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Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2017

National Inventory Report for the German Greenhouse
Gas Inventory 1990 – 2015

German Environment Agency - UNFCCC-Submission

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List of Abbreviations

AbfAbIV	Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (Abfallablagerungsverordnung)
ABL	Old German Länder
AGEB	Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen)
AK	Working group (Arbeitskreis)
ALH	All other deciduous/broadleaf trees with high life expectancies (BWI tree-species group)
ALN	All other deciduous/broadleaf trees with low life expectancies (BWI tree-species group)
ANCAT	Abatement of Nuisances from Civil Air Transport
AR	Activity data (=AD)
ARD	Afforestation, reforestation, deforestation
ATKIS	Official topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem)
AWMS	Animal Waste Management System
BAFA	Federal Office of Economics and Export Control
BAT	Best Available Technique
BDZ	Federal Association of the German Cement Industry (Bundesverband der Deutschen Zementindustrie)
BEF	Biomass-expansion factor
BEU	Balance of emissions sources for stationary and mobile combustion processes (Bilanz der Emissionsursachen für stationäre und mobile Verbrennungsprozesse)
BGR	Federal Institute for Geosciences and Raw Materials (Bundesanstalt für Geowissenschaften und Rohstoffe)
BGS	Fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) publicly connected to such operations
BGW	Federal Association of the German Gas and Water Industry (Bundesverband der deutschen Gas- und Wasserwirtschaft)
BHD	Diameter at breast height (= DBH; tree-trunk diameter at a height of 1.30 m above the ground)
BHKW	Combined heat and power (CHP) unit (Blockheizkraftwerk)
BKG	Federal Agency for Cartography and Geodesy (Bundesamt für Kartographie und Geodäsie)
BImSchV	Statutory Ordinance under the Federal Immission Control Act
BML	cf. BMEL
BMUB	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
BMEL	Federal Ministry of Food and Agriculture
BMVEL	cf. BMEL
BMVG	Federal Ministry of Defence
BMWA	cf. BMWi
BMWi	Federal Ministry for Economic Affairs and Energy

BoHE	Main survey on soil use (Bodennutzungshaupterhebung)
BREF	BAT (Best Available Technique) Reference Documents
BSB	Biological oxygen demand (= BOD; Biologischer Sauerstoffbedarf)
BSB ₅	Biological oxygen demand within 5 days (BOD ₅)
BV Kalk	German Lime Association (Bundesverband der Deutschen Kalkindustrie)
BÜK	Soil-overview map (Bodenübersichtskarte)
BWI	National Forest Inventory (Bundeswaldinventur)
BZE	Forest Soil Inventory (Bodenzustandserhebung im Wald)
C ₂ F ₆	Hexafluorethane
CAPIEL	Coordinating Committee for the Associations of Manufacturers of Industrial Electrical Switchgear and Controlgear in the European Union
CFC	Chlorofluorocarbons (= Fluorchlorkohlenwasserstoffe (FCKW))
CFI	Continuous Forest Inventory
CH ₄	Methane
C _{org}	Organic carbon stored in the soil
CO	Carbon monoxide
CO ₂	Carbon dioxide
CORINAIR	Coordination of Information on the Environment, sub-project: Air
CORINE	Coordinated Information on the Environment
CRF	Common Reporting Format
CSB	Chemical oxygen demand (COD)
D	Germany (Deutschland)
DBFZ	Deutsches Biomasseforschungszentrum (German centre for biomass research)
DEHSt	German Emissions Trading Authority (Deutsche Emissionshandelsstelle)
DESTATIS	Federal Statistical Office (official abbreviation: StBA)
DFIU	Franco-German Institute for Environmental Research, at the University of Karlsruhe (Deutsch-Französisches Institut für Umweltforschung an der Universität Karlsruhe)
DG	Landfill gas (Deponiegas)
DGMK	German Association of Oil, Natural Gas and Coal Science (Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle eV.)
DIN	DIN standard (Deutsche Industrienorm)
DIW	German Institute for Economic Research (Deutsches Institut für Wirtschaftsforschung)
DLR	German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt)
DMKW	Diesel-engine power stations (Dieselmotorkraftwerke)
D _N	Nitrogen in wastewater
DOC	Degradable organic carbon Degradable organic carbon)
DOC _F	Fraction of DOC dissimilated (converted into landfill gas) Fraction of DOC dissimilated)
DSWF	"Forest Fund Database" for the former GDR (Datenspeicher Waldfonds)
DTKW	Steam-turbine power stations (Dampfturbinenkraftwerke)
DVGW	German Association of the Gas and Water Industry (Deutsche Vereinigung des Gas- und Wasserfachs eV.)
D7	Tree-trunk diameter at a height of 7 m above the ground
EBZ	Energy Balance line in the BEU (Energiebilanzzeile)
EEA	European Environment Agency
EECA	European Electronic Component Manufacturers Association

EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz); promulgated in Federal Law Gazette Part I No. 40 of 31 July 2004, p. 1918 ff.)
EF	Emission factor
EI	Emission index = emission factor
E _{KA}	Inhabitant connected to wastewater-treatment system (Einwohner mit Kläranlagenanschluss)
EL	Fuel oil EL (EL = easily liquid)
EM	Emission
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
EMEV	Emissions-relevant energy consumption (Emissionsrelevanter Energieverbrauch)
ERT	Expert Review Team
ESIA	European Semiconductor Industry Association
ETS	EU Emissions Trading Scheme
EU	European Union
EU-EH	ETS (Europäischer Emissionshandel)
EUROCONTROL	European Organisation for the Safety of Air Navigation
EUROSTAT	Statistical Office of the European Communities
EW	Population (Einwohnerzahl)
FA	Combustion systems (Feuerungsanlagen)
FAP	Specialised contact person in the NaSe (Fachlicher Ansprechpartner)
FAL	Federal Agricultural Research Institute (as of 2008: cf. TI)
FAO	United Nations Food and Agriculture Organisation of the United Nations
FCKW	CFC (Fluorchlorkohlenwasserstoffe)
F gases	Fluorinated greenhouse gases
FHW	District heating stations (Fernheizwerke)
FKW	Perfluorocarbons (PFC)
FKZ	Research project number (Forschungskennzahl)
FV	Responsible expert (Fachverantwortlicher) in the NaSe
FWL	Thermal output from combustion (Feuerungswärmeleistung)
GAS-EM	GASeous EMISSIONS (programme for calculation of agricultural emissions)
GEREF	GERman Emission Factor Database
GFA	Large combustion systems (Großfeuerungsanlagen)
GG	Total weight (Gesamtgewicht)
GIS	Gas-insulated switching systems
GMBL	Joint Ministerial Gazette (Gemeinsames Ministerialblatt)
GMES	Global Monitoring for Environment and Security
GMKW	Gas-engine power stations (Gasmotorkraftwerke)
GPG	Good Practice Guidance
GSE FM-INT	GMES Services Elements Forest Monitoring: Inputs for national greenhouse-gas reporting
GT	Gas turbines
GTKW	Gas-turbine power stations (Gasturbinenkraftwerke)
GuD	Gas and steam turbine power stations (Gas- und Dampfturbinenkraftwerke)
GWP	Global Warming Potential
HFC	Hydrofluorocarbons (= HFKW)

HFCKW	Hydrochlorofluorocarbons (HCFCs; Wasserstoffhaltige Fluorchlorkohlenwasserstoffe)
HFKW	Hydrofluorocarbons (HFC)
Hi	Net calorific value (Heizwert)
HK	Key category (Hauptkategorie); is applied to both emissions sources and sinks
HS-GIS	High-voltage gas-insulated switching systems
IAI	International Aluminium Institute
IE	Included elsewhere
IEA	International Energy Agency
IEF	Implied emission factor
IfE	Institute for Energy and Environment (Institut für Energetik und Umwelt)
IFEU	Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung)
IKW	Industrial power stations (Industriekraftwerke)
IMA	Interministerial Working Group (Interministerielle Arbeitsgruppe)
IPCC	Intergovernmental Panel On Climate Change
IS08	Inventory Study 2008 (Inventurstudie 2008)
K	Fuel input for power generation (direct drive)
k.A.	No entry (keine Angabe)
KP	Kyoto Protocol
KS	Sewage sludge (Klärschlamm)
KTBL	Association for Technology and Structures in Agriculture (Kuratorium für Technik und Bauwesen in der Landwirtschaft)
l	Level (= Level assessment pursuant to IPCC Good Practice Guidance)
LF	Agriculturally used land (landwirtschaftlich genutzte Flächen)
LKW	Truck (Lastkraftwagen)
LTO	Landing/take-off cycle
LUCF	Land Use Change and Forestry
LULUCF	Land Use, Land Use Change and Forestry
MBA	Mechanical-biological waste treatment (MBT; Mechanisch-Biologische Abfallbehandlung)
MCF	Methane Conversion Factor
MS	Medium voltage (Mittelspannung)
MSW	Municipal solid waste
MVA	Waste incineration plant (Müllverbrennungsanlage)
MW	Megawatt
N	Nitrogen
N ₂ O	Nitrous oxide (laughing gas)
NA	Not applicable
NASA	National Aeronautics and Space Administration
NaSE	German National System of Emissions Inventories (Nationales System Emissionsinventare)
NBL	New German Länder (neue Bundesländer)
NE	Not estimated
NEAT	Non-energy Emission Accounting Tables
NEC	Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain air pollutants National Emission Ceilings).

NEV	Non-energy-related consumption (nichtenergetischer Verbrauch)
NF ₃	Nitrogen trifluoride
NFR	New Format on Reporting, Nomenclature for Reporting to the UN ECE
NFZ	Utility vehicles (Nutzfahrzeuge)
NH ₃	Ammonia
NIR	National Inventory Report
NMVOC	Non-Methane Volatile Organic Compounds
NO	Not occurring
NO	Nitrogen monoxide
NSCR	Non-selective catalytic reduction
OCF	One-component foam (installation foam)
OX	Oxidation factor
PAH	Polycyclic aromatic hydrocarbons (= PAK)
PAK	Polycyclic aromatic hydrocarbons (Polycyclische aromatische Kohlenwasserstoffe; = PAH)
PARTEMIS	Measurement and prediction of emissions of aerosols and gaseous precursors from gas turbine engines
PCDD/F	Polychlorinated dibenzo-dioxins/- furans
PF	Process combustion (Prozessfeuerungen)
PFC	Perfluorocarbons (= FKW)
PKW	Automobile (Personenkraftwagen)
PU	Polyurethane
QK	Quality control (QC; Qualitätskontrolle)
QS	Quality assurance (QA; Qualitätssicherung)
QSE	Quality System for Emissions Inventories
REA	Flue-gas desulphurising plant (Rauchgasentschwefelungsanlage)
ROE	Oil equivalent (OE; Rohöleinheit)
RSt	Raw steel
RWI	Rheinisch-Westfälisches Institut für Wirtschaftsforschung
S	Fuel input for power generation
S	Heating oil, heavy (high viscosity; "Heizöl S")
S&A Report	Synthesis and Assessment Report
SA	Heating oil, heavy (high viscosity; low sulphur content; "Heizöl SA")
SE	Sampling error
SF ₆	Sulphur hexafluoride
SKE	Hard-coal units (Steinkohleneinheiten)
SNAP	Selected Nomenclature for Air Pollution
SO ₂	Sulphur dioxide
StBA	Federal Statistical Office (Statistisches Bundesamt Deutschland)
STEAG	STEAG Aktiengesellschaft (a large power producer in Germany)
T	Trend (= trend assessment pursuant to IPCC Good Practice Guidance, in the category overview tables)
TA Luft	Technical directive on air quality control; First General Administrative Provision on the Federal Immission Control Act (Clean Air Directive; Technische Anleitung zur Reinhaltung der Luft)
TAN	Total Ammoniacal Nitrogen
THG	Greenhouse gases (GHG; Treibhausgase)
TI	Johann Heinrich von Thünen Institute

TI-AK	Johann Heinrich von Thünen Institute, Institute of Climate-Smart Agriculture (Institut für Agrarklimaschutz)
TI-WO	Johann Heinrich von Thünen Institute, Institute of Forest Ecosystems (Institute für Waldökosysteme)
TM	Dry matter (Trockenmasse)
TOC	Total Organic Carbon
TREMOD	Traffic Emission Estimation Model
TS	Siccative (Trockenstoff)
TÜV	Technischer Überwachungsverein (Certifying body for technical and product safety)
TVF	Tonne of utilisable production (Tonne verwertbare Förderung)
UBA	Federal Environment Agency (Umweltbundesamt)
UN ECE	United Nations Economic Commission for Europe
UN FCCC	United Nations Framework Convention on Climate Change
UN	United Nations
UStatG	Environmental Statistics Act (Umweltstatistikgesetz)
VDEh	German Iron and Steel Institute (Verein Deutscher Eisenhüttenleute; in 2003, renamed "Stahlinstitut VDEh")
VDEW	Electricity Industry Association (Verband der Elektrizitätswirtschaft)
VDI	Association of German Engineers (Verein Deutscher Ingenieure e.V.)
VDN	Association of German network operators (Verband der Netzbetreiber e.V.)
VDZ	German Cement Works Association (Verein Deutscher Zementwerke e.V.)
VGB	Technical association of operators of large power stations (Technische Vereinigung der Großkraftwerksbetreiber e.V.)
VIK	Association of the Energy and Power Industry (Verband der Industriellen Energie- und Kraftwirtschaft e.V.)
VOC	Volatile Organic Compounds
VS	Volatile Solids
W	Fuel input for heat generation
WS	Portion of a specific wastewater treatment system (e.g. aerobic, anaerobic)
WZ	Economic activity listed in the National Classification of Economic Activities (NACE; Wirtschaftszweig)
XPS	Extruded polystyrene
ZSE	Central System of Emissions (CSE)
ZVEI	Zentralverband Elektrotechnik und Elektronikindustrie e.V.

Units and sizes

Multiplication factors, abbreviations, prefixes and symbols

Multiplication factor	Abbreviation	Prefix/symbol	
		Name	Symbol
1,000,000,000,000,000	10 ¹⁵	peta	P
1,000,000,000,000	10 ¹²	tera	T
1,000,000,000	10 ⁹	giga	G
1,000,000	10 ⁶	mega	M
1,000	10 ³	kilo	k
100	10 ²	hecto	h
0.1	10 ⁻¹	deci	d
0.01	10 ⁻²	centi	c
0.001	10 ⁻³	milli	m
0.000001	10 ⁻⁶	micro	μ

Units and abbreviations

Abbreviation	Units
°C	degrees Celsius
a	year
cal	calorie
g	gram
h	hour
ha	hectare
J	joule
m ³	cubic metre
ppm	parts per million
t	tonne
W	watt

Standard conversions

Units	is equivalent to
1 tonne (t)	1 megagram (Mg)
1 kilotonne / thousand tonnes (kt)	1 gigagram (Gg)
1 megatonne / million tonnes (Mt)	1 teragram (Tg)

Reading the introductory information tables

The introductory information tables appear at the beginning of each source category chapter. Each such table provides an overview of the relevant source category's importance and of the methods used in connection with it.

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990- 2015
L/T	1A1c Manufacture of Solid Fuels and Other Energy Industries	All fuels	CO ₂	65,289.0	(5.36%)	10,267.5	(1.10%)	-84.3%
-/-	1A1c Manufacture of Solid Fuels and Other Energy Industries	All fuels	N ₂ O	659.2	0.05%	150.1	0.02%	-77.2%
-/-	1A1c Manufacture of Solid Fuels and Other Energy Industries	All fuels	CH ₄	92.0	(0.01%)	13.9	(0.00%)	-84.9%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	NS	CS
CH ₄	Tier 2	NS	CS
N ₂ O	Tier 2	NS	CS
NO _x , CO, NMVOC, SO ₂			CS

Key category

The upper section of the table shows the key-category-analysis lines that are relevant for the source category in question; the emissions, as an absolute figure (kt CO₂ equivalent) and as a percentage of total emissions in 1990 and in the last reported year; and the pertinent emissions trend between the base year (1990 or 1995 for the F gases) and the last reported year. In the German-language version of the NIR, the term "Hauptkategorie" is used synonymously with the term "key category".

- L = Key category in terms of emissions level
- T = Key category in terms of emissions trend
- 2 = Key category pursuant to Tier-2 analysis

Gas

The lower section of the table provides information about the methods used, the source for the activity data and the emission factors (EF) used.

Method used

- D = IPCC default
- RA = Reference Approach
- Tier 1 = IPCC tier 1
- Tier 2 = IPCC tier 2
- Tier 3 = IPCC tier 3
- C = CORINAIR
- CS = Country-specific
- M = Model

Source for the activity data

- M = Model
- Q = Questionnaires, surveys
- PS = Plant-specific data
- AS = Associations, business organizations
- RS = Regional statistics
- NS = National statistics
- IS = International statistics

Emission factor (EF)

- D = IPCC default
- C = CORINAIR
- CS = Country-specific
- PS = Plant-specific
- M = Model

0 Summary (ES)

As a Party to the United Nations Framework on Climate Change (UNFCCC), since 1994 Germany has been obliged to prepare, publish and regularly update national emission inventories of greenhouse gases. In February 2005, the Kyoto Protocol entered into force. As a result, the international community of nations is required to implement binding action objectives and instruments for global climate protection. This leads to very extensive and detailed obligations vis-à-vis the preparation, reporting and review of emissions inventories. In keeping with Article 3 of the Kyoto Protocol, the EU countries have been making use of the option of jointly fulfilling obligations under the Kyoto Protocol and the UN Framework Convention on Climate Change. They have been doing so via European regulations, most recently EU Regulation 525/2013¹ and its Implementing Regulation 749/2014². Current European implementation of the Kyoto Protocol, via regulations, has made the Protocol's provisions legally binding for Germany.

Pursuant to Decision 24/CP.19, all Parties listed in ANNEX I of the UNFCCC are required to prepare and submit annual National Inventory Reports (NIRs) containing detailed and complete information on the entire process of preparation of such greenhouse-gas inventories. The purpose of such reports is to ensure the transparency, consistency and comparability of inventories and support the independent review process.

Pursuant to decision 15/CMP.1, as of 2010 all of the countries listed in ANNEX I of the UN Framework Convention on Climate Change that are also parties to the Kyoto Protocol must submit annual inventories in order to be able to make use of flexible mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol.

Together with the inventory tables, Germany submits a National Inventory Report (NIR), which refers to the period covered by the inventory tables and describes the methods and data sources on which the pertinent calculations are based. The report, and the report tables in the Common Reporting Format (CRF), have been prepared pursuant to the UNFCCC guidelines on annual inventories (FCCC/CP/2013/10/Add.3) and in conformance with the 2006 IPCC Guidelines for national Greenhouse Gas Inventories (IPCC Guidelines, 2006) and the IPCC Good Practice Guidance (IPCC-GPG, 2000). The NIR contains a Part II, along with additional sub-chapters, that fulfill the expanded requirements under the Kyoto Protocol and the relevant obligations at the European level.

Part I of the NIR comprising Chapters 1 to 10, contains all the information relevant to the annual greenhouse-gas inventory.

Chapter 1 provides background information about climate change and about greenhouse-gas inventories, as well as further information relative to the Kyoto Protocol. This section describes the National System pursuant to Article 5.1 of the Kyoto Protocol, which system is designed to aid and assure compliance with all reporting obligations with respect to atmospheric emissions and removals in sinks. In addition, this chapter describes the basic principles and methods with which the emissions and sinks of the IPCC categories are calculated, presents a short summary of key-

¹ REGULATION (EU) No 525/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC

² COMMISSION IMPLEMENTING REGULATION (EU) No 749/2014 of 30 June 2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council

category assessment and describes the Quality System for Emissions Inventories (QSE). The chapter concludes with sections on uncertainties analysis and completeness analysis.

Chapter 2 provides a general overview of development of emissions of direct and indirect greenhouse gases and of removals of carbon dioxide in sinks.

Chapters 3 through 9 present information about the individual source and sink groups. Along with general descriptions and information relative to the methods used, sub-chapters in this section also include information about pertinent uncertainties, quality assurance and quality control, recalculations carried out and planned improvements for relevant source and sink categories.

The inventories, the National System and the Quality System for Emissions Inventories have all been further improved in keeping with the results of the reviews that have taken place in recent years. More-detailed information about recalculations, and information relative to the improvements and changes made with regard to the last greenhouse-gas inventory, is presented in **Chapter 10**.

Part II of the NIR, comprising **Chapters 11 to 16**, presents the so-called "Kyoto-NIR", in fulfillment of the expanded requirements for Kyoto reporting, and in keeping with the required organisation (annotated NIR).

Chapter 11 contains all information relative to Kyoto reporting in the areas of land use, land-use changes and forestry (LULUCF), especially the definition of "forest" chosen, details on the land-classification technique used and all information relative to selected activities pursuant to Arts. 3.3 and 3.4 of the Kyoto Protocol.

Chapter 12 is devoted completely to accounting for Kyoto units, a process for which, in Germany, the German Emissions Trading Authority (DEHSt) is responsible.

Chapters 13 and 14 provide an overview of changes made in the National System, and at the German Emissions Trading Authority, with the aim of ruling out the possibility of any undue influences on Kyoto reporting.

Chapter 15 lists all the measures that Germany is taking to minimise negative impacts pursuant to Article 3 (14).

Chapter 16 presents any required further information relative to Kyoto reporting.

Annexes 1 through 7, comprising **Chapters 17-23**, contain more-detailed descriptions of key categories, of individual categories, of the CO₂-reference procedure, of completeness issues, of the National System and the Quality System, of the CSE emissions database and of uncertainties.

More-detailed information about specific relevant issues is presented in the literature listed in **Chapter 24**.

The Federal Environment Agency makes all calculations for the greenhouse-gas inventory and carries out all relevant compilation. Data on emissions and sinks in the land use, land-use changes and forestry sector have been provided by the Johann Heinrich von Thünen Institute (TI).

0.1 Background information on greenhouse-gas inventories and climate change (ES.1)

0.1.1 Background information about climate change (ES1.1)

Ever since the start of industrialisation, significant trans-regional and global changes in the substance balance of the atmosphere have been observed as a consequence of human activities. Worldwide, concentrations of carbon dioxide (CO₂) have risen by approximately 43 % compared to their levels in pre-industrial times, whilst those of methane (CH₄) have increased by 150 % and those of nitrous oxide (N₂O) have risen by 20 %. Furthermore, a number of brand-new substances – i.e. substances that for all intents and purposes do not occur in nature and are produced almost exclusively by humans – such as chlorofluorocarbons (CFCs), halons, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF₆) and nitrogen trifluoride (NF₃) have entered the atmosphere. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)³ shows that human impacts on climate are scientific fact.

0.1.2 Background information about greenhouse-gas inventories (ES1.2)

In February 2005, the Kyoto Protocol entered into force. As a result, the international community of nations is required to implement binding action objectives and instruments for global climate protection. In the first commitment period, which lasted from 2008 through 2012, the European Community (at the time, with 15 Member States) committed itself to reducing its greenhouse-gas emissions by 8 % with respect to the base year (1990 and 1995⁴). This commitment has been divided and fulfilled within the EU in the framework of a burden-sharing agreement between the participating Member States⁵. In that agreement, Germany agreed to reduce its emissions by 21 % in comparison to the base year and thus agreed to make a substantial contribution to fulfillment of the EU's commitment. With a 25.8 % reduction by 2012, Germany reached and considerably exceeded that goal.

In the framework of the now-commenced second commitment period of the Kyoto Protocol, the European countries have committed themselves to reducing their greenhouse-gas emissions by 20 % by 2020. At the same time, they have announced that, under certain conditions, this European contribution could be increased to a 30 %⁶ reduction with respect to 1990.

On 3 December 2014, Germany's federal cabinet adopted the Climate Action Programme 2020⁷. With this move, the Federal Government wishes to ensure that Germany will reduce its greenhouse-gas emissions by 40 %, with respect to 1990, by 2020.

³ IPCC Fifth Assessment Report: Climate Change 2007, available in the Internet at: <http://www.ipcc.ch/ipccreports/assessments-reports.htm>

⁴ For HFC, PFC and SF₆

⁵ Burden-sharing agreement, adopted with Council Decision 2002/358/EC of 25 April 2002 concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments thereunder [O] L 130 of 15 May 2002]

⁶ Information on the quantified emission limitation or reduction objectives (QELROs) for the second commitment period under the Kyoto Protocol; SUBMISSION BY DENMARK AND THE EUROPEAN COMMISSION ON BEHALF OF THE EUROPEAN UNION AND ITS MEMBER STATES, Copenhagen, 19 April 2012

⁷ <http://www.bmub.bund.de/themen/klima-energie/klimaschutz/nationale-klimapolitik/aktionsprogramm-klimaschutz/>

0.1.3 Background information relative to supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol (ES.1.3)

The present report, in keeping with decision 15/CMP.1, presents, for the first time, supplementary information pursuant to Article 7 (1) of the Kyoto Protocol, for support of the review process under the Kyoto Protocol. This information includes:

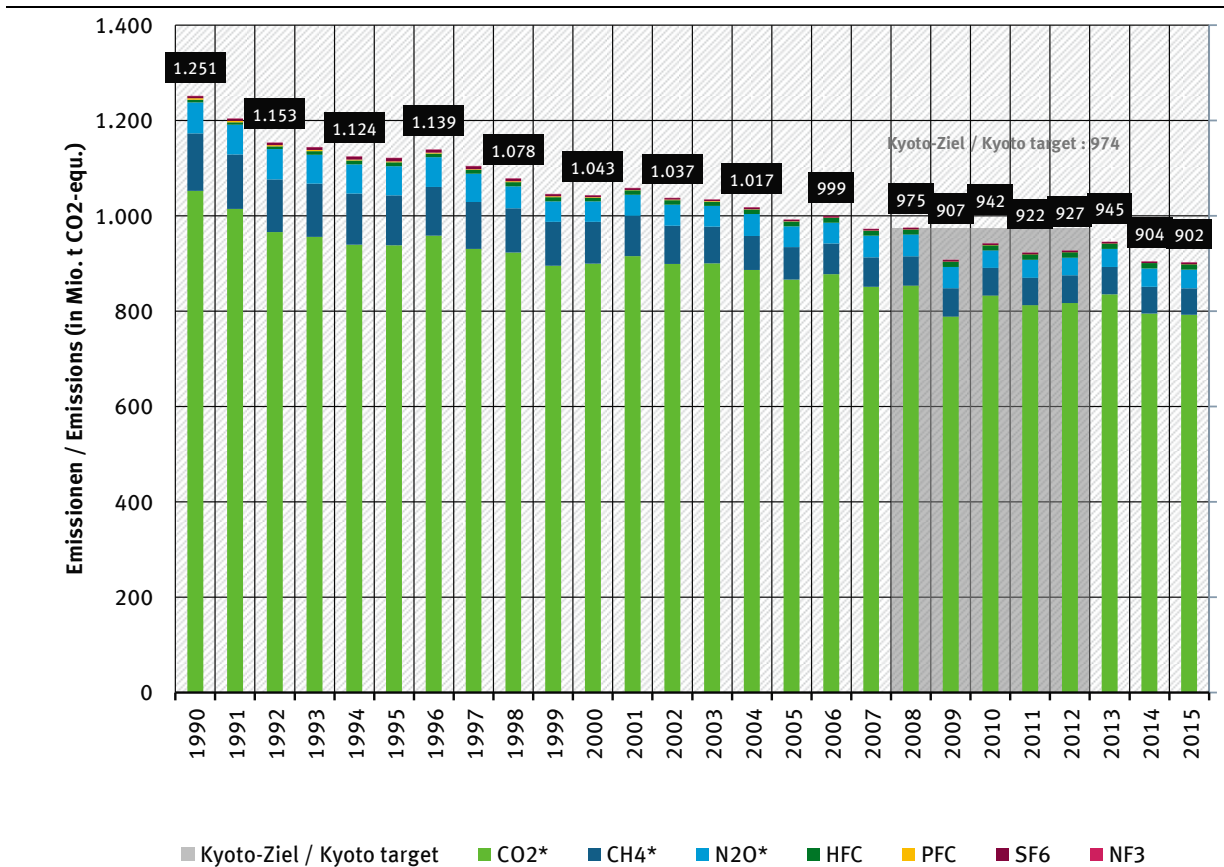
- General information on inventory preparation in connection with reporting pursuant to Article 3 (3) Kyoto Protocol and for the selected additional activities pursuant to Article 3 (4) Kyoto Protocol; (cf. Chapter 10)
- Information regarding the certificates under the Kyoto Protocol in connection with decisions 13/CMP.1 and 5/CMP.1; (cf. Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**)
- Information regarding changes in the National System of emissions reporting pursuant to Article 5 (1) of the Kyoto Protocol; (cf. Chapter 13)
- Information regarding changes in the National Registry; (cf. Chapter 14)
- Information regarding minimisation of negative impacts pursuant to Article 3 (14) of the Kyoto Protocol; (cf. Chapter 15)

0.2 Combined greenhouse-gas emissions, their removals in sinks, and emissions and removals from KP-LULUCF activities (ES.2)

0.2.1 Greenhouse-gas inventory (ES.2.1)

In the relevant interval, 2008 through 2012, Germany completely fulfilled its obligations within the framework of the aforementioned European obligation, with regard to the base-year emissions determined in 2007⁸. It did this by achieving a reduction of 1,232,429.543 Gg (CO₂ equivalent). In the following year, 2013, emissions increased by 2.0 % over their levels in 2012. Cold winter weather in 2013 was the primary factor for this increase. In 2014 and 2015, as a result of very mild winters, emissions decreased sharply, however – especially emissions of the residential & commercial/institutional (commerce, trade & services) sectors (cf. Chapter 2.1).

⁸ The reference figures for determining achievement of reduction obligations under the Kyoto Protocol have been defined in keeping with results of the review, carried out in 2007, of the initial report and of reporting for 2006 pursuant to Article 8 of the Kyoto Protocol. Pursuant to its obligations under the Kyoto Protocol and EU burden sharing (Council Decision 2002/358/EC), Germany's reduction obligations amount to 21 %.

Figure 1: Development of greenhouse gases in Germany since 1990, by greenhouse gases ⁹.

The individual greenhouse gases contributed to this development to varying degrees (cf. Table 1). This is hardly surprising given that, in any given year the various greenhouse gases account for varying proportions of total emissions (cf. Table 2). Detailed tables are provided in Annex Chapter 22.3.

In 2015, with an 87.8 % share, carbon dioxide emissions again accounted for the largest share of greenhouse-gas emissions. Most of the carbon dioxide is released via stationary and mobile combustion of fossil fuels. As a result of a disproportionately large reduction of other greenhouse-gas emissions, CO₂ emissions' share of total emissions has increased by about 3.5 percentage points since the base year. Methane (CH₄) emissions, caused predominantly by animal husbandry, fuel distribution and landfills, accounted for a 6.2 % share. Emissions of nitrous oxide (N₂O), caused primarily by agriculture, industrial processes and burning of fossil fuels, contributed 4.3 % of greenhouse-gas releases. The fluorinated greenhouse gases (the so-called "F gases") accounted for about 1.7 % of total emissions. NF₃, a greenhouse gas that is now being reported for the first time, accounts for a negligible share of only 0.001%. The distribution of greenhouse-gas emissions in Germany is typical for a highly developed and industrialised country.

Information about the relevant trends is provided in Chapter 2, while all detailed tables relative to discussion of trends are provided in Annex Chapter 22.3.

⁹ * CO₂ emissions from, and removals in, soils are reported under land-use changes and forestry.

Table 1: Emissions trends in Germany, by greenhouse gas and category

Emissions Trends (kt CO ₂ equivalent)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Net CO ₂ emissions/removals	1,019,229	903,409	859,653	852,192	863,298	837,241	833,178	768,816	814,391	795,156	800,967	819,417	778,240	775,753
CO ₂ emissions (without LULUCF)	1,052,247	938,150	899,286	865,866	877,369	850,743	853,592	788,510	832,437	812,577	817,145	835,459	794,829	792,054
CH ₄ with LULUCF	121,169	105,831	88,608	69,344	65,440	63,141	62,201	59,970	59,127	58,002	58,645	58,037	56,874	56,483
CH ₄ without LULUCF	120,293	104,960	87,736	68,478	64,573	62,275	61,333	59,101	58,260	57,136	57,778	57,171	56,009	55,616
N ₂ O with LULUCF	65,819	61,783	43,890	44,204	43,935	45,866	46,380	45,603	37,602	39,016	38,190	38,766	39,437	39,933
N ₂ O without LULUCF	64,989	60,968	43,088	43,455	43,175	45,097	45,599	44,807	36,794	38,195	37,354	37,925	38,590	39,078
HFC (1995 base year)	5,891	8,217	7,806	9,940	10,162	10,448	10,589	11,170	10,753	10,953	11,140	11,096	11,183	11,356
PFC (1995 base year)	3,060	2,087	959	839	671	589	568	407	346	279	243	257	235	254
SF ₆ (1995 base year)	4,428	6,467	4,072	3,320	3,242	3,181	2,971	2,924	3,100	3,163	3,155	3,261	3,396	3,562
NF ₃ (1995 base year)	7	5	9	34	28	12	30	29	61	61	35	16	20	12
Total Emissions/Removals with LULUCF	1,219,604	1,087,801	1,004,997	979,873	986,776	960,478	955,916	888,920	925,382	906,630	912,374	930,851	889,385	887,352
Total Emissions without LULUCF	1,250,915	1,120,856	1,042,958	991,933	999,220	972,344	974,682	906,949	941,750	922,363	926,850	945,186	904,262	901,932
Emission source and sink categories * (kt CO ₂ equi.)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
1. Energy	1,036,736	917,583	869,937	831,747	841,328	815,120	820,140	761,945	801,653	781,426	788,090	806,182	764,409	762,231
2. Industrial Processes	96,643	97,339	76,895	75,488	75,740	76,954	73,149	65,496	62,534	62,463	61,492	61,373	61,446	61,534
3. Agriculture	79,582	67,952	67,563	63,446	62,560	61,973	64,328	63,664	62,853	64,538	64,077	65,242	66,591	66,955
4. Land-Use Change and Forestry	-31,312	-33,055	-37,960	-12,060	-12,444	-11,867	-18,765	-18,029	-16,369	-15,733	-14,476	-14,335	-14,877	-14,580
CO ₂ (net emissions)	-33,018	-34,741	-39,633	-13,674	-14,071	-13,502	-20,414	-19,694	-18,045	-17,421	-16,178	-16,042	-16,589	-16,301
N ₂ O + CH ₄	1,706	1,686	1,673	1,614	1,627	1,636	1,649	1,665	1,677	1,688	1,703	1,707	1,712	1,721
5. Waste	37,955	37,982	28,564	21,251	19,593	18,297	17,065	15,844	14,710	13,937	13,191	12,389	11,816	11,210

Table 2: Contributions to emissions trends in Germany, by greenhouse gas and category

GHG Emission Fractions (%)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO ₂ emissions (without LULUCF)	84.12	83.70	86.22	87.29	87.81	87.49	87.58	86.94	88.39	88.10	88.16	88.39	87.90	87.82
CH ₄	9.62	9.36	8.41	6.90	6.46	6.40	6.29	6.52	6.19	6.19	6.23	6.05	6.19	6.17
N ₂ O	5.20	5.44	4.13	4.38	4.32	4.64	4.68	4.94	3.91	4.14	4.03	4.01	4.27	4.33
HFC	0.47	0.73	0.75	1.00	1.02	1.07	1.09	1.23	1.14	1.19	1.20	1.17	1.24	1.26
PFC	0.24	0.19	0.09	0.08	0.07	0.06	0.06	0.04	0.04	0.03	0.03	0.03	0.03	0.03
SF ₆	0.35	0.58	0.39	0.33	0.32	0.33	0.30	0.32	0.33	0.34	0.34	0.35	0.38	0.39
NF ₃	0.001	0.000	0.001	0.003	0.003	0.001	0.003	0.003	0.007	0.007	0.004	0.002	0.002	0.001
GHG Emission Fractions for Categories (%)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Energy	82.88	81.86	83.41	83.85	84.20	83.83	84.14	84.01	85.12	84.72	85.03	85.29	84.53	84.51
2. Industrial Processes	7.73	8.68	7.37	7.61	7.58	7.91	7.50	7.22	6.64	6.77	6.63	6.49	6.80	6.82
3. Agriculture	6.36	6.06	6.48	6.40	6.26	6.37	6.60	7.02	6.67	7.00	6.91	6.90	7.36	7.42
5. Waste	3.03	3.39	2.74	2.14	1.96	1.88	1.75	1.75	1.56	1.51	1.42	1.31	1.31	1.24

Information on the structure of the Common Reporting Format (CRF): <http://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch1ri.pdf>

0.2.2 KP-LULUCF activities (ES.2.2)

Removals of CO₂ pursuant to Article 3.3 (afforestation and deforestation) increased by 4.7 % with respect to 2014. That is equivalent to CO₂ removals of -4,594 kt CO₂- equivalent for the year 2015.

Activities in the areas of Forest, Cropland and Grazingland Management are reported under Article 3.4. The emissions and sinks for all three activity areas have hardly changed with respect to the previous year, 2014. They range from 0.1 % (forest management) to 1.4 % (cropland management). With regard to total emissions, a 0.5 % decrease in sinks was determined with respect to the previous year, 2014. That is equivalent to CO₂-equivalent removals of -18,038 kt for the year 2015.

0.3 Combined emissions estimates, and trends for source and sink groups, including KP-LULUCF activities (ES.3)

0.3.1 Greenhouse-gas inventory (ES.3.1)

Figure 2 shows the contributions of the individual categories to total greenhouse-gas emissions. It highlights the considerable constancy of the relative shares of the various categories and the absolute predominance of energy-related emissions. On the other hand, absolute energy-related emissions have continuously decreased over time. The variations that are superimposed over this trend are largely temperature-related. Because temperatures – especially in winter – affect heating patterns, they also affect energy consumption for heating, and thus they have major impacts on annual trends in energy-related CO₂ emissions.

On the whole, greenhouse-gas emissions have decreased by 28.1 % since 1990¹⁰. Considerations of the various components involved confirm this trend, to varying degrees. With respect to the base-year emissions (in 1995 for the F gases & NF₃; otherwise, in 1990), the relevant emissions changes for the most important greenhouse gases in terms of quantity were as follows: - 24.7 % for carbon dioxide (CO₂), - 53.8 % for methane (CH₄) and - 39.9 % for nitrous oxide (N₂O). The corresponding trends for the so-called "F" gases, which contribute about 1.6 % of greenhouse-gas emissions overall, have not been as clearly similar to each other; however. In keeping with the introduction of new technologies, and with use of these substances as substitutes, since base year 1995 SF₆ emissions decreased by 44.9 % and PFC emissions dropped by 87.8 %, while HFC emissions increased by 38.2 %. Emissions of NF₃, a new greenhouse gas that has to be reported, have increased considerably since 1995: by more than +124.7%. That gas's contribution to total emissions is exceedingly small, however about 0.001 %.

With respect to the previous year, 2014, total emissions decreased by another 0.3 %. This followed a sharp decrease from 2013 to 2014, of 4.3%, and thus brought a second year in succession with very low emissions. Mild weather had the largest impact on the emissions trend. The years 2014 and 2015 were unusually warm. As a result, considerably less heating energy was required, and that led to lower CO₂ emissions.

In addition, CO₂ emissions from electricity generation decreased markedly in 2014 and 2015. Use of all fossil fuels decreased. The largest decreases in this area were registered for natural gas and hard coal. Decreases in use of the latter fuel occurred even though new hard-coal-fired power stations went online. Renewable energies' share of electricity generation increased.

¹⁰ All figures do not include emissions from the category of Land Use, Land-Use Change & Forestry (LULUCF).

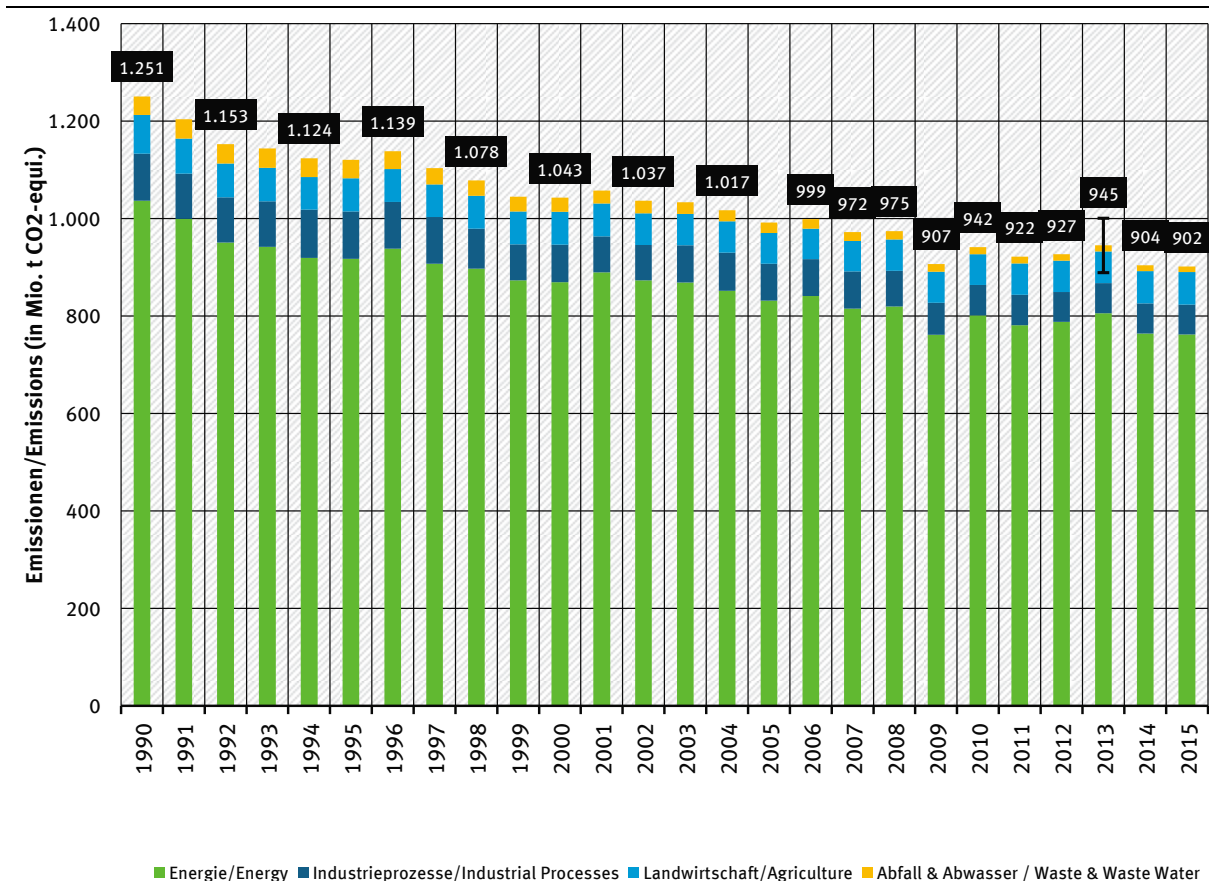
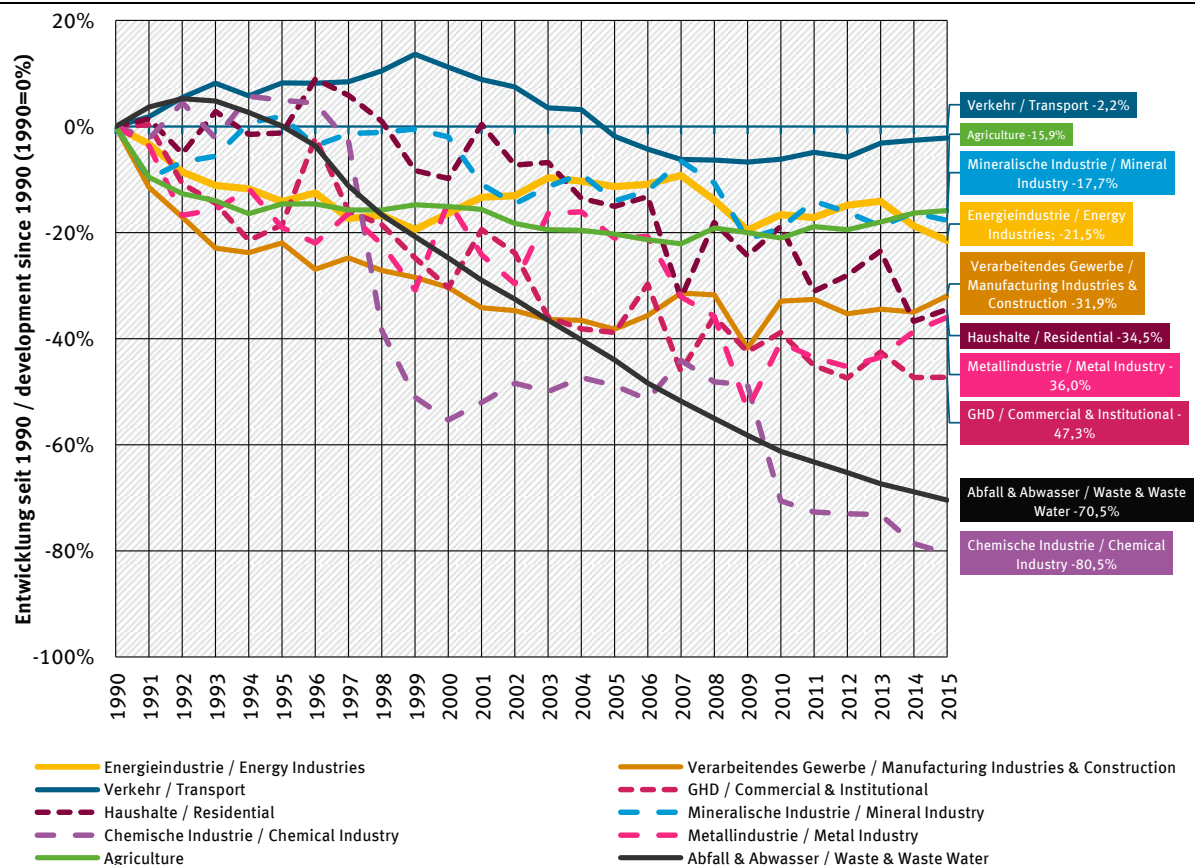
Figure 2: Emissions trends in Germany since 1990, by categories¹¹.

Figure 3 shows the relative developments of emissions from categories since 1990. The most significant reduction occurred in the area of waste emissions. Increased recycling of recyclable materials (Packaging Ordinance), and reuse of materials as compost (Biowaste Ordinance), have led to a sharp reduction in the quantity of waste that is landfilled and hence to continuous reductions in landfill emissions. Emissions-reducing measures carried out in 1997 and 2009 in the sector of adipic-acid production had major impacts on emissions from industrial processes. Emissions from solvent and other product use decreased markedly, as a result of decreased narcotic use of N₂O. The development of emissions from agriculture essentially follows the development of livestock data. A detailed discussion of emissions trends is presented in Chapter 2, Trends in Greenhouse Gas Emissions.

¹¹ CO₂ emissions from, and removals in, soils are reported under land-use changes and forestry.

Figure 3: Relative development of greenhouse-gas emissions since 1990, by categories^{12,13}

0.3.2 KP-LULUCF activities (ES.3.2)

Germany reports afforestation and deforestation pursuant to KP-LULUCF Article 3 (3). It reports forest management, cropland management and grazing-land management pursuant to Article 3 (4) of the Kyoto Protocol. It reports emissions of the greenhouse gases carbon dioxide, methane and nitrous oxide.

Under Article 3.3, it is reporting removals of -4,593.88 kt CO₂ equivalent for the year 2015. The removals consist of -6,688.57 kt CO₂ equivalent of removals via afforestation and reforestation and 2,094.69 kt CO₂ equivalent of emissions from deforestation. In the category of afforestation and deforestation, it is reporting CO₂ emissions of -4,749.06 kt CO₂, CH₄ emissions of 14.44 kt CO₂ equivalent and N₂O emissions of 140.74 kt CO₂ equivalent.

Under Article 3.4, it is reporting removals of -18,037.61 kt CO₂ equivalent in the year 2015. The figure comprises removals of -54,853.17 kt CO₂ equivalent from forest management, emissions of 14,656.22 kt CO₂ equivalent from cropland management and of 22,159.34 kt CO₂ equivalent from grazing-land management. The emissions for the three activities break down as follows by gases: CO₂: -19,203.46 kt; CH₄: 751.97 kt CO₂ equivalent; and N₂O: 413.88 kt CO₂ equivalent.

¹² Emissions from land-use changes and forestry are reported in detail in the relevant chapter.

¹³ The reference value consists of the emissions in 1990 (=100%), and not of base-year emissions.

1 Introduction

1.1 Background information regarding greenhouse-gas inventories and climate change, and supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

1.1.1 Background information about climate change

Climate change consists of changes in average weather conditions, and in extreme events, over an extended period of time; it can occur in a particular area or be global.

Climate change may be attributable to the following causes:

- Changes in so-called "geo-astrophysical parameters" such as the solar constant, elements of the earth's orbit, etc.
- Changes in the earth's surface
- Changes in the energy balance in the "earth's surface and atmosphere" system
- Changes in the substance balance in the atmosphere (such as changes in the concentration of greenhouse gases).

Greenhouse gases, among which are carbon dioxide, nitrous oxide (laughing gas), methane, ozone and other gases (especially water vapour, the most important natural greenhouse gas), have a particular property: They allow the energy-rich radiation falling onto the earth from the sun (primarily in the visible, short-wave range) to pass almost unhindered, yet partially absorb the long-wave radiation emitted by the heated earth. This places them in an energetically excited state for a brief time, after which they return to their original basic state whilst emitting infrared radiation. Heat radiation occurs equally in all spatial directions – in other words, a substantial portion of this is returned to the earth's surface ("*thermal back radiation*"). So that this additional quantity of energy may nevertheless be irradiated (this must occur due to the dynamic, energetic equilibrium, at whose centre are the earth and the atmosphere), the earth must have a correspondingly higher temperature. This is a simplified description of the greenhouse effect.

Without the greenhouse gases occurring naturally, life on our planet would not be possible. Instead of having an average global temperature of approximately 15°C, the earth would have an average temperature of approximately –18°C. In other words, the natural greenhouse effect protects our life on earth.

Since the beginning of the industrial era, mankind has brought about marked changes in the atmosphere's substance cycles, however. These changes have been caused by humans' energy-intensive lifestyles and related emissions of greenhouse gases. From 1750 to 2015, the worldwide concentrations of carbon dioxide (CO₂) increased by about 43 %. The current CO₂ concentration in the atmosphere, at nearly 400 ppm, is the highest to have occurred over the past 800,000 years (Global Carbon Project, 2015). In the same period, the concentration of methane (CH₄) in the atmosphere increased by a factor of 2.5, and the concentration of nitrous oxide (N₂O) increased by about 21.5 % (Blasing, 2016 #49). Furthermore, a number of brand-new substances – i.e. substances that for all intents and purposes do not occur in nature and are produced almost exclusively by humans – such as chlorofluorocarbons (CFCs), halons, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF₆) and nitrogen trifluoride (NF₃) have entered the atmosphere.

In spite of being "trace gases", greenhouse gases have considerable impacts. Their increasing concentrations have led to the anthropogenic (human-caused) greenhouse effect, which supplements the natural greenhouse effect.

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change ({IPCC, 2015 #53}) has clearly confirmed that the earth's climate is currently changing: A wide range of changes have occurred throughout the entire climate system since the middle of the last century. The temperature of the lower atmosphere is rising, the oceans are warming, glaciers are melting, permafrost soils are thawing, icecaps are losing mass and sea levels are continuing to rise.

Extensive observations, expanded models and profound insights into the pertinent interrelationships indicate, with great reliability, that human activities are the main cause of the climate change currently taking place.

Significant examples of observed climate changes include the following:

- From 1880 to 2012, the global mean temperature near the ground rose by 0.85 °C. Each of the past three decades has been warmer than all previous decades since 1850. In the northern hemisphere, the last 30-year period (from 1983 to 2012) was the warmest such period in the past 1400 years.
- 2015 was the warmest year since the beginning of regular weather records, in the second half of the 19th century. Nine of the ten warmest years observed to date have occurred in the 21st century. Only one year in the 20th century – 1998 – ranks among the ten warmest years.
- In the period 1971 to 2010, the oceans have stored more than 90 % of the additional energy fed into the climate system. The **upper water layers** in the world's oceans (0 to 700 meters) warmed considerably in the period from 1971 to 2010. From 1971 to 2010, the temperature in the oceans' upper 75 meters rose by an average of 0.11°C per decade. In addition, data gained during the observation period 1957 through 2009 suggest a likelihood that the oceans have also warmed at **water depths between 700 and 2,000 meters**. Adequate measurement data for greater water depths are available only for the period 1992 through 2005. For depths below 3,000 meters, they show warming that is most pronounced in the southern oceans. Glaciers around the world have continued to retreat, apart from just a few exceptions, and the earth's polar icecaps have lost mass. In the entirety of the period 1971 through 2009, the average annual mass loss of **glaciers** (not including glaciers at the periphery of the large ice caps) worldwide amounted to about 226 gigatonnes per year. In a recent fraction of that period (1993 through 2009), the loss rate had increased to about 275 gigatonnes per year, however.
- Over the period 1979 through 2012, the area covered by **Arctic sea ice** decreased at a rate of 3.5 to 4.1 percent per decade. During the summer minimum (September), the decrease reached rates of 9.4 to 13.6 percent per decade. During the same period, the duration of the melting period increased by about 5.7 days per decade, and the thickness of the winter pack ice in the Northern Arctic Ocean decreased by about 1.3 to 2.3 meters.
- The spring **snow cover** in the Northern Hemisphere has been decreasing since the middle of the 20th century. From 1967 through 2012, snow cover during the months of March and April decreased by an average of 1.6 percent per decade, while the June snow cover decreased by 11.7 percent per decade.
- As a result of continuing melting of glaciers and icecaps, and of warming-related ocean-water expansion, the global mean sea level rose by about 19 cm from 1901 to 2010. The average rise during that period amounted to about 1.7 millimeters per year. Over the last 20 years, the average rise, at about 3.2 millimeters per year, was nearly twice as large, however.

The climate change will have extensive impacts on ecological and societal systems, with potentially serious consequences.

If dangerous impacts of climate change are to be prevented, global warming must be constrained to no more than 2 °C in comparison to pre-industrial levels (of that increase, 1.0°C have already taken place ({World Meteorological Organization, 2016 #62}). Successful limiting of warming to less than 2 °C can be expected only in a scenario with highly ambitious climate policies.

The latest research findings indicate that greenhouse-gas emissions must reach their final maximum no later than 2020 and that a trend reversal must then begin taking place. In subsequent years, global emissions then urgently need to be reduced by at least 50 % by the year 2050, with respect to the emission level of the year 2000 .

1.1.2 Background information about greenhouse-gas inventories

The world's nations were quick to recognize that the expected temperature changes would pose threats to ecosystems and to human civilisation, because the changes would take place relatively quickly, and existing systems would not be able to adapt to the new climate conditions without suffering damage.

The Framework Convention on Climate Change was adopted in 1992, in Rio de Janeiro, by nearly all nations of the world. Since 1994, the countries listed in Annex I of the Framework Convention on Climate are required to submit annual inventories of greenhouse gases, as of 15 April of each year, to the Secretariat of the Framework Convention. Such inventories must include data on emissions and sinks for the base year (1990 for CO₂, N₂O, CH₄; 1995 for HFCs, PFCs, SF₆ and NF₃) and for all years until two years prior to the year of the relevant report.

At the third Conference of the Parties, held in Kyoto, legally binding obligations on emissions limitations and reductions were defined, for the first time, for industrialised countries. In the first commitment period under the Kyoto Protocol, industrialised nations were required to reduce their emissions of the six greenhouse gases carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆) by an average of 5.2 percent in the period 2008 through 2012¹⁴. In the second commitment period of the Kyoto Protocol, the list of relevant gases was expanded to include nitrogen trifluoride (NF₃) and six hydrofluorocarbons (HFC-152, HFC-161, HFC-236cb, HFC-236ea, HFC-245fa, HFC-365mfc) and two fully fluorinated hydrocarbons (C₃F₆, C₁₀F₁₈).

For the first commitment period, the European Union adopted an obligation to reduce emissions by 8 %, with respect to the base year. For the second commitment period in the framework of the Kyoto Protocol, the European Union has adopted an obligation to reduce its GHG emissions by 20 %, with respect to the base year, by 2020. Via the European Effort Sharing Decision¹⁵, that obligation has been divided among the 28 Member States and the European Union. While emissions reductions in those areas of inventories that are subject to emissions trading are implemented at the European level, the Member States are responsible at the national level for emissions reductions in inventory areas not subject to emissions trading. Germany is obligated to reduce its emissions to 445.9 million tonnes of CO₂-equivalents.

In the second commitment period of the Kyoto Protocol – as in the first – the effectiveness and success of the Kyoto Protocol vis-à-vis reduction of global greenhouse gas emissions depend on

¹⁴ The average reduction, 5.2 %, was calculated from the emissions limitations and reductions that the various parties to the Kyoto Protocol entered in the Protocol's Annex B.

¹⁵ Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009

two key factors: Whether its Parties abide by the rules of the Protocol and meet their obligations, and whether the emissions data used for controlling compliance are reliable. As such, national reporting and the subsequent international review of emissions inventories play a key role.

1.1.3 Background information relative to supplementary information, as required pursuant to Article 7 (1) of the Kyoto Protocol (KP NIR 1.1.3.)

Pursuant to decision 15/CMP.1 of the 1st COP of the Kyoto Protocol, as of 2010 all of the countries listed in ANNEX I of the UN Framework Convention on Climate Change that are also parties to the Kyoto Protocol must submit annual inventories in order to be able to make use of flexible mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol.

In 2008 (with the NIR 2008), Germany began early, on a voluntary basis, to fulfill these reporting obligations. In the process, over the past two years it has begun preparing intensively for the binding reporting required pursuant to Art. 7 of the Kyoto Protocol.

The first binding report, that for 2010 (NIR 2010), was reviewed in detail in September 2010 in the framework of an In-Country Review. The recommendations made in the 2010 In Country Review were implemented in a resubmission of November 2010, and in subsequent reports in the period 2011 through 2014.

The first report within the second commitment period of the Kyoto Protocol (NIR 2016) was also reviewed in the framework of an In Country Review. Implementation of its recommendations has begun with a resubmission in November 2016 and the present 2017 report.

In submitting its fifteenth National Inventory Report (NIR 2017), Germany also submits its ninth inventory report pursuant to the Kyoto Protocol (its second report within the second commitment period) that includes all of the information called for in Art. 7.

Information relative to Arts. 3.3 and 3.4 of the Kyoto Protocol (KP-LULUCF) is provided in Chapter 10. Information on accounting of Kyoto units for the second commitment period is provided in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden..** The relevant changes in the national System are described in Chapter 13, and the changes in the National Registers are described in Chapter 14. Information on minimisation of negative influences pursuant to Art. 3 (14) of the Kyoto Protocol is presented in Chapter 15.

1.2 Description of institutionalisation of inventory preparation, including the legal and procedural definitions relative to the planning, preparation and management of the inventory

Decision 24/CP.19 calls on all Annex I states to establish and describe national institutions for preparation of greenhouse-gas inventories. In addition, Article 5.1 of the *Kyoto Protocol* calls on the parties to the Kyoto Protocol to establish National Systems for preparation of GHG inventories. The requirements pertaining to such systems are set forth in the *Guidelines for National Systems* (UNFCCC Decision 19/CMP.1). The National system for Germany fulfills the requirements, as set forth by both decisions and by the European Regulation on a mechanism for monitoring and reporting greenhouse gas emissions in the European Union and its Member States.¹⁶

¹⁶ Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change

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 use of the methodological regulations from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, through ongoing quality management and through continuous inventory improvement.

The National System has been institutionalised in a process lasting until 2011, on the basis of a 2007 agreement between state secretaries of the involved ministries. Initially, this occurred via the establishment of a National Co-ordinating Committee and of pertinent in-house regulations for the Federal Environment Agency (UBA). Later, institutionalisation was completed primarily via signing of relevant agreements with other federal institutions, with industrial associations and with individual business enterprises. In 2013 and 2014, the National System was adapted to the requirements applying under the second commitment period of the Kyoto Protocol and expanded (cf. Chapter 13).

The requirements-conformal institutionalisation and function of the National System has been confirmed by all international reviews carried out to date and, most recently, by the 2016 In Country Review.

1.2.1 Overview of the institutional, legal and procedural definitions relative to preparation of greenhouse-gas inventories and of supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

In Germany, the National System has been institutionalised, in the main, at three levels: at the ministerial level of the Federal Government; at the subordinate level of federal administration, with this especially including the Federal Environment Agency (UBA); and at a level outside of the federal administrative sector.

At the ministerial level, the National System has been established under the leadership of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), via an agreement 5 June 2007 signed by state secretaries of the participating ministries that serves as a pertinent policy paper and is entitled "National Emissions Reporting System" ("Nationales System zur Emissionsberichterstattung"). With the inclusion of the Federal Ministry of Food and Agriculture (BMEL), the Federal Ministry for Economic Affairs and Energy (BMWi), the Federal Ministry of Transport and Digital Infrastructure (BMVI), the Federal Ministry of the Interior (BMI), the Federal Ministry of Finance (BMF) and the Federal Ministry of Defence (BMVg), all key institutions and organisations are now involved in preparing emissions inventories that are in a position to provide high-quality specialised contributions (cf. Chapter 1.2.1.4). The policy paper on emissions reporting defines the relevant responsibilities of the various participating federal ministries, and it mandates that the National System is to be built on the basis of existing data streams. Where the data streams are incomplete, the pertinent gaps are to be closed by the responsible ministries, via suitable activities. In support of the reporting process, the participating ministries established a co-ordinating committee (cf. Chapter 1.2.1.1).

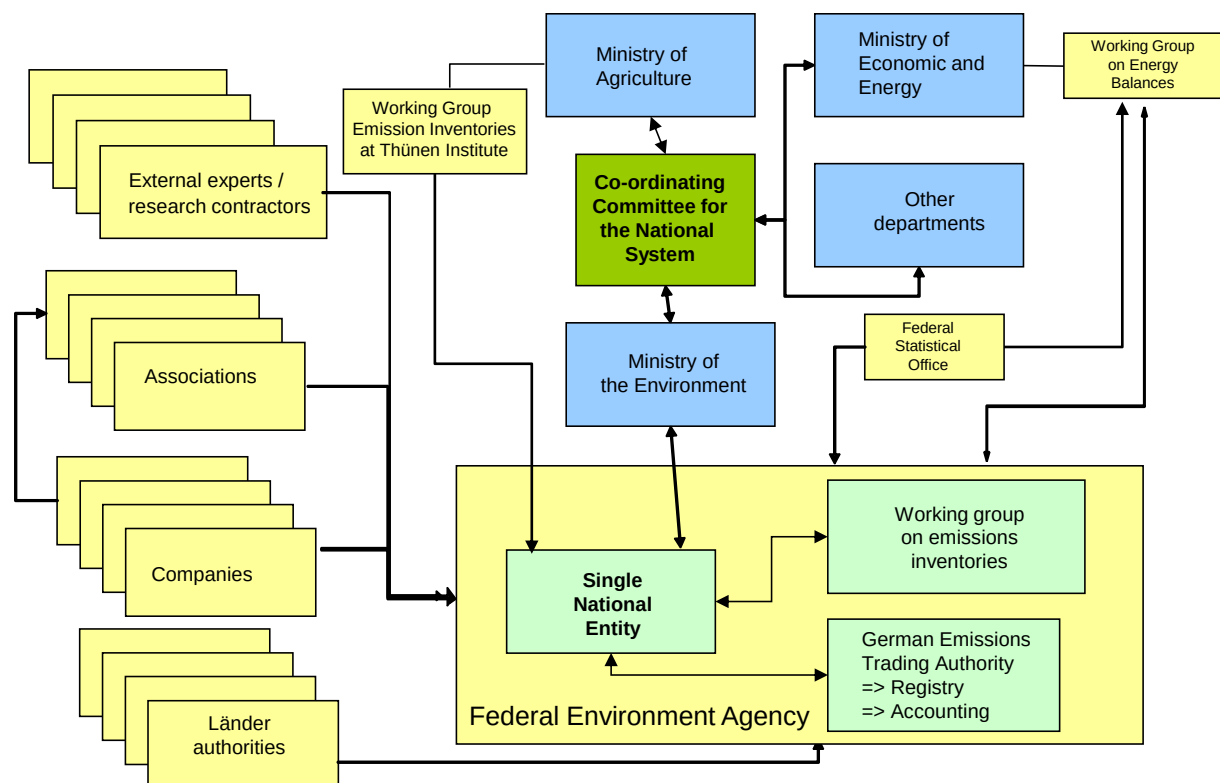
The "National Emissions Reporting System" policy paper also assigns the Federal Environment Agency the task of serving as the Single National Entity for Germany. Within the Federal Environment Agency, the Emissions Situation section has been entrusted with this task (cf. Chapter 1.2.1.2). At the level of the Federal Environment Agency, the Single National Entity integrates other specialised agencies within the National System and coordinates the contributions of the other institutions and organisations involved in emissions reporting. For co-ordination of pertinent work within the Federal Environment Agency, a working group on

emissions inventories was established (cf. Chapter 1.2.1.3). For implementation of the IPCC Good Practice Guidance within the Federal Environment Agency, with regard to quality control and assurance, a Quality System of Emissions was established in 2005, via an in-house directive (cf. Chapter 1.3.3.1.1).

The following Figure 4 provides an overview of the structure of the National System in Germany.

The "National Emissions Reporting System" policy paper of 5 June 2007 is presented in Annex Chapter 22.1.1.

Figure 4: Structure of the National System of Emissions (NaSE)



1.2.1.1 The National Co-ordinating Committee

In its Sec. 2, the state secretaries' resolution of 5 June 2007 provides for the establishment of a National Co-ordinating Committee that is to be headed by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and to include representatives of all federal ministries that participate in emissions reporting.

The National Co-ordinating Committee has the tasks of supporting the emissions-reporting process and clarifying open issues pertaining to the National System. In particular, the Committee carries out consultations with regard to gaps in data streams and settles issues pertaining to assigned responsibilities.

In addition, the National Co-ordinating Committee is responsible for approving inventories and the reports required pursuant to Arts. 5, 7 and 8 of the Kyoto Protocol.

The National Co-ordinating Committee met for the first time on 21 December 2007. It meets at least once per year, at the invitation of the BMUB. Between meetings, the participating federal ministries carry out co-ordination via electronic communication.

In the second commitment period, the National Co-ordinating Committee continues to be an important, established component of the National System.

1.2.1.2 Single National Entity (co-ordination agency) for the National System

Via a policy paper of 05 June 2007, the state secretaries appointed the Federal Environment Agency to carry out tasks of the **Single National Entity (national co-ordination agency)** for emissions reporting. The Federal Environment Agency's in-house directive (Hausanordnung) 11/2005 gave section "Emissions Situation" (FG I 2.6) responsibility for carrying out that function.

The Single National Entity's tasks include planning, preparing and archiving of inventories, describing inventories in the inventory reports and carrying out quality control and assurance for all important process steps. The Single National Entity serves as a central point of contact, and it co-ordinates and informs all participants in the National System. During the period 2003 to 2007, the Single National Entity has given priority to developing new data sources. Since 2008, its focus has been especially on a) improving existing data sources and safeguarding their availability for the long term, and b) maintaining the **institutionalisation of the National System**. Furthermore, institutions that need to be integrated within the *National System* have been identified and are now being successively integrated (cf. Chapter 1.2.1.4). In 2014 its work focused especially on implementation of provisions under the second commitment period of the Kyoto Protocol, and of the Revised UNFCCC Reporting Guidelines, in reporting and in the National System. Other important work has had to do with implementing the Quality System for Emissions Inventories (cf. Chapter 1.2.2).

The Single National Entity has developed two key **instruments** for carrying out those tasks:

The Federal 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 data, emission factors). The CSE is the main instrument for documentation and quality assurance at the data level.

Both within and outside of the Federal Environment Agency, the Quality System for Emissions Inventories (QSE) provides the necessary framework for good inventory practice and for routine quality assurance. Established within the Federal Environment Agency in 2005 via in-house directive 11/2005, it comprises the processes necessary for continually improving the quality of greenhouse-gas-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). Ongoing quality improvement in the framework of the QSE is supported by a database that serves as the repository for all tabular documents emerging from the national QC/QA process (QC/QA plan, checklists, lists of responsibilities, etc.).

The quality control procedures have been developed with the help of external experts, taking special account of the Federal Environment Agency's work structures, general guidelines for quality assurance and the *IPCC Good Practice Guidance*. For the second commitment period, the quality control procedures have been brought into line with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Since 2008, the QSE has been expanded to cover the entire National System. This has occurred via integration of additional authorities, institutions and inventory experts in the quality-management process – via specification of minimum requirements for data documentation, QC/QA and archiving. In addition, the procedure is designed to enable other organisations to

develop their own internal quality assurance systems on the basis of their existing structures. The QSE is described in detail in Chapter 1.3.3.

1.2.1.3 Working Group on Emissions Inventories, in the Federal Environment Agency

In its inventory work, and especially in work relative to emission factors, the Single National Entity receives significant support from other working units of the Federal Environment Agency, as well as from the Thünen institutes involved in preparation of the inventory. In addition, associations, companies and other independent organisations are integrated within the National System, for purposes of data provision, primarily via the Federal Environment Agency's specialised units that are responsible for the specific issues involved in each case.

In 2003, a *Working Group on Emissions Inventories* was set up to co-ordinate relevant work within the Federal Environment Agency; it liaises with all of the agency's employees who are involved in inventory preparation.

The Single National Entity convenes meetings of the working group at least once a year. In addition, relevant members of the working group meet as necessary to discuss specific issues and to make any necessary in-house arrangements.

As necessary, information is provided via events of the working group, via the intranet of the Single National Entity for emissions reporting and via newsletters produced by the Single National Entity on the National System and on the Central System on Emissions (CSE) database (i.e. one for the National System and one for the database).

1.2.1.4 Co-operation by the Single National Entity with other federal institutions and with non-governmental organisations, in the framework of the National System

Via the "National Emissions Reporting System" policy paper of 05 June 2007, the involved ministries defined their responsibilities, relative to the various relevant source and sink categories, for the first commitment period of the Kyoto Protocol.

Furthermore, the relevant resolution sets forth that involved federal ministries are to undertake suitable activities to close data gaps that fall within their areas of responsibility. As necessary, data gaps are to be closed via provision of pertinent data, or via relevant calculations. In some cases, required data may be provided by reliable third parties.

The relevant arrangements are remaining in place during the second commitment period.

For some of the data streams moving to the Single National Entity from other federal institutions, special agreements have been concluded between a) the relevant institution in the case in question and b) the Single National Entity.

With regard to **data provision by the *Federal Statistical Office***, relative to emissions reporting, a legal arrangement was made in 2009, in the framework of the 3rd SME Relief Act (Mittelstandsentlastungsgesetz 3; MEG 3), that enables provision of data, from confidential energy, environmental and production statistics, for purposes of emissions reporting. On that basis, on 13 January 2010 an administrative agreement between the Federal Environment Agency and the *Federal Statistical Office* came into force that specifies data deliveries for emissions-reporting purposes. The agreement provides for annual reviews of the Federal Environment Agency's data requirements. In addition, a process of close direct exchanges between the Single National Entity and the Federal Statistical Office, regarding issues of emissions reporting, has been institutionalised.

The "National Emissions Reporting System" policy paper assigns responsibility for the areas of agriculture and LULUCF to the Federal Ministry of Food and Agriculture (BMEL). The BMEL has commissioned its subordinate departments to carry out the tasks necessary for emissions reporting. That commissioning took place via a directive of 29 July 2007 to the (then) Federal Agricultural Research Centre (FAL). As a result of a restructuring of the FAL as of 1 July 2008, the tasks are now carried out by the **Thünen Institute (TI)**. The relevant work includes all tasks in the agriculture and forestry sectors that are necessary for the preparation of the annual emissions inventories, including the writing of the relevant reports. The TI sends the pertinent data and report to the Single National Entity. With a concept that names and specifies all pertinent processes and actors, and the actors' roles, the BMEL and TI have codified the procedures for preparation of emissions and carbon inventories for source and sink categories 3 and 4 (agriculture and forestry), and for KP-LULUCF (Art. 3.3. and 3.4 KP), and including a quality assurance concept.

In addition, on 13 February 2008, the TI concluded an agreement with the Federal Statistical Office on provision of emissions data on the basis of agricultural statistics. A research and development agreement between the TI and the *Association for Technology and Structures in Agriculture* (KTBL) has been in place since 7 July 2009. That agreement specifies the necessary supporting work for emissions reporting.

Furthermore, a working group on emissions reporting has been established within the TI, to serve as liaison to the Single National Entity within the Federal Environment Agency. That working group also has responsibility for planning and QC/QA for categories CRF 3 and CRF 4.

Responsibility for co-ordination of the Working Group on Emissions Reporting lies with the TI's Institute of Climate-Smart Agriculture (AK). Responsibility for reporting on agriculture and LULUCF lies with the same institute, while responsibility for reporting on forests pursuant to the Convention and Kyoto Protocol Arts. 3.3 and 3.4 lies with the TI's Institute of Forest Ecosystems. As of the second commitment period of the Kyoto Protocol, the Thünen Institute of Wood Research (TI-HF) has responsibility for reporting on emissions from harvested wood products (HWP).

