 1990 was based on a detailed analysis of the Adlershof caremissions-testing agency in 1992 and the time series in the statistical annuals of the GDR. For the period between 1991 and 1993, it was necessary to estimate the figures with the aid of numerous assumptions.

Fleet data for the TREMOD model, for the reference years 2001 through 2003, are obtained from the database of the Federal Motor Transport Authority (KBA). The supplied data include vehicle fleets for each reference year, broken down as required for emissions calculation, i.e. in accordance with the following characteristics: type of engine (petrol, diesel, other), size class, vehicle age and emissions standard. For each reference year, the mid-year fleet is assumed to be representative of the fleet's composition for the year. The fleet figures for the years 2004 through 2007 were calculated with the help of a fleet-shifting module in TREMOD that extrapolates past fleet-growth trends.



## Mileage

Mileage data were updated on the basis of the “2002 mileage survey” (“Fahrleistungserhebung 2002”; Institute of Applied Transport and Tourism Research (IVT, 2004 <sup>5)</sup>), the “2005 road-transport census” “Straßenverkehrszählungen 2005”; Federal Highway Research Institute (BAST, 2007 <sup>6)</sup>) and data on growth of transports on federal highways (BAST, 2008).

## Shifting of fuel purchases to other countries

Because fuel prices in Germany are higher – significantly, in some cases – than in almost all of Germany's neighbours (Denmark is the only exception), for some time the fuels used in Germany have included fuels purchased in other countries and brought into the country as “grey” imports.

At present, no precise data are available on this phenomenon, which is significant for Germany's border regions and which is referred to as “refuelling tourism” (“Tanktourismus”). Although several detailed studies have been carried out, no reliable overall picture of the situation is yet available (cf. Lenk et al., 2004 <sup>7)</sup>). The sources that have documented shifting of consumers' fuel purchases to other countries (along with the resulting negative impacts on neighbouring countries' own emissions inventories) have included a study published by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW, 2005 <sup>8)</sup>).

## Emission factors

All emission factors are listed in the “Handbook Emission Factors for Road Transport” versions 4.1 (Keller et al., (2019) <sup>9)</sup>) and 4.2 (Notter et al., (2022) <sup>10)</sup>).

This reference work is prepared via co-operation, between the environmental protection agencies of Germany, Switzerland and Austria also supported by Sweden, Norway, France as well as the JRC (European Research Center of the European Commission), in derivation of emission factors for road traffic.

The emission factors in this manual originate predominantly from the measurement programmes of TÜV Rheinland (TÜV, Technical Control Association) and RWTÜV. Those programmes have included fundamental surveys for the reference years 1989/1990. In those surveys, a new method was used, for both passenger cars and heavy duty vehicles, whereby emission factors were derived according to driving habits and the traffic situation. Within the context of field monitoring data, the passenger-car emission factors were updated for cars produced up to 1994. Version 3.4 of the “Emission-factor Manual for Road Transports” (“Handbuch der Emissionsfaktoren des Straßenverkehrs”: HBEFA), which is used for the current emissions calculations, draws on findings of the EU working group COST 346 and the ARTEMIS research programme. The emission factors are derived from the development of the various vehicle layers and from the data provided by the HBEFA. The emissions reduction achieved via the introduction of sulphur-free fuels was estimated by the German Environment Agency.

## Derivation of emission factors

### Emission factors from TREMOD

In the CSE, emission factors for the “engines” (“Antrieb”) category are listed in [kg/TJ], while those for the “Evaporation” category are given in [kg/t]. For gasoline, diesel oil, LPG and CNG, these values can be derived from TREMOD for all structural elements. To this end, emissions (in tonnes [t]) and energy consumption (in terajoules [TJ]); converted from the results “energy consumption in t”, using the net calorific values) are derived from the TREMOD results and allocated to the relevant structural elements. The emission factor for each structural element then results as the quotient resulting from emissions, in tonnes per structural element, divided by the energy consumption, per structural element, in terajoule.

A similar procedure is used to obtain the emission factors for fugitive emissions, in [kg/consumption on municipal roads], in tonnes [t]). For purposes of this derivation, TREMOD results without correction to the Energy Balance are used, since such correction is already contained in the activity data for the CSE. Use of the corrected values (emissions and energy consumption) leads to the same results, however, since the correction factor cancels out in calculation of mean emission factors (emissions corrected / energy corrected = emissions uncorrected / energy uncorrected).

**Emission factors for biodiesel, bioethanol, petroleum, Liquefied Petroleum Gas (LPG), and Compressed Natural Gas (CNG)**

The emission factors for biodiesel and petroleum are set at the same values as those for conventional diesel fuel. The emission factors for bioethanol are set at the same values as those for conventional gasoline.

Exception: \* The SO<sub>2</sub> emission factor for petroleum is set to 24 kg/TJ for those years in which diesel fuel has a higher value. In all other years, the lower value for diesel fuel is used.

<sup>1)</sup> Knörr et al. (2002): Knörr, W., Höpfner, U., & Lambrecht, U. (2002): Aktualisierung des "Daten- und Rechenmodells": Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1980-2020 : Endbericht / Wolfram Knörr (Projektleiter): Heidelberg [u.a.] 2002.

<sup>2)</sup> AGEb (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; <https://ag-energiebilanzen.de/wp-content/uploads/EBD23e.xlsx>, (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>3)</sup> AGEb (2025a): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEb): Energiebilanz für die Bundesrepublik Deutschland; [https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?\\_jahresbereich-bilanz=2021-2030](https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-ab-1990/?_jahresbereich-bilanz=2021-2030), (Aufruf: 04.12.2025), Köln & Berlin, September 2025

<sup>4)</sup> Knörr et al. (2025a): Knörr, W., Heidt, C., Gores, S., & Bergk, F.: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2035, sowie TREMOD, Ifeu Institut für Energie- und Umweltforschung Heidelberg GmbH, on behalf of the Umweltbundesamt, Heidelberg & Berlin / Dessau-Roßlau, 2025.

<sup>5)</sup> IVT, 2004: Institut für angewandte Verkehrs- und tourismusforschung e.V.: Fahrleistungserhebung 2002, Teil: Begleitung und Auswertung. Untersuchung im Auftrag der Bundesanstalt für Straßenwesen, Projektnummer FE 82.201/2001. Heilbronn/Mannheim.

<sup>6)</sup> BASt, 2007: Federal Highway Research Institute (Bundesanstalt für Straßenwesen, BASt): Unterreihe Verkehrstechnik; V 164: "Straßenverkehrszählung 2005: Ergebnisse", Thorsten Kathmann, Hartmut Ziegler, Bernd Thomas; 62 Seiten; Bergisch Gladbach, 2007.

<sup>7)</sup> Lenk et. al (2004): Lenk, T., Vogelbusch, F., & Falken, C.: Auswirkungen des Tanktourismus auf das deutsche Steueraufkommen – eine finanzwissenschaftliche Bestandsaufnahme. Paper presented at the UNITI Bundesverband mittelständischer Mineralölunternehmen e. V. - Mitgliederversammlung 2004, München.

<sup>8)</sup> BMLFUW, 2005: Federal Ministry for Agriculture, Forestry, Environment and Water Management (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft): Abschätzung der Auswirkungen des Tanktourismus auf den Treibstoffverbrauch und die Entwicklung der CO<sub>2</sub>, -Emissionen in Österreich.; Wien, 2005.

<sup>9)</sup> Keller et al. (2019): Keller, M., Hausberger, S., Matzer, C., Wüthrich, P., & Notter, B.: Handbook Emission Factors for Road Transport, version 4.1 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.1) URL: [https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8\\_HBEFA41\\_Development\\_Report.pdf](https://assets-global.website-files.com/6207922a2acc01004530a67e/625e8c74c30e26e022b319c8_HBEFA41_Development_Report.pdf) - Dokumentation, Bern, 2019.

<sup>10)</sup> Notter et al. (2022): Notter, B., Cox, B., Hausberger, S., Matzer, S., Weller, K., Dippold, M., Politschnig, N., Lipp, S. (IVT TU Graz), Allekotte, M., Knörr, W. (ifeu), André, M. (IFSTTAR), Gagnepain, L. (ADEME), Hult, C., Jerksjö, M. (IVL): Handbook Emission Factors for Road Transport, version 4.2 (Handbuch Emissionsfaktoren des Straßenverkehrs 4.2) URL: [https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0\\_HBEFA42\\_Update\\_Documentation.pdf](https://assets-global.website-files.com/6207922a2acc01004530a67e/6217584903e9f9b63093c8c0_HBEFA42_Update_Documentation.pdf) - Dokumentation, Bern, 2022.

## Appendix 2.3 - Heavy Metal Exhaust Emissions From Mobile Sources

This appendix chapter provides additional information regarding the approaches applied for estimating exhaust heavy metal emissions from mobile sources in:

- [Road Transport](#) (1.A.3.b i - iv)
- [Non-road Mobile Machinery](#) in 1.A.2.g vii, 1.A.4.a ii/b ii/c ii, and 1.A.5.b
- [Railways](#) (1.A.3.c)
- [Maritime Vessels and Ships](#) in 1.A.3.d i, 1.A.3.d ii, 1.A.4.c iii and 1.A.5.b
- [Aircraft](#) in 1.A.3.a and 1.A.5.b

### Road Transport

For heavy-metal exhaust emissions (other than lead from leaded gasoline), energy-related tier1 values have been derived from mass-related tier1 defaults provided in the 2023 EMEP/EEA Guidebook in chapter 1.A.3.b (Update 2025), page 100, table 3-82, taking into account not only the fuel heavy-metal content, but also the contribution of engine wear (*“These values have been calculated by encompassing the impact of engine wear to the heavy metal emissions. Therefore, by multiplying these apparent factors with fuel consumption, it is expected that the combined emissions of fuel and engine wear are estimated.”*)

**Table 3-82: Heavy metal emission factors for all vehicle categories in ppm/wt fuel**

| Category               | Pb     | Cd     | Cu     | Cr     | Ni     | Se     | Zn    | Hg     | As     |
|------------------------|--------|--------|--------|--------|--------|--------|-------|--------|--------|
| Passenger cars, petrol | 0.0016 | 0.0002 | 0.0045 | 0.0063 | 0.0023 | 0.0002 | 0.033 | 0.0087 | 0.0003 |
| Passenger cars, diesel | 0.0005 | 5 E-05 | 0.0057 | 0.0085 | 0.0002 | 0.0001 | 0.018 | 0.0053 | 0.0001 |
| LCVs, petrol           | 0.0016 | 0.0002 | 0.0045 | 0.0063 | 0.0023 | 0.0002 | 0.033 | 0.0087 | 0.0003 |
| LCVs, diesel           | 0.0005 | 5 E-05 | 0.0057 | 0.0085 | 0.0002 | 0.0001 | 0.018 | 0.0053 | 0.0001 |
| HDVs, petrol           | 0.0016 | 0.0002 | 0.0045 | 0.0063 | 0.0023 | 0.0002 | 0.033 | 0.0087 | 0.0003 |
| HDVs, diesel           | 0.0005 | 5 E-05 | 0.0057 | 0.0085 | 0.0002 | 0.0001 | 0.018 | 0.0053 | 0.0001 |
| L-category             | 0.0016 | 0.0002 | 0.0045 | 0.0063 | 0.0023 | 0.0002 | 0.033 | 0.0087 | 0.0003 |

From these default values, the following country-specific energy-related tier1 EF were derived via the average NCVs of the fuels used:

**Table 1: Tier1 emission factors derived from EMEP/EEA Guidebook 2023 defaults, in g/TJ**

|                                    | Pb     | Cd     | Hg     | As     | Cr     | Cu     | Ni     | Se     | Zn     | additional info:                          |
|------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------------------------------------------|
| <b>Diesel oil</b>                  | 0.0116 | 0.0012 | 0.1234 | 0.0023 | 0.1979 | 0.1327 | 0.0047 | 0.0023 | 0.4190 | derivation of tier1 EF<br>(MS Excel file) |
| <b>Biodiesel<sup>1</sup></b>       | 0.0134 | 0.0013 | 0.1423 | 0.0027 | 0.2282 | 0.1531 | 0.0054 | 0.0027 | 0.4833 |                                           |
| <b>Gasoline fuels</b>              | 0.0367 | 0.0046 | 0.1998 | 0.0069 | 0.1447 | 0.1033 | 0.0528 | 0.0046 | 0.7579 |                                           |
| <b>Natural gas (CNG &amp; LNG)</b> | NE     | NE     | NE     | NE     | NE     | NE     | NE     | NE     | NE     |                                           |
| <b>LPG</b>                         | NE     | NE     | NE     | NE     | NE     | NE     | NE     | NE     | NE     |                                           |
| <b>Biomethane</b>                  | NE     | NE     | NE     | NE     | NE     | NE     | NE     | NE     | NE     |                                           |

<sup>1</sup> values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel

Here, biodiesel has a slightly lower NCV compared to fossil diesel resulting in higher emissions per TJ, whereas for biogasoline the same NCV is applied as for fossil gasoline.

In addition, the 2023 EMEP/EEA Guidebook (chapter 1.A.3.b (Update 2025), page 100, table 3-83) provides separate values for heavy metals from the unintended co-incineration of lube oil. The latter are reported in [NFR sub-category 2.G.4](#) as

emissions from product use. (Note: This country-specific approach has been discussed and accepted at both the 2018 TFEIP meeting and the 2018 NEC review.)

**Table 3-83: Heavy metal emission factors for all vehicle categories in ppm/wt lubricant**

| Category               | Pb     | Cd   | Cu  | Cr   | Ni    | Se   | Zn    | Hg | As |
|------------------------|--------|------|-----|------|-------|------|-------|----|----|
| Passenger cars, petrol | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| Passenger cars, diesel | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| LCVs, petrol           | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| LCVs, diesel           | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| HDVs, petrol           | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| HDVs, diesel           | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |
| L-category             | 0.0332 | 4.56 | 778 | 19.2 | 31.89 | 4.54 | 450.2 | 0  | 0  |

## Non-road Mobile Machinery in 1.A.2.g vii, 1.A.4.a ii/b ii/c ii, and 1.A.5.b

Without country-specific information, tier1 values are applied.

However, instead of using the emission factors provided in (EMEP/EEA, 2023) <sup>1)</sup>, Table 3-1 Tier 1 emission factors for off-road machinery,...

**Table 3-1 Tier 1 emission factors for off-road machinery**

| Tier 1 emission factors |                                                    |           |             |                 |
|-------------------------|----------------------------------------------------|-----------|-------------|-----------------|
| Fuel                    | NFR sector                                         | Pollutant | Units       | Emission factor |
| Diesel                  | 1.A.2.g.vii, 1.A.4.a.ii, 1.A.4.b.ii and 1.A.4.c.ii |           |             |                 |
|                         |                                                    | Cadmium   | mg/kg fuel  | 0.010           |
|                         |                                                    | Copper    | mg/ kg fuel | 1.70            |
|                         |                                                    | Chromium  | mg/ kg fuel | 0.050           |
|                         |                                                    | Nickel    | mg/ kg fuel | 0.07            |
|                         |                                                    | Selenium  | mg/ kg fuel | 0.01            |
| Gasoline                | 1.A.2.g.vii, 1.A.4.a.ii, 1.A.4.b.ii and 1.A.4.c.ii |           |             |                 |
|                         |                                                    | Cadmium   | mg/kg fuel  | 0.01            |
|                         |                                                    | Copper    | mg/kg fuel  | 1.70            |
|                         |                                                    | Chromium  | mg/kg fuel  | 0.05            |
|                         |                                                    | Nickel    | mg/kg fuel  | 0.07            |
|                         |                                                    | Selenium  | mg/kg fuel  | 0.01            |
|                         |                                                    |           |             |                 |
|                         |                                                    |           |             |                 |
|                         |                                                    |           |             |                 |
|                         |                                                    |           |             |                 |
|                         |                                                    |           |             |                 |
|                         |                                                    |           |             |                 |

...the EF for exhaust HMs from NFR 1.A.3.b.i-iv (see above) are applied in order to assure the separate reporting of emissions from fuel and engine wear and the unintended co-incineration of lube oil:

Table 2: Tier1 emission factors derived from EMEPEEA Guidebook 2023 defaults for NFRs 1.A.3.b i-iv, in g/TJ

|  | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn |
|--|----|----|----|----|----|----|----|----|----|
|--|----|----|----|----|----|----|----|----|----|

|                                              | <b>Pb</b> | <b>Cd</b> | <b>Hg</b> | <b>As</b> | <b>Cr</b> | <b>Cu</b> | <b>Ni</b> | <b>Se</b> | <b>Zn</b> |
|----------------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| <b>Diesel oil</b>                            | 0.0116    | 0.0012    | 0.1234    | 0.0023    | 0.1979    | 0.1327    | 0.0047    | 0.0023    | 0.4190    |
| <b>Biodiesel<sup>1</sup></b>                 | 0.0134    | 0.0013    | 0.1423    | 0.0027    | 0.2282    | 0.1531    | 0.0054    | 0.0027    | 0.4833    |
| <b>Gasoline fuels - 4-stroke</b>             | 0.0367    | 0.0046    | 0.1998    | 0.0069    | 0.1447    | 0.1033    | 0.0528    | 0.0046    | 0.7579    |
| <b>Gasoline fuels - 2-stroke<sup>2</sup></b> | 0.0522    | 2.29      | 0.1958    | 0.0068    | 9.78      | 391       | 16.1      | 2.28      | 227       |
| <b>LPG (1.A.4.a ii only)</b>                 | NE        | NE        | NE        | NE        | NE        | NE        | NE        | NE        | NE        |

<sup>1</sup> values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel

<sup>2</sup> including the HM of 1:50 lube oil mixed to the gasoline



Until submission 2017, the EMEP/EEA default EFs provided for NRMM were used in the German inventory. As these EFs do not differentiate between fuel combustion and lubricant co-incineration, the inventory compiler decided to apply the more specific EFs from road transport to NRMM in 1.A.2.g vii, 1.A.4.a ii, b ii and c ii and 1.A.5.b, too. This country-specific approach has been discussed and accepted at both the 2018 TFEIP meeting and the 2018 NEC review.

Furthermore, as stated in the 2023 EMEP/EEA Guidebook, similar EF are applied for land based military vehicles and mobile machinery as part of NFR 1.A.5.b:

### Notes:

For land based military emissions, use emission factors for 1.A.2.g.vii as no other data are available.

Heavy-metal emissions from lubricants (as far as not used in 2-stroke mix) are reported under [NFR sub-category 2.G.4](#) as emissions from product use.