The working group on emissions reporting at the TI is integrated within the National System via direct (inter-departmental) participation within the Single National Entity's communications structures. The working group at the TI is also part of the working group on emissions inventories (Arbeitskreis Emissionsinventare – AKEI) within the Federal Environment Agency, and it is fully integrated within the Single National Entity's Quality System for Emission Inventories (QSE).

At least twice per year, additional co-ordinating meetings take place between the working group at the TI and the Single National Entity, for purposes of co-ordination and information provision – for example, with regard to inventory improvements and research projects.

Involvement of economic associations, companies and other independent organisations is achieved primarily via those departments of Federal Environment Agency divisions I and III that are responsible for pertinent concrete issues. The *Single National Entity* supports the departments in discussion of reporting requirements and in determination of requirements for data-sharing by associations. The data flows are continually reviewed by the Single National Entity and, where necessary, are safeguarded by suitable agreements between the Single National Entity and associations / business enterprises.

The Working Group on Energy Balances (AGEB) is contractually obligated, via the Federal Ministry for Economic Affairs and Energy (BMWi), to provide Energy Balances. Use of a co-ordinated

schedule ensures that a provisional Energy Balance for the last reported year is prepared on time, and is transmitted to the Federal Environment Agency, by 31 July of each year, for purposes of inventory preparation. An effort is made to transmit the final Energy Balance by 28 February of year x+2.

In 2008, a sample agreement was prepared for inclusion of non-governmental agencies within the National System. That agreement is used to involve stakeholders, under binding terms, within preparation of inventories. The sample agreement is adapted to the various data suppliers' own requirements and needs as is necessary. In July 2009, the Federal Ministry for Economic Affairs and Energy (BMWi) and the Federal Environment Agency concluded an agreement, with the German Chemical Industry Association (VCI) and German producers, on data provision in the categories Ammonia (2.B.1) and Nitric acid (2.B.2). In early summer 2014, that agreement was adapted to the requirements applying under the Revised UNFCCC Reporting Guidelines. In addition, in 2009 agreements on data provision were reached with producers of adipic acid (2.B.3) located in Germany. Furthermore, an association agreement was concluded with the VDD industry association for bitumen paper and bitumen roof sheeting relative to the category Bitumen for roof sheeting (2.D.3.c). Since 2009, data for the aforementioned categories for emissions reporting have been provided on the basis of these agreements. In June 2011, the Single National Entity, acting with the support of the responsible ministry, the Federal Ministry for Economic Affairs and Energy (BMWi), entered into a cooperation agreement with the Wirtschaftsvereinigung Stahl German steel industry association. That agreement had become necessary because the Federal Statistical Office had discontinued its data collection and publication activities for Fachserie 4 Reihe 8.1 (iron and steel statistics) as of 31 December 2009, due to the expiration of the pertinent legal basis (Raw materials act; Rohstoffstatistikgesetz). That move had considerably reduced the availability of the bases for calculations in that area, and it created a significant gap in the pertinent data streams. The new cooperation agreement closed that gap. The agreement assures data provision by both member companies of the association and by non-member companies.

A relevant voluntary commitment of semiconductor manufacturers with production sites in Germany, a commitment that served as the basis for data provision for category 2.F.6, expired on 31 December 2010. In August 2012, the Single National Entity acted to close the resulting potential data gap by entering into a cooperation agreement, with the Electronic Components and Systems (ECS) division of the German Electrical and Electronic Manufacturers' Association (ZVEI), that is designed to assure long-term provision of data to the Federal Environment Agency for category 2.E.1.

These agreements provide a reliable long-term framework for data provision, and they have had the effect of considerably improving data quality in the relevant categories.

1.2.1.5 Binding schedule in the framework of the National System

The binding schedule for preparation of emissions inventories and of the NIR is announced to all relevant internal and external stakeholders via the Federal Environment Agency's intranet site and via publication within the NIR itself:

15 May	The Federal Environment Agency's national co-ordinating agency (Single National Entity) requests responsible experts to submit data and report texts
31 July	Delivery of energy data of the Working Group on Energy Balances (AGEB), of statistical data of the Federal Statistical Office and of data provided under agreements with



	associations and companies, where such data serve as the basis for further calculations
by 1 September	Deliveries of ready-to-use inventory data from the Federal Environment Agency and from external institutions of the NaSE
as of 2 September	Validation / discussion of deliveries by responsible experts and quality managers, taking account of review results
by 1 October	Preparation of CRF time series and of national trend tables; final editing by the Single National Entity within the Federal Environment Agency
8 November	In-house consultations at the Federal Environment Agency
as of 15 November	Final quality assurance by the QSE/CSE/NIR co-ordinator
25 November	Report of the Single National Entity to the BMUB, for commencement of inter-ministerial co-ordination relative to the CRF data and the National Inventory Report
by 20 December	Approval via departmental co-ordination (initiated by the BMUB)
as of 2 January	Final editing by the Federal Environment Agency's national co-ordinating agency (Single National Entity)
15 January	Report (CRF and certain parts of the NIR) goes to the European Commission (in the framework of the CO ₂ Monitoring Mechanism) and to the European Environment Agency
15 March	Report (corrected CRF and complete NIR) goes to the European Commission (in the framework of the CO ₂ Monitoring Mechanism) and to the European Environment Agency
15 April	Report goes to the FCCC Secretariat
May	Initial check by the FCCC Secretariat
June	Synthesis and assessment report I (by the UN FCCC Secretariat)
August	Synthesis and assessment report II (country-specific; by the UN FCCC Secretariat)
September - October	Inventory review by the UN FCCC Secretariat

1.2.2 Overview of inventory planning

Inventory preparation draws on the expertise of *research institutions*, via execution of research projects in the UFOPLAN (environmental research plan) framework. This takes place via consideration of specific questions and via overarching projects. In each of the UFOPLANs for the 2002-2009 period, the Single National Entity had a global project on *updating emissions-calculation methods*, a framework for initiating measures for continuous inventory improvement. In 2010 and 2011, measures for continuous inventory improvement were financed completely via the budget title for expert services. The Federal Environment Agency promised to provide the Single National Entity with funding, from the budget title for expert services (Title 526 02, Chapter 1605), for short-term contracting for purposes of inventory improvement under the responsibility of the Agency. The funding, provided as of 2005, in the interest of emissions reporting, comes in addition to the research funding available from the UFOPLAN. Since 2012, the Single National Entity has again been able to finance research in the framework of emissions reporting from the UFOPLAN. In addition, the budget title for expert services remains available for such financing.

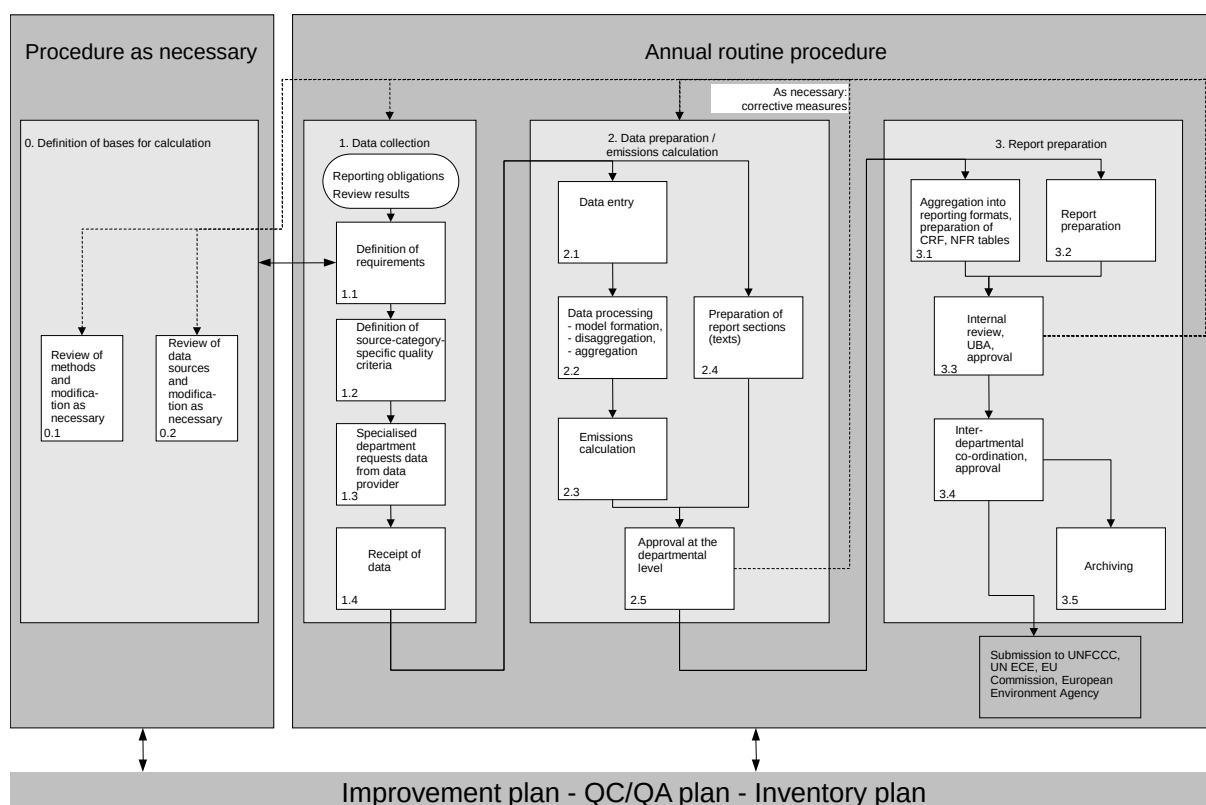
1.2.3 Overview of inventory preparation and management, including overview of supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

The emissions-reporting process is a regular, annual process. Since it is a decentralised process, carried out by a range of different persons, it can differ for different parts of the inventory. Prior to the introduction of the QSE (in 2005), this process was intensively studied and analysed. As a result of that work, within the overall emissions-reporting process, the QSE differentiates the following main processes, which are described in detail in Chapter 1.3.2:

- Definition of the bases for calculation,
- Data collection,
- Data processing and emissions calculation, and
- Report preparation.

These main processes are broken down into sub-processes (cf. Figure 5).

Figure 5: Overview of the emissions-reporting process



It has proven to be the case that the workflow sequence chosen for inventory planning and preparation can influence the quality of the inventories. In other words, the sequence in which procedures are carried out is not irrelevant with regard to inventory quality. That is one of the reasons why the inventory-preparation process is closely tied to quality assurance and control measures. Suitable QC/QA measures have thus been assigned to each sub-process, to ensure that quality assurance not only safeguards the quality of inventory data in its final form, but also safeguards such quality on the pathways leading to that final form. This, in turn, makes it possible to carry out periodical internal evaluations of the inventory-preparation process pursuant to paragraph 26 of the *Reporting Guidelines* (24/CP.19).

The process, including QC/QA measures, fulfills the requirements of paragraph 21 (b) of the *Reporting Guidelines* (24/CP.19) with regard to inventory preparation.

The workflow for inventory preparation is described in detail in Chapter 1.3.

1.3 Inventory preparation

As the overview in Chapter 1.2.3 shows, inventory preparation functions in accordance with a regular, annual scheme. The processes for preparation of greenhouse-gas inventories, KP-LULUCF inventories and National Inventory Reports, and for execution of quality control and quality assurance measures, are very closely linked.

At the same time, the upstream processes for inventory preparation (cf. Chapter 1.3.1.1), including definition of bases for calculation (cf. Chapter 1.3.2.1), and data collection, processing and storage (cf. Chapter 1.3.2), remain distinct from those for quality control and quality assurance (cf. Chapter 1.3.3).

1.3.1 Greenhouse-gas and KP-LULUCF inventories

The upstream processes of inventory preparation and definition of the bases for calculation are identical for greenhouse-gas inventories and for KP-LULUCF inventories.

1.3.1.1 Preliminary/upstream processes

Apart from the sub-processes for emissions reporting, as outlined in Figure 5, certain upstream (preliminary) processes are carried out – in each case, between a pair of emissions-reporting cycles.

The following sub-processes are considered preliminary/upstream processes:

- Continuous review and assurance of data streams from data suppliers to the Federal Environment Agency, via improvement of institutionalisation of the National System;
- Implementation of improvements in inventory planning and inventory preparation;
- Identification of key categories (using Approach 1 pursuant to Chapter 4.3.1, Vol. 1 of the IPCC GL 2006);
- Calculation and aggregation of uncertainties relative to emissions, using Monte Carlo simulation (pursuant to Tier 1 or Tier 2, in keeping with the *IPCC Good Practice Guidance*);
- Expanded identification of key categories, via Monte Carlo simulation (using Approach 2 pursuant to Chapter 4.3.2, Vol. 1 of the IPCC GL 2006).

1.3.1.1.1 Improvement of the National System

The National System builds on existing data streams, and it provides for suitable measures to assure long-term data provision where such assurance is lacking (cf. Chapter 1.2.1.2). Consequently, data streams continually have to be reviewed between pairs of reporting cycles.

Where voluntary commitments expire, discussions have to be carried out with the relevant data suppliers in order to secure the commitments' renewal or their conversion into cooperation agreements. Where continued data provision is not assured, relevant commitments or co-operation agreements have to be obtained. In cases of any doubt, relevant legal provisions relative to data provision have to be reviewed and implemented.

Existing agreements have to be adapted as necessary to new circumstances and reporting requirements (for example, to changes in reporting procedures). Such efforts help assure the consistent high quality of the National System and the inventory preparation process.

Changes and improvements in the National System, during the current reporting cycle, are described in Chapter 13.

1.3.1.1.2 Implementation of improvements in inventory planning and inventory preparation

The quality system helps to assure the high quality of the inventory, and it supports the continual improvement of the inventory and of inventory planning.

Whenever possible, the following are implemented between reporting cycles: a) improvement requirements that have emerged from past quality control and quality assurance; b) results of past reviews; and c) planned improvements listed in the NIR.

A detailed description of the quality control and quality assurance procedures is provided in Chapter 1.6. The improvements achieved for the present report are described in the relevant category chapters.

1.3.1.1.3 Determination of key categories (pursuant to Tier 1)

In order to be able to focus the many and detailed activities and capacities required for inventory preparation and improvement on the principal categories of the inventory, the IPCC has introduced the definition of a "key category". Key categories are source/sink categories that play an especially prominent role in the national inventory because their emissions/removals have a significant influence on the total emissions of direct greenhouse gases – because of their absolute quantities, because of their contribution to the emissions trend over time, because of their uncertainties, or because they have been assessed by an expert as an important category.

The Single National Entity identifies key categories once per year, prior to the emissions-reporting process. Whereas in the reporting framework results are reported for year x, they cannot be taken specifically into account until inventory preparation for the year x+1. A category's designation as a key category helps decide what calculation method (Tier approach) must be used for the category and, as a result, how detailed emissions modelling for the category must be. In addition, the key-category selection process is used to identify any categories to which priority must be given in inventory improvement.

The *2000 IPCC Good Practice Guidance* (Vol. 1, Chapter 4) specifies the methods – "Approaches" – to be applied in identifying key categories. These methods identify the relevant key categories with the help of analysis of the inventory for one year with regard to emissions levels for individual categories (Tier 1 level assessment), time-series analysis of inventory data (Tier 1 trend assessment) and detailed analysis of inventory data with error evaluation (Tier 2 level and trend assessment with consideration of uncertainties).

The key categories have been defined by applying the two Approach 1 procedures, Level (for the base year and for the last year reported) and Trend (for the last year reported, as compared to the base year), to German greenhouse-gas emissions. In keeping with IPCC provisions, analyses have taken account of both emissions from sources and removals of greenhouse gases in sinks.

1.3.1.1.4 Calculation and aggregation of uncertainties relative to emissions

Uncertainties are a basic component of emissions inventories; an emissions inventory's uncertainties are determined in order to quantitatively assess the inventory's accuracy. While uncertainties are determined in connection with data gathering, and thus are part of the "data collection" section of the emissions-reporting process, they can be aggregated only after an inventory – or the pertinent emissions-reporting cycle – has been completed.

In calculation and aggregation of uncertainties, uncertainties for activity data and emission factors, which are normally estimated by experts at the lowest category level of the CSE, are converted into uncertainties for emissions and then aggregated. Uncertainties pursuant to Tier 1 are aggregated once per year, at the end of the report-preparation cycle for the current report year. Every three years, uncertainties are additionally determined pursuant to the Tier 2 method.

In the current NIR, Germany reports uncertainties that have been calculated pursuant to the Tier 1 method. For uncertainties determination, the individual uncertainties have been estimated, wherever possible to date, by data-supplying experts of the relevant Federal Environment Agency specialised sections and by external institutions.

1.3.1.1.5 Expanded determination of key categories

Aggregated uncertainties serve as a basis for expanded identification of key categories (Tier 2 key-categories determination).

1.3.2 Data collection, processing and storage, including data for KP-LULUCF inventories

1.3.2.1 Definition of bases for calculation

Selection and review of, and (where necessary) changes in, the calculation methods used to determine emissions affect the entire emissions-reporting process. For this reason, the main process "determination of the bases for calculation" must begin with review of the suitability of the methods to be used. The *2006 IPCC Guidelines* specify, via use of decision trees, what methods are to be used for the various categories. In each case, such methods selection depends on whether the group in question is a key category or not. Any use of different – country-specific – methods, instead of the prescribed methods, must be justified in the NIR. In each case, an outline of why the method in question is of equivalent or higher value is to be provided, along with clear documentation.

Another factor that is critical to the success of the overall process is **selection and review of, and (where necessary) changes in, data sources**, since the quality of results of all downstream processes (data preparation, calculation, reporting) cannot be better than that of the primary data used. Data sources may be oriented to the activity data, emission factors or emissions for/of a specific category. In many cases, the data sources used have been relied on for a number of years. It can become necessary to select new data sources – for example, as a result of required changes in methods, of the elimination of an existing data source, of a need for additional data or of findings from quality checks of previously used data sources.

The suitability of a given data source depends on various criteria. These include:

- Long-term availability,
- Institutionalisation of data provision,
- Good documentation,
- Execution of quality assurance and control measures, by the persons/organisations providing data,
- Identification of uncertainties,
- Representative nature of the data in question, and
- Completeness of the expected data.

In each case, it is vital that the reasons for choosing a particular data source be documented and, where the data source has significant deficits, that suitable measures for improving the data be planned.

Providers of data must always be given requirements relative to quality control, quality assurance and documentation; where research projects are commissioned, this requirement is particularly relevant, since the Federal Environment Agency, as the customer for such services, must be able to influence such projects.

1.3.2.2 Data collection

Data collection and documentation take place under the responsibility of the relevant experts. One way of collecting data is to evaluate official statistics, association statistics, studies, periodicals and third-party research projects. Other ways of obtaining data include carrying out own research projects, applying personally available information and exchanging data via relevant Federal/Länder channels. Often, work results obtained by other means are also reused for the purposes of emissions reporting.

Data collection comprises the following steps:

- Definition of requirements,
- Determination of the category-specific quality criteria for the data,
- Requesting of data from data providers (carried out by the relevant experts' group), and
- Receipt of data.

In each case, the National Single Entity (national co-ordinating agency) also requests inventory input from the experts responsible for the category in question, via the experts' superiors. A master file, specifying the structure for such input, is provided for NIR preparation. The requirements for later data input are provided by the relevant CSE (ZSE) specifications (direct entry or fill-in of the import format). Reporting requirements (including pertinent QC/QA measures), along with the results of all inventory reviews, the databases for the various specific categories and the current results of key-category identification, are all communicated to the responsible experts via informational events held by the *Federal Environment Agency's Working Group on Emissions Inventories*, via the Federal Environment Agency's intranet and share-point sites for emissions reporting and via an electronic inventory description (cf. Chapter 1.3.3.1.5). On this basis, responsible experts **define requirements** relative to data sources and to calculation methods.

Such requirements influence the upstream process of defining the bases for calculation (review and selection of methods and data sources) – a process which always takes place when requirements have not yet been fulfilled or have changed.

Before any third parties begin with data collection – after the requirements pertaining to data sources and methods have been defined – the **category-specific quality criteria for such third-party data should be defined**, in order to support the QC process on the data level.

When a responsible expert **requests data** from a third party able to supply data, the expert is expected to accompany his or her request with a description of the amount of data expected from the prospective data supplier, of the relevant data-quality requirements and of the relevant data-documentation requirements. Upon **receipt of data**, the data are checked for completeness, compliance with quality criteria and currentness. Data validation is carried out by the relevant expert.

1.3.2.3 Data preparation and emissions calculation

The process of data preparation and emissions calculation comprises the following steps:

- Data entry,

- Data preparation (model formation, disaggregation, aggregation)
- Calculation of emissions,
- Preparation of report sections (texts), and
- Approval by the relevant experts.

Report texts are prepared along with the time series for activity data, emission factors, uncertainties and emissions. As a result, the term "data" is understood in a broad sense. In addition to number data, time series, etc., it also includes contextual information such as the sources for time series, and descriptions of calculation methods, and it also refers to **preparation of report sections** for the NIR and documentation of recalculations.

Large shares of **data entry and processing** (processing of data, and emissions calculation) take place in the CSE. This considerably enhances transparency and consistency, and it opens up the possibility of automating required data-level quality-control measures in the CSE (such as checking of orders of magnitude and of completeness, and specification of checking parameters in CalQlator). In cases that lend themselves to such automation, certain QC measures then do not have to be carried out manually. At the same time, plausibility cross-checks, with simplified assumptions, should be applied to results of calculations with complex models.

After all checks have been carried out, and the relevant parties have been consulted where necessary, the **emissions are calculated** in the CSE by means of an automated procedure, based on the following principle:

activity data * emission factor = emissions

If upstream calculation routes are also stored in the CSE, these calculations are initiated first, before the actual calculation of emissions takes place.

In each case, the relevant expert responsible for QC also has responsibility for **issuing expert-level approvals**, for written texts and for calculation results, prior to any further use of such texts and results by the Single National Entity. Such issuance normally takes place in connection with transmission to the Single National Entity, and it is carried out via approval of completed QC/QA checklists.

1.3.2.4 Report preparation

Report preparation includes the following steps:

- Aggregation of emissions data for the national trend tables and reporting formats, preparation of data tables for the NFR, export / import of XML files into the CRF reporter,
- Compilation of submitted report texts to form a report draft (NIR), and editing of the complete NIR,
- Internal review of the draft (national trend tables and NIR) by the Federal Environment Agency, followed by approval as appropriate,
- Handover to the BMUB, for interdepartmental co-ordination, leading to approval by the co-ordinating committee, followed by the final steps of
- Handover to the UNFCCC Secretariat, the EU Commission and the UNECE Secretariat, and
- Archiving.

Following complete preparation of data, report sections and QC/QA checklists by the responsible experts, and transmission of those materials to the Single National Entity, the materials are reviewed by category-specific, specialised contact persons at the Single National Entity, on the basis of a QC checklist. The results of this review are then provided to the relevant responsible

experts, to enable these experts to revise their contributions (if necessary, following suitable consultation) accordingly.

Before emissions data can be transferred into the report formats for the Framework Convention on Climate Change (CRF = Common Reporting Format), the Kyoto Protocol and the UN ECE Geneva Convention on Long-range Transboundary Air Pollution (NFR = New Format on Reporting), emissions data from CSE time series (in the data-collection format) **must be aggregated** into the CRF/NFR category **report formats**. This is accomplished via hierarchical allocation within the CSE, a process that, in Annex 3, is described in detail for the various key categories. Where no changes with respect to the previous year have occurred, the aggregations are carried out automatically.

Following calculatory aggregation, activity data and emissions are read, via export in XML-file form, into the CRF reporter, which automatically prepares the IPCC CRF reporting tables. Nonetheless, quality control still has to be carried out to ensure that the emissions inventory and the CRF-Reporter tables agree with respect to relevant values and to the implied emission factors calculated by the CRF Reporter. Furthermore, suitable explanatory remarks have to be provided for any recalculations and notation keys.

Calculation of greenhouse gases in CO₂ equivalents is carried out in keeping with Art. 2 of Decision 24/CP.19 and of Art. 31 of the Revised UNFCCC Reporting Guidelines (FCCC/CP/2013/10/Add. 3), on the basis of the relevant global warming potentials (GWP), as published in the *Fourth Assessment Report*. The GWP, which are oriented to greenhouse gases' impacts within a 100-year time frame, are listed in the following table.

Table 3: Global Warming Potential (GWP) of greenhouse gases

Greenhouse gas	Chemical formula	IPCC AR4 GWP
Carbon dioxide	CO ₂	1
Methane	CH ₄	25
Nitrous oxide	N ₂ O	298
Hydrofluorocarbons (HFC)		
HFC-23	CHF ₃	14800
HFC-32	CH ₂ F ₂	675
HFC-41	CH ₃ F	92
HFC-43-10mee	CF ₃ CF ₂ CHFCHFCF ₃	1640
HFC-125	CHF ₂ CF ₃	3500
HFC-134	CHF ₂ CHF ₂	1100
HFC-134a	CH ₂ FCF ₃	1430
HFC-143	CHF ₂ CH ₂ F	353
HFC-143a	CF ₃ CH ₃	4470
HFC-152	CH ₂ FCH ₂ F	53
HFC-152a	CH ₃ CHF ₂	124
HFC-161	CH ₃ CH ₂ F	12
HFC-227ea	CF ₃ CHFCF ₃	3220
HFC-236cb	CH ₂ FCF ₂ CF ₃	1340
HFC-236ea	CHF ₂ CHFCF ₃	1370
HFC-236fa	CF ₃ CH ₂ CF ₃	9810
HFC-245ca	CHF ₂ CF ₂ CH ₂ F	693
HFC-245fa	CHF ₂ CH ₂ CF ₃	1030
HFC-365mfc	CH ₃ CF ₂ CH ₂ CF ₃	794
Perfluorocarbons (PFC)		
Perfluoromethane	CF ₄	7390

Greenhouse gas	Chemical formula	IPCC AR4 GWP
Perfluoroethane	C ₂ F ₆	12200
Perfluoropropane	C ₃ F ₈	8830
Perfluorocyclopropane	c-C ₃ F ₆	17340
Perfluorobutane	C ₄ F ₁₀	8860
Perfluorocyclobutane	c-C ₄ F ₈	10300
Perfluoropentane	C ₅ F ₁₂	9160
Perfluorohexane	C ₆ F ₁₄	9300
Perfluorodecalin	C ₁₀ F ₁₈	7500
Sulphur hexafluoride		
Sulphur hexafluoride	SF ₆	22800
Nitrogen trifluoride		
Nitrogen trifluoride	NF ₃	17200
Fluorinated ethers		
HFE-125	CHF ₂ OCF ₃	14900
HFE-134	CHF ₂ OCHF ₂	6320
HFE-143a	CH ₃ OCF ₃	756
HFE-227ea	CF ₃ CHFOCF ₃	1540
HCFE-235da2	CHF ₂ OCHClCF ₃	350
HFE-236ca12	CHF ₂ OCF ₂ OCHF ₂	2800
HFE-236ea2	CHF ₂ OCHF ₂ CF ₃	989
HFE-236fa	CF ₃ CH ₂ OCF ₃	487
HFE-245cb2	CH ₃ OCF ₂ CF ₃	708
HFE-245fa1	CHF ₂ CH ₂ OCF ₃	286
HFE-245fa2	CHF ₂ OCH ₂ CF ₃	659
HFE-254cb2	CH ₃ OCF ₂ CHF ₂	359
HFE-263fb2	CF ₃ CH ₂ OCH ₃	11
HFE-329mcc2	CHF ₂ CF ₂ OCF ₂ CF ₃	919
HFE-338mcf2	CF ₃ CH ₂ OCF ₂ CF ₃	552
HFE-338mmz1	(CF ₃) ₂ CHOCHF ₂	380
HFE-338pcc13	CHF ₂ OCF ₂ CF ₂ OCHF ₂	1500
HFE-347mcc3	CH ₃ OCF ₂ CF ₂ CF ₃	575
HFE-347mcf2	CHF ₂ CH ₂ OCF ₂ CF ₃	374
HFE-347mmy1	(CF ₃) ₂ CFOCH ₃	343
HFE-347pcf2	CHF ₂ CF ₂ OCH ₂ CF ₃	580
HFE-356mec3	CH ₃ OCF ₂ CHF ₂ CF ₃	101
HFE-356mmz1	(CF ₃) ₂ CHOCH ₃	27
HFE-356pcc3	CH ₃ OCF ₂ CF ₂ CHF ₂	110
HFE-356pcf2	CHF ₂ CH ₂ OCF ₂ CHF ₂	265
HFE-356pcf3	CHF ₂ OCH ₂ CF ₂ CHF ₂	502
HFE-365mcf3	CF ₃ CF ₂ CH ₂ OCH ₃	11
HFE-374pc2	CHF ₂ CF ₂ OCH ₂ CH ₃	557
HFE-449sl	C ₄ F ₉ OCH ₃	297
HFE-569sf2	C ₄ F ₉ OC ₂ H ₅	59
HFE-43-10pccc124	CHF ₂ OCF ₂ OC ₂ F ₄ OCHF ₂	1870
	CF ₃ CF ₂ CH ₂ OH	42
	(CF ₃) ₂ CHOH	195
	-(CF ₂) ₄ CH(OH)-	73
Perfluoropolyethers		
PFPME	CF ₃ OCF(CF ₃)CF ₂ OCF ₂ OCF ₃	10300

Source: FCCC/CP/2013/10/Add. 3, p.24

At the same time, the report co-ordinator **compiles the checked report texts to produce the draft** of the NIR.

Review and approval, within the Federal Environment Agency, of the completed report tables and the NIR, and of the inventory plan to be included in future, are certified via co-signing in the framework of the Federal Environment Agency's **internal co-ordination process**. Then, the materials are **forwarded** to the BMUB, for the second approval phase within the framework of **interdepartmental co-ordination**. In a concluding step, the co-ordinating committee approves the report tables and the NIR for submission to the UNFCCC Secretariat. The ministry arranges for translation of the NIR and for its **submission to the UNFCCC Secretariat**.

The data tables and the pertinent NIR are archived in secure form in the inventory description (cf. also Chapter 1.3.3.1.5). The content of the CSE database used for calculation purposes is also archived.

1.3.3 Procedures for quality assurance and quality control (QA/QC), and detailed review of greenhouse-gas and KP-LULUCF inventories

1.3.3.1 The Quality System for Emissions Inventories

The QSE takes account of provisions of the *2006 IPCC Guidelines (Vol. 1, Chapter 6)*, of national circumstances in Germany and of the internal structures and procedures of the Federal Environment Agency (UBA), the reporting institution. The QSE's procedures are flexible enough to be able to routinely incorporate future changes in requirements. The QSE's scope of application comprises the entire emissions-reporting process.

The QSE covers all participants of the NaSE. Within the Federal Environment Agency, the QSE has been made binding via the agency's in-house directive (UBA-Hausanordnung) 11/2005. Details regarding assurance of the QSE's binding nature for other NaSE participants are provided in Annex 22.1.1.

1.3.3.1.1 Directive 11/2005 of the Federal Environment Agency

In 2005, via its *in-house directive (Hausanordnung) 11/2005*, the Federal Environment Agency established a *Quality System for Emissions Inventories (QSE)*, within the Agency. The QSE provides the necessary framework for compliance with good inventory practice and for execution of routine quality assurance. The QSE conforms to the provisions of the *2006 IPCC Guidelines (Vol. 1, Chapter 6)*, and it has been adapted to the national circumstances prevailing in Germany and to the internal structures and procedures of the Federal Environment Agency (UBA), the reporting institution. The in-house directive (Hausanordnung 11/2005) issues binding provisions on relevant competencies within the Agency, lists deadlines for the various inventory-preparation steps and describes the necessary relevant review actions for purposes of quality control / quality assurance.

The directive has fulfilled requirements, pursuant to Paragraph 20 of the *Reporting Guidelines (24/CP.19)*, for specification of relevant procedures and, pursuant to Paragraph 23 (a), for definition of specific responsibilities at the Agency level.

1.3.3.1.2 Minimum requirements pertaining to a system for quality control and assurance

The requirements pertaining to the 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 Guidelines (Vol. 1)*.

In 2007, the Federal Environment Agency derived General minimum requirements pertaining to a quality control and quality assurance system for GHG-emissions reporting" ("Allgemeine Mindestanforderungen an die Qualitätskontrolle und Qualitätssicherung bei der

Treibhausgasemissionsberichterstattung") from the previously applicable Good Practice Guidance (Chapter 8) (cf. Chapter 22.1.2.1). External National System participants then adopted the minimum requirements after representatives of the participating federal ministries approved them in the framework of the National Co-ordinating Committee for the National System of Emissions Inventories (cf. Annex Chapter 22.1.1).

Further information regarding the Federal Environment Agency's necessary organisational measures for implementing these requirements is provided in the following chapters and in a complementary section in the Annex, 22.1.2.1.11.

1.3.3.1.3 Start-up organisation for establishing the Quality System for Emissions Inventories

Within the QSE framework, a concept for a start-up organisation was developed that defines binding responsibilities, for the Federal Environment Agency, for implementation of the necessary QC and QA measures. The defined roles and responsibilities have the purpose of facilitating effective information exchange and directive-conformal execution of QC and QA (cf. Table 4).

Table 4: QSE – Roles and responsibilities

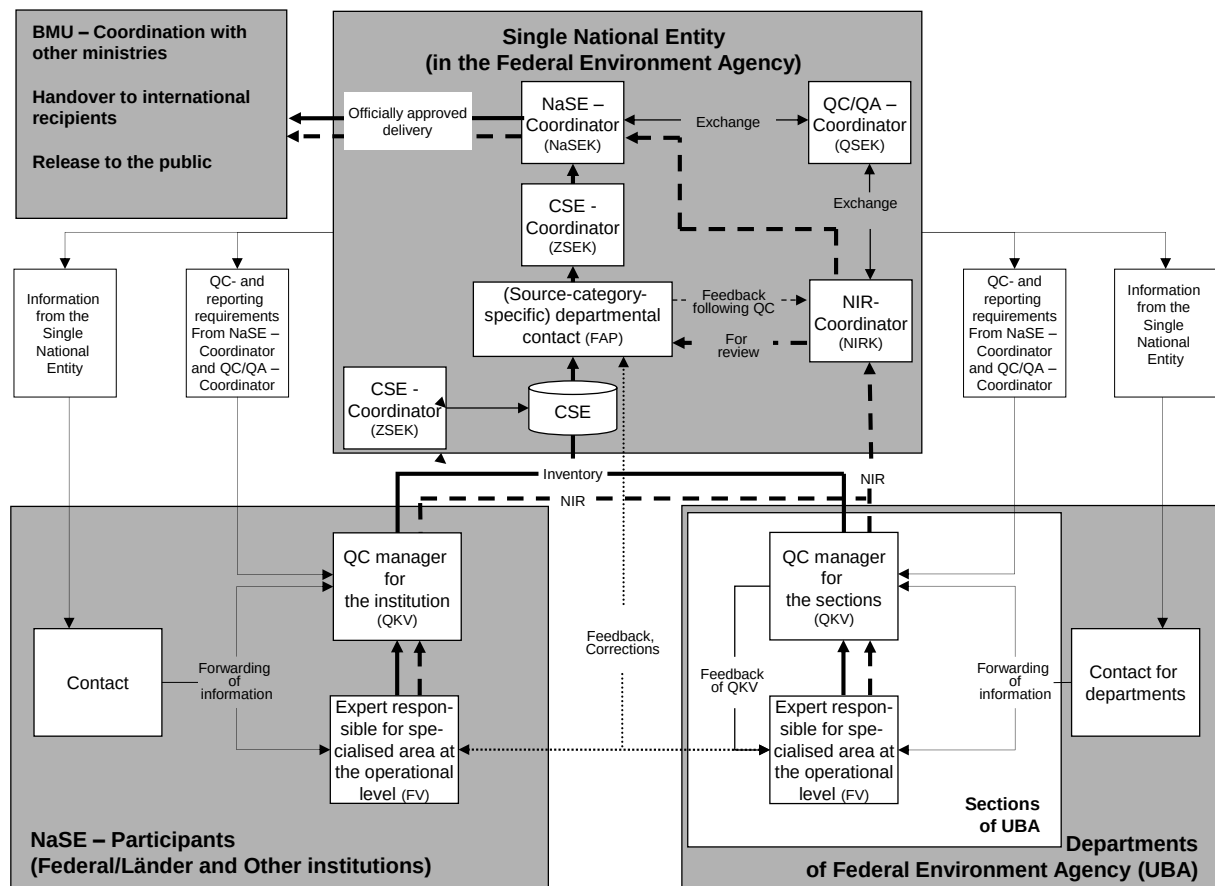
Role	Task	Responsible
Responsible expert at the operational level (FV)	Preparation of parts of the National Inventory Report (NIR) Data collection and data entry in the CSE, and calculation in keeping with the selected/prescribed methods Execution of systematic QC measures in the NIR, CSE and inventory description Execution of verification measures Archiving of all category-specific inventory information (inventory description and decentralised documentation) If necessary (for category-specific QC): Definition of category-specific quality targets and of the criteria for their achievement, in consultation with the QC section representative, the specialised contact person and the QC/QA co-ordinator (QSEK). Review, processing and answering of review results Active participation in review processes. This includes giving presentations, providing explanations and being available for questions (before and during the process, and in any follow-up). Initiating and developing (preparing specifications) R&D projects, and providing specialised support	All category-specific staff appointed by the head (FGL)
	Execution of systematic measures for assuring the quality of the data and report sections delivered to the Single National Entity Checking and approving data and report sections Ensuring that the necessary inventory work, quality controls, documentation and archiving are carried out Defining responsibilities relative to emissions reporting in specialised fields, and provision of the necessary time resources Providing support for review processes, and participating in them	
QC/QA section representative (QKV)	Category-specific support for responsible experts (FV) and QC/QA section representatives (QKV); support/guidance of FV/QKV in: • Implementation of international requirements • Supporting work involving data and report texts • Quality control / quality assurance ○ Preparation of lacking parts of the National Inventory Report (NIR) ○ Collection of any data lacking in the CSE, entry of such data into the CSE and carrying out of calculations in keeping with the selected/prescribed methods ○ Ensuring that the necessary inventory work, quality controls, documentation and archiving are carried out ○ Execution of systematic QC/QA measures in the NIR, CSE and inventory description ○ Archiving of any lacking category-specific inventory information (inventory description and decentralised documentation)	All responsible heads (Federal Government and the Länder)
Specialised contact person (category-specific) in the SNE (FAP)	Initiating and supporting R&D projects	Single National Entity (SNE) staff members appointed to specific categories

Role	Task	Responsible
	Execution of all work using the CRF reporter, and execution of quality control Assumption of tasks of unavailable responsible experts (FV) and of positions that have not been filled Review, processing and answering (as necessary) of review results Support, participation in and execution of (as necessary) FV tasks in connection with review processes Execution of overarching work (affecting more than one category) If necessary (for category-specific QC): Definition of category-specific quality targets and of the criteria for their achievement, in consultation with the QC section representative, the specialised contact person (FAP) and the QC/QA co-ordinator (QSEK).	
Report co-ordinator (NIRK)	Coordination of text contributions Compilation of the NIR, from the various contributions Overarching QC and QA for the NIR and, some cross-checking with the CRF	An appointed staff member of the Single National Entity (SNE)
CSE co-ordinator (ZSEK)	Overarching QC and QA in connection data entry and calculations for the inventory (data) Assuring the integrity of databases and report tables (Common Reporting Format (CRF)) Emissions reporting and data aggregation into report formats Supporting specialised departments in connection with questions relating to the Central System of Emissions (CSE) and to the report tables Determination of uncertainties (Tier 2), using Monte Carlo simulation	An appointed staff member of the Single National Entity (SNE)
QSE coordinator (QSEK)	Overarching QC and QA throughout the entire reporting process Maintenance and further development of the QSE Management and updating of the QC and QA plans, QC checklists and QSE manual Management for the administration and updating of the inventory plan and of the improvement plan If necessary (for category-specific QC): Definition of category-specific quality targets and of the criteria for their achievement, in consultation with the responsible experts (FV), the QC section representatives and the specialised contact person (FAP).	An appointed staff member of the Single National Entity (SNE)
NaSE co-ordinator (NaSEK)	Ensuring of on-time, requirements-conformal reporting Initiation of overarching measures from the inventory plan Selection of institutions and collection of relevant informational materials and legal agreements Organisation of expert-peer reviews – for example, in the framework of NaSE workshops Ensuring that all relevant inventory information in addition to that archived in the inventory description is centrally archived Preparation of execution and post-processing of inventory reviews	An appointed staff member of the Single National Entity (SNE)

1.3.3.1.4 The process organisation of the Quality System for Emissions Inventories

Procedures for QC/QA measures in the QSE are oriented to the emissions-reporting process described in Chapter 1.2.3. At the same time, quality management is directly linked with the various steps in the inventory process. Suitable QC measures, assigned to the various process players, have been allocated to each step of the inventory-preparation process (cf. Figure 6).

Figure 6: QSE – Roles, responsibilities and workflow

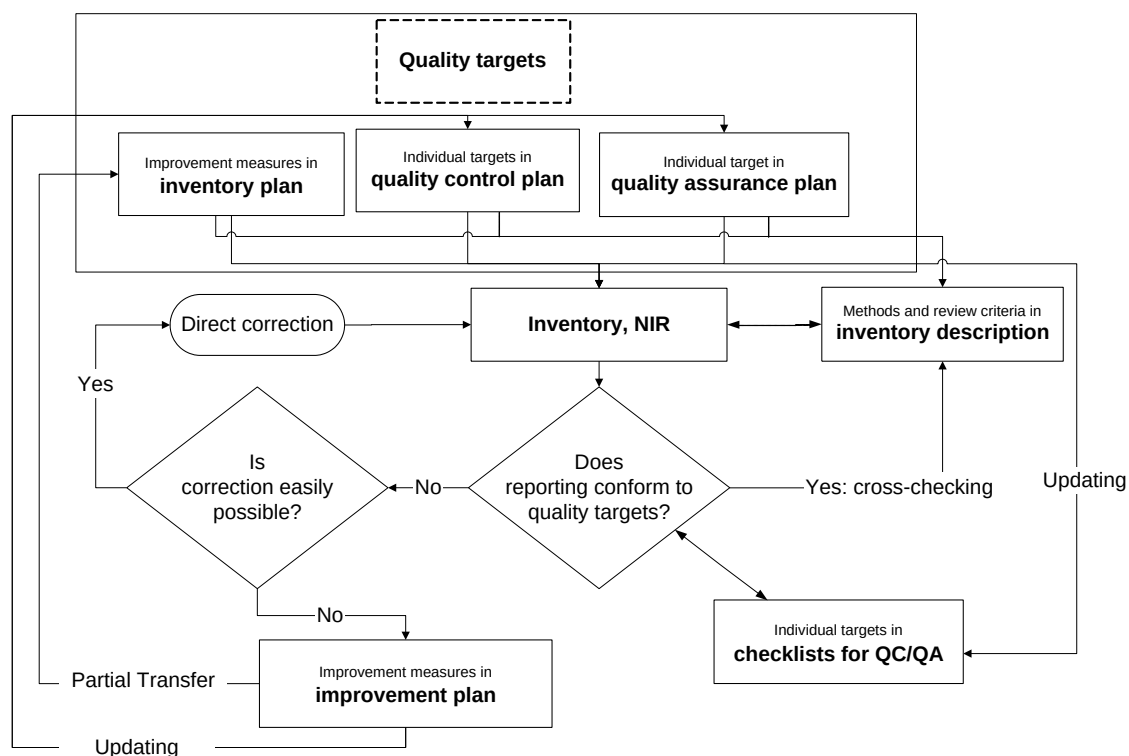


The required quality reviews pursuant to Paragraph 25 (f) of the *Reporting Guidelines* (24/CP.19) are provided, in the form of quality checklists and along with data requirements, to the FV, QKV, FAP and NIRK (cf. Table 4). They are completed in the course of the relevant supporting work.

1.3.3.1.5 Documentation in the Quality System for Emissions Inventories

The requirements pertaining to the execution, description and documentation of QC/QA measures, as formulated in connection with the minimum requirements for a QC/QA system (cf. Chapter 22.1.2.1), are largely being fulfilled in conjunction with production of the pertinent inventory contributions. For the QSE, a documentation concept was developed that represents all such measures and related actions in an integrated form tailored to the specific parties and tasks concerned. The various components of such documentation are shown in Figure 7.

Figure 7: Control and documentation



A general description of the **quality targets** is provided in the QSE handbook; the description is derived from the *2006 IPCC Guidelines (Vol. 1, Chapter 6)*. In addition, individual operational objectives, relative to quality control and quality assurance, have to be derived for the various categories from comparison of the requirements from the *2006 IPCC Guidelines*, the results of independent inventory review, the improvements required in the NIR framework and assessment of inventory realities.

Pursuant to the *2006 IPCC Guidelines (Vol. 1, Chapter 6)* and Paragraph 19 of the *Reporting Guidelines (24/CP.19)*, the necessary QC/QA measures for emissions reporting should be summarised in a QC/QA plan. Such a QC/QA plan is to serve the primary purpose of organising, planning and monitoring such QC/QA measures. To permit transparent, effective control of execution and monitoring of measures for achieving these objectives, the measures are set forth in a **quality control plan (QC plan)** and a **quality assurance plan (QA plan)** with respect to specific roles – and, if necessary – specific categories. Quality targets may be focused on the inventory, the reporting process or the QSE itself. In the framework of the quality assurance plan, scheduling of quality-assurance measures is also carried out. Such measures are executed partly by internal staff and mostly by independent, third parties (external). Both plans may be understood as sets of specifications.

As to their structure, the QC and QA plans are combined with the **checklists for quality control and quality assurance**, which are used to review and document successful execution of QC/QA. In this context, quality checks are actually defined not as checks but as quality objectives (data quality objectives pursuant to 2006 IPCC GL, Vol. 1, Chapter 6.5); in each case, either compliance with the objectives must be confirmed or non-compliance must be justified. The QC/QA checklists

have to be completed by the participants in the NaSE¹⁷ in parallel with the inventory preparation process. They facilitate immediate improvements. Where improvements cannot be carried out immediately, they are still useful in providing important information about the quality of the inventory's underlying data, methods and texts). The first time the Federal Environment Agency carried out systematic QC/QA, in the form of checklists, and in co-operation with the NaSE participants, was for the 2006 report. Since then, the checklists for general quality control are filled out every report year, and for all reported categories – i.e. both for key categories and for categories that are not key categories. Since the 2007 report, the checklists have been used in electronic form. Also as of the 2007 report, the general QC checks (formerly, Tier 1 checks) have been expanded to include a number of category-specific QC checks (formerly, Tier 2 checks), for key categories. For the 2008, 2009 and 2010 reports, the checklists for the experts involved in the various specialised areas, and for specialised contact persons, have been comprehensively revised. Such revision has been aimed at further enhancing the clarity, practical usefulness and logical structure of the checklists. To ensure the success of the pertinent improvements, a number of persons from the affected group of persons were selected for inclusion in the revision process. No content-oriented requirements have been modified as a result. The checklists are reviewed annually for any need for updating, and then they are revised or expanded as necessary. Like the checklists, the QC and QA plan is continually refined. As of the 2013 report, the checklists of the QC/QA section representatives (QKV), which were formerly category-specific, have been consolidated into single overarching checklists for each QKV (i.e. one checklist per QKV). This has been done in order to make the QC/QA process clearer for management personnel and to enhance resource efficiency.

As of the 2015 report, it has been assured that the general checklists meet the revised requirements applying under the 2006 *IPCC Guidelines (Vol.1, Kapitel 6)*. Lacking requirements have been added as necessary.

The two plans and the QC/QA checklists are instruments for reviewing fulfillment of the applicable international requirements, and they make it possible to control inventory quality via initiation of quality assurance measures pursuant to Paragraph 13 of the *Guidelines for National Systems*.

The **improvement plan** documents all potential improvements identified in the framework of the relevant last completed emissions-reporting cycle, as well as the findings that result from independent inventory review. In the plan, such improvements and findings are correlated with feasible corrective measures. The Single National Entity categorises the corrective measures, prioritises them and then, as a rule and via consultations with the relevant responsible experts, integrates them completely within the **inventory plan**. There, they are linked with deadlines and responsibilities. As an annex to the NIR, the inventory plan undergoes a co-ordination and release process. It is thus a binding set of specifications for improvements to be carried out in the coming reporting year.

The Single National Entity also maintains an **inventory description**, a central document record for the various categories. The description covers all key aspects of inventory preparation. It includes descriptions of all work that pertains to specific categories and that is relevant to preparation of category-specific inventories. The inventory description consists of a server-based folder (directory) system that is available both on mobile devices and on the desktops of the persons working in the framework of emissions reporting. The obligation to prepare defined documentation was introduced in the Federal Environment Agency via an in-house directive (cf.

¹⁷ These include responsible experts (FV), specialised contact persons (Fachliche Ansprechpartner – FAP), QC/QA section representatives (QKV – quality control managers) and the coordinator for the national inventory report (Koordinator für den Nationalen Inventar Report – NIRK).

Chapter 1.3.3.1.1). It provides the key basis for archiving inventory information pursuant to the provisions of Paragraph 27 (a) of the *Reporting Guidelines* (24/CP.19).

- For a range of different reasons, the documentation concept calls for an archive that is predominantly, but not exclusively, centralised. The key reasons for this decision included the fact that the body of data that provides the basis for calculating the German inventory is extensive, and non-centralised.
- In addition, external parties hold some of the responsibility for the data,
- and confidentiality criteria preclude, for legal reasons, provision of certain data items, for archiving purposes, to a central agency.

The inventory description contains information as to the locations of documents that are not centrally stored.

1.3.3.1.6 The QSE handbook

The international requirements for quality assurance and quality control measures in emissions reporting have been set forth, for the National System of Emissions Inventories (NaSE) in Germany, in the "Handbook for quality control and quality assurance in preparation of emissions inventories and reporting under the UN Framework Convention on Climate and EU Decision 525/2013/EC" ("Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU Entscheidung 280/2004/EG". That document, which is binding for the Federal Environment Agency, describes the Quality System for Emissions Inventories (QSE).

The QSE handbook has entered into force via an in-house directive of the Federal Environment Agency (cf. Chapter 1.3.3.1.1). It has been published, along with pertinent, co-applicable documents, in the Federal Environment Agency's intranet.

1.3.3.1.7 Support for the UNFCCC review

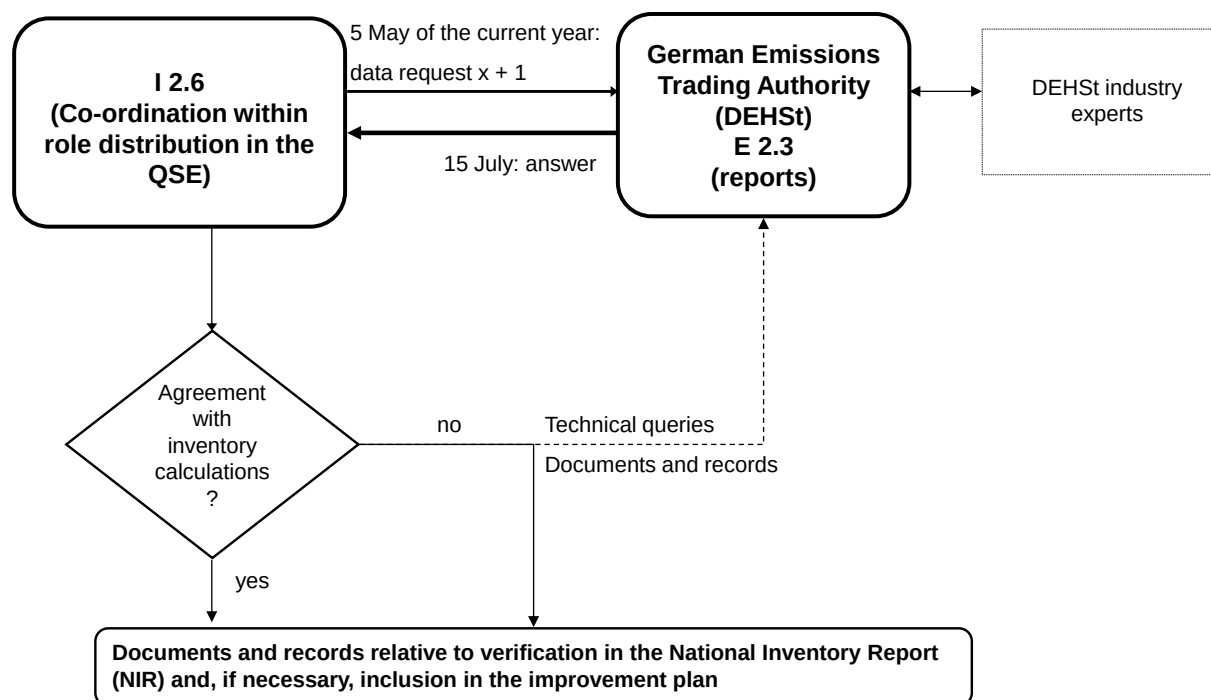
In addition to the Federal Environment Agency's own quality control and assurance measures, the UNFCCC review provides important impetus for inventory improvement. It is thus in the Single National Entity's own interest to fulfil the requirements for provision of archived inventory information for the review process and for responding to questions of expert review groups. This relationship has been given priority in the design of the QSE.

1.3.3.1.8 Use of EU ETS monitoring data for improvement of GHG-emissions inventories

Monitoring data from European emissions trading will be used to improve the quality of annual national emissions inventories with respect to categories that include installations subject to reporting obligations under the CO₂ Emissions Trading Scheme (ETS).

The comparisons have confirmed, in principle, the usefulness of such comparisons for verifying individual categories and identifying data gaps. A formalised procedure, with defined deadlines and workflow, has been agreed for their regular use and for the relevant annual required data exchanges.

Figure 8: Procedural flow for annual inventory verification using ETS monitoring data



Regarding the details of data use in QC/QA, cf. also Chapter 1.6.2.1.

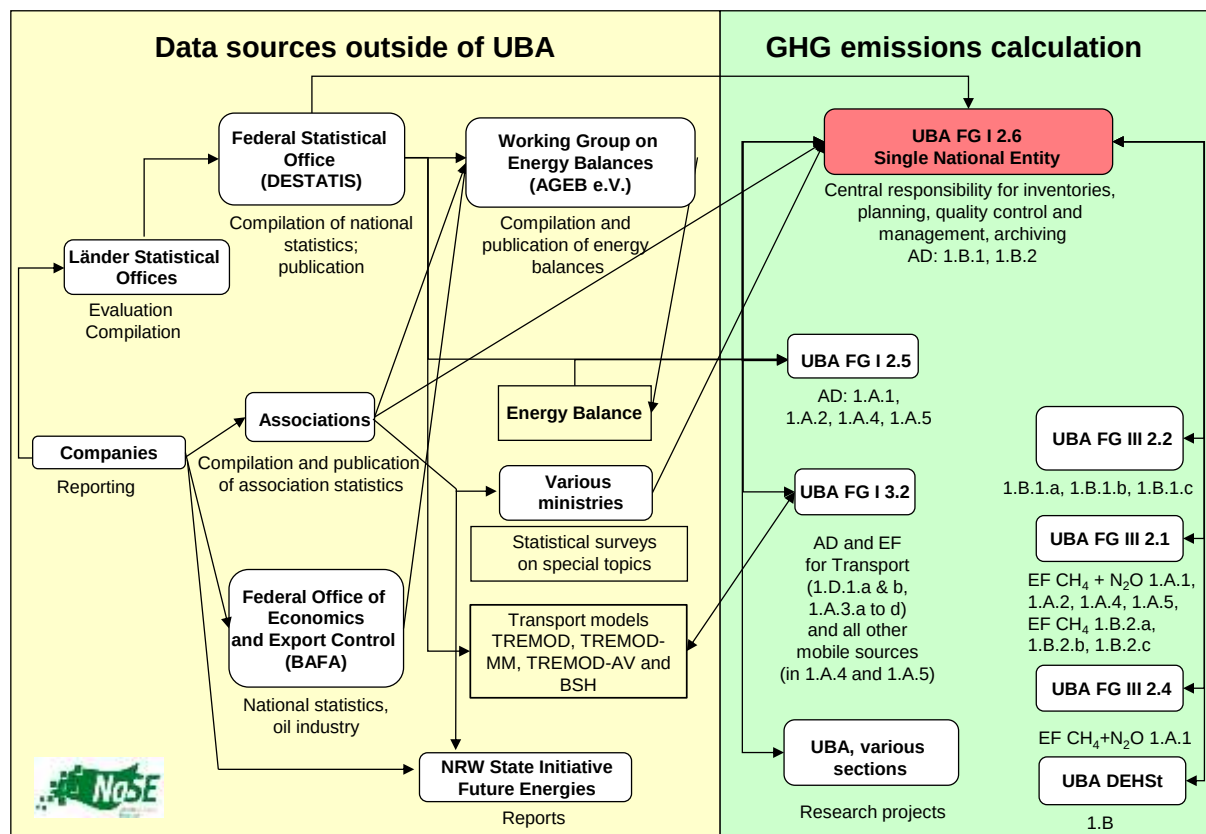
1.4 Short, general description of the methods and data sources used

1.4.1 Greenhouse-gas inventory

1.4.1.1 Data sources

1.4.1.1.1 Energy

Figure 9: Responsibilities and data flows for calculation of greenhouse-gas emissions in the energy sector



In all likelihood, the most important data sources for determination of activity data for category 1.A are the "Energy Balances of the Federal Republic of Germany" ("Energiebilanzen der Bundesrepublik Deutschland"), 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 categories. The data for Energy Balances come from a wide range of other sources.

The AGEB was commissioned to prepare the Energy Balances for the years 2007 – 2012. Subsequently, it was commissioned by the Federal Ministry for Economic Affairs and Energy (BMWi) to prepare the Balances for the years 2013 – 2018. In such commissioning, the AGEB was obligated to apply minimum requirements relative to quality assurance for the National System. For the Energy Balances of recent years, the German Institute for Economic Research (DIW) and the firm of Energy Environment Forecast Analysis GmbH Co. KG have prepared quality reports detailing the quality control and assurance measures applied. As of 2012, the Working Group on Energy Balances (AGEB) provides a joint quality report for the Energy Balance (cf. Chapter 18.4.1). Also as of 2012, the AGEB prepares an "Energy-Data Action Plan for inventory improvement"

("Aktionsplan Energiedaten Inventarverbesserung"; cf. Chapter 18.5) that outlines actions to be taken to address the criticism that emerged from the inventory review. This action plan fulfills the action-plan requirement set forth in Paragraph 39 of the 2011 review report (FCCC/ARR/2011/DEU).

Along with the main Energy Balance, a *Satellite Balance of Renewable Energies* (Satellitenbilanz Erneuerbare Energieträger; hereinafter referred to as: Satellite Balance) also appears. This balance describes the growth and use of renewable energies in detail. The Satellite Balance appears together with the Energy Balance.

The *Federal Statistical Office* is another important source of data for determination of activity data. The resources of that office that are used in the present context include the *Fachserien 4 (technical series 4) Reihe (sub-series) 4.1.1, Reihe 6.4*, and, for waste data, *Fachserie 19*. These data are published relatively promptly after collection (about one year), and they are broken down finely in accordance with various areas of the manufacturing sector. To support further data differentiation, and clarification of details, the Federal Statistical Office provides special evaluations.

For the iron and steel sector, as of the 2012 report, data of the *Wirtschaftsvereinigung Stahl* German steel industry association are being used. Inter alia, these data replace the so-called "BGS form" (Fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) locally connected to such operations), a section of the "Fachserie 4, Reihe 8.1", publication of which was discontinued as of 31 December 2009.

The series *STATISTIK DER KOHLENWIRTSCHAFT* ("Coal industry statistics"), especially its annual publication "*Der Kohlenbergbau in der Energiewirtschaft der Bundesrepublik Deutschland*" ("Coal mining in the energy sector of the Federal Republic of Germany"), is used as an additional data source. In addition, the special evaluations provided by the *Bundesverband Braunkohle* (DEBRIV; federal German association of lignite-producing companies and their affiliated organisations) are used for differentiation of the different types of raw lignite coal that are burned. Furthermore, DEBRIV provides the necessary data for calculation of fuel inputs for lignite drying.

Another data source consists of the "*Petroleum Data*" of the *Association of the German Petroleum Industry (MWV)*, which include data on petroleum production and consumption in Germany, broken down by various production, transformation and utilisation sectors. These statistical data, which are a key basis for the National Energy Balance, are published within just a few months after the relevant survey and are thus a relatively current source.

The quantities of secondary fuels used for energy generation (listed under CRF 1.A.2) are taken from the annual report of the German Pulp and Paper Association (*Verband der Papierindustrie*) and from reports of the German Cement Works Association (*Verband der Zementindustrie – VDZ*).

Another important data source is the Emissions Trading System (ETS). It keeps highly detailed, plant-specific data that are also used for the inventory. Emissions trading data is used especially in areas that are not covered by national statistics:

- fuel-related CO₂ emission factors for stationary combustion systems,
- fuel inputs for natural gas compressors,
- emissions from coke burn-off in catalyst regeneration, and in calcining, in refineries, and
- fugitive emissions in coking plants.

For collection of transport emissions data (1.A.3), *Official Mineral-oil Data* (amtliche Mineralöl-daten) of the *Federal Office of Economics and Export Control (BAFA)* and *Petroleum Data* (Mineralöl-Zahlen) of the *Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry (MWV) e.V.* are used, in addition to Energy Balance data.

For air transports, in addition to data of the aforementioned sources, data of *EUROCONTROL, the European Organisation for the Safety of Air Navigation*, and of the *Federal Statistical Office* (Statistisches Bundesamt (DESTATIS)) are used: The fuel consumption and emissions are broken down in accordance with national and international flights, on the basis of data on real aircraft movements. Those data are collected and made available by DESTATIS, and then they are processed in the TREMOD AV model, a separate module of the TREMOD ("Transport Emission Estimation Model") database. Fuel consumption and emissions are also broken down in accordance with the flight phases L/TO cycle (Landing and Take Off; movements below an elevation of 3,000 feet) and cruise (movements above 3,000 feet); this is also done on the basis of the aircraft-movement data collected by the Federal Statistical Office.

Country-specific consumption and emissions data provided by Eurocontrol are used solely for verification purposes.

Road-transport emissions are calculated primarily with the TREMOD model. For calculations carried out in TREMOD, extensive basic data from generally accessible statistics and special surveys are used, co-ordinated, and supplemented. A precise description of the data sources for emission factors is provided by the "Handbook of road-traffic emission factors" ("Handbuch Emissionsfaktoren des Straßenverkehrs") (HBEFA, Version 3.2).

TREMOD is also used for modelling emissions from fuel combustion in railway vehicles and inland waterway vessels. The emissions caused by historic steam railways, via combustion of coal and coke, are calculated outside of TREMOD, on the basis of operator information.

The specific consumption and emissions of ship transports departing from German seaports are calculated within a model developed by the Federal Maritime and Hydrographic Agency (BSH). For this area, the breakdown of fuel consumption and emissions in accordance with domestic and international transports is based on data derived, inter alia, from the ships' AIS messages.

Data on emissions of other mobile sources (in 1.A.4 and 1.A.5.b) are also collected from figures of the Working Group on Energy Balances (AGEB), of the Federal Office of Economics and Export Control (BAFA) and of the Association of the German Petroleum Industry (MWV). Military transports (1.A.5.b) have a special status in this regard; the consumption data for such transports, which as of 1995 are no longer listed in the Energy Balances, are obtained directly from BAFA statistics.

Due to a lack of reliable figures on consumption of biofuels by mobile sources in the construction, agricultural and forestry sectors, and by the residential and military sectors, the relevant annual quantities are calculated on the basis of the official admixture quotas.

Data for categories of category 1.B.1 are taken from publications of Statistik der Kohlenwirtschaft e.V. (coal-industry statistics), the Federal Ministry for Economic Affairs and Energy (BMWi), the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations, Deutsche Montan Technologie GmbH (DMT), the German Society for Petroleum and Coal Science and Technology (DGMK) and Interessenverband Grubengas e.V. (IVG; association for the pit-gas sector).

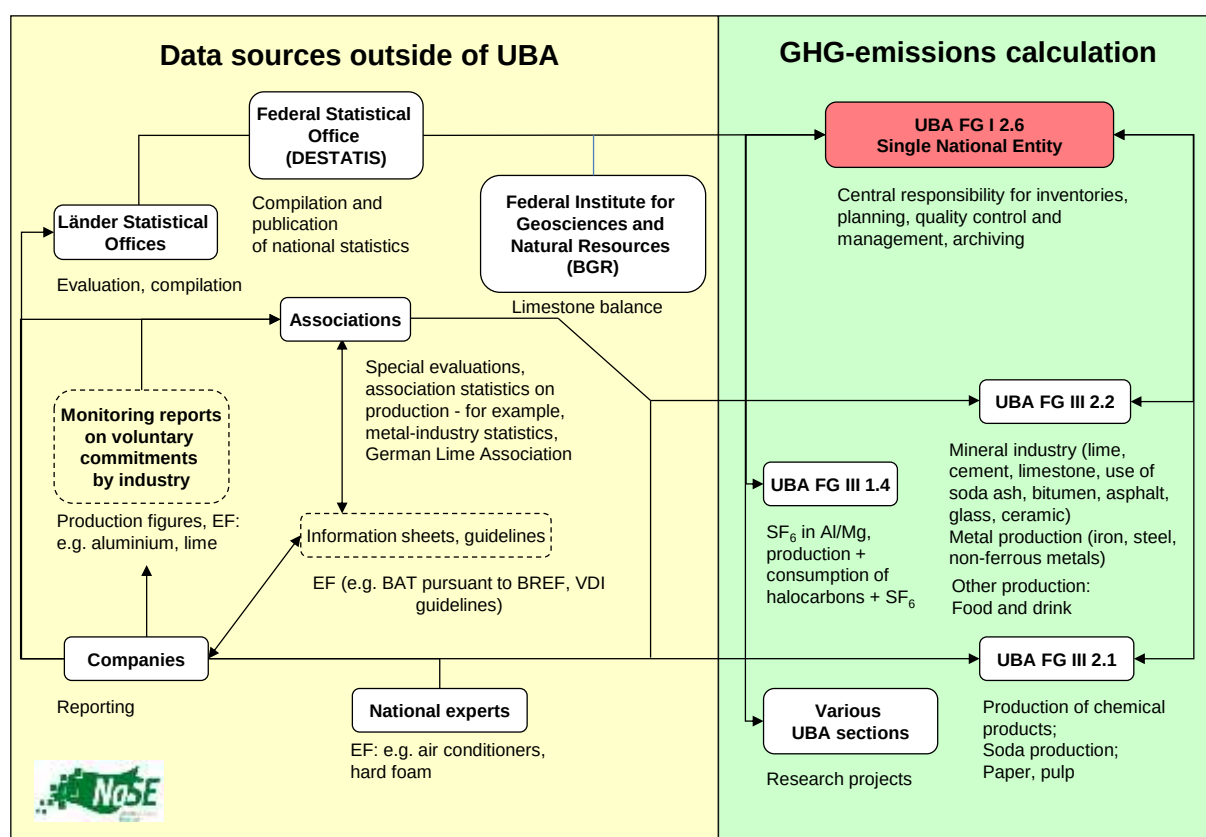
The publication "Statistik der Kohlenwirtschaft" (coal-industry statistics) is especially important in this context. It is processed with the help of federal and Land (state) ministries, including their authorities (such as supreme state mining authorities), and with use of reports and expert opinions of the "Landesinitiative Zukunftsenergien" NRW ("NRW State Initiative for Future Energies"; here, the AG Grubengas mine-gas working group). Inventory preparation is co-ordinated with the support of the Gesamtverband Steinkohle (Association of the German hard-coal mining industry).

Data for categories in category 1.B.2 are taken from publications of the *Federal Statistical Office*, the Association of the German Petroleum Industry (MWV), the German Society for Petroleum and Coal Science and Technology (DGMK), the Association of the petroleum and natural-gas industry (Wirtschaftsverband Erdöl und Erdgasgewinnung e.V. – WEG), the German Technical and Scientific Association for Gas and Water (DVGW), the Federal association of the German gas and water industry (Bundesverband der deutschen Gas- und Wasserwirtschaft – BDEW; gas statistics) and the German Emissions Trading Authority (DEHSt).

1.4.1.1.2 Industrial processes

Activity data for the mineral industry are obtained primarily from association statistics. The data for the cement industry (2.A.1) were provided by the German Cement Works Association (Verband der Zementindustrie – VDZ), especially by that association's research institute, as well as by the Federal association of the German cement industry (Bundesverband der Deutschen Zementindustrie e.V. - BDZ). For the most part, the data in question consist of data published in the framework of CO₂ monitoring under the industry's voluntary climate-protection commitment. The figures for lime and dolomite-lime production (2.A.2) are collected by the German Lime Association (BVK) on a per-plant basis and then provided annually in aggregated form. Glass-production figures (2.A.3) are taken from the regularly published annual reports of the Federal glass industry association (Bundesverband Glasindustrie), although relevant orientational figures on glass recycling are taken from other statistics. Production trends in the ceramics industry (2.A.4.a) are determined via official statistics and via conversion factors provided by the Federal association of the German brick industry (Bundesverband der Deutschen Ziegelindustrie). Figures for soda ash use (2.A.4.b) are obtained via expert assessment carried out by the Federal Environment Agency. .

Figure 10: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of industrial processes



A range of different sources are used to determine emission factors for the mineral industry. The emission factor used for calculation of emissions from cement-clinker production (2.A.1) is based on a calculation of the German Cement Works Association (VDZ) carried out by aggregating plant-specific data. CO_2 emissions from lime production (2.A.2) and from soda-ash use (2.A.4.b) are calculated with the help of stoichiometric factors. The CO_2 -emission factors for various types of glass (2.A.3) have been derived from glass-composition data, while CO_2 -emission factors for the ceramics industry (2.A.4) have been derived, by Federal Environment Agency experts, from raw-material inputs.

The activity data for category 2.B Chemical industry are determined from activity data of the *Federal Statistical Office* (*Fachserie 4 Reihe 3.1*) and directly from figures of industry associations and producers. Some of these data are confidential. The relevant emission factors have been determined by experts in the Federal Environment Agency, via research projects or by the pertinent producers. Until 2008, activity data for 2.B.1 Ammonia production and 2.B.2 Nitric acid production were collected by the *Federal Statistical Office*. Since 2009, data for ammonia and nitric-acid production have been collected by producers themselves – plant-specifically, on the basis of an agreement with the chemical industry and for the entire time series as of 1990. These data are forwarded to the association, which aggregates them and forwards them, in anonymised form, to the Federal Environment Agency. For this purpose, in addition to determining the applicable activity data, the producers also determine the applicable emissions for 2.B.1 and the applicable emission factors for 2.B.2. Until the mid-1990s, plant-by-plant activity data were supplied for 2.B.3 Adipic acid production. The default emission factor for N_2O was applied to that data. Now, plant operators are supplying emissions data directly to the Federal Environment Agency, on a confidential basis. For the area of adipic-acid production, data delivery has also been

assured for the long term, via an agreement from 2009. Producers in Germany find the IPCC's default emission factors for NO_x, CO and NMVOC rather puzzling. This is the reason why emissions of these substances have not been reported to date. In 2.B.4, only emissions from caprolactam production play a significant role. Through 2008, the relevant activity data were provided by *the Federal Statistical Office*. Since then, as a result of a harmonisation of national production statistics with international requirements, caprolactam is no longer listed separately, and thus the confidential activity data have been carried forward. The relevant emission factors have been determined via a research project and information provided by producers. Since there is only one calcium carbide (2.B.4) producer in Germany, the relevant data are confidential. The Federal Environment Agency obtains these data directly from the producer. The CO₂ emissions from titanium dioxide production are not reported, because they lie below the applicable threshold (2.B.6). The *Federal Statistical Office* determines the total amounts of soda ash (2.B.7) produced in Germany. The pertinent emission factors are derived from the ETS monitoring data of the German Emissions Trading Authority (DEHSt). The activity data for production of the products listed under 2.B.8 Petrochemicals and carbon black production are obtained from statistics of the *Federal Statistical Office*. Some of the data are subject to confidentiality. The emission factors are obtained from experts' estimates, research projects and default figures provided in the IPCC Guidelines. In the area of production of halocarbons and SF₆ (2.B.9), data are obtained from *producers' figures and surveys of producers*. For the most part, activity data are researched in the framework of research projects, directly in accordance with the inventory's requirements. In some cases, producers supply only emissions data. Only small numbers of companies are involved in the various sub- source categories, and thus data in these areas are confidential. Under 2.B.10 Other, emissions of precursor substances from production of sulphuric acid and fertilisers are reported. The activity data are obtained from information provided by producers and from data of the Federal Statistical Office. The emission factors are obtained from experts' estimates and research projects.

The activity data for the metal industry (2.C) are provided by the *Federal Statistical Office*, by the relevant associations (Steel Institute VDEh, Wirtschaftsvereinigung Metalle (metals industry association) and Gesamtverband der Aluminiumindustrie (aluminium industry association) and by sellers of industrial gases. The emission factors for the metals industry (2.C) are normally calculated by experts in the Federal Environment Agency; in some cases, emission factors are provided by industrial associations or IPCC default values are used.