## Railways

Tier1 default EF as provided in the corresponding chapter of the EMEP/EEA Guidebook 2023:

Table 3-1 Tier 1 emission factors for railways

| Tier 1 emission factor |                                                                       |               |                         |       |                          |
|------------------------|-----------------------------------------------------------------------|---------------|-------------------------|-------|--------------------------|
|                        | Code                                                                  | Name          |                         |       |                          |
| NFR Source Category    | 1.A.3.c                                                               | Railways      |                         |       |                          |
| Fuel                   | Gas Oil/Diesel                                                        |               |                         |       |                          |
| Not applicable         | HCH, PCB, HCB                                                         |               |                         |       |                          |
| Not estimated          | SOx, Pb, Hg, As, PCDD/F, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene |               |                         |       |                          |
| Pollutant              | Value                                                                 | Unit          | 95% confidence interval |       | Reference                |
|                        |                                                                       |               | Lower                   | Upper |                          |
| NOx                    | 52.4                                                                  | kg/tonne fuel | 25                      | 93    | Aggregated Tier 2 method |
| CO                     | 10.7                                                                  | kg/tonne fuel | 6                       | 19    | Guidebook (2006)         |
| NM VOC                 | 4.65                                                                  | kg/tonne fuel | 2                       | 8     | Guidebook (2006)         |
| NH <sub>3</sub>        | 0.007                                                                 | kg/tonne fuel | 0.004                   | 0.012 | Guidebook (2006)         |
| TSP                    | 1.52                                                                  | kg/tonne fuel | 3                       | 23    | Aggregated Tier 2 method |
| PM10                   | 1.44                                                                  | kg/tonne fuel | 2                       | 16    | Aggregated Tier 2 method |
| PM2.5                  | 1.37                                                                  | kg/tonne fuel | 2                       | 14    | Aggregated Tier 2 method |
| Cd                     | 0.01                                                                  | g/tonne fuel  | 0.003                   | 0.025 | Guidebook (2006)         |
| Cr                     | 0.05                                                                  | g/tonne fuel  | 0.02                    | 0.2   | Guidebook (2006)         |
| Cu                     | 1.7                                                                   | g/tonne fuel  | 0.5                     | 4.9   | Guidebook (2006)         |
| Ni                     | 0.07                                                                  | g/tonne fuel  | 0.02                    | 0.2   | Guidebook (2006)         |
| Se                     | 0.01                                                                  | g/tonne fuel  | 0.003                   | 0.025 | Guidebook (2006)         |
| Zn                     | 1                                                                     | g/tonne fuel  | 0.3                     | 2.5   | Guidebook (2006)         |
| Benzo(a)pyrene         | 0.03                                                                  | g/tonne fuel  | 0.01                    | 0.1   | Guidebook (2006)         |
| Benzo(b)fluoranthene   | 0.05                                                                  | g/tonne fuel  | 0.02                    | 0.2   | Guidebook (2006)         |
| Benz(a)anthracene      | 0.08                                                                  | g/tonne fuel  | 0.03                    | 0.2   | Guidebook (2006)         |
| CO <sub>2</sub>        | 3140                                                                  | kg/tonne fuel | 3120                    | 3160  | Guidebook (2006)         |
| Dibenzo(a,h)anthracene | 0.01                                                                  | g/tonne fuel  | 0.004                   | 0.03  | Guidebook (2006)         |

## Notes

B(k)f & Indeno (1,2,3-cd) pyrene and dioxins emission factor values are not available for railway emissions. It is therefore recommended to use values corresponding to old technology heavy duty vehicles from the Exhaust Emissions from Road Transport chapter (1.A.3.b.iii).

BC fraction of PM (f-BC): 0.65. Source: for further information see Appendix A

Besides these emissions from fuel combustion and engine wear, the German inventory also covers **abrasive emissions from brakes, wheels on rail and contact line**. Here, a country-specific approach is applied with emissions of (i) chromium and nickel being estimated as part of the particle emissions from brake wear whereas emissions of copper (ii) copper are estimated as part of the PM emissions from the contact line.

Table 4: Country-specific emission factors for abrasive emissions, in g/km

|                                                                     | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP     | BC | Pb | Cd | Hg | As | Cr      | Cu      | Ni      | Se | Zn |
|---------------------------------------------------------------------|-------------------|------------------|---------|----|----|----|----|----|---------|---------|---------|----|----|
| <b>Contact line</b> <sup>1</sup>                                    | 0.00016           | 0.00032          | 0.00032 | NA | NA | NA | NA | NA | NA      | 0.00033 | NA      | NA | NA |
| <b>Tyres on rails</b> <sup>2</sup>                                  | 0.009             | 0.018            | 0.018   | NA | NA |    |    |    |         |         |         |    |    |
| <b>Braking system</b> <sup>3</sup>                                  | 0.004             | 0.008            | 0.008   | NA | NA | NA | NA | NA | 0.00008 | NA      | 0.00016 | NA | NA |
| <b>Current collector</b> <sup>4</sup>                               | NE                | NE               | NE      | NE | NA |    |    |    |         |         |         |    |    |
| <sup>1</sup> assumption: 100 per cent copper                        |                   |                  |         |    |    |    |    |    |         |         |         |    |    |
| <sup>2</sup> assumption: 100 per cent steel                         |                   |                  |         |    |    |    |    |    |         |         |         |    |    |
| <sup>3</sup> assumption: steel alloy containing Chromium and Nickel |                   |                  |         |    |    |    |    |    |         |         |         |    |    |

|                                                                                                         | PM <sub>2.5</sub> | PM <sub>10</sub> | TSP | BC | Pb | Cd | Hg | As | Cr | Cu | Ni | Se | Zn |
|---------------------------------------------------------------------------------------------------------|-------------------|------------------|-----|----|----|----|----|----|----|----|----|----|----|
| <sup>4</sup> typically: aluminium alloy + coal contacts; no particulate matter emissions calculated yet |                   |                  |     |    |    |    |    |    |    |    |    |    |    |

**Inland Vessels and Ships in 1.A.3.d ii**

Table 5: Tier1 default emission factors applied to inland ships and vessels, in g/TJ

|                                                                      | Pb    | Cd    | Hg    | As    | Cr   | Cu   | Ni    | Se    | Zn   |
|----------------------------------------------------------------------|-------|-------|-------|-------|------|------|-------|-------|------|
| Diesel oil                                                           | 1.21  | 0.233 | 0.123 | 0.002 | 1.16 | 39.6 | 1.63  | 0.233 | 23.3 |
| Biodiesel <sup>1</sup>                                               | 0.013 | 0.001 | 0.142 | 0.003 | 0.23 | 0.15 | 0.005 | 0.003 | 0.48 |
| <sup>1</sup> similar EF for biodiesel applied for all mobile sources |       |       |       |       |      |      |       |       |      |

**Maritime Vessels and Ships in 1.A.3.d i, 1.A.3.d ii, 1.A.4.c iii and 1.A.5.b**

Tier1 default EF as provided in the corresponding chapter of the EMEP/EEA Guidebook 2023:



**Table 3-1 Tier 1 emission factors for ships using bunker fuel oil**

| Tier 1 default emission factors |                 |                                                                       |                         |       |                                 |
|---------------------------------|-----------------|-----------------------------------------------------------------------|-------------------------|-------|---------------------------------|
|                                 | Code            | Name                                                                  |                         |       |                                 |
| NFR Source Category             | 1.A.3.d.i       | International navigation                                              |                         |       |                                 |
|                                 | 1.A.3.d.ii      | National navigation                                                   |                         |       |                                 |
|                                 | 1.A.4.c.iii     | Agriculture / forestry / fishing: National fishing                    |                         |       |                                 |
|                                 | 1.A.5.b         | Other, mobile (including military, land based and recreational boats) |                         |       |                                 |
| Fuel                            | Bunker Fuel Oil |                                                                       |                         |       |                                 |
| Not applicable                  |                 |                                                                       |                         |       |                                 |
| Not estimated                   | NH <sub>3</sub> |                                                                       |                         |       |                                 |
| Pollutant                       | Value           | Unit                                                                  | 95% confidence interval |       | Reference                       |
|                                 |                 |                                                                       | Lower                   | Upper |                                 |
| NO <sub>x</sub>                 | 69.1            | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021)                  |
| CO                              | 3.67            | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021)                  |
| NM VOC                          | 1.67            | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021)                  |
| SO <sub>2</sub>                 | 19.2            | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021)See also note (1) |
| PM <sub>10</sub>                | 5.2             | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021)                  |
| BC                              | 0.0903          | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021)                  |
| Benzo(b)fluoranthene            | 0.03            | g/tonne fuel                                                          |                         |       | average value                   |
| Benzo(k)fluoranthene            | 0.02            | g/tonne fuel                                                          |                         |       | average value                   |
| Benzo(a)pyrene                  | 0.005           | g/tonne fuel                                                          |                         |       | average value                   |
| Indeno(1,2,3- cd)pyrene         | 0.009           | g/tonne fuel                                                          |                         |       | average value                   |
| Pb                              | 0.18            | g/tonne fuel                                                          | 0                       | 0     | average value                   |
| Cd                              | 0.02            | g/tonne fuel                                                          | 0                       | 0     | average value                   |
| Hg                              | 0.02            | g/tonne fuel                                                          | 0                       | 0     | average value                   |
| As                              | 0.68            | g/tonne fuel                                                          | 0                       | 0     | average value                   |
| Cr                              | 0.72            | g/tonne fuel                                                          | 0                       | 0     | average value                   |
| Cu                              | 1.25            | g/tonne fuel                                                          | 0                       | 0     | average value                   |
| Ni                              | 32              | g/tonne fuel                                                          | 0                       | 0     | average value                   |
| Se                              | 0.21            | g/tonne fuel                                                          | 0                       | 0     | average value                   |
| Zn                              | 1.2             | g/tonne fuel                                                          | 0                       | 0     | average value                   |
| PCB                             | 0.57            | mg/tonne fuel                                                         | 0                       | 0     | Cooper (2005)                   |
| PCDD/F                          | 0.47            | ug I-TEQ /tonne fuel                                                  | 0                       | 0     | Cooper (2005)                   |
| HCB                             | 0.14            | mg/tonne fuel                                                         | 0                       | 0     | Cooper (2005)                   |



**Table 3-2 Tier 1 emission factors for ships using marine diesel oil/marine gas oil**

| Tier 1 emission factor  |                                            |                                                                       |                         |       |                                  |
|-------------------------|--------------------------------------------|-----------------------------------------------------------------------|-------------------------|-------|----------------------------------|
|                         | Code                                       | Name                                                                  |                         |       |                                  |
| NFR Source Category     | 1.A.3.d.i                                  | International navigation                                              |                         |       |                                  |
|                         | 1.A.3.d.ii                                 | National navigation                                                   |                         |       |                                  |
|                         | 1.A.4.c.iii                                | Agriculture / forestry / fishing: National fishing                    |                         |       |                                  |
|                         | 1.A.5.b                                    | Other, mobile (including military, land based and recreational boats) |                         |       |                                  |
| Fuel                    | Marine diesel oil/marine gas oil (MDO/MGO) |                                                                       |                         |       |                                  |
| Not applicable          | HCH                                        |                                                                       |                         |       |                                  |
| Not estimated           | NH <sub>3</sub>                            |                                                                       |                         |       |                                  |
| Pollutant               | Value                                      | Unit                                                                  | 95% confidence interval |       | Reference                        |
|                         |                                            |                                                                       | Lower                   | Upper |                                  |
| NOx                     | 72.2                                       | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021)                   |
| CO                      | 3.84                                       | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021)                   |
| NM VOC                  | 1.75                                       | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021)                   |
| SO <sub>2</sub>         | 1.82                                       | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021) See also note (1) |
| PM <sub>10</sub>        | 1.07                                       | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021)                   |
| BC                      | 0.0483                                     | kg/tonne fuel                                                         | 0                       | 0     | Scipper (2021)                   |
| Benzo(b)fluoranthene    | 0.01                                       | g/tonne fuel                                                          |                         |       | average value                    |
| Benzo(k)fluoranthene    | 0.01                                       | g/tonne fuel                                                          |                         |       | average value                    |
| Benzo(a)pyrene          | 0.002                                      | g/tonne fuel                                                          |                         |       | average value                    |
| Indeno(1,2,3- cd)pyrene | 0.001                                      | g/tonne fuel                                                          |                         |       | average value                    |
| Pb                      | 0.13                                       | g/tonne fuel                                                          | 0                       | 0     | average value                    |
| Cd                      | 0.01                                       | g/tonne fuel                                                          | 0                       | 0     | average value                    |
| Hg                      | 0.03                                       | g/tonne fuel                                                          | 0                       | 0     | average value                    |
| As                      | 0.04                                       | g/tonne fuel                                                          | 0                       | 0     | average value                    |
| Cr                      | 0.05                                       | g/tonne fuel                                                          | 0                       | 0     | average value                    |
| Cu                      | 0.88                                       | g/tonne fuel                                                          | 0                       | 0     | average value                    |
| Ni                      | 1                                          | g/tonne fuel                                                          | 0                       | 0     | average value                    |
| Se                      | 0.1                                        | g/tonne fuel                                                          | 0                       | 0     | average value                    |
| Zn                      | 1.2                                        | g/tonne fuel                                                          | 0                       | 0     | average value                    |
| PCB                     | 0.038                                      | mg/tonne fuel                                                         | 0                       | 0     | Cooper (2005)                    |
| PCDD/F                  | 0.13                                       | ug I-TEQ/tonne                                                        | 0                       | 0     | Cooper (2005)                    |
| HCB                     | 0.08                                       | mg/tonne fuel                                                         | 0                       | 0     | Cooper (2005)                    |

From these mass-related default emission factors, energy-related tier1 EF were derived via average NCVs for the fuels used:

Table 6: Tier1 emission factors derived from EMEP/EEA Guidebook 2023 defaults, in g/TJ

|                                   | Pb   | Cd   | Hg   | As   | Cr   | Cu   | Ni   | Se   | Zn   |
|-----------------------------------|------|------|------|------|------|------|------|------|------|
| <b>Heavy Fuel oil<sup>1</sup></b> | 4.46 | 0.50 | 0.50 | 16.9 | 17.8 | 31.0 | 793  | 5.20 | 29.7 |
| <b>Diesel oil<sup>2</sup></b>     | 3.03 | 0.23 | 0.70 | 0.93 | 1.16 | 20.5 | 23.3 | 2.33 | 27.9 |
| <b>LNG</b>                        | NE   |      |      |      |      |      |      |      |      |

<sup>1</sup> tier1 defaults from <sup>2)</sup>, Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Table 3-1

<sup>2</sup> tier1 defaults from <sup>3)</sup>, Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Table 3-2

These “country-specific” values are similarly applied for exhaust HMs from ships and vessels in NFR categories 1.A.3.d i, 1.A.3.d ii, 1.A.4.c iii, and 1.A.5.b.

## Aircraft in 1.A.3.a and 1.A.5.b

The EMEP/EEA Guidebook 2023 does not provide specific default values for heavy metal emissions from the combustion of jet kerosene and aviation gasoline, stating that for aviation gasoline these emissions are *not estimated* (NE):

Therefore, the inventory compiler decided to adopt the tier1 EF from gasoline fuel used in non-road mobile machinery as a proxy. Although the Party assumes that HM emissions are also likely to occur from the combustion of jet kerosene, no gap-filling is carried out for this fuel. Instead, all heavy metal emission from jet kerosene are reported as *not estimated* (NE).

Table 7: Tier1 default emisison factors applied to aircraft, in g/TJ

|                          | Pb                 | Cd    | Hg    | As    | Cr    | Cu    | Ni    | Se    | Zn    |
|--------------------------|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| <b>Kerosene</b>          | NE                 |       |       |       |       |       |       |       |       |
| <b>Aviation gasoline</b> | 9,481 <sup>1</sup> | 0.005 | 0.200 | 0.007 | 0.145 | 0.103 | 0.053 | 0.005 | 0.758 |

<sup>1</sup> estimated from average lead content of AvGas 100 LL (see also: 1.A.3.a ii (i) and FAQs) of 0.56 g Pb/liter

<sup>1), 2), 3)</sup> EMEP/EEA, 2023: EMEP/EEA air pollutant emission inventory guidebook 2023; Chapter 1.A - Combustion; URL: <https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion>, Copenhagen, 2023 & 2025 (road transport).

## Appendix 2.4 - POP emissions from mobile combustion sources

This appendix chapter provides additional information regarding the approaches applied for estimating exhaust POP emissions from mobile sources in:

- [Road Transport](#) (in 1.A.3.b i - iv)
- [Non-road Mobile Machinery](#) (in 1.A.2.g vii, 1.A.4.a ii, 1.A.4.b ii, 1.A.4.c ii and 1.A.5.b)
- [Railways](#) (1.A.3.c)
- [Inland vessels and ships](#) (in 1.A.3.d ii)
- [Maritime vessels and ships](#) (in 1.A.3.d i, 1.A.3.d ii, 1.A.4.c iii, and 1.A.5.b)
- [Aircraft](#) (in 1.A.3.a and 1.A.5.b)

### Road Transport

For **exhaust emissions of Benzo[a]Pyrene, Benzo[b]Fluoranthene, Benzo[k]Fluoranthene, and Indeno[1,2,3-c,d]Pyrene** the tier2 emission factors as provided in the 2023 EMEP/EEA Guidebook, Chapter 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv (Update 2025), tables 3-18 to 3-26 <sup>3)</sup> are being used:

**Table 3-18: Tier 2 exhaust emission factors for passenger cars, NFR 1.A.3.b.i**

| Type         | Technology           | PM2.5          | ID(1,2,3,cd)P | B(k)F    | B(b)F    | B(a)P    |
|--------------|----------------------|----------------|---------------|----------|----------|----------|
| Units        |                      | g/km           | g/km          | g/km     | g/km     | g/km     |
| Notes        |                      | PM2.5=PM10=TSP |               |          |          |          |
| Petrol Mini  | Euro 4 - 98/69/EC II | 0.0011         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | Euro 5 – EC 715/2007 | 0.0014         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | Euro 6 up to 2016    | 0.0014         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | Euro 6 2017-2019     | 0.0016         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | Euro 6 2020+         | 0.0016         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
| Petrol Small | PRE ECE              | 0.0022         | 1.03E-06      | 3.00E-07 | 8.80E-07 | 4.80E-07 |
|              | ECE 15/00-01         | 0.0022         | 1.03E-06      | 3.00E-07 | 8.80E-07 | 4.80E-07 |
|              | ECE 15/02            | 0.0022         | 1.03E-06      | 3.00E-07 | 8.80E-07 | 4.80E-07 |
|              | ECE 15/03            | 0.0022         | 1.03E-06      | 3.00E-07 | 8.80E-07 | 4.80E-07 |
|              | ECE 15/04            | 0.0022         | 1.03E-06      | 3.00E-07 | 8.80E-07 | 4.80E-07 |
|              | Open Loop            | 0.0022         | 1.03E-06      | 3.00E-07 | 8.80E-07 | 4.80E-07 |
|              | Euro 1 - 91/441/EEC  | 0.0022         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | Euro 2 - 94/12/EEC   | 0.0022         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | Euro 3 - 98/69/EC I  | 0.0011         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | Euro 4 - 98/69/EC II | 0.0011         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | Euro 5 – EC 715/2007 | 0.0014         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | Euro 6 up to 2016    | 0.0014         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | Euro 6 2017-2019     | 0.0016         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | Euro 6 2020+         | 0.0016         | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|              | PRE ECE              | 0.0022         | 1.03E-06      | 3.00E-07 | 8.80E-07 | 4.80E-07 |

|                            |                      |        |          |          |          |          |
|----------------------------|----------------------|--------|----------|----------|----------|----------|
| Diesel Medium              | Conventional         | 0.2209 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 1 - 91/441/EEC  | 0.0842 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 2 - 94/12/EEC   | 0.0548 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 3 - 98/69/EC I  | 0.0391 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 4 - 98/69/EC II | 0.0314 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 5 - EC 715/2007 | 0.0021 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 6 up to 2016    | 0.0015 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 6 2017-2019     | 0.0015 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 6 2020+         | 0.0015 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
| Diesel Large SUV-Executive | Conventional         | 0.2209 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 1 - 91/441/EEC  | 0.0842 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 2 - 94/12/EEC   | 0.0548 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 3 - 98/69/EC I  | 0.0391 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 4 - 98/69/EC II | 0.0314 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 5 - EC 715/2007 | 0.0021 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 6 up to 2016    | 0.0015 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 6 2017-2019     | 0.0015 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                            | Euro 6 2020+         | 0.0015 | 1.62E-06 | 1.53E-06 | 1.95E-06 | 1.74E-06 |
| LPG                        | Conventional         | 0.0022 | 1.00E-08 | 1.00E-08 | 0.00E+00 | 1.00E-08 |
|                            | Euro 1 - 91/441/EEC  | 0.0022 | 1.00E-08 | 1.00E-08 | 0.00E+00 | 1.00E-08 |
|                            | Euro 2 - 94/12/EEC   | 0.0022 | 1.00E-08 | 1.00E-08 | 0.00E+00 | 1.00E-08 |
|                            | Euro 3 - 98/69/EC I  | 0.0011 | 1.00E-08 | 1.00E-08 | 0.00E+00 | 1.00E-08 |
|                            | Euro 4 - 98/69/EC II | 0.0011 | 1.00E-08 | 1.00E-08 | 0.00E+00 | 1.00E-08 |
| 2-Stroke                   | Conventional         | n.a.   | 1.03E-06 | 3.00E-07 | 8.80E-07 | 4.80E-07 |
| Hybrid Petrol Small        | Euro 4 - 98/69/EC II | n.a.   | 3.9E-07  | 2.60E-07 | 3.60E-07 | 3.20E-07 |
| Hybrid Petrol Medium       | Euro 4 - 98/69/EC II | n.a.   | 3.9E-07  | 2.60E-07 | 3.60E-07 | 3.20E-07 |
| Hybrid Petrol Large        | Euro 4 - 98/69/EC II | n.a.   | 3.9E-07  | 2.60E-07 | 3.60E-07 | 3.20E-07 |
| E85                        | Euro 4 - 98/69/EC II | 0.0011 | 3.90E-07 | 2.60E-07 | 3.60E-07 | 3.20E-07 |
| CNG                        | Euro 4 - 98/69/EC II | 0.0011 | 3.90E-07 | 2.60E-07 | 3.60E-07 | 3.20E-07 |

Table 3-20: Tier 2 exhaust emission factors for light commercial vehicles, NFR 1.A.3.b.ii

| Type   | Technology           | PM2.5              | ID(1,2,3,cd)P | B(k)F    | B(b)F    | B(a)P    |
|--------|----------------------|--------------------|---------------|----------|----------|----------|
| Units  |                      | g/km               | g/km          | g/km     | g/km     | g/km     |
| Notes  |                      | PM2.5=PM10<br>=TSP |               |          |          |          |
| Petrol | Conventional         | 0.0023             | 1.03E-06      | 3.00E-07 | 8.80E-07 | 4.80E-07 |
|        | Euro 1 - 93/59/EEC   | 0.0023             | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|        | Euro 2 - 96/69/EEC   | 0.0023             | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|        | Euro 3 - 98/69/EC I  | 0.0011             | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|        | Euro 4 - 98/69/EC II | 0.0011             | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|        | Euro 5 - EC 715/2007 | 0.0014             | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|        | Euro 6 up to 2017    | 0.0012             | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|        | Euro 6 2018-2020     | 0.0012             | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|        | Euro 6 2021+         | 0.0012             | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
| Diesel | Conventional         | 0.356              | 2.54E-06      | 2.87E-06 | 3.30E-06 | 2.85E-06 |
|        | Euro 1 - 93/59/EEC   | 0.117              | 7.00E-07      | 1.90E-07 | 6.00E-07 | 6.30E-07 |
|        | Euro 2 - 96/69/EEC   | 0.117              | 7.00E-07      | 1.90E-07 | 6.00E-07 | 6.30E-07 |
|        | Euro 3 - 98/69/EC I  | 0.0783             | 7.00E-07      | 1.90E-07 | 6.00E-07 | 6.30E-07 |
|        | Euro 4 - 98/69/EC II | 0.0409             | 7.00E-07      | 1.90E-07 | 6.00E-07 | 6.30E-07 |
|        | Euro 5 - EC 715/2007 | 0.0010             | 7.00E-07      | 1.90E-07 | 6.00E-07 | 6.30E-07 |
|        | Euro 6 up to 2017    | 0.0009             | 7.00E-07      | 1.90E-07 | 6.00E-07 | 6.30E-07 |
|        | Euro 6 2018-2020     | 0.0009             | 7.00E-07      | 1.90E-07 | 6.00E-07 | 6.30E-07 |
|        | Euro 6 2021+         | 0.0009             | 7.00E-07      | 1.90E-07 | 6.00E-07 | 6.30E-07 |



**Table 3-22: Tier 2 exhaust emission factors for heavy-duty vehicles, NFR 1.A.3.b.iii**

| Type              | Technology              | PM2.5                  | ID(1,2,3,c<br>d)P | B(k)F    | B(b)F    | B(a)P    |
|-------------------|-------------------------|------------------------|-------------------|----------|----------|----------|
| Units             |                         | g/km                   | g/km              | g/km     | g/km     | g/km     |
| Notes             |                         | PM2.5=P<br>M10=TS<br>P |                   |          |          |          |
| Petrol >3.5 t     | Conventional            | 0.000                  | 1.03E-06          | 3.00E-07 | 8.80E-07 | 4.80E-07 |
| Diesel <=7.5 t    | Conventional            | 0.333                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro I - 91/542/EEC I   | 0.129                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro II - 91/542/EEC II | 0.061                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro III - 2000         | 0.0566                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro IV - 2005          | 0.0106                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro V - 2008           | 0.0106                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro VI                 | 0.0005                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
| Diesel 7.5 - 16 t | Conventional            | 0.3344                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro I - 91/542/EEC I   | 0.201                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro II - 91/542/EEC II | 0.104                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro III - 2000         | 0.0881                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro IV - 2005          | 0.0161                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro V - 2008           | 0.0161                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro VI                 | 0.0008                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
| Diesel 16 - 32 t  | Conventional            | 0.418                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro I - 91/542/EEC I   | 0.297                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro II - 91/542/EEC II | 0.155                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro III - 2000         | 0.13                   | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro IV - 2005          | 0.0239                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro V - 2008           | 0.0239                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro VI                 | 0.0012                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
| Diesel >32 t      | Conventional            | 0.491                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro I - 91/542/EEC I   | 0.358                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro II - 91/542/EEC II | 0.194                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro III - 2000         | 0.151                  | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro IV - 2005          | 0.0268                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro V - 2008           | 0.0268                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                   | Euro VI                 | 0.0013                 | 1.40E-06          | 6.09E-06 | 5.45E-06 | 9.00E-07 |

**Table 3-24: Tier 2 exhaust emission factors for buses, NFR 1.A.3.b.iii**

| Type                 | Technology              | PM2.5          | ID(1.2.3.cd)P | B(k)F    | B(b)F    | B(a)F    |
|----------------------|-------------------------|----------------|---------------|----------|----------|----------|
| Units                |                         | g/km           | g/km          | g/km     | g/km     | g/km     |
| Notes                |                         | PM2.5=PM10=TSP |               |          |          |          |
| Urban CNG Buses      | Euro I - 91/542/EEC I   | 0.0200         | n.a.          | n.a.     | n.a.     | n.a.     |
|                      | Euro II - 91/542/EEC II | 0.0100         | n.a.          | n.a.     | n.a.     | n.a.     |
|                      | Euro III - 2000         | 0.0100         | 3.00E-08      | 4.00E-08 | 8.00E-08 | 5.00E-08 |
|                      | EEV                     | 0.0050         | 1.00E-08      | 1.00E-08 | 1.00E-08 | 3.00E-08 |
| Urban Buses Standard | Conventional            | 0.9090         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro I - 91/542/EEC I   | 0.4790         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro II - 91/542/EEC II | 0.2200         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro III - 2000         | 0.2070         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro IV - 2005          | 0.0462         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro V - 2008           | 0.0462         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro VI                 | 0.0023         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
| Coaches Standard     | Conventional            | 0.4700         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro I - 91/542/EEC I   | 0.3620         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro II - 91/542/EEC II | 0.1650         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro III - 2000         | 0.1780         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro IV - 2005          | 0.0354         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro V - 2008           | 0.0354         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |
|                      | Euro VI                 | 0.0018         | 1.40E-06      | 6.09E-06 | 5.45E-06 | 9.00E-07 |

**Table 3-26: Tier 2 emission factors for L-category vehicles, NFR 1.A.3.b.iv**

| Type                               | Technology          | PM2.5              | ID(1,2,3,cd)P | B(k)F    | B(b)F    | B(a)P    |
|------------------------------------|---------------------|--------------------|---------------|----------|----------|----------|
| Units                              |                     | g/km               | g/km          | g/km     | g/km     | g/km     |
| Notes                              |                     | PM2.5=PM1<br>0=TSP |               |          |          |          |
| 2-stroke <50 cm <sup>3</sup>       | Conventional        | 0.176              | 2.06E-07      | 6E-08    | 1.76E-07 | 9.6E-08  |
|                                    | Mop - Euro 1        | 0.045              | 7.8E-08       | 5.2E-08  | 7.2E-08  | 6.4E-08  |
|                                    | Mop - Euro 2        | 0.026              | 7.8E-08       | 5.2E-08  | 7.2E-08  | 6.4E-08  |
|                                    | Mop - Euro 3 and on | 0.018              | 7.8E-08       | 5.2E-08  | 7.2E-08  | 6.4E-08  |
| 4-stroke <50 cm <sup>3</sup>       | Conventional        | 0.176              | 2.06E-07      | 6E-08    | 1.76E-07 | 9.6E-08  |
|                                    | Mop - Euro 1        | 0.04               | 7.8E-08       | 5.2E-08  | 7.2E-08  | 6.4E-08  |
|                                    | Mop - Euro 2        | 0.007              | 7.8E-08       | 5.2E-08  | 7.2E-08  | 6.4E-08  |
|                                    | Mop - Euro 3 and on | 0.004              | 7.8E-08       | 5.2E-08  | 7.2E-08  | 6.4E-08  |
| 2-stroke >50 cm <sup>3</sup>       | Conventional        | 0.16               | n.a.          | n.a.     | n.a.     | n.a.     |
|                                    | Mot - Euro 1        | 0.064              | n.a.          | n.a.     | n.a.     | n.a.     |
|                                    | Mot - Euro 2        | 0.032              | n.a.          | n.a.     | n.a.     | n.a.     |
|                                    | Mot - Euro 3 and on | 0.0096             | n.a.          | n.a.     | n.a.     | n.a.     |
| 4-stroke <250 cm                   | Conventional        | 0.014              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|                                    | Mot - Euro 1        | 0.014              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|                                    | Mot - Euro 2 and on | 0.0035             | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
| 4-stroke 250 - 750 cm <sup>3</sup> | Conventional        | 0.014              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|                                    | Mot - Euro 1        | 0.014              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|                                    | Mot - Euro 2 and on | 0.0035             | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
| 4-stroke >750 cm <sup>3</sup>      | Conventional        | 0.014              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|                                    | Mot - Euro 1        | 0.014              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|                                    | Mot - Euro 2 and on | 0.0035             | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
| Mini-cars                          | Conventional        | 0.250              | 1.62E-06      | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                                    | Euro 1              | 0.150              | 1.62E-06      | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                                    | Euro 2              | 0.150              | 1.62E-06      | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                                    | Euro 3              | 0.150              | 1.62E-06      | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                                    | Euro 4              | 0.080              | 1.62E-06      | 1.53E-06 | 1.95E-06 | 1.74E-06 |
|                                    | Euro 5              | 0.001              | 1.62E-06      | 1.53E-06 | 1.95E-06 | 1.74E-06 |
| ATVs                               | Conventional        | 0.200              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|                                    | Euro 1              | 0.080              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|                                    | Euro 2              | 0.040              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|                                    | Euro 3              | 0.040              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|                                    | Euro 4              | 0.010              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |
|                                    | Euro 5              | 0.002              | 3.90E-07      | 2.60E-07 | 3.60E-07 | 3.20E-07 |

For further information on the actual emission factors derived from these default values and applied in the German emissions inventory, please refer to the overview chapter on [Emissions from Fuel Combustion in Road Vehicles](#).

Regarding PCDD/F, a tier1 EF from (Rentz et al., 2008)<sup>2)</sup> is used instead.

## Non-road Mobile Machinery

Table 1 provides the emission factors applied for POPs from non-road mobile machinery as covered as part of NFR categories 1.A.2.g vii, 1.A.4.a ii, 1.A.4.b ii, 1.A.4.c ii and 1.A.5.b. Please note that these energy input related emission factors have been derived from mass-related values taking into account the NCVs of the fuels used.

Table 1: Tier1 default emission factors applied to NRMM

|                              | B[a]P  | B[b]F | B[k]F | I[...]P | PAH 1-4 | PCDD/F            |
|------------------------------|--------|-------|-------|---------|---------|-------------------|
|                              | [mg/T] |       |       |         |         | [µg/T]            |
| <b>Diesel oil</b>            | 698    | 1.164 | 801   | 184     | 2,847   | 1.62 <sup>3</sup> |
| <b>Biodiesel<sup>1</sup></b> | 806    | 1.343 | 924   | 212     | 3,284   | 1.87              |

|                                              |      |      |      |      |       |                   |
|----------------------------------------------|------|------|------|------|-------|-------------------|
| <b>Gasoline fuels - 4-stroke</b>             | 919  | 919  | 90   | 204  | 2,131 | 2.76 <sup>3</sup> |
| <b>Gasoline fuels - 2-stroke<sup>2</sup></b> | 919  | 919  | 90   | 204  | 2,131 | 57.5 <sup>3</sup> |
| <b>LPG (1.A.4.a ii only)</b>                 | 4.35 | 0.00 | 4.35 | 4.35 | 13.04 | NE                |

<sup>1</sup> values differ from EFs applied for fossil diesel oil to take into account the specific NCV of biodiesel

<sup>2</sup> no separate values available for 2-stroke-mix including 1:50 lube oil

<sup>3</sup> tier1 values derived from Rentz et al. (2008) <sup>3)</sup>

## Railways

For **exhaust emissions of Benzo[a]Pyrene, Benzo[b]Fluoranthene, Benzo[k]Fluoranthene, and Indeno[1,2,3-c,d]Pyrene**, tier1 emission factors as provided in the EMEP/EEA Guidebook 2023 in chapters 1.A.3.c and 1.A.3.b (Update 2024) are applied. Here, as no tier1 defaults are provided for B[k] and I[123cd]P, the values provided for road heavy-duty vehicles are applied instead, as proposed in Table 3-9 in chapter 1.A.3.c of the EMEP/EEA Guidebook 2023.

**Table 3-1 Tier 1 emission factors for railways**

| Tier 1 emission factor |                                                                       |               |                         |       |                          |
|------------------------|-----------------------------------------------------------------------|---------------|-------------------------|-------|--------------------------|
|                        | Code                                                                  | Name          |                         |       |                          |
| NFR Source Category    | 1.A.3.c                                                               | Railways      |                         |       |                          |
| Fuel                   | Gas Oil/Diesel                                                        |               |                         |       |                          |
| Not applicable         | HCH, PCB, HCB                                                         |               |                         |       |                          |
| Not estimated          | SOx, Pb, Hg, As, PCDD/F, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene |               |                         |       |                          |
| Pollutant              | Value                                                                 | Unit          | 95% confidence interval |       | Reference                |
|                        |                                                                       |               | Lower                   | Upper |                          |
| NOx                    | 52.4                                                                  | kg/tonne fuel | 25                      | 93    | Aggregated Tier 2 method |
| CO                     | 10.7                                                                  | kg/tonne fuel | 6                       | 19    | Guidebook (2006)         |
| NMVOC                  | 4.65                                                                  | kg/tonne fuel | 2                       | 8     | Guidebook (2006)         |
| NH <sub>3</sub>        | 0.007                                                                 | kg/tonne fuel | 0.004                   | 0.012 | Guidebook (2006)         |
| TSP                    | 1.52                                                                  | kg/tonne fuel | 3                       | 23    | Aggregated Tier 2 method |
| PM10                   | 1.44                                                                  | kg/tonne fuel | 2                       | 16    | Aggregated Tier 2 method |
| PM2.5                  | 1.37                                                                  | kg/tonne fuel | 2                       | 14    | Aggregated Tier 2 method |
| Cd                     | 0.01                                                                  | g/tonne fuel  | 0.003                   | 0.025 | Guidebook (2006)         |
| Cr                     | 0.05                                                                  | g/tonne fuel  | 0.02                    | 0.2   | Guidebook (2006)         |
| Cu                     | 1.7                                                                   | g/tonne fuel  | 0.5                     | 4.9   | Guidebook (2006)         |
| Ni                     | 0.07                                                                  | g/tonne fuel  | 0.02                    | 0.2   | Guidebook (2006)         |
| Se                     | 0.01                                                                  | g/tonne fuel  | 0.003                   | 0.025 | Guidebook (2006)         |
| Zn                     | 1                                                                     | g/tonne fuel  | 0.3                     | 2.5   | Guidebook (2006)         |
| Benzo(a)pyrene         | 0.03                                                                  | g/tonne fuel  | 0.01                    | 0.1   | Guidebook (2006)         |
| Benzo(b)fluoranthene   | 0.05                                                                  | g/tonne fuel  | 0.02                    | 0.2   | Guidebook (2006)         |
| Benz(a)anthracene      | 0.08                                                                  | g/tonne fuel  | 0.03                    | 0.2   | Guidebook (2006)         |
| CO <sub>2</sub>        | 3140                                                                  | kg/tonne fuel | 3120                    | 3160  | Guidebook (2006)         |
| Dibenzo(a,h)anthracene | 0.01                                                                  | g/tonne fuel  | 0.004                   | 0.03  | Guidebook (2006)         |

### Notes

B(k)f & Indeno (1,2,3-cd) pyrene and dioxins emission factor values are not available for railway emissions. It is therefore recommended to use values corresponding to old technology heavy duty vehicles from the Exhaust Emissions from Road Transport chapter (1.A.3.b.iii).