One exception in this regard is the category Ferroalloys (2.C.2); for it, activity data from statistics of the UK Geological Survey are used, while the relevant emission factors are taken from the results of a research project (in some cases, IPCC default values are also used).

In category 2.D Non-energy-related products from fuels and solvents, the activity data have been taken from published surveys of the Federal Statistical Office and of other federal authorities (for production and foreign-trade statistics, and for petroleum statistics) and of relevant associations (the VDD industry association for bitumen paper and bitumen roof sheeting; the German asphalt industry association (Deutscher Asphaltverband – DAV)). The activity data are supplemented with industry statistics and information supplied by experts.

The emission factors have been taken from various sources. For example, those for lubricant and paraffin-wax use have been calculated by the relevant expert unit in the Federal Environment Agency, with the help of IPCC default values. NMVOC emissions from lubricant use have been given only as CO₂ emissions, however, in keeping with the 2006 IPCC Guidelines. The emission factors for production and laying of bitumen paper and bitumen roof sheeting (2.D.3), and for production

of asphalt for road paving (2.D.3), refer only to NMVOC, and they have been taken from research reports.

Emission factors, along with other parameters that enter into calculation of emissions from solvent use, are taken from national studies, experts' opinions and research projects directly commissioned by the Federal Environment Agency; in some cases, they are also based on information provided by experts in the context of dialogs with industry.

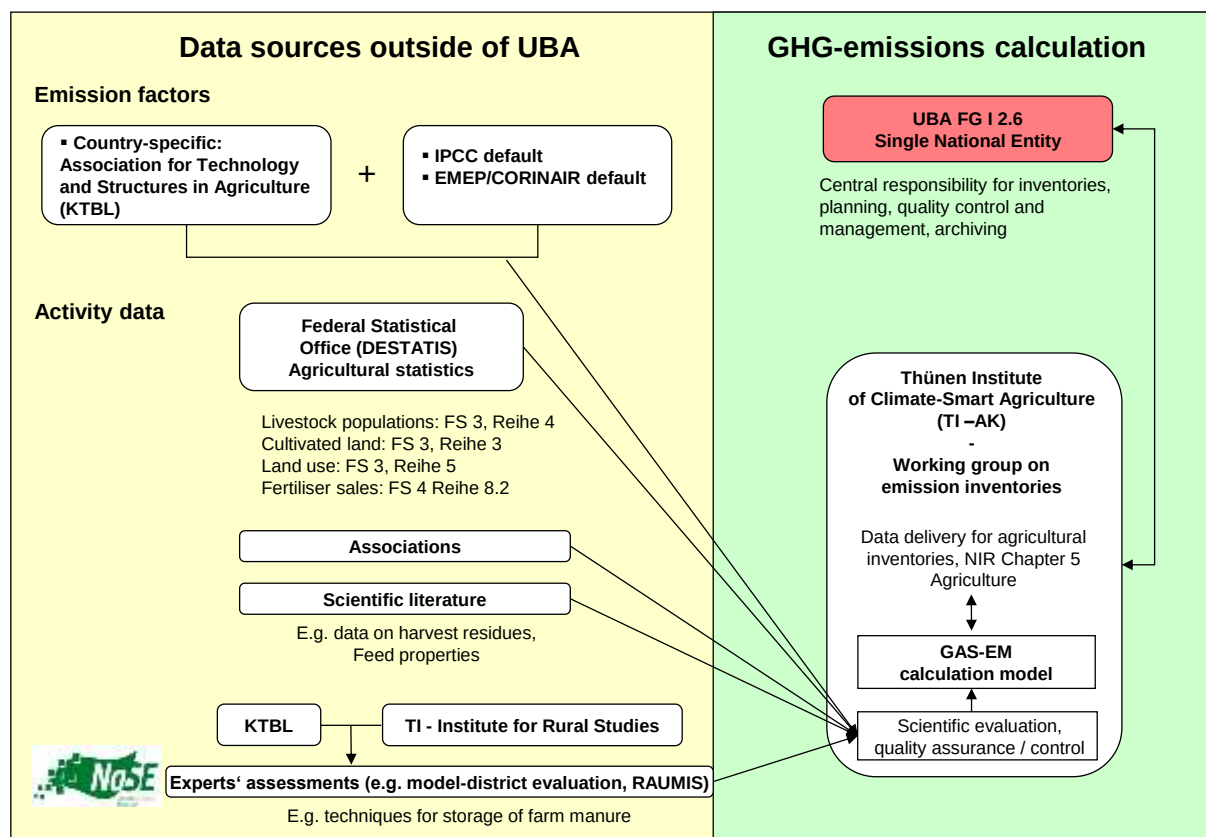
More-detailed pertinent information regarding emission factors is presented in the descriptions of methods for the various categories. The activity data for the electronics industry (2.E), for product use as substitutes for ODS (2.F) and for other product production and use (2.G), have been determined from information provided by producers and associations, from surveys of the Federal Statistical Office and of other federal authorities and with the help of calculation models. In individual cases, producers provide emissions data directly. The data are classified into several subcategories. Product use as ODS substitutes is also subdivided into production, use and disposal emissions. In these categories as well, the data in some areas are subject to confidentiality requirements.

Emission factors for fluorinated greenhouse gases are obtained in part from national and international fact sheets and directives or via surveys of experts; where necessary, IPCC default values are used.

In the area of 2.H.1 Other production: Pulp and paper production, data from the production report of the German Pulp and Paper Association (Verband Deutscher Papierfabriken – VDP) are used. In the area of 2.H.1 Other production: Food and beverages, data of the Federal Food Industry Association (Bundesvereinigung der Deutschen Ernährungsindustrie; BVE), of the Federal Statistical Office (Statistisches Bundesamt) and of the Federal Ministry of Food and Agriculture (BMEL) are used. The emission factors have been obtained from a research project that was completed in 2008.

1.4.1.1.3 Agriculture

Figure 11: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of agriculture



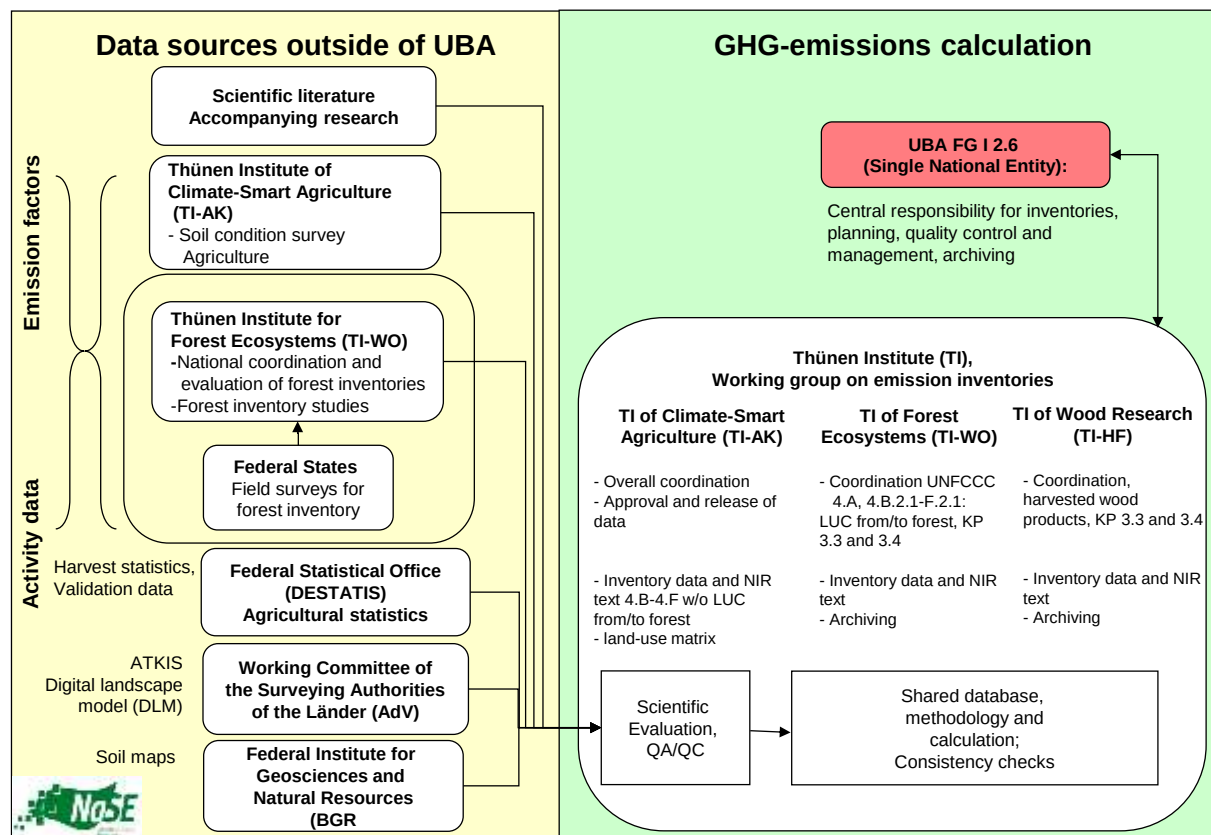
Emissions calculations for category 3 (Agriculture) are carried out by the Thünen Institute (TI). For calculation of agricultural emissions in Germany, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the Federal Ministry of Food and Agriculture (BMEL) 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) (DÄMMGEN et al, 2002 & HAENEL et al. 2012). The BMUB 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 FAL.

Agricultural statistics of the Federal Statistical Office are another important data source for calculation of agricultural emissions. Animal statistics have been obtained from the *Federal Statistical Office (FEDERAL STATISTICAL OFFICE, FS3 R4)*; other Fachserien (technical series) provide data on amounts of fertiliser sold and agricultural land under cultivation. In some areas, such data are supplemented by figures from the pertinent literature (for example, crop residues and recommended fertiliser quantities). Additional data are available from experts' assessments (for example, an evaluation of model districts with regard to techniques for storing farm fertilisers).

In many areas, calculations for the agriculture sector are based on highly differentiated activity data obtained via national data sources. Also in many areas, such data are combined with the standard emission factors given in the 1996b and 2006 IPCC Guidelines or the EMEP/EEA manual of the United Nations Economic Commission for Europe (UN ECE).

1.4.1.1.4 Land-use changes and forestry

Figure 12: Data flows for calculation of greenhouse-gas emissions from the areas of land-use changes and forestry (LULUCF) and KP-LULUCF



In the 2012 Submission, a consistent, unified method was introduced for taking account of land-use changes in the LULUC sector and the forestry sector. The method expands the existing sample-based system for determining forest-land areas, and land-use changes to and from forest land, for all land-use categories and change types.

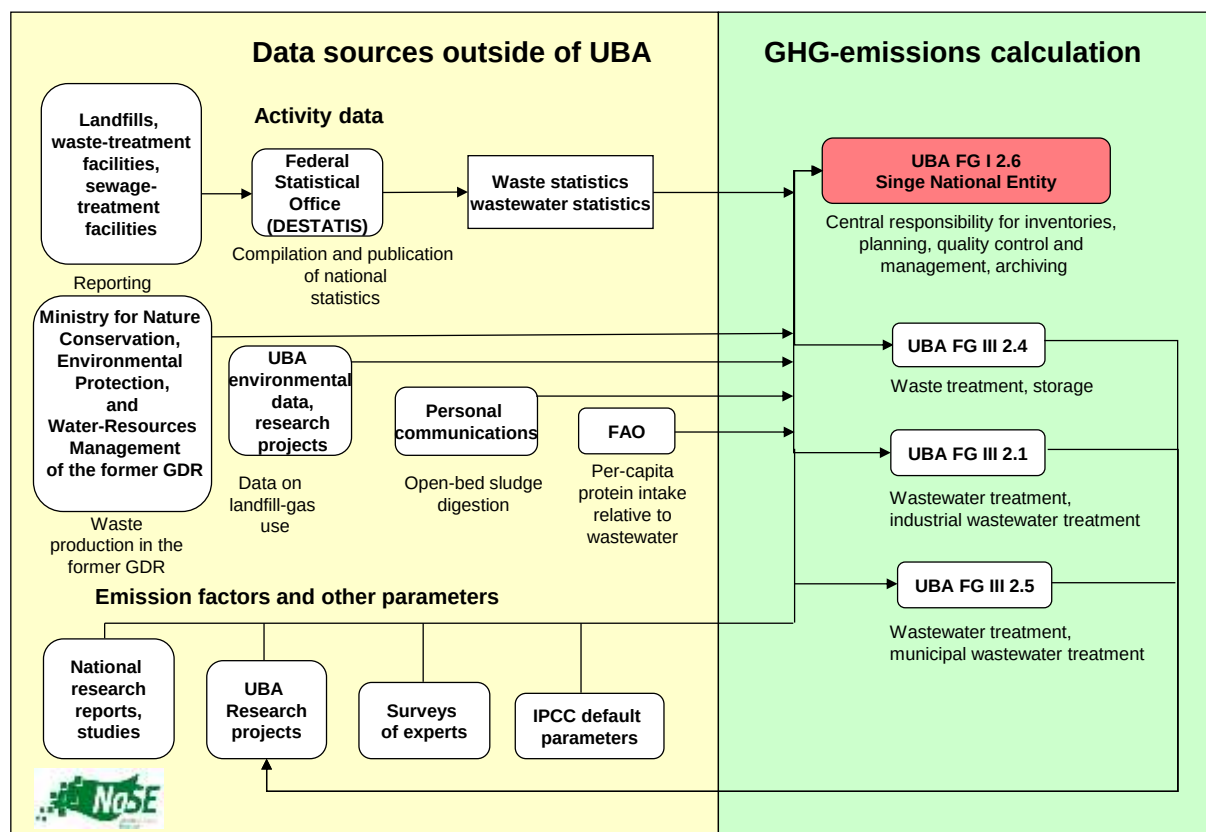
Soil carbon stocks are estimated with the help of soil maps and soil-profile data (both differentiated to show usages), and of data from the Forest Soil Inventory (BZE), while use-change-related changes in these stocks are estimated on the basis of changes in the mean stocks per land-use category.

Changes in biomass carbon stocks are estimated on the basis of harvest statistics, the main survey on soil use (Bodennutzungshaupterhebung), the National Forest Inventory (BWI) and specific factors given in the pertinent scientific literature (and used in conjunction with area data).

Projects for improvement of activity data, and especially for determination of country-specific emission factors for carbon and nitrogen, and for CO₂, CH₄ and N₂O – for example, the project "Organic Soils" (since 2009), the agricultural soil survey (Bodenzustandserhebung Landwirtschaft; since 2011) and others – will help validate and improve national estimates of emissions and removals.

1.4.1.1.5 Waste and wastewater

Figure 13: Data flows for calculation of greenhouse-gas emissions from the area of waste and wastewater



Federal Environment Agency Section FG III 2.4 *Waste technology, waste technology transfer* is responsible for selecting the methods, parameters and data for calculating emissions from the waste sector. In recalculation of landfill emissions in 2003 (development of the Tier 2 method for the Federal Republic of Germany), and in refinement of the Tier 2 method in 2006, the Federal Environment Agency was supported by a research project (ÖKO-INSTITUT, 2004b).

Activity data in the waste sector are drawn mainly from published data of the Federal Statistical Office, which provides detailed, disaggregated time series. The section on waste provides precise information as to what statistical series and sources were used. The Federal Statistical Office has not published any data on amounts of waste produced in the former GDR. In this area, an official source of the former GDR's ministry for nature conservation, environmental protection and water-resources management was used. The calculations relative to landfill-gas use are based on data from the Energy Balances and from Fachserie 19 of the Federal Statistical Office. The database for landfill-gas use was updated in the framework of the 2010 In-Country Review. Statistical data on gas collection at landfills in the follow-on care phase have been collected since 2012.

The emission factors and other parameters that enter into calculation of emissions from waste landfilling, from mechanical-biological waste treatment and from composting were taken from national studies and research reports conducted/prepared in research projects commissioned directly by the Federal Environment Agency. IPCC default parameters were also used for this purpose. Selected experts were also consulted regarding a few of the relevant parameters (for example, half-life selection). The relevant chapter presents the sources for the various parameters, in detail.

The Federal Environment Agency's Section for *General Aspects, Chemical Industry, Combustion Plants* (III 2.1) is responsible for selecting the methods, parameters and data for calculating emissions from the industrial wastewater / sewage sludge handling sector (5.D.2). The Federal Environment Agency's Section III 2.5 *Monitoring Methods, Waste Water Management* is responsible for selecting the methods, parameters and data for calculating emissions from the municipal wastewater handling sector (wastewater and sewage sludge) (5.D.1).

Activity data in the wastewater sector are drawn mainly from published data of the Federal Statistical Office, which provides detailed, disaggregated time series. The section on wastewater provides precise information as to what technical series and sources were used. The data on per-capita protein intake are taken from FAO data.

The emission factors and other parameters that enter into calculation of emissions from wastewater treatment were taken from national studies and research projects commissioned directly by the Federal Environment Agency. IPCC default parameters are also used. Various experts were consulted directly regarding a few parameters and methodological issues (for example, production of CH₄ emissions in aerobic wastewater-treatment processes).

1.4.1.2 Methods

The methods used for the individual categories are outlined in the overview tables for the various categories and in summary tables 3s1 and 3s2 of the CRF reporting tables. In addition, detailed descriptions are provided in the relevant category chapters.

A distinction is made between calculations made with country-specific ("CS") methods and calculations made, in the various categories, with IPCC calculation methods of varying degrees of detail (of varying "Tiers")¹⁸. The manner in which a calculation is assigned to the various IPCC methods depends on the pertinent category's share (expressed as equivalent emissions) of total emissions. Such assignment is carried out via an instrument known as "key-category analysis" (cf. Chapter 1.5 in this regard).

NMVOC emissions from solvent use, converted into indirect CO₂, are calculated on the basis of a product-consumption approach pursuant to the 2006 IPCC Guidelines. A similar procedure is used in the area of lubricant use.

1.4.2 KP LULUCF activities

The data sources and methods used for KP reporting do not differ from the data sources and methods used for reporting for categories with CRF categories 4.A, 4.B and 4.G in the UNFCCC framework. There are thus no differences with regard to the present purpose. Cf. also Chapter 1.4.1.1.4 and Chapter 5 and Annex Chapter 19.3.

1.5 Brief description of key categories

1.5.1 Greenhouse-gas inventory (with and without LULUCF)

The key categories were identified by applying two Approach 1 procedures, Level (for the base year, 1990, and for the most current year) and Trend (for the most current year, as compared to the base year), to German greenhouse-gas emissions. In addition, the Approach 2 procedure was used. In keeping with the pertinent IPCC specifications for the Approach 1 procedure, analysis focussed both on emissions from sources and on removals of greenhouse gases in sinks. The

¹⁸ Tier 1 refers to the simpler calculation methods that may be used with fewer input data, whereas Tier 2 and Tier 3 require more differentiated input data and hence generally lead to more accurate results.

analyses are first carried out solely for emissions from the sources listed in Annex 1 of the UN Framework Convention on Climate Change and, then, in a second step, for storage of greenhouse gases in sinks. All specified key categories result either from level analysis, or from trend assessment, or from Approach-2 key-category analysis on the basis of current uncertainties determination. No new key categories have been added as a result of assessment of qualitative aspects (explanations regarding this aspect are provided in Annex Chapter 17.1.2).

For the current report, the Approach 1 procedure identified 44 categories, out of a total of 147 source and sink categories studied, as key categories. Only 30 of these were identified, by both trend and level analysis, as key categories. In addition, 8 categories were identified as key categories solely by trend analysis, and 6 categories were so identified solely by level analysis. Via the Approach 2 procedure, 6 additional key categories were identified (most recently) (cf. Table 8).

Ultimately, 52 key categories were defined as a result. These are summarised in Table 5.

Table 5: Number of categories and key categories

Category			120
			Key categories
by Level	Level & Trend	Trend	
6	30	8	
			44 (Tier 1)
			+6 (Tier 2*)
			52 (total)

* Tier 2 analysis not yet updated for 2015

Table 6 provides an overview of the results of Tier-1 key-category analysis. Table 8 shows the additional key categories identified via Tier 2 analysis. Annex 1 (Chapter 17) of this report presents detailed explanations of the key-category analysis carried out.

Only few changes have occurred with respect to the results obtained in the previous year. The number of key categories pursuant to Tier 1 analysis, at 44, has increased by 1. The newly added key category is: CH₄ emissions from Other: Residential (1.A.4b) from the energy sector. All the other key categories of the past year have remained key categories.

Germany uses all recommended procedures for identifying and evaluating categories. The 2006 IPCC Guidelines (Vol. 1, Chapter 4.3) mandate that 95% of emissions from sources / removals in sinks be classified in key categories. The key categories that Germany has identified comprise emission-causing activities that account for about 98 % of the total inventory. This high percentage results from Germany's practice of identifying key categories by combining the results of all analysis procedures and evaluations.

A comparison of the key-category analysis carried out within the CRF Reporter and Germany's key-category analysis has found that the two analyses differ only slightly. Small differences of approach are apparent; for example, Germany divides the energy sector into sub-categories, while the CRF Reporter differentiates it in accordance with fuel types. The resulting number of key categories is virtually the same in both analyses, however.

1.5.2 Inventory with KP-LULUCF reporting

As a result of the analysis of the UNFCCC inventory, as described in the previous chapter, CO₂ emissions / removals in the categories *Forest Land* (4.A), *Cropland* (4.B) *Grassland* (4.C) and *Wetlands* (4.D) have been identified as key categories. For these categories, additional detailed analyses were carried out, in keeping with the methodological recommendations in Chapter "2.3.6

Choice of method" of the 2013 Revised Supplementary Methods and with the Good Practice Guidance Arising from the Kyoto Protocol. As a result, the sub-categories listed in Table 7 were identified as key categories for the KP-LULUCF inventory pursuant to Article 3.3. The key factors in such selections were the relevant emissions-contribution levels and emissions trends. With the help of Table 2.1.1, the activities selected in accordance with Article 3.4 were then correlated with these categories. Under this article of the Kyoto Protocol, Germany has selected the categories forest management, cropland management and grazing land management. These results, as well as the criteria used for the selection, are presented in CRF Table NIR.3 (Table 469 in Chapter 17.1.4)).

Table 6: Key categories for Germany pursuant to the Tier 1 method

IPCC Categories	Activity	Emissions of	Base Year	Base Year + sinks	Level				Trend		Emission Base Year (in kt CO ₂ equi.)	Emission 2015 (in kt CO ₂ equi.)
					Level 1990	1990 + sinks	Level 2015	2015 + sinks	2015	2015 + sinks		
1.A.1.a Public electricity and heat production	All fuels	CO ₂	●	●	●	●	●	●	●	●	L/T	338,451.2
1.A.1.a Public electricity and heat production	All fuels	CH ₄	-	-	-	-	●	●	●	●	L/T	172.2
1.A.1.a Public electricity and heat production	All fuels	N ₂ O	-	-	-	-	●	-	-	-	L/-	2,407.5
1.A.1.b Petroleum refining	All fuels	CO ₂	●	●	●	●	●	●	●	●	L/T	20,165.6
1.A.1.c Manufacture of solid fuels and other energy industries	All fuels	CO ₂	●	●	●	●	●	●	●	●	L/T	65,289.1
1.A.2.a Manufacturing industries and construction: iron and steel	All fuels	CO ₂	●	●	●	●	●	●	●	●	L/T	35,269.3
1.A.2.e Manufacturing industries and construction: Food processing	All fuels	CO ₂	-	-	-	-	-	-	●	●	-/T	2,015.9
1.A.2.f Manufacturing industries and construction: Non-metallic minerals	All fuels	CO ₂	●	●	●	●	●	●	-	-	L/-	18,507.4
1.A.2.g Manufacturing industries and construction: Other	All fuels	CO ₂	●	●	●	●	●	●	●	●	L/T	127,682.0
1.A.3.b Transport: Road transportation	All fuels	CO ₂	●	●	●	●	●	●	●	●	L/T	151,880.6
1.A.3.b Transport: Road transportation	All fuels	CH ₄	-	-	-	-	-	-	●	-	-/T	1,316.8
1.A.3.c Transport: Railways	All fuels	CO ₂	●	●	●	●	-	-	●	●	L/T	2,900.5
1.A.3.d Transport: Navigation	All fuels	CO ₂	●	●	●	●	-	-	●	●	L/T	3,644.5
1.A.4.a Other Sectors: Commercial/institutional	All fuels	CO ₂	●	●	●	●	●	●	●	●	L/T	64,105.9
1.A.4.a Other Sectors: Commercial/institutional	All fuels	CH ₄	-	-	-	-	-	-	●	●	-/T	1,461.6
1.A.4.b Other Sectors: Residential	All fuels	CO ₂	●	●	●	●	●	●	●	●	L/T	128,635.8
1.A.4.b Other Sectors: Residential	All fuels	CH ₄	-	-	-	-	-	-	●	●	-/T	2,483.9
1.A.4.c Other Sectors: Agriculture/Forestry/Fisheries	All fuels	CO ₂	●	●	●	●	●	●	●	●	L/T	10,270.1
1.A.5. Other: Include Military fuel use under this category	All fuels	CO ₂	●	●	●	●	-	-	●	●	L/T	11,797.5
1.B.1 Fugitive Emissions from Fuels	Solid fuels	CH ₄	●	●	●	●	●	●	●	●	L/T	25,553.4
1.B.2.a Fugitive Emissions from Fuels: Natural gas	Gaseous fuels	CH ₄	●	●	●	●	●	●	●	●	L/T	7,939.9
2.A.1. Mineral Products: Cement Production	Clinker Burning	CO ₂	●	●	●	●	●	●	●	●	L/T	15,145.8
2.A.2. Mineral Products: Lime Production	Burning of limestone and dolomite	CO ₂	●	●	●	●	●	●	-	-	L/-	5,986.6
2.B.1 Chemical Industry	Ammonia production	CO ₂	●	●	●	●	●	●	-	-	L/-	6,025.0
2.B.2. Chemical Industry	Nitric acid production	N ₂ O	●	●	●	●	-	-	●	●	L/T	3,258.5
2.B.3. Chemical Industry	Adipic acid production	N ₂ O	●	●	●	●	-	-	●	●	L/T	18,076.7
2.B.9. Fluorochemical production		HFCs	●	●	●	●	-	-	●	●	L/T	C
2.C.1. Metal Production: Iron and steel production	Steel (integrated production)	CO ₂	●	●	●	●	●	●	-	-	L/-	22,810.3
2.C.3. Aluminium production	Primary aluminium production	PFCs	-	-	-	-	-	-	●	●	-/T	1,800.7
2.F. Product uses as substitutes for ODS	0	HFCs	-	-	-	-	●	●	●	●	L/T	C

IPCC Categories	Activity	Emissions of	Base Year	Base Year + sinks	Level			2015 + sinks	Trend		Emission Base Year (in kt CO ₂ equi.)	Emission 2015 (in kt CO ₂ equi.)
					Level 1990	1990 + sinks	Level 2015		2015	2015 + sinks		
2.G. Other product manufacture and use	includes 2.B.10. Other N-dodecanedioic acid	N ₂ O	-	-	-	-	-	-	●	●	-/T	2,029.5
2.G. Other product manufacture and use	0	SF ₆	●	●	●	●	●	●	●	●	L/T	C
3.A.1. Enteric fermentation	Dairy cows	CH ₄	●	●	●	●	●	●	●	-	L/T	19,089.1
3.A.1. Enteric fermentation	Other cattle	CH ₄	●	●	●	●	●	●	●	●	L/T	14,163.3
3.D. Agricultural soils	0	N ₂ O	●	●	●	●	●	●	●	●	L/T	28,575.0
3.G. Liming	0	CO ₂	●	-	-	-	-	-	-	-	L/-	2,704.0
3.J. Other	0	CH ₄	-	-	-	-	-	-	●	●	-/T	0.3
4.A. Forest land	0	CO ₂		●		●		●		●	L/T	-75,542.1
4.B. Cropland	0	CO ₂		●		●		●		●	L/T	12,436.4
4.C. Grassland	0	CO ₂		●		●		●		●	L/T	25,543.6
4.D. Wetlands	0	CO ₂		●		●		●		●	L/T	4,064.0
4.E. Settlements	0	CO ₂		-		-		●		●	L/T	1,810.7
5.A. Solid Waste Disposal on Land	Managed Waste Disposal on Land	CH ₄	●	●	●	●	●	●	●	●	L/T	34,250.0
5.B Wastewater Handling	Domestic Wastewater	CH ₄	-	-	-	-	-	-	●	●	-/T	2,696.2

Table 7: Results of KP-LULUCF key-category assessment

Category	Selected KP activities (cf. KP supplement, Table 2.1.1)	matter	1990	2015	1990	2015
4.A.1 Forest Land remaining Forest Land	FM	CO ₂	70,327.1	53,534.3	●	●
4.A.1 Forest Land remaining Forest Land	FM	CH ₄	0.6	0.6	-	-
4.A.1 Forest Land remaining Forest Land	FM	N ₂ O	0.2	0.3	-	-
4.A.2 Land converted to Forest Land	AD	CO ₂	5,215.0	4,392.7	●	●
4.A.2 Land converted to Forest Land	AD	CH ₄	0.2	0.2	-	-
4.A.2 Land converted to Forest Land	AD	N ₂ O	0.6	0.2	-	-
4.B.1 Cropland remaining Cropland	CM	CO ₂	5,880.3	7,553.3	●	●
4.B.1 Cropland remaining Cropland	CM	CH ₄	5.2	6.7	-	-
4.B.2 Land converted to Cropland	D, CM	CO ₂	6,556.1	6,795.1	●	●
4.B.2 Land converted to Cropland	D, CM	CH ₄	2.7	3.2	-	-
4.B.2 Land converted to Cropland	D, CM	N ₂ O	0.9	1.0	-	-
4.C.1 Grassland remaining Grassland	GM	CO ₂	26,368.4	22,790.1	●	●
4.C.1 Grassland remaining Grassland	GM	CH ₄	21.9	19.5	-	-
4.C.1 Grassland remaining Grassland	GM	N ₂ O	0.3	0.3	-	-

Category	Selected KP activities (cf. KP supplement, Table 2.1.1)	matter	1990	2015	1990	2015
4.C.2 Land converted to Grassland	D, CM, GM	CO ₂	824.8	697.9	-	-
4.C.2 Land converted to Grassland	D, CM, GM	CH ₄	1.9	1.0	-	-
4.C.2 Land converted to Grassland	D, CM, GM	N ₂ O	0.0	0.0	-	-
4.D.1 Wetlands remaining Wetlands	-	CO ₂	3,674.7	3,591.5	●	●
4.D.1 Wetlands remaining Wetlands	-	CH ₄	1.5	1.4	-	-
4.D.1 Wetlands remaining Wetlands	-	N ₂ O	0.1	0.1	-	-
4.D.2 Land converted to Wetlands	D, CM, GM	CO ₂	389.3	415.3	-	-
4.D.2 Land converted to Wetlands	D, CM, GM	CH ₄	0.2	0.3	-	-
4.D.2 Land converted to Wetlands	D, CM, GM	N ₂ O	0.0	0.0	-	-
4.E.1 Settlements remaining Settlements	-	CO ₂	636.6	1,011.4	-	-
4.E.1 Settlements remaining Settlements	-	CH ₄	0.5	0.9	-	-
4.E.1 Settlements remaining Settlements	-	N ₂ O	0.1	0.2	-	-
4.E.2 Land converted to Settlements	D, CM, GM	CO ₂	1,174.1	2,290.7	-	-
4.E.2 Land converted to Settlements	D, CM, GM	CH ₄	0.4	0.8	-	-
4.E.2 Land converted to Settlements	D, CM, GM	N ₂ O	0.3	0.5	-	-
4.F.1 Other Land remaining Other Land		CO ₂	0.0	0.0	-	-
4.F.2 Land converted to Other Land	D, CM, GM	CO ₂	0.0	0.0	-	-
4.G Harvested wood products	FM	CO ₂	1,330.0	2,123.5	-	-
4.H Other	-	N ₂ O	0.4	0.3	-	-

Table 8: Key categories for Germany identified solely via the Tier 2 approach

IPCC Source Categories	Activity	Emissions of
1.A.4.b Other Sectors: Residential	All fuels	CH ₄
3.B.1.a Manure Management	Dairy cows	CH ₄ & N ₂ O
3.B.5 Indirect N ₂ O emissions	Atmospheric deposition	N ₂ O
4.C Grassland		CH ₄
4.G Harvested Wood Products		CO ₂
5.B Wastewater Handling	Domestic Wastewater	N ₂ O

1.6 Information regarding the quality assurance and quality control plan , the inventory plan (including verification) and management of confidential information

1.6.1 Quality assurance and quality control procedures

1.6.1.1 QC/QA plan

Pursuant to the 2006 IPCC Guidelines, the necessary QC/QA and verification measures for emissions reporting should be summarised in a QC/QA plan. Such a QC/QA plan is to serve the primary purpose of organising, planning and assuring the proper execution of such QC/QA measures. The QC section of the plan is relatively simply structured, and it remains unchanged from year to year. This is in keeping with the National System's basic purpose, which is to subject the entire inventory, each year, to a complete QC process in accordance with the Guidelines, and to cover all categories in the process, regardless of whether they are key categories or not. The QC section of the plan basically consists of the QC/QA checklists (cf. Chapter 1.6.1.2) and the inventory plan (cf. Chapter 1.6.1.3). A nearly identical approach is used with the QA section of the plan. This means that quality checks are carried out each year, as required by the Guidelines. At the same time, the required "peer reviews" are carried out periodically (see also below). The QA section of the plan thus basically consists of the QC/QA checklists (cf. Chapter 1.6.1.2) and of the schedule for emissions reporting (cf. Chapter 1.2.1.5), including the tasks that schedule entails. Those checklists and schedule, along with the approval processes specified by the QSE, ensure that inventories annually undergo numerous checks, including internal checks and (especially) checks carried out by external checking authorities focussed on quality assurance. The external checks also include the "basic expert peer reviews" that are carried out annually by the participating ministries. The results of those reviews, including any required corrections, enter into inventories prior to completion of the reporting process, and in the framework of the established routines. These quality assurance activities are complemented and reinforced by periodic peer reviews (cf. Chapter 1.6.1.4).

Regular adaptation and revision of the aforementioned instruments, also taking country-specific requirements into account, ensure that the requirements of the 2006 Guidelines are met also in terms of proper consideration of specific national circumstances.

A general description of the manner in which the quality assurance and control process is organised – with regard to both establishment and workflow – is provided in Chapter 1.3.3.1. That section also describes the principles by which QC/QA measures are controlled and documented.

The requirements for quality assurance and quality control measures in emissions reporting are described in detail in the "Handbook for quality control and quality assurance in preparation of emissions inventories and reporting under the UN Framework Convention on Climate and EU Decision 525/2013/EC" ("Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU Entscheidung 280/2004/EG" (Federal Environment Agency, 2015, unpublished). The most important specifications set forth in the handbook consist of quality reviews carried out primarily prior to the conclusion of inventory preparation.

1.6.1.2 Checklists

The quality checks are carried out with the help of checklists (for the relevant content, cf. Chapters 1.3.3.1.5 and 22.1.2.1.11). These lists currently comprise some 85 role-specific individual targets and some 50 optional targets.

Currently, some 50 Federal Environment Agency and external staff, in various functional roles, and in four layered, cumulative QC/QA review levels, are involved in emissions reporting. The review levels are represented, in each case, by the relevant expert (Fachverantwortlicher – FV); his superior, the QC/QA section representative (QKV); a specialised contact person, within the Single National Entity, for the relevant category (Fachlicher Ansprechpartner – FAP); and, finally, the co-ordinators responsible for achieving a consistent overall result comprising the NIR, the inventory, the QSE and uncertainties estimates.

In inventory preparation, role-specific QC/QA reviews are linked with general quality targets (cf. Chapter 22.1.2.1.10.3) and individual process steps (cf. Chapter 1.2.3), so that final evaluation can take account of such targets and steps. As a whole, the reviews cover the entire inventory-preparation process.

Subsequent evaluation of the checklists reveals, for specific categories, aspects that need to be reviewed – and, possibly, revised – with regard to fulfillment of specific inventory requirements. Such fulfillment is achieved via addition of pertinent further information. The great majority of all identified review requirements are added to the binding inventory plan. The inventory plan undergoes internal and interdepartmental approval processes and is then published in aggregated form.

1.6.1.3 Inventory plan

For the annual preparation of the inventory plan, the results of the QC/QA checklists for all categories are evaluated, and targets that have not been achieved are assigned improvement measures as necessary, as well as deadlines for their implementation (follow-up procedure). Those measures are then complemented by the improvement activities mentioned in the NIR (cf. Chapter 10.4.1), the results of the various review procedures of the UNFCCC and the EU Commission, by the results of audits (cf. Chapter 1.6.1.4) and by any listings of further required improvements. In a longer time frame, further potential verification activities are outlined (cf. 1.6.1.4). The inventory plan comprises a range of individual measures that are to be implemented by the various roles within the QSE (cf. the role concept within QSE, Chapter 1.3.3.1.3) and by the Federal German ministries involved in emissions reporting (cf. Chapter 1.3.3.1.3), along with their subordinate authorities. The included measures are binding, i.e. have to be completed within the time periods defined within the inventory plan, although it must be noted that the relevant responsible NaSE participants have to provide the necessary personnel and financial resources for the measures.

During the preparation for each current IP, the QSE coordinator reviews whether the required actions defined in previous years have been completed. The IP is then updated with the information that results from such review. Required actions that could not be completed by the defined deadlines are flagged with an "overdue" status and given higher priority (in the "follow-follow-up procedure").

Because the individual measures included within the inventory plan are so numerous – they are too many to be listed here – they have been combined into overarching measures, as shown in Table 9. The inventory plan is updated at least once a year, via an ongoing process.

As measures within the inventory plan are implemented, large numbers of the included individual measures are processed to the point where they can be removed from the list. This occurs on a regular basis.

Table 9: Inventory plan– areas in which action is required

Main Category	CRF-Code	Data quality objective	Source	Source-Reference-Year of Reporting
Industrial Processes	2.A.4.a	Check whether there are any gaps in the available data for time series as of 1990.	CHKL	2013
Industrial Processes	2.C.2, 2.C.3.a	Check whether the source category is completely covered by the relevant data source and whether the defined data sets for EF and AR are consistently delimited.	Audit	2016
General	-		ARR, Audit	2013, 2016
Energy	1.A.2.g.vii., 1.A.3.b+c+d.(a), 1.A.4.a.ii+b.ii+c.ii, 1.B.2.a+b	Check whether uncertainties have been determined, are complete and up to date.	Audit, CHKL	2012, 2014-16
Industrial Processes	2.A.4.a., 2.B.10.(i), 2.C.3.a., 2.D.3.(a+b), 2.D.3.(a,d,e,f,g,h,i)		Audit, CHKL	2012, 2016+17
Waste	5.A.1		Audit	2016
General	-		Audit, CHKL	2015, 2016
Energy	1.A.1, 1.A.2, 1.A.2.e, 1.A.2.g.vii., 1.A.3.a.ii, 1.A.3.b+c+d.(a+b)+e., 1.A.4.a.ii+b.ii+c.ii+iii,, 1.A.5.b+(iii), 1.B.2.a+b, 1.D.1.b	Check whether obligations pertaining to keeping of records and documentation are fulfilled and whether the relevant documents are complete, meaningful and up to date.	Audit, CHKL	2012-2017
Industrial Processes	2.A.1+3+4a, 2.B.3+8, 2.C.3.a., 2.D.3.(a,d,e,f,g,h,i), 2.F.5		Audit, CHKL	2016+17
Agriculture LULUCF	3.A+B+D+G 4.LULUCF(Total area)		Audit Audit	2016 2016
Waste	5.A.1, 5.B.1+2, 5.D.1+2		Audit, CHKL, Sonstige	2012, 2014-2017
General	-	Check whether data suppliers and contracted supporting entities are carrying out suitable routine quality controls, and whether the emissions-reporting requirements defined by the Single National Entity have been provided to such suppliers and entities and are being fulfilled.	Audit, Sonstige	2014, 2016
Energy	1.A.3.a-c+d, 1.A.4.c.iii, 1.A.5, 1.A.5.b		Audit, CHKL	2012, 2015-17
Industrial Processes	2.B.8.a., 2.B.9, 2.C.2, 2.D.3.(b), 2.F.5		Audit, CHKL	2012, 2016-17
Waste	5.B.1+2, 5.D.1		Audit, CHKL	2012, 2016
General	-		CHKL, Sonstige	2015, 2017
Energy	1.A, 1.A.2f, 1.D.1.a. 2.A.4.a,		ARR, Audit, Sonstige	2014-2016
Industrial Processes	2.B.3+4.a+8+10.(i), 2.C.2, 2.D.1, 2.E.4	Check whether requirements for cross-checking and verification of data and their underlying assumptions have been fulfilled.	Audit, CHKL	2013, 2015-17
Agriculture LULUCF	3.H+J 4, 4.B+C		CHKL NIR, Sonstige	2015 2012, 2014, 2017
Waste	5.D.1		CHKL	2014, 2015, 2017
General	-		ARR, ESD	2010, 2015
Industrial Processes	2.B.8, 2.D.1	Check whether it was possible to take pointers from inventory reviews and inventory plan into account.	CHKL	2017
Waste	5.B.1+2, 5.D.1		ESD	2015
Energy	1.A.5.b(ii+iii),	Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.	CHKL	2016+17
Industrial Processes	2.B.3		Audit, CHKL	2016+17
Waste	5.A.1, 5.D., 5.D.1+2		CHKL, NIR, Sonstige	2013, 2016+17
Industrial Processes	2.A.3, 2.A.4.a., 2.C.6, 2.F.5	Check whether the EF are plausible and complete (have no gaps and are completely documented) and up to date.	Audit, NIR	2015+16
LULUCF	4. (Total area)		NIR	2015, 2016
Waste	5.B.1+2		Audit	2016

Main Category	CRF-Code	Data quality objective	Source	Source-Reference- Year of Reporting
Industrial Processes	2.A.3, 2.B.4.a., 2.B.10(i), 2.D.3.(a)	Check whether the AR are plausible and complete (have no gaps and are completely documented) and up to date.	Audit, NIR, CHKL	2015-17
LULUCF	4.A.		NIR	2012
General	-	Check whether data has been entered into the CSE correctly, including whether all numbers, units and conversion factors have been correctly entered and properly integrated.	CHKL	2015
Industrial Processes	2.B.8+10.(i), 2.D.3.(a)	Check whether the NIR source category has been completely and logically described in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	CHKL	2016-17
LULUCF	4 (II), 4.A.(b)		CHKL	2017
Waste	5.D.1		CHKL	2015-2017
General	-		Sonstige	2014, 2016
Energy	1.A.2.e, 1.A.3.a+d.(a), 1.A.4.c.iii, 1.A.5.b.(iii), 1.B.2, 1.D.1.a	Various types of required action.	Audit, CHKL, Sonstige	2013, 2015-17
Industrial Processes	2.A.2, 2.A.4.a., 2.B.8+10.(i), 2.C.3.a., 2.D.1, 2.F.5		Audit, CHKL, NIR	2015-17
Agriculture	3.A+B+D+J		CHKL, NIR	2011, 2012, 2017
LULUCF	4.C-E, 4.Total area		CHKL	2017
Waste	5.D.1		CHKL	2015-17
KP	KP		ARR	2013, 2014
Energy	1.A.1, 1.A.1.c, 1.A.3.a+b, 1.B.1, 1.B.2.a+b	Check whether pertinent responsibilities need to be updated.	Audit, CHKL	2016+17
Industrial Processes	2.B.4.a+8.+10.(i)		CHKL	2016
Waste	5.D.1		Audit	2016
Industrial Processes	2.A.4.a, 2.D.3.(b)	Initiated research projects for inventory improvement.	Audit, NIR	2012, 2016
LULUCF	4.A		NIR	2011
Waste	5.D.1		NIR	2016

The first inventory plan was published together with the 2007 Submission. Since then, several thousand items for action or improvement have been addressed within the quality system. Since that total is too unwieldy to be presented in any clear manner, we simply provide an overview of the development of the IP since the 2010 Submission.

As of the end of the current reporting year, the inventory plan comprises some 2,000 items for action or improvement. Of those items, which are distributed throughout about 160 categories, some 1,550 have been completed to date.

In the current report cycle, an additional group of about 185 required improvements were identified – and an additional 5 of the required changes that emerged from reviews of past years were addressed and completed. The focuses of all improvements completed to date include the areas of documentation, review results and verification. The focuses of the some 350 improvement items that are still open or still undergoing processing include documentation and verification, as well as various other types of improvements. If one takes into account the number of repetitions that necessarily result via recurrence of checklist and review results of past years, then the number of open improvement items decreases to an actual figure of about 450.

The overview in Table 10 presents more-detailed information on the improvement items that have been successfully addressed. Both tables (Table 9 & Table 10) include the review results from the years 2006 through 2014, the statements made in the NIR relative to planned improvements in the years as of 2011, the other improvement items for the years as of 2008 and the CHKL results from the years as of 2010.

Detailed information regarding individual improvements, with respect to categories, priorities, deadlines, responsibilities, gases, fuels, needs for action, etc., cannot be provided here, due to the sheer scope of the information involved. With regard to successfully addressed Review results, more-detailed excerpts from the inventory plan are provided in Table 425, while information relative to statements made in the NIR regarding planned improvements is provided in Table 426.

Table 10: Inventory plan – Items for action/improvement that have been successfully addressed

Main Category	CRF	Data quality objective	Source	Source-Reference-Year of Reporting
Energy	1.A, 1.A.4.c.iii., 1.D.1.b.	Check whether requirements of IPCC Good Practice Guidance pertaining to selection of calculation method and to procedures for applicable methods changes are fulfilled or if it's necessary to adjust already existing calculation methods/modells.	ARR, CHKL	2008, 2011-2014
Industrial Processes	2.A., 2.B.8, 2.C., 2.C.1, 2.E., 2.F.1+6		S&A I, NIR, CHKL	2006, 2010, 2012
Agriculture LULUCF	3.A+B 4.D		NIR, ARR, Sonstige	2009, 2011-2013
Waste	5.A, 5.D.1		ARR, CHKL	2011-2014
Energy	1.A.1, 1.A.2.f, 1.A.2.g.viii, 1.A.3.e	Check whether the data source (s) used will be available throughout the long term.	CHKL	2011, 2014-2016
Agriculture LULUCF	3.A.(a), 3.B.(a) 4		CHKL Sonstige	2010 2008
Waste	5.D.2, 5.E.1		CHKL	2010, 2015
Energy	1.A.3.c		CHKL	2010, 2013+2014
Industrial Processes	2.C.2+3	Check whether there are any gaps in the available data for time series as of 1990.	CHKL	2010-2011
Agriculture	3.A.(b), 3.B.(b), 3.D		CHKL	2010-2011
LULUCF	4. (total area), 4.A.(a)		CHKL, NIR	2012, 2015
Waste	5.D.2.		NIR	2013
Energy	1.A.1, 1.A.2.g.viii, 1.A.3.e.ii, 1.A.4.c.ii, 1.D.1.b., 2.B.2., 2.C.1, 2.D.3.(c)	Check whether the source category is completely covered by the relevant data source and whether the defined data sets for EF and AR are consistently delimited.	CHKL	2011, 2014, 2015
Industrial Processes	2.D.3.(c)		Audit, CHKL, NIR	2012, 2016
Waste	5.A.1, 5.D.1+2		CHKL, NIR	2011, 2012, 2015
General	General		ARR, CHKL	2011, 2013, 2015
Energy	1.A.2, 1.A.3.a.ii, 1.A.3.b+c, 1.A.3.e.ii, 1.A.4.a-c, 1.A.5.b	Check whether uncertainties have been determined, are complete and up to date.	CHKL	2010-2012, 2014, 2015
Industrial Processes	2.C.1-3, 2.D.3.c, 2.F.5, 2.G.4.(a)		Audit, CHKL, NIR	2010-2011, 2015, 2016
LULUCF	4, 4(III+IV), 4.A, 4.B-F		Sonstige, CHKL, NIR, ARR	2008, 2010-2011
Waste	5.A.1, 5.D.1		CHKL	2010-2014

Main Category	CRF	Data quality objective	Source	Source-Reference-Year of Reporting
Energy	1.A, 1.A.1+2, 1.A.1.c, 1.A.2.a+g.vii, 1.A.3.a-e, 1.A.4, 1.A.4.b.ii+c.ii+iii, 1.A.5.a+b, 1.B.1+2, 1.D.1.a+b	Check whether obligations pertaining to keeping of records and documentation are fulfilled and whether the relevant documents are complete, meaningful and up to date.	Audit, CHKL, ARR	2010-2017
Industrial Processes	2.B.1.+2+9, 2.C.1-3, 2.F.1, 2.G.2.(c), 2.G.3.a.(i)+b, 2.H.1+2, 2.B.10.(i)			
Agriculture	3.A.+B+D+G			
LULUCF	4, 4(III+IV), 4.A-F, LULUCF - Total area			
Waste	5.A.1, 5.B.1, 5.D.1+2, 5.E.1		Audit, CHKL	2010-2013, 2015+2016
General	General 1.A.1+2, 1.A.3.a.ii, 1.A.3.b-d, 1.A.3.e.ii, 1.A.4.c.ii, 1.A.5.b, 1.D.1.b	Check whether data suppliers and contracted supporting entities are carrying out suitable routine quality controls, and whether the emissions-reporting requirements defined by the Single National Entity have been provided to such suppliers and entities and are being fulfilled.	CHKL	2014
Energy	2.C.2, 2.C.3.a.		CHKL	2010-2011, 2014
Industrial Processes	3, 3.A., 3.B., 3.D		Audit, CHKL	2011, 2016
Agriculture	4, 4(III), 4.A.1, 4.B-F		CHKL, Sonstige	2008, 2010-2011
LULUCF	5.D.1		CHKL, Sonstige	2008, 2010, 2012
Waste			CHKL	2010-2011
General	General 1, 1.A, 1.A.1+2, 1.A.3.a-e, 1.A.4, 1.A.4.a.ii+b.ii., 1.A.4.c.ii+iii, 1.A.5.a+b, 1.B.1+2, 1.D.1.a	Check whether requirements for cross-checking and verification of data and their underlying assumptions have been fulfilled.	ARR, CHKL	2008, 2017
Energy	2.A.1-4, 2.B.1+3+7+8, 2.C.1-3, 2.D.1+2+3.(b), 2.G.3.a.(i), 2.G.4.(a+c), 2.H.2		ARR, Audit, Eu-Rev, S&A I, CHKL, NIR	2006-2008, 2010-2017
Industrial Processes	3.H		Audit, ARR, CHKL, NIR	2010-2016
Agriculture	4(II-V), 4.A-F, 4.LULUCF(Total area)		CHKL	2015
LULUCF	5.A.1, 5.B.2, 5.D, 5.D.2		Audit, CHKL, NIR	2010, 2012, 2014-2017
Waste			Audit, CHKL	2010-2016

Main Category	CRF	Data quality objective	Source	Source-Reference-Year of Reporting
General	General		ARR, IRR	2006, 2008-2013
Energy	1, 1.A, 1.A.1.a+b, 1.A.2, 1.A.2.a+f, 1.A.3.b-d, 1.B.1+2, 1.B.2.a.iii, 1.B.2.b. iv, 1.D.1 2, 2.A.1+2,		ARR, ESD, IRR, SL	2006, 2008-2013, 2015
Industrial Processes	2.A.4.b+d., 2.B.1-3+4.b+9, 2.C.1-4, 2.D.3.(a), 2.F+G	Check whether it was possible to take pointers from inventory reviews and inventory plan into account.	ARR, ESD, IRR, CHKL	2006, 2008-2010, 2012-2015
Agriculture	3, 3.A-D+G		ARR, ESD, IRR, NIR	2006, 2008-2010, 2012-2015
LULUCF	4, 4.A-D		ARR, IRR, SL	2006, 2008-2010, 2012-2013
Waste	5, 5.A, 5.A.1., 5.C.1, 5.D, 5.D.2, 5.E		ARR, ESD, IRR, CHKL	2006, 2008-2010- 2015
KP	Kyoto Protocol		ARR	2010-2013
General	General		ARR	2011
Energy	1, 1.A, 1.A.1+2, 1.A.2.a+f+g, 1.A.3.a.ii+b-d, 1.A.4, 1.A.5.b, 1.B.1.a, 1.B.2 2, 2.A.4.d, 2.B.2+4.a+8,	Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.	ARR, EU-Rev, S&A I, CHKL, NIR	2006-2008, 2010- 2016
Industrial Processes	2.B.10.(i), 2.C.1, 2.D.3.(b+c), 2.F.1, 2.G.4.(a), 2.H.1.(b)		ARR, EU-Rev, CHKL	2007, 2010-2013, 2016
Agriculture	3, 3.D		ARR	2008
LULUCF	4, 4.A.2, 4.B.1, 4.C.1		EU-Rev, NIR	2007, 2013
Waste	5.A, 5.D, 5.E.1		ARR, EU-Rev, CHKL, NIR	2007, 2011-2014
Energy	1.A.1, 1.A.2, 1.A.2.f.(d), 1.A.3.d(b)+e.ii, 1.A.4, 1.A.5.a	Check whether the EF are plausible and complete (have no gaps and are completely documented) and up to date.	ARR, Audit, CHKL, EU-Rev, S&A I, NIR	2006, 2007, 2011- 2014, 2016
Industrial Processes	2.B.1, 2.B.9., 2.C.4, 2.F		Audit, EU-Rev, NIR	2007, 2011, 2016
Agriculture	3.B, 3.B.(b)		EU-Rev, NIR	2007, 2012
LULUCF	4.C.2		EU-Rev	2007
Waste	5.B.1, 5.D.1		CHKL, NIR	2013+2014
General	General		Sonstige	2008
Energy	1.A.1; 1.A.2; 1.A.3.a+b+d, 1.A.4+a.i+c.i; 1.A.5.a, 1.B.1.c, 1.D.1.a+b	Check whether the AR are plausible and complete (have no gaps and are completely documented) and up to date.	EU-Rev, S&A I, NIR, CHKL	2006, 2007, 2011- 2013, 2015, 2016
Industrial Processes	2.A.3		NIR	2011-2012
Agriculture	3.A(b)+B+D		NIR	2011-2012
LULUCF	4.A-C		NIR	2011-2012
Waste	5.A.1, 5.D.2, 5.E.1		ARR, NIR, Sonstige	2011-2013, 2015
Waste	5.D.1	Check whether data has been entered into the CSE correctly, including whether all numbers, units and conversion factors have been correctly entered and properly integrated.	CHKL, Sonstige	2011, 2013-2015

Main Category	CRF	Data quality objective	Source	Source-Reference-Year of Reporting
General	General		ARR	2011
Energy	1, 1.A., 1.A.1, 1.A.2.f.(a-d), 1.B.1, 1.B.2.a		ARR, CHKL	2008, 2011-2013
Industrial Processes	2.A.4(a), 2.B.3+4.a, 2.B.1+9, 2.C, 2.C.2+3, 2.D.3.(b), 2.G.3.a.(i), 2.G.4.(a), 2.H.1.(a)	Check whether the NIR source category has been completely and logically described in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	ARR, EU-Rev, CHKL	2007, 2010-2011-2016
LULUCF	4, 4.A.(b), 4.G		ARR, CHKL	2011, 2015
Waste	5.C.1, 5.D		ARR, CHKL	2011-2013
General	General		ARR	2011
Energy	1, 1.A.1+2+4		EU-Rev, S&A I	2006, 2007
Industrial Processes	2	Check whether any recalculations are required. If they are they must be documented in a logical manner.	ARR, EU-Rev, S&A I	2006, 2007, 2011-2013
Agriculture	3		S&A I	2006
LULUCF	4.A		ARR	2011
Waste	5, 5.E		S&A I, EU-Rev	2006, 2007
General	General		ARR, CHKL, Sonstige	2010+2011, 2013+2014, 2016
Energy	1.A., 1.A.2.f.(a-d), 1.A.2.g.vii., 1.A.3.a-e, 1.A.4.+a.ii+bii+c.i i+iii, 1.A.5.b, 1.B.1+2, 1.B.2.d 2.A.4.a+d., 2.B.4.a+8.f.+9+10	Various types of required action.	NIR, Sonstige, CHKL	2009-2015
Industrial Processes	(i), 2.C.1+6, 2.D.1-3.(a+c), 2.G.3.a.(i), 2.G.3.b., 2.G.4, 2.H.1.		ARR, Audit, CHKL, NIR, Sonstige	2010-2013, 2016
Agriculture	3		NIR	2011
LULUCF	4, 4.A-D		ARR, NIR	2008, 2011, 2013
Waste	5.D		CHKL, Sonstige	2013, 2016
Energy	1.A.2.a+b+d+e+f. (d), 1.A.3.a+b+d.(a)+ e., 1.A.4.c.iii., 1.B.1, 1.B.2.b, 1.B.2.c.iii.- Flaring, 1.D.1.a. 2.A.3+4.(b), 2.B.3+8.a-c+g.(i), 2.C.1-3(a), 2.D.3.(b+c), 2.G.3.a.(i), 2.G.3.b, 2.H.1.		Audit, CHKL	2010, 2013-2016
Industrial Processes	2.B.3+8.a-c+g.(i), 2.C.1-3(a), 2.D.3.(b+c), 2.G.3.a.(i), 2.G.3.b, 2.H.1.	Check whether pertinent responsibilities need to be updated.	Audit, CHKL	2010-2014, 2016
Agriculture	3.A.+B.+D.+G.		Audit	2016
LULUCF	4.A., 4.LULUCF(Total area)		Audit	2016
Waste	5.D.1.		Audit, CHKL	2010, 2013, 2016

Main Category	CRF	Data quality objective	Source	Source-Reference-Year of Reporting
Energy	1.A.1, 1.A.2.f, 1.A.3.c-e, 1.A.4.c.iii., 1.B.1.c, 1.B.2, 1.D.1.b.	Initiated research projects for inventory improvement.	CHKL, NIR	2011-2014
Industrial Processes	2.A.2+4.a, 2.G.2		Audit, NIR	2011+2012, 2016
Agriculture	3.B		NIR	2012
LULUCF	4.A-C+E		NIR	2011-2012
Waste	5.A.1, 5.B.1		CHKL, NIR	2011-2012, 2014

1.6.1.4 Audits

In April 2016, the Federal Environment Agency's Quality System for Emission Inventories (QSE) was externally audited for the first time. The aims of the audit were to:

- Check whether the QSE is conformal with the quality requirements of the 2006 IPCC Guidelines,
- Identify any potential for improvement,
- Identify any possible risks for the continuing maintenance of data quality.

An audit program was developed that covers more than simply a representative cross-section of all emissions categories, since the audited staff, in most cases, also handle additional, "related" categories, and do so with procedures that differ little from those used in the directly considered cases.

In February 2016, the so-developed audit plan was used as a basis for carrying out a pre-audit for two categories, and for the coordinators of the Quality System for Emission Inventories (QSE), the Central System of Emissions (CSE) (the database) and the National System (NaSE), with a view to testing the audit's suitability and time requirements and to determining whether the audit plan needed to be adjusted in any way. In parallel with the revision of the audit plan, a schedule for the execution of the audit, with 5 auditors, was prepared. During the audit, the following procedure was normally carried out on three successive days: the responsible experts (Fachverantwortlicher; FV) and their specialised contact persons (Fachlicher Ansprechpartner; FAP) were audited in pairs. This work covered a total of 44 of 148 categories. The reviewed procedures and workflows in the audited categories represent more than 80 % of the total emissions covered by the German greenhouse-gas inventory. In addition, all coordinators who had not already been covered in the pre-audit were included in the audit program, in the framework of individual audits.

The audit plan covered the following topic areas:

- Roles and responsibilities
- The use of general quality control procedures
- Implementation of requirements set forth in the QSE manual (IB, IP, NIR)
- Category-specific quality controls for
 - emission factors
 - measurements
 - activity data
 - calculation procedures and determination of uncertainties

The key findings of the audit include:

1. The minimum requirements pertaining to quality control / quality assurance (QC/QA), as specified by the 2006 IPCC Guidelines, are being met, without exception. All target requirements are being met via the design and the implementation of the QSE.
2. The QSE's prescribed QC/QA procedures function effectively in assuring data quality, in conformance with the requirements of the IPCC Guidelines, and in ensuring that a continual improvement process takes place. The success of the system depends on consistent fulfillment of the QSE requirements via the involved staff and areas.
3. The QSE accomplishes much more than its goal of fulfilling the minimum requirements; for many aspects of the inventory process, it provides best-practice examples modelled after the 2006 IPCC Guidelines. The structure and the scope of the inventory description are worthy of particular mention. In nearly all categories studied, the description serves as a comprehensive, transparent tool for documentation of data, the processing status and the procedures applied. Only in the area of category-specific quality control – in a small number of aspects – is some room for improvement seen, and the relevant improvements could well be carried out in the longer term (such as preparation of standardised spread-sheet templates)
4. The risk that data quality could decrease is seen as very low, in light of the QSE's structure and design, as well as of the extensive, detailed information contained in the inventory descriptions. Risks might apply with regard to temporary gaps in the continual, consistent use of survey and calculation procedures, since extrapolation calculations, for reporting purposes, sometimes have to be carried out in cases in which experienced staff suddenly become unavailable. By no means does such unavailability lead to a loss of information, however – it would always be possible to subsequently restore the database, at the customary data quality levels.
5. In some categories, data quality could be improved still further via more-frequent review of the currentness of the data used. It thus could be useful to review, at mandatory intervals, whether emission factors are still current, or whether in the meantime data that would support use of higher-Tier approach (such as national factors, instead of the IPCC defaults) have become available or could be obtained. Where factors prove to require updating, the necessary studies could be included in the research budget.
6. Individual potential improvements for the categories studied, and for general areas, could also be determined. Such aspects would be included in the existing instruments for improvement (the inventory plan).

An external audit has proven to be a useful element in the process of providing quality assurance for the national reports. Current plans call for such audits to be repeated at regular intervals (of about 5 years). Such audits could be complemented by internal audits – carried out by internal auditors – that would monitor the implementation of improvement processes and that, via annually changing focuses throughout a multi-year repeating schedule, would cover all procedural steps for quality control and reporting.

1.6.1.5 Workshops on the National System (Peer Review)

In November 2004, the Federal Environment Agency held a first workshop on the National System of Emissions Inventories. This created a forum that significantly promoted inclusion of associations and other independent organisations, as well as supporting implementation of Paragraph 15 (b) of the *Guidelines for National Systems*, which requires that inventories be reviewed by third parties (peer review).

Subsequently, several workshops were held with the purpose of facilitating review of the inventories by independent third parties, pursuant to Paragraph 15 (b) of the *Guidelines for*

National Systems. In 2009, a second workshop focussed on selected specific categories of the inventory, such as "N₂O from product use," "emissions from non-energy-related use of fossil fuels" and "SF₆ emissions from the photovoltaics industry". The extensive and intensive discussions conducted during the workshop contributed significantly to overall improvement of the data – and, thus, to the quality of the reporting.

In 2011, an international experts' workshop on the German LULUCF-reporting system was carried out that reviewed the methodological changes made as a result of the In-Country Review of September 2010. All of the recommendations made by experts in that framework have been fully implemented.

Technical discussions on the topic of natural gas statistics were conducted with the Federal Statistical Office in 2012 and in summer 2015 (one discussion at each time). The participants in the technical discussion in 2012 included representatives of the Federal Statistical Office, the Federal Environment Agency (UBA) and the German Association of Energy and Water Industries (BDEW), as well as representatives of various gas companies and the German Institute for Economic Research (DIW; Working Group on Energy Balances (AGEB)). In preparation for revision of the national Energy Balance, the discussion focussed on the available natural gas statistics. In the process, measures were approved that will directly improve the Energy Balance and, thus, will improve the emissions inventory. In addition, agreement was reached on additional study that will be carried out in order to verify the available statistical data. The technical discussion in 2015 served the purpose of coordinating data exchange between the Federal Statistical Office and the Federal Environment Agency, also with regard to the new reporting requirements set forth in the 2006 IPCC Guidelines and the European Greenhouse gas Monitoring Mechanism Regulation (MMR).

In March 2014, a workshop was held with European inventory experts on the topic of implementation of the 2006 IPCC Guidelines in German greenhouse-gas reporting. That workshop, which had about 60 participants, focussed especially on the sectors of energy (CRF 1) and industrial processes and product use (CRF 2). With the help of the findings from experience that were shared during that event, it proved possible to significantly improve implementation of the new methods in German greenhouse-gas inventories.

1.6.1.6 Cross-Country Review on fluorinated gases

In February 2011, a group of experts met in Vienna for a cross-country review focussing on reporting on F gases. The participating countries included the UK, Austria and Germany. After basic presentations of data collection in the three countries, the various individual areas of application concerned were considered in detail and compared in terms of data sources, precision, emission factors and other criteria. In the process, it emerged that, of the three countries, Germany has the most extensive specialised knowledge resources and presumably is thus best able to assess the completeness and plausibility of the available data.

One of the key results that emerged from the cross-country review is that all three countries have to commit high levels of manpower to reporting on F gases. Any reduction in such resources commitments would mean that reporting would no longer be IPCC-conformal.

As a result of the meeting, a report was prepared that has entered into German reporting regarding F gases.

1.6.2 Activities for verification

1.6.2.1 Verification in selected categories

In the 2015/2016 reporting year, a verification project was carried out, in keeping with the *2006 IPCC Guidelines (Vol.1, Chapter 6)*. In the project, all of the inventory's categories were reviewed for any need for verification. The following categories were identified:

- 1.A.2.a Iron & Steel
- 1.A.3.e Other Transportation
- 1.B.1.a.ii Surface Mining
- 1.B.2.b.v.i Natural Gas: Other
- 2.A Mineral Industry
- 2.B.1 Ammonia Production
- 2.B.2 Nitric Acid Production
- 2.B.3 Adipic Acid Production
- 3 Agriculture
- 4 Land Use Matrix
- 4 Consistency between the descriptions in the NIR and the CRF tables
- 4.A Forest Land
- 5.A.1 Managed Waste Disposal

For each of the listed categories, verification has been, or will be, carried out by the project holder. Upon completion of this work, the results will be listed in the relevant categories' verification chapters (i.e. the results for a given category will be listed in that category's verification chapter).

1.6.2.2 Procedure for using monitoring data from European emissions trading

In efforts to fulfil mandatory quality criteria, a need has been seen – especially within the EU – to use data from the EU Emissions Trading Scheme (EU ETS) to improve greenhouse-gas emissions inventories. All Member States are now called upon to use ETS data to improve the quality of their annual national emissions inventories.

A reliable database from emissions trading, showing relevant annual emissions, is available for the period since ETS monitoring commenced. Those data can be used, in aggregated form, to draw category-specific conclusions regarding the completeness and consistency of certain parts of emissions inventories. In addition, they provide a basis for reviewing emission factors used and for verifying activity data. Since emissions calculations for all components are all based on the same activity data, such verification is of significance for all reported emissions inventories.

Emissions-trading data required for improvement of inventory data subject to reporting are available in electronic form, in the installations database of the German Emissions Trading Authority (DEHSt). In 2005, agreement was reached regarding a general procedure for individual data queries related to inventory preparation. In the main, this procedure involves direct communication between the Single National Entity and the German Emissions Trading Authority's section E 2.3, which is responsible for reports (cf. Chapter 1.3.3.1.8). To make it possible to use this "resource" on a regular basis, this formalised procedure for the pertinent required annual data exchanges, including deadlines and defined workflows, has been agreed.

Monitoring data from European emissions trading will be used to improve the quality of annual national emissions inventories with respect to categories that include installations subject to reporting obligations under the CO₂ Emissions Trading Scheme (ETS). Relevant information is provided in the category chapters on verification, although the detailed comparisons involved are

presented only in some cases. For reasons of confidentiality, especially regarding certain inventory details, the results of the comparisons are usually simply described in text form. Tables with the data used can be made available only in connection with inventory reviews. The comparison of fuel-related CO₂ emission factors in the Annex, Chapter 18.7, provides a sample overview of a successful verification.

The process of data provision, from the German Emissions Trading Authority (DEHSt) to the responsible experts for the inventories, called for several instances of project-based support. In a research project (ÖKO-INSTITUT, 2006b), allocation rules were developed that make it possible to compare data from verified emissions reports with data from the inventories' database, on a year-by-year basis. The comparisons, which have been carried out only once to date, have confirmed, in principle, the usefulness of such comparisons for verifying individual categories and identifying data gaps. A follow-on project begun in 2011, "D.E.N.K.", studied whether the allocation rules can be improved and the relevant procedure can be further automated. In the process, it became clear that the data quantities the ETS provides for inventory calculations present challenges in terms of available resources and time. When discrepancies occur in existing aggregates that fulfill requirements for confidentiality of business and operational secrets, the underlying data sets for individual operational steps have to be checked. At an international workshop held within the project framework, experts of other countries confirmed that issue's importance for the German situation. The number of ETS data sets is so large – 35,000 – that the limits of capacities for checking such sets (instead of automatically using the pertinent aggregates) are being reached. Consequently, it will not be possible to bring the procedure used in this area into line with the procedures used in other countries.

1.6.3 Handling of confidential information

When the Federal Statistical Office began providing data in connection with the entry into force of the 3rd SME Relief Act (Mittelstandsentlastungsgesetz 3; MEG 3), the Federal Environment Agency received access to data subject to statistical secrecy.

In addition, from associations and companies, the Single National Entity receives activity data, emission factors and emissions data that reflect operational and business secrets and that are otherwise confidential.

In storing and using such data, therefore, the Single National Entity must take special precautions, and apply special procedures, to protect the confidentiality of the data.

In particular, it must provide for strict separation (both spatial and in terms of staff assignments) of statistical work / analysis and any enforcement of legal provisions pertaining to the installations for which data are collected.

The Single National Entity and the affected sections of the Federal Environment Agency have taken various measures for the purpose of fulfilling these requirements. For example, as a basic rule, persons charged with enforcement of laws in a specific area are never permitted to carry out specialised tasks relative to emissions reporting in the same area.

In 2008, the Single National Entity commissioned a legal study with the aim of precisely assessing the requirements and possibilities pertaining to use and management of data for emissions reporting. The results entered into revision and refinement of the Single National Entity's concept for handling confidential data.

Previously, access to the Central System on Emissions (CSE) database was already limited to a specified group of authorised persons. That measure represents the key precaution for dealing

with confidential data. In particular, it makes it practicable to separate – in terms of the persons involved – the tasks of data analysis and legal control. In addition, in 2009 a special access-restricted area was set up, on a central server of the Federal Environment Agency, for confidential electronic data that are not centrally stored in the CSE (for example, energy data subject to statistical confidentiality, emissions-control declarations, data relative to large combustion plants, information about production processes, etc.).

Furthermore, data provided by the *Federal Statistical Office* are placed on a password-/access-protected server (i.e. available only for specifically authorised persons) at the *Federal Statistical Office*.

1.7 General estimation of uncertainties

1.7.1 Greenhouse-gas inventory

The 2006 IPCC Guidelines characterise determination of uncertainties as a key element of any complete inventory. As a result of the need to continually improve the inventories, uncertainties in the inventories play an important role. Uncertainties information is used primarily as an aid for improving the precision of inventories, as well as for selecting methods and carrying out recalculations for inventories. The declared aim is to minimise uncertainties to the greatest possible degree, in order to maximise the inventories' accuracy. Annex I countries must thus first quantify the uncertainties for all categories and sinks, in order to enhance their assessment of inventory quality – which assessment, in turn, is the key to effective inventory planning.

Uncertainties are quantified for emission factors and activity data; in some cases, they are also quantified for emissions.

In general, two methods for determining uncertainties are differentiated. The Tier 1 method combines, in a simple way, the uncertainties in activity data and emission factors, for each category and greenhouse gas, and then aggregates these uncertainties, for all categories and greenhouse-gas components, to obtain the total uncertainty for the inventory. The Tier 2 method for uncertainties determination is the same, in principle, but it also considers the distribution function for uncertainties and carries out aggregation using Monte Carlo simulation. In the Tier 2 method, this process also necessarily includes determining a probability density function for both parameters. Ideally, these functions can be determined via statistical evaluation of individual data items (such as measurements for a large number of facilities). In many cases, few relevant values are available, however, and thus the uncertainty must be determined on the basis of experts' assessments.

Research project 202 42 266 (UBA, 2004) has determined uncertainties, for the first time, in keeping with the Tier 1 and Tier 2 methods, pursuant to Chapter 6 of the 2000 Good Practice Guidance. Since then, the resulting database has been continually improved, and the uncertainties data for the greenhouse-gas inventory have been further improved for the 2016 report. In addition, the provisions of the 2006 Guidelines have been adopted. In the current NIR, Germany reports uncertainties that have been calculated pursuant to the Tier 1 method. The uncertainties for the activity data, emission factors and emissions data used were taken from the CSE database. They are based on estimates of experts in relevant departments of the Federal Environment Agency and at external institutions. In cases in which uncertainties information is not yet available in complete form, as an expert's estimate, pertinent figures are added from other sources (such as relevant technical literature).

1.7.1.1 Germany carries out Tier 2 uncertainties analysis every 3 years. Tier 1 approach for uncertainties determination

In the Tier 1 method, in keeping with Chapter 3 of the 2006 IPCC Guidelines, uncertainties are determined on the basis of the uncertainties for AR (activity data), EF and EM, as determined on the lowest sub-category level (primarily by responsible experts of the Federal Environment Agency), and as listed in the CSE. Where asymmetric uncertainties figures are yielded, the larger of the two relevant values is used, under the assumption of a normal distribution, as both the upper boundary and the lower boundary. In each sector, the uncertainties for the individual time series are aggregated to form a total uncertainty for the sector pursuant to the IPCC Good Practice Guidance.