BC fraction of PM (f-BC): 0.65. Source: for further information see Appendix A



**Table 3-9: Tier 1 emission factors for B(b)F and B(a)P**

| Category   | Fuel        | B(b)F       |          |          | B(a)P       |          |          |
|------------|-------------|-------------|----------|----------|-------------|----------|----------|
|            |             | (g/kg fuel) |          |          | (g/kg fuel) |          |          |
|            |             | Mean        | Min      | Max      | Mean        | Min      | Max      |
| PC         | Petrol      | 7.15E-06    | 4.08E-06 | 1.74E-05 | 5.81E-06    | 3.63E-06 | 9.51E-06 |
|            | Diesel      | 3.59E-05    | 1.72E-05 | 5.41E-05 | 3.20E-05    | 9.39E-06 | 4.82E-05 |
|            | LPG         | N/A         | N/A      | N/A      | 1.98E-07    | 1.91E-07 | 1.98E-07 |
| LCV        | Petrol      | 6.44E-06    | 3.89E-06 | 1.51E-05 | 5.03E-06    | 3.46E-06 | 8.25E-06 |
|            | Diesel      | 2.70E-05    | 1.72E-05 | 3.82E-05 | 2.41E-05    | 9.39E-06 | 3.41E-05 |
| HDV        | Diesel      | 2.12E-05    | 1.11E-05 | 5.30E-05 | 3.50E-06    | 1.83E-06 | 8.76E-06 |
|            | CNG (Buses) | 1.48E-05    | 9.82E-06 | 1.76E-05 | 2.44E-06    | 1.62E-06 | 2.91E-06 |
| L-category | Petrol      | 1.09E-05    | 6.01E-06 | 2.72E-05 | 8.12E-06    | 5.34E-06 | 1.84E-05 |

From these tier1 defaults, energy-related EF presented in chapter [1.A.3.c - Railways](#) have been derived and are applied in the German emissions inventory.

## Inland Vessels

The following table provides the emission factors applied for POPs from inland vessels as covered as part of NFR category 1.A.3.d ii - National Navigation (Shipping). Please note that these energy input related emission factors have been derived from mass-related values taking into account the NCVs of the fuels used.

Table 2: Tier1 default emission factors applied to inland ships and vessels

|                                                                                                                                                                                                                  | B[a]P            | B[b]F              | B[k]F            | I[...] <sub>p</sub> | PAH 1-4 <sup>2</sup> | HCB               | PCBs              | PCDD/F            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------------------|------------------|---------------------|----------------------|-------------------|-------------------|-------------------|
|                                                                                                                                                                                                                  | [mg/TJ]          |                    |                  |                     |                      |                   |                   | [µg/TJ]           |
| <b>Diesel oil</b>                                                                                                                                                                                                | 698 <sup>4</sup> | 1,164 <sup>4</sup> | 801 <sup>5</sup> | 184 <sup>5</sup>    | 2,847                | 1.86 <sup>3</sup> | 0.88 <sup>3</sup> | 93.0 <sup>7</sup> |
| <b>Biodiesel<sup>1</sup></b>                                                                                                                                                                                     | 806              | 1,343              | 924              | 212                 | 3,284                | 1.02              | 2.15              | 107               |
| <sup>1</sup> similar EF for biodiesel applied for all mobile sources; due to lack of better information EF values are derived from conventional diesel oil but taking into account the specific NCV of biodiesel |                  |                    |                  |                     |                      |                   |                   |                   |
| <sup>2</sup> sum of tier1 default values applied for B[a]P, B[b]F, B[k]F, and I[1,2,3-c,d]P                                                                                                                      |                  |                    |                  |                     |                      |                   |                   |                   |
| <sup>3</sup> tier1 defaults from <sup>4)</sup> , Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Tables 3-1 and 3-2                                                                                      |                  |                    |                  |                     |                      |                   |                   |                   |
| <sup>4</sup> tier1 defaults from <sup>5)</sup> , Chapter: 1.A.3.c Railways: Diesel, Table 3-1                                                                                                                    |                  |                    |                  |                     |                      |                   |                   |                   |
| <sup>5</sup> tier1 defaults from <sup>6)</sup> , Chapter: 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv - Road transport, Table 3-8: HDV, Diesel                                                                |                  |                    |                  |                     |                      |                   |                   |                   |



The specific tier1 default emission factors available from the latest (2023) version of the EMEP/EEA Guidebook have not yet been implemented in the inventory but will be applied with the next annual submission. (see also: [improvements planned for future submissions](#) and [specific information on NFR 1.A.3.d](#) )

## Maritime Vessels

The following table provides the emission factors applied for POPs from ships and vessels in both civil and military operation in NFR categories 1.A.3.d i - International Maritime Navigation, 1.A.3.d ii - National Navigation (Shipping), 1.A.4.c iii - Fishery and 1.A.5.b iii - Other: Military Navigation. Please note that these energy input related emission factors have been derived from mass-related values taking into account the NCVs of the fuels used.

Table 3: Tier1 default emission factors applied to maritime ships and vessels

|  | B[a]P | B[b]F | B[k]F | I[...] <sub>p</sub> | PAH 1-4 <sup>2</sup> | HCB | PCBs | PCDD/F |
|--|-------|-------|-------|---------------------|----------------------|-----|------|--------|
|--|-------|-------|-------|---------------------|----------------------|-----|------|--------|

|                                                                                                                                                                                                                  | [mg/TJ]          |                    |                  |                  |       |                   |                   | [µg/TJ]           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------------------|------------------|------------------|-------|-------------------|-------------------|-------------------|
| <b>Diesel oil</b>                                                                                                                                                                                                | 698 <sup>4</sup> | 1,164 <sup>4</sup> | 801 <sup>5</sup> | 184 <sup>5</sup> | 2,847 | 1.86 <sup>3</sup> | 0.88 <sup>3</sup> | 93.0 <sup>7</sup> |
| <b>Biodiesel<sup>1</sup></b>                                                                                                                                                                                     | 806              | 1,343              | 924              | 212              | 3,284 | 2.15              | 1.02              | 107               |
| <b>Heavy Fuel oil<sup>6</sup></b>                                                                                                                                                                                | 741              | 1,235              | 849              | 195              | 3,020 | 3.46              | 14.1              | 98.7              |
| <sup>1</sup> similar EF for biodiesel applied for all mobile sources; due to lack of better information EF values are derived from conventional diesel oil but taking into account the specific NCV of biodiesel |                  |                    |                  |                  |       |                   |                   |                   |
| <sup>2</sup> sum of tier1 default values applied for B[a]P, B[b]F, B[k]F, and I[1,2,3-c,d]P                                                                                                                      |                  |                    |                  |                  |       |                   |                   |                   |
| <sup>3</sup> tier1 defaults from <sup>7)</sup> , Chapter: 1.A.3.d.i, 1.A.3.d.ii, 1.A.4.c.iii Navigation: Tables 3-1 and 3-2                                                                                      |                  |                    |                  |                  |       |                   |                   |                   |
| <sup>4</sup> tier1 defaults from <sup>8)</sup> , Chapter: 1.A.3.c Railways: Diesel, Table 3-1                                                                                                                    |                  |                    |                  |                  |       |                   |                   |                   |
| <sup>5</sup> tier1 defaults from <sup>9)</sup> , Chapter: 1.A.3.b.i, 1.A.3.b.ii, 1.A.3.b.iii, 1.A.3.b.iv - Road transport, Table 3-8: HDV, Diesel                                                                |                  |                    |                  |                  |       |                   |                   |                   |
| <sup>6</sup> derived from default for fossil diesel oil, but adapted to specific NCV of heavy fuel oil                                                                                                           |                  |                    |                  |                  |       |                   |                   |                   |
| <sup>7</sup> tier1 value derived from <sup>10)</sup>                                                                                                                                                             |                  |                    |                  |                  |       |                   |                   |                   |



The specific tier1 default emission factors available from the latest (2023) version of the EMEP/EEA Guidebook have not yet been implemented in the inventory but will be applied with the next annual submission. (see also: [improvements planned for future submissions](#) and [specific information on NFR 1.A.3.d](#) )

## Aircraft

The EMEP/EEA Guidebook 2023 does not provide specific defaults for POP emissions from the combustion of jet kerosene and aviation gasoline, stating that for aviation gasoline these emissions are *not estimated* (NE). Therefore, the inventory compiler decided to apply the tier1 EF for **PAHs** from gasoline fuel used in non-road mobile machinery here.

Furthermore, both **HCB** and **PCBs** emissions are stated as *not applicable* in <sup>11)</sup>, chapter 1.A.3.a, 1.A.5.b Aviation, Table 3.3 - Tier 1 emission factors for NFR 1.A.3.a.ii.(i): Civil aviation (domestic, LTO).

As the Party assumes that POP emissions from the combustion of jet kerosene are unlikely to occur, these emissions are reported as *not applicable* (NA).

Table 4 provides the emission factors applied for PAH emissions from aircraft in 1A.3.a and 1.A.5.b ii as derived from tier1 EF for **PAHs** from gasoline fuel used in non-road mobile machinery:

Table 4: Tier1 default emission factors applied to aircraft, in mg/TJ

|                          | B[a]P | B[b]F | B[k]F | I[...] <sub>p</sub> | PAH 1-4 | PCDD/F |
|--------------------------|-------|-------|-------|---------------------|---------|--------|
| <b>Kerosene</b>          | NA    | NA    | NA    | NA                  | NA      | NA     |
| <b>Aviation gasoline</b> | 126   | 182   | 90    | 205                 | 602     | NE     |

<sup>1), 11)</sup> EMEP/EEA (2023): EMEP/EEA air pollutant emission inventory guidebook 2023, Copenhagen, 2023.

<sup>2), 3), 10)</sup> Rentz et al., 2008: Nationaler Durchführungsplan unter dem Stockholmer Abkommen zu persistenten organischen Schadstoffen (POPs), im Auftrag des Umweltbundesamtes, FKZ 205 67 444, UBA Texte | 01/2008, January 2008 - URL: <https://www.umweltbundesamt.de/en/publikationen/nationaler-durchfuhrungsplan-unter-stockholmer>

<sup>4), 5), 6), 7), 8), 9)</sup> EMEP/EEA (2019): EMEP/EEA air pollutant emission inventory guidebook 2019, Copenhagen, 2019.

## Appendix 3

Appendix 3 provides a further elaboration of completeness, uses of NE & IE and (potential) sources of air pollutant emissions excluded (where relevant).

## Appendix 4 - The Energy Balance for the Federal Republic of Germany

The basis for determination of energy-related emissions is the Energy Balance of the Federal Republic of Germany, which is prepared by the Working Group on Energy Balances (AG Energiebilanzen – AGEB) under commission to the Federal Ministry for Economic Affairs and Climate Action (BMWK). The most important data source for the Energy Balance is the Federal Statistical Office (Statistisches Bundesamt). The surveys of the Federal Statistical Office that were used are listed in Table 477: Zur Erstellung der Energiebilanzen für die Bundesrepublik Deutschland verwendeten Erhebungen des . Data on renewable energy sources are obtained by the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat)), working under the leadership of the German Environment Agency (UBA), and transferred directly to the Working Group on Energy Balances (AGEB), for purposes of the Energy Balances. The data involved include provisional data on renewable energy sources, which enter into the estimated Energy Balance and the evaluation tables. Additional data, supplementing those provided by the aforementioned data sources, are provided by associations of the German energy industry, and by German research institutes. The final Energy Balance includes data from the following associations: Nuclear Technology Germany (KernD); the Federal German association of lignite-producing companies and their affiliated organisations (DEBRIV); the Federal German association of the energy and water-resources industries (bdew); the Gesamtverband Steinkohle association of the German hard-coal-mining industry (GVSt); and the Fuels and Energy industry association (en2x). In the Federal Republic of Germany, energy statistics are published by numerous other agencies, and their statistics can differ in terms of their presentation, scope, methods and aggregation.

The complete Energy Balances for the years since 1990 are available on the Internet at (AGEB, 2025) <sup>1)</sup>.

The AGEB's website presents a foreword for the Energy Balances (AGEB, 2015) that describes the structure of the Energy Balance. The overall responsibility for preparation of Energy Balances lies with the AGEB.

In recent years, German experts on energy statistics have expended considerable efforts on the task of minimizing the differences between the provisional and final Energy Balances. In 2020, the Federal Statistical Office obtained the EU grant “improvement of timeliness of energy statistics” from EUROSTAT. In the framework of a dedicated project, this funding is expected to enable the Federal Statistical Office to provide data for year x-1, to the AGEB, as early as August of the relevant year. The pertinent project was launched in 2020, and it includes the statistical offices of the Länder, which are responsible for the concrete surveys involved. Key surveys for the preparation of the Energy Balance and the emissions inventories have been given temporal priority. As a result, the Federal Statistical Office, working on the basis of the data collected by the reference date, and using imputation procedures, was able – in July 2020 – to extrapolate a complete data set for the year 2019. In July 2021, the so-developed methods were used in routine operations for the first time.

In October 2021, quality assurance for the methods was carried out by comparing the extrapolated results with the final 2020 survey data. In the 2022 survey year, the resulting methodological improvements made it possible to prepare a considerably improved provisional Energy Balance, now based, for the first time, on extrapolations – the 2021 provisional Energy Balance. The participating institutions coordinated their scheduling for the relevant data flow so carefully that a number of process steps were carried out in the shortest possible time, and the relevant data were made available for inventory preparation in reporting year 2023.

### Structure of the Energy Balances

Via a matrix structure, each Energy Balance presents an overview of production, transformation and use of energy sources / fuels throughout a defined period. In the Energy Balance of the Federal Republic of Germany, energy flows are shown for a total of 30 energy sources / fuels (groups). The production balance shows

- domestic production,
- imports,
- removals from stocks,
- exports,
- international marine bunkers, and
- additions to stocks,

of energy resources, and it summarises them under primary energy consumption. The primary Energy Balance provides the basis for calculations under the IPCC reference procedure (Plinke & Schonert, 2000). The usage balance provides a key basis for preparation of emissions inventories. The usage balance can also be used for determination of primary energy consumption. It comprises:

- the transformation balance
- flaring and line losses
- non-energy-related consumption, and
- final energy consumption.

Data on non-energy-related consumption, broken down by industrial sectors, are regularly provided to the Federal Environment Agency (UBA) in the framework of an additional table included with the Energy Balance for Germany.

Differences between the production and usage balances are compensated for in the position "Statistical differences".

The transformation balance, part of the usage balance, shows what energy resources are transformed into other, "secondary" resources. The transformation production shows the results of such transformation. Energy transformation can involve conversions of substances – such as conversion of crude oil (conversion input) into petroleum products (conversion output) – or conversions of energy – such as combustion of hard coal (conversion input) – in power stations, for production of electrical energy (conversion output). The energy consumption in the transformation sector shows how much energy was needed for operation of transformation systems (the transformation sector's own consumption). The transformation balance is divided into a total of 12 different sectors.

Non-energy-related consumption, as a component of the consumption balance, is shown as a total, without allocation to industrial sectors. Data on non-energy-related consumption, broken down by industrial sectors, are regularly provided to the Federal Environment Agency (UBA) in the framework of an additional table included with the Energy Balance for Germany. It describes which energy resources are used as raw materials (e.g. in the chemicals industry, transformation of energy resources into plastics).

The description of final energy consumption (by energy sources / fuels) shows the potential scope of energy consumption in the final consumption sectors. (The energy that is ultimately required (for applications such as work, lighting, space heat and process heat) has to be differentiated from final energy consumption. It is not listed in the EB (AGEB, 2019).) The breakdown covers the areas of industry – sub-divided into 14 sectors – transport, households, commercial use, trade, services and other consumers (including agriculture). The energy flow in the Energy Balances is depicted for 30 energy sources / fuels. These energy resources can be allocated to the following main groups:

- hard coal,
- lignite,
- petroleum (including LPG and refinery gas),
- gases (coke-oven and blast furnace gas, natural gas and firedamp, and excluding landfill gas and the gases in the previous category),
- renewable energies (including renewable waste and, as of 2013, sewage sludge),

electrical power and other energy sources / fuels (non-renewable waste, waste heat). Detailed information about the transformation balance, non-energy-related consumption, final energy consumption and the energy sources / fuels groups is provided in the NIR (2023). In this regard, we call attention to the brochure "Energie in Zahlen – Arbeit und Leistungen der AG Energiebilanzen" ("Energy in numbers – the work and services of the AG Energiebilanzen") (AGEB, 2019), which presents further details and background information about the German Energy Balance.

Energy Balances for Germany as a whole are available for the years as of 1990 (AGEB, 2003). As of the year 2000, the energy-resource structure in the area of renewable energies / waste was changed: hydroelectric and windpower systems, and photovoltaic systems, were combined, and waste/biomass was divided into renewable and non-renewable fractions. Since 2003, non-renewable waste and waste heat are also listed under final-energy consumption within the Energy Balance.

In the Energy Balance, fuels / energy sources are listed in natural units, including tonnes (t) for solid and liquid fuels, cubic metres (m<sup>3</sup>) for gases (except for natural gas), kilowatt hours (kWh) for electrical power and natural gas, and joules (J) for waste, renewable energy sources, nuclear power and district heating. In order to render the data comparable, and to allow them to be added up, all values are converted into joules (J), via suitable conversion factors. With respect to gases, the Energy Balance differs from gas statistics in that it views all gases in terms of their net calorific value  $H_i$  – and not of their gross calorific value,  $H_s$ .

To meet the need for emissions reporting to be as up to date as possible, the following procedure will be carried out on an annual basis as of 2022 for purposes of inventory preparation: at the end of August, the Working Group on Energy Balances (AGEB) will provide the German Environment Agency (UBA) with a complete provisional Energy Balance, based on extrapolated statistics of the Federal Statistical Office, for the year  $x-1$ . The AGEB will then deliver the final Energy Balance to UBA in the following February (at that point, the EB will be for the year  $x-2$ ). Publication will then take place in about the following April.

## Methodological issues: Energy-related activity rates

Essentially, the inventories for air pollutants and greenhouse gases prepared by the German Environment Agency are based on the Energy Balances for Germany prepared by the Working Group on Energy Balances (AGEB). The data required for emissions calculation can be read directly from Energy Balance lines 11, 12, 15, 16, 40, 60, 65 and 68. For natural gas and light heating oil, EB line 14 is also used in calculation.

In a few cases, the special requirements pertaining to emissions calculation, and the need to assure the completeness of data, necessitate a departure from the above-described system, and additional data have to be added:

- The emissions-relevant fuel inputs for lignite drying have to be calculated out of EB line 10. A precise description of category 1.A.1.c is provided in Chapter 3.2.6.2.
- Natural gas inputs in compressors, for the years 1995-2002, were taken directly from the Energy Balance (EB line 33). For the years 1990-1994, and for the period as of 2003, the values have to be calculated outside of the Energy Balance. The method is described in the NIR 2022's Chapter for category 1.A.3.e.
- For systematic reasons, and for reasons having to do with a focus on energy production, the Energy Balance does not list incinerated waste quantities completely for all relevant years. In this area as well, therefore, the lacking data have to be added from waste statistics. Relevant explanations are provided in Chapter for category 1.A.1.a and in the Chapter for category 1.A.2.g Other (stationary).
- Firewood use in the categories commercial and institutional is not listed in the Energy Balances through 2012; it has to be added. The method is described in Chapter for category 1.A.4.

In the Energy Balance, inputs of reducing agents, in pig-iron production, are listed in part as energy-related consumption, in EB line 54, and in part as transformation inputs, in EB line 17 (top-gas equivalent). Use, for energy production, of the blast-furnace gas produced in pig-iron production is listed in the relevant Energy Balance lines, 11, 12, 15, 33 and 54. To prevent double counting, the reducing-agent inputs from blast furnaces, as listed in EB line 54, and the relevant top-gas equivalent, are not reported.

## Uncertainties, time-series consistency and quality assurance in the Energy Balance

While the Act on Energy Statistics (which entered into force in 2003) improved the relevant basic data foundations for the Energy Balance somewhat, the dynamic development of the energy sector soon necessitated an amendment of that Act. The currently valid amendment of the Act on Energy Statistics of 6 March 2017 (Federal Law Gazette (BGBl) I p. 392) introduces improvements in statistical coverage, updates the survey groups involved and adds a number of new aspects to be surveyed. In addition, the survey periodicity has changed – in part, in favour of monthly surveys. The first survey covered survey year 2018.

The data structures of the Energy Balance are adjusted on an ongoing basis, in order to ensure that the best-possible data are provided. These changes are made at relatively large intervals and are documented by the Working Group on Energy Balances (AGEB) in each case:

- Explanations relative to revision of the Energy Balances 2003 – 2006
- Remarks regarding changes in the Energy Balances 2003 through 2007
- Revision of the Energy Balances 2003 through 2009
- Methodological changes in the 2012 Energy Balance
- Explanations relative to the Energy Balances (updated as of November 2015)

In October 2021, the AGEB prepared a report, in compliance with its contract, on “Germany's Energy Balance – required revisions” (“Revisionsbedarf in der Energiebilanz Deutschland”) resulting in a fundamental revision of the time series in 2023 and for the 2024 emission reporting (see NID and IIR 2024) <sup>2)</sup>.

## Quality report of the Working Group on Energy Balances (AGEB) regarding preparation of Energy Balances for the Federal Republic of Germany

Since 2012, the Working Group on Energy Balances (AGEB) has regularly submitted joint quality reports, to the German Environment Agency (UBA), that document its quality-assurance measures in preparation of Energy Balances. As of 2020, in the framework of the contract for the Energy Balances, and in the interest of quality assurance, the Energy Balances are being prepared and provided in a time-series format. This facilitates detection of time-series jumps during compilation of the data.

The following section presents the content of the current report, in its original wording (marked with a different typeface).

## **Background**

In the framework of greenhouse-gas reporting, the National Co-ordinating Committee for the National System of Emissions Inventories has established minimum requirements pertaining to quality control and quality assurance (QC/QA). Those requirements are to be fulfilled on all levels of inventory preparation. One of the most important data sets for determination of greenhouse-gas emissions consists of the Energy Balances for the Federal Republic of Germany, which the Working Group on Energy Balances (AGEB) has been commissioned to prepare. The German Institute for Economic Research (DIW Berlin), the EEFA research institute (Münster) and the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW; Stuttgart) support the AGEB in its work, as sub-contractors. In the current Energy Balance cycle, the German Institute for Economic Research is participating for the last time in preparation of an Energy Balance for Germany. All persons working on Energy Balances are required to comply with minimum requirements pertaining to QC/QA, in areas such as transparency, consistency, comparability, completeness and accuracy.

To document its data sources and quality-assurance measures in preparation of Energy Balances, the Working Group on Energy Balances (AGEB) herewith submits its current quality report to the Federal Environment Agency (UBA). It focuses especially on the 2021 Energy Balance.

## **Work-sharing in preparation of Energy Balances**

The basic working method for preparation of Energy Balances has changed, partly for the reason that revisions of Balance data are pending. Now, the Energy Balances for Germany are now being centrally generated, via a database (which is stored at the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW)). The basic responsibilities for the various energy sources / fuels (Energy Environment Forecast and Analysis (EEFA) institute: hard coal, lignite, coking gas, blast furnace gas, basic oxygen furnace gas and mine gas; ZSW: petroleum and petroleum products, natural gas, petroleum gas, and other fuels; office of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat): renewable energies) have not been affected by the change. Also, in connection with its Energy Balance work, the DIW Berlin has coordinated the quarterly estimates of primary energy consumption for the Federal Republic of Germany, and prepared estimates for the energy area "Other." In this framework, the EEFA research institute is responsible for the fuel "hard coal." Figures on renewable energies are calculated and published on the basis of the relevant data, in consultation with the office of the Working Group on Renewable Energy Statistics (GS AGEE-Stat).

In February of 2022, EEFA/ZSW prepared an "early-estimate" version of the 2021 Energy Balance (with data available as of 15 February 2022). The 2021 provisional Energy Balance was then submitted in May 2022. In September of the same year, a further 2021 provisional, "early-estimate" Energy Balance was prepared, along with the pertinent evaluation tables. That Balance included data and estimates of the Federal Statistical Office, including data and estimates on development of final energy consumption by industry. In the normal process, data from official Mineral Oil Statistics (AMS) of the Federal Office of Economics and Export Control (BAFA) <sup>3)</sup> are integrated within the petroleum section of the Energy Balance. Those data, covering the previous year, are usually in April.

In February or spring of any given year, important official data sources, such as surveys relative to energy consumption of industrial sectors, are normally not yet available. Consequently, the pertinent data gaps have to be closed with the help of estimates. Understandably, an estimated Energy Balance (or an early-estimate version of the Balance) cannot fulfill the strict data-quality requirements met by the final Energy Balance, which is a work published with a time lag of about one year.

## **Quality of the data sources used**

The following data of the Federal Statistical Office (StaBuA) are used in the preparation of the Energy Balances for the Federal Republic of Germany:

- Annual survey (No. 060) of energy use by manufacturing, mining and quarrying companies,
- Monthly survey (No. 061E) of coal imports,
- Annual survey (No. 062) of heat and electricity generation from geothermal energy,
- Annual survey (No. 063) of production of biofuels,
- Annual survey (No. 064) of generation and use of heat and of heating-network operations,
- Monthly survey (No. 066K) of electricity and heat generation for the public supply,
- Annual survey (No 067) of electricity and heat generation by manufacturing, mining and quarrying companies,



- Monthly survey (No. 068) of the gas supply,
- Annual survey (No. 070) of electricity feed-in, and electricity demand, as recorded by electricity grid operators,
- Annual survey (No. 073) of production, use and supply of sewage gas,
- Annual survey (No. 075) of supply of LP gas,
- Annual survey (No. 082) of gas sales and income in the gas-supply sector,
- Energiesteuerstatistik (energy taxation statistics), Fachserie 14, Reihe 9.3).

The data of the Federal Statistical Office (StaBuA) are subject to official quality requirements. The quality reports of the Federal Statistical Office are available online at (Destatis, 2025) <sup>4)</sup>.

In addition, data from the Official Mineral Oil Statistics (AMS) of the Federal Office of Economics and Export Control (BAFA) are applied (BAFA, 2024) <sup>5)</sup>.

The AMS, which are published monthly and annually, are a closed, consistent system covering all petroleum production and consumption in Germany. The statistical basis for the AMS consists of the Integrated Mineral Oil Report (Integrierte Mineralölbericht – IM), which is prepared monthly, on the basis of the Act on mineral oil data (Mineralölstatistikgesetz), with input from companies operating in Germany's petroleum market. The Federal Office of Economics and Export Control (BAFA) reports the pertinent production and consumption data, together with the relevant data of the Federal Statistical Office, to IEA and Eurostat, which publish internationally comparable energy balances. The calorific values for crude oil inputs, and the petroleum products, that are covered by these reports are cross-checked against the national Energy Balance. For the Energy Balance's section on petroleum, both AMS data and data of the Federal Statistical Office are used.

In addition to the available official data, association data are also used. Among the statistics provided by associations, the Statistik der Kohlenwirtschaft (coal-industry statistics; since 2020, available only for lignite) play a special role. The data used for the Energy Balance include the following:

- Data on extraction, production of lignite products, producers' own consumption and sales (form 5), and information from production reports,
- Data on domestic sales / use, broken down by Länder and consumer groups,

The coal-statistics data available in Germany have a semi-official status, and they are very precise and reliable. For more than 60 years, the Statistik der Kohlenwirtschaft coal-sector-statistics association has served as a liaison between coal-sector companies and official producers of statistics. Official coal statistics in this area are based on surveys carried out by the Statistik der Kohlenwirtschaft association. A large portion of the coal data is made publicly accessible on the website <http://www.kohlenstatistik.de>. The transparency this provides also attests to the reliability and accuracy of these data sources. The Act on Energy Statistics (Energiestatistikgesetz) has no separate paragraph relative to surveys on the domestic coal sector; it refers instead explicitly to the functioning system of coal statistics.

A considerable portion of the data used for preparation of the overall natural-gas balance (Erdgasbilanz) comes from official statistics. In some areas, the data and information provided by official statistics have gaps that have to be closed. This is accomplished with the help of additional association data, as well as of model calculations. For natural gas, associated gas:

- Data on flaring losses are obtained using the implied net calorific value given by the Federal association of the natural gas, oil and geothermal energy industry (BVEG, the former WEG oil and gas industry association). The 2019 Statistical Report (Statistischer Bericht 2019) (page 22) introduced a change in the breakdown of flaring losses into the categories of "routine," "safety-relevant" and "non-routine."
- In early Balance years, data on natural gas consumption in the transport sector were derived by Zukunft Erdgas (formerly Erdgas mobil), from data provided by the German Association of Energy and Water Industries (BDEW). Energy tax statistics also yield data for this sector.
- As a result of the change in the statistical report of the Federal association of the natural gas, oil and geothermal energy industry (BVEG), own consumption is now listed as process-related own consumption, i.e. including processing losses, measuring differences and flaring losses. For purposes of preparation of Energy Balances, the BVEG has provided actual-own-consumption figures for the years 2018 through 2020.
- The following additional sources are also used:
- In the framework of monitoring under the CHP act (Kraft-Wärme-Kopplungsgesetz), the Öko-Institut e.V. Institute for Applied Ecology estimates inputs of natural gas, and light fuel oil, for electricity and heat generation in compact gas-/oil-fired CHP systems that are not covered by official statistics.
- Detailed information on how the various data sources are used in preparation of the Energy Balance is provided by the "cookbook" ("Kochbuch"; it contains source information for specific entries in the Balance).

In addition to quality, the important aspects of the available data, relative to preparation of Energy Balances, include their multi-year availability and their standardised, consistent presentations of time series. Such aspects play a critically important role in ensuring that the procedures and methods used for preparation of Energy Balances generate data that can be consistently integrated, without structural discontinuities, in the basic scheme for the Balances. Both the relevant official



sources and the coal statistics data have a long tradition. Where breaks in time series cannot be avoided, as a result of reviews or changes in statistical foundations (for example in the Act on Energy Statistics), such breaks are documented in the sources used for preparation of Energy Balances. This ensures that methods are always properly adjusted.

### **Transparency of methods and procedures**

The Act on Energy Statistics (Energienstatistikgesetz – (EnStatG) entered into force on 1 January 2003. That act consolidates official energy statistics, from different legal frameworks, and adapts them to users' changed information requirements. Since the act's entry into force, the Federal Statistical Office has also collected and provided data for the areas heat market, combined heat / power generation (CHP) and renewable energy sources. As a result of the restructuring, the Federal Statistical Office, in addition to providing data on electricity and heat generation from combined heat / power generation (CHP), also provides data on all fuel inputs for CHP, for both the general public supply and industry (broken down by energy sources).

Such changes in the available statistics have made it necessary to adjust the methods used for the Energy Balances – especially for their descriptions of industrial final energy consumption. As a consequence of the described expansion in the data supply, separate data on fuel inputs as of 2003 for industrial electricity generation – i.e. for electricity-only generation – are now available.

The Federal Statistical Office does not collect data on breakdowns of fuel inputs by “electricity” and “heat” in industrial and public-supply combined heat / power generation (CHP) systems; such statistics are collected by the Working Group on Energy Balances (AGEB) and estimated by institutes it commissions. The “Finnish” method used for such purposes is based on Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004. That method is precisely defined, mathematically, and it is explained in the forewords to the Energy Balances. Currently, it is also explained in the brochure “Energie in Zahlen – Arbeit und Leistungen der AG Energiebilanzen” (“Energy in figures – the work and services of the Working Group on Energy Balances”), p. 10, 11 f.

With regard to quality assurance, the Finnish method makes calculations relative to power/heat production for the public supply and for industry logical and transparent. The necessary pertinent assumptions, such as the reference efficiencies of non-CHP generation as provided in the documentation for the Energy Balances, are stated in the process. In sum, although Energy Balance preparation is a process that makes use of frequently complex transformational methods, its results can still be highly transparent and unambiguous. As a result, all Energy Balance entry fields can always be traced back to their primary statistical foundations. Primary data provided by official or association sources – regardless of its quality – can seldom simply be “plugged into” the Energy Balance without undergoing the statistical processing normally used to prepare the Energy Balances. Description of relevant complex energy flows, using matrices that conform to the formal parameters and methodological specifications for the Energy Balances, and on the basis of statistical raw data, requires numerous transformation steps, recalculations and reallocations. What is more, in some (few) areas of the Energy Balance primary statistics are no longer available, and thus data gaps have to be closed through use of formal estimation methods, applied in accordance with the requirements of each relevant individual case.

### **Checking and verification of results**

Measures for quality assurance and control cover the following areas:

- Assurance of data quality / transparency of methods and procedures,
- Mechanisms for checking and critically reviewing the Energy Balances, measures that assure the Balances' correctness, completeness and consistency,
- Measures for documentation and archiving, designed to ensure the Balances' clarity and reproducibility,
- Expert responsibility for preparation of Energy Balances.

Critical discussion, verification and checking of results take place on various levels: \* The involved experts mutually check their work and review it, on the basis of control figures (such as changes emerging year-to-year comparisons, implied calorific values, utilisation levels), for plausibility.

- The time-series consistency is regularly verified. Where a time series shows implausible jumps that cannot be attributed to transfer or calculation errors, and that must be tied to developments in the underlying primary statistics, the problem is discussed constructively with the relevant data-supplying institution (such as the Federal Statistical Office). In preparation of the 2018 Energy Balance, for example, it was seen in the Statistik 064 statistics, with respect to the fuels natural gas, petroleum gas, and light fuel oil, that plants' case numbers had increased, while their fuel inputs had remained at about the same level. This was due to a change of perspective from companies to plants (cf. Table 1 in this regard).

- The Energy Balances are cross-checked against the data provided to IEA/Eurostat.
- In addition, the AGEb member associations carry out supporting checks.
- Furthermore, at early stages data and results are exchanged and discussed with responsible experts of the Federal Environment Agency (UBA), also in consultation with AGEe-Stat.
- Statistical questions pertaining to the Energy Balance are also discussed by the “Working Group on methods” (“Arbeitskreis Methodik” – AKM) sited within the Federal Ministry for Economic Affairs and Climate Action (BMWK).

Only when the completed Energy Balance has successfully passed through all controlling bodies is it published on the AGEb's website and are provisional Energy Balance data provided to the Federal Environment Agency for further processing within the system for the national greenhouse-gas inventory. With a view to effective prevention of errors in data calculation and estimation for the Energy Balances, the annual balances are prepared via standardised procedures. To that end, a broad range of instruments has been developed that automate proven estimation procedures, and formal calculation methods, within the context of Energy Balance preparation. This approach, which often permits simple entry of statistical raw data into the suitable calculation tools, largely eliminates calculation and transformation errors. What is more, its use of consistent, standardised methods plays an important role in assuring time-series consistency.

#### **Documentation and archiving**

The EEFA research institute, the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) and the German Institute for Economic Research (DIW Berlin) keep detailed, written documentation relative to the annual Energy Balances. The documentation covers every Energy Balance entry, lists the statistical sources and surveys used and precisely describes the calculation methods and procedures used. The purpose of the documentation is to ensure that all steps can be retraced, both by the organisations themselves and by the Federal Ministry for Economic Affairs and Climate Action (BMWK) and the German Environment Agency (UBA). Furthermore, regular updating of the documentation contributes to data quality and helps to assure consistency in time series and methods.

All statistical data, calculation methods and estimation procedures used in preparation of Energy Balances for the Federal Republic of Germany are archived. The electronic data are stored on servers of the ZSW (AGEb database). For archiving of electronic content, the EEFA institute uses a range of computers and removable disk drives, as well as network-based server and cloud-computing solutions. Data back-ups are carried out both automatically and manually (at regular intervals).

#### **Qualified staff**

For execution of the service project “Preparation of Energy Balances for the Federal Republic of Germany” (“Erstellen von Energiebilanzen für die Bundesrepublik Deutschland”), the EEFA research institute, ZSW and DIW Berlin rely on experienced staff with solid backgrounds in the areas of statistics, economics and the energy sector.

#### **Explanations regarding the currentness and availability of data for preparation of Energy Balances**

**Official statistics** Since 2022, and in the framework of national inventory preparation, every August the Federal Statistical Office has collected/calculated additional data that enter into the Energy Balance of the previous year (in 2022, therefore, into the 2021 Energy Balance) and the Joint Annual Questionnaire. As a result, official data now become available much earlier than was previously the case. The “cookbook” for the Energy Balance shows, on a specific-cell level, what statistics provided by the Federal Statistical Office, and by BAFA, etc., are used.

**Association statistics** In the final Energy Balance, gaps in the available official data are closed, at various points, with data provided by associations (see above). Also, thanks to the quarterly estimates that the Working Group on Energy Balances carries out in cooperation with energy industry associations, current data and forecasts are available, on an ongoing basis, relative to the development of primary energy consumption in Germany.

The BDEW provides important provisional data, dated as of May and August, that are also of relevance to final energy consumption as recorded in the estimate Balance. Every summer, that organisation publishes data under the heading “The German energy market – facts and figures on the gas, electricity and district-heating sectors” (“Energemarkt Deutschland – Zahlen und Fakten zur Gas-, Strom- und Fernwärmeversorgung”). In addition, the estimated Energy Balance incorporates BDEW data on gross electricity generation, data of Statistik der Kohlenwirtschaft coal-industry statistics, and data of the Fuels&Energy industry association (Wirtschaftsverband Fuels&Energie – en2x, formerly Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry).

#### **Ongoing early estimate of the German Energy Balance, beginning in February of the following year**

The fact that the early estimate of the complete German Energy Balance for the previous year now becomes available as of 15 February of each year must be seen as a significant improvement, schedule-wise, in the availability of complete energy data. The early estimate of the Energy Balance is not based solely on the energy data that are available at the time it is produced; extensive portions of the early Balance (such as those covering final energy consumption) are also based on formal forecasting procedures (models).

Details on the approach used in preparing the early estimate of the German Energy Balance are provided in the UBA study "Pilotprojekt zur Frühschätzung der Energiebilanz 2020 und Vergleich zu späteren definierten Datenständen" ("Pilot project on the early estimate of the 2020 Energy Balance, and comparison with later defined data inventories") from Buttermann & Nieder (2023) <sup>6)</sup>.