1.7.1.2 Results of uncertainties assessment

In general, uncertainties for activity data can be assumed to be smaller than those for emission factors. In particular, the uncertainties are smaller for activity data derived from fuel use and based on the Federal Energy Balance. On the other hand, uncertainties for activity data derived from disaggregated fuel use normally increase as the relevant disaggregation increases.

- Pursuant to the results from an R&D project (RENTZ et al, 2002), the uncertainties in emission factors for indirect greenhouse gases in stationary combustion systems (CRF 1.A.1) are relatively small, as a result of regular monitoring of such emissions. Higher uncertainties are listed for N₂ emission factors, since N₂ emissions are not normally monitored. The same applies to the emission factors for CH₄.
- The uncertainties in the Transport category (primarily CRF 1.A.3) can generally be considered to be small, since precise relevant data on fuel use and vehicle fleets are available, due to taxation obligations, and since that category's emission factors have been very finely modelled and are normally determined via measurements. Some uncertainties may arise via systematic measuring errors or wrong disaggregation.
- In the category Fugitive emissions from fuels (CRF 1.B), the uncertainties for the activity data for oil and natural gas (CRF 1.B.2) are low, as a result of the fuels' being subject to taxation. Flaring of gases represents the only exception. The activity data for Coal mining (CRF 1.B.1) are also well-represented by production volumes. By contrast, the uncertainties for emission factors for fugitive emissions are likely to be higher. This results from the great number and diversity of the technical factors that affect fugitive emissions in transport, storage and processing of oil and natural gas.

- Considerable uncertainties are seen in many areas in the category of industrial processes (CRF 2). Activity rates based on production figures that must be reported to the Federal Statistical Office can be subject to uncertainties, especially as a result of discrepancies between reporting structures and relevant industry definitions. Activity rates determined from association information are subject to uncertainties that correlate, in each case, with the degree to which the relevant industrial sector is represented in the association in question. For emission factors, uncertainties – which can be considerable, depending on the greenhouse gas in question – result, understandably, from the factors' strong dependence on technology, in combination with extensive technological diversification. Furthermore, equipment-specific emission factors often are tied to business secrets, particularly in sectors with few market players (for example, manufacturing of chemical products (CRF 2.B)), and this tends to make operators hesitant to publish such data or leads them to provide information in consolidated form. In addition, uncertainties can be higher for complex processes in which non-combustion-related activities generate emissions, if relevant emissions-generating processes are inadequately understood and the relevant contributions of pertinent individual activities are not known.
- In the area of production of alcoholic beverages, within the area of Food and drink production (CRF 2.H.2), the activity-rate uncertainties must be considered very small, since production of such beverages is subject to taxation regulations that require very precise determination of production volumes. On the other hand, statistics for sectors with large numbers of small and medium-sized enterprises (such as baked-goods production) tend to be significantly less precise, and thus the activity data for such sectors are subject to higher uncertainties. The uncertainties for the relevant emission factors are also larger, due to the sectors' extensive technological diversification.
- The uncertainties for emissions parameters for the categories Managed waste disposal in landfills (CRF 5.A.1, 5.B and 5.E) and Industrial wastewater treatment (CRF 5.D) are presumed to be high. This applies especially to the areas of composting, MBT and waste landfilling, which have high waste-type diversity that tends to reduce the reliability of data for the relevant emissions parameters. The reasons for the higher uncertainties seen for activity data include the fact that the underlying statistical data make use of non-standardised waste and recycling definitions. The general assumptions relative to the uncertainties of activity data also apply to thermal treatment of waste.

Pursuant to Tier 1, the inventory's total uncertainty figures for 2015 are 4.5 % (level) and 5.1 % (trend).

Nitrous oxide emissions overall also contribute significantly to the total uncertainty. This effect is shaped especially by nitrous oxide emissions from agricultural soils (3.D) and from municipal wastewater treatment (5 D.1).

The CO₂ sinks and sources in the LULUCF sector also account for an important share of the total uncertainty.

The CO₂ emissions of the sector Combustion of fuels (1.A) contribute another important share of the total uncertainty. The predominating components of that share include solid fuels in the sector Public electricity and heat production (1.A.1.a) and mobile sources (1.A.3), especially road transports (1.A.3.b) and combustion in the residential, commercial and institutional sectors (1.A.4.a/b/c).

Significant contributions to the total uncertainty also come from the areas of methane emissions from waste storage (5.A) and animal husbandry (enteric fermentation, 3.A). Detailed information about the applicable uncertainties is provided in Annex 7 (cf. Chapter 23).

1.7.2 KP LULUCF inventory

Since the same data and methods are used, under both UNFCCC and KP, for reporting for categories 4.A-4.G, the uncertainties for the two reporting areas are comparable. The information provided in the previous chapter and in the relevant category chapters (cf. Chapters 11.3.1.5 and 19.4.3) applies.

1.8 General checking of completeness

1.8.1 Greenhouse-gas inventory

Completeness information for the various individual categories is presented in CRF Table 9(a), which is summarised in NIR Chapter 21 (Table 520 and Table 521). The following are differentiated in Germany:

- Source-specific emissions and sinks that do not occur (NO – not occurring),
- Source-specific emissions and sinks that are not reported in Germany, either because they are not quantitatively relevant or because the necessary data for calculation are lacking (NE – not estimated).

The following section touches on a few category-specific approaches for improving the completeness of the inventory.

All combustion-related activities (1 A) from the area of energy are recorded in full. At certain points, the Energy Balance of the Federal Republic of Germany is supplemented if it is evident that complete coverage is not achieved in selected sub-sections (such as the non-commercial use of wood, secondary fuels). In some categories, separation of combustion-related and non-combustion-related emissions from industry requires further verification. In general, avoidance of duplicate counting is an important part of quality assurance for such categories, however.

In the area of industrial processes, some use is made of production data from association statistics and of manufacturers' information. In the interest of the inventory's completeness and reliability, where emissions reporting is based on such sources, checking of category definitions and data-collection methods will continue to receive priority.

The "Not Estimated" (NE) emissions, which are still reported, consist primarily of non-calculated emissions that, pursuant to IPCC GPG (2003, p.1.11), do not have to be calculated by a reporting country, since those emissions are listed in Appendices 3a.2, 3a.3 and 3a.4..

Some of the emissions data available to the Federal Environment Agency are confidential, due to data-protection requirements, and thus are reported only in aggregated form – although they are reported completely.

1.8.2 KP LULUCF inventory

Since, for reporting for categories 5.A-5.G, the data and methods used for reporting under UNFCCC do not differ from those used for reporting under KP, the information provided in the previous chapter applies.

2 Trends in Greenhouse Gas Emissions

Table 11 below shows the total emissions, as determined for this inventory, of direct and indirect greenhouse gases and of the acid precursor SO₂. Table 12 shows the annual progress achieved, with respect to 1990, for each pertinent year. With the exception of HFC, and the rather minimal emissions of NF₃, considerable emissions reductions were achieved for all substances. In total, greenhouse-gas emissions, calculated as CO₂ equivalents, decreased by 28.1 %, with respect to 1990¹⁹.

All detailed tables relative to discussion of trends are presented in Annex Chapter 22.2.4.3.

Trends, taking account of changes with respect to the previous year of the reporting period

With regard to the previous year, 2014, total emissions decreased by 0.3 %. As was the case in 2014, the decrease was tied to lower CO₂ emissions that, in turn, were tied to a mild winter weather and its lower heating requirements. In addition, CO₂ emissions from electricity generation decreased further, as a result of lower coal and natural gas inputs in that sector.

¹⁹ All figures do not include emissions from the category of Land Use, Land-Use Change & Forestry (LULUCF).

Table 11: Emissions of direct and indirect greenhouse gases and SO₂ in Germany since 1990

Emissions Trends (kt)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Net CO ₂ emissions/removals	1,019,229	903,409	859,653	852,192	863,298	837,241	833,178	768,816	814,391	795,156	800,967	819,417	778,240	775,753
CO ₂ emissions (without LULUCF)	1,052,247	938,150	899,286	865,866	877,369	850,743	853,592	788,510	832,437	812,577	817,145	835,459	794,829	792,054
CH ₄ with LULUCF	4,847	4,233	3,544	2,774	2,618	2,526	2,488	2,399	2,365	2,320	2,346	2,321	2,275	2,259
CH ₄ without LULUCF	4,812	4,198	3,509	2,739	2,583	2,491	2,453	2,364	2,330	2,285	2,311	2,287	2,240	2,225
N ₂ O with LULUCF	221	207	147	148	147	154	156	153	126	131	128	130	132	134
N ₂ O without LULUCF	218	205	145	146	145	151	153	150	123	128	125	127	129	131
HFC (CO ₂ equivalent, 1995 base year)		8,217	7,806	9,940	10,162	10,448	10,589	11,170	10,753	10,953	11,140	11,096	11,183	11,356
PFC (CO ₂ equivalent, 1995 base year)		2,087	959	839	671	589	568	407	346	279	243	257	235	254
SF ₆ (CO ₂ equivalent, 1995 base year)		6,467	4,072	3,320	3,242	3,181	2,971	2,924	3,100	3,163	3,155	3,261	3,396	3,562
NF ₃		5	9	34	28	12	30	29	61	61	35	16	20	12
NO _x	2,887	2,168	1,928	1,575	1,558	1,486	1,412	1,311	1,334	1,314	1,271	1,267	1,220	1,186
SO ₂	5,485	1,745	644	472	473	456	453	396	409	399	381	373	357	352
NM VOC	3,389	2,025	1,599	1,311	1,316	1,252	1,197	1,101	1,216	1,130	1,105	1,092	1,016	1,020
CO	12,498	6,436	4,790	3,718	3,621	3,503	3,398	2,952	3,317	3,230	2,855	2,828	2,715	2,678

Table 12: Changes in emissions of direct and indirect greenhouse gases and SO₂ in Germany, since the relevant reference years

Emissions Trends	Base Year	Base Year to 2014	Base Year to 2015	Compared to prev. year (2014 – 2015)
Changes compared to base year / prev. year (%)				
Net CO ₂ emissions/removals	1990	-23.6	-23.9	-0.3
CO ₂ emissions (without LULUCF)	1990	-24.5	-24.7	-0.3
CH ₄ (including LULUCF)	1990	-53.1	-53.4	-0.7
N ₂ O (including LULUCF)	1990	-40.1	-39.3	+1.3
HFC	1995	+36.1	+38.2	+1.5
PFC	1995	-88.8	-87.8	+8.1
SF ₆	1995	-47.5	-44.9	+4.9
NF ₃	1995	+283.4	+124.7	-41.4
Total emissions (without LULUCF)	Base Year	-27.9	-28.1	-0.3
NO _x	1990	-57.8	-58.9	-2.7
SO ₂	1990	-93.5	-93.6	-1.4
NM VOC	1990	-70.0	-69.9	+0.4
CO	1990	-78.3	-78.6	-1.4

2.1 Description and interpretation of trends in aggregated greenhouse-gas emissions

From 1990 through 2014, greenhouse-gas emissions were reduced considerably, by 28.1 %²⁰. The individual greenhouse gases contributed to this development to varying degrees (cf. Table 1). Among the direct greenhouse gases, emissions of those gases that predominate in terms of quantity were markedly reduced, with the strongest reductions occurring for methane. The main reasons for these developments are found in the following areas:

- Transition from use of solid fuels to use of liquid and gaseous fuels, which have lower emissions, in the period since 1990;
- Growing use of renewable energies, and growing, related, use of substitutes for fossil fuels;
- Increased plant (installation) efficiencies;
- Changes in animal-housing methods, and reductions of livestock populations;
- Fulfillment of legal regulations in the waste-management sector;

Such areas are considered in greater detail in the discussion below of trends for the various individual greenhouse gases.

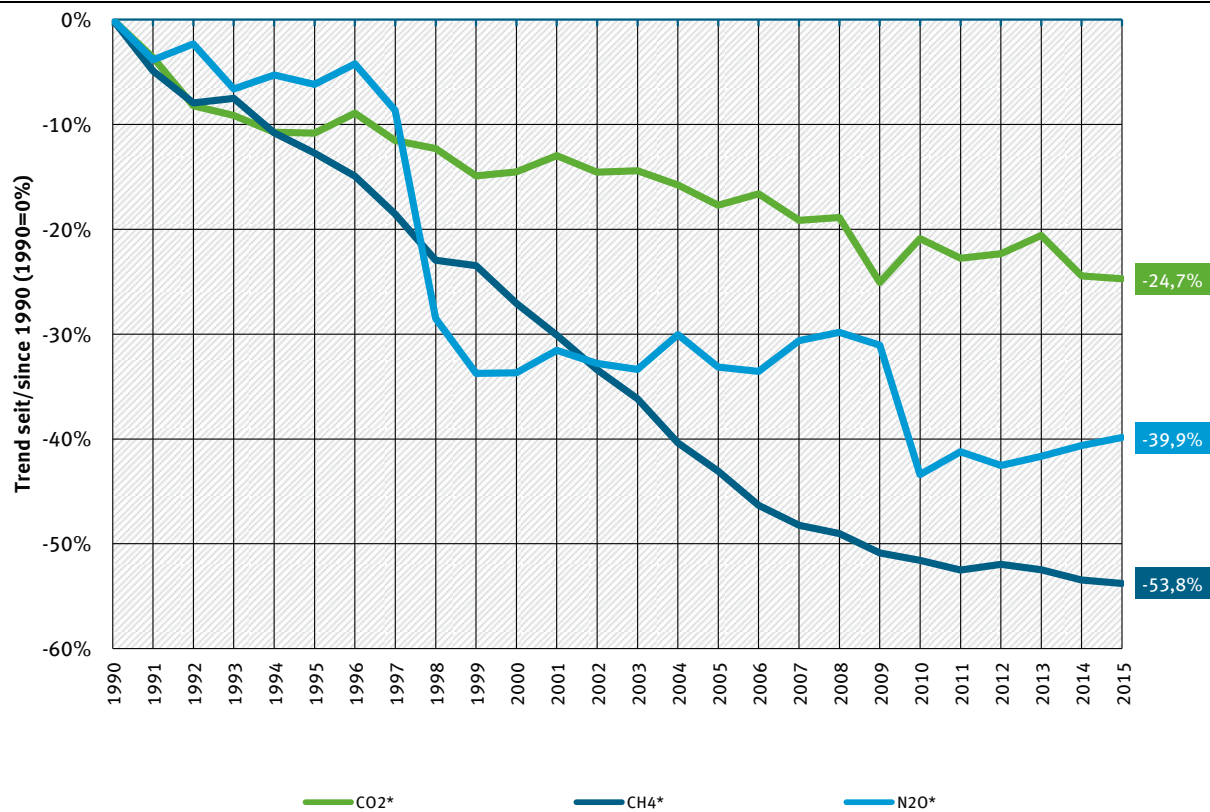
Releases of carbon dioxide – the great majority of which are caused by stationary and mobile combustion processes – predominate in the overall picture of greenhouse-gas emissions. Due to a disproportionately large decrease in emissions of the other greenhouse gases, the proportion of total greenhouse gases attributable to CO₂ emissions has increased since 1990 (cf. Table 2). All other greenhouse gases together account for only slightly more than one-tenth of greenhouse-gas emissions. Germany's range of greenhouse-gas emissions is typical for a highly industrialised country.

²⁰ All figures do not include emissions from the category of Land Use, Land-Use Change & Forestry (LULUCF).



2.2 Description and interpretation of emission trends, by greenhouse gases

Figure 14: Relative development of greenhouse gases in comparison to their levels in 1990



* Carbon dioxide emissions apart from LULUCF

Figure 14 shows the relative development of emissions of the various greenhouse gases since 1990. In the discussion, it must be remembered that the development of each of these greenhouse gases as shown here is largely dominated by specific developments in a single category.

2.2.1 Carbon dioxide (CO₂)

The reduction in CO₂ emissions is closely linked to trends in the energy sector. The sharp emissions reduction in this area seen in the early 1990s was primarily the result of restructuring in the new German Länder, including related conversions to cleaner fuels and decommissioning of obsolete facilities. The changes in the fuel mix have continued, to a somewhat lesser degree, through the current report year.

Use of gases, primarily natural gas, as substitutes for solid and liquid fuels is also reflected in emissions trends for stationary combustion systems. While CO₂ emissions from liquid fuels decreased by about 23 %, with respect to their levels in 1990, and emissions from solid fuels decreased by about 40 percent, emissions from gaseous fuels increased by about 25 percent.

When these emissions trends are viewed at the level of individual categories, a highly consistent picture emerges. In comparison to 1990 levels, emissions in all sub-categories of energy-related emissions decreased by a total of nearly 244 million t CO₂.

The situation is somewhat different only in the transport sector, which is dominated by road transports: CO₂ emissions in this area increased slightly through 1999, and then decreased slightly

as a result of reductions in consumption, shifting of refueling to other countries²¹, substitution of diesel fuel for gasoline²² and use of admixtures with biodiesel. In about 2007, the trend began stagnating, in part as a result of ongoing increases in average engine power. In the years as of 2013, that stagnation ended, in an upwardly direction, as a result of further increases in transport densities and mileage travelled, and as a result of decreased use of biofuels (between 2012 and 2015, a constant increase amounting to 5.8 million t). The transport sector's CO₂ emissions, at about 159 million t, are thus just slightly below their outset level in 1990 (162 million t).

Trends, taking account of changes with respect to the previous year of the reporting period

CO₂ emissions decreased again slightly with respect to the previous year. Reductions in the energy sector were partly offset by slight increases in the manufacturing sector and by somewhat higher heating requirements in the Residential sector.

2.2.2 Nitrous oxide N₂O

Since 1990, N₂O emissions have decreased by about 40 %. The main emissions areas/sources include agricultural use of nitrogen-containing fertilisers, animal husbandry and fuel use. Smaller amounts of emissions are caused by wastewater treatment, by the chemical industry and by product use of N₂O (for example, as an anaesthetic). Industry has had the greatest influence on emissions reductions, especially in the area of adipic acid production – via installation of waste-gas-treatment systems in 1997 and 2009. Via technological reduction measures, the chemical industry's emissions have been reduced by over 96%, with respect to 1990. Since 1999, emissions trends have been strongly influenced by economic trends in the chemical industry sector.

Trends, taking account of changes with respect to the previous year of the reporting period

The total emissions increased slightly, primarily as a result of continuing emissions increases in the agricultural sector.

2.2.3 Methane (CH₄)

Methane emissions are caused mainly by animal husbandry in agriculture, waste landfilling and distribution of liquid and gaseous fuels; energy-related and process-related emissions, and emissions from wastewater treatment, play an almost negligible role. Methane emissions have been reduced by 53.8 % since 1990. This trend has been primarily the result of environmental-policy measures (waste separation, with intensified recycling and increasing energy recovery from waste) that has decreased landfilling of organic waste. A second important factor is that use of pit gas from coal mining, for energy recovery, has increased, while overall production of such gas has decreased (via closure of hard-coal mines). Emissions in this area have decreased by nearly 76 % since 1990. Yet another reason for the emissions reductions is that livestock populations in the new Federal Länder have been reduced, with reductions occurring especially in the first half of the 1990s. Repairs and modernisations of outdated gas-distribution networks in that part of Germany, along with improvements in fuel distribution, have brought about further reductions of total emissions.

²¹ The emissions are calculated on the basis of domestic fuel sales. Fuel quantities not purchased in Germany thus do not enter into the German emissions inventory.

²² Diesel fuel's share of total fuel consumption in road transports has increased sharply throughout the entire time period. In 1990, nearly two-thirds of road transport emissions were the result of gasoline consumption. Now, this ratio has nearly reversed itself.

Trends, taking account of changes with respect to the previous year of the reporting period

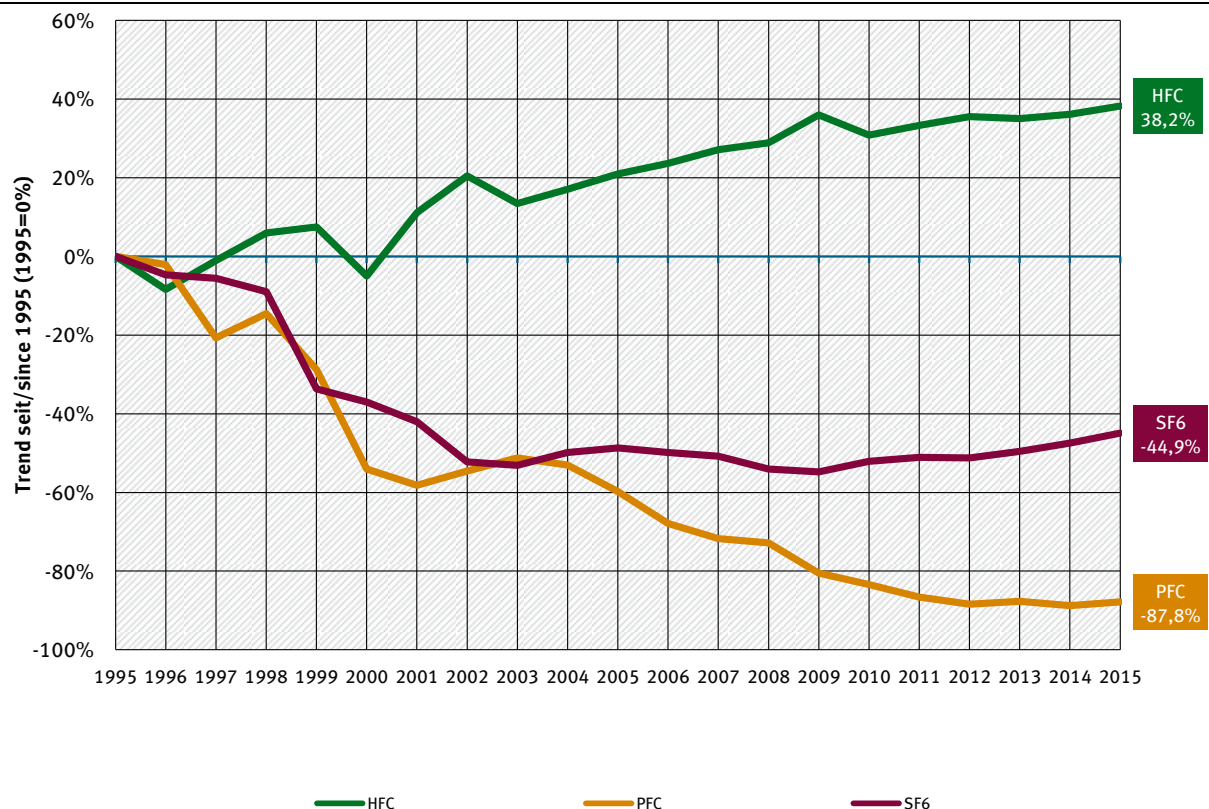
Emissions again decreased slightly with respect to the previous year. Decreases in landfill emissions, and in agricultural emissions, have been partly offset by increases in energy-related emissions.

2.2.4 F gases

Figure 15 shows emissions trends for so-called "F" gases for the period 1995 through 2015. HFC emissions increased primarily as a result of intensified use of HFCs as refrigerants in refrigeration systems and of increasing disposal of pertinent systems. This more than offset emissions reductions resulting from their reduced use in PUR installation foams. The emissions reductions for PFCs were achieved primarily through efforts of primary aluminium producers and semiconductor manufacturers. The SF₆ emissions reduction until 2003 is due primarily to decreasing use of the gas in automobile tyres since the mid-1990s. In this area, efforts to increase environmental awareness have been successful, resulting in emissions reductions of over 100 t and greenhouse-gas reductions of 2.5 million t of CO₂ equivalents. Similar success has been achieved with soundproof windows, for which production use of SF₆ has been reduced to nearly zero since 1995. And a large share of current and future SF₆ emissions (will) result from open disposal of old windows. Emissions from electricity-transmission facilities have also decreased considerably. Important remaining emissions sources include welding, production of solar cells and production of optical glass fibre.

In Germany, NF₃ is used only in semiconductor and photovoltaics production. In 2015, NF₃ emissions accounted for 0.0013 % of total GHG emissions. In the base year, they accounted for 0.0006 % of those emissions. Because those emissions are of such minor importance with regard to total GHG emissions, we have not carried out a separate trend analysis for them.

Figure 15: Relative development of F gases in comparison to relevant 1995 levels



2.3 Description and interpretation of emission trends, by greenhouse gases

Energy

The emissions reduction in the energy sector results primarily from a sharp decrease in combustion-related CO₂ emissions (cf. in this regard also the results of the key-category analysis). On the other hand, emissions of other greenhouse gases are negligible in this sector. The situation is different solely for emissions that are not combustion-related (category 1.B.). In this area, CO₂ emissions are very low, while emissions trends are clearly shaped by CH₄ emissions caused by distribution of liquid and gaseous fuels.

On the whole, energy-related emissions of all greenhouse gases have decreased by 26.5 % since 1990. The transport-related emissions included in greenhouse-gas emissions have decreased by slightly more than 0.2 % during the same period, meaning they have decreased considerably less than emissions from stationary combustion systems have. For combustion-related emissions, this has been achieved through fuel changeovers and higher energy and technical efficiencies. In addition, increasing use of renewable energy sources is having an effect, because carbon dioxide from use of biomass is not reflected in the emissions trends. For distribution emissions, it has resulted from increased use of pit gas, modernisation of gas-distribution networks and introduction of vapour-recovery systems in fuel distribution.

Table 528 in the Annex shows the relevant emissions changes, in comparison to the previous year in each case, for the period since 1990. For CO₂ from the energy sector, for example, it is clear that largely temperature-related fluctuations over time – especially variations in winter temperatures

– influence heating patterns. Such fluctuations thus affect energy consumption for space heating, thereby having a major impact on annual trends in energy-related emissions.

Industrial processes (including product use)

In the area of emissions from industrial processes, carbon dioxide and nitrous oxide are the predominant greenhouse gases. Relatively noticeable changes in emissions of F gases, on the other hand, have no major impacts on overall trends, because such emissions account for only a small share of total emissions.

Emissions from industrial processes are closely tied to production levels. CO₂ emissions trends, in particular, reflect economic trends in the mineral, chemical and metal-producing industries.

The trend for N₂O emissions has been decoupled from production ever since adipic acid producers' emissions-reducing measures began taking effect. In 1997 and 2010 in particular, those measures yielded considerable reductions in this sector's N₂O emissions. Overall since 1990, the sector's N₂O emissions have decreased to about one-twentieth of their outset level.

For greenhouse gases since 1990, and for all industrial processes and product use together, a reduction of 36.3 % GHG equivalents results, along with stagnating emissions in comparison to previous years.

Agriculture

The decrease in agricultural emissions since 1990, amounting to over 15.9 %, is due primarily to reductions in livestock populations, although it is also due to reductions in emissions from agricultural soils and from fertiliser use.

Land use, land-use changes and forestry

The reduction in greenhouse-gas removals via land-use changes and forestry is due primarily to a change of the sink function in the category "Forest Land remaining Forest Land". In the period 2002 through 2007, the decrease in forests' sink function was due to increasing harvesting of wood, for a range of different types of uses. In 2008, the sink function began increasing again, although it did not reach the level seen in the period 1990 through 2001. This was also due to wood use.

Waste and wastewater

The most significant emissions reduction, at 70.5 %, occurred in the area of waste emissions. In that area, intensified recycling of recyclable materials ("yellow sack" for recyclable materials, Ordinance on Packaging, etc.), and the ban, in effect since June 2005, on landfilling of biodegradable waste, have reduced annual quantities of landfilled waste. All in all, these factors have reduced landfill emissions by 73.9 %. Emissions from wastewater treatment, which also belong to this category, are produced in considerably lower quantities than landfill emissions are. Nonetheless, they also decreased very sharply.

The relevant detailed data are presented in Table 529 in Annex Chapter 22.2.4.3.

Table 13: Changes in greenhouse-gas emissions in Germany, by categories, since 1990 / since the relevant previous year

Emissions change with respect to 1990; change in %	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1. Energy	0.0%	-11.5%	-16.1%	-19.8%	-22.7%	-24.6%	-24.0%	-22.2%	-26.3%	-26.5%
2. Industrial processes	0.0%	0.7%	-20.4%	-21.9%	-35.3%	-35.4%	-36.4%	-36.5%	-36.4%	-36.3%
3. Agriculture	0.0%	-14.6%	-15.1%	-20.3%	-21.0%	-18.9%	-19.5%	-18.0%	-16.3%	-15.9%
4. Land use, land-use changes and forestry (CO ₂ , CH ₄ & N ₂ O)	0.0%	5.6%	21.2%	-61.5%	-47.7%	-49.8%	-53.8%	-54.2%	-52.5%	-53.4%
5. Waste	0.0%	0.1%	-24.7%	-44.0%	-61.2%	-63.3%	-65.2%	-67.4%	-68.9%	-70.5%
Emissions change, in each case with respect to the previous year; change in %	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1. Energy	0.0%	-0.2%	-0.4%	-2.4%	5.2%	-2.5%	0.9%	2.3%	-5.2%	-0.3%
2. Industrial processes	0.0%	-1.8%	4.1%	-3.9%	-4.5%	-0.1%	-1.6%	-0.2%	0.1%	0.1%
3. Agriculture	0.0%	2.2%	-0.4%	-0.9%	-1.3%	2.7%	-0.7%	1.8%	2.1%	0.5%
4. Land use, land-use changes and forestry (CO ₂ , CH ₄ & N ₂ O)	0.0%	1.6%	6.6%	28.8%	-9.2%	-3.9%	-8.0%	-1.0%	3.8%	-2.0%
5. Waste	0.0%	-2.5%	-5.0%	-6.3%	-7.2%	-5.3%	-5.4%	-6.1%	-4.6%	-5.1%

2.4 Description and interpretation of trends in emissions of indirect greenhouse gases and of SO₂

The relative development of emissions of indirect greenhouse gases and SO₂ are graphically depicted, in each case as time series since 1990, in Figure 16 and in Table 12. Over this period, considerable reductions of emissions of these pollutants have been achieved. For example, emissions of SO₂ decreased by over 93.6 %, those of CO decreased by 78.6 %, those of NMVOC decreased by 69.9% and those of NO_x decreased by about 58.9 %.

The vast majority of emissions of sulphur dioxide, nitrogen oxide and carbon monoxide are caused by stationary and mobile combustion processes. In the category of NMVOC emissions, however, solvent use is the most important emissions factor.

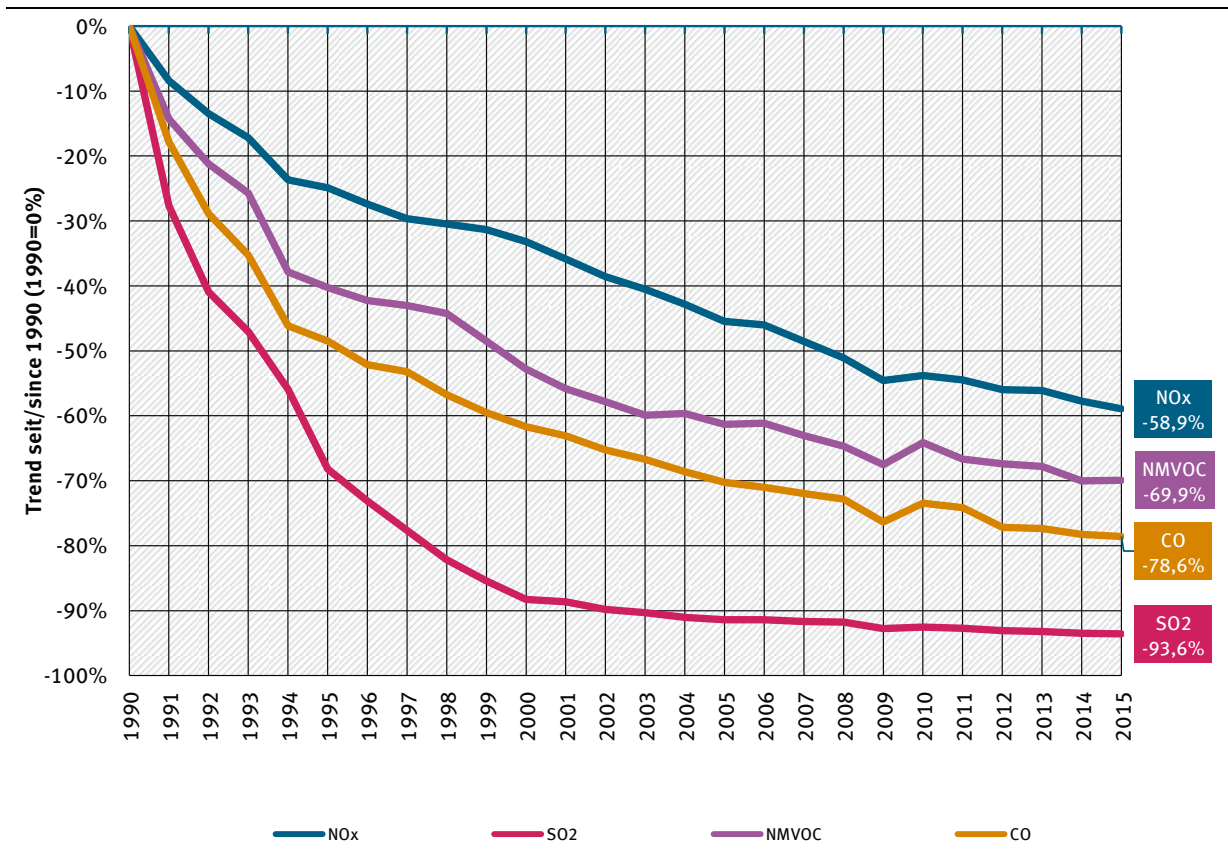
A range of different factors are responsible for this trend. These factors, which differ in the significance and extent of their relevance, include:

- As a result of Germany's reunification in 1990, emissions from the territory of the former GDR in particular made the starting level relatively high.
- In the years that followed, obsolete industrial facilities in the eastern part of Germany were decommissioned. Some of the old installations were replaced with new installations that met requirements for state-of-the-art systems at the time. Non-decommissioned old installations were extensively retrofitted with emissions-reduction and efficiency-enhancing equipment.
- In addition, changes were made in the mix of fuels used. In eastern Germany in particular, local-lignite fractions were reduced in favour of energy carriers such as natural gas and petroleum, which produce fewer emissions.
- In the transport sector, newer vehicles equipped with emissions-control technology were introduced.
- In the years since 1990, the immission-protection provisions of the former Federal Republic of Germany have become legally binding for eastern Germany. Following the expiration of provisional rulings, applicable laws have been repeatedly adapted in keeping with technological progress.
- Established legal regulations and market-economic incentives have led to thriftier use of energy and raw materials.

- International legislation, particularly from the European Community, has had an emissions-reducing effect (e.g. the NEC Directive).
- Increasing use of renewable energy sources (electricity/heat from solar and wind systems, and from geothermal systems) has also had an impact on emissions of indirect greenhouse gases, especially in recent years.

Descriptions of the emission calculations for these pollutants, along with additional, detailed parameters influencing the emissions trends for the various individual air pollutants involved, are provided on the website of the Federal Environment Agency²³.

Figure 16: Emissions trends for indirect greenhouse gases and SO₂



2.5 Description and interpretation of emissions trends with regard to the KP-LULUCF inventory, for aggregated emissions and by activity and greenhouse gas

Germany reports under KP-LULUCF Article 3 (3) (Afforestation/Reforestation, AR; Deforestation, D). In the second commitment period, Germany has to credit Forest Management (FM) activities pursuant to Article 3 (4) of the Kyoto Protocol. The following activities have been selected and reported as voluntary activities under Article 3.4 of the Kyoto Protocol:

7. Cropland management (CM)
8. Grazing land management (GM).

It reports emissions of the greenhouse gases carbon dioxide, methane and nitrous oxide.

²³ <http://www.umweltbundesamt.de/emissionen/index.htm> and directly in the Informative Inventory Report (IIR): <http://iir-de.wikidot.com/>

Under Article 3.3, it is reporting removals of -4,593.88 kt CO₂ equivalent for the year 2015. The removals consist of -6,688.57 kt CO₂ equivalent of removals via afforestation and reforestation and 2,094.69 kt CO₂ equivalent of emissions from deforestation. Under afforestation and deforestation, it is reporting CO₂ emissions of -4,749.06 kt CO₂, CH₄ emissions of 14.44 kt CO₂ equivalent and N₂O emissions of 140.74 kt CO₂ equivalent.

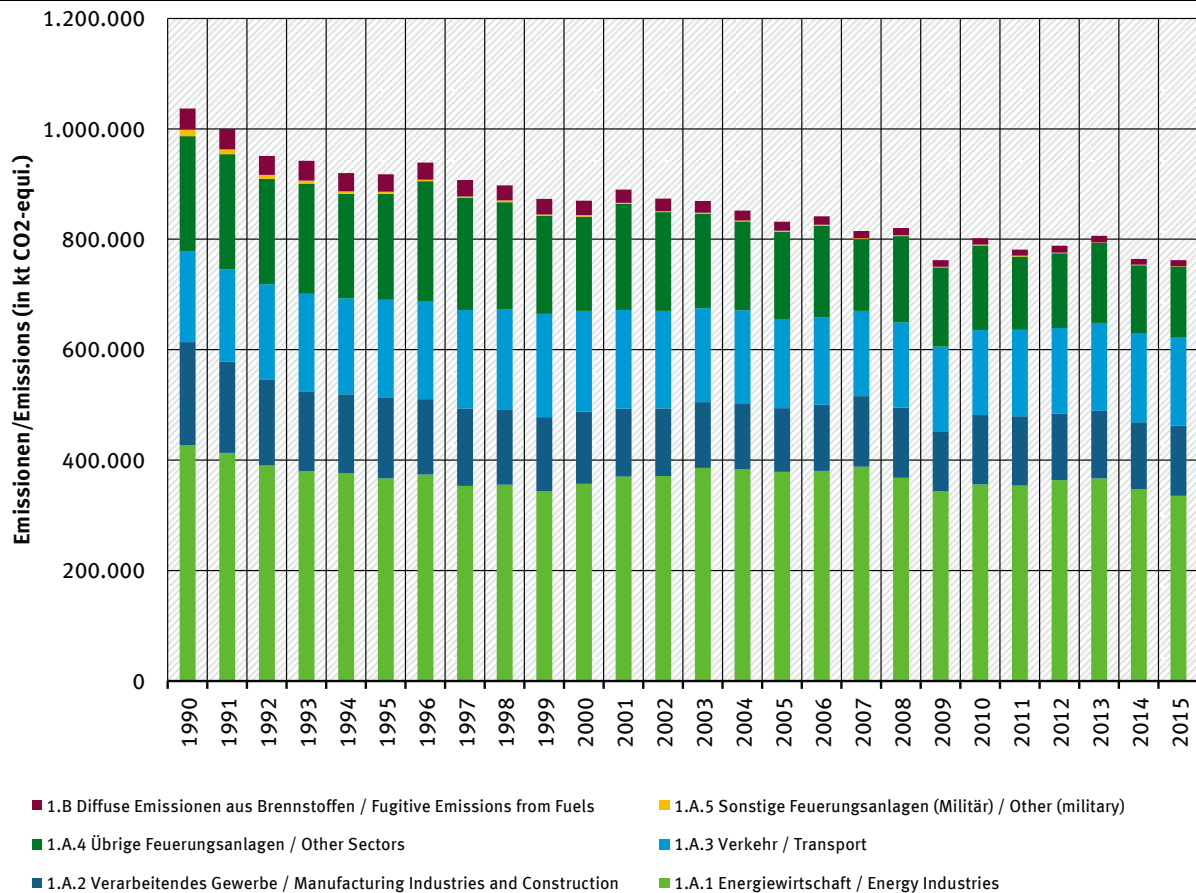
Under Article 3.4, it is reporting removals of 18,037.61 kt CO₂ equivalent in the year 2015. The figure comprises removals of -54,853.17 kt CO₂ equivalent from forest management, emissions of 14,656.22 kt CO₂ equivalent from cropland management and of 22,159.34 kt CO₂ equivalent from grazing-land management. The emissions for the three activities break down as follows by gases: CO₂: -19,203.46 kt; CH₄: 751.98 kt CO₂ equivalent; and N₂O: 413.88 kt CO₂ equivalent.

Table 14: Emissions in 2015 for the KP-LULUCF activities afforestation and deforestation, pursuant to Article 3.3, and for forest management, cropland management and grazing land management pursuant to Article 3.4.

Category	Emissions, 2015 [kt CO ₂ equivalent]
KP 3.3 Afforestation/Reforestation	-6,688.57
KP 3.3 Deforestation	2,094.69
KP 3.4 Forest Management	-54,853.17
KP 3.4 Cropland Management	14,656.22
KP 3.4 Grazing Land Management	22,159.34

3 Energy (CRF Sector 1)

3.1 Overview (CRF Sector 1)

Figure 17: Overview of greenhouse-gas emissions in CRF Sector 1²⁴.

For determination of activity data from combustion, different models are used for mobile and stationary sources. The model used for stationary sources is the "Balance of Emissions Sources" ("Bilanz der Emissionsursachen" – BEU), while the model used for mobile sources is the "Transport Emission Estimation Model" (TREMOD). In both models, combustion-related activities are determined and then recorded in the "Central System of Emissions" (CSE) emissions database.

Within the CSE, relevant emissions are then calculated by multiplying these combustion-related activities by the pertinent emission factors (cf. Chapter 18.7). In the process, complete oxidation of the carbon contained in the fuels is assumed.

3.2 Combustion of fuels (1.A)

The activity data for stationary combustion are calculated in the "Balance of Emissions Sources" (BEU) model. The database for this model, which was developed by the Federal Environment Agency, consists of the Energy Balance of the Federal Republic of Germany. The Energy Balance is described in detail in Chapters 18.1 through 18.4.

²⁴ CO₂ emissions from, and removals in, soils are reported under land-use changes and forestry.

With the help of additional statistics, and of various assumptions, these data are then further disaggregated and supplemented for the relevant energy-transformation and final-consumption sectors. Relevant criteria for this work include permits under immissions-control laws, technologies and differentiation between certain fuels. The model consists of two parts: a sub-model for the old German Länder, covering the years 1987-1994, and a sub-model for all of Germany, covering the years as of 1995. The model for all of Germany has been revised and, in the reports of two research projects (FKZ 203 41 142: ÖKOINSTITUT, 2005 and 204 41 132: ÖKOINSTITUT / DIW, 2007), comprehensively documented. Since 2009, relevant calculations have been carried out with the help of a database-supported system of the BEU that is based on MESAP software and that was developed in the framework of the research projects FKZ 204 42 203/03 and FKZ 360 16 010 (GICON, 2008), via an approach similar to that used for the sub-model for Germany. Data for the new German Länder, for the period 1990-1994, have already been entered into the CSE. The manner in which those data were obtained is described in detail in Chapter 19.1.1.

The following Energy Balance lines are used for determination of emissions-relevant fuel inputs from stationary sources:

A: Transformation inputs (Energy Balance lines 9 through 19)

9. Public thermal power stations (line 11) are plants whose operators are sited within the public utility sector. This category also includes industrial plants which operate their power stations together with electricity utility companies, as joint-venture power stations. The fuel input for electricity generation is reported here. This line of the Energy Balance also includes the fuel input in public thermal power stations attributable to electricity production.

10. Industrial thermal power stations (line 12) comprise the following operator groups:

- Power stations in the hard-coal-mining sector,
- Power stations in the lignite-mining sector,
- Power stations in the petroleum-processing sector (refinery power stations),
- Power stations that generate single-phase power for Deutsche Bahn AG (German Railways) (until 1999, the relevant input amounts for Deutsche Bahn power stations were reported under 1.A.2.g.vii (EB line 12); as of 2000, they have been reported together with public power stations under 1.A.1.a (EB line 11)),
- Industrial power stations (quarrying, other mining, manufacturing industry).

11. Hydroelectric, wind-power, photovoltaic systems and other similar systems (line 14) comprises all systems/plants that generate electricity from biogas, landfill gas, sewage-treatment gas or solid or liquid biomass and feed the electricity into the public grid. In addition, this section of the Energy Balance also reports on fuel inputs in mini-CHP systems fired with natural gas or light heating oil. Since no cut-off limit applies for such systems, this category includes very small systems in the residential and commercial/institutional sectors.

12. Thermal (CHP) power stations (line 15): only the fuel input which can be allocated to district heat generation is given. Adding lines 11 and 15 together produces the total fuel input in public thermal power stations. The district heat generated is fed into the public heating grid. These stations also supply industrial customers with process heat.

13. District heating stations (line 16): here, the fuel input for the public district heat supply, from heating stations, is given. The facilities are often used to cover peak loads in district heating networks in which the basic load is met by thermal power stations.

B: Energy consumption in the transformation sector (Energy Balance lines 33 through 39)

14. Lines 33 to 39 and the total line 40 (**Energy consumption in the transformation sector**) include the fuel input for heat generation which is needed to operate the transformation stations. No distinction is made here with regard to the type of heat generation involved. This means that fuel inputs for heat generation in combined heating and power stations, steam and hot water boilers and process firing installations are combined. There is an inconsistency in the Energy Balance with respect to summing-up for lignite pits and briquette plants. Since 1980, this own consumption has been listed together with production-related transformation inputs of briquette plants, in line 10. As a result, the emissions-causing inputs within own consumption can no longer be read out of the Energy Balance; they must be calculated from the transformation input. The fuel inputs used to generate heat in combined heat and power generation stations, together with fuel inputs used for electricity generation by the power stations of hard coal pits, lignite pits and refinery power stations, combine to form the total fuel input in such plants. Deduction, from the total listed in line 40, of fuel inputs for heat generation in power stations leaves the quantity of fuel used in process firing installations, steam and hot water boilers.

C: Final energy consumption (Energy Balance lines 46 through 67)

15. **Final energy consumption by industry** (line 60 of the Energy Balance) refers to the fuel used for heat generation which is required for both production purposes and space heating. Here as well, no distinction is made with regard to the type of heat generation involved. Hence, a part of the final energy consumption in these categories, together with industrial power stations' fuel input for generating electricity, constitutes the total fuel input in such facilities.
16. The data on **Final energy consumption in the residential sector** (line 66 of the Energy Balance) comprise fuel inputs for heat generation and include the application areas of heating, water heating and cooking.
17. The data on **final energy consumption in the commercial/institutional sector and by other consumers** (line 67 of the Energy Balance) comprise fuel inputs used for hot water production, space heating and process-heat generation in this sector/area.

The Energy Balance data scheme is no longer able to accommodate all of the diverse requirements of national and international energy and emissions reporting. For example, the Energy Balance combines fuel inputs

- In facilities with different requirements under immission protection legislation (e.g. large furnaces, medium-sized furnaces, small furnaces, waste incineration plants)
- In plants that operate according to different technical principles (e.g. steam turbine power stations, gas turbine power stations, combustion-engine stations)
- That exhibit regional peculiarities (e.g. different individual mining regions have different qualities of crude lignite)
- With different category allocations in national and international emissions reporting
- That are listed in different Energy Balance lines, in keeping with their intended purpose (for electricity or heat generation), but are used in a single facility group (e.g. steam turbine power stations)

These characteristics have impacts on emissions behaviour. In order to make allowance for the various differing requirements that thus arise, the Energy Balance data in the model *Balance of Emission Causes* (BEU) are disaggregated, using additional statistics as well as the Federal

Environment Agency's own calculations. The following Figure 18 provides an overview of the relevant structure:

Balance of emission causes (BEU)	
The categories include: • Public thermal power stations, • Hard coal mining, • Lignite mining, • Deutsche Bahn AG (until 1999), • Production of refined petroleum products, • District heating stations, • Other energy transformation • Quarrying of non-metallic minerals, other mining and manufacturing industry (further sub-classification of process combustion), (The residential, commercial/institutional and other consumers sectors are listed and analysed directly within the CSE, outside of the BEU model.)	
The types of facilities involved include: • Steam turbine power stations, • Gas turbine power stations, • Gas and steam turbine power stations, • Motor power stations, • Boiler furnaces (excluding power station boilers), • Process furnaces (sub-classified into 12 processes).	
By fuels/energy sources: • About 40 different fuels	
On the basis of immission protection legislation provisions, the following are differentiated: • Facilities under the 13th BImSchV, • Facilities under the 17th BImSchV, • Facilities under the 1st BImSchV, • Installations under the Technical Instructions on Air Quality Control (TA Luft) • Installations not subject to licensing	

Abbreviations:

BImSchV	Ordinance on the Execution of the Federal Immission Control Act,
TA-Luft	First General Administrative Provision on the Federal Immission Control Act (Clean Air Directive)

Figure 18: Characteristics of the Federal Environment Agency's structure of the Balance of Emission Causes, for disaggregation of the Energy Balance

The BEU model is designed to provide a data structure that can be used in meeting a range of different reporting obligations. In particular, finer disaggregation has been needed for determination of emissions of "classical" air pollutants, including calculation of nitrous oxide and methane emissions.

Despite the conversion of the Energy Balance to the classification of industrial sectors (WZ 93) and altered grouping of energy resources from the year 1995 onwards, it has been possible to fit the data within the outlined basic structure; this has facilitated preparation of consistent time

series. As of 2008, classification of economic sectors (Wirtschaftszweige = WZ), in energy statistics, was again changed – from the "WZ 2003" standard to the "WZ 2008" standard. As a result, activity data relative to process combustion are now being taken from individual statistics, and documented, in keeping with the relevant key for the change (STATISTISCHES BUNDESAMT (FEDERAL STATISTICAL OFFICE) 2008: "Umsteigeschlüssel WZ 2003 auf WZ 2008" (key for the change from WZ 2003 to WZ 2008))

The structure and the characteristics of the Balance of Emissions Sources (BEU) were presented and described in the 2011 National Inventory Report – in Figure 20 and in Tables 16 through 22 (in tabular form). Since there have been no structural changes in the BEU since then, here we simply refer to that source, which assigns the structural elements of the BEU to the database of the Central System of Emissions (CSE), via unique names.

In addition to being classified in the aforementioned structure, the various fuels and energy sources are listed individually in the database. In the main, the various fuel categories are oriented to the Energy Balance. In some cases, there is a need to subdivide the individual fuel categories. This is done with the help of energy statistics, coal-industry statistics and a smaller number of sets of association statistics. The various fuel-quality levels, with their various carbon-content levels, are combined, in keeping with reporting provisions, in the following five categories: gases, liquid fuels, solid fuels, biomass and other fuels. Because of the many different fuels involved, and because the fuels' shares of the various categories vary, the implied emission factors listed in the CRF tables often change.

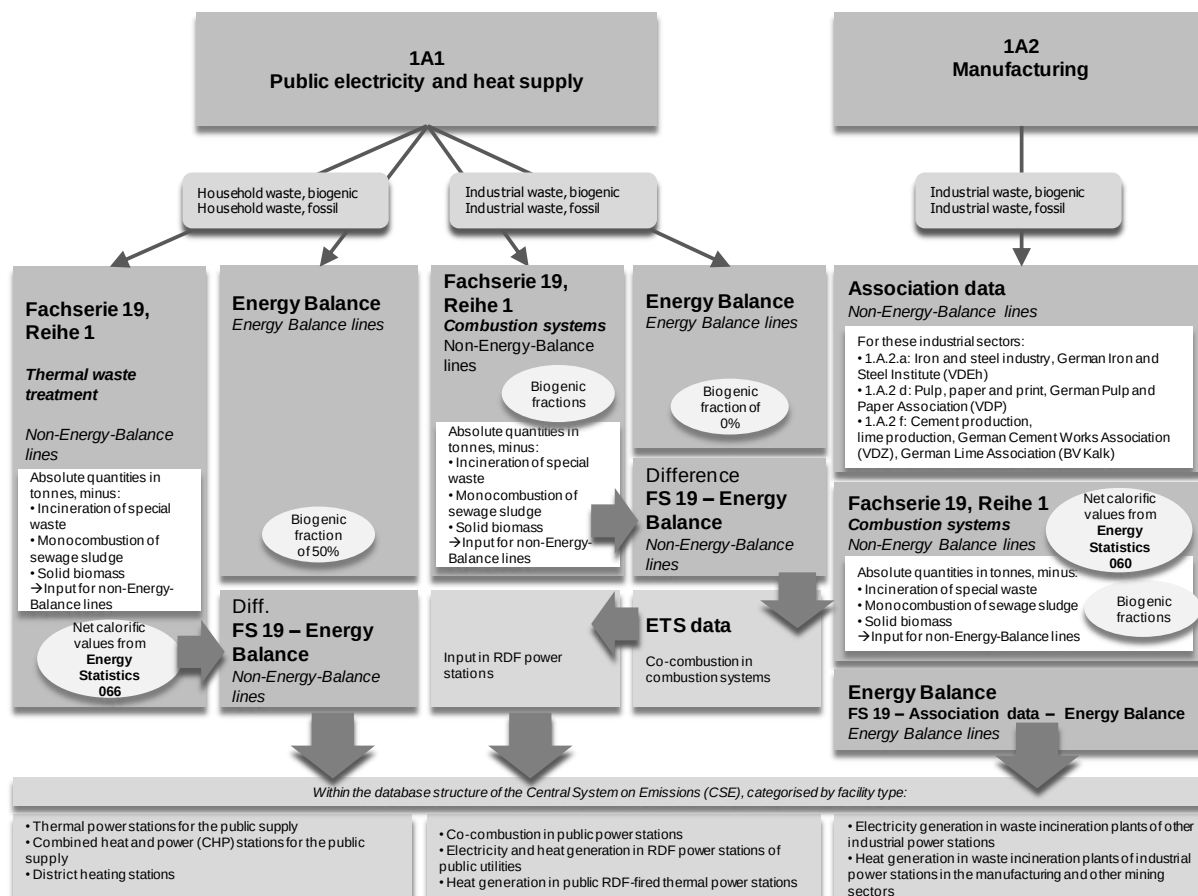
To determine activity data for waste in waste incineration plants and for co-combustion in combustion systems in the sectors Public electricity and heat generation (1.A.1) and Manufacturing (1.A.2), the Federal Environment Agency, working in the framework of a research project of its own, has carried out a thorough evaluation of fuel inputs in energy statistics (Energiestatistik) 060 and 066 (STATISTISCHES BUNDESAMT, 2013) and waste statistics (STATISTISCHES BUNDESAMT, FS 19 Reihe 1) of the Federal Statistical Office. To ensure that all fuel quantities were taken into account, as completely as possible, the relevant waste quantities in both sets of statistics, broken down by individual industries and economic sectors, were compared. To that end, the waste quantities from waste statistics were allocated to the same fuel groups used in energy statistics: solid biomass, other petroleum products, sewage sludge, household and settlement waste and industrial waste. In recent years, the fuel quantities recorded in energy statistics have continually increased. The reasons for this include the fact that in recent years more and more solid biomass (primarily waste and scrap wood) and processed settlement waste have been used for energy generation. Nonetheless, the waste-fuel quantities in energy statistics are still smaller, in some areas, than those in waste statistics. For that reason, the activity data for municipal and industrial waste are taken from the Energy Balance and then supplemented with the difference relative to waste statistics. In the Energy Balance, waste wood is listed as solid biomass, and not as waste. Consequently, to prevent double counting, in waste statistics it has to be deducted from the listed inputs for waste-incineration and combustion systems.

With regard to waste composition, as of the NIR 2006 the fossil and biogenic fractions of household / municipal waste are listed separately, in a ratio of 1:1. That split factor has been confirmed via a published research project, "Use of biogenic waste fractions for energy generation" ("Nutzung der Potenziale des biogenen Anteils im Abfall zur Energieerzeugung") (UBA, 2011; Förderkennzeichen (funding reference number) 3707 33 303). The biogenic fractions of industrial waste vary widely by industrial sector and installation type. Accordingly, for the sector Manufacturing (1.A.2), and for the sectoral classifications iron and steel, paper, cement and

lime, detailed substitute-fuel data continue to be used that are provided by the associations German Iron and Steel Institute (VDEh), German Pulp and Paper Association (VDP), the German Lime Association (BV Kalk) and the German Cement Works Association (VDZ).

Figure 19 schematically shows all important sources of data on use of waste as fuel inputs for energy generation.

Figure 19: Sources of data, in the context of the inventory of greenhouse-gas emissions, on use of waste as fuel inputs for energy generation



3.2.1 Verification of the sectoral approach for CRF 1.A

3.2.1.1 Comparison with the CO₂ Reference Approach

Reporting on combustion-related CO₂ emissions is centrally important within the context of international climate protection, because such emissions account for a predominant share of total emissions. To this end, industrialised countries routinely adopt the category-specific approach, which addresses the level of individual energy consumption sectors and therefore permits greater differentiation in analysis of emissions structures.

In addition to being determined source-specifically, via this "Sectoral Approach" (1.AA), the CO₂ emissions are determined with the Reference Approach (1.AB) pursuant to (2006 IPCC Guidelines (Vol. 2, Ch. 6. Reference Approach)). This Reference Approach makes use of primary data relative to production, imports and exports of fuels, as well as of data on changes in stocks, that are taken directly from the National Energy Balances of the Working Group on Energy Balances (AGEB).

As with the Sectoral Approach, complete oxidation is assumed. In conformance with the 2006 IPCC Guidelines, the carbon emission factors used are equivalent to those of the Sectoral Approach and thus comprise nationally referenced values. The so-calculated CO₂ emissions data are used for verification of the Sectoral Approach.

The Reference Approach is carried out for all years as of 1990. In each case, the basis for relevant calculations consists of the National Energy Balances on primary energy consumption. At the time the inventory was being prepared, only a provisional balance was available for the year 2015.

As a rule, the so-calculated CO₂ reference emissions are lower than the results obtained via the Sectoral Approach. Currently, the reference emissions lie between 0.31 % (2003) and a maximum of 3.03 % (2010) below the Sectoral Approach. The only exception thus far is the year 1990, with emissions that are 0.51 % higher.

The results of the Reference Approach (1.AB) are presented in Table 15 and in Chapter 19 in Annex 4 of this report. In Figure 20 and Figure 21, they are compared with other available data sets, such as data of the IEA and of individual German Länder.

3.2.1.2 Verification with other data sets available for Germany

Below, for verification purposes, the results of the detailed category-based calculation of energy-related CO₂ emissions for Germany, carried out in accordance with the specifications of the *IPCC Guidelines*, are compared with other available (for Germany) national and international data records on energy-related CO₂ emissions for the years 1990 to 2012. For 2013, these comparative data are not yet available.

In the comparison, the calculation results are compared with data:

- from the IEA (category-specific approach) and
- from the CO₂ calculations performed at Länder level.

Table 15 and Figure 20 compare the results of the approaches for calculating CO₂ emissions, throughout the different years involved. The key development trends emerge in all calculation approaches, including the Reference Approach, albeit at differing levels. In Figure 21, the relative discrepancies in the data records are depicted in order to illustrate these level differences.

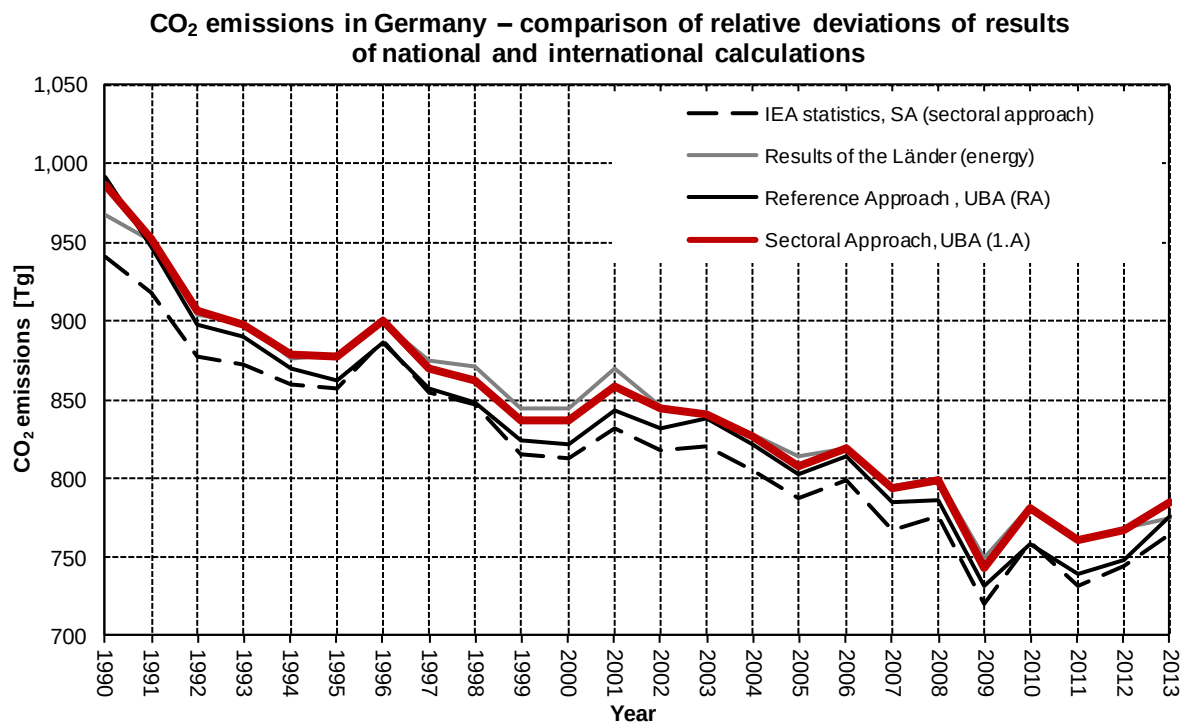
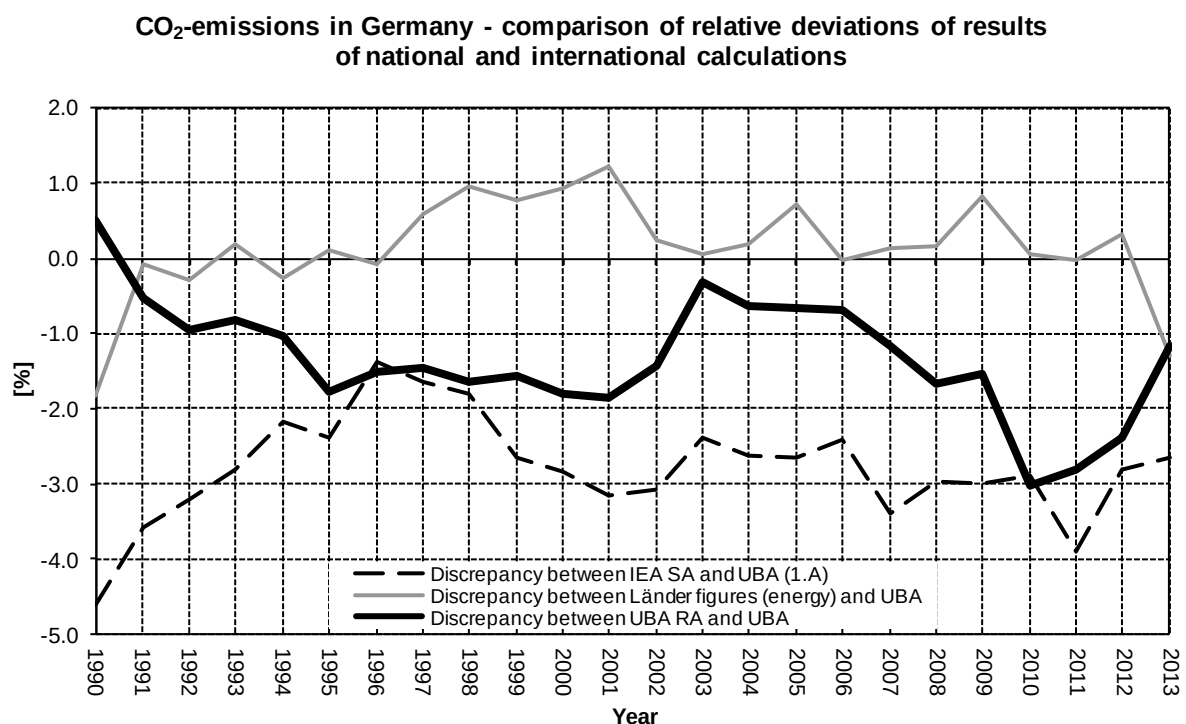
Nevertheless, on the whole, these comparisons clearly confirm the CO₂ emissions figures calculated for Germany. On an average for the years 1990 to 2013, the total national energy-related emissions calculated with the *Sectoral Approach* (cf. UBA (CRF 1.A)) differ as follows from the relevant comparative data sets:

• IEA (detailed Sectoral Approach): IEA (SA))	2.8 %
• National Reference Approach (UBA (RA))	1.4 %
• Results of the Länder	0.5%

Table 15: Comparison of CO₂ inventories with other independent national and international results for CO₂ emissions

Results, difference	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
IEA statistics, SA (sectoral approach)	940.3	917.8	877.8	872.0	859.2	856.7	887.2	855.0	847.0	815.0
How IEA (SA) differs from UBA (CRF 1.A)	-4.6	-3.6	-3.2	-2.8	-2.2	-2.4	-1.4	-1.6	-1.8	-2.7
Results of the Länder (energy)	967.7	951.2	904.2	898.8	876.0	878.7	898.9	874.4	870.8	843.8
How the Länder results (energy) differ from UBA	-1.8	-0.1	-0.3	0.2	-0.3	0.1	-0.1	0.6	1.0	0.8
Reference Approach UBA (RA)	990.8	946.9	898.1	889.6	869.2	862.1	886.0	856.4	848.5	824.2
How UBA RA differs from UBA (CRF 1.A)	0.5	-0.5	-1.0	-0.8	-1.0	-1.8	-1.5	-1.5	-1.6	-1.6
Sectoral approach UBA (CRF 1.A)	985.7	951.9	906.7	897.1	878.3	877.6	899.6	869.2	862.6	837.3
Results, difference	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
IEA statistics, SA (sectoral approach)	812.4	831.6	818.0	820.8	804.8	786.8	799.3	766.8	775.3	720.3
How IEA (SA) differs from UBA (CRF 1.A)	-2.8	-3.2	-3.1	-2.4	-2.6	-2.7	-2.4	-3.4	-3.0	-3.0
Results of the Länder (energy)	843.9	869.1	845.9	841.1	828.1	813.9	818.9	795.0	800.3	748.7
How the Länder results (energy) differ from UBA	0.9	1.2	0.2	0.0	0.2	0.7	0.0	0.1	0.2	0.8
Reference Approach UBA (RA)	821.1	842.7	831.9	838.2	821.3	802.9	813.4	784.5	785.7	731.2
How UBA RA differs from UBA (CRF 1.A)	-1.8	-1.9	-1.4	-0.3	-0.6	-0.7	-0.7	-1.2	-1.7	-1.5
Sectoral approach UBA (CRF 1.A)	836.2	858.6	843.9	840.8	826.5	808.2	819.1	793.9	799.1	742.6
Results, difference	2010	2011	2012	2013						
IEA statistics, SA (sectoral approach)	758.9	731.3	744.8	763.9						
How IEA (SA) differs from UBA (CRF 1.A)	-2.9	-3.9	-2.8	-2.7						
Results of the Länder (energy)	781.7	760.7	768.8	774.5						
How the Länder results (energy) differ from UBA	0.0	0.0	0.3	-1.3						
Reference Approach UBA (RA)	757.7	739.6	748.1	775.5						
How UBA RA differs from UBA (CRF 1.A)	-3.0	-2.8	-2.4	-1.2						
Sectoral approach UBA (CRF 1.A)	781.4	761.0	766.4	784.8						

Source: CO₂ Emissions from Fuel Combustion (2016 Edition), IEA, Paris.

Figure 20: CO₂ emissions in Germany – comparison of results of national and international calculationsFigure 21: CO₂ emissions in Germany – comparison of relative discrepancies of national and international calculations

3.2.1.2.1 Comparison with the IEA results

The data used are data published annually, in updated form, by the IEA (most recently: OECD/IEA 2016). Since the method for determining, processing and applying the basic data used for this

purpose currently is not precisely comparable with the national procedure in Germany at present, and relevant additional methodological information is lacking – particularly information with regard to the detailed data used – this comparison is provided only for reasons of completeness.

In spite of this restriction, the comparison with the results obtained with IEA's Sectoral Approach confirms the data obtained via the national, detailed method: The average discrepancy over the period to date – 24 years – is 2.8 %. In all of the years concerned, the comparable national emissions are higher than the pertinent results obtained by the IEA. The individual discrepancies vary throughout a range of - 4.6 % (1990) to - 1.4 % (1996).

3.2.1.2.2 Comparison with the data obtained for the individual Länder

The German Länder publish data on their own CO₂ emissions²⁵. Regarding the relevant procedures, responsible and participating institutions, and methodological descriptions, we call the reader's attention to that Web site and to the pertinent more detailed remarks in the NIR 2009.

The following section presents a comparison, for energy-related CO₂ emissions, of a) available Länder results published to date in the Balance of Emissions Sources (BEU) and b) inventories calculated at the national level. One difficulty hampering the comparison is that pertinent information for the individual Länder is not always available in the form of complete time series. Gaps in the time series were closed primarily via interpolation. Since data for 2014 are currently available for only a few German Länder, the comparison is limited to the period 1990 to 2013.

²⁵ Landesarbeitskreis Energiebilanzen – CO₂-Bilanzen <http://www.lak-energiebilanzen.de/co2-bilanzen/>

Table 16: Comparison of the results of CO₂ calculations of individual Länder with corresponding figures from the federal inventories

State (Land)	1990	1991	1992	1993	1994 [Gg CO ₂]	1995	1996	1997	1998	1999
Baden-Württemberg	73,772	78,079	77,571	78,177	73,900	77,521	81,230	77,999	79,412	76,746
Bavaria	83,365	87,899	86,019	89,241	86,724	87,129	90,726	88,173	90,856	88,576
Berlin	26,661	27,674	24,913	26,303	25,237	24,079	24,367	23,196	22,479	23,148
Brandenburg	81,894	66,591	58,744	56,908	53,814	50,540	50,100	50,520	59,004	57,511
Bremen	13,376	13,535	12,848	12,444	13,267	13,162	14,169	14,082	13,763	12,694
Hamburg	12,160	13,863	12,572	13,226	12,741	12,793	13,865	13,285	12,951	12,662
Hesse	42,204	46,106	44,861	47,208	46,893	46,578	50,093	47,128	46,966	43,787
Mecklenburg – West Pomerania	15,539	10,757	9,360	9,473	9,510	10,233	11,636	10,654	10,413	10,627
Lower Saxony	76,907	82,104	80,724	79,344	77,964	78,067	78,169	79,028	79,887	76,799
North Rhine – Westphalia	297,281	308,160	304,377	298,004	293,723	301,029	310,042	304,648	302,239	291,442
Rhineland-Palatinate	27,394	29,448	28,914	30,248	30,274	31,490	31,463	31,646	31,167	30,311
Saarland	23,680	25,750	24,378	23,194	24,289	23,109	23,829	21,802	23,769	22,800
Saxony	91,465	77,072	64,026	65,993	62,928	61,244	56,102	50,907	37,020	34,961
Saxony-Anhalt	49,522	38,085	31,892	27,887	26,307	25,200	25,652	25,294	25,261	26,900
Schleswig-Holstein	24,417	24,032	24,303	24,823	24,462	23,253	23,778	23,189	22,934	22,404
Thuringia	28,098	22,068	18,684	16,332	13,988	13,233	13,634	12,800	12,682	12,398
Result for all German Länder	967,735	951,223	904,186	898,805	876,021	878,660	898,855	874,351	870,803	843,766
National result (CRF 1.A + CRF 1.D.1.a)	985,705	951,895	906,738	897,065	878,341	877,613	899,631	869,199	862,567	837,299
Difference between the Länder results and the national results (Gg)	-17,970	-672	-2,552	1,740	-2,320	1,047	-776	5,152	8,236	6,467
Difference between the Länder results and the national results (%)	-1.8	-0.1	-0.3	0.2	-0.3	0.1	-0.1	0.6	1.0	0.8

State (Land)	2000	2001	2002	2003	2004 [Gg CO ₂]	2005	2006	2007	2008	2009
Baden-Württemberg	74,285	79,579	76,012	75,034	74,025	76,451	77,430	70,053	71,882	65,625
Bavaria	86,587	88,325	82,485	81,600	80,115	77,126	78,094	71,038	76,391	73,419
Berlin	23,038	23,414	20,632	20,597	19,527	19,287	19,144	16,679	17,708	17,236
Brandenburg	60,145	60,544	61,123	57,693	58,680	59,615	57,892	57,796	56,234	52,644
Bremen	13,972	14,038	13,936	14,575	12,970	12,152	12,627	13,558	12,947	12,511
Hamburg	12,373	12,084	11,795	11,996	11,887	11,500	11,473	10,958	11,088	11,187
Hesse	44,341	46,375	43,374	43,735	42,926	42,036	41,228	38,587	39,164	37,623
Mecklenburg – West Pomerania	10,256	10,718	10,908	10,696	10,906	10,354	11,133	10,044	10,835	9,515
Lower Saxony	73,711	72,668	71,624	70,589	69,553	69,644	69,734	69,258	68,782	65,371
North Rhine – Westphalia	291,407	297,628	293,074	293,626	288,415	279,180	283,310	285,647	282,936	256,712
Rhineland-Palatinate	28,853	29,574	27,793	26,453	26,026	25,956	26,484	24,959	26,907	25,636
Saarland	23,409	23,213	22,914	23,232	23,900	24,776	23,555	25,697	22,947	18,498
Saxony	41,364	48,664	48,865	49,460	48,335	46,850	47,989	46,384	45,809	46,900
Saxony-Anhalt	26,301	26,840	27,518	28,171	27,145	27,846	27,821	26,477	26,973	26,772
Schleswig-Holstein	21,905	23,184	21,865	21,815	21,867	19,737	19,763	17,480	18,838	18,555
Thuringia	11,994	12,280	12,005	11,866	11,791	11,424	11,260	10,404	10,888	10,513
Result for all German Länder	843,941	869,128	845,923	841,138	828,068	813,934	818,937	795,019	800,329	748,717
National result (CRF 1.A + CRF 1.D.1.a)*	836,167	858,626	843,864	840,786	826,529	808,180	819,086	793,859	799,054	742,572
Difference between the Länder results and the national results (Gg)	7,774	10,502	2,059	351	1,539	5,753	-149	1,160	1,275	6,145
Difference between the Länder results and the national results (%)	0.9	1.2	0.2	0.0	0.2	0.7	0.0	0.1	0.2	0.8

State (Land)	2010	2011	2012	2013	2014 [Gg CO ₂]	2015	2016	2017	2018	2019
Baden-Württemberg	67,094	65,833	65,239	70,423						
Bavaria	76112	74619	74138	74964						
Berlin	18989	16962	18040	17884						
Brandenburg	55266	55981	57340	57297						
Bremen	13851	13150	13388	13412						
Hamburg	11563	10918	10740	10378						
Hesse	38,433	36,674	36,846	36,550						
Mecklenburg – West Pomerania	10,939	10,346	10,987	10,429						
Lower Saxony	67,072	66,178	64,031	65,037						
North Rhine – Westphalia	271891	264618	268337	263936						
Rhineland-Palatinate	26782	24995	25031	26200						
Saarland	19104	20667	21527	22808						
Saxony	47153	44977	47019	49635						
Saxony-Anhalt	27375	27173	27771	26991						
Schleswig-Holstein	19364	17514	18031	18103						
Thuringia	10750	10083	10367	10502						
Result for all German Länder	781,738	760,688	768,832	774,549						
National result (CRF 1.A + CRF 1.D.1.a)*	781,387	760,961	766,404	784,763						
Difference between the Länder results and the national results (Gg)	351	-273	2,428	-10,214						
Difference between the Länder results and the national results (%)	0.0	0.0	0.3	-1.3						

Remark: The italicised figures, in grey table cells, are not part of consistent time series and were generated via gap-closure procedures (see text).