The most-current early estimate of the Energy Balance for the 2022 reporting year will be provided to the Federal Ministry for Economic Affairs and Climate Action (BMWK) on 15 February 2023.

## Other data

All renewable-energies-trends data that are used in Energy Balance preparation are obtained from calculations of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat)).

Figures for electricity generation and fuel inputs in small CHP systems fired with natural gas and HEL (< 1 MW) were calculated with data the BHKW (compact combined heat-and-power (CHP) generating systems) database of the Öko-Institut e.V. Institute for Applied Ecology. The same data are used for reporting in the IEA/Eurostat context. Data on use of petroleum coke in metallurgical coking plants are provided for the Federal balance by the relevant German Länder, on the basis of an agreement between the Working Group on Energy Balances (AGEB) and the Länder working group on Energy Balances (Länderarbeitskreis Energiebilanzen).

<sup>1)</sup> AGEB (2025): Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen (Hrsg.), AGEB): Energiebilanz für die Bundesrepublik Deutschland;

<https://ag-energiebilanzen.de/daten-und-fakten/bilanzen-1990-bis-2030/?wpv-jahresbereich-bilanz=2021-2030>, Köln & Berlin, 2025

<sup>2)</sup> AGEB (2021): Germany's Energy Balance - required revisions (Revisionsbedarf in der Energiebilanz Deutschland): special report of the Working Group on Energy Balances (AGEB),

[https://ag-energiebilanzen.de/wp-content/uploads/2023/11/AGEB\\_InfoAusgabe-3-2023.pdf](https://ag-energiebilanzen.de/wp-content/uploads/2023/11/AGEB_InfoAusgabe-3-2023.pdf); 2021

<sup>3), 5)</sup> BAFA (2024): Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA): Infothek zu den Amtlichen Mineralöl-daten für die Bundesrepublik Deutschland; URL:

[https://www.bafa.de/SiteGlobals/Forms/Suche/Infothek/Infothek\\_SucheEinstieg\\_Rechtsgrundlagen\\_Formular.html?nn=1468600&sortOrder=dateOfIssue\\_dt+desc](https://www.bafa.de/SiteGlobals/Forms/Suche/Infothek/Infothek_SucheEinstieg_Rechtsgrundlagen_Formular.html?nn=1468600&sortOrder=dateOfIssue_dt+desc), Eschborn, 2024.

<sup>4)</sup> Destatis (2025): Federal Statistical Office (Statistisches Bundesamt - Destatis): Quality Reports (Qualitätsberichte: <https://www.destatis.de/DE/Methoden/Qualitaet/Qualitaetsberichte/Energie/einfuehrung.html>, Wiesbaden, 2025

<sup>6)</sup> Buttermann, H.-G. & Nieder, Th. (2023): Pilot project on the early estimate of the 2020 Energy Balance, and comparison with later defined data inventories (Pilotprojekt zur Frühschätzung der Energiebilanz 2020 - Berechnung einer vorläufigen Version der Energiebilanz zum Berichtsjahr 2020 und Vergleich zu späteren definierten Datenständen);

[https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/texte\\_18-2023\\_pilotprojekt\\_zur\\_fruehschaetzung\\_der\\_energiebilanz\\_2020.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/texte_18-2023_pilotprojekt_zur_fruehschaetzung_der_energiebilanz_2020.pdf); UBA-Texte 18/2023 on order of the Umweltbundesamt, Dessau-Roßlau, Januar 2023

# Appendix 5 - Verification with Independent Data

## 5.1 Introduction

Four independent datasets were used for the verification work for the German Informative Inventory Report (IIR). The selection of these verification data were carried out on the basis of broadly accepted, independent data similar to the good guidelines for verification in the 2019 refinements of the IPCC guidelines for verification (Romano et al., 2019)<sup>1)</sup>.

The first recommended dataset is the air-pollution (AP) dataset of the Emission Database for Global Atmospheric Research (EDGAR) of the JRC (Crippa et al., 2023)<sup>2)</sup>, which is a worldwide gold standard source of data for global and local air-quality modelling. It contains standard air-pollutants, such as NO<sub>2</sub> or NMVOC. Data for several heavy metals species are, however, missing in this dataset. The second source of data is the mass median data for the German data from the European moss survey (Schröder and Nickel, 2019)<sup>3)</sup>, which is also part of the monitoring carried out at the Umweltbundesamt in Germany. Here the median of the mass fraction in moss for each heavy metal species is compared to the reported inventory data. The third dataset used is the Pollution Release and Transfer Register (PRTR) (Umweltbundesamt, 2025)<sup>4)</sup>. Details for the PRTR data, as well as the database may be found under: <https://thru.de/thrude/>. Here analysis has been split into two parts, first the heavy metal air-pollutants and secondly the ordinary air-pollutants, due to their different mass in the reporting tables.

The most important, modern dataset used in the verification work is available via the Copernicus Atmospheric Monitoring Service, Atmospheric Datastore (CAMS-ADS), which are the CAMS global reanalysis (EAC4) monthly averaged field (ECMWF, 2024)<sup>5)</sup>. Details of these dataset are detailed in (Inness et al., 2019)<sup>6)</sup>. These data provide monthly averaged fields for standard air-pollutants such as NO<sub>2</sub>, or particulate matter. Data for more insight into the distribution of heavy metal species are, however, missing.

Time series data from all the four datasets are compared to the reported national inventory data time series on the basis of the national totals for Germany. This is done in a visual-quantitative way using plots of the time series data of the national totals, as well as scatter plots between the reported national totals and each of the four sets of data. In addition a quantitative analysis in form of correlation is carried out using standard mathematical similarity operators such as the Pearson and Spearman-Rank correlations, which are widely used to compute similarity between two mathematical vectors. The overall goal is to offer a semi-quantitative and qualitative comparison between the reported national totals of air pollution species and the independent datasets using time-series data. A direct sector-based comparison has not been considered, yet, as only EDGAR and PRTR data would offer a sectoral disaggregation of the national total data.

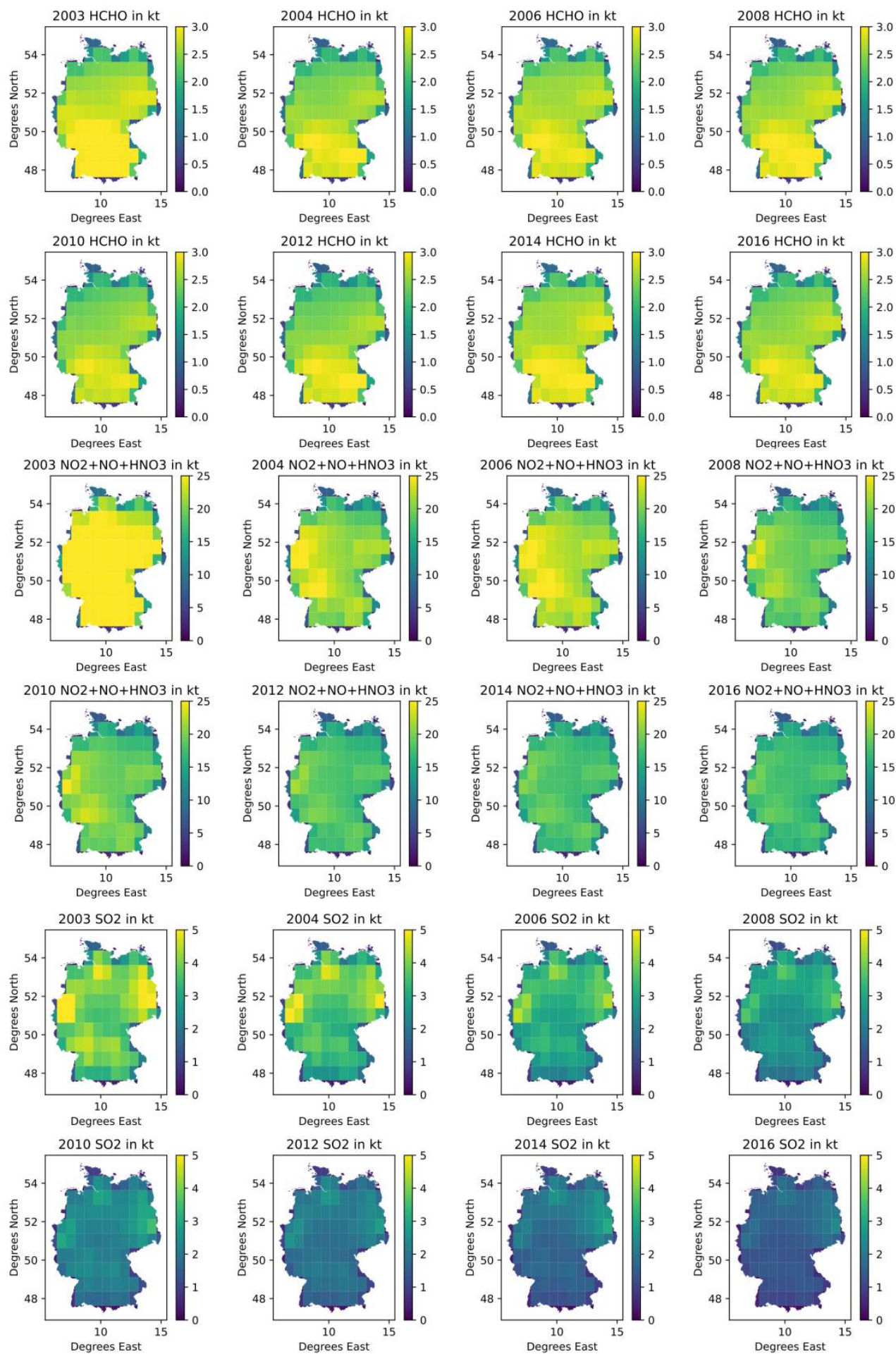




Figure 1: This is an example of the CAMS-EAC4 monthly data provided by ECMWF atmospheric datastore aggregated to the respective years shown in the figure.

## 5.2 Methods and Materials

Each of the four datasets require separate analysis using specialized python scripts, that have been developed for this verification work. The EDGAR spreadsheet data was used for the extraction of the EDGAR-AP national totals for Germany (Crippa et al., 2023)<sup>7)</sup>. PRTR data were used in form of an sql-database file, which offers all the national reported data on large point sources (Umweltbundesamt, 2025)<sup>8)</sup>. CAMS data from the European Centre for Medium-Range Weather Forecasts (ECMWF) were used, which are available in monthly slices in netcdf-Format (Inness et al., 2019)<sup>9)</sup>. Data from the German part of the European moss survey (Schröder et al., 2019)<sup>10)</sup> was kindly provided by Gudrun Schütze from the Umweltbundesamt.

### 5.2.1 The EDGAR AP Inventory

EDGAR Inventory Data and its database (Crippa et al., 2023)<sup>11)</sup> are available from the Joint Research Center (JRC) of the European Commission. We used the version 8.1 air-pollution database, which offers annual totals of major air pollutants, as well as gridded emissions, for air pollution modelling. National totals of air-pollutants (AP) were extracted from the EDGAR spreadsheets for verification. The air-pollutants offered in the database are NO<sub>2</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, CO, NMVOC and NH<sub>3</sub>. The current EDGAR timeseries (Crippa et al., 2023)<sup>12)</sup> covers the time period from 1970 until 2023. The EDGAR AP inventory is frequently update on a longer product cycle.

### 5.2.2 The CAMS EAC4 data

The CAMS global reanalysis data products are available from the ECMWF Atmospheric Composition Reanalysis (EAC4) process. They are available as either daily or monthly (ECMWF, 2024)<sup>13)</sup> data products in either single, or multi-level variants. More detail on the data products and their generation can be found in (Inness et al., 2019)<sup>14)</sup>.

For the verification work presented here the 0.75°x0.75° monthly averaged fields data product was used, which is available for the time-period from 2003 till 2022. Therefore, we used the time-period from 2005 until 2022 for comparison to the German inventory data. The update frequency of this monthly dataset is every six months, carried out by the ECMWF. The CAMS monthly dataset offers total column values for the following major air-pollutants (NO<sub>2</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub> and several species of NMVOC such as HCHO), which were used in the following for a comparison to the national total values for Germany. An example of the monthly data aggregated to the respective year can be seen in [figure 1](#).

### 5.2.3 The Pollution Release and Transfer Register

The PRTR database is an SQL-Database file, which is available for download at the domain thru.de. The data is compiled and curated by the Umweltbundesamt in Germany. It compiles data, which are reported for the large emission sources in Germany, which are e.g.: power plants, smelters, or plants from the chemical industry. The European Union Regulation No 166/2006 on the establishment of a PRTR register governs the process of PRTR data compilation.

A modified Python script was used, to extract data from the PRTR database. The tool is based on the PRTR reporting tool of (Hausmann, Zagorski and Mielke, 2021)<sup>15)</sup>. [Figure 2](#) shows the data of PRTR point sources extracted from the PRTR database file for visualization. We used the PRTR data from 2007 till 2018 for our verification work for the air pollutants: CO, NO<sub>2</sub>, SO<sub>2</sub>, NMVOC, PM<sub>10</sub> and NH<sub>3</sub>. Data from the heavy-metals species: Cd, Ni, Zn, As, Hg, Cr, Cu and Pb were also used for the here presented verification work of the national totals of Germany.

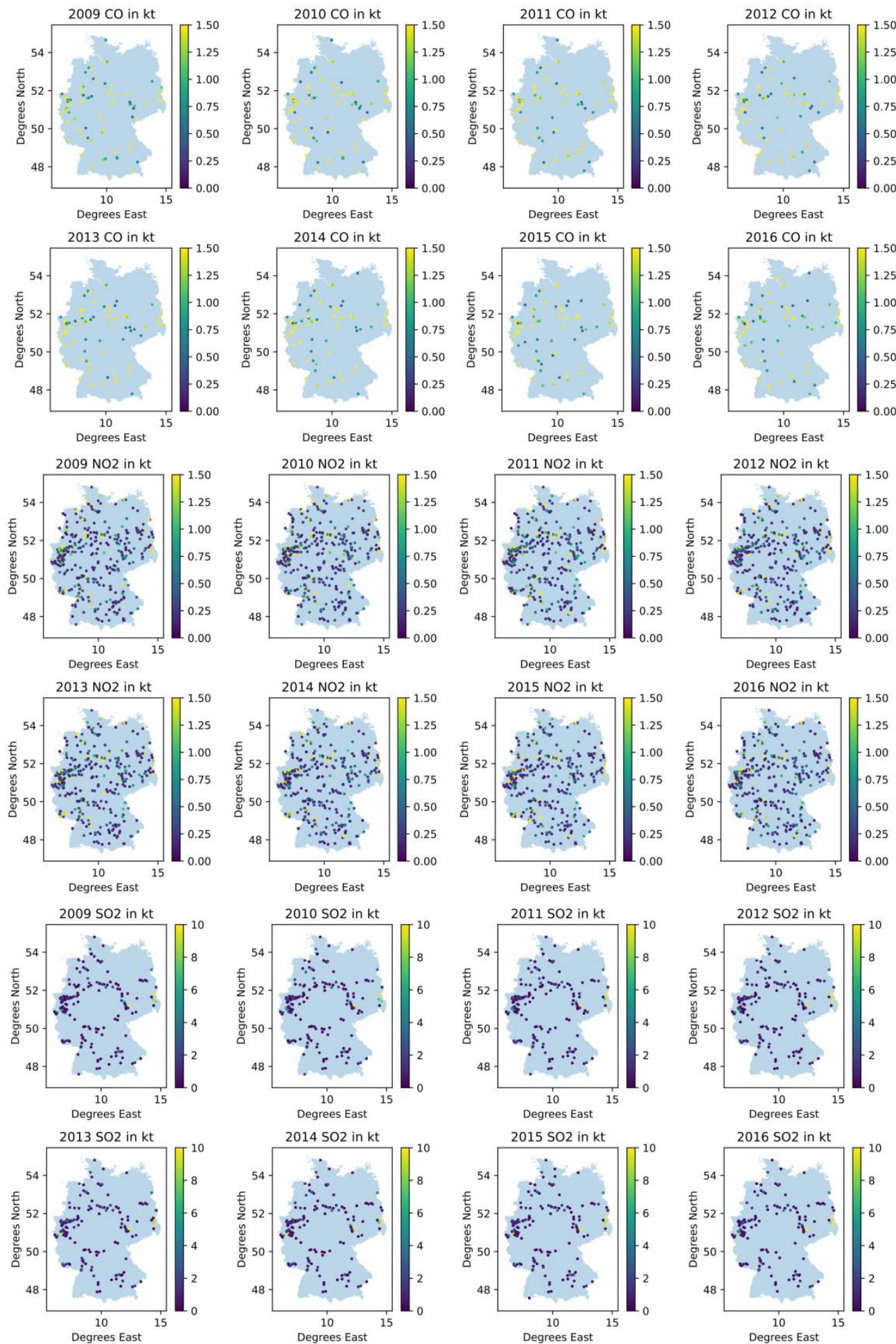


Figure 2: This is an example of the PRTR data extracted from the PRTR database for the years and substances shown.

### 5.2.4 The German Moss Survey Data

Data from the German Moss survey, which is carried out within the larger context of the European moss survey (Frontasyeva et al. 2020)<sup>16)</sup>; (Schröder et al., 2019)<sup>17)</sup> is also used for verification of the temporal trend of heavy metals in the German inventory. This survey is carried out every 5 years. It has been conducted since 1990. The time series for Germany currently covers 1990, 1995, 2000, 2005 and 2015. The data is sampled in a specified grid following a specific methodology detailed in (Schröder and Nickel, 2019)<sup>18)</sup> and (Schröder et al., 2019)<sup>19)</sup>.

## 5.3 Analysis

The analysis of the data for the national totals is carried out on the available time-series/air-pollutant species data, as offered by the four datasets. Therefore, the temporal resolution and series length is dependant on the verification data offered. Only those timestamps matching, with the reported national totals for Germany could be compared. [Figure 1](#) and [figure 2](#) are visual examples of the CAMS and PRTR data of Germany, to illustrate the spatial distribution of the data. Pearson and the spearman-rank correlation were computed for each, individual time-series pair (verification data and reported national total). These standard similarity measures were computed, to quantify the similarity between the temporal trends of the individual air-pollutant dataset.

### 5.3.1 The EDGAR AP Inventory

EDGAR data was extracted from the national totals spread-sheets, offered as download from the JRC (Crippa et al., 2023)<sup>20)</sup> using python scripts. The national totals for Germany were extracted as individual time series for the respective air pollutants (NO<sub>2</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, CO, BC, NMVOC, and NH<sub>3</sub>).

The EDGAR data for the eight AP species and a scatter plot are shown in [figure 3](#). The orange line depicts the time series from the EDGAR national total, whilst the blue line illustrates the national total from the German inventory, together with a scatterplot of all eight individual AP species.



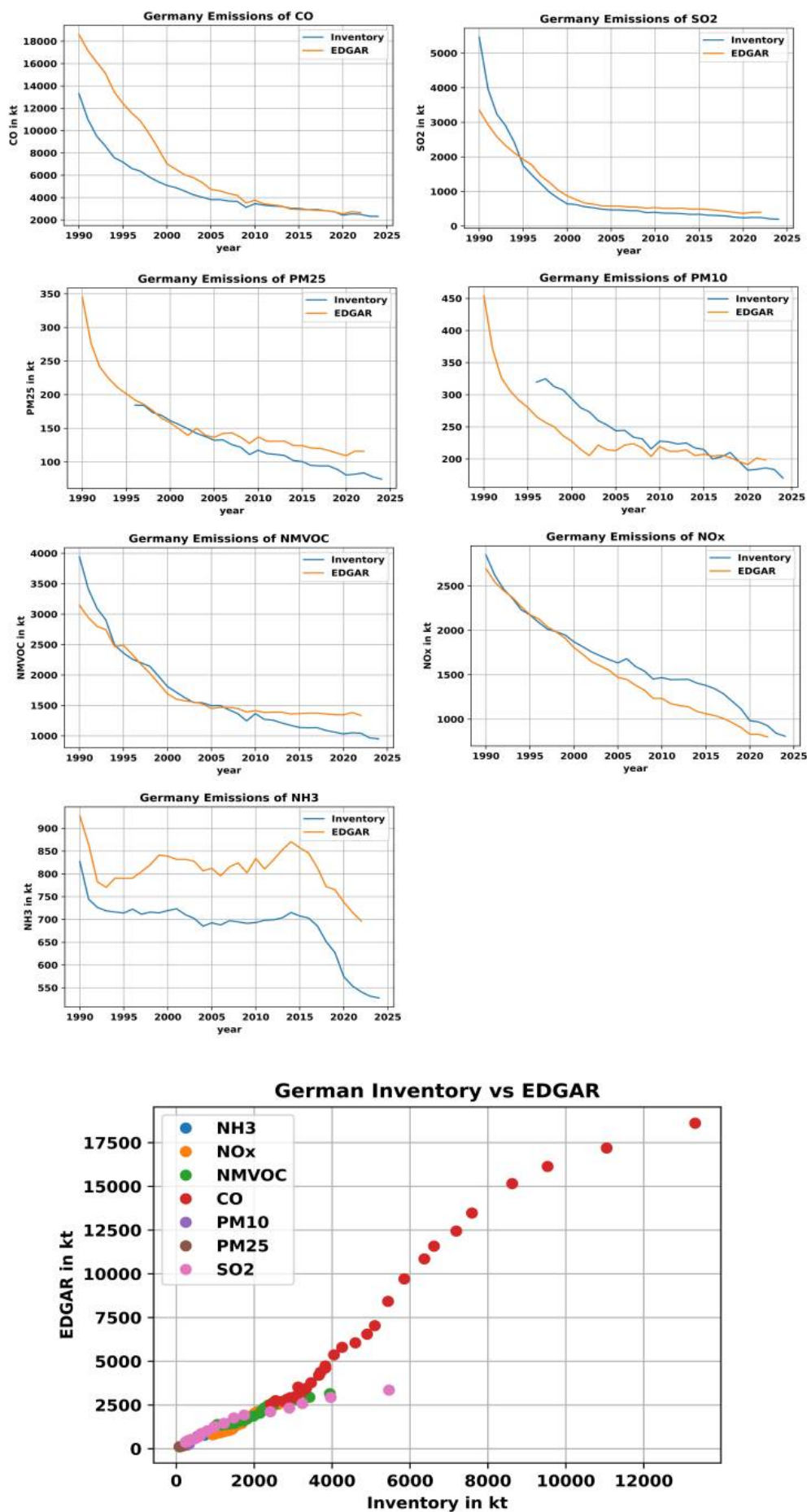


Figure 3: The upper images show EDGAR time series data plotted versus the reported inventory data of Germany. The lowermost image illustrates the correlation between each of the reported time-series with the respective EDGAR data.

### 5.3.2 The CAMS EAC4 Data

The monthly averaged CAMS EAC4 data has been aggregated to the spatial scale of Germany with the help of a spatial vector data file, which symbolizes the country area of Germany (Patterson and Kelso, 2022)<sup>21)</sup>. It has been intersected with the CAMS EAC4 data, enabling the cropping of the data pixels to the shape of Germany. The equal earth projection of (Šavrič, Patterson and Jenny, 2019)<sup>22)</sup> was used after this procedure to calculate the area of each cell in-order to convert the CAMS EAC4 field data to mass per pixel and month. These monthly time slices were summed up for all twelve months to retrieve the national total for the respective AP species of each year. The data is shown in [figure 4](#).

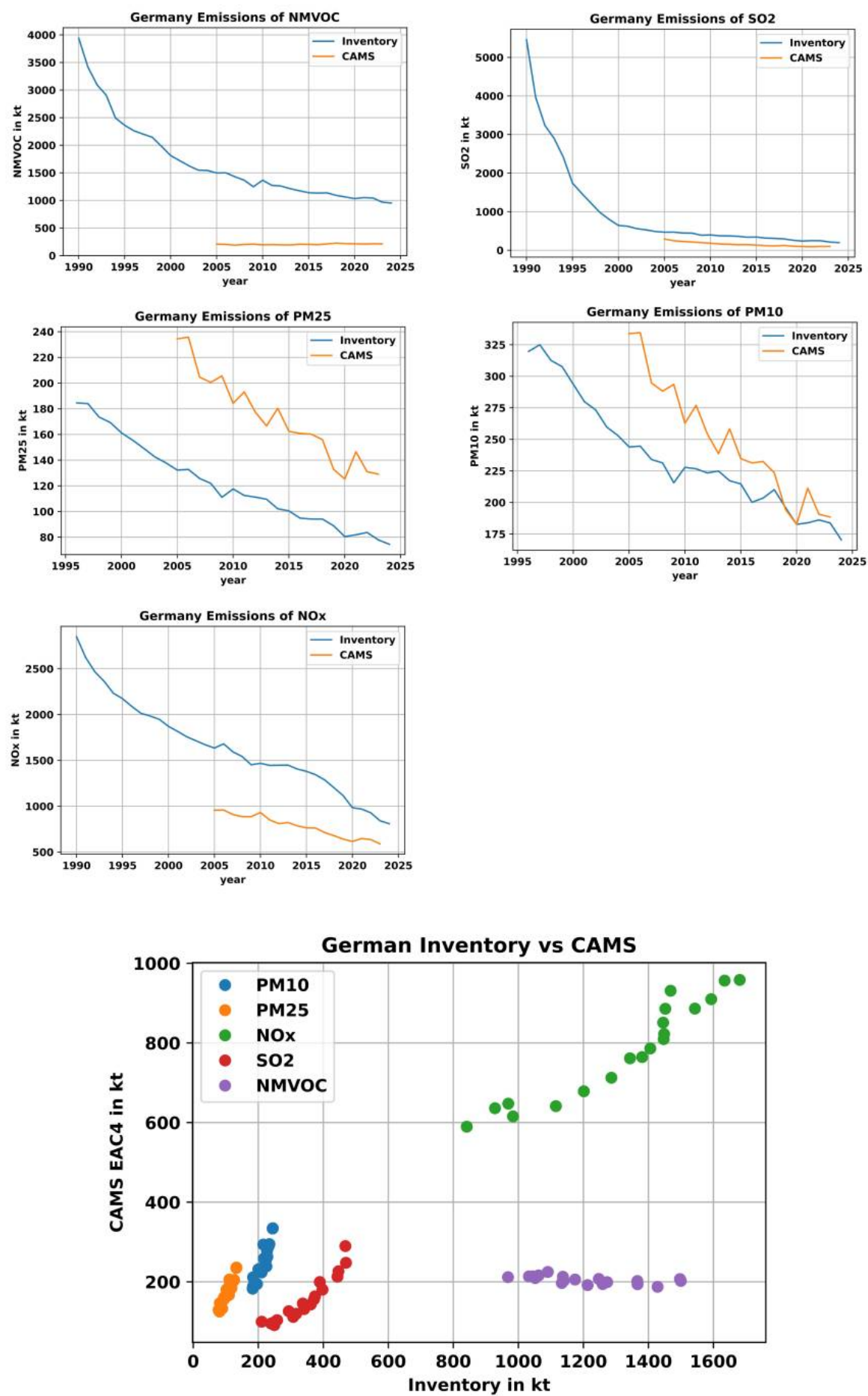


Figure 4: The upper images show yearly aggregated CAMS time series data plotted versus the reported inventory data of Germany. The lowermost image illustrates the correlation between each of the reported time-series with the respective

CAMS data.

### 5.3.3 The Pollution Release and Transfer Register

The PRTR database is an SQL-Database file, which is available for download at the domain [thru.de](https://thru.de). The data is compiled and curated by the Umweltbundesamt in Germany. It compiles data, which are reported for the large emission sources in Germany, which are e.g.: power plants, smelters, or plants from the chemical industry. The European Union Regulation No 166/2006 on the establishment of a PRTR register governs the process of PRTR data compilation. A modified Python script was used, to extract data from the PRTR database. The tool is based on the PRTR reporting tool of (Hausmann, Zagorski and Mielke, 2021)<sup>23)</sup>. [Figure 2](#) shows the data of PRTR point sources extracted from the PRTR database file for visualization. We used the PRTR data from 2007 till 2022 for our verification work for the air pollutants: CO, NO<sub>2</sub>, SO<sub>2</sub>, NMVOC, PM<sub>10</sub> and NH<sub>3</sub>. Data from the heavy-metals species: Cd, Ni, Zn, As, Hg, Cr, Cu and Pb were also used for the here presented verification work of the national totals of Germany.

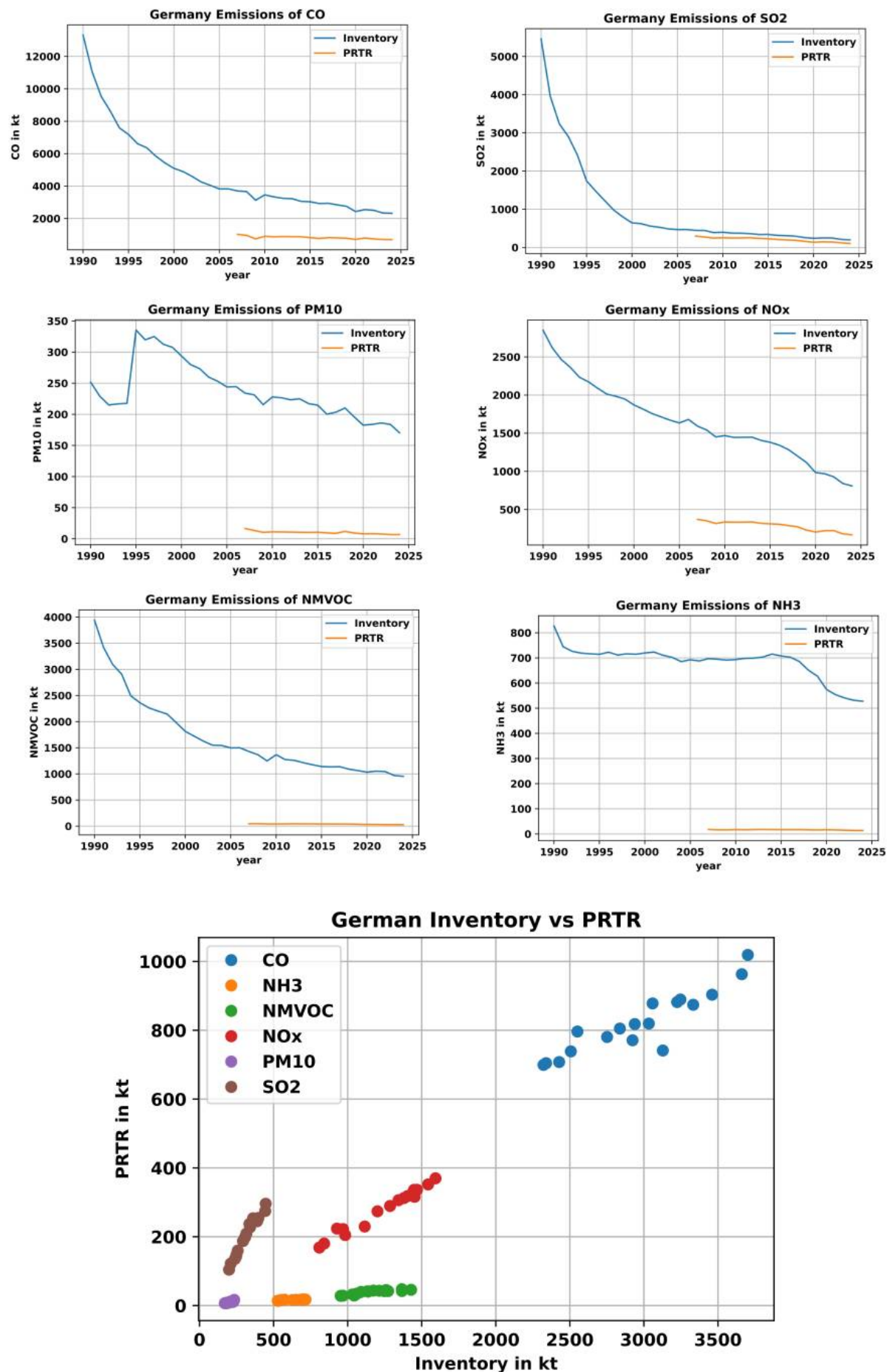


Figure 5: The upper images show yearly time series data for air-pollutants extracted from the PRTR database plotted versus the reported inventory data of Germany. The lowermost image illustrates the correlation between each of the reported time-

series with the respective AP species from the PRTR data.

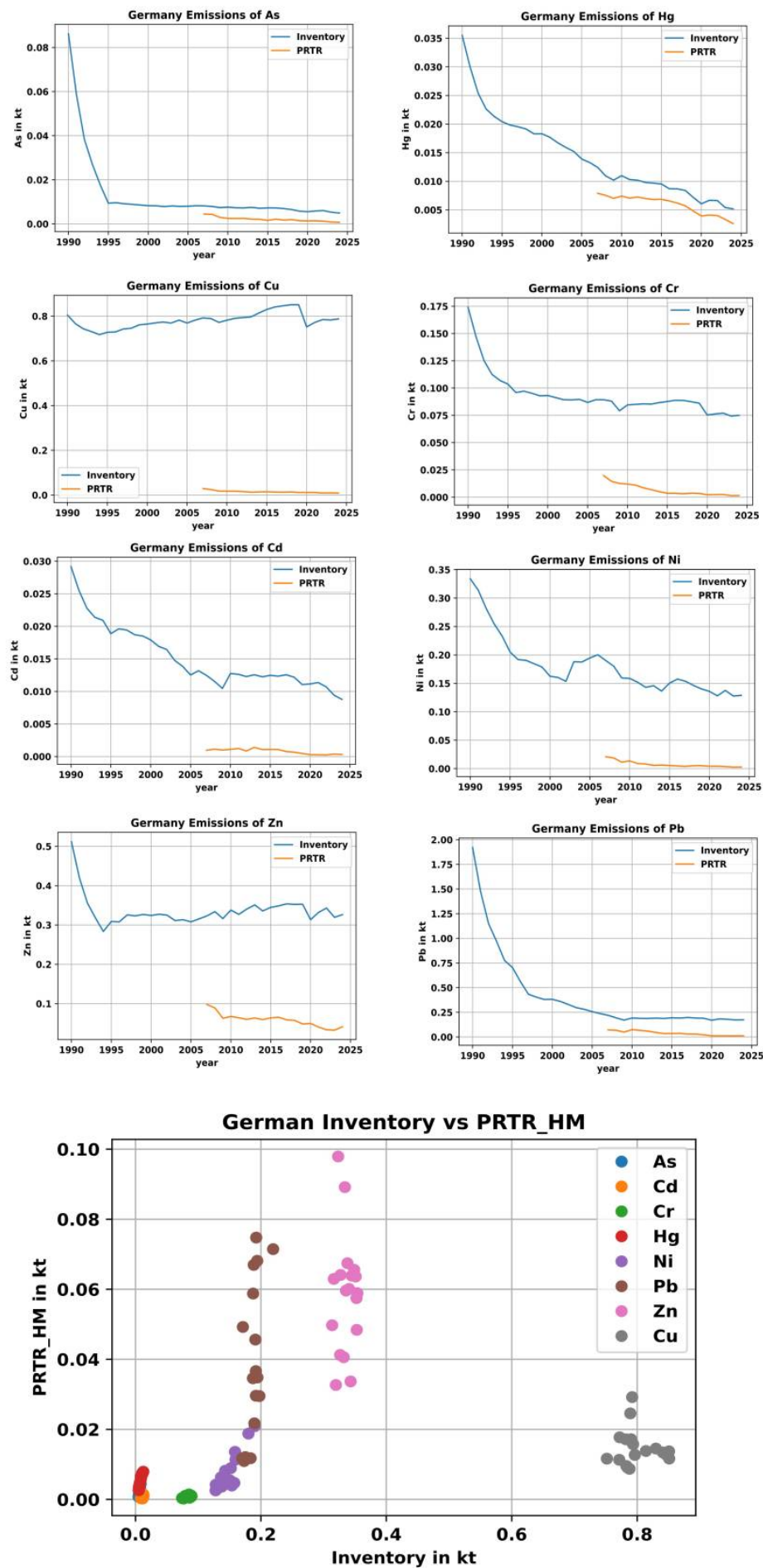


Figure 6: The upper images show yearly time series data for heavy metals extracted from the PRTR database plotted versus

the reported inventory data of Germany. The lowermost image illustrates the correlation between each of the reported time-series with the respective HM species from the PRTR data.

#### **5.3.4 The German Moss Survey Data**

Data from the German Moss survey, which is carried out within the larger context of the European moss survey (Frontasyeva et al. 2020; Schröder et al., 2019) is also used for verification of the temporal trend of heavy metals in the German inventory. This survey is carried out every 5 years. It has been conducted since 1990. The time series for Germany currently covers 1990, 1995, 2000, 2005 and 2015. The data is sampled in a specified grid following a specific methodology detailed in (Schröder and Nickel, 2019)<sup>(24)</sup> and (Schröder et al., 2019)<sup>(25)</sup>. Here the median for each heavy metal species per year was calculated and compared to the reported heavy metal emission value of that year as shown below in [figure 7](#).