Source: © 2017 Länderarbeitskreis Energiebilanzen (Last revision: 10 March 2017)

In terms of trend, the comparison found excellent agreement between the combined Länder results and the Federal inventory. On an average for the 24 years in question, the total CO₂ emissions for the Länder differed by 0.5 % from the Federal result. The extremes of the deviations ranged from -1.8 % in 1990 to 1.2 % in 2001.

3.2.1.2.3 Planned improvements

Following the reporting process, the results of the comparison are regularly discussed, and reviewed with regard to potential for improvement, with the representatives of the Länder Working Group on Energy Balances (Länderarbeitskreis Energiebilanzen). At present, no concrete plans for further improvements are in place.

3.2.2 International bunker fuels

3.2.2.1 Emissions from international transports (1.D.1.a/1.D.1.b)

The area of international transports is divided into international civil air transports (1.D.1.a) and international maritime navigation (1.D.1.b).

3.2.2.2 Emissions from international air transports (1.D.1.a)

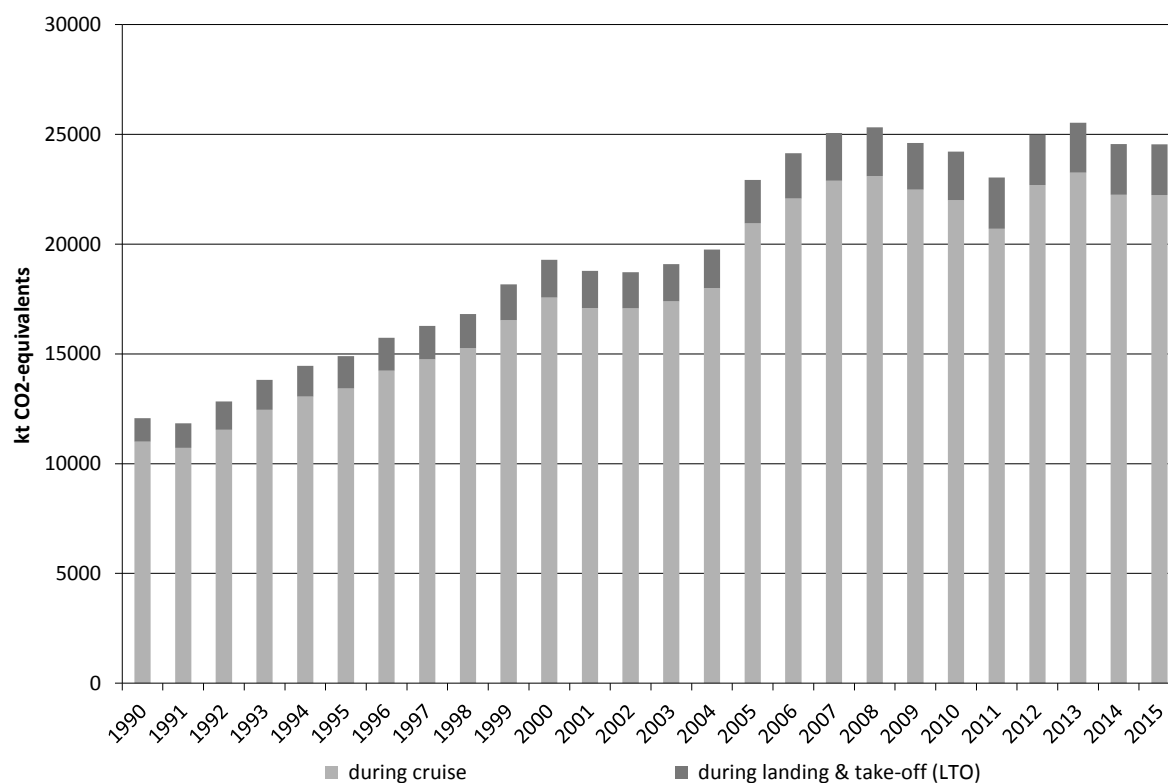
3.2.2.2.1 Category description (1.D.1.a)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS (Tier 3)	NS/IS/M	CS / D ^a
CH ₄	CS (Tier 3)	NS/IS/M	CS (M)
N ₂ O	CS (Tier 3)	NS/IS/M	CS (M)
NO _x , CO, NMVOC	CS (Tier 3)	NS/IS/M	CS (M)
SO ₂	Tier 1	NS/IS/M	CS

^a Co-combusted lubricants

The emissions from consumption of fuels for international civil aviation are included in the inventory calculations, but they are not reported as part of the national overall inventories, and thus they are not included in key-category analysis.

Figure 22: Greenhouse-gas emissions of international air transports departing from Germany, 1990-2015



3.2.2.2.2 Methodological issues (1.D.1.a)

Since German energy statistics do not break annual fuel quantities down by international and domestic air transports, that breakdown is carried out after the fact, on the basis of national air transports' annual shares of total kerosene inputs, a total calculated, using a Tier 3 method, within TREMOD-AV (IFEU & ÖKOINSTITUT, 2015). Avgas consumption is reported separately, and solely for domestic air transports. It does not enter into calculation of the split factor.

International air transports' so-determined shares of the kerosene quantities listed in the Energy Balance (AGEB, 2016a&b) and in the official mineral-oil data (Amtliche Mineralöl-daten) of the Federal Office of Economics and Export Control (BAFA, 2016), are as follows:

Table 17: International flights' annual shares of domestic kerosene deliveries, in [%]

1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
84.45	86.27	87.71	90.18	90.4	90.52	90.49	90.63	90.54	89.99	91.21	92.15	91.79	(91.79)

Source: 1990-2014: TREMOD AV (IFEU & ÖKOINSTITUT, 2015); 2015: own calculations

Due to scheduling reasons, it was not possible to enter any original data for the year 2015 into the model. For this reason, the specific kerosene-consumption figures for domestic flights in 2014 were carried forward, unchanged. This updating approach is based on several mutually offsetting effects. As a result of this updating, the 2015 figure for international flights, as a percentage share of domestic kerosene deliveries, is not a modelled figure; it has simply been derived from the consumption figures that have been carried forward.

Additional information relative to the activity data and emission factors used is presented in Chapter 3.2.10.1 on national civil air transports.

3.2.2.2.3 Uncertainties and time-series consistency (1.D.1.a)

Cf. National air transport, Chapter 3.2.10.1.3.

3.2.2.2.4 Category-specific quality assurance / control and verification (1.D.1.a)

Cf. National air transport, Chapter 3.2.10.1.4.

3.2.2.2.5 Category-specific recalculations (1.D.1.a)

With respect to the 2016 Submission, recalculations were carried out solely for the years 2004 and 2014. In the process, an erroneous domestic-sales figure was corrected, and provisional activity data were replaced with final data.

Table 18: Revision of figures for domestic sales of kerosene, 2004 & 2014, in TJ

	2004	2014
2017 Submission	298,779	361,868
2016 Submission	316,211	361,870
Absolute change	-17,432	-2.00
Relative change	-5.5%	-0.001%

Table 19: Resulting revision of kerosene consumption inputs for international flights, 2004 & 2014, in TJ

	2004	2014
2017 Submission	267,117.53	332,166.17
2016 Submission	282,701.98	332,168.01
Absolute change	-15,584	-1.84
Relative change	-5.5%	-0.001%

Accordingly, the greenhouse-gas emissions reported for 2004 and 2014 have been revised as follows:

Table 20: Revised GHG emissions, in kt CO₂ equivalents

	2004	2014
2017 Submission	19,753.22	24,563.54
2016 Submission	20,905.68	24,563.68
Absolute change	-1,152	-0.14
Relative change	-5.5%	-0.001%

3.2.2.2.6 Category-specific planned improvements (1.D.1.a)

Cf. National air transport, Chapter 3.2.10.1.

3.2.2.3 Emissions from international water-borne navigation (1.D.1.b)**3.2.2.3.1 Category description (1.D.1.b)**

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS (Tier 2)	NS/IS/M	D a / CS
CH ₄	CS (Tier 2)	NS/IS/M	CS (M)
N ₂ O	CS (Tier 2)	NS/IS/M	CS (M)
NO _x , CO, NMVOC, SO ₂	CS (Tier 2)	NS/IS/M	CS (M)

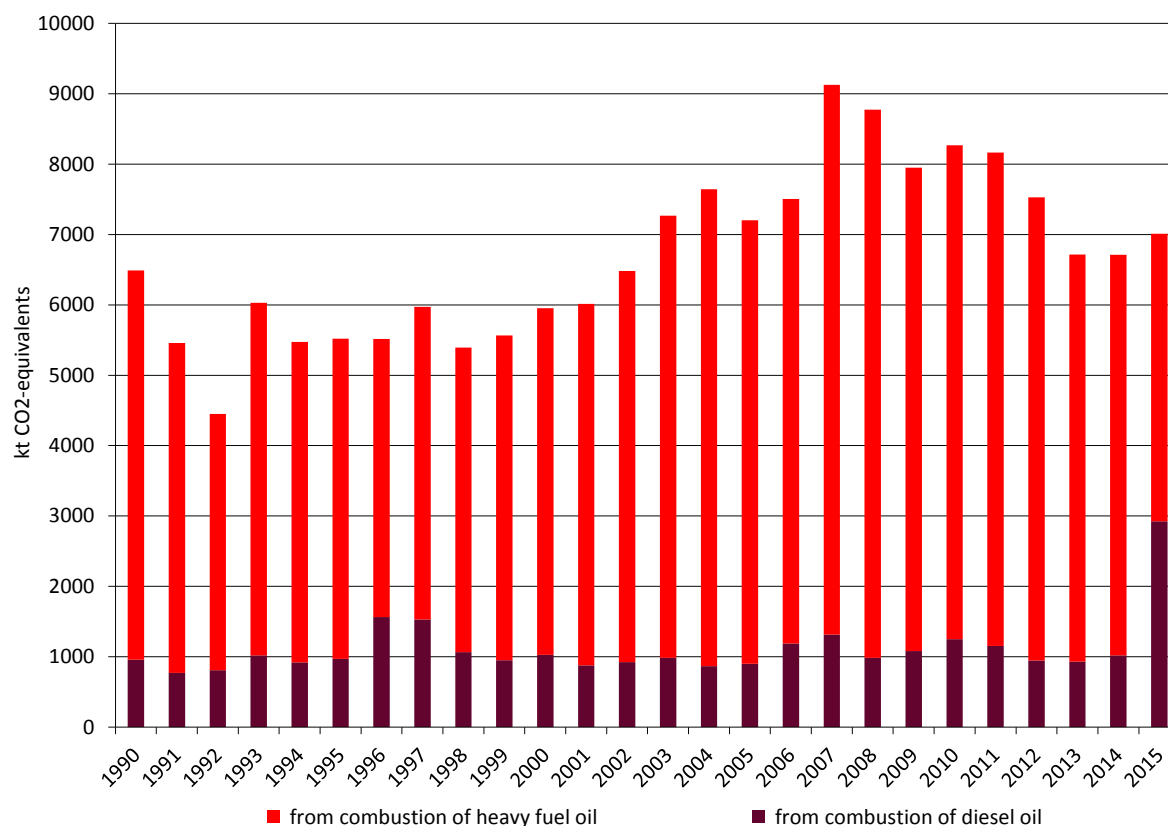
^a co-combusted lubricants

The emissions caused by international sea transports leaving German ports are not reported as part of the national overall inventories, and thus they are not included in the key-category analysis.

Since 1984, consumption of heavy fuel oil has been increasing, as high oil prices have pushed up prices for diesel fuels, the maritime-transport sector has grown worldwide and use of diesel

engines that can run on heavy fuel oil has increased. Temporary emissions reductions, especially those that occurred in 1992 and 2009, have been / were caused by trade and oil crises.

Figure 23: Development of greenhouse-gas emissions from international maritime navigation since 1990



3.2.2.3.2 Methodological issues (1.D.1.b)

Germany reports in keeping with Tier 1. This means that emissions are calculated as the product of fuel sales in Germany, country-specific emission factors for CO₂ and default emission factors for CH₄ and N₂O.

In general, the **activity data** for sea-going ships are taken from the Energy Balances of the Federal Republic of Germany (AGEB, 2016a). In Energy Balance line 6 (EBZ 6), those Balances list international bunkering for IMO-registered ships separately, because such bunkering is subject to different taxation.

For years for which an Energy Balance does not become available on time, data are obtained from the "Amtliche Mineralölstatistik für die Bundesrepublik Deutschland" ("Official mineral-oil data for the Federal Republic of Germany"), which are published by the Federal Office of Economics and Export Control (BAFA) (BAFA, 2016; for the present context: Table 6j, column: "Bunker int. Schifffahrt" ("bunkering, international shipping") and enter into the National Energy Balances.

As a rule, the bunkered quantities, included in these statistics, of ocean ships traveling domestic routes (freight and passengers (1.A.3.d), fisheries (1.A.4.c iii) and military (1.A.5.b iii)) are calculated separately, pursuant to (BSH, 2015), and deducted from the total quantities listed in EBZ 6. The resulting remainder is allocated to the international water-borne navigation departing from Germany. For the present Submission, it was not possible to generate any model data for the

year 2015. As a result, the data in this category were carried forward, in the manner described in 3.2.10.4.

The sharp increase seen between 2014 and 2015 in the quantities of diesel used results from a de-facto ban on heavy fuel oil in "SECAs" (*Sulphur Emission Control Areas*). That ban is tied to the entry into force of considerably tighter standards for the sulphur content of ship fuels.²⁶

In addition, pertinent quantities of co-combusted lubricants, along with the resulting CO₂ emissions, are recorded and reported. Pursuant to (VSI, 2014), it is assumed that the quantities of co-combusted lubricants are equivalent to 0.15 % of the fuel quantities used (cf. the Annex Chapter 19.1.4).

With regard to the pertinent **emission factors** for carbon dioxide, we refer to Chapter 18.7.

The pertinent methane and nitrous oxide emissions are calculated with the emission factors from (BSH, 2015) that are used for national maritime transports. On the other hand, also with regard to co-combustion of lubricants, it is assumed that the pertinent N₂O and CH₄ emissions are already included in the emission factors for the fuels used and thus have to be reported here as IE (*included elsewhere*).

3.2.2.3.3 Uncertainties and time-series consistency (1.D.1.b)

Cf. Chapter 3.2.10.4.3.

3.2.2.3.4 Category-specific quality assurance / control and verification (1.D.1.b)

Cf. Chapter 3.2.10.4.4.

3.2.2.3.5 Category-specific recalculations (1.D.1.b)

No recalculations were out with respect to the data provided in 2016 Submission.

3.2.2.3.6 Category-specific planned improvements (1.D.1.b)

No source-specific improvements are currently planned, apart from ongoing routine revisions of the calculation model used.

3.2.3 Storage

This emissions are taken into account in the framework of the CO₂ Reference Approach.

3.2.4 CO₂ capture and storage (CCS) (CRF 1.C)

At present, CO₂ capture and storage (CCS) technology is still in the research phase in Deutschland. One pilot system is in place. According to the operator of that system, some 67 kt of CO₂ in have been injected into storage in Germany, on a trial basis. Monitoring of the relevant experimental facilities, with measurements, has found no evidence of leakage of CO₂ from such storage. In the interest of conservative reporting, the so-stored quantities have not been deducted from the German inventory, however. For this reason, any possible leakage has already been taken into account.

In keeping with recommendations from the 2016 In Country Review, the notation key has been changed from *NE* to *NO*.

²⁶ As of 1 January 2015: 0.10 %, instead of the previous maximum permitted level of 1.00 %

[http://www.imo.org/en/OurWork/environment/pollutionprevention/airpollution/pages/sulphur-oxides-\(sox\)-%E2%80%93regulation-14.aspx](http://www.imo.org/en/OurWork/environment/pollutionprevention/airpollution/pages/sulphur-oxides-(sox)-%E2%80%93regulation-14.aspx)

3.2.5 Special country-specific aspects

There are no special aspects that would influence reporting.

3.2.6 Public electricity and heat production (1.A.1.a)

3.2.6.1 Category description (1.A.1.a)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	1.A.1.a Public electricity and heat production	All fuels	CO ₂	338,451.2	27.67%	301,705.7	34.00%	-10.9%
L/-	1.A.1.a Public electricity and heat production	All fuels	N ₂ O	2,407.5	0.20%	2,423.3	0.27%	0.7%
L/T	1.A.1.a Public electricity and heat production	All fuels	CH ₄	172.2	0.01%	2,560.0	0.29%	1386.9%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	NS	CS
CH ₄	Tier 2	NS	CS
N ₂ O	Tier 2	NS	CS
NO _x , CO, NMVOC, SO ₂	CS	NS	CS

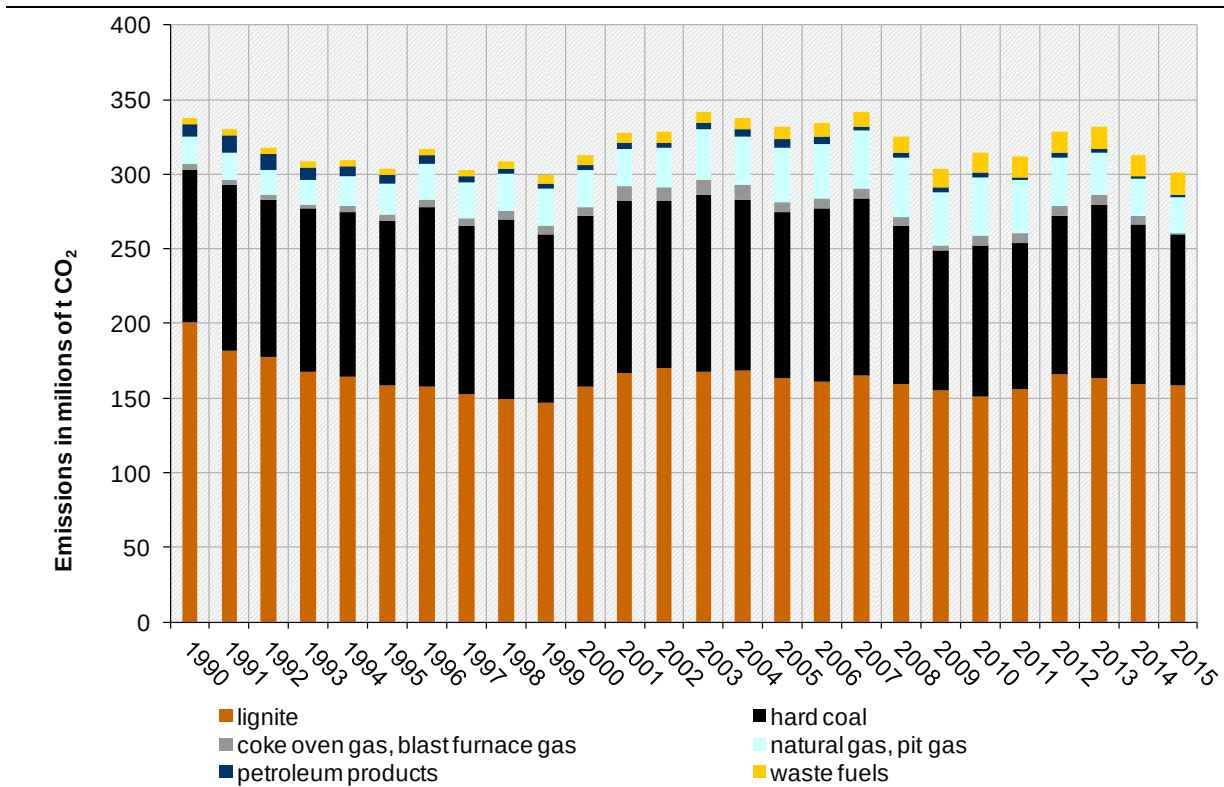
The category *Public electricity and heat production* is a key category for CO₂ and CH₄ emissions in terms of level and trend. For N₂O emissions, it is a key category only in terms of level.

Under category 1.A.1.a, "Public electricity and heat production", the CSE includes district heating stations and electricity and heat production of public power stations. Plants that feed electricity produced from biomass into the public grid are also assigned to category 1.A.1.a.

Some 100 GW of net bottleneck capacity were in place in the public electricity generating sector in 2015. Of this amount, about 76 GW were operated with fossil fuels or with transformation products of fossil fuels. As a group, all fossil-driven plants generated some 301 TWh of electrical work (gross). This corresponds to about 70 % of all public electricity generation (about 434 TWh). About 267 TWh of electricity were generated solely with lignite and hard coal.

In 2015, combined heat and power (CHP) stations contributed net electricity production of about 45 TWh, and net heat production of 91 TWh, to the public energy supply. The district-heat supply is supplemented with heat from heat-only boiler stations that are normally run in peak-load operation. (*Statistisches Bundesamt (Federal Statistical Office)*, 2015a).

The following figure presents an overview of development of CO₂ emissions in category 1.A.1.a:

Figure 24: Development of CO₂ emissions in category 1.A.1.a

Overall, emissions until 1999 show a falling trend, due primarily to closure of four lignite-fired installations in the new German Länder. Thereafter, a number of installations were replaced. As of 2000, then, the newly installed capacities, in the category of lignite-fired power stations, exceeded those of the decommissioned power stations, and thus emissions began increasing again. In 2012, and once again, several new power-station units went online, and this led to further increases in emissions from lignite. Thereafter, the emissions decreased as a result of plant closures. Throughout the entire time series, emissions from lignite-based electricity generation remained considerably below the corresponding level seen in 1990.

In the main, the emissions trend is shaped by the development and structures of the electricity generation installations involved, since those installations account for the majority of the pertinent emissions. From 1990 through 1993, electricity consumption decreased, as a result of the collapse of industry in the new German Länder. From 1994 until 2007, a marked increase in electricity consumption occurred in all sectors, sparking increases in electricity production. As a result, emissions from electricity production also increased. In addition, electricity exports increased. Those exports begin showing up in the overall balance as of 2003. The increasing trend continued through 2007, as low prices for emissions certificates prompted consumption of particularly large quantities of coal for electricity generation. Thereafter, beginning in 2008, a temporary marked emissions decrease occurred, as a result of increased use of nuclear power, natural gas and renewable energies. In 2009, the financial and economic crisis occurred, also affecting the public energy supply. In 2010, emissions increased again as a result of economic recovery. As seen via the relevant time series, hard-coal-fired power stations show higher fluctuations in fuel inputs than lignite-fired power stations do. The reason is that they, in contrast to lignite-fired power stations, are operated primarily in the medium-load range, where they respond more markedly to fluctuations in demand. What is more, they are dependent on import prices. Furthermore, as of the mid-1990s sectoral shifting occurred, from industry (1.A.1.c and

1.A.2.g) to the public electricity supply (1.A.1.a), as more and more operators reported their data in the public electricity supply category. In 2012, the classification for another major company in the hard-coal mining sector (1.A.1.c) shifted to the public electricity supply (1.A.1.a), and this led to a significant shift of emissions between the two sectors. Another reason for the emissions increase from hard-coal-fired power stations in source category 1.A.1.a is that world-market prices for hard coal have fallen considerably since 2012. In addition, natural gas prices have increased at the same time, and this has tended to shift the fuel mix in favour of hard coal. Petroleum plays only a minor role in Germany's electricity supply. It is used primarily for auxiliary and supplementary firing in coal-fired and waste-to-energy CHP power stations, as well as for peak-load generation. Use of petroleum in these roles has dropped by more than half since 1990. In the crisis year 2009, when petroleum became considerably cheaper than natural gas, use of petroleum for peak-load generation increased again somewhat. Since then, fuel inputs have been decreasing again, and thus emissions from use of petroleum have been decreasing as well.

Use of natural gas for electricity generation has increased markedly since 1990. That trend has not led to an equivalent emissions increase, however, since the specific CO₂ emissions of natural gas are considerably lower than those of coal. The significant increase in natural gas use seen since 2005 is due especially to the commissioning of a considerable number of major gas and steam turbine power stations and medium-sized gas-turbine power stations. What is more, natural gas is increasingly being used as balancing energy for electricity generation with fluctuating renewable energies. Use of natural gas for electricity generation has been decreasing since 2010. By 2015, gas consumption even fell considerably below its level in 2005. This trend is due primarily to high natural gas prices.

Since 1990, waste inputs in waste-incineration plants and for co-incineration have also been increasing, as a result of changes in relevant laws. The additional emissions resulting from increased waste combustion have reduced methane emissions from landfills. Use of blast furnace gas and basic oxygen furnace gas for electricity generation depends on production of those gases in the steel industry, and thus is subject to economic fluctuations. In addition, operators of relevant facilities are free to report, in the framework of statistical surveys, either in the context of industry or as part of the public supply. Overall, changes in sectoral classification repeatedly occur in connection with all fuels.

In 2010, electricity generation with nearly all fossil fuels increased – sharply, in some cases – as a result of economic recovery, and this led to increased CO₂ emissions. Emissions continued to increase until 2013. On the one hand, the trend resulted from high export surpluses, which in 2015 climbed to over 50 TWh, a new maximum. On the other, it was tied to a considerable reduction in nuclear power's share of the electricity mix. Cold winters have been another reason why CO₂ emissions increased in 2010, 2012 and 2013. Overall, the ongoing expansion of use of renewable energies has been tending to reduce emissions. CO₂ emissions have been decreasing again since 2014. The marked emissions reduction seen in 2015 is due primarily to statistical reclassification of steel industry power stations fired with blast furnace gas, as well as to considerable efficiency increases tied to their commissioning of new hard-coal-fired power stations.

The trend for the greenhouse gas N₂O is determined primarily by coal use. Since energy generation plants are not known to have any measures in place for reducing N₂O emissions, the decreasing trend seen since 1990 is due to reductions in coal use.

CH₄ emissions, by contrast, have been increasing since 1990. The considerable increases in biogas use since 2003 have played an especially noticeable role in this trend. Biogas is used primarily in combustion engines that have high specific methane emissions.

3.2.6.2 Methodological issues (1.A.1.a)

Activity data

In the "Balance of Emissions Sources" model, the energy inputs listed in the Energy Balance are divided among several time series, with the help of statistical data. The aim of the calculations is to produce a database that is adjusted to the special technical characteristics of electricity and heat production. As a result, fuel-specific and technology-specific emission factors can be applied to the relevant activity data.

In 2014, the Federal Environment Agency (UBA) developed a procedure for taking account of known efficiencies (with the help of the UBA's power-station database) in calculations. This was done in order to make it possible to calculate use of natural gas and light heating oil for electricity and heat generation, in gas turbines, gas-and-steam (combined cycle) systems, steam turbines and gas engines. As a result, fuel inputs can now be calculated via the electricity-generation data for the aforementioned installation types as shown in energy statistics.

As of 2012, the Energy Balance lists mini-CHP systems as producers for the public grid (i.e. to be feeding energy into the grid). Consequently, emissions from combustion of natural gas, and of light heating oil, in these installations are reported in source category 1.A.1.a. The fuel inputs for heat generation are reported in source category 1.A.4. Since the installations lie below the relevant statistical cut-off thresholds, additional data sources had to be used for this purpose. For example, analyses of sales of engine manufacturers were carried out, and the resulting data were checked by comparison with pertinent invoicing pursuant to the German Combined Heat and Power Act (KWK-Gesetz). Since relevant data are available only for the years 2012, 2013 and 2014, inconsistencies can occur in the IEF, especially that for methane.

For the 2006 report, the activity data for the new German Länder for the year 1990 were revised and substantiated in the framework of a research project (FKZ 205 41 115 / sub-project A, "Revision and Documentation of Fuel Inputs for Stationary Combustion System in the new German Länder for the year 1990").

In the case of electricity and heat generation in waste incineration plants of public power stations, and of heat generation in waste incineration plants of public district heating stations, the pertinent activity data for household and municipal waste, and for industrial waste, are taken both from the Energy Balance and from the waste statistics of the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, FS 19 Reihe 1).

To date, the waste quantities listed in both energy statistics and the Energy Balance have been considerably lower than those given by the waste statistics of the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, FS 19 Reihe 1). The quality of the data provided by energy statistics has increased considerably in recent years. Such statistics now differentiate fuel data in a way that makes it possible, via calculation, to separate out figures for solid biomass (especially waste and scrap wood), biogenic gases, sewage sludge and waste heat. Industrial waste appeared as a fuel category in energy statistics for the first time in 2008. To ensure that all waste-related fuel inputs are taken into account as completely as possible, i.e. to close the gap that emerges with respect to energy statistics, it is necessary to make use of additional data from waste statistics.

As of the NIR 2006, the fossil and biogenic fractions of household / municipal waste are listed separately, in a ratio of 1/1. The fossil/biogenic composition of industrial waste varies in keeping with the type of facility involved. As a result, the biogenic fractions for co-combustion in lignite-fired and hard-coal-fired power stations, and for electricity and heat generation in public utilities' power stations fired with substitute fuels, are listed separately.

The existing assumptions relative to the biogenic fraction of sewage sludge have been retained.

The activity data for other fuels are taken directly from the Energy Balance. Where pertinent statistical indications or experts' assessments are available, fuel inputs are additionally divided into two size classes (combustion systems smaller and larger than 50 MW). The dividing line between these two categories is based on legal regulations pertaining to licensing of combustion systems in the Federal Republic of Germany.

As of the NIR 2011, CO₂ emissions from blast-furnace-gas combustion in public power stations are reported in category 1.A.1.a. The following table provides an overview of relevant emissions from use of blast-furnace gas, for the entire time series since 1990.

Table 21: CO₂ emissions from blast-furnace-gas combustion in public power stations

[Millions of t of CO ₂]									
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3.244	3.291	3.015	2.631	3.647	3.764	4.816	5.305	5.465	5.808
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
5.956	9.284	9.030	9.766	9.640	6.738	7.086	6.370	5.851	3.425
2010	2011	2012	2013	2014	2015				
6.276	6.258	6.080	6.465	5.532	0.013				

Emission factors

Since CO₂ emissions depend on fuel quality, CO₂ emission factors are calculated and used on an overarching, inter-sectoral basis. A detailed description of the relevant procedures, and a list of the factors used, is presented in the Annex, Chapter 18.7.

The underlying data for the emission factors used for all other greenhouse gases and precursor substances 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 plants in Germany for the years 1995, 2000 and 2010"; RENTZ et al, 2002). The values for the intermediate years 1996 - 1999 and 2001 - 2009 are obtained via linear interpolation. That project, along with the linear interpolation for the intermediate years, has also provided the underlying data for the emission factors presented in Chapters , 3.2.7, 3.2.8 and 3.2.9, where the factors include power stations, gas turbines and boilers for generation 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 it was completed at the end of 2002. The project aim was to determine and evaluate representative emission factors for the main air pollutants produced by combustion systems in Germany that are subject to licensing requirements, and to do so for the years 1995, 2000 and 2010. The procedure for achieving that aim consists primarily of analysing and characterising the relevant emitter structures, and the pertinent emission factors, for the year 1995, and then of adequately carrying that data forward for the years 2000 and 2010. The procedure systematically determines emission factors for the substances SO₂, NO_x, CO, NMVOC, particulates and N₂O. Furthermore, it 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, and CH₄ for gas turbines and combustion systems subject to licensing requirements that fall under the TA Luft. Annex 3 (Chapter 19.1.2) discusses the procedure used in the research project.

In connection with a major research project that began at the end of 2008 and was completed in 2011 (FICHTNER et al., 2011), we have updated the described database for emission factors (except for that for CO₂). The reference year for the proposed values is 2004. On that basis, emission factors are being predicted for the years 2010, 2015 and 2020. As described in the reports for 2012, 2013 and 2014, numerous emission factors in the Central System of Emissions (CSE) have been updated on the basis of the research results. In Germany, N₂O is monitored only in exceptional cases; for this reason, no relevant data from regular measurements are available. On the other hand, relevant emissions behaviour in combustion of hard coal and lignite, especially in fluidised-bed combustion, has been specifically studied (this occurred especially in the 1990s). The FICHTNER et al. (2011) project has reviewed and updated the values used to date. Table 22 shows the results for large installations of public power stations (with thermal outputs from combustion of 50 megawatts or more), while Table 23 shows the results for smaller installations of the energy sector and of industry. These factors have been used as a basis for calculating the category-specific emission factors for the CSE.

Table 22: Technological emission factors for nitrous oxide from large combustion systems

Fuel / combustion technology	N ₂ O emission factor [kg/TJ]
Public power stations:	
Hard coal / dry firing	1.0
Hard coal / slag tap firing	1.9
Lignite / dry firing	3.5
Liquid fuel / boiler firing	1.0
Natural gas / boiler firing	0.5
Industrial power stations, industrial boilers and district heating stations:	
Hard coal / dry firing	1.0
Hard coal / slag tap firing	2.0
Hard coal / fluidised bed combustion	20
Hard coal / grate firing	4.0
Lignite / dry firing	3.4
Lignite / fluidised bed combustion	8.0
Lignite / grate firing	3.5
Liquid fuel / boiler firing	1.0
Natural gas / boiler firing	0.5
Gas turbines and gas and steam turbine plants:	
Natural gas	1.7
Light heating oil	2.0
Waste incineration plants	1.2

Table 23: Technological emission factors for nitrous oxide from systems < 50 MW furnace thermal output

Fuel / combustion technology	N ₂ O emission factor [kg/TJ]
Boiler firing with:	
Hard coal	10.0
Lignite	10.7
Biomass	3.0
Light heating oil	1.1
Heavy heating oil	3.0
Natural gas	0.6
Gas turbines and gas and steam turbine plants:	
Natural gas	1.7
Light heating oil	2.0

Table 24: Methane emission factors for combustion systems with at least 50 MW furnace thermal output and for gas turbines

Facility type	Fuel	CH ₄ emission factor [kg/TJ]
Combustion systems ≥ 50 MW furnace thermal output	Hard coal	1.0
	Lignite	0.63
	Heating oil, heavy	4.1
	Heating oil, light	3.3
	Natural gas	2.0
Gas turbines (including gas-and-steam systems)	Heating oil, light	8.0
	Natural gas	10.925
Combustion engines	Natural gas	309.0
	Biogases	312.3
Waste incineration		1.8

In a research project carried out by the Institute for Future Studies and Technology Assessment (IZT), "Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV" ("Processing of data in emissions declarations pursuant to the 11th Ordinance on the Execution of the Federal Immission Control Act"), special CH₄ emission factors for gas engines were determined. The average value for natural gas as a fuel, 309 kg/TJ, is markedly higher than the previously used value, 0.3 kg/TJ, which is approximately the same as the value for steam-turbine power stations. With emissions-monitoring data, it was possible to confirm that significant methane leakage occurs via leakage of unburned natural gas. The pertinent measurements can vary considerably, in keeping with the type of engine and engine-maintenance standards involved. For biogas, sewage gas and landfill gas, an average CH₄ emission factor of 312.3 kg/TJ is used. That value was determined in the project "Emissions analysis and quantification of material flows through biogas plants, with regard to ecological assessment of agricultural biogas production and to inventory-taking in the German agricultural sector" ("Emissionsanalyse und Quantifizierung von Stoffflüssen durch Biogasanlagen im Hinblick auf die ökologische Bewertung der landwirtschaftlichen Biogasgewinnung und Inventarisierung der deutschen Landwirtschaft"), carried out by the Deutsches Biomasseforschungszentrum (German biomass research centre; DBFZ).

Most of the emission factors used for waste incineration have been obtained from a research project carried out by the waste-management and recycling firm ATZ, "Review of emission factors for waste incineration" ("Überprüfung der Emissionsfaktoren für die Abfallverbrennung"). The N₂O emission factors have been obtained from a Danish study, "Emissions from decentralized CHP plants 2007". Since the emission factors for other pollutants agree well with those for German waste incineration plants, the relevant N₂O factors may be adopted for purposes of the German inventory. For co-combusted waste, weighted emission factors are used that vary in keeping with the pertinent shares for the various coal types that are used as the main fuel.

Information on process-related CO₂ emissions from flue-gas scrubbing (flue-gas desulphurisation) in large combustion systems is provided by Annex 3 in Chapter 19.1.2.2.

3.2.6.3 Uncertainties and time-series consistency (1.A.1.a)

Uncertainties for activity data were determined, for the first time ever, for the 2004 report year (research project FKZ 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, Chapter 13.6 of the NIR 2007.

Other aspects relative to time-series consistency of activity data are explained in Chapter 18.4 and Chapter 18.6.

The figures for the uncertainty of the CO₂ emission factor, and for the statistical distribution function for that uncertainty, have been estimated by the Federal Environment Agency. The figures are based on the range covered by the carbon contents of the various individual fuels.

The uncertainty of the determined emission factors was evaluated in the framework of the project (mentioned in Chapter 3.2.6.2) of RENTZ et al. (2002) and FICHTNER et al. (2011).

3.2.6.3.1 Methods for determining uncertainties of emission factors

The uncertainties in emissions data result from several different factors. These include *precision*, which is influenced by chance and systematic errors in the framework of emission measurement, as well as by the completeness of the database with regard to available measurements. Another factor consists of *variability* of emissions. In this area, a distinction must be made between variability in emissions of a single plant, within the period in question (*intra-plant variability*) and differences between the emissions behaviours of the various sources considered (*inter-plant variability*).

Other sources of possible uncertainties can affect calculation of emissions with the help of emission factors. In the framework of IPCC-GPG (2000: Chapter 6), methods – adapted, in each case, to data availability – are proposed:

Where *continuous* measurements have been carried out, uncertainties should be characterised via direct determination of statistical indexes such as standard deviation and the 95%-confidence interval.

In determination of *plant-specific emission factors*, any available local measurements should be used. In addition, any special operational states (start-up and shut-down processes) and load changes should be taken account of, and available measurements should be reviewed for representativeness in light of the relevant plant's emissions behaviour.

In use of *emission factors from the literature*, all of the data-quality information provided by the sources in question should also be used. Furthermore, transferability should be reviewed – to what extent is the emission factor in question representative of the situation in the relevant area being studied? If the factor is not representative, an experts' assessment should be carried out.

In general, use of *experts' assessments* is recommended in cases in which available empirical data do not suffice for quantification. A sample explanation is provided in Annex 3, Chapter 14.1.2.2, of the NIR 2007.

3.2.6.3.2 Result for N₂O

The individual evaluations of the uncertainties for the N₂O emission factors are described in the final report of the research project (FICHTNER et al, 2011). A Monte Carlo simulation carried out by the research contractor yielded percentage uncertainties of up to +/- 50 % for CRF category 1.A.1.a (as well as for categories 1.A.1.b, 1.A.1.c and 1.A.2.gviii / all other) (remark: values for +/- ranges must be divided by 2; cf. IPCC-GPG (2000: Chapter 6, p. 6.14). In the process, we continue to assume a uniform distribution of uncertainties.

3.2.6.3.3 Result for CH₄

Combustion systems in Germany are not subject to monitoring of CH₄ emissions; for this reason, no systematic-measurement data are available in this area. Consequently, relevant individual data items available in Germany and Switzerland have been relied on. As a result of this database limitation, the research project did not attempt any systematic correlation with source categories treated by the project (cf. Chapter 3.2.6.2). The CH₄ emission factors that were determined in the

research project FICHTNER et al (2011) for various fuels, and that are used in the present report for combustion and gas-turbine systems (including gas-and-steam systems), have been compiled in Annex 19.1.2.2. As part of an experts' assessment carried out by the research contractor, pursuant to Tier 1 of the IPCC-GPG (2000: Chapter 6), an upper limit of +/- 50 % was estimated for the percentage uncertainty in source category 1.A.1.a (as well as in source categories 1.A.1.b, 1.A.1.c and 1.A.2.gviii / all other); in the process, we assume a uniform distribution of uncertainties – as was the case for N₂O.

3.2.6.3.4 Time-series consistency of emission factors

The emission factors for N₂O were determined in the framework of a research project (FICHTNER et al 2011), for the year 2004 (reference year). The research project saw no indications of changes over time in the individual emission factor. Earlier assumptions to the effect that at least the values for gas turbines might vary over time were not confirmed. For this reason, we have used constant values in each time series, for the period 1995 to 2015, and assumed that the values are valid predictive values for the period through 2020.

In this light, the time series for N₂O between 1995 and 2015 must be assessed as consistent overall. The time series of CH₄ emission factors for 1995 to 2015 were also reviewed and assessed as internally consistent.

In this light, the time series for N₂O between 1995 and 2015 must be assessed as consistent overall. The time series of CH₄ emission factors for 1995 to 2015 were also reviewed and assessed as internally consistent.

In the NIR 2009, we reported on the period from 1990 to 1994.

To ensure time-series consistency, the CH₄ emission factors determined for combustion-engine systems were retroactively applied for the period back to 1990. Methane leakage is likely to have been higher in the early 1990s than it is with modern engine systems. Too little relevant measurement data is available for that period, however.

For most biogenic fuels, statistical fuel-input data are available only for the period since 2003. As a result, it is not possible to provide a consistent time series, for the period since 1990, for such fuels. That limitation affects only the trend for CH₄ emissions, which increases sharply as of the year 2003.

3.2.6.4 Category-specific quality assurance / control and verification (1.A.1.a)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

To document its quality-assurance measures in preparation of Energy Balances, the Working Group on Energy Balances (AGEB) submits pertinent quality reports to the Federal Environment Agency (UBA) (cf. Chapter 18.4.1). Since 2012, the AGEB has carried out systematic comparisons of the estimated Energy Balance of year x-1 (provisional) and the Energy Balance of year x-2 (final); this was done for the first time for the report year 2010 (cf. Chapter 18.4.1).

Quality assurance for official statistics is carried out via an internal quality system. That system's quality reports are available for inspection within the Internet publications of the *Federal Statistical Office*.

In addition to these measures, the AGEB plays a role in the annual review process, and regular exchanges take place with the AGEB in the framework of an annual meeting to which the Federal Environment Agency (UBA) invites all institutes that take part in preparing the Energy Balance. At

such meetings, methodological issues are discussed, and general exchanges take place for the purposes of clarifying data-collection issues and verifying data. All of this is done in light of experience gained in inventory preparation and inventory review.

General measures for assuring the quality of emission factors for combustion plants, as applied in the framework of the research projects RENTZ et al (2002) and FICHTNER et al (2011), are outlined in the methods description in Annex 3, Chapter 19.1.2.1 (after Figure 90). Their results were reported in the NIR 2005.

3.2.6.5 Category-specific recalculations (1.A.1.a)

Table 25: Recalculations, CRF 1.A.1.a

Units [Gg]	NIR 2016	NIR 2017	Difference, absolute					Difference, relative
			gas	liquid	other	solid	Total	
Year	Total	Total						Total
2008	325,981	326,380	0	0	399	0	399	0.12%
2009	304,506	304,634	0	0	128	0	128	0.04%
2010	315,089	315,223	0	0	135	0	135	0.04%
2011	312,694	312,819	0	0	125	0	125	0.04%
2012	329,126	329,248	0	0	122	0	122	0.04%
2013	333,037	332,922	13	0	-114	-14	-115	-0.03%
2014	313,285	313,949	399	-246	-215	726	664	0.21%

Recalculations for the years 2008 – 2014 were carried out to take account of an error correction in the calculation model for waste fuels. For the year 2014, recalculations were carried out, as usual, to take account of the fact that provisional data were replaced by figures from the final Energy Balance.

3.2.6.6 Planned improvements, category-specific (1.A.1.a)

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.7 Petroleum refining (1.A.1.b)

3.2.7.1 Category description (1.A.1.b)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	1.A.1.b Petroleum refining	All fuels	CO ₂	20,165.6	1.65%	18,154.0	2.05%	-10.0%
-/-	1.A.1.b Petroleum refining	All fuels	N ₂ O	100.4	0.01%	55.8	0.01%	-44.4%
-/-	1.A.1.b Petroleum refining	All fuels	CH ₄	16.1	0.00%	13.7	0.00%	-14.7%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	NS	CS
CH ₄	Tier 2	NS	CS
N ₂ O	Tier 2	NS	CS
NO _x , CO, NMVOC, SO ₂	CS	NS	CS

The category *Petroleum refining* is a key category for CO₂ emissions in terms of emissions level and trend.

The figures given above apply for refinery power stations (part of category 1.A.1.b).

The crude oil distillation capacity of German petroleum refineries totalled around 105 Mt in 2015. In that period, 93.3 Mt of crude oil, along with 11.2 Mt of intermediate products, were input for processing. Production of petroleum products totalled 102 Mt, of which about 52 Mt consisted of

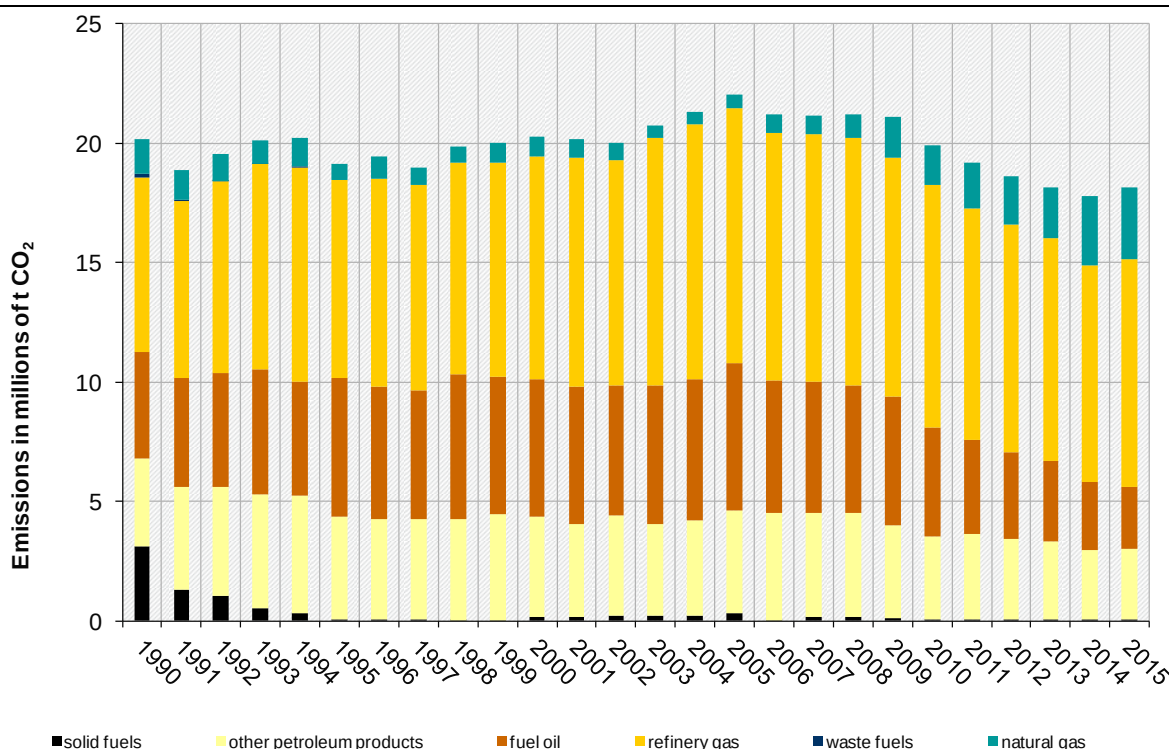
fuels, about 21.4 Mt consisted of heating oils, about 8 Mt consisted of naphtha and about 20.8 Mt consisted of other products. (MWV, 2016, Tab PRE1.1, Tab 4, Tab 5j).

Petroleum processing plants operate power stations with electrical output of about 1.1 GW. In 2014, those power stations generated 6.2 TWh of electricity. (*Statistisches Bundesamt* (Federal Statistical Office), 2015c).

Under category 1.A.1.b, Petroleum refining, the CSE lists the sub-categories "refinery bottom-heating systems" and "electricity and heat production of refinery power stations".

The following figure provides an overview of emissions trends in category 1.A.1.b:

Figure 25: Development of CO₂ emissions in category 1.A.1.b



In the early 1990s, raw lignite was still being used in the new German Länder. Now, only a small quantity of coke-oven gas is reported under solid fuels in this category. Overall, the emissions show a slightly increasing trend through 2005. Thereafter, they decreased again. While some relevant installations have been decommissioned since 1990 – although such decommissioning has taken place on a smaller scale than that seen in the hard-coal and lignite mining sectors – production increased nevertheless. And while installation efficiencies were improved, increased production of lighter petroleum products, and intensified ultra-hydrodesulphurisation, initially led to increases in specific fuel consumptions. The emissions fluctuations that have occurred over the years can be explained as the result of differences in production quantities. The maximum production of petroleum products to date, totalling 123.6 million t, occurred in 2005. The pertinent emissions were correspondingly high. Thereafter, production decreased, to a level of 103.3 million t of petroleum products in 2011, and emissions decreased as a result. The market situation for oil refineries is still difficult, due to overcapacities – especially in Europe. One German refinery terminated its operations in 2010, thereby making it possible to increase capacity utilisation somewhat at the other German refineries. Emissions decreased in 2012, even though the overall production quantity increased slightly, to 104.4 million t. This trend is due to increased

use of natural gas, which has lower emissions, and to improvements in plant efficiency. The trend continued in 2015. In 2015, following a production decrease in 2013 and 2014, gross refinery production increased by 2.2 %, to 102.6 million t (Bafa 2015 Tab.5j). In keeping with this trend, CO₂ emissions have also increased in the current year.

3.2.7.2 Methodological issues (1.A.1.b)

Activity data

All Energy Balance data relative to production of petroleum products have been obtained from the Official Mineral Oil Statistics. The Mineral Oil Statistics provide a comprehensive picture of petroleum imports, of transformation inputs in refineries and of refineries' own consumption. To ensure consistency, reporting in this area adheres to the structure and the definitions used in Mineral Oil Statistics. In energy statistics, other types of companies and plants, such as companies that process coal and refineries for waste oil and lubricants, also report under industrial sector (Wirtschaftszweig) 19.2 Petroleum processing (Mineralölverarbeitung). Such installations are reported in category 1.A.1.c. Consequently, only crude oil processing is reported in category 1.A.1.b.

For purposes of reporting on emissions from crude oil refineries, the relevant plants are subdivided into refinery power stations and bottom-heating systems. The activity data for refinery-process bottom heating are obtained by subtracting fuel inputs in refinery power stations (as taken from the energy statistics) from refineries' own energy consumption (as taken from the Official Mineral Oil Statistics). This distinction plays no role in calculation of the pertinent greenhouse-gas emissions. The distinction is important, however, with regard to calculation of emissions of precursor substances and of other air pollutants, since the relevant plants differ in their emissions behaviour.

The figures for own consumption of petroleum coke that are listed in the Official Mineral Oil Statistics represent coke burn-off in catalyst regeneration within the plants. Since the basis on which the plant operators calculate their petroleum-coke inputs is not known, it is not possible to obtain a suitable CO₂ emission factor. For the years 2005 through 2014, it has been possible to determine emission factors from data, available via emissions trading, on total emissions from coke burn-off in catalyst regeneration and from plants' own consumption of petroleum coke. As a result, therefore, it has been possible to determine emissions from coke burn-off in catalyst regeneration precisely, for the relevant current years, and in agreement with the data available from emissions trading. To make it possible to determine the pertinent factors retroactively, back to 1990, first a specific factor was defined that is oriented to the capacity of the reforming plants involved. Various reviews have found that this procedure comes closest to the underlying reality, since the available statistics do not include data on inputs and outputs of the reformers and of fluid catalytic cracking (FCC) plants. The result obtained is that emissions from coke burn-off in catalyst regeneration were considerably lower in 1990 than they were in the current year. This seems plausible, since processing of heavy petroleum products has increased considerably since 1990.

For the years 1990 – 1993, no data on own consumption of petroleum coke are available for the new German Länder. As a result, the pertinent data for those Länder had to be calculated from the emission factor determined from the emissions-trading data.

Since virtually all of oil refineries' emissions result from combustion processes, the refineries' emissions are reported in category 1.A.1.b. In two exceptions, fugitive emissions from production of calcined petroleum coke, and flare emissions, are reported in category 1.B.2.a.iv.

Emission factors

A detailed description of the relevant procedures, and a list of the CO₂ emission factors used, is presented in the Annex, Chapter 18.7.

The emission factors for N₂O, CH₄ and precursor substances for refinery power stations have been taken from the research projects RENTZ et al (2002) and FICHTNER et al (2011). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3. The cited project does not provide any emission factors for the bottom-heating systems that supply process heat. To compensate for this gap, for bottom-heating systems the same values for N₂O and CH₄ were chosen that are used for refinery power stations.

3.2.7.3 Uncertainties and time-series consistency (1.A.1.b)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, in the Chapter "Uncertainties in the activity data of stationary combustion systems" (Chapter 13.6 of the NIR 2007).

3.2.7.3.1 Result for N₂O

The results of Chapter 3.2.6.3.2 apply mutatis mutandis.

3.2.7.3.2 Result for CH₄

The results of Chapter 3.2.6.3 apply mutatis mutandis.

3.2.7.3.3 Time-series consistency of emission factors

The results of Chapter 3.2.6.3.4 apply mutatis mutandis.

3.2.7.4 Category-specific quality assurance / control and verification (1.A.1.b)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

With regard to refineries, comparisons with data from the British inventory were carried out. The two countries' refinery capacities are roughly similar in size. To enhance comparability, numerous indicators were defined, for factors such as transformation inputs and production data, in addition to emissions-relevant own consumption. Comparisons of the indicators show excellent agreement.

In addition, a carbon balance is prepared for the purpose of checking data quality. The balance shows only very minor statistical differences over the relevant years.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

With regard to emission factors, the results of Chapter 3.2.6.3 apply mutatis mutandis.

3.2.7.5 Category-specific recalculations (1.A.1.b)

Table 26: Recalculations, CRF 1.A.1.b

Units [Gg]	NIR 2016	NIR 2017	Difference, absolute				Difference, relative
			gas	liquid	solid	Total	
2013	18,283	18,135	1	-149	0	-148	-0.81%
2014	17,635	17,787	614	-454	-7	152	0.86%

The emission factor for refinery gas was adjusted to the current net calorific value, and the figures for liquid fuels in the years 2013 and 2014 were recalculated to take account of this change. The

provisional values were replaced when the final Energy Balance for 2014 became available. That led to recalculations for all fuels.

3.2.7.6 Planned improvements, category-specific (1.A.1.b)

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.8 Manufacture of solid fuels and other energy industries (1.A.1.c)

3.2.8.1 Category description (1.A.1.c)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990- 2015
L/T	1.A.1.c Manufacture of solid fuels and other energy industries	All fuels	CO ₂	65,289.1	5.34%	10,157.9	1.14%	-84.4%
-/-	1.A.1.c Manufacture of solid fuels and other energy industries	All fuels	N ₂ O	659.2	0.05%	154.2	0.02%	-76.6%
-/-	1.A.1.c Manufacture of solid fuels and other energy industries	All fuels	CH ₄	92.0	0.01%	171.9	0.02%	86.8%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	NS	CS
CH ₄	Tier 2	NS	CS
N ₂ O	Tier 2	NS	CS
NO _x , CO, NMVOC, SO ₂	CS	NS	CS

The category *Manufacture of solid fuels and other energy industries* is a key category, in terms of both emissions level and trend, of CO₂ emissions.

The above figures refer to power stations, and to other boiler furnaces for production of steam and hot/warm water, in category 1.A.1.c.

Category 1.A.1.c includes hard-coal and lignite mining, coking and briquetting plants and extraction of crude oil and natural gas. In 2015, the German hard-coal mining sector extracted 6.2 million t of usable hard coal (7.6 million t in 2014)²⁷. Coke production in 2015 amounted to 8.8 million t (2014: 8.77 million t)²⁸. Production of hard-coal briquettes was discontinued at the beginning of 2008.

In 2015, a total of 178.1 million t of crude lignite was extracted in Germany (2014: 178.2 million t)²⁹. Production of lignite briquettes and other lignite products (fluidised-bed lignite, dry lignite and lignite coke) amounted to 6.66 million t (2014 6.71 million t)(ibid.). Steam for drying of raw lignite, for production of refined lignite products, is obtained from lignite-fired power stations with process-steam extraction (CHP plants). From these plants, steam is drawn off for drying crude lignite for production of lignite products.

German petroleum production in 2015 amounted to 2.4 million t (2014: 2.4 million t)³⁰, while natural gas production in 2015 amounted to about 99 billion kWh (AGEB, 2016). The fuel inputs for the relevant plants' own operating requirements are reported in category 1.A.1.c.

²⁷ Statistik der Kohlenwirtschaft coal-sector-statistics association; cf.

<http://www.gvst.de/site/steinkohle/kennzahlen20145.htm> of 13 September 2016

²⁸ Verein deutscher Kokerei-Fachleute VdKF – cf. <http://web.vdkf-ev.de/site/index.php/produktionskennzahlen/> of 13 September 2016

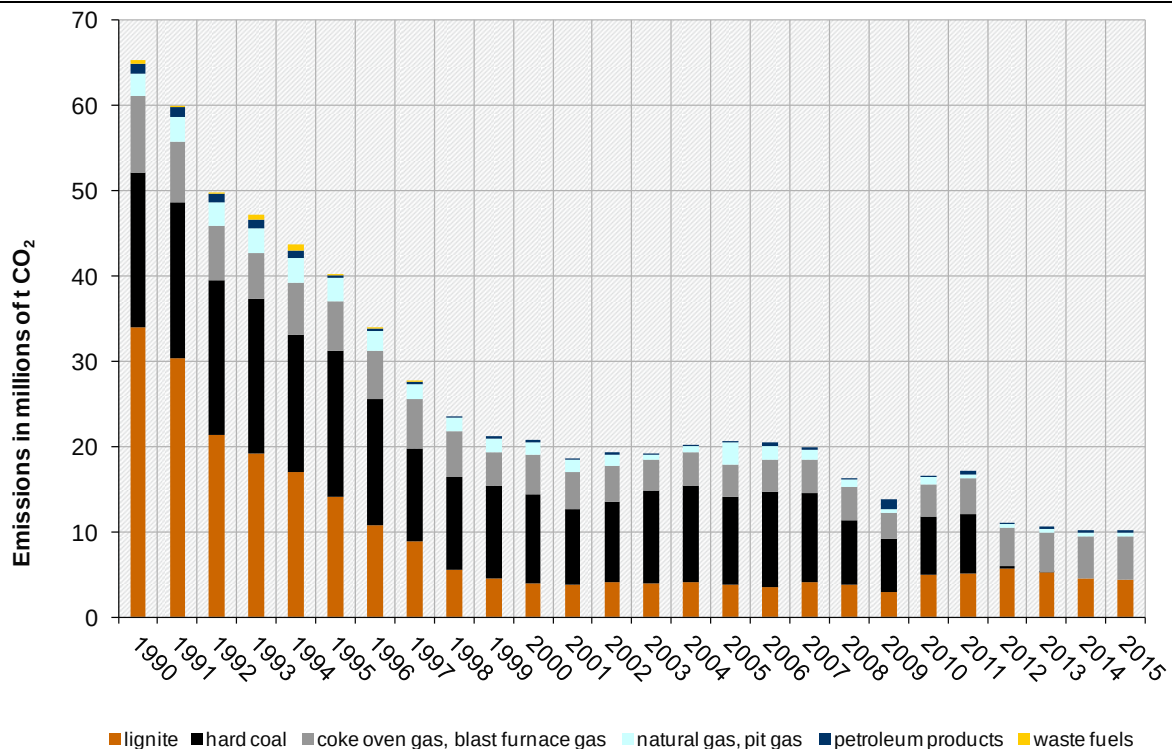
²⁹ cf. DEBRIV – <http://www.braunkohle.de/122-0-Kohlenfoerderung.html>

³⁰ cf. MWV, 2016 – <http://www.mwv.de/index.php/daten/statistikeninfoportal>

In the CSE, category 1.A.1.c Manufacture of solid fuels and other energy industries includes electricity and heat production in steam-turbine power stations, broken down by hard-coal mining and lignite mining (mine power stations); electricity and heat production in gas turbines, gas engines and diesel engines of all colliery and mine power stations; other heat production in industrial boilers within the transformation sector (not including refineries); and manufacture of hard-coal coke and operation of diesel engines for propulsion purposes in colliery and mine power stations. In reporting, they are broken down into the categories "large combustion systems" and "plants falling under the Technical Instructions on Air Quality Control" (TA Luft).

The following figure provides an overview of emissions trends in category 1.A.1.c:

Figure 26: Development of CO₂ emissions in category 1.A.1.c (in millions of t)



The figure clearly shows how sharply emissions in this category have decreased since 1990. The largest emissions decrease occurred in the area of lignite, use of which decreased strongly in the new German Länder in the early 1990s. The industry of the former GDR was based centrally on lignite. From raw lignite, a range of refined products used to be produced for industry, households and small commercial operations. A comprehensive transition from lignite to other fuels then took place until the end of the 1990s. In a – then considerably reduced – number of industrial plants and commercial operations, use of hard coal, petroleum and natural gas intensified, while coal-burning stoves in homes were replaced with more modern heating systems fired with heating oil and natural gas. As a result, coal briquette and dust production in the new German Länder decreased from nearly 39 million t in 1990 to about 2.6 million t in 1997. Most lignite-processing plants were closed in that period, and thus emissions decreased sharply. As of 1998, energy for drying lignite products in the new German Länder was provided solely via process steam from public power stations. In the old German Länder, improvements in plants' efficiencies, along with reduced production in that area as well, until 2003, reduced emissions. Thereafter, slight increases occurred again, as a result of production increases.

Emissions from use of hard coal in sector 1.A.1.c have been decreasing markedly since 1990. That decrease is due, firstly, to a sharp reduction in hard coal mining; while hard coal production still exceeded 70 million t in 1990, by 2015 it amounted to about 6 million t. Secondly, the decrease is due to the fact that over the years some installations have shifted, for reporting purposes, from the hard coal mining category to the public electricity supply category, thereby shifting their emissions as well. The power stations remaining in category 1.A.1.c until 2011 also fed electricity into the public grid.

Beginning in 2010, fuel inputs in the lignite-fired and hard-coal-fired power stations allocated to category 1.A.1.c. increased, as a result of economic recovery and related increased electricity demand. Another explanation for the increased lignite consumption is that some power stations have been taken from the public electricity generation sector and placed in the lignite mining sector. This has led to higher emissions overall.

Use of industrial gases (coke-oven gas, blast furnace gas and basic oxygen furnace gas) also decreased until the end of the 1990s. The primary reason for this is that city-gas production was phased out through 1996, in a process involving decommissioning of local gas works. Coke production also decreased markedly. Production of hard coal coke decreased from 19 million t in 1990 to just less than half of that figure in 2008. Production in 2009 amounted to only 6.7 million t, as a result of low steel production. In 2010, then, as the economic situation improved, hard-coal-coke production increased again, to about 8 million t. Production then remained at that level through the year 2013. As a result of the expansion of one coking plant, in 2014, coke production increased again, reaching 8.8 million t in 2015. Emissions from combustion of blast-furnace gas and coke oven gas also increased as a result. In 1990, a total of 8 mine coking plants were still in operation. Today, only five coking plants remain in operation, and all belong to the steel industry ("metallurgical coking plants"). Overall, plant closures and efficiency increases have decreased emissions markedly in this sector.

In 2012, several important installations in the hard-coal mining sector were shifted, for reporting purposes, into the public sector. This very markedly reduced emissions in category 1.A.1.c. At the same time, this statistical effect led to an increase of emissions from hard-coal use in sector 1.A.1.a. For all sectors overall, emissions from hard-coal-fired electricity generation increased in 2012.

The slight emissions decrease seen in 2013 is due mainly to the closure of a mine-mouth power plant in the central German lignite-mining district and to decreased fuel inputs in mine-mouth power plants in the Rhineland area. The emissions decrease was considerably smaller, since natural gas inputs for "other energy producers" increased at the same time. Emissions remained stable in the years 2014 and 2015.

3.2.8.2 Methodological issues (1.A.1c)

The calculation method has been selected on the basis of the latest key-category analysis.

Fuel inputs for electricity production in power stations of the hard-coal and lignite mining sector are listed in Energy Balance line 12, "Industrial thermal power stations". Fuel inputs for heat production in the transformation sector are listed in Energy Balance lines 33-39 and in sum line 40 ("Total energy consumption in the transformation sector").

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 (*STATISTISCHES BUNDESAMT*, 2015c). The activity data for heat production in power stations of the hard-coal mining sector correspond to Energy Balance line 34 "Energy input in collieries and briquette plants of the hard-coal mining sector".

The listed fuel input for electricity production in mine power stations is based on association information (personal communication 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 n.y.) and from the specific fuel inputs required for drying (personal communication from DEBRIV, February 2016), listed as "non- Energy-Balance inputs" in the CSE, and reported as such. The data are collected and updated via annual surveys.

The quantities of fuel used for production of hard-coal coke are taken directly from the Energy Balance, line 33 (coking plants). That line includes the coking plants' own consumption. Fuel combustion for bottom-heating systems is the largest emission source in the coking plant sector. In the coking process, fugitive emissions also occur before the coke is quenched, however; these are reported in category 1.B.1.b.

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

As of the 2011 report, CO₂ emissions from blast-furnace-gas combustion in coking plants are reported in category 1.A.1.c. The following table provides an overview of CO₂ emissions from use of blast-furnace gas in coking plants, for the entire time series since 1990.

Table 27: CO₂ emissions from blast-furnace-gas combustion in coking plants

[Millions of t of CO ₂]									
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
5.340	5.251	4.590	4.083	5.066	4.924	4.707	4.969	4.362	3.145
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3.652	3.741	3.684	3.029	3.356	3.247	3.281	3.226	3.226	2.500
2010	2011	2012	2013	2014	2015				
3.245	3.895	4.289	4.341	4.554	4.702				

Revision of the data for 1990, and for the years 1991-1994, for the new German Länder is described in Annex Chapter 19.1.1.

Emission factors

A list of the CO₂ emission factors used, and a description of the relevant methods, are provided in the Annex, Chapter 18.7.

The emission factors for power stations and other boiler combustion for production of steam and hot/warm water, in category 1.A.1.c, have been taken from RENTZ et al (2002) and FICHTNER et al (2011). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3. Within the sector, the research projects differentiate between STEAG power stations, other power stations in the hard-coal mining sector, power stations in the lignite mining sector and other boiler combustion for production of steam and hot/warm water.

The majority of emission factors for coking plants have been obtained from BFI (2012). That data source's emission factors for contained sources have been allocated to category 1.A.1.c, since those emissions result primarily from bottom-heating of coke ovens. By contrast, the emission factors

determined for fugitive sources have been allocated, by definition, to category 1.B.1.b. In both categories, calculations cover CO emissions from coking plants, along with other pollutants.

3.2.8.3 Uncertainties and time-series consistency (1.A.1.c)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project FKZ 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, Chapter 13.6 of the NIR 2007.

The procedure for determining uncertainties for the emission factors is described in Chapter 3.2.6.3.1.

3.2.8.3.1 Result for N₂O

Relatively large numbers of fluidised-bed combustion systems are used in plants within the lignite-mining sector – which plants are part of sector 1.A.1.c. Such systems are known to have relatively higher N₂O emissions than systems using other types of coal-combustion technologies. On the other hand, relevant emissions behaviour in combustion of hard coal and lignite, particularly in fluidised-bed combustion, has been specifically studied, especially in the 1990s. For this reason, enough measurement data were available to permit systematic survey of N₂O emission factors in the research project. The remarks made in Chapter 3.2.6.3.2 apply mutatis mutandis.

3.2.8.3.2 Result for CH₄

The results of Chapter 3.2.6.3.3 apply mutatis mutandis.

3.2.8.3.3 Time-series consistency of emission factors

The results of Chapter 3.2.6.3.4 apply mutatis mutandis.

3.2.8.4 Category-specific quality assurance / control and verification (1.A.1.c)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The results of Chapter 3.2.6.2 apply mutatis mutandis.

3.2.8.5 Category-specific recalculations (1.A.1.c)

Table 28: Recalculations, CRF 1.A.1.c

Units [Gg]	NIR 2016	NIR 2017	Difference, absolute					Difference, relative
			gas	liquid	other	solid	Total	
Year	Total	Total						Total
2011	17,090	17,092	0	0	0	2	2	0.01%
2014	10,250	10,180	16	-57	0	-28	-69	-0.68%

Slight recalculations were carried out for the year 2011 to take account of correction of an error in the raw lignite figures. Provisional figures for the year 2014 were replaced with figures from the now-available final Energy Balance for that year. That necessitated recalculations for nearly all fuels.

3.2.8.6 Planned improvements (category-specific) (1.A.1.c)

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.9 Manufacturing industries and construction (1. A.2)

This category consists of several sub- source categories defined in close harmony with the IPCC categorisations (CRF). It is described in detail via the relevant sub-chapters.

The calculation algorithms for BEU structural elements in category 1.A.2 were revised, within the research project "Substantiation of the data quality of activity data" (FKZ 204 41 132), and they are now governed by a consistent system. For the most part, they are based on reliable data of the Federal Statistical Office.

Sectoral differentiation of activity data was carried out solely for process combustion. A number of reallocations were carried out, as of the 2015 NIR, as a result of the new CRF categorisation.

As of 2008, classification of economic sectors (Wirtschaftszweige = WZ), in energy statistics, is being changed from the "WZ 2003" standard to the "WZ 2008" standard. As a result, activity data relative to process combustion are now being taken from individual statistics in keeping with the relevant key for the change (STATISTISCHES BUNDESAMT 2008: "Umsteigeschlüssel WZ 2003 auf WZ 2008" (key for the change from WZ 2003 to WZ 2008))

As of the 2015 report, this creates difficulties in allocations to the new CRF categories of the 2006 Guidelines. At the time the 2006 Guidelines were prepared, the 2008 economic sectors (WZ) were not yet known and thus were not taken into account.

With respect to power and heat production, industrial power stations and boiler systems are aggregated by technologies (gas engines, gas turbines, gas and steam plants and steam turbines), as well as by permit-law provisions (TA-Luft and 13th BImSchV).

The various individual calculation algorithms were substantiated in detail in the aforementioned research project.

Following emission calculation at the structural-element level, the sum values for the sub-categories in 1.A.2 were produced pursuant to the 1996 Guidelines – through the 2014 NIR. As of the 2015 NIR, the sum values are produced pursuant to the 2006 Guidelines. In all cases, the aggregation is largely IPCC-conformal. Since the NIR 2006, most process combustion has been reported on a sector-specific basis. The available data do not permit fully IPCC-conformal disaggregation. For example, heat and power production of industrial power stations and thermal power stations cannot be completely oriented to specific sectors; for this reason, it is reported in combined form, under 1.A.2.gviii Other.

Differentiation of energy-related process combustion for heat and power production in industrial power stations and in boiler systems was carried out via Statistik 067 (Statistics 067; electricity-production systems of the manufacturing sector, and of the mining and quarrying sectors (Stromerzeugungsanlagen des Verarbeitenden Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden); *STATISTISCHES BUNDESAMT*, 2015c).

A change in Statistics 067 (op. cit.) of the Federal Statistical Office has led to a jump in the activity data for heat and electricity production. Until 2001, only the fuel inputs for electricity production in electricity production systems were listed. As of 2002, fuel inputs for heat and electricity production are listed. No data are available for inputs for heat production for years prior to 2002.

The ratio between the fossil and biogenic fractions in industrial waste is obtained from the Energy Balance, from waste statistics (STATISTISCHES BUNDESAMT, FS 19 Reihe 1) and from the relevant industry association figures for substitute fuels.

All of the listed amounts of standard fuels used in all sub-categories have been taken from the Energy Balance of the Federal Republic of Germany and disaggregated in the Balance of Emission Causes (BEU). In addition to the figures provided from the Energy Balance, in various sub-categories substitute fuels have now been listed. The relevant amounts were determined in a research project (UBA 2005b, FKZ 204 42 203/02) and are now updated annually with the help of association data (see below). This work has shown that substitute fuels are increasingly being used as replacements for more-expensive conventional fuels.

In the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; (UBA 2005b, FKZ 204 42 203/02)), the required improvements relative to the topic of "waste fuels" in the energy sector were found to be tied to substitute fuels in four industrial sectors, and the pertinent data were obtained from the relevant industrial associations. As a result, considerably improved, sector-specific data are now available relative to use of substitute fuels in process combustion, and in industrial power stations, in the industrial sectors pig-iron production, pulp and paper production and lime and cement production.

Special aspects of the various sub-categories are described in the relevant sub-chapters. Special note should be taken of the collective group 1.A.2.g Other.

The uncertainties for the new structural elements created in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; (FKZ 204 41 132) were determined in keeping with the method described in the research project 204 42 203/02. That determination is described in the final report for the research project (FKZ 204 41 132) and in Annex 13.6 of the NIR 2007.

Carbon dioxide emissions predominate in CRF category 1.A.2. Other greenhouse gases account for only very small shares of total emissions.

A sharp reduction in greenhouse-gas emissions occurred in the period 1990 through 1994. It was caused by decommissioning of inefficient manufacturing plants in the new German Länder following the 1990 political transition in Germany.

The emissions fluctuations that occurred in subsequent years reflect production trends in Germany's manufacturing sector, which were tied to overall economic trends.

3.2.9.1 Manufacturing industries and construction – iron and steel (1.A.2.a)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	1.A.2.a Manufacturing industries and construction: iron and steel	All fuels	CO ₂	35,269.3	2.88%	38,576.0	4.35%	9.4%
-/-	1.A.2.a Manufacturing industries and construction: iron and steel	All fuels	N ₂ O	155.1	0.01%	118.5	0.01%	-23.6%
-/-	1.A.2.a Manufacturing industries and construction: iron and steel	All fuels	CH ₄	62.5	0.01%	68.6	0.01%	9.9%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	NS	CS
CH ₄	CS	NS	CS
N ₂ O	CS	NS	CS
NO _x , CO, NMVOC, SO ₂	CS	NS	CS

The category *Manufacturing industries and construction – iron and steel* is a key category, in terms of emissions level and trend, for CO₂ emissions.

The iron and steel industry (sub-category 1.A.2.a) is the second important CO₂-emissions source, along with the cement industry, in the area of process combustion.

3.2.9.1.1 Category description (1.A.2.a)

The category comprises the production areas of pig iron (blast furnaces), sponge iron (direct reduction), sinter, rolled steel, iron and steel casting, Siemens-Martin steel, electric steel and the power stations and boilers of the entire steel industry.

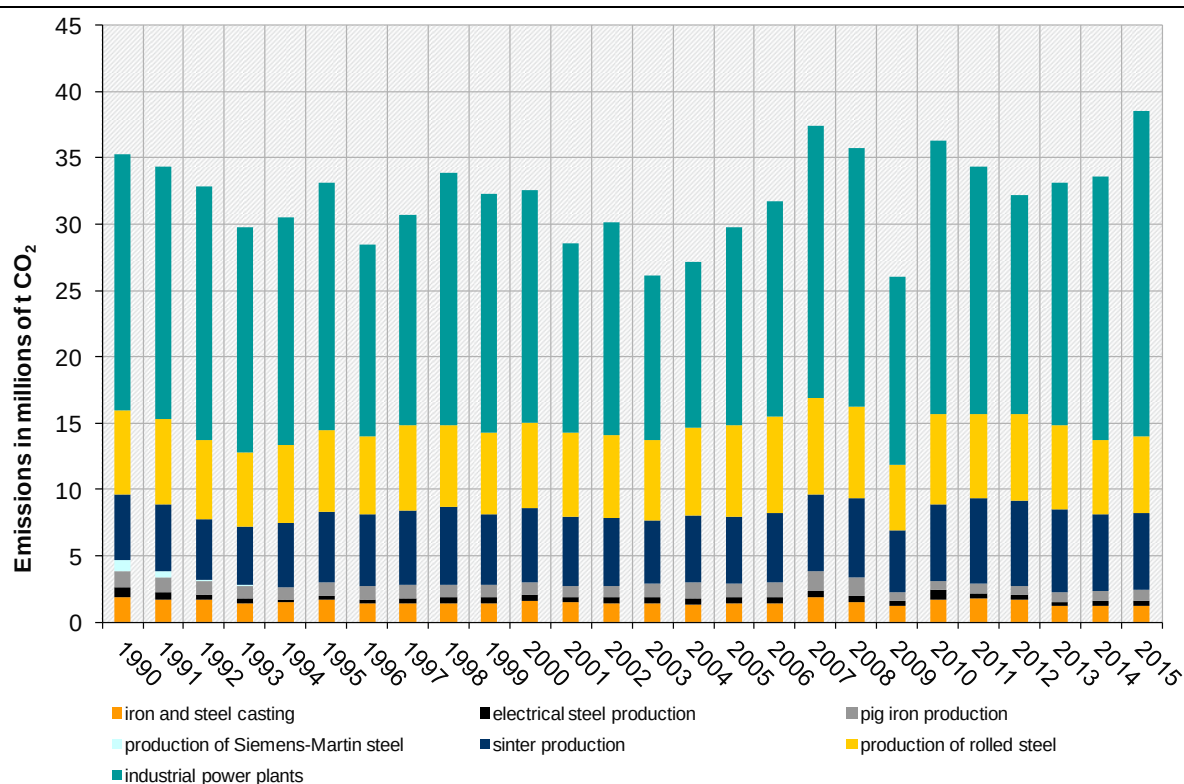
Production of Siemens-Martin steel generated emissions only in the new German Länder, and only until shortly after 1990. In the old German Länder, production of Siemens-Martin steel was discontinued before 1990.

Sponge iron (direct-reduced iron (DRI)) is produced in Germany only on a relatively small scale (about 0.5 million t per year), and only in one plant. The CO₂ emissions that occur in DRI production result from the use of natural gas, i.e. from use of a reducing-agent mixture, comprising H₂ and CO, obtained from natural gas. The relevant quantities of natural gas used are included, throughout the entire time series, in the natural-gas inputs that are reported under 1.A.2.a. Consequently, CO₂ emissions from DRI production are reported, throughout the entire time series, under 1.A.2.a. The CO₂ emissions from DRI production cannot be listed separately, because such disclosures could be used to derive confidential production-quantity data for individual installations.

In production of pig iron, large amounts of the fuels used in blast furnaces are needed for the reduction processes that take place in the furnaces, while most of the fuel used in other production areas of the iron and steel industry is used for heat production.

The following figure provides an overview of CO₂ emissions in the various sub-categories in 1.A.2.a.

Figure 27: Development of CO₂ emissions in category 1.A.2.a



As the overview reveals, major fluctuations have occurred over the years. In most cases, those swings were tied to fluctuations in production. In the period 1990 through 1994, emissions

reductions occurred primarily as a result of restructuring of the iron and steel sector in the new German Länder following the political transition of 1990.

The drop in CO₂ emissions is particularly pronounced in the crisis year 2009, in which the steel industry registered a sharp production decrease. The recurring emissions increase in 2010 resulted from an economic recovery in which the steel industry nearly reattained its production level of 2008. In subsequent years, through 2013, raw steel production – and, thus, CO₂ emissions – decreased, but only slightly. In 2014 and 2015, pig-iron production and emissions both increased again, in keeping with the trend in raw steel production.

The noticeably high emissions increase in 2015 is due to shifting, for reporting purposes, of several power stations fired with blast furnace gas – from the public electricity supply (CRF 1.A.1.a) to industry. This has entailed only a shifting of emissions. Overall, CO₂ emissions have been increasing only slightly as a result of the increase in production. This relationship is clearly apparent in Figure 44: Chronological trend and source-category allocation of the CO₂ emissions resulting from use of reducing agents for primary steel production and from use of top gas in Chapter 4.4.1 Metal production: Iron and steel production (2.C.1).

Installations in the areas of rolled-steel and sinter production account for the second-highest shares of emissions, after industrial power stations (which generate electricity for their own use from blast furnace gas and basic oxygen furnace gas). In the blast furnace category, only the natural-gas and coking-gas inputs required for furnace operation are reported in category 1.A.2.a. Process-related emissions are listed in category 2.C.1.

In the area of pig-iron production in blast furnaces, inputs of heavy fuel oil have been decreasing continuously since 2010. The heating oil is being replaced largely by PCI coal. This is made possible by conversions of the relevant injection systems. The fuel changes are price-driven. In some blast furnaces, ground lignite is also used along with ground hard coal, with the choice between the two alternatives depending solely on price. Overall, this has led to a slight increase in specific emissions.

3.2.9.1.2 Methodological issues (1.A.2.a)

This sub-category comprises process combustion in the various production areas of the iron and steel industry. The relevant fuel-use amounts, including those for secondary fuels, are contained in the Balance of Emission Causes (BEU).

In work to obtain activity data for conventional fuels in this category, a new data source was developed as of reporting year 2011: the so-called "BGS" group (fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) locally connected to such operations). That source allows enhanced disaggregation of energy data in the Balance of Emissions Sources (BEU). While the legal basis for surveys relative to the BGS group was no longer available as of reporting year 2012, the pertinent data have since been provided, in the same structure, on the basis of an agreement with the Wirtschaftsvereinigung Stahl German steel industry association. This change has no impact on relevant calculations.

In addition to providing activity data for sintering plants, blast furnaces, basic oxygen furnaces (converters) and rolling mills, BGS-group data support additional disaggregation of the electric steel sector.

The BGS-group data also permit data-based differentiation of the solid-fuel categories "hard coal and hard coal briquettes"; "coke" and "coke breeze with particle size less than 10 mm". In the

database, the fuel inputs for coke and coke breeze are listed in sum as "coke", since the energy statistics list the aggregated fuel "coke". The "liquid fuels" listed for the BGS group are classified under "heating oil, heavy".

The BGS-group data list fuel inputs in natural units. For the present purpose, those units are converted into energy units, using the relevant net calorific values listed by the Working Group on Energy Balances (AGEB) for the various solid and liquid fuels. For gases, the BGS-group data use a norm of 35.16912 MJ/m³. That figure has been adopted in the methods for calculating activity data for blast-furnace gas, coke-oven gas, natural gas and basic oxygen furnace gas.

The method for calculating emissions from secondary fuels has been retained, in keeping with the results of the research project "Einsatz von Sekundärbrennstoffen" ("Inputs of secondary fuels"; UBA 2005b, FKZ 204 42 203/02).

In the area of emissions from the iron and steel industry, a distinction is made, for the entire time series as of 1990, between process-related emissions and energy-related emissions. The method for calculation of process-related emissions is described in Chapter 4.4.1.2 of category 2.C.1.

3.2.9.1.3 Uncertainties and time-series consistency (1.A.2.a)

Uncertainties were determined for all fuels in 2004 (except for substitute fuels), and for substitute reducing agents, with regard to the entire time series. The relevant method is described in a research report (UBA 2005b, FKZ 204 42 203/02). The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and included in the relevant final report.

The statistical data used for calculation until the 2011 report, from the Federal Statistical Office's Fachserie 4 Reihe 8.1, were aggregated in keeping with the BGS-group framework in those statistics. When production of those statistics has been discontinued, the basic BGS-group data will be used directly for calculation.

Direct use of the BGS-group data does not increase the uncertainties. The uncertainties as determined on the basis of the research report were retained, in keeping with the conservative approach applied.

3.2.9.1.4 Category-specific quality assurance / control and verification (1.A.2.a)

General quality control and, for the emission factors and emissions data, category-specific quality control, and quality assurance, have been carried out, in conformance with the requirements of the QSE manual and its associated applicable documents, by the relevant involved experts and the Single National Entity.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

The aforementioned agreement with the steel-industry association calls for the association to carry out quality assurance for the BGS-group data in keeping with the QSE manual. The association's quality report is provided along with the data.

3.2.9.1.5 Category-specific recalculations (1.A.2.a)

Provisional figures for the year 2014 were replaced with figures from the now-available final Energy Balance for that year. That necessitated recalculations for nearly all fuels.

Table 29: Recalculations in CRF 1.A.2.a

Units [Gg]	NIR 2016	NIR 2017	Difference, absolute				Difference, relative
			gas	liquid	solid	Total	
2014	33,834	33,615	7	-2	-224	-219	-0.65%

3.2.9.1.6 Planned improvements (category-specific) (1.A.2.a)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.9.2 Manufacturing industries and construction – non-ferrous metals (1.A.2b)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	1.A.2.b Manufacturing industries and construction: non-ferrous metals	All fuels	CO ₂	1,629.2	0.13%	1,513.3	0.17%	-7.1%
-/-	1.A.2.b Manufacturing industries and construction: non-ferrous metals	All fuels	N ₂ O	17.1	0.00%	7.7	0.00%	-55.2%
-/-	1.A.2.b Manufacturing industries and construction: non-ferrous metals	All fuels	CH ₄	1.4	0.00%	1.7	0.00%	22.2%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	NS	CS
CH ₄	CS	NS	CS
N ₂ O	CS	NS	CS
NO _x , CO, NMVOC, SO ₂	CS	NS	CS

The category *Non-ferrous metals* is not a key category.

3.2.9.2.1 Category description (1.A.2.b)

This category aggregates process combustion of various areas of non-ferrous-metal production. The available data do not support more detailed description.

3.2.9.2.2 Methodological issues (1.A.2.b)

The pertinent fuel inputs are contained in the Balance of Emission Causes (BEU). The source for fuel inputs consists of statistics for the manufacturing sector (Statistik 060 – Energieverwendung des produzierenden Gewerbes (energy use in the manufacturing sector; *STATISTISCHES BUNDESAMT* (Federal Statistical Office) 2015b) (Melde-Nr. (reporting number) 27.43 (WZ 2003 old; WZ = classification system for economic data) → 24.43 (WZ 2008 new); Erzeugung und erste Bearbeitung von Blei, Zink und Zinn (production and initial processing of lead, zinc and tin) 27.44 (WZ 2003 old) → 24.44 (WZ 2008 new); Erzeugung und erste Bearbeitung von Kupfer (production and initial processing of copper)) and, for differentiations relative to heat and electricity production, Statistik 067 (*STATISTISCHES BUNDESAMT*, 2015c).

Descriptions of calculation algorithms for activity data in the Balance of Emissions Sources (BEU) were revised in the interest of standardisation, consistency and transparency.

As a result of such revision, production and initial processing of precious metals, aluminium and other non-ferrous metals are now taken into account in determination of activity data.

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

The 1990 activity data for the new German Länder were revised and substantiated, with the help of new data, in the project "Base year and updating" ("Basisjahr und Aktualisierung" (UBA 2005c: FKZ 205 41 115); see Annex Chapter 19.1.1).

3.2.9.2.3 Uncertainties and time-series consistency (1.A.2.b)

Uncertainties for all activity data were determined in 2004. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.2.4 Category-specific quality assurance / control and verification (1.A.2.b)

General QA/QC measures have been carried out, in conformance with the requirements of the QSE manual and its associated applicable documents, by the relevant involved experts and the Single National Entity.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.2.5 Category-specific recalculations (1.A.2.b)

Table 30: Recalculations in CRF 1.A.2.b

Units [Gg]	NIR 2016	NIR 2017	Difference, absolute				Difference, relative
Year	Total	Total	gas	liquid	solid	Total	Total
2014	1,378	1,496	111	7	0	118	8.57%

Provisional values for the year 2014 were replaced when the figures from the final Energy Balance for 2013 became available. This has led to recalculations of the figures for gaseous and liquid fuels.

3.2.9.2.6 Planned improvements (category-specific) (1.A.2.b)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.9.3 Manufacturing industries and construction – Chemicals (1.A.2.c)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990- 2015
-/-	1.A.2.c	All fuels	IE	IE	IE	IE	IE	IE

In the chemical industry, the main relevant plants consist of industrial power stations and boilers. Such installations are reported, for all sectors, in sub-category 1.A.2.g Other.

Fuel inputs in calcium-carbide production are process-related and are reported under CRF 2.B.5 (cf. Chapter 4.3.5).

This approach has been confirmed by the research project "Base year and updating" (UBA 2005c, FKZ 205 41 115), for 1990 in the new German Länder (the most important production location): the relevant coke was used as a production material and not as a fuel for energy. Calcium-carbide production is thus not a source of energy-related CO₂ emissions.

The emissions for the entire sub-category 1.A.2.c are thus included elsewhere (IE). For this reason, sub-category 1.A.2.c is not listed separately in the key-category analysis.

The majority of the emissions in the chemical industry originate in combustion processes. Since fuel-input data for the chemical industry are available only as of the year 2003, no time series as of 1990 can be produced. For this reason, emissions from energy-related use of fuels in the chemical industry are reported together with emissions for other industrial sectors in category

1.A.2.gviii "Other". Nonetheless, the available data can be cross-checked against relevant available data from emissions trading. As this is done, double counting with the IPPU Sector has to be avoided. In addition, it is important to ensure that emissions from combustion of other produced gases are not underestimated. The comparison shows that the data reported in energy statistics for the period as of 2012 agree well with the fuel-quantity data from emissions trading. The gas quantities given by statistics for earlier years are too low overall. The first analytical step, therefore, was to identify the chemical industry areas in which other produced gases occur and are used for energy generation. Overall half of the total gas produced is used in production of other organic basic materials and chemicals. The next-largest share is used in production of other inorganic basic materials and in production of dyes and pigments. A still-smaller share of these gases is used in production of plastics in primary forms. For recalculation of the relevant gas consumption, the main products produced in each sector were determined. The pertinent data are available, for the period back to 1990, in the annual "Chemiewirtschaft in Zahlen" ("Chemical industry figures") reports of the VCI. Data are lacking only for the new German Länder in the year 1990. Since the Energy Balance lists major quantities of "fuel gases" ("Brenngase") for the new German Länder, it may be assumed that those gases have been taken into account at least in the area of energy use. With the help of the production data, and the gas-quantity data listed in the energy statistics for the year 2013, specific factors were developed, for each sub-sector, with which it was possible to calculate the pertinent fuel inputs retroactively.

3.2.9.4 Manufacturing industries and construction – Pulp, paper and print (1.A.2.d)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990- 2015
-/-	1.A.2.d Manufacturing industries and construction: Pulp, paper and print	All fuels	CO ₂	3.6	0.00%	6.1	0.00%	66.6%
-/-	1.A.2.d Manufacturing industries and construction: Pulp, paper and print	All fuels	N ₂ O	2.8	0.00%	12.4	0.00%	342.3%
-/-	1.A.2.d Manufacturing industries and construction: Pulp, paper and print	All fuels	CH ₄	0.7	0.00%	2.9	0.00%	342.3%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	NS	CS
CH ₄	CS	NS	CS
N ₂ O	CS	NS	CS
NO _x , CO, NMVOC, SO ₂		IE	

The category *Pulp, paper and print* is not a key category.

3.2.9.4.1 Category description (1.A.2.d)

The energy consumption for production of pulp, paper and printed products – otherwise referred to as the "pulp and paper industry" for short – can be described only for substitute fuels, of which this industry uses large amounts.

Emissions from use of regular fuels in process combustion, and emissions generated by plants in own-power production, have not been listed separately. They are summarised under 1.A.2.g Other.

3.2.9.4.2 Methodological issues (1.A.2.d)

Only some of the substitute fuels used by the paper industry are listed in the Energy Balance. The fuels in question consist of waste from the relevant sectors' own production areas. The data on the types and amounts of substances used were provided by the German Pulp and Paper Association (VDP). The great majority of the substitute fuels used in the sector consist of wood and pulp fibres – and, thus, of biomass. The biogenic and fossil fractions of pertinent fuels were derived in the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen") (UBA 2005b,

FKZ 204 42 203/02). In addition, CO₂ emission factors were derived on the basis of data on carbon content, water content and net calorific values.

The official statistical data on inputs of standard fuels in the paper industry were reviewed.

In the statistics for the manufacturing sector (Statistik 060 – Energieverwendung des produzierenden Gewerbes ("energy use in the manufacturing sector"); *STATISTISCHES BUNDESAMT* 2015b), under the new system for classification of economic activities (Wirtschaftszweigsystematik – WZ 2008 new), the source for the fuel inputs is assigned WZ number 17 "Herstellung von Papier, Pappe und Waren daraus" (production of paper, cardboard and related goods").

At present, the source for one time series cannot be unambiguously assigned in keeping with the old system for classification of economic activities (WZ 2003).

The class WZ 17 within the new system for classification of economic activities (Wirtschaftszweigsystematik 2008) corresponds to classes WZ 17, 21, 22 and 36 under the old system, WZ 2003.

Currently, the individual fuel inputs cannot be listed in disaggregated form, due to the need to protect confidentiality.

The same applies for Statistik 067 (*STATISTISCHES BUNDESAMT*, 2015c), which is used for differentiation from electricity and heat generation.

3.2.9.4.3 Uncertainties and time-series consistency (1.A.2.d)

In the framework of a research project, the uncertainties of the CO₂ emission factors derived for substitute fuels were determined using the Monte Carlo method (UBA 2005b, FKZ 204 42 203/02). In the procedure, figures for C content, water content and net calorific value were taken into account. Such figures are based on varying estimates, as well as on small numbers of measurements and analysis results, and thus show wide spreads. The CO₂ emission factors for secondary fuels, along with the relevant uncertainties, apply throughout the entire relevant time series, because no findings on trends are available. The time series are thus consistent.

3.2.9.4.4 Category-specific quality assurance / control and verification (1.A.2.d)

General QA/QC measures have been carried out, in conformance with the requirements of the QSE manual and its associated applicable documents, by the relevant involved experts and the Single National Entity.

The paper industry has long kept records of inputs of secondary fuels (VDP, various years). In spite of small structural breaks in the time series in such records, the records clearly show the paper industry's increasing use of substitute fuels in place of regular fuels.

3.2.9.4.5 Category-specific recalculations (1.A.2.d)

Table 31: Recalculations in CRF 1.A.2.d

Units [Gg] Year	NIR 2016 Total	NIR 2017 Total	Difference, absolute Total	Difference, relative Total
2013	8	8	0	0.17%
2014	7	7	0	0.91%

Recalculations were carried out in the inventory to take account of recalculations in the pertinent original statistics, the paper industry's own production report ("Leistungsbericht"), for the period as of 2013. For biomass, recalculations were carried out throughout the entire time series, since

the CO₂ emission factor was revised to take account of measurements. The previously used factor was considerably too low.

3.2.9.4.6 Planned improvements (category-specific) (1.A.2.d)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.9.5 Manufacturing industries and construction – Sugar production (1.A.2.e)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990- 2015
-/T	1.A.2.e Manufacturing industries and construction: Food processing	All fuels	CO ₂	2,015.9	0.16%	290.2	0.03%	-85.6%
-/-	1.A.2.e Manufacturing industries and construction: Food processing	All fuels	N ₂ O	24.6	0.00%	2.5	0.00%	-89.7%
-/-	1.A.2.e Manufacturing industries and construction: Food processing	All fuels	CH ₄	4.5	0.00%	0.2	0.00%	-95.0%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	NS	CS
CH ₄	CS	NS	CS
N ₂ O	CS	NS	CS
NO _x , CO, NMVOC, SO ₂	CS	NS	CS

The *Sugar production* category is a key category for CO₂ emissions in terms of trend (cf. Table 6). Because relevant emissions have fallen sharply since 1990 (-85.6 %), and thus an extremely low emissions level has been attained, the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this category that are required for key categories.

3.2.9.5.1 Category description (1.A.2.e)

This category includes only the sugar industry's process combustion. Plants generating their own power are not listed separately; they are reported under 1.A.2.g Other.

3.2.9.5.2 Methodological issues (1.A.2.e)

Descriptions of calculation algorithms for activity data in the Balance of Emissions Sources (BEU) were revised in the interest of standardisation, consistency and transparency.

As a result of this revision, it was determined that the statistics publications Statistik 060 (*STATISTISCHES BUNDESAMT*, 2015b) and Statistik 067 (*STATISTISCHES BUNDESAMT*, 2015c) list all of the fuels required for calculation of the pertinent activity data and should be used as data sources.

The relevant calculation algorithms, and special analyses relative to fuel inputs, are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

3.2.9.5.3 Uncertainties and time-series consistency (1.A.2.e)

For 2004, the uncertainties for all activity data were determined for the first time. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.5.4 Category-specific quality assurance / control and verification (1.A.2.e)

General QA/QC measures have been carried out, in conformance with the requirements of the QSE manual and its associated applicable documents, by the relevant involved experts and the Single National Entity.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.5.5 Category-specific recalculations (1.A.2.e)

Table 32: Recalculations in CRF 1.A.2.e

Units [Gg] Year	NIR 2016 Total	NIR 2017 Total	Difference, absolute				Difference, relative Total
			gas	liquid	solid	Total	
2014	247	286	1	13	25	39	15.80%

Provisional figures for the year 2014 were replaced with figures from the now-available final Energy Balance for that year. That necessitated recalculations for nearly all fuels. Since the sugar industry is only a small sector, the recalculations required as a result of replacement of the provisional figures are especially significant, percentage-wise. It is very difficult to make any reliable estimates for this industrial sector.

3.2.9.5.6 Planned improvements (category-specific) (1.A.2.e)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.9.6 Manufacturing industries and construction – Non-metallic minerals industry (1.A.2.f)

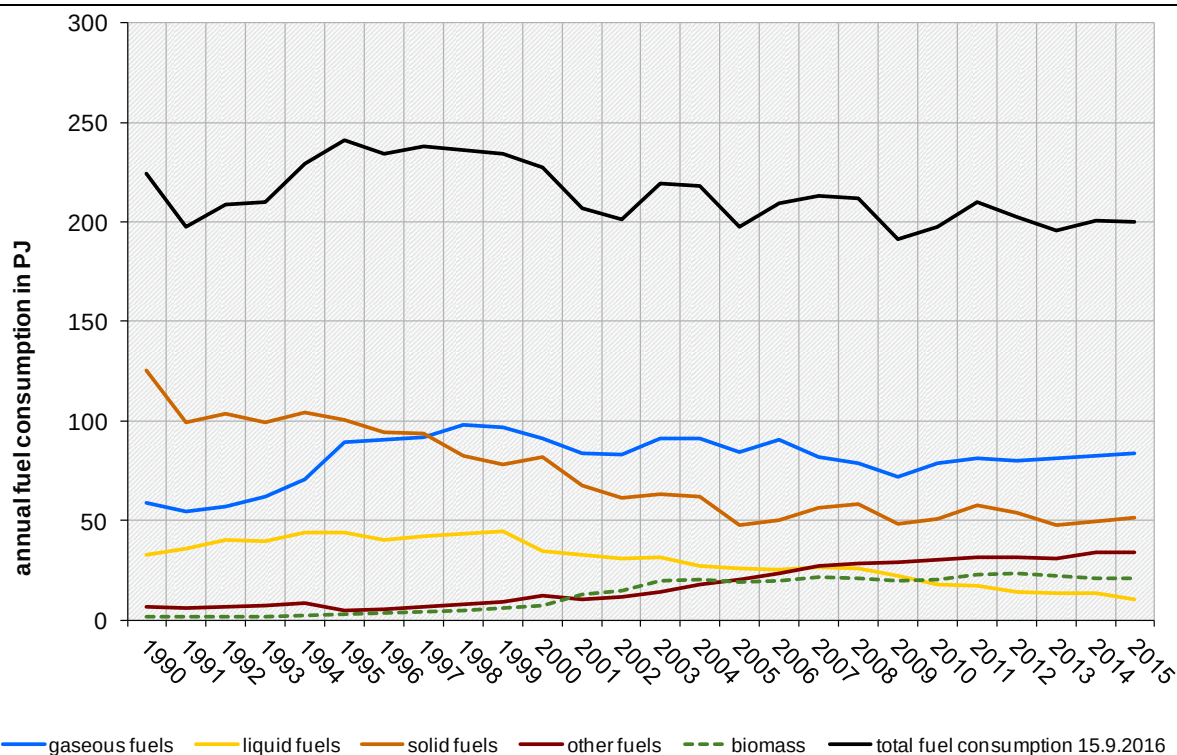
KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990- 2015
L/-	1.A.2.f Manufacturing industries and construction: Non-metallic minerals	All fuels	CO ₂	18,507.4	1.51%	13,145.4	1.48%	-29.0%
-/-	1.A.2.f Manufacturing industries and construction: Non-metallic minerals	All fuels	N ₂ O	205.3	0.02%	119.8	0.01%	-41.6%
-/-	1.A.2.f Manufacturing industries and construction: Non-metallic minerals	All fuels	CH ₄	50.3	0.00%	15.1	0.00%	-69.9%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	NS	CS
CH ₄	CS	NS	CS
N ₂ O	CS	NS	CS
NO _x , CO, NMVOC, SO ₂	CS/IE	NS/IE	CS/IE

The category *Manufacturing industries and construction – Non-metallic minerals industry*, including all of its sub-categories, is a key category, in terms of emissions level, for CO₂ emissions.

In general in the inventory, those categories are listed separately in which combustion systems with a specific emissions behaviour – so-called "process combustion" systems – are used. For this reason, the sub-categories 1.A.2.f Cement (structural element "Production of cement clinkers (process combustion)"), 1.A.2.f Ceramics (structural element "Production of ceramics products (process combustion)"), 1.A.2.f Glass (structural element "Production of glass (process combustion)") and 1.A.2.f Lime (structural element "Production of lime (process combustion)") are listed individually.

Figure 28: Development of fuel inputs in category 1.A.2.f Non-metallic minerals



Two changes of fuels occurred in the area of the non-metallic minerals industry.

In the mid-1990s, gaseous fuels increasingly began to be used instead of solid fuels. These two fuel groups are currently predominant in this source category.

In the 2000s, the majority of liquid fuels began to be replaced – first by waste and secondary fuels, and then by biomass.

In 2015, use of natural gas and solid fuels increased slightly, while use of biomass and waste fuels remained at about the relevant levels seen in 2014. As a result, fuel inputs for petroleum decreased slightly, and thus total fuel inputs remained stable by comparison to the previous year.

3.2.9.6.1 Category description (1.A.2.f, Non-metallic minerals industry)

In this category, process combustion from burning of clinkers is listed. The final step in cement production, i.e. grinding and mixing, is not included. As a power-intensive process, it is included in power production (1.A.1). In addition, process combustion in the brick industry, and in production of other structural ceramics, are reported as well. In the glass industry, process combustion includes production of flat glass, hollow glass and glass fibres; shaping and processing of flat glass; and production and shaping of other types of glass and technical glassware. Process combustion in lime production is also taken into account. Some plants within this category also generate power for their own use; such generation is not listed separately, but is included under 1.A.2.gviii "Other".

3.2.9.6.2 Methodological issues (1.A.2.f, Non-metallic minerals industry)

The pertinent inputs of conventional fuels are contained in the Balance of Emission Sources (BEU). The fuel-input data for energy-related process combustion are obtained from the manufacturing sector's own statistics. The following numbers from the WZ classification of industrial sectors are

relevant: Reporting number (Melde-Nr.) 26.51(WZ 2003 old) → 23.51 (WZ 2008 new), Cement production; Reporting number 26.40 (WZ 2003 old) → 23.32 (WZ 2008 new), Brick production, Production of other structural ceramics; Reporting number 26.1 (WZ 2003 old) → 23.1 (WZ 2008 new), Production of glass and glassware; and Reporting number 26.52 (WZ 2003 old) → 23.52 (WZ 2008 new), Lime production. As a result of the change in the reporting numbers, the data for lime can no longer be easily separated from those for gypsum. The necessary differentiation is achieved with the help of a split factor determined on the basis of old individual statistics. For differentiation from heat and electricity production, cf. Statistik 067 (*STATISTISCHES BUNDESAMT* (Federal Statistical Office), 2015c).

As of 2002, the data for Statistik 067 (op. cit.) are found only among three-digit reporting numbers. This means that only data for reporting number 26.5 (WZ 2003 old) → 23.5 (WZ 2008 new) (production of cement, lime and burnt plaster) can be used as a basis.

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132) and in the 2013 NIR, 3.2.9.7 through 3.2.9.10.

The fuel inputs for the new German Länder in 1990 were calculated on the basis of specific fuel consumption in 1989 and production in 1990.

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 quantities are taken from statistics of the relevant industry associations. The procedure used to compile activity data oriented to the old and new German Länder as of 1990, and to all of Germany as of 1995, is described in the final report of the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; UBA 2005b, FKZ 204 42 203/02). In a first step, fuel inputs were allocated to the groups "Biomass" or "Other fuels (waste)", in keeping with IPCC procedures. In the research project "Inputs of secondary fuels", the biogenic fractions of relevant fuels were derived and then entered into the calculations, with the help of split factors. In the same project, CO₂ emission factors were derived for substitute fuels, on the basis of data on carbon content, water content and net calorific value (UBA 2005b, FKZ 204 42 203/02).

3.2.9.6.3 Uncertainties and time-series consistency (1.A.2.f, Non-metallic minerals industry)

Uncertainties were determined for all fuels in 2004 and for the aforementioned substitute fuels with regard to the entire time series. The relevant methods are explained in Annex Chapter 13.6 of the NIR 2007 and in the final report of the research project (UBA 2005b, FKZ 204 42 203/02).

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and included in the relevant final report.

The activity data for the new German Länder, for base year 1990 and the following years, 1991-1994, were adjusted in keeping with findings from the pertinent research project (FKZ 205 41 115 / Sub-project A "Revision and substantiation of fuel inputs for stationary combustion plants in the new German Länder for the year 1990").

3.2.9.6.4 Category-specific quality assurance / control and verification (1.A.2.f, Non-metallic minerals industry)

General QA/QC measures have been carried out, in conformance with the requirements of the QSE manual and its associated applicable documents, by the relevant involved experts and the Single National Entity.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.6.5 Category-specific recalculations (1.A.2.f, Non-metallic minerals industry)

Table 33: Recalculations in CRF 1.A.2.f

Units [Gg]	NIR 2016	NIR 2017	Difference, absolute					Difference, relative
	Total	Total	gas	liquid	other	solid	Total	Total
2014	12,307	13,243	311	464	1	160	936	7.61%

For the year 2014, extensive recalculations were carried out, to take account of the fact that provisional data were replaced by figures from the final Energy Balance.

3.2.9.6.6 Planned improvements (category-specific) (1.A.2.f, Non-metallic minerals industry)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.9.7 Manufacturing industries and construction – Other energy production (1.A.2.g, Other, stationary + mobile)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	1.A.2.g Manufacturing industries and construction: Other	All fuels	CO ₂	127,682.0	10.44%	72,445.4	8.16%	-43.3%
-/-	1.A.2.g Manufacturing industries and construction: Other	All fuels	N ₂ O	937.7	0.08%	549.9	0.06%	-41.4%
-/-	1.A.2.g Manufacturing industries and construction: Other	All fuels	CH ₄	130.7	0.01%	184.9	0.02%	41.5%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	NS	CS
CH ₄	CS	NS	CS
N ₂ O	CS	NS	CS
NO _x , CO, NMVOC, SO ₂	CS	NS	CS

The stationary and mobile sources in 1.A.2.g are grouped together for purposes of assignment to key categories. As a result, category *1.A.2.g Manufacturing industries and construction – Other energy production* is a key category for CO₂ in terms of emissions level and trend.

As a result of its function as a collective category for fuel inputs that cannot be disaggregated to the individual-sector level, this sub-category is particularly significant; it contributes substantially to the entire energy sector's CO₂ emissions.

3.2.9.7.1 Category description (1.A.2.g Other, stationary)

In this sub-category, all those emissions are reported for which the relevant energy inputs cannot be disaggregated in keeping with the categories in 1.A.2. This sub-category is responsible for about 70 % of all CO₂ emissions of category 1.A.2.

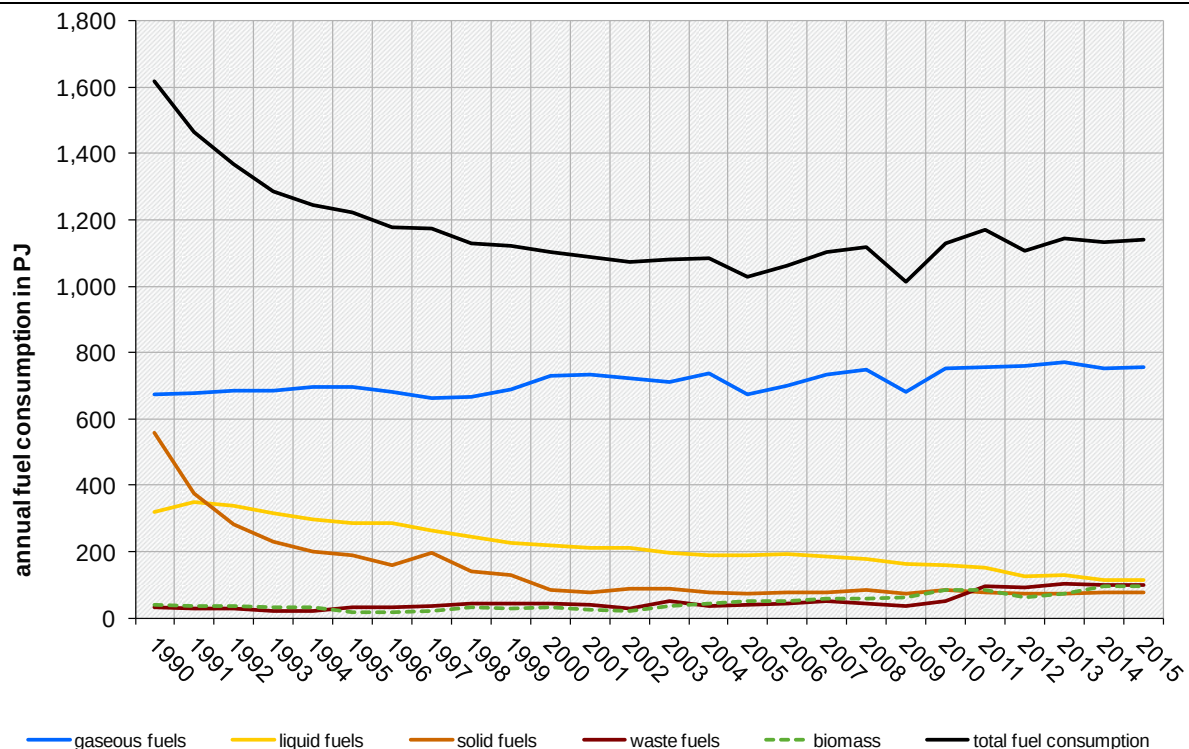
All electricity and heat generation in industrial power stations and boilers is listed in this sub-category, because such systems can justifiably be grouped together, in light of their emissions behaviour. Since the chemical industry primarily uses CHP systems and boilers, the pertinent emissions from category 1.A.2.c are reported in sub-category 1.A.2.gviii "Other". Any further subdivision of industrial power stations and boilers, among the otherwise planned sub-categories, would not improve the data, since such systems' emissions behaviour does not depend on the industrial sector involved. Time series are difficult to prepare, since in 1990 Germany consisted of

two countries. Those two countries had two different statistical systems, and those systems were combined during a transition period lasting until 1994. Great efforts were made to provide the required documentation and quality data for the reference year, 1990. In addition, in 2003 the Act on Energy Statistics (Energiestatistikgesetz) was amended. This considerably improved data collection, especially for CHP systems. Such data for the period cannot be retroactively collected for the period 2002 – 1990, however. By and large, time-series consistency has been achieved at the aggregated level. Any further disaggregation would lead to breaks in the time series, however, because the data are not all available in disaggregated form, and cannot all be systematically allocated. Nonetheless, the possibilities for further disaggregation have been carefully reviewed. No successful solution for this problem has been found, however. Also, many energy data in Germany are subject to confidentiality restrictions, and thus often must be aggregated (aggregation safeguards confidentiality). In some sectors that have been listed separately to date, data for certain fuels now have to be combined, for reasons of confidentiality, and reported in category 1.A.2.gviii "Other". This considerably reduces the conclusiveness of the data in various individual sectors.

Ultimately, the boundary between the various individual industrial sectors and the public supply sector cannot be unambiguously drawn. The "autoproducers" described in the IPCC Guidelines hardly exist in reality in the clear-cut form outlined. Different companies manage their electricity and heat generation in different ways. Some companies operate power stations of their own that often also feed electricity into the public grid. Other companies draw electricity and/or heat from the public grid. As a result of energy-market liberalisation, the structures in this area often change. Since national statistics serve as the basis for inventory preparation, the inventory adopts those statistics' sectoral allocations of the various kinds of installations and plants involved. Such allocations do not remain constant throughout the time series, and they are not thoroughly consistent with the corresponding allocations in the emissions trading sector. As a result, they cannot be harmonized in the existing data records.

International comparisons of those sub-categories in which industrial power stations play the primary role are not feasible, since the pertinent supply structures differ considerably from country to country.

Figure 29: Development of fuel inputs in category 1.A.2.g viii Other



This category exhibits a marked change in fuel inputs.

A decrease in the use of solid fuels – including, especially, a significant reduction in the use of lignite – is especially noticeable. On the other hand, use of gas, biomass and substitute fuels (waste) increased.

A statistical discontinuity is seen in the area of biomass. Prior to the entry into force of the Act on Energy Statistics (Energiestatistikgesetz), biomass inputs for energy generation either were not recorded statistically or were recorded only in part. The biomass fraction has been growing continuously.

In 2013, the quantities listed in waste statistics relative to inputs of industrial waste in combustion systems, and to hazardous waste (STATISTISCHES BUNDESAMT, FS 19 Reihe 1), increased slightly, while the figures for "other gases" in the Energy Balance decreased significantly. In 2013, increased consumption of gas and heating oil produced another slight increase overall in this category. In 2014 and 2015, fuel inputs remained largely constant.

3.2.9.7.2 Methodological issues (1.A.2.g Other, stationary)

The 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, mine power stations, power stations in the hard-coal-mining sector and, for the period until 1999, for the power stations of Deutsche Bahn (German Railways) consists of the activity data for other industrial power stations. These data cannot be further differentiated at present.

Additional data from the Federal Statistical Office are needed for allocation of fuel inputs to heat production in industrial power stations and boiler systems. Fuel inputs for heat production in CHP systems can be determined from relevant statistics. The activity data for boiler systems are calculated as the pertinent difference.

For both electricity generation and heat generation, the data are broken down into the categories steam turbines, gas turbines, gas-and-steam (combined cycle) systems and gas engines, since (for the present purpose) these different combustion technologies differ especially in terms of their methane emissions. This breakdown, which has been revised for the current report, is described under 1.A.1.a.

A detailed description of the relevant calculation algorithms, which were extensively revised for the 2008 reporting year, is provided in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; FKZ 204 41 132).

With the new data source "BGS-Bogen" ("BGS form; see above), it has become possible to list, separately, use of top gas for energy production in live-steam boilers in the iron and steel industry.

In some years, the total energy quantity listed in Energy Balance line 54 (metal production), for use of top gas, is lower than the total top-gas input as shown by the BGS data. In such cases, the Energy Balance data are supplemented with the BGS-form data.

Emission factors

A list of the CO₂ emission factors used, and a description of the relevant methods, are provided in the Annex, Chapter 18.7.

All other emission factors for greenhouse gases and precursor substances, for power stations and other boiler combustion for production of steam and hot/warm water, in category 1.A.1.f / all other, have been taken from RENTZ et al. (2002) and FICHTNER et al. (2011). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3. The research projects break down the relevant sector into power stations of Deutsche Bahn AG, other industrial power stations and other boiler combustion systems for production of steam and hot/warm water.

3.2.9.7.3 Uncertainties and time-series consistency (1.A.2.g, Other, stationary)

Activity data

The uncertainties were determined, for the first time, for 2004. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and included in the relevant final report.

Emission factors

The procedure for determining uncertainties is described in Chapter 3.2.6.3.1.

Result for N₂O: The results of Chapter 3.2.6.3.2 apply mutatis mutandis.

Result for CH₄: The results of Chapter 3.2.6.3.3 apply mutatis mutandis.

The results obtained in Chapter 3.2.6.3.4 in determination of time-series consistency apply mutatis mutandis.

3.2.9.7.4 Category-specific quality assurance / control and verification (1.A.2.g, Other, stationary)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

Activity data

The quality of the data was reviewed in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; FKZ 204 41 132) and improved via use of statistics of the Federal Statistical Office as a database. No other data sources with long-term availability have been identified.

Emission factors

The results obtained in Chapter 3.2.6.2, in the general procedure for source-specific quality assurance / control and verification, apply mutatis mutandis.

3.2.9.7.5 Category-specific recalculations (1.A.2.g, Other, stationary)

Table 34: Recalculations in CRF 1.A.2.gviii

Units [kt]	NIR 2016	NIR 2017	Difference, absolute					Difference, relative
			gas	liquid	other	solid	Total	
2013	71,127	71,037	0	-2	-88	0	-90	-0.13%
2014	68,084	68,714	856	-469	-195	438	629	0.92%

Recalculations for the area of other fuels were carried out for the period as of 2004, to take account of correction of an error in the waste model. The changes in the CO₂ emission factors for diesel fuels and "other petroleum products" led to slight recalculations, for the period as of 2008, in the figures for liquid fuels. The recalculations for solid fuels were carried out in order to take account of changes that the Working Group on Energy Balances (AGEB) made in calorific values. Provisional values for the year 2013 were replaced when the figures from the final Energy Balance for 2013 became available. This has led to recalculations for all fuels.

3.2.9.7.6 Planned improvements (category-specific) (1.A.2.g, Other, stationary)

Activity data:

No improvements are planned at present.

Emission factors:

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.9.8 Construction-sector transports (1.A.2.g vii)

3.2.9.8.1 Category description (1.A.2.g vii)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1 ^a , CS	NS/M	CS, D ^a
CH ₄	CS (Tier 2)	NS/M	CS (M)
N ₂ O	CS (Tier 2)	NS/M	CS (M)
NO _x , CO, NMVOC, SO ₂	CS (Tier 2)	NS/M	CS (M)

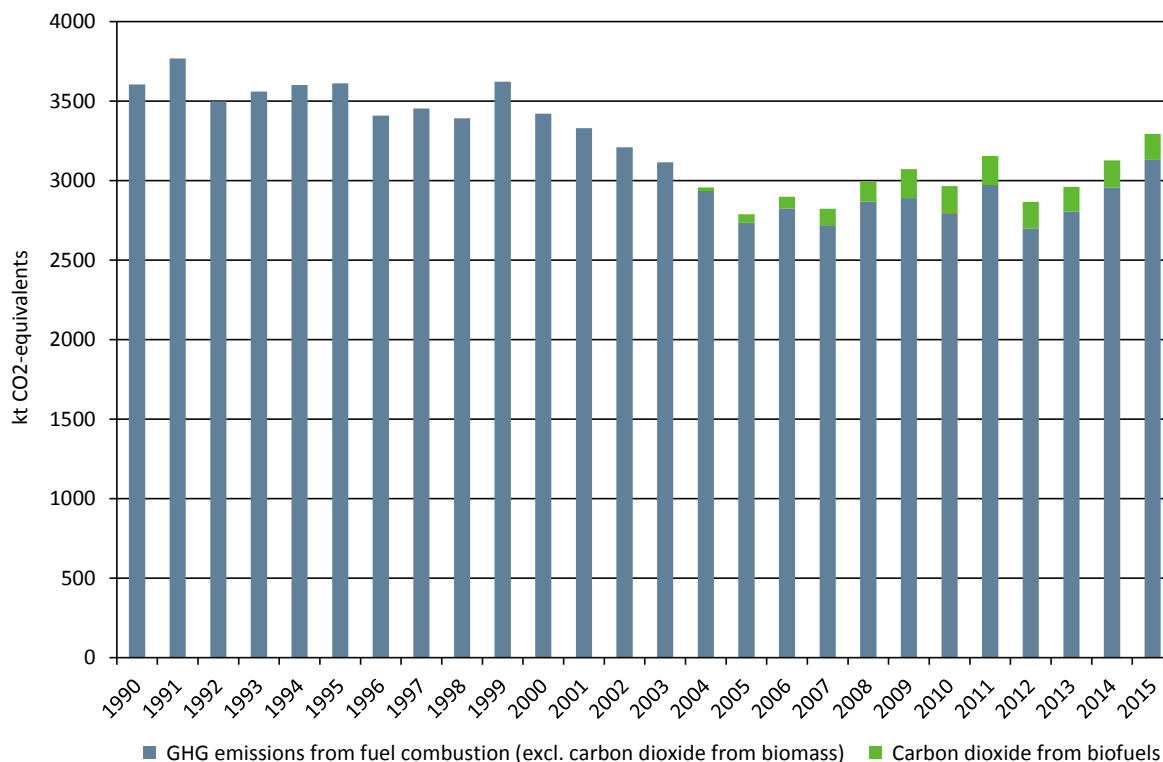
^a biodiesel: 2006 IPCC GL (Tab. 2.4)

The stationary and mobile sources in 1.A.2.g are grouped together for purposes of assignment to key categories. (For an overview, cf. Chapter 3.2.9.7.). Accordingly, the category 1.A.2.g vii – *Other: Offroad vehicles and other machines*, in which emissions from construction-sector transports are taken into account, is a key category for CO₂ in terms of emissions level and trend.

3.2.9.8.2 Methodological issues (1.A.2.g vii)

Pursuant to (IPCC 2006 Guidelines; page 3.33; equation 3.3.2), the emissions are calculated, using a Tier 2 method, as products of consumed fuels and technology-specific emission factors.

Figure 30: Development of GHG emissions from vehicles and mobile construction-sector machinery, 1990-2015



The **activity data** for fossil diesel fuel and petrol, including their biogenic admixtures, are calculated, following deduction of energy inputs for military transports, from the data in Energy Balance lines 79 (until 1994) and 67 "*Commercial and Institutional*" ("*commerce, trade, services and other consumers*"). For the years 2005 through 2009, figures of the Association of the German Petroleum Industry (MWV) are used in the area of diesel-fuel and petrol consumption in the various vehicle categories (cf. the following chapters on road and railway transports). To assure the necessary consistency with the relevant total quantities pursuant to the NEB, therefore, the primary data on which the figures for those five years are based are calculated within TREMOD. Inputs of biofuels are also determined via calculation, on the basis of the official admixture quotas.

Finer allocation of fuel quantities to mobile sources in the construction sector, commerce & trade (1.A.4.a ii) and agriculture and forestry (1.A.4.c ii) is achieved with the help of annually fluctuating split factors modelled in TREMOD-MM (Transport Emission Model-Mobile Machinery (IFEU, 2016b)).

The relevant **emission factors** are based on the results of various Federal Environment Agency research projects and expert opinions.

With regard to carbon dioxide, we refer in general to Chapter 18.7. Both country-specific and default values (biodiesel, avgas) are used. Further information regarding co-combustion of lubricants in particular is provided in Chapter 19.1.4.

For methane and nitrous oxide, country-specific values from (IFEU, 2016b) are used. The development of these values reflects the gradual phasing-in of emissions standards, since the mid-1990s, for construction-sector machinery.

With regard to releases of methane and nitrous oxide from co-combustion of lubricants, it is assumed that such emissions are already taken into account in the pertinent emission factors for the fuels used and thus are to be reported as IE (*included elsewhere*).

Table 35: Emission factors used for report year 2014, in kg/TJ

	CH ₄	N ₂ O	Origin
Diesel	1.13 (4.15)	2.92 (28.60)	pursuant to (EMEP/EEA, 2016) and (IFEU, 2016b)
Biodiesel	1.13 (-)	2.92 (-)	Equivalent to the EF for diesel
Gasoline	19.75 (50)	1.41 (2.00)	pursuant to (EMEP/EEA, 2016) and (IFEU, 2016b)
Bioethanol	19.75 (-)	1.41 (-)	equivalent to the EF for gasoline

In parentheses: Sector-sector prescribed values for "Industry" pursuant to 2006 IPCC Guidelines, Tab. 3.3.1

3.2.9.8.3 Uncertainties and time-series consistency (1.A.2.g vii)

The uncertainty figures for the specific energy inputs, which are shaped primarily by the mathematical uncertainty in the distribution key developed in TREMOD MM (cf. above: Methodological aspects), are based on experts' assessments. The same holds for the carbon-dioxide emission factors used. While the emission factors for methane are based on results from (IFEU & INFRAS, 2009), the emission factors for nitrous oxide – for the time being – have to be oriented to guideline values pursuant to the IPCC.

3.2.9.8.4 Category-specific quality assurance / control and verification (1.A.2.g vii)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Quality reports of the Working Group on Energy Balances (AG Energiebilanzen – AGEb) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances.

Table 36: Overview of relevant data comparisons

Comparison with...	Completed	Remark
Alternative emissions inventories for Germany	no	No comparable data records cf. Table 37 Comparison of a) the EF(CO ₂) used and b) default values, in kg/TJ
Sector-specific Tier 1 default EF pursuant to (IPCC, 2006): Volume 2, Table 3.3.1: Industry: CO ₂	yes	Table 37: Comparison of a) the EF(CO ₂) used and b) default values, in kg/TJ
Sector-specific Tier 1 default EF pursuant to (IPCC, 2006): Volume 2, Table 3.3.1: Industry: CH ₄ , N ₂ O	yes	cf. Table 35
Specific IEF of other countries	yes	cf. Table 38

Table 37: Comparison of a) the EF(CO₂) used and b) default values, in kg/TJ

	Inventory values ^a	Default ^b	Lower bound	Upper bound
Diesel fuel	74,027	74,100 ^c	72,600	74,800
Gasoline	73,105	69,300 ^c	67,500	73,000
Biodiesel	70,800 ^d		59,800	84,300
Bioethanol	71,607	70,800 ^d	59,800	84,300

^b for report year 2015; ^a pursuant to 2006 IPCC Guidelines, Vol. 2: ^c Chap. 3, Tab. 3.3.1; ^d Chap. 2, Tab. 2.4

The following table provides a comparison with specific implied emission factors of other countries as well as with the relevant values resulting for the EU(28). It should be noted that the comparison is hampered by the fact that the factors involved represent a heterogeneous group of source categories.

Table 38: International comparison of IEF reported for liquid fossil fuels, in kg/TJ

	CO ₂	CH ₄	N ₂ O
Germany	74,009	1.57	3.05
Denmark	73,226	2.35	3.12
Netherlands	73,349	2.60	3.18
UK	73,650	9.46	26.78

Germany: Current IEF for report year 2015; all other countries: IEF for 2014, pursuant to 2016 CRF Submission

3.2.9.8.5 Category-specific recalculations (1.A.2.g vii)

As described above, the activity data for construction-sector transports are part of the primary data given in Energy Balance line 67. The provisional data provided for the year 2014, in the 2016 Submission, have been replaced with the corresponding figures from the final 2014 NEB. The quantities of consumed biofuels that were determined via the official admixture quotas have been recalculated as necessary. The 2014 admixture quota for biodiesel was corrected in the process.

Table 39: Revised primary activity data for 2014, in TJ

	Diesel	Gasoline	Biodiesel	Bioethanol
2017 Submission	97,410	4,941	5,937	215
2016 Submission	96,022	4,862	5,806	211
Absolute change	1,388	79	132	3
Relative change	1.45%	1.62%	2.27%	1.62%

Source: 2014 Energy Balance (AGEB, 2016), and own calculations – based on (IFEU, 2016b)

In addition, the distribution key, based on TREMOD-MM data, was corrected with regard to the diesel-fuel sub-sectors subsumed under Energy Balance line 67. For 1.A.2.g vii, this revision led to increases in the applicable percentage shares, as well as to increases in the sectoral activity data calculated on the basis of those shares. The distribution key for gasoline has not been changed, however.

Table 40: Revised annual shares of CRF 1.A.2.g vii with respect to the diesel quantities given in EB line 67, in %

	1990	1995	2000	2005	2010	2011	2012	2013	2014
2017 Submission	42.28	42.78	46.45	45.91	46.85	45.40	44.39	41.14	39.98
2016 Submission	42.05	42.39	45.85	45.19	46.02	44.56	43.54	40.25	39.19
Absolute change	0.23	0.39	0.61	0.72	0.83	0.84	0.85	0.89	0.79
Relative change	0.54%	0.91%	1.33%	1.59%	1.81%	1.88%	1.96%	2.21%	2.02%

Source: Own calculations, based on (IFEU, 2016b)

The described effects lead to the following changes in the sectoral activity data used in the last report:

Table 41: Resulting revision of the activity data for diesel fuels, in TJ

	1990	1995	2000	2004	2005	2010	2011	2012	2013	2014
Diesel										
2017 Submission	47,301	44,401	42,199	35,312	32,753	35,023	37,602	35,673	37,142	39,104
2016 Submission	47,046	43,582	41,388	34,547	32,103	34,093	36,499	34,657	36,086	37,396
Absolute change	256	819	812	765	650	930	1,103	1,016	1,056	1,707
Relative change	0.54%	1.88%	1.96%	2.21%	2.02%	2.73%	3.02%	2.93%	2.93%	4.57%
Biodiesel										
2017 Submission	NO	NO	NO	304	716	2,285	2,477	2,339	2,161	2,384
2016 Submission	NO	NO	NO	298	702	2,225	2,404	2,272	2,099	2,261
Absolute change				7	14	61	73	67	61	122
Relative change				2.21%	2.02%	2.73%	3.02%	2.93%	2.93%	5.42%

Source: Own calculations, based on (IFEU, 2016b)

The above-described corrections lead to the following recalculated emissions quantities:

Table 42: Revised emissions figures, in kt and kt CO₂ equivalents

	1990	1995	2000	2005	2010	2011	2012	2013	2014
Carbon dioxide^a									
2017 Submission	3,605	3,612	3,422	2,736	2,796	2,973	2,698	2,806	2,956
2016 Submission	3,586	3,552	3,362	2,688	2,727	2,891	2,623	2,728	2,825
Absolute change	19	61	60	48	69	82	75	78	130
Relative change	0.53%	1.71%	1.79%	1.79%	2.53%	2.82%	2.87%	2.87%	4.61%
Methane									
2017 Submission	0.25	0.27	0.22	0.16	0.11	0.11	0.07	0.07	0.07
2016 Submission	0.25	0.27	0.22	0.16	0.11	0.11	0.07	0.07	0.06
Absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Relative change	0.47%	1.19%	1.23%	0.94%	1.35%	1.56%	2.23%	2.22%	5.15%
Nitrous oxide									
2017 Submission	0.14	0.13	0.13	0.10	0.11	0.12	0.11	0.12	0.12
2016 Submission	0.13	0.13	0.13	0.10	0.11	0.12	0.11	0.11	0.12
Absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Relative change	0.54%	1.79%	1.87%	1.90%	2.63%	2.92%	2.90%	2.90%	4.64%
Total GHG ^a									
2017 Submission	3,652	3,659	3,466	2,771	2,832	3,011	2,733	2,843	2,994
2016 Submission	3,633	3,597	3,405	2,722	2,763	2,929	2,657	2,763	2,862
Absolute change	19	61	61	49	70	83	76	79	132
Relative change	0.53%	1.71%	1.79%	1.79%	2.53%	2.82%	2.87%	2.87%	4.61%

^a Not including CO₂ from use of biofuels; source: own calculations

3.2.9.8.6 Planned improvements (category-specific) (1.A.2.g vii)

No further category-specific improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.10 Transport (1.A.3)

3.2.10.1 Transport – Civil aviation (1.A.3.a)

3.2.10.1.1 Category description (1.A.3.a)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990- 2015
-/-	1.A.3.a Transport: Civil aviation	All fuels	CO ₂	2,373.5	0.19%	2,214.5	0.25%	-6.7%
-/-	1.A.3.a Transport: Civil aviation	All fuels	N ₂ O	23.8	0.00%	22.1	0.00%	-7.2%
-/-	1.A.3.a Transport: Civil aviation	All fuels	CH ₄	2.6	0.00%	2.0	0.00%	-24.8%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1 a, CS (Tier 3)	NS/IS/M	D a, CS
CH ₄	CS (Tier 3)	NS/IS/M	CS (M)
N ₂ O	CS (Tier 3)	NS/IS/M	CS (M)
NO _x , CO	CS (Tier 3)	NS/IS/M	CS (M)
NMVOC	CS (Tier 3)	NS/IS/M	CS (M)
SO ₂	Tier 1	NS/IS/M	CS

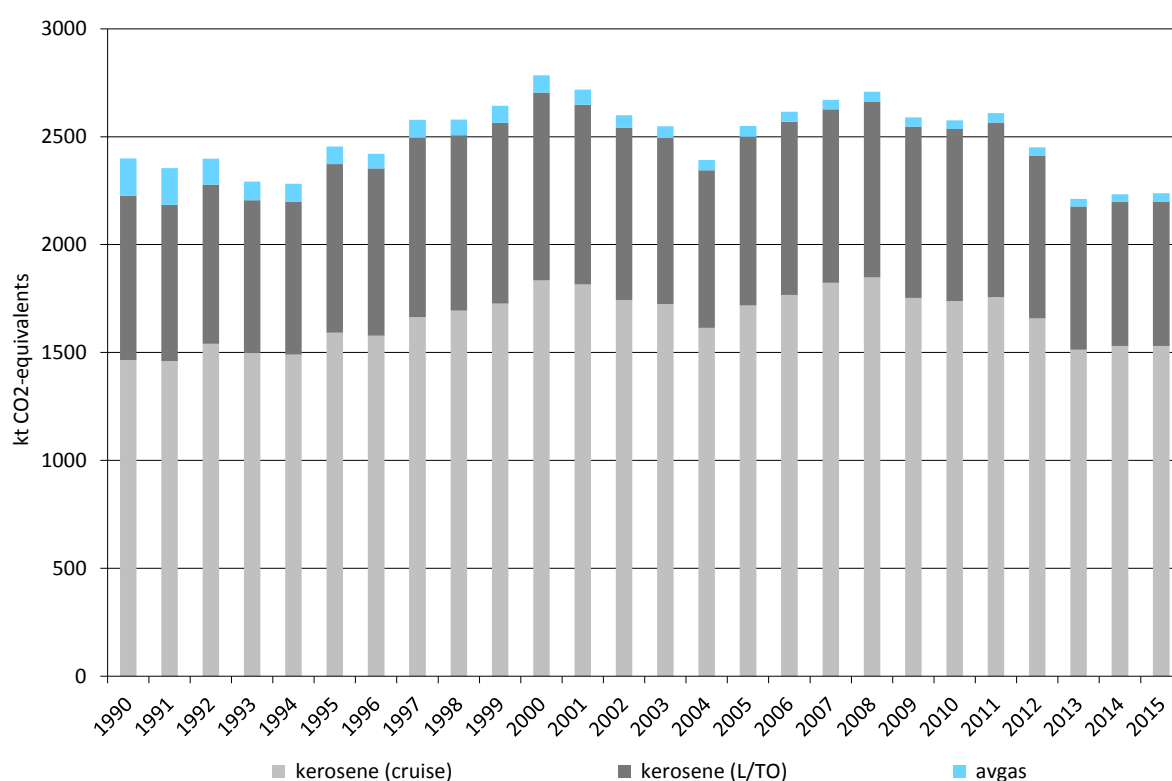
^a Avgas: 2006 IPCC Guidelines, Chapter 3.6 – *Civil Aviation*, Table 3.6.4

The category *Civil aviation* is not a key category.

In terms of emissions origins, air transports differ considerably from land and water transports, since aircraft burn most of their fuel under atmospheric conditions that differ from those on the ground and that are not constant. 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 flight altitude.

In addition to considering carbon dioxide, the debate on the climate effects and airborne-emissions-related environmental impacts of air transports focuses mainly on water vapour and nitrogen oxides and, secondarily, on hydrocarbons, particulates, carbon monoxide and sulphur dioxide. In the framework of national emissions reporting, figures for other emissions are also required, however. The following remarks thus refer to emissions of carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O, laughing gas), nitrogen oxides (NO_x, i.e. NO and NO₂), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO₂).

Figure 31: Development of GHG emissions in national civil air transports since 1990



3.2.10.1.2 Methodological issues (1.A.3.a)

Air-transport emissions are calculated in accordance with Tier 3aa, i.e. taking account of the annual flight mileages logged by the relevant individual aircraft types, broken down by national and international flights, and taking account of the operational states LTO cycle (landing/take-off cycle, i.e. aircraft movements to an elevation of 3,000 feet / about 915 m) and cruise (cruising flight at elevations above 3,000 feet).

In general, emissions are determined on the basis of the Energy Balance data for consumption of kerosene and aviation gasoline (AGEB, 2016a&b). For years for which no Energy Balance is yet available, or only a provisional Energy Balance is available, data of the Federal Office of Economics and Export Control (BAFA, 2016) are used. Within the TREMOD AV (TREMOD Aviation) (IFEU & ÖKOINSTITUT, 2015) model, flights are categorised as either intra-German or international flights.

This breakdown plays a decisive role in reporting. The relevant flight data are collected by the Federal Statistical Office.

For reporting purposes, emissions are determined, in each case, by multiplying fuel consumption for the relevant flight phase by the pertinent specific emission factor. CO₂ and SO₂ emissions figures do not depend on what method is used; they depend solely on the quantities and characteristics of consumed fuel. Emissions of NMVOC, CH₄, CO, NO_x and N₂O, on the other hand, depend on engines, flight altitudes, flight phases, etc., and thus they are described more precisely by higher-Tier methods. The emission factors for NO_x, CO and HC are thus taken from the results of the TREMOD calculations.

In a departure from this approach, as proposed in (IPCC, 2006: Volume 2, Chapter 3: Mobile Combustion), the emissions caused by use of avgas are calculated separately, in a Tier 1 approach, with adjusted emission factors and calorific values. In such calculation, there is no need for any breakdown into domestic and international transports; aviation gasoline is used only in smaller aircraft that fly mostly domestic routes.

The **activity data** (energy inputs) are in keeping with the aviation fuel sold in Germany pursuant to (AGEB, 2016a&b; currently, for the period through 2015) and the *Official mineral-oil data for the Federal Republic of Germany* (*Amtliche Mineralöl-daten für die Bundesrepublik Deutschland*) that are published by the Federal Office of Economics and Export Control (BAFA, 2016).

The calculations made within TREMOD-AV, with regard to **kerosene**, take account of the numbers of flights, for the various aircraft types and great-circle distances involved, and for national and international air transports. In the process, the commercial flights recorded by the Federal Statistical Office, for certain airports, are included. The Federal Statistical Office breaks down flights from "other airfields", and non-commercial flights, only by weight or aircraft classes, and not by destinations. The great majority of the flights concerned are flights by small aircraft fueled with aviation gasoline. Rough calculations pursuant to (IFEU & ÖKOINSTITUT 2010) indicate that it is appropriate to allocate such flights to (solely national) avgas consumption.

Table 43: Domestic flights' annual shares of domestic kerosene deliveries, in [%]

1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
15.55	13.73	12.29	9.82	9.60	9.48	9.51	9.37	9.46	10.01	8.79	7.85	8.21	(8.21)

Source: 1990-2014: TREMOD AV (IFEU & ÖKOINSTITUT, 2015); 2015: own calculations

Jet-kerosene consumption is broken down, in accordance with the two flight phases landing / take-off (LTO cycle) and cruise, on the basis of data of the Federal Statistical Office, and via TREMOD-AV calculations. Those results make it possible to extract kerosene consumption figures for the LTO flight phase for both domestic and international air traffic. Consumption in the cruise flight phase is obtained as the difference in kerosene consumption, pursuant to the Energy Balance, less the LTO consumption.

Due to scheduling reasons, it was not possible to enter any original data for the year 2015 into the model. For this reason, the specific kerosene-consumption figures for national (domestic) flights in 2014 were carried forward, unchanged. This updating approach is based on several mutually offsetting effects. As a result of this updating, the 2015 figure for international flights, as a percentage share of domestic kerosene deliveries, is not a modelled figure; it has simply been derived from the consumption figures that have been carried forward.

The activity data for **avgas** are in keeping with the avgas sold in Germany pursuant to (AGEB, 2016a&b) and (BAFA, 2016). In a conservative approach, all relevant consumption is assumed to

occur in national flight operations. Pursuant to (IPCC, 2006: Volume 2, Chapter 3: Mobile Combustion) the data do not have to be broken down in terms of LTO and cruising flight phases.

The pertinent quantities of **co-combusted lubricants** are derived, pursuant to (VSI, 2014), from the relevant annual fuel quantities (cf. Chapter 19.1.4 in the Annex).

With regard to the **emission factors** used for carbon dioxide, we refer, in general, to Chapter 18.7.

The emission factor for *carbon dioxide* from use of **kerosene** was derived from the carbon content of kerosene; it is *3,150 g/kg*. That value, which has been substantiated by numerous published studies, is used for all air transports.

Nitrous oxide (laughing gas) is a product of nitrogen oxidation in the combustion chamber, and it can occur in traces. The available data for this substance are poor. Since the emission factors have to be broken down in accordance with the two flight phases, the emission factors for both nitrous oxide and *methane* have been taken from the IPCC emission factor database (cf. Table 482).

Other emissions are calculated separately by flight phases, on the basis of the relevant emission factors. In the process, different sources are used.

The data for emissions of NO_x, CO and NMVOC are based on aircraft-type-specific emission factors listed in TREMOD-AV. Those emission factors are used to generate average (implied) emission factors. For reporting purposes, annual average (implied) emission factors are also derived for the entire fleet.

The emissions per LTO cycle are calculated using standard values for jet-kerosene consumption per LTO cycle: for national flight operations, the relevant figure is 850 kg jet kerosene / LTO, while for international flight operations an average value of 1,675 kg kerosene / LTO is assumed (IPCC 2006b). Figures relative to the air pollutants additionally considered are presented in Chapter 19.1.3.1 in the Annex.

The emission factors expressed in the units [g/kg] are converted into the units [g/TJ] on the basis of a net calorific value of 43,000 kJ/kg (AGEB, 2016a&b).

For **avgas**, emission factors do not have to be divided into LTO and cruise categories.

For purposes of calculation of *CO₂ emissions*, the standard value pursuant to (IPCC, 2006: Volume 2, Chapter 3: Mobile Combustion) is used. In those guidelines (page 3-64), the emission factors for *methane* and *nitrous oxide* are explicitly defined as equal to the relevant values given for jet-kerosene use. That assumption has been adopted here.

In a procedure similar to that used for jet kerosene, the emission factors for NO_x and CO were obtained from the results of TREMOD calculations carried out with aircraft-type-specific emission factors from the EMEP/EEA database. Those factors were then divided by the relevant avgas consumption, to obtain annual, average emission factors for reporting purposes.

CO₂ emissions from **co-combustion of lubricants** are reported under CRF 2.D.1 With regard to releases of methane and nitrous oxide, it is assumed that such emissions are already taken into account in the pertinent emission factors for the fuels used and thus are to be reported as IE (*included elsewhere*).

Table 44: Emission factors used for report year 2015, in kg/TJ

	CH ₄	N ₂ O	Origin
Kerosene			
LTO	8.21 (0.50)	2.74 (2.00)	Country-specific values pursuant to TREMOD AV
Cruise flight	0.00 (0.50)	2.33 (2.00)	
Avgas	8.21 (-)	2.33 (-)	Corresponds to Tier 2 EF for kerosene, CH ₄ : LTO; N ₂ O: Cruise
Lubricants	IE	IE	Included in the EF for fuels

Source: (IFEU & ÖKOINSTITUT, 2015); in parentheses: Sector-specific prescribed values pursuant to the 2006 IPCC Guidelines (Volume 2, Chapter 3.6 – *Civil Aviation*)

3.2.10.1.3 Uncertainties and time-series consistency (1.A.3.a)

For determination of uncertainties, the individual components that enter into emissions calculation are identified, and their uncertainties (U_1 to U_n) are quantified. Pursuant to the 2006 IPCC Guidelines³¹, the total uncertainty U_{total} is obtained via additive linking of squared partial uncertainties, in accordance with the following formula:

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \dots + U_n^2}$$

For all time series and flight phases, uncertainties were estimated as mean values. The total uncertainties were calculated as is shown in Annex Chapter 19.1.3.1.2. The left column in that section contains the components that enter into the uncertainty calculation; the relevant partial uncertainties are listed in the neighbouring columns to the right. The columns that then follow to the right contain the values for the required total uncertainties. Some of these, in turn, are individual components of the uncertainties calculation for other values. For example, the uncertainty for national jet-kerosene consumption in the two relevant flight phases, LTO and cruise, is calculated from the partial uncertainties for total national jet-kerosene consumption and from the partial uncertainty for the LTO/cruise breakdown. The latter of these partial uncertainties is based on the number of relevant flights, pursuant to the *Federal Statistical Office*, as well as on assumptions pertaining to the manner in which the fleet is divided (in national flight operations, an average consumption of 850 kg jet kerosene per LTO cycle is applied, in keeping with the IPCC's assumptions). The total uncertainty for kerosene consumption during the LTO and cruise flight phases, in turn, serves as a partial uncertainty in determination of the uncertainties for emissions data.