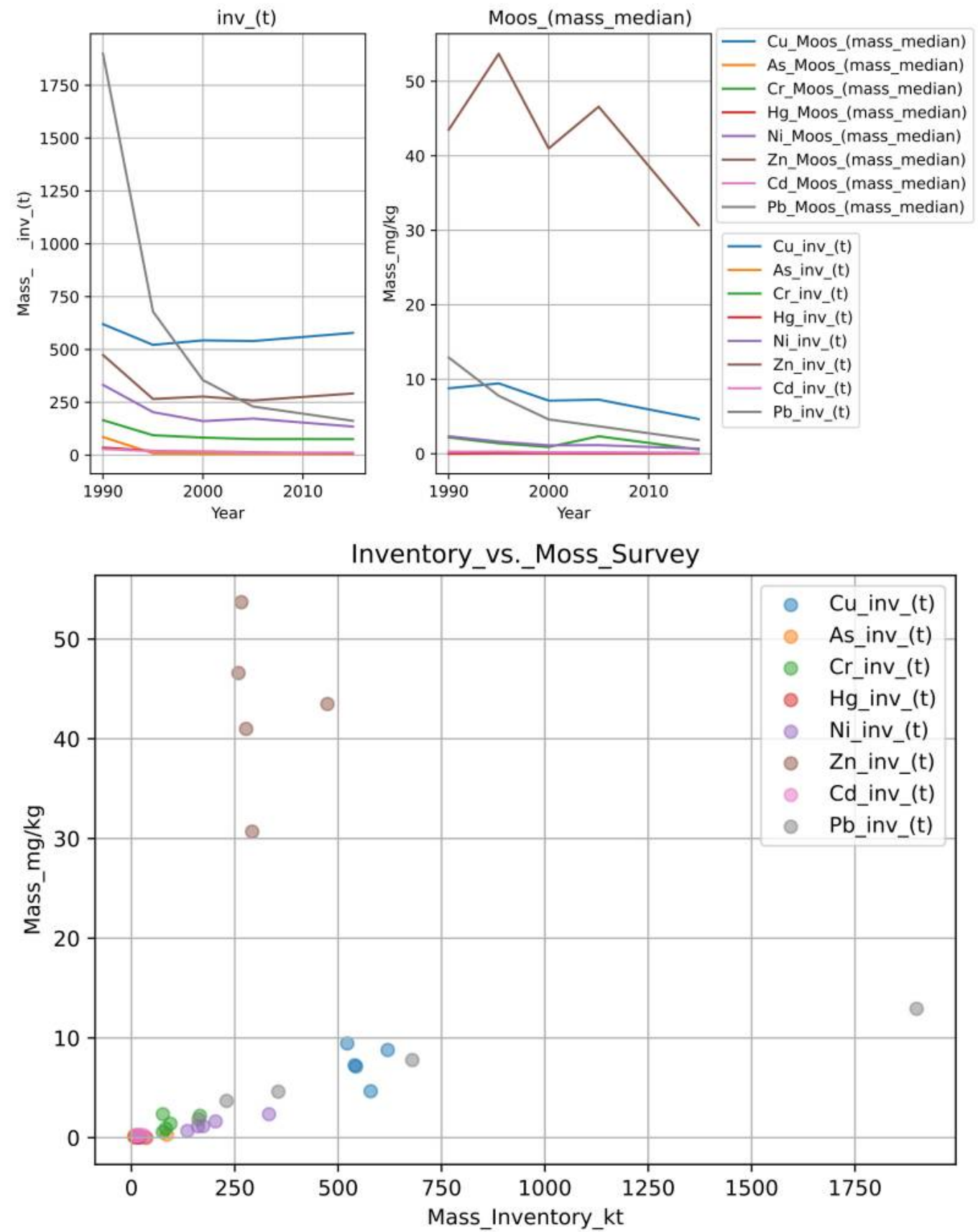


Figure 7: The upper images show yearly time series data for heavy metals extracted from the German moss survey plotted versus the reported inventory data of Germany. The lowermost image illustrates the correlation between each of the reported time-series with the respective HM species from the heavy metal moss data.

5.4 Results and Discussion



The trend data in figures 3-7 show an overall good agreement of the national totals from the verification data with the national inventory data in the time series, as well as scatter plots. Individual differences in the four datasets for specific air-pollutants are discussed below.

| EDGAR   | pearson      | spearman     | MOSS      | pearson      |
|---------|--------------|--------------|-----------|--------------|
| NH3     | 0.8415398247 | 0.4812834225 | Cu        | -0.135       |
| Nox     | 0.9870752436 | 0.9973262032 | As        | 0.747        |
| NMVOC   | 0.9803385035 | 0.9816176471 | Cr        | 0.49         |
| CO      | 0.9799085463 | 0.9969919786 | Hg        | -0.798       |
| PM10    | 0.8859578593 | 0.8931623932 | Ni        | 0.79         |
| PM25    | 0.9641442118 | 0.9774114774 | Zn        | -0.0949      |
| SO2     | 0.9735278655 | 0.9976604278 | Cd        | 0.617        |
| PRTR_AP | pearson      | spearman     | Pb        | 0.969        |
| CO      | 0.9135913719 | 0.9133126935 | CAMS_EAC4 | pearson      |
| NH3     | 0.9149835367 | 0.8121775026 | PM10      | 0.9215372108 |
| NMVOC   | 0.8756318354 | 0.9277605779 | PM25      | 0.9536099983 |
| NOX     | 0.989540334  | 0.9711042312 | NOX       | 0.9519523781 |
| PM10    | 0.8595056977 | 0.9029927761 | SO2       | 0.9420505815 |
| SO2     | 0.9836033009 | 0.9772961816 | NMVOC     | -0.588466416 |
| PRTR_HM | pearson      | spearman     |           |              |
| As      | 0.8479022548 | 0.9029927761 |           |              |
| Cd      | 0.6852636158 | 0.7172342621 |           |              |
| Cr      | 0.5879995223 | 0.5892672859 |           |              |
| Hg      | 0.8730585136 | 0.9504643963 |           |              |
| Ni      | 0.8889441391 | 0.742002064  |           |              |
| Pb      | 0.587140351  | 0.5706914345 |           |              |
| Zn      | -0.123522914 | -0.02373581  |           |              |
| Cu      | -0.092466434 | 0.1166150671 |           |              |

Figure 8: Here the tabulated results for the correlation analysis between the individual datasets and the respective reported emissions time series are shown as individual blocks.

#### 5.4.1 The EDGAR Inventory

The EDGAR inventory usually is in good agreement with the national inventory data as shown in figure [figure 3](#). Close, almost perfect matches of the EDGAR national totals with the reported inventory data can be found in case of SO<sub>2</sub>, NMVOC, NO<sub>2</sub>, PM<sub>2.5</sub> and PM<sub>10</sub>. Slight deviations with a convergence around 2015 exist for CO. Ammonia data from EDGAR are considerably higher than the reported national totals (~200 kt difference). This needs to be further investigated in future disaggregated, detailed analysis, which is not offered in this report, yet. The scatterplot shows similar exceptional correlations between the EDGAR data and the reported national totals of Germany as shown in the lowermost figure of [figure 3](#). The correlation values for the individual time series of the EDGAR data towards the inventory data can be found in [figure 8](#). Here correlation values are relatively high above 0.8-0.9 with the already discussed exception of the ammonia data, as shown in [figure 3](#).

#### 5.4.2 The CAMS EAC4 Data

The CAMS EAC4 data shows very high correlation values to the reported national totals as shown in [figure 8](#)., all correlation values are above 0.9 with the exception of formaldehyde (HCHO). The low values here for formaldehyde are compared to

the much higher national total values for NMVOC. This shows that formaldehyde is anticorrelated with NMVOC in case of Germany.

PM<sub>2.5</sub> and PM<sub>10</sub> values of the EAC4 data show a good agreement to the trend of the national totals of Germany as shown in figure 4, however, both species show an offset.

### 5.4.3 The Pollution Release and Transfer Register

Data for PM<sub>10</sub>, NO<sub>2</sub> and SO<sub>2</sub> are well correlated with the reported emissions with correlation values above 0.9 as shown in figure 8. This is also shown in the scatterplots and trend diagrams of figure 5. NMVOC and CO show moderate correlation values above 0.5. For the heavy metals As and Hg correlation values above 0.8 are shown in figure 8, whilst only moderate correlation values exist for Pb and Ni (around 0.5), whilst Cu, Cr, Zn show almost no correlation, which is also visible in the scatter plot of figure 6.

### 5.4.4 The German Moss Survey Data

The moss survey data shows exceptional high correlation values (above 0.97) for As, Ni and Pb, as illustrated in figure 8, whilst data for Cd shows only values around 0.87. All other correlation values are considerably lower. Figure 7 shows the similar picture in the accompanying scatterplot.

## References

<sup>26)</sup> <sup>27)</sup> (Accessed: 27 February 2026).] <sup>28)</sup> <sup>29)</sup> <sup>30)</sup> <sup>31)</sup> <sup>32)</sup> <sup>33)</sup> <sup>34)</sup> <sup>35)</sup> <sup>36)</sup>

<sup>1)</sup> <sup>31)</sup> Romano, D. et al. (2019) 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories — IPCC General Guidance and Reporting. General Guidance and Reporting Volume 1. IPCC. Available at: <https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/> (Accessed: 8 January 2026).

<sup>2)</sup> <sup>7)</sup> <sup>11)</sup> <sup>12)</sup> <sup>20)</sup> <sup>26)</sup> Crippa, M. et al. (2023) 'EDGAR v8.1 Global Air Pollutant Emissions'. Available at: [https://edgar.jrc.ec.europa.eu/index.php/dataset\\_ap81](https://edgar.jrc.ec.europa.eu/index.php/dataset_ap81) (Accessed: 27 February 2025).

<sup>3)</sup> <sup>18)</sup> <sup>24)</sup> <sup>34)</sup> Schröder, W. and Nickel, S. (2019) 'Spatial structures of heavy metals and nitrogen accumulation in moss specimens sampled between 1990 and 2015 throughout Germany', Environmental Sciences Europe, 31(1), p. 33. doi:10.1186/s12302-019-0216-y.

<sup>4)</sup> <sup>8)</sup> <sup>35)</sup> Umweltbundesamt (2025) Thru.de, Pollution Release and Transfer Register (PRTR). Available at: [https://thru.de/wp-content/uploads/2024/06/PRTR\\_20231120\\_de.zip](https://thru.de/wp-content/uploads/2024/06/PRTR_20231120_de.zip) (Accessed: 24 January 2025).

<sup>5)</sup> <sup>13)</sup> <sup>27)</sup> CAMS global reanalysis (EAC4) monthly averaged fields, Copernicus ADS. Available at: <https://ads.atmosphere.copernicus.eu/cdsapp#!/dataset/cams-global-reanalysis-eac4-monthly?tab=overview>

<sup>6)</sup> <sup>9)</sup> <sup>14)</sup> <sup>29)</sup> Inness, A. et al. (2019) 'The CAMS reanalysis of atmospheric composition', Atmospheric Chemistry and Physics, 19(6), pp. 3515–3556. doi:10.5194/acp-19-3515-2019.

<sup>10)</sup> <sup>17)</sup> <sup>19)</sup> <sup>25)</sup> <sup>33)</sup> Schröder, W. et al. (2019) 'Nutzung von Bioindikationsmethoden zur Bestimmung und Regionalisierung von Schadstoffeinträgen für eine Abschätzung des atmosphärischen Beitrags zu aktuellen Belastungen von Ökosystemen', Abschlußbericht, (91/2019), p. 189.

<sup>15)</sup> <sup>23)</sup> <sup>28)</sup> Hausmann, K., Zagorski, A. and Mielke, C. (2021) Convert ePRTR data to CLRTAP LPS submission. Umweltbundesamt (EPA Germany), V1.6 - Emission situation. Available at: <https://gitlab.opencode.de/uba-emsit/reporting/eptr2lps> (Accessed: 24 September 2024).

<sup>16)</sup> <sup>36)</sup> Frontasyeva, Marina, Harry Harmens, Alexander Uzhinskiy, and O. Chaligava. (2020) "Mosses as biomonitors of air pollution: 2015/2016 survey on heavy metals, nitrogen and POPs in Europe and beyond." In Report of the ICP Vegetation Moss Survey Coordination Centre. Joint Institute for Nuclear Research Dubna, Russian Federation.

<sup>21)</sup> <sup>30)</sup> Patterson, T. and Kelso, V. (2022) Natural Earth - Free vector and raster map data at 1:10m, 1:50m, and 1:110m scales. Available at: <https://www.naturalearthdata.com/> (Accessed: 8 January 2026).

<sup>22)</sup> <sup>32)</sup> Šavrič, B., Patterson, T. and Jenny, B. (2019) 'The Equal Earth map projection', International Journal of Geographical Information Science, 33(3), pp. 454–465. doi:10.1080/13658816.2018.1504949.

## DOWNLOADS & LINKS

Additional information available from this site include **previous Submissions** (NFR Tables, IIRs, Adjustment Applications), **Review Reports** (UNECE Stage 3, NEC, Adjustments) and pollutant-specific **uncertainty spreadsheets** (for current submission).

As time allows, further additional and background information will be included here to improve transparency not only for the annual review activities.

### INVENTORY SUBMISSIONS



|                        | Data                           |                              | IIR                      |                          | ADJUSTMENTS                               |
|------------------------|--------------------------------|------------------------------|--------------------------|--------------------------|-------------------------------------------|
|                        | NFR tables                     | Online                       | PDF                      | Link                     |                                           |
| <b>Submission 2026</b> | <a href="#">NFR 2026 @ CDR</a> | <a href="#">UBA DataCube</a> | <a href="#">IIR 2026</a> | <a href="#">IIR 2026</a> | <i>No adjustments.</i>                    |
| <b>Submission 2025</b> | <a href="#">NFR 2025 @ CDR</a> | <a href="#">UBA DataCube</a> | <a href="#">IIR 2025</a> | <a href="#">IIR 2025</a> | <i>No adjustments.</i>                    |
| <b>Submission 2024</b> | <a href="#">NFR 2024 @ CDR</a> | <a href="#">UBA DataCube</a> | <a href="#">IIR 2024</a> | <a href="#">IIR 2024</a> | <i>No adjustments.</i>                    |
| <b>Submission 2023</b> | <a href="#">NFR 2023 @ CDR</a> | NA                           | <a href="#">IIR 2023</a> | <a href="#">IIR 2023</a> | <i>No adjustments.</i>                    |
| <b>Submission 2022</b> | <a href="#">NFR 2022 @ CDR</a> | NA                           | <a href="#">IIR 2022</a> | <a href="#">IIR 2022</a> | <i>No adjustments.</i>                    |
| <b>Submission 2021</b> | <a href="#">NFR 2021 @ CDR</a> | NA                           | <a href="#">IIR 2021</a> | <a href="#">IIR 2021</a> | <a href="#">Approved Adjustments 2021</a> |
| <b>Submission 2020</b> | <a href="#">NFR 2020 @ CDR</a> | NA                           | NA                       | <a href="#">IIR 2020</a> | <a href="#">Approved Adjustments 2020</a> |
| <b>Submission 2019</b> | <a href="#">NFR 2019 @ CDR</a> | NA                           | NA                       | <a href="#">IIR 2019</a> | <a href="#">Approved Adjustments 2019</a> |
| <b>Submission 2018</b> | <a href="#">NFR 2018 @ CDR</a> | NA                           | NA                       | <a href="#">IIR 2018</a> | <a href="#">Approved Adjustments 2018</a> |
| <b>Submission 2017</b> | <a href="#">NFR 2017 @ CDR</a> | NA                           | NA                       | NA                       | <a href="#">Approved Adjustments 2017</a> |

### REVIEW RESULTS



|                        | CLRTAP                                                       | NEC                                                                | NEC Adjustments                |
|------------------------|--------------------------------------------------------------|--------------------------------------------------------------------|--------------------------------|
| <b>Submission 2026</b> | ongoing (March 23 <sup>rd</sup> to May 8 <sup>th</sup> 2026) | scheduled for April 22 <sup>nd</sup> to June 19 <sup>th</sup> 2026 | <i>No adjustments applied.</i> |
| <b>Submission 2025</b> | <a href="#">Stage 3 Report 2025: Projections</a>             | <a href="#">Review Report 2025</a>                                 | <i>No adjustments applied.</i> |
| <b>Submission 2024</b> | <a href="#">Stage 3 Report 2024: Solvents</a>                | <a href="#">Review Report 2024</a>                                 | <i>No adjustments applied.</i> |
| <b>Submission 2023</b> | <a href="#">Stage 3 Report 2023: Agriculture</a>             | <a href="#">Review Report 2023</a>                                 | <i>No adjustments applied.</i> |
| <b>Submission 2022</b> | <a href="#">Stage 3 Report 2022</a>                          | <a href="#">Review Report 2022</a>                                 | <i>No adjustments applied.</i> |
| <b>Submission 2021</b> | <i>No Stage 3 Review applied.</i>                            | <a href="#">Review Report 2021</a>                                 | NA                             |
| <b>Submission 2020</b> | <i>No Stage 3 Review applied.</i>                            | <a href="#">Review Report 2020</a>                                 | NA                             |
| <b>Submission 2019</b> | <i>No Stage 3 Review applied.</i>                            | <a href="#">Review Report 2019</a>                                 | NA                             |
| <b>Submission 2018</b> | <i>No Stage 3 Review applied.</i>                            | <a href="#">Review Report 2018</a>                                 | NA                             |
| <b>Submission 2017</b> | <i>No Stage 3 Review applied.</i>                            | <a href="#">Review Report 2017</a>                                 | NA                             |
| <b>Submission 2016</b> | <i>No Stage 3 Review applied.</i>                            | NA                                                                 | <a href="#">Review Report</a>  |
| <b>Submission 2015</b> | <i>No Stage 3 Review applied.</i>                            | NA                                                                 | <a href="#">Review Report</a>  |
| <b>Submission 2014</b> | <a href="#">Stage 3 Report 2014</a>                          | NA                                                                 | <a href="#">Review Report</a>  |

NFR-SPECIFIC INVENTORY DATA



|                            |                               |                                      |                                |                                 |                            |                            |                             |
|----------------------------|-------------------------------|--------------------------------------|--------------------------------|---------------------------------|----------------------------|----------------------------|-----------------------------|
| <a href="#">1.A.3.a</a>    | <a href="#">1.A.3.a i (i)</a> | <a href="#">1.A.3.a ii (i)</a>       | <a href="#">1.A.3.a i (ii)</a> | <a href="#">1.A.3.a ii (ii)</a> | <a href="#">1.A.3.b i</a>  | <a href="#">1.A.3.b ii</a> | <a href="#">1.A.3.b iii</a> |
| <a href="#">1.A.3.b iv</a> | <a href="#">1.A.3.b v</a>     | <a href="#">1.A.3.b vi &amp; vii</a> | <a href="#">1.A.3.b vi</a>     | <a href="#">1.A.3.c</a>         | <a href="#">1.A.4.a ii</a> | <a href="#">1.A.4.b ii</a> | <a href="#">1.A.4.c iii</a> |

POLLUTANT-SPECIFIC UNCERTAINTY ANALYSIS

(for current submission only)



[spreadsheet for nitrogen oxides](#)  
[spreadsheet for sulphur oxides](#)  
[spreadsheet for non-methane volatile organic compounds \(NMVOC\)](#)  
[spreadsheet for ammonia](#)  
[spreadsheet for PM2.5](#)

GRIDDING (with GRETA, the GRidding Emission Tool for ArcGIS)



[GRETA distribution parameters](#)  
[doku on GRETA extension 2018](#)  
[doku on GRETA extension 2021](#)  
[doku on further development of GRETA 2024](#)