3.2.10.1.4 Category-specific quality assurance / control and verification (1.A.3.a)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

For a growing share of aircraft types for which no specific data are available, emission factors have to be obtained via regressions carried out on the basis of take-off weight. Use of more current, and more complete, aircraft-type-specific data would further improve the quality of the calculations. Furthermore, expansion of the TREMOD calculations, to include differentiation in accordance with the different engines used, would also improve the quality of the calculations.

Except for the emission factors for sulphur dioxide, international standard values were used, taken from the IPCC emission-factors database, the EMEP-EEA database or the EMEP/EEA Guidebook 2013 (EMEP/EEA 2013). Discussions of the various individual values are presented in the "Methodological Aspects" chapters of the presentations of the various emission factors.

³¹ Volume 1, Chapter 3, page 3.28, formula 3.1

Country-specific consumption and emissions data provided by Eurocontrol are currently being used only to verify our own surveys.

Table 45: Overview of relevant data comparisons

Comparison with...	Completed	Remark
Alternative emissions inventories for Germany	no	No comparable data records
Sector-specific Tier 1 default EF pursuant to (IPCC, 2006: Volume 2, Table 3.6.4): CO ₂	yes	cf. Table 46
Sector-specific Tier 1 default EF pursuant to (IPCC, 2006: Volume 2: Table 3.6.5): CH ₄ , N ₂ O	yes	cf. Table 44
Specific IEF of other countries	yes	cf. Table 47

Table 46: Comparison of the EF(CO₂) used in the inventory with default values ^a, in kg/TJ

	Inventory value	Default ^b	Lower bound	Upper bound
Kerosene	73,256	71,500	69,700	74,400
Avgas	70,000		67,500	73,000

^a Pursuant to 2006 IPCC Guidelines, Volume 2, Tab. 2.4

The following table provides a comparison with specific implied emission factors of other countries.

Table 47: International comparison of reported IEF, in kg/TJ

	Kerosene			Avgas		
	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
Germany ^a	73,256	2.49	2.45	70,000	8.21	2.33
Denmark	71,887	0.54	3.32	72,485	18.92	2.00
France	71,591	1.00	2.36	70,500	1.88	2.41
Netherlands	71,500	0.50	2.00	72,000	20.00	0.50
UK	71,660	0.87	2.28	69,454	15.61	2.22
EU (28)	71,973	1.34	2.40	70,353	6.24	2.25

Sources: ^a IEF for report year 2015; all other countries: IEF for 2014, pursuant to 2016 CRF Submission

3.2.10.1.5 Category-specific recalculations (1.A.3.a)

With respect to the 2016 Submission, recalculations were carried out solely for the years 2004 and 2014. In the process, an erroneous domestic-sales figure was corrected, and provisional activity data were replaced with final data.

Table 48: Revision of figures for domestic sales of kerosene, 2004 & 2014, in TJ

	2004	2014
2017 Submission	298,779	361,868
2016 Submission	316,211	361,870
Absolute change	-17,432	-2.00
Relative change	-5.513%	-0.001%

For both years, the kerosene consumption figures for domestic flights thus had to be recalculated:

Table 49: Resulting revision of kerosene consumption inputs for national (domestic) flights, 2004 & 2014, in TJ

	2004	2014
2017 Submission	31,661	29,702
2016 Submission	33,509	29,702
Absolute change	-1,847	-0.2
Relative change	-5.5%	-0.001%

Accordingly, the greenhouse-gas emissions reported for 2004 and 2014 have been revised as follows:

Table 50: Revised GHG emissions, in kt CO₂ equivalents

	2004	2014
2017 Submission	2,365.5	2,232.83
2016 Submission	2,501	2,232.84
Absolute change	-135	-0.01
Relative change	-5.4%	-0.001%

3.2.10.1.6 Planned improvements (category-specific) (1.A.3.a)

Apart from a routine revision of the TREMOD AV model, in which the consumption figures for the year 2015 – which are values that have simply been carried forward – will be replaced with modeled figures, no source-specific improvements are planned.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.10.2 Transport – Road transportation (1.A.3.b)

3.2.10.2.1 Category description (1.A.3.b)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990- 2015
L/T	1.A.3.b Transport: Road transportation	All fuels	CO ₂	151,880.6	12.42%	152,955.1	17.24%	0.7%
-/T	1.A.3.b Transport: Road transportation	All fuels	CH ₄	1,316.8	0.11%	137.8	0.02%	-89.5%
-/-	1.A.3.b Transport: Road transportation	All fuels	N ₂ O	1,113.5	0.09%	1,496.9	0.17%	34.4%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1 ^a , CS (Tier 2)	NS / M	D ^a , CS
CH ₄	Tier 1 ^b , CS (Tier 3)	NS / M	D ^b , CS (M)
N ₂ O	Tier 1 ^b , CS (Tier 3)	NS / M	D ^b , CS (M)
NO _x , CO, NMVOC, SO ₂	CS (Tier 3)	NS / M	CS (M)

^a Biodiesel, petroleum, lubricants co-combusted in two-stroke engines; ^b LP gas

The category *Road transportation* is a key category for CO₂ emissions in terms of level and trend. For CH₄ emissions, it is a key category only in terms of trend.

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 that 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 on autobahns).

3.2.10.2.2 Methodological issues (1.A.3.b)

- cf. also Chapter 19.1.3.2 -

Since 1990, emissions of CH₄, NO_x, CO, NMVOC and SO₂ 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.

Between 1990 and 1993, the methane emission factor for petrol dropped sharply, producing a corresponding sharp reduction in methane emissions. This was due especially to a massive reduction in the numbers of vehicles with two-stroke engines in the new German Länder. Further EF decreases have resulted via the aforementioned tightening of emissions standards.

For buses and heavy duty vehicles (over 3.5 t total permissible vehicle weight), maximum permissible levels of hydrocarbon (HC) emissions were lowered considerably (-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. A similar trend occurred for methane, emissions of which are calculated as a fixed share of total HC emissions.

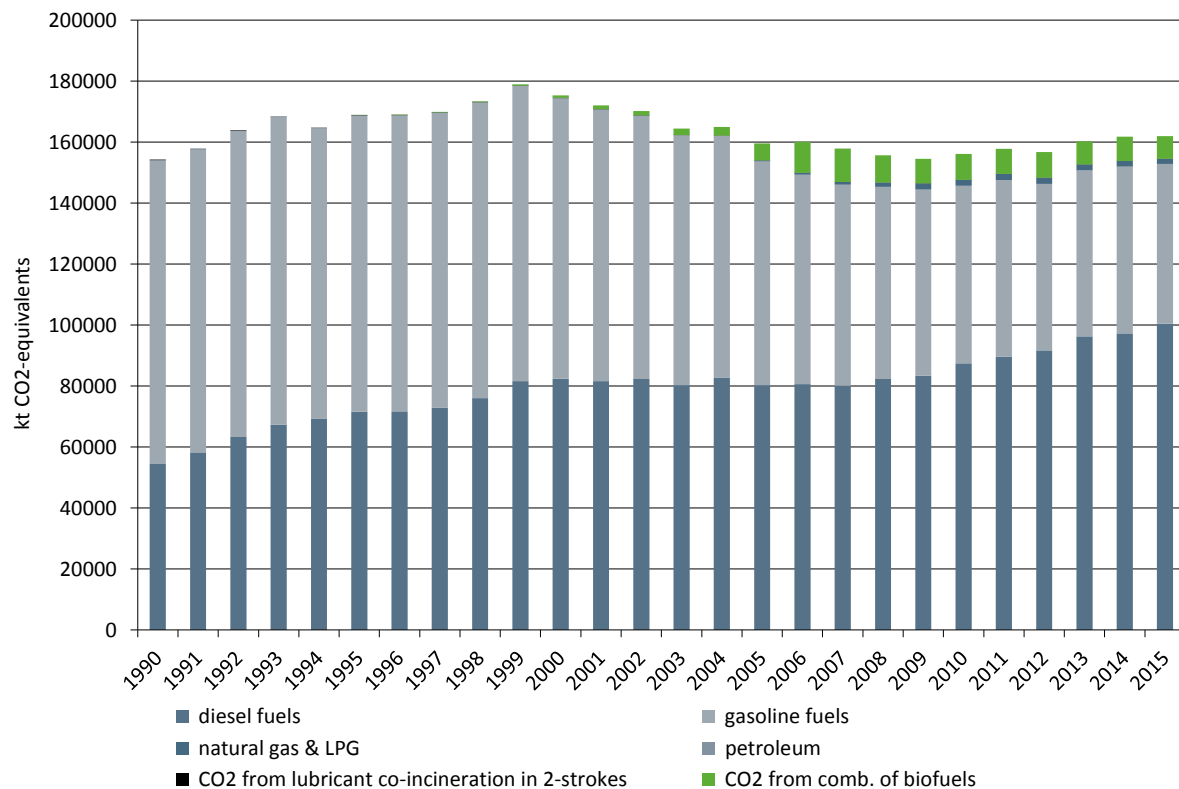
N₂O emissions result primarily from incomplete reduction of NO to N₂ in 3-way catalytic converters. They are not limited by law. Initially, growth in numbers of cars with catalytic converters caused increases in N₂O emissions in comparison to the 1990 level. Newer catalytic converters are optimised to produce only small amounts of N₂O, however. As a result, N₂O decreased during the period 2000-2006. Since then, such emissions have been increasing again. Those increases are due to increasing use of selective catalytic reduction (SCR) equipment in heavy-duty vehicles; under certain conditions, such equipment can produce N₂O as an undesired by-product.

CO₂ emissions depend directly on fuel consumption. From 1990-1999, these emissions increased, since growth in mileage travelled outweighed improvements in vehicle fuel consumption. In the 2000-2009 period, road-transport emissions from consumption of fossil fuels decreased for the first time. The likely reasons for this trend include reductions in specific fuel consumption, the marked shift toward diesel vehicles in new registrations, continual increases in fuel prices, use of biofuels – and consumers' growing tendency to travel to other countries in order to make their fuel purchases (see the following paragraphs).

In the years 2010 and 2011, the emissions increased again, as the aforementioned trends slowed and overall mileage increased. In 2012, they decreased by 1.3 million t with respect to the previous year, however, because traffic volumes and mileage decreased. Since 2012, emissions have increased again by more than 4 %, as a result of renewed increases in mileage travelled, decreases in use of biofuels and, for a considerable number of years now, constant increases in the average

engine power of newly registered automobiles³². In 2015, they amounted to 153.0 million t, or 1.1 million t above the corresponding emissions level of 1990.

Figure 32: Development of greenhouse-gas emissions in road transportation, 1990 – 2015



CO₂ emissions from motorised road transports in Germany are calculated via a Tier-2 "*bottom-up*" approach pursuant to (IPCC, 2006: Volume 2, Chapter 3.2, page 3.12): In the pertinent process, the fuels sold in Germany (petrol, (bio-) ethanol fuel, diesel fuel, biodiesel, LP and natural gas, petroleum (until 2002)) are allocated, within the TREMOD ("Transport Emission Model") model, to the various relevant vehicle layers (cf. Chapter 19.1.3.2) (IFEU, 2016a)³³. The consumption data that enter into the model, for each type of fuel, are obtained from the *Energy Balances*. The actual emission calculation is carried out in the Central System of Emissions (CSE), after the pertinent specific fuel consumption data and emission factors have been imported.

The procedure for calculation of non-CO₂ emissions is based on a Tier-3 method, implemented in TREMOD, in which the mileage data for the relevant individual vehicle layers are multiplied by the applicable specific emission factors. For passenger cars and light duty vehicles, a "*cold start surplus*" is also added. The total consumption determined for each fuel type is cross-checked against consumption pursuant to the Energy Balance. Then, the relevant emissions as calculated in TREMOD are corrected with the help of correction factors obtained via such cross-checking. For

³² According to the Federal Statistical Office (Destatis), the average engine performance of newly registered automobiles in 2013 was 137 hp. The corresponding figure eight years earlier was just under 123 hp.

https://www.destatis.de/DE/PresseService/Presse/Pressemitteilungen/2015/06/PD15_213_85pdf.pdf?__blob=publicationFile

³³ To make it possible to derive and assess reduction measures, energy consumption and CO₂ emissions for the various vehicle categories are also calculated with TREMOD. The resulting values are subsequently checked against total consumption and total CO₂ emissions.

petrol-powered vehicles, the VOC-evaporation emissions are calculated as a function of the pollution-control technology used. From emissions and fuel consumption data for the individual TREMOD vehicle layers, implied emission factors (IEF) in [kg/TJ] are derived. The IEF, fuel-based, are differentiated by fuel type and road type (autobahn, country road, municipal streets) and, within the individual vehicle categories, by "with/without" emissions-control equipment. After being derived, the IEF are entered into the Central System of Emissions (CSE). The following categories of emissions-control equipment are differentiated:

Table 51: Differentiation of emissions-control categories in road transports

Vehicle classes considered	Emissions-control system	
	Without	With
Passenger cars / light duty vehicles with petrol-burning engines	Without catalytic converter	With catalytic converter
Passenger cars / light duty vehicles with diesel engines, as well as buses, heavy duty vehicles and motorcycles	Prior to the EURO 1 standard	As of the EURO 1 standard

The actual emission calculation is carried out in the Central System of Emissions (CSE), after the pertinent specific fuel consumption data and IEF have been imported.

Table 52: Emissions from road transports, in kt

	CO ₂		CH ₄	N ₂ O	NO _x	CO	NMVOC ^c	SO ₂
	fossil ^a	biogenic ^b						
1990	151,881	0	52.67	3.74	1,342.66	6,658.25	1,064.31	90.20
1995	166,437	106	29.12	5.64	1,136.23	3,469.60	445.21	69.31
2000	172,494	869	18.60	5.20	1,034.23	2,157.98	259.75	19.67
2005	152,728	5,573	11.18	3.31	738.09	1,373.78	162.75	0.80
2006	148,706	10,176	10.13	3.25	713.76	1,246.48	149.50	0.80
2007	145,715	11,005	9.10	3.38	650.72	1,133.77	134.10	0.79
2008	145,491	8,914	7.91	3.55	570.62	1,029.55	118.81	0.78
2009	145,202	8,024	7.33	3.72	519.87	971.04	110.49	0.78
2010	146,258	8,483	6.69	4.02	502.12	906.17	102.27	0.78
2011	148,199	8,175	6.47	4.29	478.36	883.31	98.41	0.79
2012	146,860	8,421	6.00	4.53	463.00	824.27	91.22	0.79
2013	151,124	7,621	5.85	4.79	455.03	804.27	88.77	0.80
2014	152,257	7,913	5.78	4.87	432.10	786.24	87.31	0.81
2015	152,955	7,384	5.51	5.02	403.54	738.45	82.38	0.81

^a including CO₂ from lubricants co-combusted in two-stroke engines

^b CO₂ emissions from biofuels are listed here solely for informational purposes

^c including emissions from fuel evaporation

For calculation with TREMOD, extensive basic data from generally accessible statistics and special surveys are used, co-ordinated, and supplemented. The main data sources used, and key assumptions made, are outlined only briefly here. A detailed description of the databases, including information on the sources used, and the calculation methods used in TREMOD, is provided in (IFEU, 2016a).

For western Germany from 1990 through 1993, and for Germany as a whole as of 1994, total-automobile-fleet data are calculated on the basis of the officially published fleet 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 car-emissions-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.

The fleet data in the TREMOD model, as of reference years as of 2001, have been obtained by querying 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.

Mileage data are updated on the basis of the "2002 Mileage Survey" ("Fahrleistungserhebung 2002"; IVT, 2004) and the 2010 road transport census (Straßenverkehrszählung 2010; BASt, 2013). For heavy duty vehicles, the data are also cross-checked against road-toll statistics.

With regard to the **emission factors** used for carbon dioxide, we refer, in general, to Chapter 18.7.

For petrol and natural gas, year-specific values, weighted in accordance with the fuel qualities produced in Germany, are available. For all other fuels, standardised values are used, throughout all relevant years. Further information – in particular, with regard to carbon dioxide from lubricant co-combustion – is also provided in Chapter 19.1.4.

All other emission factors are listed in the "Handbook Emission Factors for Road Transport 3.2" (HBEFA) (INFRAS, 2014), which has been produced via a cooperative effort, involving Germany, Switzerland, Austria and the Netherlands, aimed at deriving emission factors for road transports. In large part, the factors were obtained via measurement programmes of TÜV Rheinland and RWTÜV and via fundamentally oriented studies oriented to the reference years 1989/1990. In those studies, a new method was used, for both passenger cars and heavy duty vehicles, whereby emission factors were derived on the basis of driving habits and traffic situations. Emission factors for automobiles until the 1994 (automobile-)model year were updated with the help of field-monitoring data. Version 3.2 of the Handbook Emission Factors for Road Transport (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 development of the $EF(N_2O)$ reflects the ongoing tightening of emission limit values (ELVs) for NO_x , as well as the continuing development of the technologies and exhaust-emissions standards (Euro norms) introduced to ensure compliance with those limit values. Pollution-control equipment, while reducing nitrogen oxide (NO_x) emissions overall, has increased nitrous oxide emissions, however.

With regard to co-combustion of lubricants, it is assumed that the pertinent non- CO_2 emissions are already included in the emission factors for the relevant fuels and thus have to be reported here as IE (*included elsewhere*).

Shifting of fuel purchases to other countries

Because fuel prices in Germany are higher – significantly, in some cases – than in several of Germany's neighbours, 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 truck and automobile traffic in Germany's border regions and which is referred to as "refueling tourism" ("Tanktourismus"). Although several detailed studies have been carried out, no reliable overall picture of the situation is available (cf. LENK et al., 2005).

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). The relevant neighbouring countries profit, to a not-inconsiderable degree, from additional revenue from energy taxation of such fuels. Such revenue is likely to be significantly higher than the certificate costs for the pertinent CO₂ emissions would be.

3.2.10.2.3 Uncertainties and time-series consistency (1.A.3.b)

In the framework of a study (IFEU & INFRAS 2009), uncertainties were calculated for the activity data entered into TREMOD, for the emission factors generated in TREMOD and for the emissions calculated in the Central System of Emissions (CSE).

3.2.10.2.4 Category-specific quality assurance / control and verification (1.A.3.b)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet³⁴.

³⁴ AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2009; URL:
http://www.ag-energiebilanzen.de/index.php?article_id=7&clang=0#revision_der_energiebilanzen_2003_bis_2009_05
(last checked on 18 Sept. 2013)

Table 53: Overview of relevant comparisons

Comparison with...	Completed	Remark
Alternative emissions inventories for Germany	no	No comparable data records
Category-specific Tier 1 default EF pursuant to (IPCC, 2006: Volume 2, Table 3.2.1): CO ₂	no	No Tier 1 default EF for biofuels and petroleum
Tier 1 default EF pursuant to (IPCC, 2006: Volume 2, Tab. 2.4): CO ₂	yes	cf. Table 54
Category-specific Tier 1 default EF pursuant to (IPCC, 2006: Volume 2, Tab. 3.2.2): CH ₄ , N ₂ O	yes	Results are inconclusive
Tier 1 default EF pursuant to (IPCC, 2006: Volume 2, Tab. 2.4): CH ₄ , N ₂ O	yes	Results are inconclusive
Specific IEF of other countries	yes	cf. Table 55

Table 54: Comparison of a) the EF(CO₂) used and b) default values*, in kg/TJ

	Inventory value ^a	Default ^b	Lower bound	Upper bound
Fossil-based diesel fuel	74,027	74,100	72,600	74,800
Fossil-based gasoline	73,105	69,300	67,500	73,000
Natural gas	55,936	56,100	54,300	58,300
LP gas	65,440	63,100	61,600	65,600
Petroleum	74,000	-	-	-
Co-combusted lubricants	73,300		71,900	75,200
Biodiesel	70,800		59,800	84,300
Bioethanol	71,607	70,800	59,800	84,300

^a used for report year 2015; ^b pursuant to 2006 IPCC Guidelines, Chapter 2, Table 2.4

The following table provides a comparison with specific implied emission factors of other countries as well as with the relevant values resulting for the EU(28).

Table 55: International comparison of reported IEF, in kg/TJ

	Fossil-based gasoline			Fossil-based diesel fuel		
	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
Germany	73,105	6.92	0.63	74,027	0.20	3.20
Denmark	72,988	6.76	1.17	73,997	0.84	3.20
France	70,579	13.56	1.86	75,032	0.80	3.00
Netherlands	72,000	12.04	1.07	74,300	0.60	2.56
UK	69,999	7.10	0.78	72,947	0.63	2.92
EU (28)	71,739	10.81	1.58	73,805	1.02	2.87

Germany: current IEF for 2015; otherwise: IEF for 2014, pursuant to 2016 CRF Submission

3.2.10.2.5 Category-specific recalculations (1.A.3.b)

Since the Submission 2016, recalculations have been carried out to take account of revised activity data and emission factors.

In addition, provisional energy-consumption figures for 2014 have been replaced with final values taken from the 2013 Energy Balance.

Table 56: Revised energy inputs for 2014, in TJ

	Diesel	Biodiesel	Gasoline	Bioethanol	LP gas	Lubricants ^a
2017 Submission	1,296,828	79,014	744,661	32,383	21,464	90.12
2016 Submission	1,307,520	79,094	745,025	32,399	22,715	89.87
Absolute change	-10,692	-80	-364	-16	-1,251	0.25
Relative change	-0.82%	-0.10%	-0.05%	-0.05%	-5.51%	0.28%

Source: TREMOD 5.61 (IFEU, 2016a), based on (AGEB, 2016a&b) and (MWV, 2016)

^a as part of 1:50 two-stroke fuel mixtures

Table 57: Revision of the EF(CO₂) for LP gas and natural gas (2014), in kg/TJ

	Natural gas	LP gas
2017 Submission	55,936	65,461
2016 Submission	55,944	65,523
Absolute change	-8	-62
Relative change	-0.01%	-0.09%

Source: own calculations

Changes in the specific Tier-3 emission factors for methane and nitrous oxide cannot be usefully presented here.

The following table provides a comparison of the current emissions-quantities figures with the corresponding figures from the 2015 Submission.

Table 58: Revised GHG emissions, in kt CO₂ equivalents

	1990	1995	2000	2005	2010	2011	2012	2013	2014
1.A.3.b i – automobiles									
2017 Submission	113,629	115,124	111,255	103,032	95,262	96,989	93,859	96,531	99,179
2016 Submission	113,629	115,124	111,255	103,032	95,262	96,990	93,862	96,538	99,389
Absolute change	0.0	0.0	0.0	0.0	0.0	-1.4	-2.7	-7.5	-209.9
Relative change	0.000%	0.000%	0.000%	0.000%	0.000%	-0.001%	-0.003%	-0.008%	-0.211%
1.A.3.b ii – light duty vehicles									
2017 Submission	3,485	5,099	6,827	7,273	7,085	7,229	7,063	7,262	7,418
2016 Submission	3,485	5,099	6,827	7,273	7,085	7,229	7,062	7,259	7,422
Absolute change	0.0	0.0	0.0	0.0	0.0	0.4	0.8	2.9	-4.4
Relative change	0.000%	0.000%	0.000%	0.000%	0.000%	0.005%	0.012%	0.040%	-0.059%
1.A.3.b iii – Heavy duty vehicles (including buses)									
2017 Submission	35,307	47,335	54,968	42,155	43,944	44,039	46,069	47,482	45,774
2016 Submission	35,307	47,335	54,968	42,155	43,939	44,032	46,059	47,468	46,489
Absolute change	0.0	0.0	0.0	0.0	4.9	7.3	10.0	13.9	-715.2
Relative change	0.000%	0.000%	0.000%	0.000%	0.011%	0.017%	0.022%	0.029%	-1.538%
1.A.3.b iv – Motorised two-wheelers (motorcycles and mopeds)									
2017 Submission	1,713	1,264	1,452	1,526	1,327	1,375	1,363	1,417	1,475
2016 Submission	1,713	1,264	1,452	1,526	1,327	1,375	1,364	1,417	1,450
Absolute change	0.0	0.0	0.0	0.0	0.0	-0.2	-0.3	0.0	24.8
Relative change	0.000%	0.000%	0.000%	0.000%	0.000%	-0.012%	-0.021%	-0.003%	1.711%
1.A.3.b – CO₂ from lubricants co-combusted in two-stroke engines									
2017 Submission	177.12	24.56	6.55	6.46	6.42	6.63	6.44	6.47	6.61
2016 Submission	177.12	24.56	6.55	6.46	6.42	6.63	6.44	6.47	6.59
Absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Relative change	0.000%	0.000%	0.000%	0.000%	0.000%	-0.008%	-0.015%	0.002%	0.281%
1.A.3.b – TOTAL									
2017 Submission	154,311	168,846	174,507	153,993	147,624	149,639	148,360	152,698	153,852
2016 Submission	154,311	168,846	174,507	153,993	147,619	149,633	148,352	152,689	154,757
Absolute change	0	0	0	0	5	6	8	9	-905
Relative change	0.000%	0.000%	0.000%	0.000%	0.003%	0.004%	0.005%	0.006%	-0.585%

Source: own calculations

3.2.10.2.6 Planned improvements (category-specific) (1.A.3.b)

In the framework of revision of the TREMOD model, use of bio-methane as a biogenic gaseous fuel is to be taken account of, for the first time.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.10.3 Transport – Railways (1.A.3.c)

3.2.10.3.1 Category description (1.A.3.c)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990- 2015
L/T	1.A.3.c Transport: Railways	All fuels	CO ₂	2,900.5	0.24%	919.3	0.10%	-68.3%
-/-	1.A.3.c Transport: Railways	All fuels	N ₂ O	6.7	0.00%	2.3	0.00%	-66.1%
-/-	1.A.3.c Transport: Railways	All fuels	CH ₄	2.6	0.00%	0.3	0.00%	-87.0%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1 ^a , CS (Tier 2)	NS	D ^a , CS
CH ₄	CS (Tier 2)	NS	D ^{b, c, d}
N ₂ O	CS (Tier 2)	NS	D ^d , CS
NO _x , CO, NMVOC, SO ₂	CS (Tier 2)	NS	CS

^a biodiesel: 2006 IPCC GL (Tab. 2.4); ^b Diesel: EMEP/EEA, 2016 (1.A.3.c – *Railways*; Tab. 3-2 through 3-4); ^c Hard coal & hard-coal coke: 2006 IPCC GL (Tab. 3.4.1); ^d Lignite: 2006 IPCC GL (Tab. 2.5)

The source category *Railway transports* is a key category for CO₂ emissions in terms of emissions level and trend.

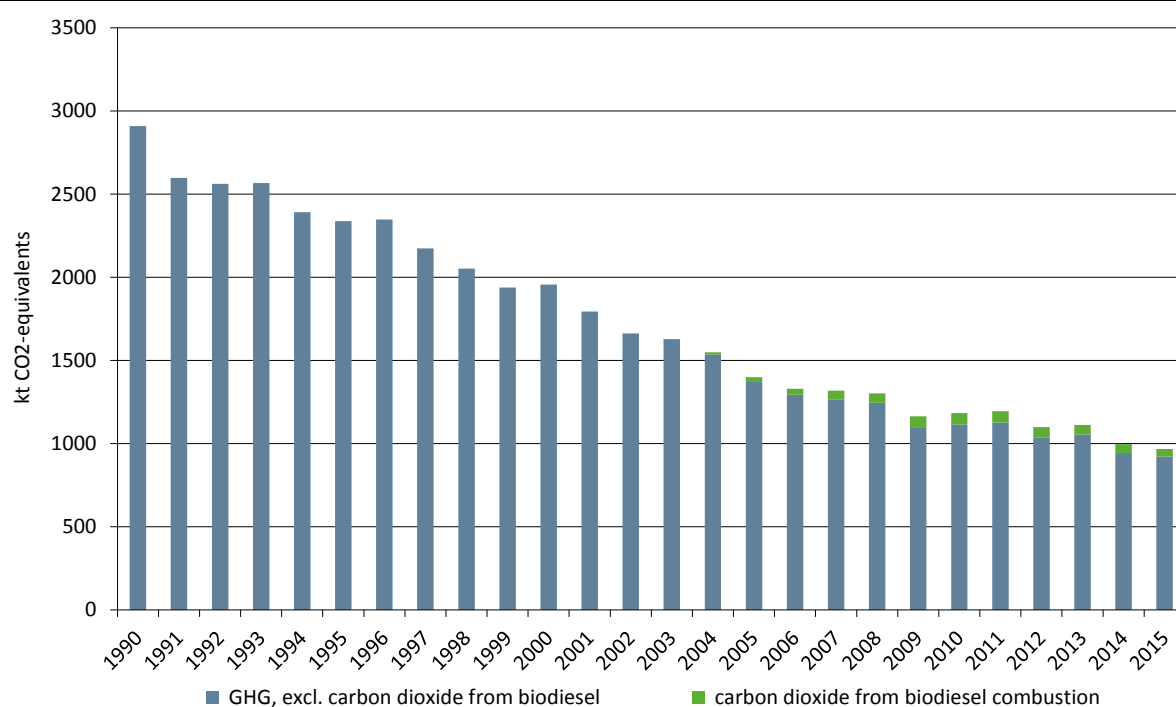
Germany's railway sector is undergoing a long-term modernisation process, aimed at making electricity the main energy source for rail transports. Its share of the energy used for traction is currently about 76 % (AGEB, 2016). Railways' power stations for generation of required traction current are allocated to the stationary component of electricity generation in public power stations (1.A.1.a) and are not included in the following section.

In energy input for trains operating in Germany, diesel fuel is the only energy source that plays a significant role apart from electric power. Since 2004, biodiesel has also been used, as an additive.

In historic vehicles, very small quantities of solid fuels are also used.

Use of other fuels – such as vegetable oils or gas – in private narrow-gauge railway vehicles has not been included to date and may be considered negligible.

Figure 33: Development of greenhouse-gas emissions from railway transports, 1990-2015 (*not including GHG from electricity generation for railways and CO₂ from co-combustion of lubricants*)



3.2.10.3.2 Methodological issues (1.A.3.c)

The relevant emissions are thus calculated as the product of fuel consumption and the relevant country-specific emission factors. This procedure conforms to the general Tier 2 method and the

basic calculation rule pursuant to Equation 3.4.2 of the 2006 IPCC Guidelines (Volume 2, page 3.42).

In general, the **activity data** (energy inputs) are taken from Energy Balance lines 74 (through 1994) and 64 (as of 1995) (AGEB, 2016). In a departure from this procedure, and for methodological reasons, the figures for the years 2005 through 2009 are based on sales figures of the Association of the German Petroleum Industry (MWV) that are published in the annual report "Petroleum Data" ("Mineralöl-Zahlen"; the table "Sectoral consumption of diesel fuel" ("Sektoraler Verbrauch von Dieselkraftstoff")) (MWV, 2016).³⁵

Due to inadequacies in the available statistical data, annual figures for biodiesel consumption continue to be calculated, for the time being, on the basis of the official mixture percentages.

In the official Energy Balances, evaluable consumption data for relevant solid fuels are available as follows: for lignite, solely for the period until 2002; for hard coal, for the period until 2000. For the present purposes, those data have been supplemented with the results of two surveys, one carried out in 2012 and one dating from 2016 (PROBST & CONSORTEN, 2012 & 2016).

Table 59: Overview of the statistics and other sources used

Fuel	Source(s) used
Diesel	until 2004: AGEB; 2005-2009: MWV; as of 2010: AGEB
Biodiesel	Calculated in keeping with official admixture quotas
Hard coal	until 1994: AGEB; 1995-2004: Interpolation; as of 2005: Survey
Hard-coal coke	until 1997: AGEB; 1998-2004: Interpolation; 2005-2010: survey; as of 2011: Extrapolation
Crude lignite & Lignite briquettes	1990-2002: AGEB; not used thereafter

With regard to the **emission factors** used for carbon dioxide, we refer, in general, to Chapter 18.7. For methane and nitrous oxide, country-specific values pursuant to (IFEU, 2016a: liquid fuels) or default values pursuant to (IPCC, 2006: solid fuels) are used. With regard to releases of methane and nitrous oxide from co-combustion of lubricants, it is assumed that such emissions are already taken into account in the pertinent emission factors for the fuels used and thus are to be reported as IE (*included elsewhere*).

Table 60: Emission factors used for report year 2015, in kg/TJ

	CH ₄	N ₂ O	Origin
Diesel	1.01 (4.15)	0.56 (28.60)	CH ₄ : country-specific value pursuant to (IFEU, 2016a); N ₂ O: Tier 2 default pursuant to (EMEP/EEA, 2016)
Biodiesel	1.01 (-)	0.56 (-)	In keeping with the factors for fossil diesel
Crude lignite & lignite briquettes	300 (-)	1.50 (-)	<i>Fuels not used in 2015</i>
Hard coal & Hard-coal coke	2.00 (2.00)	1.50 (1.50)	Use of sector-specific IPCC-prescribed values for " <i>sub-bituminous coal</i> "
Lubricants	IE	IE	Already included in the EF for liquid fuels

³⁵ AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2009; URL: http://www.ag-energiebilanzen.de/index.php?article_id=7&clang=0#revision_der_energiebilanzen_2003_bis_2009_05 (last checked on 4 Oct. 2014)

In parentheses: Sector-specific prescribed values pursuant to the 2006 IPCC Guidelines (Volume 2, Chapter 3.4 – Railways)

3.2.10.3.3 Uncertainties and time-series consistency (1.A.3.c)

In the framework of a study (IFEU & INFRAS 2009), uncertainties were calculated for the activity data entered into TREMOD, for the emission factors generated in TREMOD and for the emissions calculated in the Central System of Emissions (CSE).

The activity-rate time series for lignite briquettes, hard coal and hard-coal coke exhibit inconsistencies resulting from statistical conversion as of 1994/1995; these inconsistencies cannot be eliminated at present.

3.2.10.3.4 Category-specific quality assurance / control and verification (1.A.3.c)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet.

Table 61: Overview of relevant comparisons

Comparison with...	Completed	Remark
Alternative emissions inventories for Germany	no	No comparable data records
Category-specific Tier-1 default value pursuant to 2006 IPCC GL (Volume 2, Chapter 3.4 – Railways, p. 3.43, Tab. 3.4.1): CO ₂	yes	Tier 1 default EF not for all relevant fuels
Tier-1 default EF pursuant to 2006 IPCC GL (Volume 2, Chapter 2 – Stationary Combustion, p. 2.20, Tab. 2.4): CO ₂	yes	cf. Table 54
Category-specific Tier-1 default value pursuant to 2006 IPCC GL (Volume 2, Chapter 3.4 – Railways, p. 3.43, Tab. 3.4.1): CH ₄ , N ₂ O	yes	cf. Table 60
Tier-1 default EF pursuant to 2006 IPCC GL (Volume 2, Chapter 2 – Stationary Combustion, p. 2.20, Tab. 2.4): CH ₄ , N ₂ O	yes	Results are inconclusive
Specific IEF of other countries	yes	cf. Table 63

Table 62: Comparison of the EF(CO₂) used in the inventory with default values ^a, in kg/TJ

	Inventory value ^b	Default ^b	Lower bound	Upper bound
Fossil-based diesel fuel	74,027	74,100	72,600	74,800
Lignite briquettes	99,385	97,500	87,300	109,000
Crude lignite	103,954	101,000	90,900	115,000
Hard coal	93,510	94,600	89,500	99,700
Hard-coal coke	108,130	107,000	95,700	119,000
Biodiesel	70,800		59,800	84,300

^a Pursuant to 2006 IPCC Guidelines, Volume 2, Tab. 2.4; ^b for report year 2015

The following table provides a comparison with specific implied emission factors of other countries as well as with the relevant values resulting for the EU(28).

Table 63: International comparison of reported IEF, in kg/TJ

	Fossil liquid fuels			Fossil solid fuels		
	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
Germany ^a	74,027	1.01	1.00	93,543	2.00	1.50
Denmark	74,000	1.81	2.24	NO	NO	NO
France	75,032	4.15	2.98	NO	NO	NO
Netherlands	74,300	4.26	0.56	NO	NO	NO
UK	74,149	3.26	2.35	95,018	99.76	0.80
EU (28)	73,980	3.26	10.89	94,311	55.99	2.43

Sources: ^a IEF for report year 2015; all other countries: IEF for 2014, pursuant to 2016 CRF Submission

3.2.10.3.5 Category-specific recalculations (1.A.3.c)

Since the Submission 2016, recalculations have been carried out to take account of revised activity data and emission factors.

In the process, the energy inputs for diesel fuels, which had still been provisional, were replaced with final values for 2014. This led to a corresponding correction of the figure for biodiesel used as an admixture. The figures for hard coal inputs were revised, on the basis of a current survey, for the period as of 2005.

Table 64: Correction of fuel inputs, in TJ

	2011	2012	2013	2014
Diesel fuel^a				
2017 Submission	14,730	13,514	13,771	12,283
2016 Submission	14,730	13,514	13,771	13,658
Absolute change	0	0	0	-1,375
Relative change	0.00%	0.00%	0.00%	-10.07%
Biodiesel ^b				
2017 Submission	966	882	798	745
2016 Submission	966	882	798	822
Absolute difference	0	0	0	-77
Relative difference	0.00%	0.00%	0.00%	-9.42%
Hard coal ^c				
2017 Submission	345	357	352	341
2016 Submission	325	325	325	325
Absolute difference	20	32	27	16
Relative difference	6.22%	9.72%	8.36%	5.07%

Sources: ^a AGEb, 2106; ^b IFEU, 2016a ; ^c Probst & Consorten, 2016

At the same time, the year-specific emission factors contained in TREMOD, for methane from combustion of diesel fuels, were adjusted for the period as of 2012, and the emission factors for methane and nitrous oxide from combustion of solid fuels were replaced with IPCC defaults.

Table 65: Correction of the emission factors for methane from combustion of diesel fuel, for the period as of 2012, in kg/TJ

	2012	2013	2014
2017 Submission	1.15	1.07	1.05
2016 Submission	1.46	1.45	1.06
Absolute change	-0.31	-0.38	-0.01
Relative change	-21%	-26%	-1%

Source: IFEU, 2016a

Table 66: Correction of the emission factors for methane and nitrous oxide from combustion of solid fuels, in kg/TJ

	Hard coal (coke) ^a		Crude lignite (briquettes) ^b	
	<i>Methane</i>	<i>Nitrous oxide</i>	<i>Methane</i>	<i>Nitrous oxide</i>
2017 Submission	2.00	1.50	300.00	1.50
2016 Submission	15.00	4.00	15.00	3.50
Absolute change	-13.00	-2.50	285.00	-2.00
Relative change	-87%	-63%	1,900%	-57%

Sources: 2006 IPCC Guidelines, Volume 2 – *Energy*; ^a Chapter 3.4, Tab. 3.4.1; ^b Chapter 2, Tab. 2.5

The numerous adjustments lead to the following recalculated emissions quantities:

Table 67: Revised emissions quantities, in kt and kt CO₂ equivalents

	1990	1995	2000	2005	2010	2011	2012	2013	2014
Carbon dioxide									
2017 Submission	2,901	2,331	1,947	1,367	1,112	1,123	1,034	1,052	941
2016 Submission	2,901	2,331	1,947	1,367	1,112	1,121	1,031	1,050	1,042
Absolute change	0.0	0.0	0.0	0.0	0.0	1.9	3.0	2.5	-100.2
Relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.17%	0.29%	0.24%	-9.62%
Methane									
2017 Submission	0.10	0.08	0.19	0.03	0.02	0.02	0.02	0.02	0.01
2016 Submission	0.11	0.08	0.07	0.03	0.03	0.03	0.03	0.03	0.02
Absolute change	-0.01	0.00	0.12	0.00	0.00	0.00	-0.01	-0.01	-0.01
Relative change	-7%	-4%	180%	-10%	-16%	-15%	-33%	-37%	-29%
Nitrous oxide									
2017 Submission	0.022	0.018	0.015	0.011	0.009	0.009	0.009	0.009	0.008
2016 Submission	0.024	0.019	0.017	0.011	0.010	0.010	0.009	0.009	0.009
Absolute change	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002
Relative change	-6%	-4%	-9%	-6%	-8%	-8%	-8%	-8%	-17%
Total GHG (not including CO₂ from biodiesel)									
2017 Submission	2,910	2,339	1,956	1,371	1,116	1,126	1,037	1,055	944
2016 Submission	2,910	2,339	1,954	1,371	1,116	1,125	1,034	1,053	1,045
Absolute change	-0.62	-0.33	2.54	-0.28	-0.31	1.57	2.51	2.06	-100.87
Relative change	-0.02	-0.01%	0.13%	-0.02%	-0.03%	0.14%	0.24%	0.20%	-9.65%

Source: own calculations

The enormous recalculations for methane (1996 through 2000) result from revision of the corresponding emission factor for lignite briquettes. On the other hand, the reduction in nitrous oxide emissions seen throughout the entire time series is due to adjustment of the relevant emission factor for hard coal and hard-coal coke.

3.2.10.3.6 Planned improvements (category-specific) (1.A.3.c)

No further category-specific improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.10.4 Transport – Water-borne navigation (1.A.3.d)**3.2.10.4.1 Category description (1.A.3.d)**

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	1.A.3.d Transport: Water-borne navigation	All fuels	CO ₂	3,644.5	0.30%	1,798.4	0.20%	-50.7%
-/-	1.A.3.d Transport: Water-borne navigation	All fuels	N ₂ O	33.7	0.00%	17.1	0.00%	-49.4%
-/-	1.A.3.d Transport: Water-borne navigation	All fuels	CH ₄	1.9	0.00%	0.7	0.00%	-63.9%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1 ^a , CS (Tier 2)	NS/IS/M	D ^a , CS
CH ₄	CS (Tier 2)	NS/IS/M	CS (M)
N ₂ O	CS (Tier 2)	NS/IS/M	CS (M)
NO _x , CO, NMVOC, SO ₂	CS (Tier 2)	NS/IS/M	CS (M)

^a for biodiesel

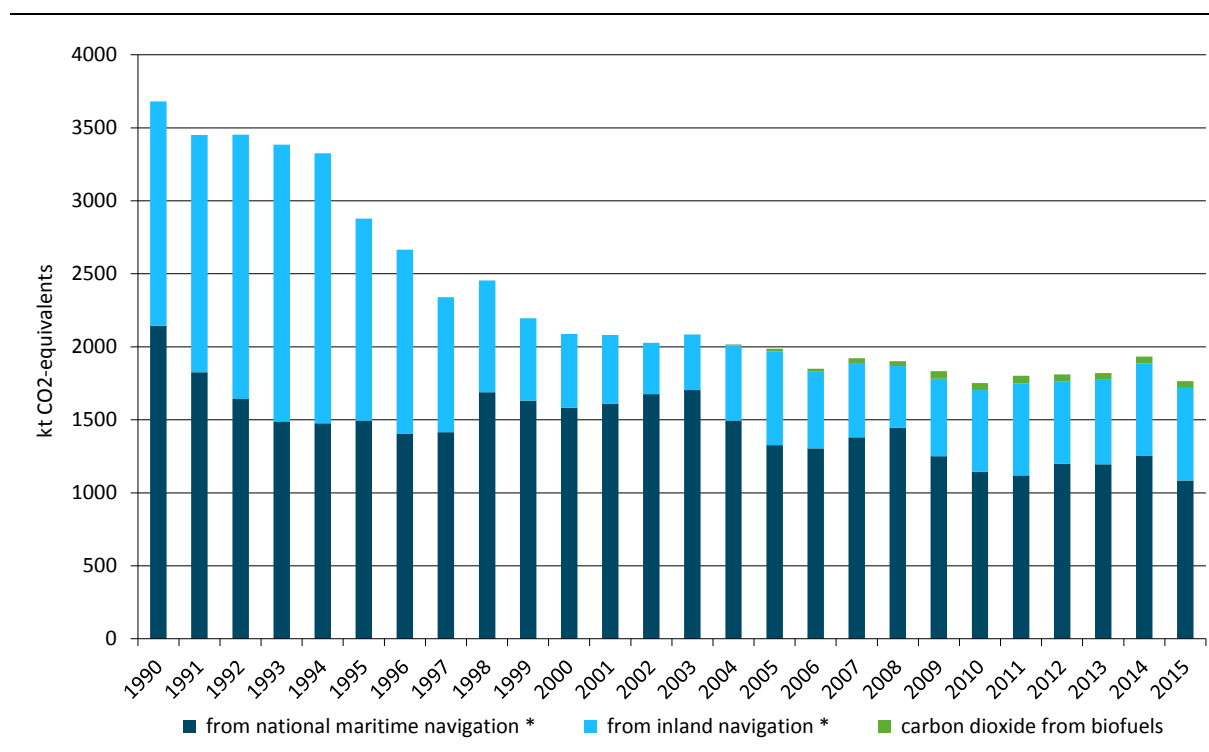
The source category *Domestic water-borne navigation* is a key category for CO₂ emissions in terms of emissions level and trend.

Water-borne navigation is broken down into the categories "domestic maritime navigation," "inland navigation" and "international maritime navigation." Emissions from international maritime navigation are listed in the emissions inventories, as a memo item, but they are not included in total emissions.

In the CSE, both inland navigation and domestic maritime navigation, i.e. travel between German ports, are assigned to category 1.A.3.d – domestic water-borne navigation.

The following figure shows the development of greenhouse-gas emissions from domestic water-borne navigation, since 1990, broken down into inland navigation and domestic maritime navigation.

Figure 34: Development of greenhouse-gas emissions from inland navigation and domestic maritime navigation since 1990



3.2.10.4.2 Methodological issues (1.A.3.d)

For the area of *domestic water-borne navigation*, all primary input data are combined in a model operated by the Federal Maritime and Hydrographic Agency (BSH), in keeping with the Tier 3 method pursuant to (EMEP/EEA 2013: Part B: Sectoral guidance chapters, 1.A.3.d Navigation (shipping), p. 19) (BSH, 2015). The underlying AIS movement data used in the process are currently available only as of the year 2010. For the period 1990 through 2009, the specific consumption fractions for national and military water-borne navigation, and for fisheries, have been derived on the basis of annual trends in relevant indicators (including data on traffic volumes in the Kiel Canal, and data on development of military and fishery fleets).

For the *inland navigation* category, primary data are combined, via a Tier 2 method, in TREMOD (IFEU, 2016a). The model integrates emission values from test-bench measurements and data on specific energy consumption aspects. The latter data have been linked with a traffic-quantity model based on the Federal Statistical Office's statistics on inland water-borne navigation, and they can be broken down by ship types, sizes and loads, and by applicable water-body types.

In general, the source for the **activity data**, as for the entire sector 1.A, is (AGEB, 2016a&b, based on BAFA and MWV). The data for the years 2005 through 2009 are based on sales data of the Association of the German Petroleum Industry (MWV), which differ from the pertinent data in the NEB, and which are published in the annual report "Petroleum Data" ("Mineralöl-Zahlen"; in this case: page 52, Table "Sectoral consumption of diesel fuel" ("Sektoraler Verbrauch von Dieselmotorkraftstoff") (MWV, 2016)).

The official balances of the AGEB and the BAFA divide the data into the categories *domestic* (AGEB: "Coastal and inland navigation" = BAFA: "an die Binnenschifffahrt" ("for inland shipping")) and

international (AGEB: "high-seas bunkering" = BAFA: "Bunker int. Schifffahrt"), in keeping with the different taxation rates applied to different ship fuels.

With respect to ship transports, the NEB – as described, solely on the basis of taxation aspects – differentiates between international marine bunkers (Energy Balance line 6) and coastal and inland navigation (Energy Balance line 64). Energy Balance line 6 lists the fuel quantities bunkered by ocean-going ships registered with the *International Maritime Organization* (IMO), as "sea-going ships" (IMO number). This category includes cargo, fishing and military ships that can operate on both domestic (between two German seaports) and international routes (from Germany to international ports). Energy Balance line 64, on the other hand, lists the fuel quantities that were a) taken on by inland vessels or b) bunkered by ocean vessels that have *not* been certified by the IMO (a category that includes smaller ships that operate only on domestic routes). For the breakdown into national and international *sea* transports, therefore, the fuel quantities listed in Energy Balance line 6 have to be divided in accordance with the categories of domestically operating and internationally operating sea-going ships. In addition, those relevant specific quantities of fishing and military ships that are reported separately under 1.A.4.c iii and 1.A.5.b are deducted.

Table 68: Sources for the activity data used

Material	Source statistics	Location within the source	
Diesel fuel and & heavy fuel oil	NEB	77 (through 1994) and 64 (since 1995)	Coastal and inland navigation
Biodiesel	NEB	Line 64 (for period as of 2004)	

Domestic maritime navigation

The activity data for *domestic maritime navigation* consists of the data for the *non*-IMO-certified seagoing vessels listed in Energy Balance line 64 and of the data for the nationally operating IMO-certified seagoing vessels listed in Energy Balance line 6 (in each case, less the figures for fisheries and military). To determine these fractions, the specific consumption figures of the domestically operating seagoing vessels are calculated – in the aforementioned BSH model – on the basis of their AIS signals (currently, as of 2010; see above) and then aggregated into annual total quantities. Since the model differentiates between IMO-certified and non-IMO-certified sea-going ships, the sub-quantities included in NEB lines 6 and 64 are available. By deducting the former of the two sub-quantities (fuel consumption in domestically operating IMO-certified sea-going vessels) from the bunkered quantities listed in NEB line 6, one obtains a remaining quantity, bunkered by internationally operating sea-going vessels in Germany, that serves as a basis for calculating the separately listed emissions for international maritime navigation (departing from Germany) (cf. Chapter 3.2.2.3).

The fuel quantities taken on annually by *inland vessels* in Germany are obtained by deducting the second sub-quantity (fuel consumption in domestically operating, non-IMO-certified sea-going vessels) from the total quantity listed in NEB line 64. As a result of variations in the navigability of inland waterways, the annual fuel consumption levels of inland ships vary widely. Since the mid-1990s, those levels have been tending to decrease, as many ships have been refueling abroad in order to take advantage of lower prices. The abrupt decrease that occurred in 1994/1995 was due to a conversion in the Energy Balance, however. Due to inadequacies in the available statistical data, annual figures for biodiesel consumption continue to be calculated, for the time being, on the basis of the official mixture percentages.

In the framework of the UNFCCC's review process, Germany has been repeatedly requested (most recently, during the 2016 In Country Review) to separately list emissions from fuels that inland vessels take on in Germany and then consume outside of Germany. For such separate listing, which the available statistics and models do not directly support, extremely involved regular surveys would have to be carried out, and then data for the period back to 1990 would have to be developed from their results. Presumably, inland vessels that operate internationally rarely refuel in Germany³⁶, and thus the value of such an effort seems questionable. Nonetheless, the review team's request is being duly considered, and a solution that is acceptable for all sides, and scientifically reliable, is being sought.

With regard to the **emission factors** used for carbon dioxide, we refer, in general, to Chapter 18.7. Further information – in particular, with regard to carbon dioxide from lubricant co-combustion – is also provided in Chapter 19.1.4.

With regard to releases of methane and nitrous oxide from co-combustion of lubricants, it is assumed that such emissions are already taken into account in the pertinent emission factors for the fuels used and thus are to be reported as IE (*included elsewhere*).

All other emission factors for the sub-sector *domestic maritime navigation* have been taken from (BSH, 2015).

For the area of *inland navigation*, CH₄ emission factors from (IFEU, 2016a) are used. They are calculated on the basis of test-bench measurements, and on data, relative to the required propulsion energy, broken down by ship types and sizes, loads and waterway types. The emission factors for N₂O are in keeping with Federal Environment Agency (UBA) experts' assessments based on the UBA study "Air Quality Control '88" ("Luftreinhaltung '88") and on analogies to heavy duty vehicles without emissions-control equipment.

Table 69: Emission factors used for report year 2015, in kg/TJ

	CH ₄	N ₂ O	Origin
Inland navigation			
Diesel	1.33 (-)	1.00 (-)	Country-specific value pursuant to (IFEU, 2016a)
Biodiesel	1.33 (-)	1.00 (-)	Equivalent to the EF for diesel oil
Domestic maritime navigation			
Diesel	0.97 (7.00)	3.30 (2.00)	Pursuant to (BSH, 2015)
Biodiesel	0.97 (-)	3.30 (-)	Equivalent to the EF for diesel oil
Heavy fuel oil	1.03 (7.00)	3.41 (2.00)	Pursuant to (BSH, 2015)
Overarching			
Lubricants	IE	IE	Included in the EF for the individual fuels

* listed in parentheses: Default values pursuant to the 2006 IPCC Guidelines (Volume 2, Chapter 3.5, p. 3.50, Tab. 3.5.3.

3.2.10.4.3 Uncertainties and time-series consistency (1.A.3.d)

While it was possible to obtain the uncertainties for national inland navigation from (IFEU & INFRAS, 2009), it is still necessary to apply the IPCC default uncertainties for the area of national maritime navigation.

³⁶ Because fuel prices in other countries along the Rhine and Danube rivers are consistently lower than they are in Germany, and because large inland vessels can easily travel several thousand kilometers on one tankful of fuel, inland ships making international trips presumably refuel in Germany only in exceptional cases.

The activity-data time series for coastal and inland water-borne navigation exhibit inconsistencies, resulting from the Energy-Balances transition between 1994 and 1995, which cannot be eliminated at present.

The emission-factor time series exhibit no inconsistencies.

3.2.10.4.4 Category-specific quality assurance / control and verification (1.A.3.d)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of NEBs as of 2003 has been published in the Internet³⁷.

Table 70: Overview of relevant data comparisons

Comparison with...	Complete d	Remark
Alternative emissions inventories for Germany	no	No comparable data records
Sector-specific Tier 1 default EF pursuant to (IPCC, 2006: Volume 2, Tab. 3.5.2): CO ₂	yes	cf. Table 71
Sector-specific Tier 1 default EF pursuant to (IPCC, 2006: Volume 2, Tab. 3.5.3): CH ₄ , N ₂ O	(yes)	Sea: cf. Table 69 Inland: no defaults
Tier 1 default EF pursuant to (IPCC, 2006: Volume 2, Tab. 2.4): CH ₄ , N ₂ O	yes	Inland: Results are inconclusive
Specific IEF of other countries	yes	cf. Table 72

Table 71: Comparison of the EF(CO₂) used in the inventory with default values

	Inventory value ^a	Default ^b	Lower bound	Upper bound
Fossil-based diesel fuel	74,027	74,100	72,600	74,800
Heavy fuel oil	81,329	77,400	75,500	78,800
Biodiesel	70,800		59,800	84,300

^a for report year 2015; ^b pursuant to 2006 IPCC Guidelines: Volume 2, Table 2.4

The following table provides a comparison with specific implied emission factors of other countries and of the EU (28).

Table 72: International comparison of reported IEF, in kg/TJ

	Fossil-based diesel fuel			Heavy fuel oil		
	CO ₂	CH ₄	N ₂ O	CO ₂	CH ₄	N ₂ O
Germany	74,027	1.17	2.00	80,877	1.04	3.41
Denmark	73,921	2.04	1.78	77,896	2.47	1.73
France	75,032	7.00	2.00	78,000	7.00	2.00
Netherlands	74,300	7.00	2.00	NO	NO	NO
UK	73,904	1.16	1.86	78,260	1.21	1.94
EU (28)	73,985	4.00	3.79	78,072	5.48	2.18

Germany: current IEF for report year 2015; all other countries: IEF for 2014, pursuant to 2016 CRF Submission

³⁷ AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2009; URL: http://www.ag-energiebilanzen.de/index.php?article_id=7&clang=0#revision_der_energiebilanzen_2003_bis_2009_05 (last checked on 18 Sept. 2013)

3.2.10.4.5 Category-specific recalculations (1.A.3.d)

With respect to the 2016 Submission, only marginal recalculations were carried out, to take account of revision of emission factors.

Table 73: Revised emission factors for methane and nitrous oxide, for consumption of diesel fuel by inland vessels; year-specific values for report year 2014, in kg/TJ

	Methane	Nitrous oxide
2017 Submission	1.3335	1.0011
2016 Submission	1.3331	1.0010
Absolute change	0.0005	0.0001
Relative change	0.03%	0.01%

Source: TREMOD (IFEU, 2016a)

The above-described corrections lead to the following recalculated emissions quantities:

Table 74: Resulting recalculation of methane and nitrous oxide emissions from consumption of diesel fuel by inland vessels, in kt

	Methane	Nitrous oxide
2017 Submission	0.063347	0.028221
2016 Submission	0.063346	0.028217
Absolute change	0.000001	0.000004
Relative change	0.002%	0.014%

Source: own calculations

The change resulting via the recalculation of the overall greenhouse-gas emissions is so small as to be meaningless in the present context.

3.2.10.4.6 Planned improvements (category-specific) (1.A.3.d)

With regard to *domestic water-borne navigation*, various types of maintenance work on the model are carried out, as necessary, in the framework of model updating. Such work cannot be described in detail at present, however.

With regard to *inland water-borne navigation*, means are being sought, in cooperation with the responsible model developers (ifeu) and national experts (CCNR: Central Commission for the Navigation of the Rhine), for obtaining precise separate sets of data on a) domestically operating ships and b) internationally operating ships. It is not yet possible to state whether pertinent results will be available as soon as the 2018 Submission, however.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.10.5 Transport – Other transportation (1.A.3.e)**3.2.10.5.1 Category description (1.A.3.e)**

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	1.A.3.e Transport: Other Transportation	All fuels	CO ₂	1,083.3	0.09%	1,223.7	0.14%	13.0%
-/-	1.A.3.e Transport: Other Transportation	All fuels	N ₂ O	14.5	0.00%	10.7	0.00%	-26.2%
-/-	1.A.3.e Transport: Other Transportation	All fuels	CH ₄	5.3	0.00%	6.0	0.00%	12.4%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	ETS	CS
CH ₄	Tier 2	ETS	CS
N ₂ O	Tier 2	ETS	CS

The category 1.A.3.e - Transport – other transportation is not a key category

Reporting in category 1.A.3.e – Other transportation includes only emissions from *gas turbines in natural-gas compressor stations of the transport network*. The emissions from gas turbines of pumping stations are reported in category 1.A.1.c. Fugitive emissions from compressors are reported under 1.B.2.b.iii & iv. Additional gas compressors are operated in the chemical industry. In keeping with the relevant statistical structure, they are reported in category 1.A.2.g Other.

3.2.10.5.2 Methodological issues (1.A.3.e)**Activity data:**

Calculation of fuel inputs for natural gas compressors was completely revised for the NIR 2012. As of 2005, the fuel inputs reported for purposes of emissions trading, and aggregated by the emissions-trading authority, are being used directly, as a new data source. In this area, the only data used from that data set are the data for natural gas compressors that are allocated to the transport network. Natural gas compressors of pumping stations are identified via energy statistics and thus are already included in category 1.A.1.c. This allocation approach prevents double-counting in the inventory.

In light of the new data situation, it seemed likely that the fuel inputs used were too low, throughout the entire time series. Only the value shown in the 2002 Energy Balance seemed plausible. While fuel inputs for natural gas compressors in the period 1995-2002 were reported in the context of statistics, it may be assumed that the recorded levels were too low. To establish consistency in the relevant time series, therefore, recalculations back to 1990 were carried out. Since the relevant fuel inputs fluctuate annually, in keeping with primary energy consumption, simple interpolation would not have led to the desired consistency. For that reason, a mean for the pertinent relationship (fuel inputs / primary energy consumption) was calculated for the period 2005-2009, and then that mean was used for the calculations back to 1990. This procedure has produced a plausible and consistent time series.

Emission factors:

The emission factors for natural-gas use in **natural gas compressor stations** are based, for each specific gas, on the results of various Federal Environment Agency research projects and expert opinions:

- With regard to CO₂, the reader's attention is called to the documentation in Annex 2, the Chapter "CO₂ emission factors".

- The CH₄ and N₂O EF have been obtained from the report FICHTNER et al. (2011). The procedure used in the studies is described in Chapter 3.2.6.2.

3.2.10.5.3 Uncertainties and time-series consistency (1.A.3.e)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, in the Chapter "Uncertainties in the activity data of stationary combustion plants", of the NIR 2007.

The procedure for determining uncertainties for the EF of natural gas compressor stations is described in Chapter 3.2.6.2. Results for N₂O are presented in Chapter 3.2.6.3.2, while those for CH₄ are presented in Chapter 3.2.6.3.3.

3.2.10.5.4 Category-specific quality assurance / control and verification (1.A.3.e)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The results of Chapter 3.2.6.2 apply mutatis mutandis.

3.2.10.5.5 Category-specific recalculations (1.A.3.e)

Table 75: Recalculations in CRF 1.A.3.e

Units [kt]	NIR 2016	NIR 2017	Difference, absolute		Total
Year	Total	Total	gas	Total	Total
2013	1,469	1,470	-0.70	-0.70	-0.05%
2014	1,195	1,195	-0.41	-0.41	-0.03%

Slight recalculations were carried out, for the years 2013 and 2014, to take account of changes in the emissions trading data for natural gas compressors.

3.2.10.5.6 Planned improvements, category-specific (1.A.3.e)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.11 Other: Residential, commercial/institutional, agriculture, forestry and fisheries (1.A.4 Stationary)

3.2.11.1 Category description (1.A.4 Stationary)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	1.A.4.a Other Sectors: Commercial/institutional	All fuels	CO ₂	64,105.9	5.24%	34,518.8	3.89%	-46.2%
-/T	1.A.4.a Other Sectors: Commercial/institutional	All fuels	CH ₄	1,461.6	0.12%	25.1	0.00%	-98.3%
-/-	1.A.4.a Other Sectors: Commercial/institutional	All fuels	N ₂ O	145.6	0.01%	81.4	0.01%	-44.1%
L/T	1.A.4.b Other Sectors: Residential	All fuels	CO ₂	128,635.8	10.52%	85,363.7	9.62%	-33.6%
-/T	1.A.4.b Other Sectors: Residential	All fuels	CH ₄	2,483.9	0.20%	743.8	0.08%	-70.1%
-/-	1.A.4.b Other Sectors: Residential	All fuels	N ₂ O	768.9	0.06%	298.3	0.03%	-61.2%
L/T	1.A.4.c Other Sectors: Agriculture/Forestry/Fisheries	All fuels	CO ₂	10,270.1	0.84%	5,811.7	0.65%	-43.4%
-/-	1.A.4.c Other Sectors: Agriculture/Forestry/Fisheries	All fuels	CH ₄	240.0	0.02%	361.7	0.04%	50.7%
-/-	1.A.4.c Other Sectors: Agriculture/Forestry/Fisheries	All fuels	N ₂ O	61.9	0.01%	77.6	0.01%	25.4%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1*, CS	NS/M	CS, D*
CH ₄	CS (Tier 2)	NS/M	CS (M)
N ₂ O	CS (Tier 2)	NS/M	CS (M)
NO _x , CO, NMVOC, SO ₂	CS (Tier 2)	NS/M	CS (M)

* biodiesel and co-combusted lubricants

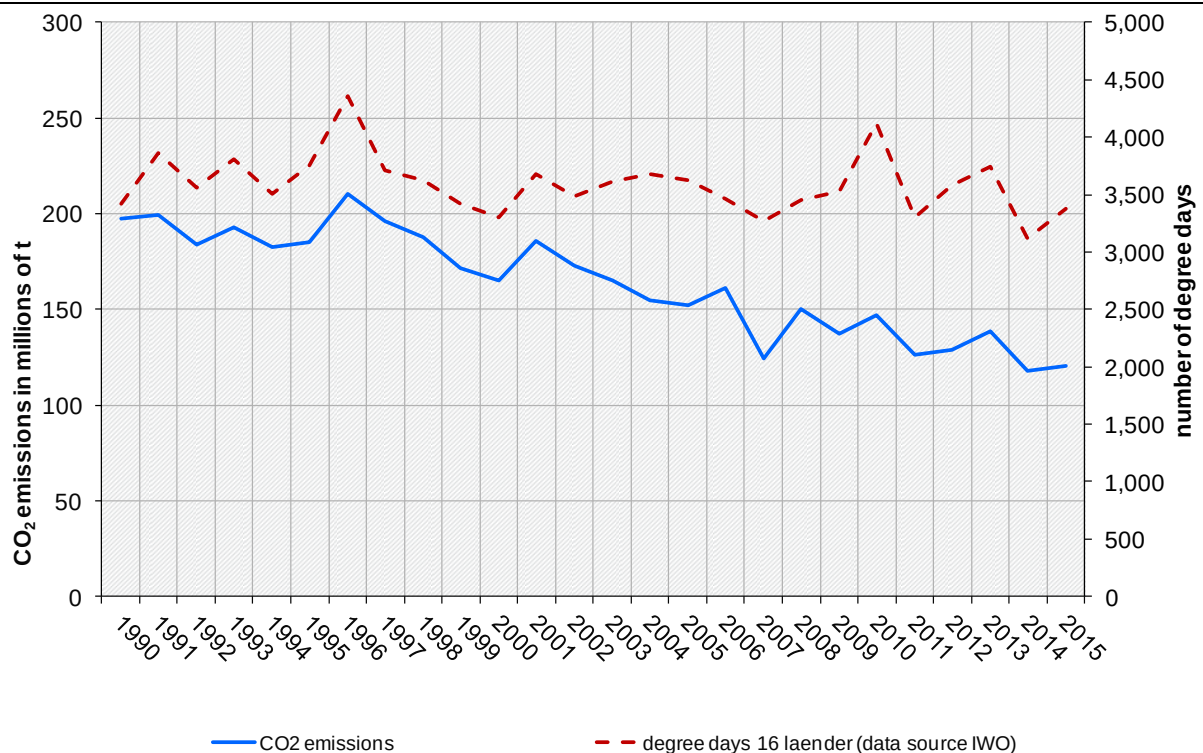
The stationary and mobile sources categories in 1.A.4 are placed in the relevant main categories together (for an overview, cf. Chapter 3.2.11.1). The category 1.A.4 *Other* is a key category for CO₂ emissions, in terms of both emissions level and trend, in all of its sub-categories. For CH₄ emissions, categories 1.A.4.a & b are a key category in terms of trend.

Category 1.A.4 Stationary comprises combustion systems in the areas *Commercial and Institutional*, *Residential* and *Agriculture*.

Heat-generation systems in small combustion systems of small commercial and institutional users are reported in sub-category 1.A.4.ai Commercial and institutional.

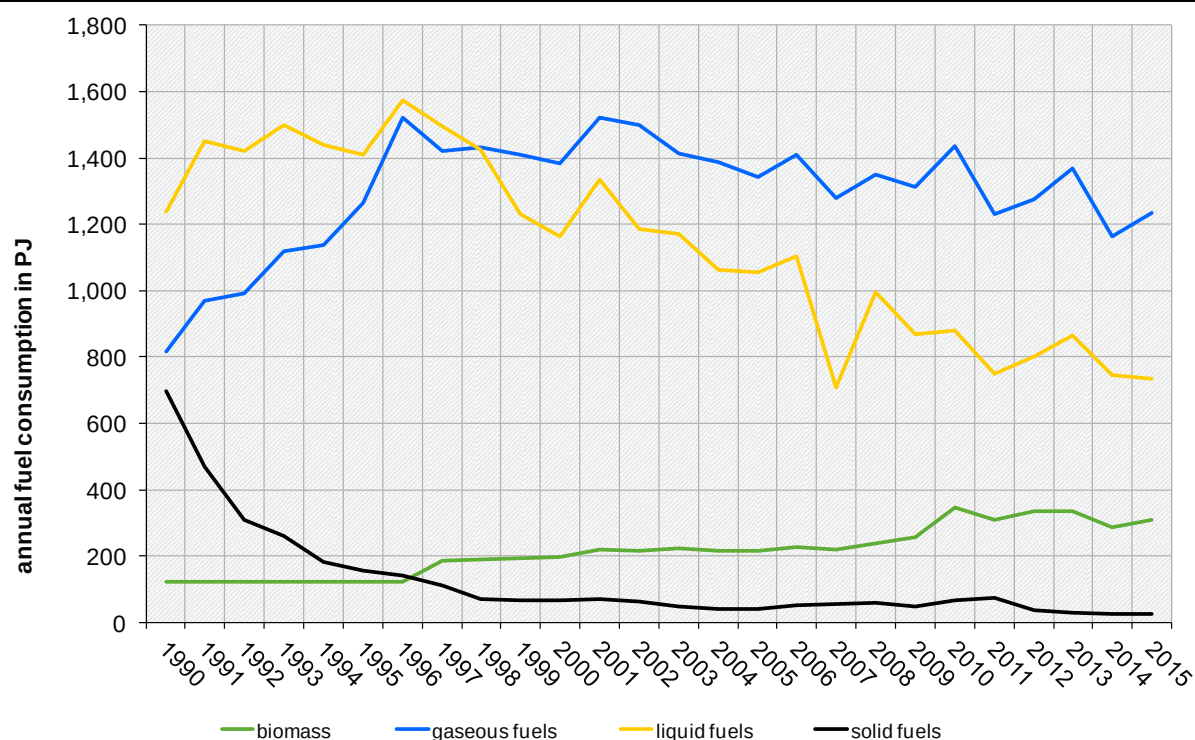
Emissions from residential combustion systems are reported in sub-category 1.A.4.bi. Sub-category 1.A.4.ci comprises the areas of agriculture, forestry and fisheries. Reporting under this category includes emissions from heat generation in small and medium-sized combustion systems.

Figure 35: Change in total emissions of 1.A.4, as a function of temperature



The main driver of CO₂ emissions in 1.A.4 is energy consumption for purposes of space heating. Consequently, fluctuations in consumption can plausibly be attributed to differences in periods of winter cold. The trend toward lower CO₂ emissions is a result of higher standards for new buildings, of successful energy-efficiency-oriented modernisations of existing buildings and of switching to fuels with low CO₂ emissions. CO₂ emissions from electrically driven heat pumps, which are being used more and more frequently in new buildings, are reported not here but under 1.A.1.a.

Figure 36: Trends in energy consumption in 1.A.4 (stationary), for 4 fuel categories



Shifting from liquid fuels (almost exclusively heating oil) and solid fuels (mainly coal) to gaseous fuels (natural gas) and biomass has brought about considerable CO₂-emissions reductions. In 2006 and 2007, a special phenomenon occurred whereby energy consumption was first above-average and then below-average, respectively, as a result of an increase in the value-added-tax (VAT) rate from 16 % to 19 %. Very high heating-oil sales in 2006 increased CO₂ emissions figures, since emissions data relative to heating oil are determined on the basis of sales, rather than consumption. In the years 2011 through 2015, trends in energy inputs, especially in the market for heat, were strongly influenced by weather conditions during winter heating periods, as well as by increased energy prices and costs. Over those years, these factors caused energy consumption – especially, consumption of light heating oil and natural gas – to fluctuate sharply.

Differing trends were seen in 2015. The weather was somewhat cooler than it had been in the previous year, which had extremely mild temperatures, and the resulting higher heating energy requirements translated into higher demand only for natural gas. Demand for light heating oil decreased, in spite of sharp reductions in prices. Expected increases in heating oil sales failed to materialize – because, clearly enough, consumers were able to meet their addition requirements with their available stocks (Working Group on Energy Balances (AGEB), *Energieverbrauch in Deutschland im Jahr 2015* ("Energy consumption in Germany in 2015")).

The group of 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 and commercial/institutional users' licensable combustion systems with a rated thermal output of several megawatts, to name but a few examples. In total in 2010, more than 36.5 million combustion systems were installed in Germany in the Residential and Commercial and

Institutional sectors (TEBERT, 2016). Gas-fired combustion systems accounted for a majority of these systems, or some 16.2 million, while combustion systems using solid fuels accounted for some 14.2 million systems and oil-fired furnaces accounted for some 5.9 million systems.

Of the wood fuels used in households and in commerce and trade, large quantities are purchased privately or obtained from system owners' own forest parcels. For this reason, in the Energy Balance, the relevant data from the Federal Statistical Office are supplemented with data from a survey of firewood consumption in private households. No official data are available on use of firewood in the categories commercial and institutional [commerce, trade and services]. As a result, data are taken from a pertinent study from the year 2000 (UBA 2000a). The consumption-level figures determined in that study have been adopted for subsequent years since then. A research project entitled "Development of methods for determination of consumption of biogenic solid fuels in the commercial and institutional sector" ("Methodenentwicklung zur Ermittlung des Verbrauchs biogener Festbrennstoffe im GHD-Sektor") was carried out to determine activity data on use of firewood in the commercial and institutional sector more precisely. Since the project yielded sample results for individual areas, a complete data set on the sector's firewood use – a data set that would support an update – is still lacking. The initial aim of the project was to develop a method that would lead to a general approach. A plan for a follow-on project that would be based on the experience gained to date, and that would complete the findings for other sectors as well, proved impossible to implement, due to a lack of suitable research contractors. The Energy Balance fuel category "Waste and other biomass" is specified in greater detail in the Satellite Balance. The information in that Balance indicates that only firewood is used in the residential sector, while only sewage gas and biogas are used in the sector "Commercial and institutional (commerce/trade/services) and other consumers".

3.2.11.2 Methodological issues (1.A.4, stationary)

Activity data

The activity data in category 1.A.4 are based on the Energy Balances for the Federal Republic of Germany, as prepared by the Working Group on Energy Balances (AGEB). For years prior to 1995 separate Energy Balances are used for the a) old German Länder and b) new German Länder. For years as of 1995, lines 66 (residential) and 67 (commercial and institutional and other consumers) are the standard.

Since the data in Energy Balance line 67 – commercial and institutional and other consumers – also include military consumption, such military consumption must be deducted from the relevant positions in line 67 (cf. Chapter 3.2.13.2 with regard to stationary and mobile sources in the military sector).

For energy inputs in *Agricultural combustion systems (1.A.4.ci)*, which are also included in line 67 of the Energy Balance, relevant data are available, in an existing study (UBA, 2000a), for 1995. That study provides an estimate of agricultural combustion systems' share of total energy inputs in line 67. That share is assumed to have remained constant since then.

Emission factors

A detailed description of the relevant procedures, and a list of the CO₂ emission factors used, is presented in the Annex, Chapter 18.7.

The underlying data for the emission factors used for N₂O and CH₄ emissions of stationary combustion systems is the research report "Ermittlung und Aktualisierung von Emissionsfaktoren für das nationale Emissionsinventar bezüglich kleiner und mittlerer Feuerungsanlagen der

Haushalte und Kleinverbraucher" ("Determination and updating of emission factors for the national emissions inventory, with regard to small- and medium-sized combustion systems in the residential and commercial/institutional sectors") (TEBERT 2016). Within the context of that project, device-related and category-specific emission factors for combustion systems in the residential and commercial/institutional sectors were calculated, with a high level of detail, for all important emissions components for the reference years 2010 and 2015.

Determination of emission factors is based on a category-specific "bottom-up" approach that, in addition, to differentiating (sub-)categories and fuels, also differentiates system technologies in detail. In the process, several system-specific emission factors are aggregated in order to obtain mean emission factors for all systems within the 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 2/3 method described in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006).

The emission factors are structured in accordance with the relevant fuels involved in final energy consumption in Germany:

- Fuel oil EL
- Natural gas,
- Lignite (briquettes from the Rhine (Rheinisch) and Lusatian (Lausitz) coal fields; 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 combustion systems was documented via an extensive evaluation of the pertinent literature. Transfer factors were used to take account of the fact that emissions in a test-bench environment tend to be lower than those of corresponding installed systems.

The breakdown of the overall pool of installed combustion systems, by system types, was obtained by carrying forward data in STRUSCHKA 2008, and drawing on sales statistics for the relevant industrial associations. Those 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. Table 76 shows the sectoral emission factors used.

Table 76: Sectoral emission factors for combustion systems in the residential and commercial/institutional sectors for reference year 2010

	CH ₄	N ₂ O
1.A.4.bi – Residential	[kg/TJ]	
Hard coal	134	11.5
Briquettes	368	9.7
Hard-coal coke	13	0.9
Lignite briquettes	237	5.2
Unprocessed wood	97	1.6
Heating oil EL	0.03	0.55
Natural gas	3	0.25
1.A.4.ai & ci – Commercial and Institutional		
Hard coal	100	8.5
Briquettes	-	-
Hard-coal coke	20	0.8
Lignite briquettes	-	-
Wood fuels	43	0.53
Heating oil EL	0.03	0.56
Natural gas	0.16	0.33

The emission factors for 2010 were used, without change, for subsequent years.

3.2.11.3 Uncertainties and time-series consistency (1.A.4, stationary)

Annex 2, Chapter 13.6 in the NIR 2007 describes the method used to determine the uncertainties for the **activity data**.

A complex procedure is required to calculate reliable emission factors in the installation sector. Apart from emission figures, it is also necessary to obtain other information; for example, one must make allowance for the relevant mode of operation (loads), installation structure and device-specific final energy consumption. In data surveys during the aforementioned research and development project, this approach was for the most part followed; nevertheless, given the sheer number of facilities concerned and the wide range of combustion systems and fuels used, the data must be assumed to have a fairly large "basic uncertainty".

For some installation types, moreover, only inadequate data or no data at all were available on emissions behaviour in connection with certain fuels. It is important to remember that the law does not require the greenhouse-gas emissions of combustion systems of residential and commercial/institutional users to be measured. When calculating the emission factors, therefore, in most cases (with the exception of CO₂, which is largely independent from furnace design) the researchers only had recourse to a few results from individual measurements on selected installations. Gaps in the data were closed via adoption of emission factors of comparable combustion systems.

The uncertainties listed for the emission factors for CH₄ and N₂O, for stationary combustion systems, were determined via expert estimation pursuant to IPCC-GPG (2000: Chapter 6). That assessment, which is based on the emissions data obtained for the aforementioned research project, was carried out in the framework of that project by experts of the University of Stuttgart's Institute of Process Engineering and Power Facility Technology (Institut für Verfahrenstechnik und Dampfkesselwesen). Uncertainties were estimated separately for all combustion technologies and fuels. The following sources of error entered into the estimates for N₂O and CH₄:

- Measuring errors in determination of pollutant concentrations;

- Uncertainties in estimating transfer factors (systematic differences between test-bench and field measurements);
- Uncertainties resulting from having too little emissions data;
- Uncertainties resulting from use of different measuring procedures;
- Uncertainties in the installation data used (overall group structure in terms of type, age and performance and fuel consumption)

In gas-fired systems, another error occurs in determination of start-up/shutdown emissions. During start-up/shutdown processes, some unburned CH₄ is emitted from natural gas. These emissions, which occur upstream and downstream from the actual combustion process, cf. Chapter 3.3.2.2 (natural gas), are a significant reason why CH₄ emission factors for gas-combustion systems are subject to high levels of uncertainties.

As to the distribution of uncertainties, a log-normal distribution is assumed for N₂O emission factors. In all likelihood, the deviations are considerably more pronounced in the vicinity of larger values than they are in the vicinity of smaller values. The emission factors for CH₄ and N₂O were determined for the year 2005, in the framework of the aforementioned research project, and are assumed to have remained constant since then.

3.2.11.4 Category-specific QA/QC and verification (1.A.4, stationary)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Information on quality assurance for **activity data** is provided in Chapter 3.2.6.4. For further information on quality assurance, cf. Chapter 18.4.1.

For the purposes of quality assurance for data relative to *stationary combustion systems*, in the context of the aforementioned research and development project, all the input data used from literature and from the research company's own investigations were reviewed for validity. As a general principle, in description of the emissions behaviour of combustion systems, emissions data were included in subsequent calculations only if the relevant literature sources contained complete, undisputed data on the fuel used, the design of the furnace, and the furnace's operating mode during measurements. All resources of significance for inventory preparation were substantiated by the research company.

In the framework of a quality review carried out by Federal Environment Agency experts, the country-specific emission factors for CH₄ and N₂O, determined in accordance with the Tier 2 standard, were compared with the IPCC Tier 2 default factors in the IPCC Guidelines for emissions inventories (IPCC 2006). For most fuels, the values agreed well (discrepancies within one order of magnitude), although the default values for CH₄ tended to be higher than the country-specific values.

In the framework of quality assurance, calculation with the Tier 1 default values was carried out, in addition to emissions determination pursuant to Tier 2/3, for the residential and commercial/institutional sectors for the year 2015. The results are shown in Table 77.

Table 77: Emissions calculation with country-specific Tier 2/3 emission factors and with the Tier 1 default emission factors pursuant to (IPCC 2006)

Emission factors	CH ₄ [t]				N ₂ O [t]			
	Residential		Commercial and institutional		Residential		Commercial and institutional	
	Tier 1 default	Country-specific EF	Tier 1 default	Country-specific EF	Tier 1 default	Country-specific EF	Tier 1 default	Country-specific EF
Heating oil EL	4,694	76	1,723	6	277	256	101	97
Fuel gases	4,223	2,534	1,763	55	84	212	35	115
Coal fuels	7,388	5,776	44	85	37	177	2	7
Wood	66,780	21,074	9,011	1,465	890	352	120	25
Total	83,085	29,459	12,541	1,611	1,289	997	258	244

The emissions for the commercial/institutional ("small consumers") sector include the emissions of the areas of agriculture, forestry and fisheries.

For N₂O, the emissions-calculation results obtained with both methods showed good agreement. Larger discrepancies were seen in determination of CH₄ emissions. Presumably, this is due to the fact that methane emissions of combustion systems depend strongly on the combustion technology used. Differences in installation structures (i.e. in sector composition), from country to country, thus manifest themselves much more strongly in total emissions (as determined) than in nitrous-oxide emissions. The default emission factor for heating oil, in particular, is very high. The technology-specific emission factor given in IPCC 2006 for boilers shows considerably better agreement with the pertinent country-specific factor for Germany.

No data sources are known that would support a comparison with the data reported here for mobile sources in the residential, agricultural and fisheries sectors. In addition, the country-specific IEF were compared with those of other countries. Due to the heterogeneous composition of the sub-categories involved, however, that comparison is largely inconclusive – especially with regard to methane and nitrous oxide.

3.2.11.5 Category-specific recalculations (1.A.4, stationary)

Table 78: Recalculations in CRF 1.A.4 (stationary)

Units [kt]	NIR 2016	NIR 2017	Difference, absolute				Difference, relative
	Total	Total	gas	liquid	solid	Total	
2013	138,240	138,276	36	0	0	36	0.03%
2014	117,233	117,592	615	-764	509	359	0.31%

The change in the natural gas inputs of the military agencies in 1.A.5 affects the natural gas inputs of the stationary sources in 1.A.4, because the two areas are related in Energy Balance line 67. For this reason, the figures for gaseous fuels in the years 2013 and 2014 had to be recalculated. For the year 2014, major recalculations were carried out, since the provisional figures in the 2015 Submission have been replaced with final figures from the Energy Balance.

3.2.11.6 Planned improvements, category-specific (1.A.4, stationary)

With regard to reporting on *stationary combustion systems*, review is currently being carried out to determine whether the applicable percentage for wood use can be determined via other scientific studies.

In addition, plans call for redetermining, and adjusting as necessary, the energy-input fraction for *Combustion systems in the agricultural sector and in nurseries (garden centers) (1.A.4.ci)*, with regard to the Commercial and Institutional sector, which is presented in Energy Balance line 67.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

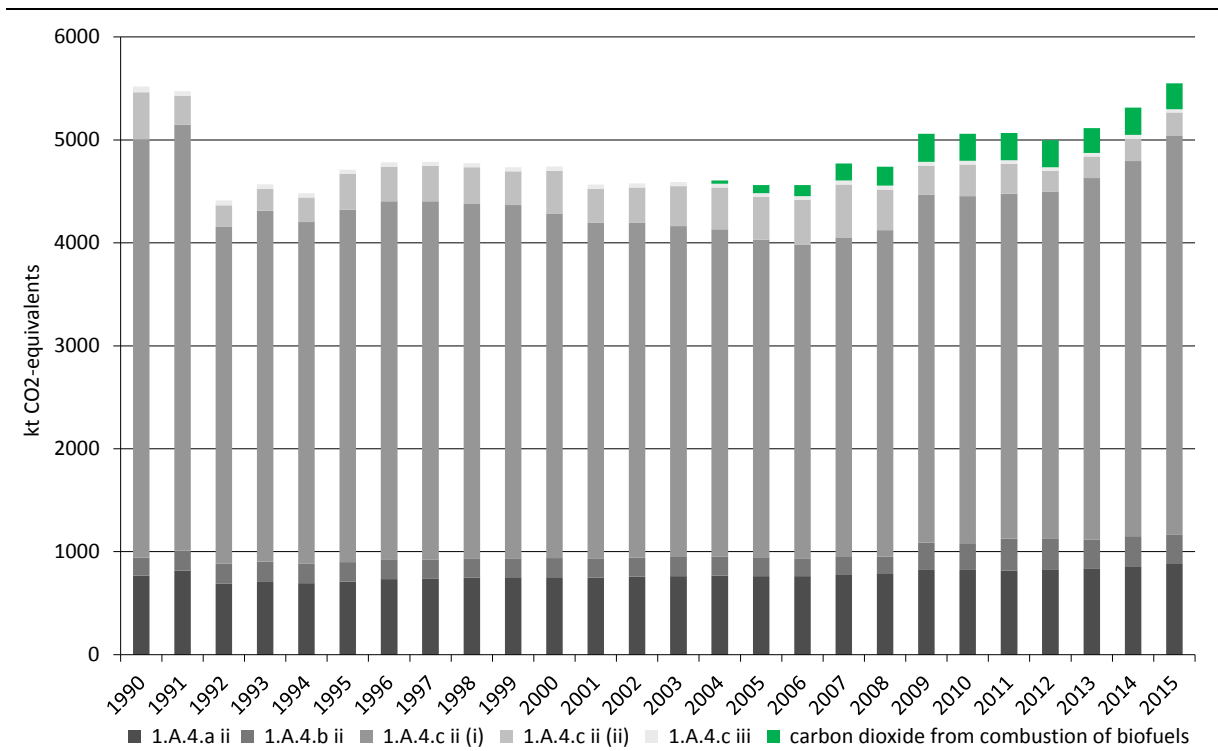
3.2.12 Other: Residential, commercial/institutional, agriculture, forestry and fisheries (1.A.4 Mobile)

3.2.12.1 Category description (1.A.4, Mobile)

The stationary and mobile sources categories in 1.A.4 are grouped together for purposes of determination of key-category status (for an overview, cf. Chapter 3.2.11.1). The category 1.A.4 *Other* is a key category for CO₂ emissions, in terms of both emissions level and trend, in all of its sub-categories. For CH₄ emissions, categories 1.A.4.a & b are a key category in terms of trend.

Category 1.A.4 – mobile comprises various mobile sources in sub-categories 1.A.4.a ii – Commercial and Institutional (commerce, trade and services), 1.A.4.b ii – Residential, 1.A.4.c ii – Agriculture and forestry and 1.A.4.c iii – Fisheries.

Figure 37: Development of GHG emissions in the various considered sub-sectors since 1990



3.2.12.2 Methodological issues (1.A.4, mobile)

The **activity data** in category 1.A.4 mobile, like those for stationary combustion systems, are taken from (AGEB, 2016a&b).

The quantities of gasoline fuels listed in Energy Balance line 66 – Residential are all allocated to *Mobile sources* (1.A.4.b ii).

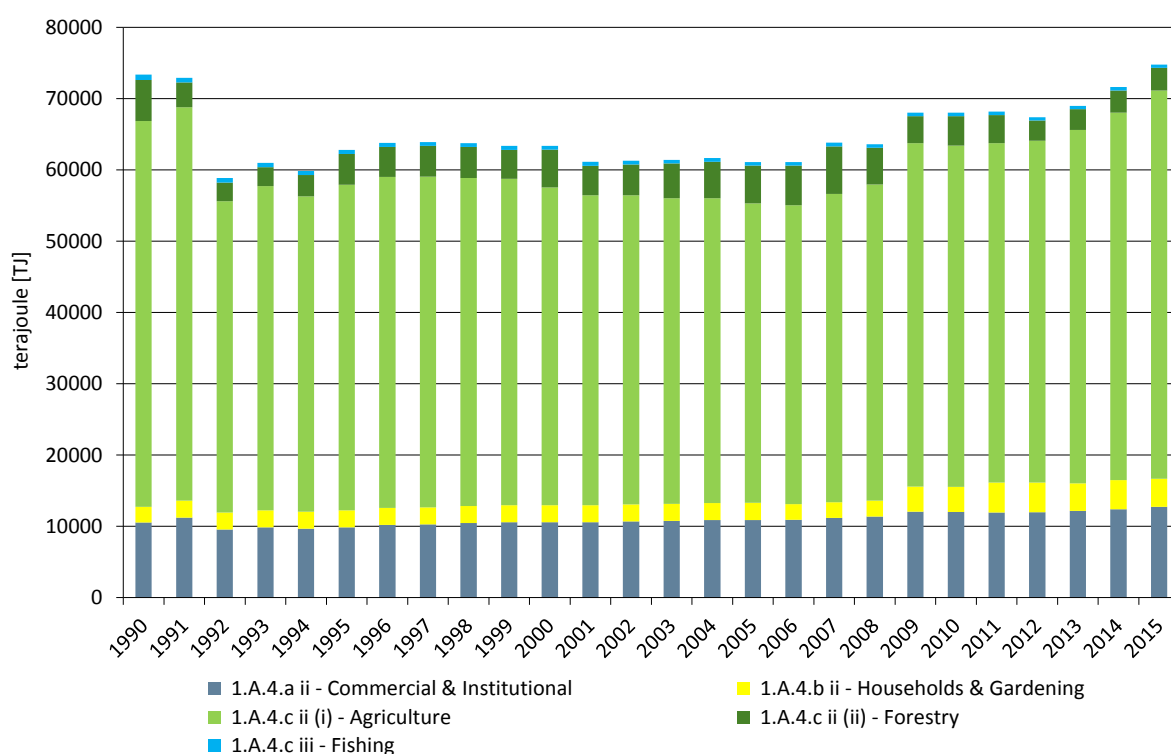
NEB line 67 – *Commercial and Institutional* also includes fuel consumption areas of the military sector that are separately recorded in (BAFA, 2016) statistics; those areas can thus be deducted here (cf. Chapter 3.2.14 regarding mobile sources in the military sector). The additional breakdown into mobile sources in *Agriculture* (1.A.4.c ii (i)) and *Forestry* (1.A.4.c ii (ii)), *Construction*

vehicles and machinery (1.A.2.g vii), and mobile sources in 1.A.4.a ii (primarily forklifts), is carried out on the basis of an annual distribution key generated in (IFEU, 2016b).

In general, the activity data for the coastal and high-seas fisheries included under 1.A.4.c (iii) – Fisheries are prepared, in the context of the BSH model described under 1.A.3.d, on the basis of AIS data (data of the IMO's Automatic Identification System) and of annual European Commission data on fleet development. For report year 2015, however, the data were carried forward, in the manner described in Chapter 3.2.10.4.

In general, the pertinent quantities of co-combusted lubricants are derived, pursuant to (VSI, 2014), from the relevant annual fuel quantities. For two-stroke petrol engines (in the residential and forestry sectors), those quantities are obtained as a two-percent addition to the quantities of petrol used for refueling (cf. also Chapter 19.1.4).

Figure 38: Development of fuel consumption within the various considered sub-categories since 1990



With regard to the **emission factors** used for carbon dioxide, we refer, in general, to Chapter 18.7. Further information – in particular, with regard to carbon dioxide from lubricant co-combustion – is also provided in Chapter 19.1.4.

For methane and nitrous oxide, country-specific values pursuant to (IFEU, 2016b) and (BSH, 2015) are used. With regard to releases of methane and nitrous oxide from co-combustion of lubricants, it is assumed that such emissions are already taken into account in the pertinent emission factors for the fuels used and thus are to be reported as IE (*included elsewhere*).

Table 79: Emission factors used for report year 2015, in kg/TJ

	CH ₄	N ₂ O	Origin
1.A.4.a ii – Mobile sources in the Commercial and Institutional (commerce, trade and services) sector			
Diesel	2.02 (4.15)	4.36 (28.60)	Pursuant to TREMOD MM (IFEU, 2016b)
Biodiesel	2.02 (-)	4.36 (-)	Equivalent to the EF for diesel
LP gas	5.20 (-)	0.69 (-)	Pursuant to (IFEU, 2016b)
1.A.4.b ii – Mobile sources of the residential sector			
Gasoline (two-stroke engines)	224 (180)	0.43 (0.40)	Pursuant to (IFEU, 2016b)
Bioethanol (two-stroke engines)	224 (-)	0.43 (-)	Equivalent to the EF for gasoline (two-stroke engines)
Gasoline (four-stroke engines)	27 (120)	1.32 (2)	Pursuant to (IFEU, 2016b)
Bioethanol (four-stroke engines)	27 (-)	1.32 (-)	Equivalent to the EF for gasoline (four-stroke engines)
1.A.4.c ii (i) – Mobile sources of the agricultural sector			
Diesel	2.63 (4.15)	2.87 (28.6)	Pursuant to (IFEU, 2016b)
Biodiesel	2.63 (-)	2.87 (-)	Equivalent to the EF for diesel
1.A.4.c ii (ii) – Mobile sources of the forestry sector			
Diesel	0.77 (4.15)	3.10 (28.6)	Pursuant to (IFEU, 2016b)
Biodiesel	0,77 ()	3,10 ()	Equivalent to the EF for diesel
Gasoline (two-stroke engines)	205 (170)	0.46 (0.40)	Pursuant to (IFEU, 2016b)
Bioethanol (two-stroke engines)	205 ()	0,46 ()	Equivalent to the EF for gasoline (two-stroke engines)
1.A.4.c (iii) – Fisheries (here: <i>high-seas fisheries</i>)			
Diesel	0.96 (-)	3.29 (-)	Pursuant to (BSH, 2016)
Biodiesel	0.96 (-)	3.29 (-)	Equivalent to the EF for diesel
Heavy fuel oil	0.73 (-)	3.42 (-)	Pursuant to (BSH, 2016)
Overarching			
Lubricants	IE	IE	Included in the EF for the individual fuels

In parentheses: Default values pursuant to 2006 IPCC GL (Volume 2, Chapter 3.3 – *Off-road transportation*, p. 3.36, Tab. 3.3.1.

3.2.12.3 Uncertainties and time-series consistency (1.A.4, mobile)

The uncertainty figures for the specific energy inputs, which are shaped primarily by the mathematical uncertainty in the distribution key developed in TREMOD MM (cf. above: Methodological aspects), are based on experts' assessments. The same holds for the carbon-dioxide emission factors used. While the emission factors for methane are based on results from (IFEU & INFRAS, 2009), the emission factors for nitrous oxide – for the time being – have to be oriented to guideline values pursuant to the IPCC.

3.2.12.4 Category-specific QA/QC and verification (1.A.4, mobile)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Table 80: Overview of relevant data comparisons

Comparison with...	Completed	Remark
Alternative emissions inventories for Germany	no	No comparable data records
Sector-specific Tier 1 default EF pursuant to (IPCC, 2006: Volume 2, Tables 3.3.1 and 3.5.2 (1.A.4.c iii)): CO ₂	yes	cf. Table 81
Sector-specific Tier 1 default EF pursuant to (IPCC, 2006: Volume 2, Tables 3.3.1 and 3.5.3 (1.A.4.c iii)): CH ₄ , N ₂ O	yes	cf. Table 79
Specific IEF of other countries	yes	cf. Table 82

Table 81: Comparison of the EF(CO₂) used in the inventory with default values*

	Inventory values ^a	Default ^b	Lower bound	Upper bound
Diesel fuel	74,027	74,100	72,600	74,800
Gasoline		69,300	67,500	73,000
<i>Two-stroke engines^b</i>	73,109			
<i>Four-stroke engines</i>	73,105			
LP gas	65,440	63,100	61,600	65,600
Heavy fuel oil	80,877	77,400	75,500	78,800
Lubricants	73,300		71,900	75,200
Biodiesel	70,800		59,800	84,300
Bioethanol		70,800	59,800	84,300
<i>Two-stroke engines^b</i>	71,641			
<i>Four-stroke engines</i>	71,607			

^a Inventory values for 2014; ^b including 2 % lubricants (EF = 73.300 kg/TJ) in 1:50 two-stroke fuel mixtures;

^c Pursuant to (IPCC, 2006: Volume 2, Table 2.4)

The following table provides a comparison with specific implied emission factors of other countries as well as with the relevant values resulting for the EU(28). It should be noted that the comparison is hampered by the fact that the factors involved represent an extremely heterogeneous group of categories.

Table 82: International comparison of IEF reported for liquid fossil fuels, in kg/TJ

	CO ₂	CH ₄	N ₂ O
Germany	69,849 ^a	7.56	2.76
Denmark	73,728	9.62	2.05
Netherlands	73,955	5.20	2.48
UK	72,682	7.69	9.72
EU (28)	72,821	5.45	4.89

Germany: Current IEF for report year 2015; all other countries: IEF for 2014, pursuant to 2016 CRF Submission

3.2.12.5 Category-specific recalculations (1.A.4, mobile)

As described above, the activity data for construction-sector transports are part of the primary data given in Energy Balance line 67. The provisional data provided for the year 2014, in the 2016 Submission, have been replaced with the corresponding figures from the final 2014 NEB. The quantities of consumed biofuels that were determined via the official admixture quotas have been recalculated as necessary. The 2014 admixture quota for biodiesel was corrected in the process.

Table 83: Revised energy inputs for sub-sectors, in TJ

	Diesel	Gasoline	Biodiesel	Bioethanol	LP gas
2017 Submission	97,410	4,941	5,937	215	17,945
2016 Submission	96,022	4,862	5,806	211	18,880
Absolute change	1,388	79	132	3	-935
Relative change	1.45%	1.62%	2.27%	1.62%	-4.95%

Source: 2014 Energy Balance (AGEB, 2016), and own calculations – based on (IFEU, 2016b)

In addition, the distribution key, based on TREMOD-MM data, was corrected with regard to the diesel-fuel sub-sectors subsumed under Energy Balance line 67. The distribution key for gasoline has not been changed, however.

Table 84: Revised applicable annual shares of the diesel-fuel quantities given in Energy Balance line 67, in %

	1990	1995	2000	2005	2010	2011	2012	2013	2014
1.A.2.g vii									
2017 Submission	42.28	45.40	44.39	39.98	39.57	41.44	40.05	40.07	40.43
2016 Submission	42.05	44.56	43.54	39.19	38.52	40.23	38.91	38.93	39.23
Absolute change	0.23	0.84	0.85	0.79	1.05	1.22	1.14	1.14	1.20
Relative change	0.54%	1.88%	1.96%	2.02%	2.73%	3.02%	2.93%	2.93%	3.06%
1.A.4.a ii									
2017 Submission	6.95	6.56	6.65	7.16	7.00	6.71	6.90	6.85	6.75
2016 Submission	7.45	8.28	8.45	9.00	9.47	9.44	9.55	9.50	9.52
Absolute change	-0.50	-1.72	-1.80	-1.84	-2.47	-2.74	-2.65	-2.65	-2.77
Relative change	-6.75%	-20.82%	-21.25%	-20.46%	-26.08%	-28.98%	-27.77%	-27.89%	-29.11%
1.A.4.c ii (i)									
2017 Submission	48.39	46.70	46.90	50.19	50.77	49.21	50.52	50.52	50.23
2016 Submission	48.13	45.84	46.00	49.20	49.42	47.77	49.08	49.08	48.74
Absolute change	0.26	0.86	0.90	1.00	1.35	1.44	1.44	1.44	1.49
Relative change	0.54%	1.88%	1.96%	2.02%	2.73%	3.02%	2.93%	2.93%	3.06%
1.A.4.c ii (ii)									
2017 Submission	2.38	1.34	2.05	2.66	2.67	2.64	2.53	2.56	2.58
2016 Submission	2.37	1.32	2.01	2.61	2.59	2.56	2.46	2.49	2.51
Absolute change	0.01	0.02	0.04	0.05	0.07	0.08	0.07	0.07	0.08
Relative change	0.54%	1.88%	1.96%	2.02%	2.73%	3.02%	2.93%	2.93%	3.06%

Source: Own calculations, based on (IFEU, 2016b)

The described effects lead to the following changes in the sectoral activity data used in the last report:

Table 85: Revised energy inputs for sub-sectors, in TJ

	1990	1995	2000	2005	2010	2011	2012	2013	2014
1.A.4.a ii									
2017 Submission	10,561	9,863	10,587	10,889	12,032	11,928	11,997	12,175	12,391
2016 Submission	11,124	11,549	12,294	12,429	14,361	14,574	14,514	14,773	15,091
Absolute change	-563	-1,686	-1,707	-1,540	-2,329	-2,646	-2,518	-2,598	-2,701
Relative change	-5.1%	-14.6%	-13.9%	-12.4%	-16.2%	-18.2%	-17.4%	-17.6%	-17.9%
1.A.4.b ii									
2017 Submission	2,177	2,395	2,395	2,411	3,510	4,236	4,172	3,879	4,118
2016 Submission	2,177	2,395	2,395	2,411	3,510	4,236	4,172	3,879	3,820
Absolute change	0	0	0	0	0	0	0	0	297
Relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.78%
1.A.4.c ii (i)									
2017 Submission	54,142	45,674	44,586	42,018	47,872	47,595	47,941	49,551	51,546
2016 Submission	53,849	44,832	43,729	41,173	46,600	46,199	46,575	48,142	49,272
Absolute change	293	843	858	845	1,271	1,396	1,366	1,409	2,274
Relative change	0.54%	1.88%	1.96%	2.05%	2.73%	3.02%	2.93%	2.93%	4.61%
1.A.4.c ii (ii)									
2017 Submission	5,759	4,315	5,274	5,284	4,137	3,959	2,817	2,916	3,082
2016 Submission	5,745	4,291	5,236	5,239	4,070	3,885	2,749	2,845	2,938
Absolute change	14	24	38	45	67	75	68	71	144
Relative change	0.25%	0.56%	0.72%	0.85%	1.64%	1.93%	2.49%	2.51%	4.91%

Source: own calculations

In addition, TREMOD MM's emission factors for methane and nitrous oxide emissions from consumption of diesel by mobile sources in Commercial and Institutional sector 1.A.4.a ii were adjusted.

Table 86: Revised EF for CH₄ and N₂O from diesel, in 1.A.4.a ii, in TJ

	CH₄	N₂O
2017 Submission	2.02	4.36
2016 Submission	1.39	3.00
Absolute change	0.63	1.36
Relative change	45%	45%

Source: TREMOD MM (IFEU, 2016b)

The numerous corrections lead to the following recalculated emissions quantities:

Table 87: Revised emissions quantities, in kt CO₂ equivalents ^a

	1990	1995	2000	2005	2010	2011	2012	2013	2014
1.A.4.a ii									
2017 Submission	767	709	752	763	824	817	822	838	852
2016 Submission	809	834	878	874	986	1,000	996	1,019	1,041
Absolute change	-42	-125	-126	-112	-162	-184	-175	-181	-189
Relative change	-5.15%	-14.95%	-14.37%	-12.76%	-16.40%	-18.34%	-17.53%	-17.81%	-18.13%
1.A.4.b ii									
2017 Submission	177	189	185	185	260	311	303	281	298
2016 Submission	177	189	185	185	260	311	303	281	276
Absolute change	0	0	0	0	0	0	0	0	22
Relative change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.78%
1.A.4.c ii (i)									
2017 Submission	4,060	3,425	3,343	3,084	3,371	3,350	3,375	3,512	3,644
2016 Submission	4,038	3,361	3,279	3,022	3,282	3,252	3,279	3,412	3,485
Absolute change	22	63	64	61	90	98	96	100	159
Relative change	0.54%	1.88%	1.96%	2.02%	2.73%	3.02%	2.93%	2.93%	4.57%
1.A.4.c ii (ii)									
2017 Submission	458	346	420	415	307	291	201	209	220
2016 Submission	457	344	417	412	302	285	196	203	210
Absolute change	1	2	3	3	5	5	5	5	10
Relative change	0.24%	0.53%	0.67%	0.79%	1.55%	1.85%	2.46%	2.49%	4.89%

^a Not including CO₂ from use of biofuels; source: own calculations

Only the figures for fisheries (1.A.4.c iii) have remained unchanged.

3.2.12.6 Category-specific planned improvements (1.A.4, mobile)

No concrete improvements are currently planned, apart from ongoing routine review and revision of the models used.

3.2.13 Other sectors (1.A.5.a stationary)

Category 1.A.5 comprises the combustion-related emissions of the military sector. It is divided into the categories 1.A.5.a "Stationary" and 1.A.5.b "Mobile".

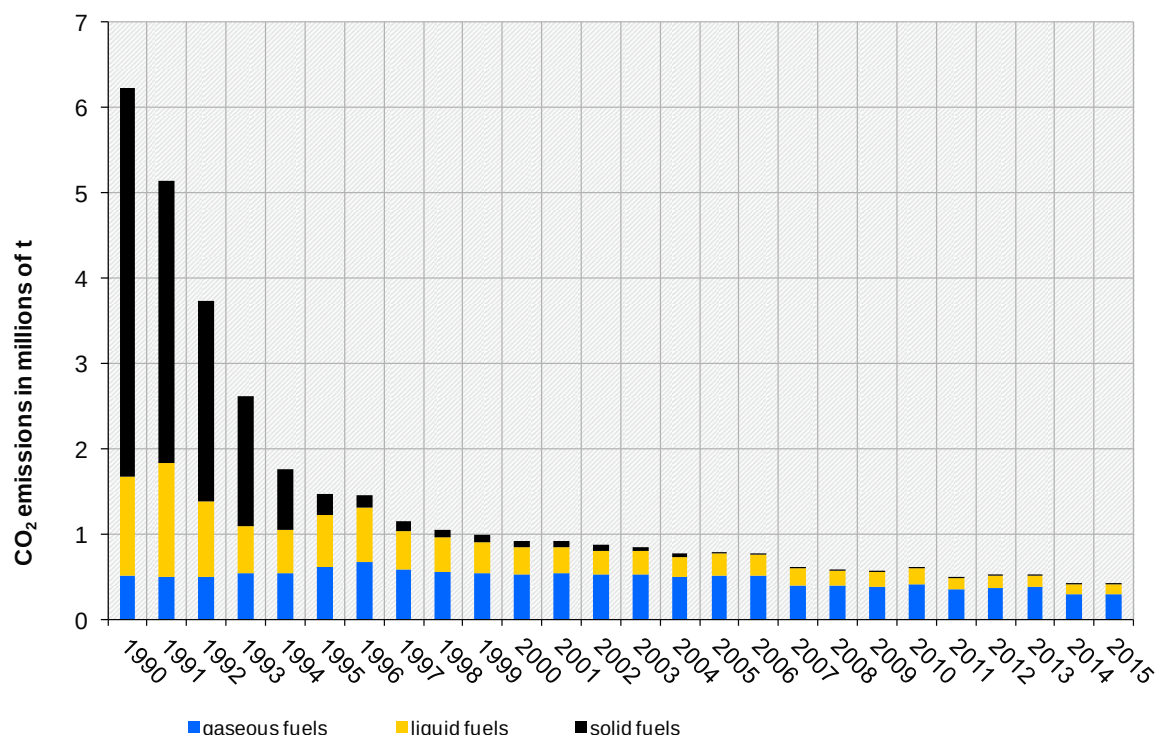
3.2.13.1 Category description (1.A.5.a Stationary)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	1.A.5. Other: Include Military fuel use under this category	All fuels	CO ₂	11,797.5	0.96%	975.8	0.11%	-91.7%
-/-	1.A.5. Other: Include Military fuel use under this category	All fuels	CH ₄	279.4	0.02%	1.5	0.00%	-99.4%
-/-	1.A.5. Other: Include Military fuel use under this category	All fuels	N ₂ O	61.3	0.01%	4.2	0.00%	-93.1%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS, Tier 1	NS	CS/D
CH ₄	CS, Tier 1, Tier 3	NS/M	CS/D/M
N ₂ O	CS, Tier 1, Tier 3	NS/M	CS/D/M

The stationary and mobile sources categories in 1.A.5 are placed in the relevant main categories together. The category *Other* is a key category for CO₂ emissions in terms of both emissions level and trend.

The following figure shows the emissions trend since 1990.

Figure 39: Development of CO₂ emissions in category 1.A.5.a

The especially large emissions reduction is the result of closure of many military agency locations, as well as of considerable shifting from use of solid fuels to use of gaseous and liquid fuels.

3.2.13.2 Methodological issues (1.A.5.a, stationary)

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 that consumption only in line 67, under "commercial, institutional and other consumers" – additional sources of energy statistics had to be found for this source category.

For reporting, use is made of data of the Bundesamt für Infrastruktur, Umweltschutz und Dienstleistungen der Bundeswehr (BAIUDBw (Federal office for infrastructure, environmental protection and services of the German Armed Forces"), 2015), which reports the "Energy input for heat production in the German Federal Armed Forces", by fuels and (in the present case) for 2000-2015, to the Federal Environment Agency. Those figures are deducted from the figures in Energy Balance line 67 (commercial, institutional) and are reported in 1.A.5, rather than in 1.A.4. As of report year 2008, use of wood in category 1.A.5.a is also reported.

Emission factors

A detailed description of the relevant procedures, and a list of the CO₂ emission factors used, is presented in the Annex, Chapter 18.7.

The database for the emission factors used for all other pollutants consists of the results of a research project carried out by the University of Stuttgart, under commission to the Federal Environment Agency (STRUSCHKA, 2008). Within that project, device-related and 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 the procedure described for category 1.A.4. Table 88 shows the sectoral emission factors used.

Table 88: Sectoral emission factors for the military sector

	CH ₄	N ₂ O
	[kg/TJ]	
Stationary combustion in military agency locations		
Hard coal	2.0	4.8
Lignite briquettes	242	0.37
Heating oil EL	0.017	0.56
Natural gas	0.042	0.29

3.2.13.3 Uncertainties and time-series consistency (1.A.5.a, stationary)

Information regarding the uncertainties for the emission factors is provided in the description for category 1.A.4. Annex 2 Chapter 13.6 in the NIR 2007 describes how the uncertainties for the activity data were determined.

3.2.13.4 Category-specific QA/QC and verification (1.A.5.a, stationary)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Since no other sources of data for Germany are known, it is currently not possible to verify the emissions reported here via comparison.

3.2.13.5 Category-specific recalculations (1.A.5.a, stationary)

Table 89: Recalculations in CRF 1.A.5.a

Units [kt]	NIR 2016	NIR 2017	Difference, absolute				Difference, relative
	Total	Total	gas	liquid	solid	Total	
2013	555	519	-36	0	0	-36	-6.52%
2014	446	413	-33	0	0	-33	-7.50%

Recalculations were carried out for the years 2013 and 2014, to take account of data updates of the Federal office for infrastructure, environmental protection and services of the German Armed Forces.

3.2.13.6 Planned improvements, category-specific (1.A.5.a, stationary)

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.14 Other (1.A.5.b Mobile)

3.2.14.1 Category description (1.A.5.b, Mobile)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1 ^a , CS	NS/M ^b	D ^a , CS
CH ₄	CS, Tier 1, Tier 3	NS/M ^b	CS (M)
N ₂ O	CS, Tier 1, Tier 3	NS/M ^b	CS (M)
NO _x , CO, NMVOC, SO ₂	CS, Tier 1, Tier 3	NS/M ^b	CS (M)

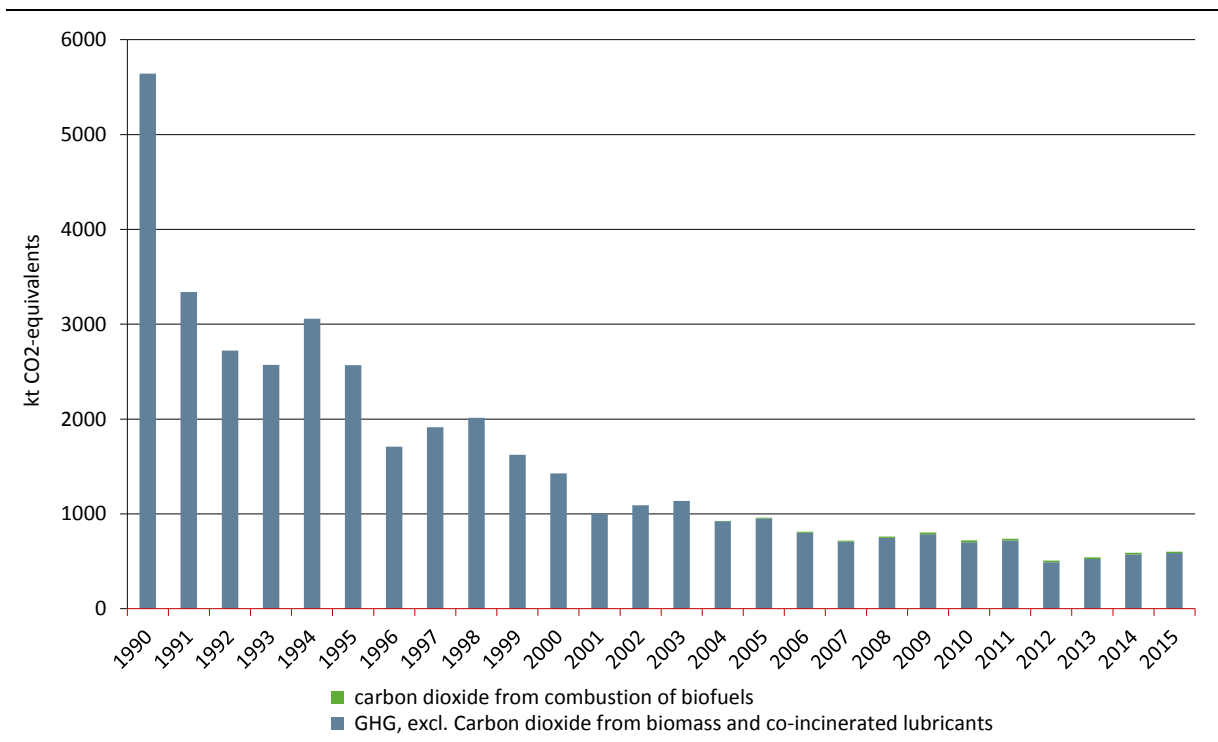
^a Biodiesel and avgas: Default EF pursuant to 2006 IPCC Guidelines (Volume 2, Chapter 2, Table 2.4)

^b Military maritime transport: pursuant to (BSH, 2015)

Key category analysis for 1.A.5 – *Other* focuses primarily on stationary and mobile sources (for an overview, cf. Chapter 3.2.13.1). The analysis shows that category 1.A.5 is a key category for CO₂ emissions in terms of both emissions level and trend.

The following figure shows the development of greenhouse-gas emissions since 1990, which development parallels that for fuel inputs in this source category.

Figure 40: Development of GHG emissions emissions of mobile sources in the military sector since 1990



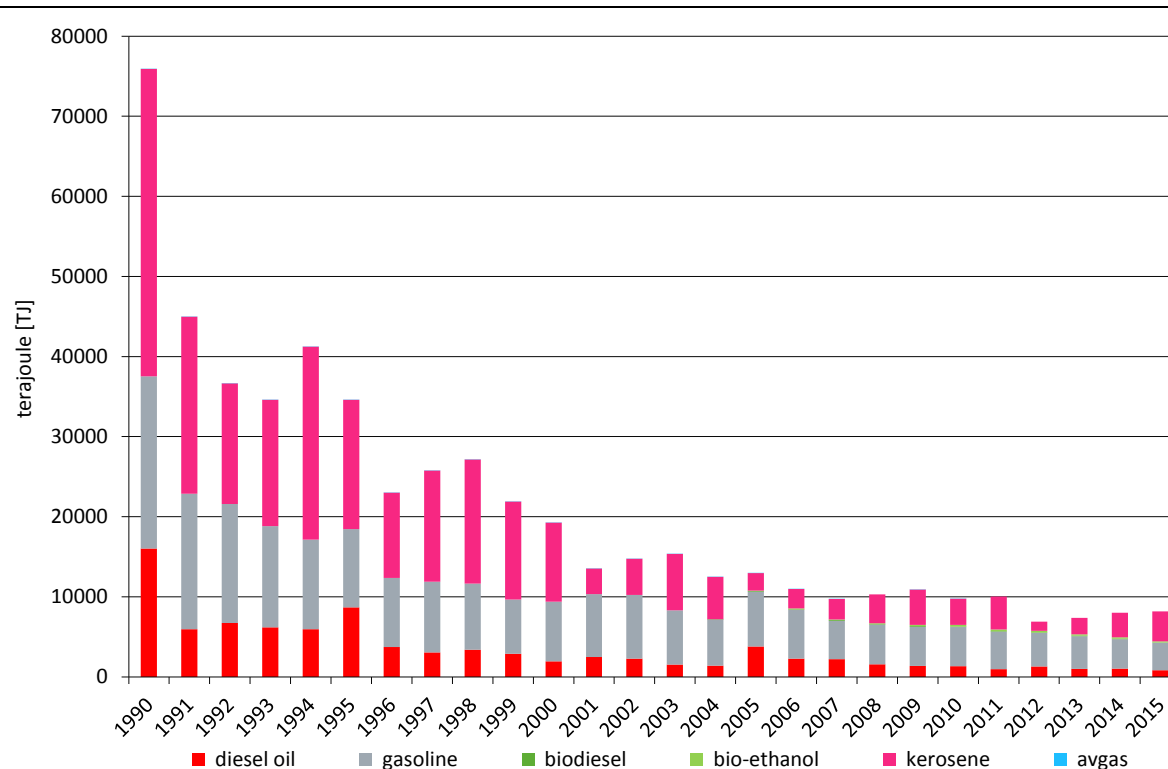
3.2.14.2 Methodological issues (1.A.5.b, mobile)

Activity data

The **activity data** used are based on the Energy Balance of the Federal Republic of Germany (AGEB), which provides directly usable fuel-input data for military air and ground transports (diesel fuel and gasoline – including any biogenic admixtures – and kerosene and avgas) only for the period until 1993. As of 1994, the source (BAFA, 2016) is used. The consumption figures in that source, which are given in units of 1000 t, are converted into terajoules on the basis of the pertinent listed net calorific values (AGEB, 2016b). On the other hand, the fuel inputs in the naval sector are only a sub-quantity of the quantities listed in *Energy Balance line 6 – International marine bunkers*. They are thus calculated separately, as described in Chapter 3.2.10.4.

In addition, the quantities of co-combusted lubricants are derived via co-combustion rates, pursuant to (VSI, 2014), from the total quantities of the fuels used in sub-categories 1.A.5.b i through iii (cf. also Chapter 19.1.4).

Figure 41: Development of fuel inputs since 1990



Emission factors

With regard to the **emission factors** used for carbon dioxide, we refer, in general, to Chapter 18.7. Both country-specific and default values (biodiesel, avgas) are used. Further information regarding co-combustion of lubricants in particular is provided in Chapter 19.1.4.

For methane and nitrous oxide, country-specific values are also used for ground transports and for use of avgas. For jet kerosene, IPCC default figures are used, in light of the fact that the aircraft used by the sector differ strongly from those used in civil aviation. The emission factors used for the naval sector are taken from (BSH, 2015). With regard to releases of methane and nitrous oxide from co-combustion of lubricants, it is assumed that such emissions are already taken into account in the pertinent emission factors for the fuels used and thus are to be reported as IE (*included elsewhere*).

Table 90: Emission factors used for report year 2015, in kg/TJ

	CH ₄	N ₂ O	Origin
1.A.5.b i – ground vehicles			
Diesel	2.97 (-)	0.81 (-)	IEF from 1.A.3.b: heavy duty vehicles
Biodiesel	2.97 (-)	0.81 (-)	Equivalent to the EF for diesel
Gasoline	7.04 (-)	0.72 (-)	IEF from 1.A.3.b
Bioethanol	7.04 (-)	0.72 (-)	Equivalent to the EF for gasoline
1.A.5.b ii – airborne ^a			
Kerosene	0.50 (0.50)	2.00 (2.00)	Tier 1 default pursuant to (IPCC, 2006)
Avgas	8.21 (-)	2.33 (-)	cf. 1.A.3.a
1.A.5.b iii – waterborne ^b			
Diesel	0.94 (7.00)	3.29 (2.00)	Pursuant to (BSH, 2015)
Biodiesel	0.94 (-)	3.29 (-)	Equivalent to the EF for diesel
Overarching			
Lubricants	IE	IE	Included in the EF for fuels

In parentheses: Default values pursuant to 2006 IPCC Guidelines, Volume 2, Chapter 3: ^a Tab. 3.6.5; ^b Tab. 3.5.3

3.2.14.3 Uncertainties and time-series consistency (1.A.5.b, mobile)

Within sub-sectors 1.A.5.b i and ii, default uncertainties pursuant to IPCC are used. In a departure from that procedure, specific uncertainties for activity data and emission factors for military maritime transports were derived in (BSH, 2015).

3.2.14.4 Category-specific QA/QC and verification (1.A.5.b, mobile)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Table 91: Overview of relevant data comparisons

Comparison with...	Completed	Remark
Alternative emissions inventories for Germany	no	No comparable data records
Sector-specific Tier 1 default EF pursuant to 2006 IPCC GL (Volume 2, Chapter 2 – <i>Stationary Combustion</i> , Tab. 2.4): CO ₂	(yes)	for 1.A.5.b ii & iii: cf. Table 92
Tier 1 default EF pursuant to 2006 IPCC GL (Volume 2, Chapter 2 – <i>Stationary Combustion</i> , Tab. 2.4): CO ₂	yes	for 1.A.5.b i: cf. Table 92
Sector-specific Tier 1 default EF pursuant to 2006 IPCC GL: CH ₄ , N ₂ O	(yes)	for 1.A.5.b ii & iii: cf. Table 88
Tier 1 default EF pursuant to 2006 IPCC GL (Volume 2, Chapter 2 – <i>Stationary Combustion</i> , Tab. 2.4): CH ₄ , N ₂ O	yes	1.A.5.b i: cf. Table 88
Specific IEF of other countries	yes	cf. Table 82

Table 92: Comparison of the EF(CO₂) used with default values, in kg/TJ

	Inventory values ^a	Default ^b	Lower bound	Upper bound
Diesel fuel	74,027	74,100 ^c	72,600	74,800
Gasoline	73,091	69,300 ^c	67,500	73,000
Kerosene	73,256	71,500 ^d	69,800	74,400
Avgas	70,000 ^d		67,500	73,000
Biodiesel	70,800 ^e		59,800	84,300
Bioethanol	71,607	70,800 ^e	59,800	84,300

^a for report year 2015; ^b pursuant to 2006 IPCC Guidelines, Volume 2, Chapter 3; ^c Tab. 3.5.2; ^d Tab. 3.6.4; ^e Chap. 2, Tab. 2.2

The following table provides a comparison with specific implied emission factors of other countries.

Table 93: International comparison of IEF reported for liquid fossil fuels, in kg/TJ

	CO ₂	CH ₄	N ₂ O
Germany	73,269	3.66	1.42
Denmark	73,753	6.60	2.63
France			
Netherlands	74,227	5.84	3.58
UK	73,753	6.60	2.63
EU (28)			

Germany: current IEF(1.A.5.b) for 2015; otherwise: IEF for 2014, pursuant to 2016 CRF Submission

3.2.14.5 Category-specific recalculations (1.A.5.b Mobile)

With respect to the 2016 Submission, only slight recalculations were carried out for the year 2014, as the result of corrections in the official admixture quotas for biodiesel. Because the total quantity of diesel fuels supplied to the military in 2014 remained unchanged, the biodiesel corrections led to corresponding corrections in the applicable quantity of fossil-based diesel fuel.

Table 94: Revised energy inputs for 2014, in TJ

	1.A.5.b i	1.A.5.b ii	1.A.5.b iii	1.A.5.b
2017 Submission	4,590.56	3,060	349	7,998.84
2016 Submission	4,590.55	3,060	349	7,998.83
Absolute change	0.01	0	0	0.01
Relative change	0.0002%	0.00%	0.00%	0.0001%

Source: Own calculations, based on (IFEU, 2016b)

Slight revisions of the emissions quantities result, but only for the year 2014.

Table 95: Revised emissions quantities for 2014, in kt CO₂ equivalents ^a

	1.A.5.b i	1.A.5.b ii	1.A.5.b iii	1.A.5.b
2017 Submission	323.10	226.01	24.79	573.89
2016 Submission	323.12	226.01	24.79	573.91
Absolute change	-0.02	0	0	-0.02
Relative change	-0.006%	0.000%	0.000%	-0.004%

^a Not including CO₂ from use of biofuels; source: own calculations

3.2.14.6 Category-specific planned improvements (1.A.5.b Mobile)

No further category-specific improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.2.15 Military

Emissions from international deployments by the Federal Armed Forces, under a UN mandate, are not recorded as a separate activity for purposes of German emission inventories. Such recording will be again be a matter for discussion in the framework of the National Emissions Reporting System. For various reasons, the relevant required activity data are not provided.

This practice does not lead to any omissions in the inventories, since the fuel inputs associated with such deployments are included in national military consumption figures.

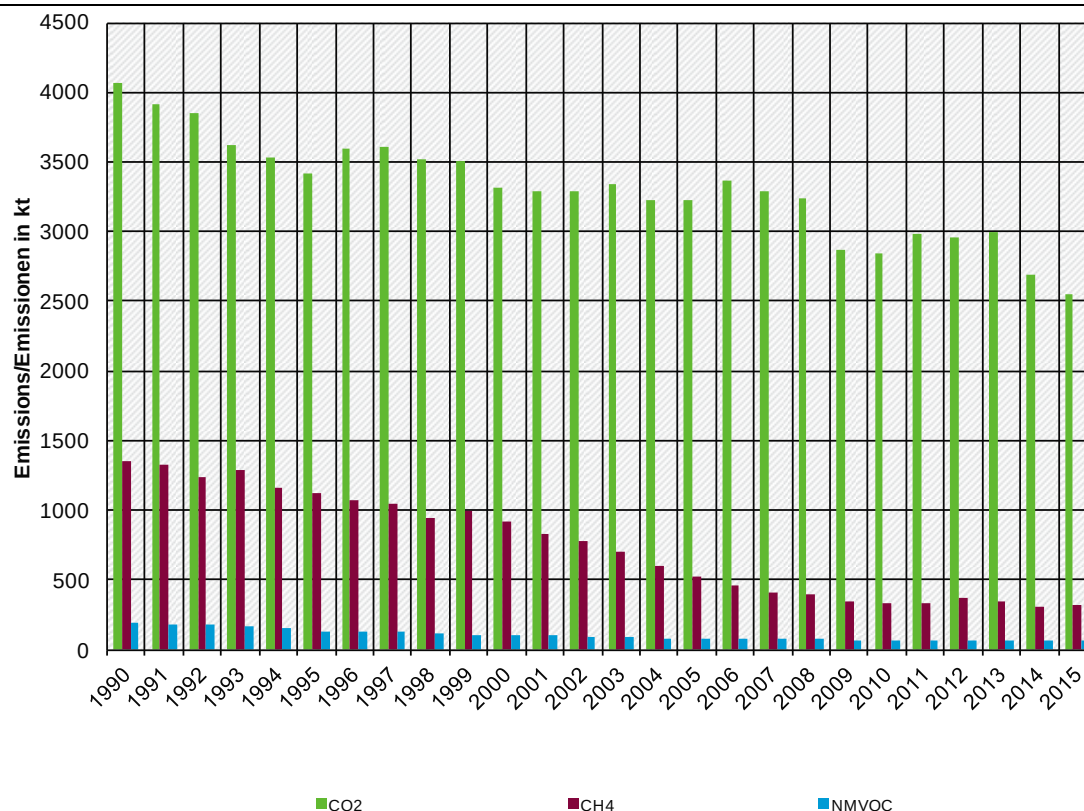
The basis for activity data for military fuels consists of the Official Mineral Oil Statistics for the Federal Republic of Germany (BAFA, 2015).

In the CSE, category 1.A.5 includes, under stationary sources, heat production of military agencies; under mobile sources, it includes military transports (land, water and air).

3.3 Fugitive emissions from fuels (1.B)

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 methane emissions are the most important emissions within the source category areas of fugitive emissions from solid fuels and fugitive emissions from natural gas, fugitive emissions of oil and natural gas also include substantial amounts of NMVOC. In category 1.B, carbon dioxide plays only a minor role in connection with processing of solid fuels, processing of hydrogen sulfide and flaring. Source category 1.B. is not a source for fluorinated gases.

Figure 42: CRF 1.B – Emissions of relevant substances



3.3.1 Solid fuels – coal mining and handling (1.B.1)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	1.B.1 Fugitive Emissions from Fuels	Solid fuels	CH ₄	25,553.4	2.09%	3,095.9	0.35%	-87.9%
-/-	1.B.1 Fugitive Emissions from Fuels	Solid fuels	CO ₂	1,832.8	0.15%	704.8	0.08%	-61.5%

The category *Coal mining and handling* is a key category for CH₄ emissions in terms of emissions level and trend.

In mining, a distinction is made between surface mining, in which deposits are extracted from pits open to the surface, and underground mining, in which deposits are extracted from sites underground. All hard coal mining in Germany is underground mining, while (since 2003) all lignite mining is open-pit mining.

This category is subdivided as follows:

Category		Included emissions
1.B.1.a. Coal mining		
i.	Underground mining	
	Mining activities	Total emissions from active hard-coal mines, consisting of emissions from a) mine ventilation and b) mine-gas extraction, less the quantity of mine gas recovered and utilized
	Follow-up mining activities	Emissions from processing, storage and transport of hard coal
	Decommissioned coal mines	Emissions from decommissioned hard-coal mines and emissions from flaring
ii.	Open-pit mining	
	Mining activities	Emissions from active open-pit lignite mining. Here, the entire potential methane content of German lignite is used as the basis – this methane is assumed to be emitted, in its entirety, during mining. Any later emissions of methane, during further processing, are thus already taken into account. No pit-gas collection or use takes place in open-pit mining.
	Follow-up mining activities	No separate listing – the emissions are already included in "mining activities"
1.B.1.b. Solid fuel transformation – coal processing and charcoal production		Emissions from coal processing and charcoal production. This area takes account of specific emissions that occur in hard-coal processing. Methane emissions from lignite processing are already included in 1.B.1.a.ii "Mining activities". The assumed activity data cover the total for all processed products from hard coal and lignite.
1.B.1.c. Other		No emissions are currently being reported in this category.

Emissions and trend (1.B.1)

Table 96: Calculation of methane emissions from coal mining for 2015

		Activity data [Mt]	CH ₄ emissions [kt]
1.B.1.a. Coal mining		(= 1.B.1.a.i + 1.B.1.a.ii) = 6.2 + 178.1 =184.3	(= 1.B.1.a.i + 1.B.1.a.ii) 119.0 + +2.0 = 121.0
i.	Underground mining		= mining and post-mining activities = 114.7 + 3.6 + 0.7 = 119.0
	Mining activities Hard-coal extraction ¹⁾	6.2	= AD * EF = 6.2*18.5 = 114.7
	Follow-up mining activities		= 3.6
	Decommissioned coal mines		Potential emissions, minus gas usage = 0.7
	Open-pit mining		= mining activities = 2.0
ii.	Mining activities Lignite extraction ¹⁾	178.1	= AD * EF = 178.1 * 0.011 = 2.0
	Follow-up mining activities		(included in 1.B.1.a.ii "mining activities") IE

		Activity data ² [Mt]	CH ₄ emissions [kt]
1.B.1.b. Solid fuel transformation			=0.4
	Coal processing		$AD_{\text{hard-coal prod.}} \cdot EF_{\text{hard-coal prod.}} + AD_{\text{lignite prod.}} \cdot EF_{\text{lignite prod.}}$ $= 8.8 \cdot 0.049 + 6.7 \cdot 0$
	Total for processed products ^{2) 1)}	15.5	= 0.4

1) pursuant to STATISTIK DER KOHLENWIRTSCHAFT (n.y.)

2) Hard-coal coke, hard-coal briquettes, lignite coke, coal dust, dry coal, fluidised-bed coal, lignite briquettes, lignite granulate

3.3.1.1 Underground mining – hard coal

3.3.1.1.1 Category description (underground mining – hard coal)

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	Tier 3	AS	CS
CO ₂	M	AS	CS

Activity data

Table 97: Usable output of hard coal, in millions of t.

1990	1995	2000	2005	2010	2014	2015
70.2	53.6	33.6	24.9	12.9	7.6	6.2

(STATISTIK DER KOHLENWIRTSCHAFT coal-sector-statistics association, n.y.).

Table 98: Number of active hard-coal mines

1990	1995	2000	2005	2010	2014	2015
27	19	12	9	5	3	3

(STATISTIK DER KOHLENWIRTSCHAFT coal-sector-statistics association, n.y.).

Emission factors

An implied emission factor (IEF) can be derived from the figures for total methane emissions and from the relevant activity data for hard-coal mining. This calculation takes pit-gas usage into account. The measurements show only actually emitted methane amounts.

Based on this approach, the released emission amount is fluctuating annually in dependency from the gas content of the hard coal, the amount of ventilated air and the share of methane used for mine-gas usage.

For calculation of CH₄ emissions from hard-coal storage, the activity data for hard-coal production is used as a basis and then multiplied by the emission factor of 0.576 kg/t. That emission factor has been taken from a study of the Fraunhofer Institute for Systems and Innovation Research (FhG-ISI) (1993).

Table 99: Methane emission factors for the area of hard-coal extraction and storage, for the year 2015

Emission factors	m ³ CH ₄ /t	kg/t
CH ₄ from extraction	41.62	27.88
CH ₄ from extraction, minus pit gas used	27.64	18.52
CH ₄ from storage	0.87	0.58
CH ₄ from mining (extraction and storage, less mine gas utilised)	28.51	19.10

No emission factor can be provided for decommissioned coal mines, since there are no pertinent activity data.

Emissions and trend

Table 100: Emissions in category 1.B.1.a.i – underground mining

Gas	Total emissions				Trend With respect to the previous year	Remark
	1990	2014	2015	Since 1990		
Methane	975 kt	103 kt	116 kt	- 89 %	12 %	The emissions have been decreasing as a result of decreases in utilisable extracted quantities and of increases in pit-gas utilisation since 2001.

3.3.1.1.2 Methods (Underground mining – hard coal)

Emissions from underground hard-coal mining are calculated pursuant to the Tier 3 method, in a procedure that meets requirements pertaining to mine-specific emissions determination. For safety reasons, gas compositions and air flows are measured continuously in all pit systems. The resulting data is used to determine levels of methane emissions. The Gesamtverband Steinkohle (GVSt) association of the German hard-coal-mining industry determines the total methane quantity by aggregating the relevant individual measurements. Expert review is carried out by the competent state supervisory authority (the mining authority – Bergamt).

3.3.1.1.3 Uncertainties and time-series consistency (underground mining – hard coal)

The uncertainties in the activity data result primarily from inaccuracies in weighing of extracted coal. Via surveys of experts carried out during the NaSE workshop of 11/2004, the relevant error has been quantified as <3 %.

Uncertainties in calculation of methane releases result from inaccuracies in measurements. As a result of the facts that underground measurements of methane concentrations are carried out primarily for safety reasons, and that their most precise measurement range does not fall within the range of common gas-release concentrations, the available measuring equipment can be expected to have a technical measurement inaccuracy of about 10 % [expert discussion on mine gas, Berlin, December 2009].

Methane releases from hard coal, during storage and transport, fluctuate considerably in keeping with storage duration and grain-size distribution. An uncertainty of 15 % is assumed [LANGE 1988 / BATZ 1995, along with information communicated personally at the NaSE workshop 11/2004].

The methane potential has been estimated on the basis of experts' knowledge. In this area, an uncertainty of 60 % has been assumed.

For the activity data, a consistent source is used throughout the entire time series.

3.3.1.1.4 Category-specific quality assurance/control and verification (underground mining – hard coal)

General and category specific quality control and quality assurance, according to the QSE-Handbook, have been carried out by the Single National Entity. Quality control for activity data has been performed by the data provider.

For underground hard-coal mining, the 2006 IPCC Guidelines recommend emission factors on the order of 10 to 25 m³/t. Conversion of the German emission factors, using a conversion factor of 0.67 Gg/10⁶ m³ (2006 IPCC Guidelines, Chapter 4: at 20° C, 1 atmosphere) yields the individual values listed in Table 99. When production, storage and deductible mine-gas use are combined in one emission factor, the resulting value per tonne of coal (marketable production) lies within the recommended range.

The emissions from decommissioned hard-coal mines, as determined by the Gesamtverband Steinkohle (GVSt) association of the German hard-coal-mining industry, have been verified via the research project "Potential for release and utilisation of mine gas" ("Potential zur Freisetzung und Verwertung von Grubengas") [DMT, 2014]. The relevant calculations were carried out for all regions with deposits in Germany.

The relevant figures for 2012, as reported in the 2014 Submission, have been compared with the corresponding figures of neighbouring countries.

Table 101: IEF for underground hard-coal mining: Germany as compared with neighbouring countries (NIR 2014)

	Hard coal extracted	Reported emissions	IEF
Germany	10.8 million t	151.1 kt	14.0 kg/t
Czech Republic	11.4 million t	100.1 kt	8.8 kg/t
UK	6.2 million t	65.4 kt	10.5 kg/t
Poland	71.3 million t	324.7 kt	4.6 kg/t
IPCC GL 2006			6.7 – 15.5 kg/t

3.3.1.2 Open-pit mining – lignite

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	Tier 2	AS	CS

3.3.1.2.1 Category description (open-pit mining – lignite)

Activity data

Table 102: Usable output of lignite, in millions of t.

1990	1995	2000	2005	2010	2014	2015
356.5	192.7	167.7	177.9	169.4	178.2	178.1

(STATISTIK DER KOHLENWIRTSCHAFT coal-sector-statistics association, n.y.).

Emission factors

In keeping with figures of the DEBRIV German lignite-industry association (Deutscher Braunkohlen-Industrie-Verein e.V; DEBRIV 2004), an average emission factor of 0.015 m³ CH₄/t (corresponds to 0.011 kg CH₄/t) is assumed for German lignite. This emission factor is based on a 1989 study of RWE Rheinbraun AG [DEBRIV, 2004] and has been substantiated by publications of the Öko-Institut e.V. Institute for Applied Ecology and of the DGMK [German Society for Petroleum and Coal Science and Technology; research report / Forschungsbericht 448-2, 1992].

No lignite storage takes place; usage is "mine-mouth", i.e. extracted coal is moved directly to processing and to power stations.

Table 103: Emissions in category 1.B.1.a.ii – open-pit mining

Emission factors	m ³ CH ₄ /t	kg/t
CH ₄ from extraction	0.016	0.011

Emissions and trend

Table 104: Emissions in category 1.B.1.a.ii – open-pit mining

Gas	Total emissions			Since 1990	Trend With respect to the previous year	Remark
	1990	2014	2015			
Methane	3.9 kt	2.0 kt	2.0 kt	-49 %	0 %	The emissions have been decreasing as a result of reductions in lignite production.

3.3.1.2.2 Methods (open-pit mining – lignite)

The emissions from open-pit lignite mining are calculated with the Tier 2 method.

3.3.1.2.3 Uncertainties and time-series consistency (open-pit mining – lignite)

The emission factor used for calculating methane emissions from lignite production is based on maximum methane content levels and thus represents the upper limit of possible methane emissions. It thus already includes possible emissions from transport and storage. Numerous studies have shown that a negative uncertainty of - 33 % must be assumed [DEBRIV / DGMK research report / Forschungsbericht 448-2, DGMK 1992].

For the emission factor and the activity data, a consistent source is used throughout the entire time series.

3.3.1.2.4 Category-specific quality assurance/control and verification (open-pit mining – lignite)

General and category specific quality control and quality assurance, according to the QSE-Handbook, have been carried out by the Single National Entity. Quality control for activity data has been performed by the data provider.

In the framework of verification for the current report, various data sources for activity data in coal mining, and the relevant EF used, were compared with the corresponding sources and EF of other countries (cf. Table 105). A by-country comparison of specific emission factors for open-pit mining shows a broad range, with Germany in the lower part of the range, in a position comparable to that of Poland. The 2011 NIR (p.103) noted that the Czech Republic uses the average IPCC default factor, in keeping with the fact that the coal mined in that country, in comparison to the coal mined in Poland and Germany, consists to a larger extent of sub-bituminous coal. The degree of coalification (rank) – and, thus, the methane content – of such coal is higher than that of the lignite found in Poland and Germany [sources: NaSE workshop 11/2004; personal communication of DEBRIV from 2005]. An assessment by VERICO [VERICO SCE 2014] reached the same conclusion.

Table 105: IEF for open-pit lignite mining: Germany as compared with neighbouring countries (NIR 2014)

	Extracted lignite	Reported emissions	IEF
Germany	185.4 million t	2.0 kt	0.011 kg/t
Poland	64.3 million t	0.8 kt	0.012 kg/t
Czech Republic	43.5 million t	33.5 kt	0.770 kg/t
IPCC GL 2006			0.2 – 1.3 kg/t

The IPCC emission factors have been derived from figures for American bituminous coal and thus, according to national experts, cannot be applied to German lignite, which did not exceed a temperature of 50°C during the coalification process. Significant methane releases occur only at temperatures above 80°C [DGMK Bericht 448-2, 1992].

3.3.1.3 Decommissioned hard-coal mines

Emissions from decommissioned hard-coal mines play a significant role in this sub- source category. As well as active mines, decommissioned hard coal mines represent another relevant source of fugitive CH₄ emissions.

When a hard-coal mine is decommissioned, methane 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 methane 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 (use 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.

3.3.1.4 Solid fuel transformation

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	Tier 2	AS	CS
CO ₂	Tier 2	AS	CS
NM VOC	Tier 2	AS	CS
CO	Tier 2	AS	CS
SO ₂	Tier 2	AS	CS

The 2006 IPCC Guidelines do not specify this category, and thus no pertinent decision tree is available.

3.3.1.4.1 Category description (solid fuel transformation)

Activity data

Table 106: activity data for processed products [figures in tonnes]

	1990	1995	2000	2005	2010	2014	2015
Lignite briquettes	40,045,000	5,010,829	1,819,263	1,489,922	2,024,103	1st 700,000	1,709,000
Lignite granulate	59,000	0	0	0	0	0	0
Lignite coke	3,355,937	191,883	179,453	173,443	175,932	175,000	170,000
Lignite dust	3,791,431	2,700,110	2,678,926	2,923,620	3,632,333	4,417,000	4,398,000
Dried lignite	694,693	569,973	0	0	0	0	0
Fluidized-bed lignite	265,000	470,692	560,822	659,906	414,855	407,000	450,000
Hard-coal briquettes	756,000	379,000	146,000	91,625	0	0	0
Hard-coal coke	17,580,000	11,102,000	9,115,000	8,397,000	8,171,000	8,770,000	8,800,000

(STATISTIK DER KOHLENWIRTSCHAFT coal-sector-statistics association, n.y.).

Emission factors

The methane emission factor used for calculation of CH₄ emissions from hard-coal-coke production (coking plants) is 0.049 kg methane per tonne of hard-coal coke [DMT 2005]. It is used for the entire time series. The CO₂-emission factor is determined on the basis of the conservative assumption that about 1% of the coke is lost, in the form of fugitive emissions, between the time the blast-furnace door is opened and the coke is quenched. The activity data used consists of the total relevant quantities of hard-coal and lignite coke.

The emission factors for the non-greenhouse gases 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") (BFI 2011).

Table 107: Emission factors for the production of hard-coal coke

Gas	Emission factor	Units
CH ₄	0.049	kg/t
CO ₂	2,777 ³⁸	kg/t
CO	0.015	kg/t
NH ₃	243.3	mg/t
NMVOC	0.310	kg/t
SO ₂	0.076	kg/t

No methane emissions are to be expected from processing of lignite products, since the EF used for 1.B.1.a.ii corresponds to the gas content of the lignite occurring in Germany. The other identified emissions are based on measurements made by the sole (at present) German producer of lignite coke at the Fortuna-Nord hearth-furnace plant.

Small quantities of charcoal are produced in Germany – by one major charcoal-factory operator and in a number of demonstration charcoal kilns. The pertinent quantities are determined by the Federal Statistical Office and are subject to confidentiality requirements. The emission factors were obtained from US_EPA 1995. Use of charcoal is reported under 2.G.4.

³⁸ The emission factor covers the area of production of hard-coal and lignite coke

Emissions and trend

Table 108: Emissions in category 1.B.1.b – solid fuel transformation

Gas	Total emissions			Trend Since 1990	With respect to the previous year	Remark
	1990	2014	2015			
Methane	2.4 kt	2.4 kt	2.4 kt	3 %	1 %	The methane emissions are affected primarily by charcoal production. The emissions from coking plants have fallen since 1990, as a result of reductions in coke production.
Carbon dioxide	1,819 kt	766 kt	704 kt	-58 %	-8 %	The emissions have fallen since 1990, as a result of reductions on coke production.

CO₂ emissions from charcoal production are considered "biogenic" and are reported within the memo-items section.

3.3.1.4.2 Methodological aspects (solid fuel transformation)

Emissions from hard-coal-coke production have been calculated via the Tier 2 method, in a manner similar to that of the IPCC Reference Manual's equation for CH₄ emissions from coal mining:

Emissions [kt CH₄] =

EF [m³ CH₄ /t] * AR_{transformation product} * conversion factor [kt/10⁶m³]

3.3.1.4.3 Uncertainties and time-series consistency (solid fuel transformation)

The uncertainties for the emission factors for processing of coal have been estimated by experts as 10% to 25%.

For the activity data, a consistent source is used throughout the entire time series.

3.3.1.4.4 Category-specific quality assurance / control and verification (solid fuel transformation)

General and category specific quality control and quality assurance, according to the QSE-Handbook, have been carried out by the Single National Entity. Quality control for activity data has been performed by the data provider.

In consideration of emission factors, the IPCC conversion factor of 0.67 Gg/10⁶m³ at 20°C and 1 atmosphere should be applied to the units used in Germany: normal cubic metres at 1.01325 bar and 0°C [DIN 2004, DIN No. 1343]. The German practice of using normal cubic metres should also be noted in consideration of the IPCC default EF, and of figures from other published sources. In use of EF data published in Germany, it is assumed that the relevant figures use normal cubic metres [substantiated via survey of experts at the NaSE workshop 11/2004].

The guideline figures are oriented to 20°C and 1,013 mbar. In keeping with methane's isobaric proportionality, the factor 1.07 can be used to convert Nm³ into m³.

Conversion factor, normal cubic metres ⇔ kilogrammes:

0.717 Nm³/kg (1.01325 bar, 0°C) = 0.67 Gg/10⁶m³ (20°C, 1 atmosphere) * 1.07 Nm³/m³

No comparisons with the corresponding data of other countries are possible in this category, since the pertinent CRF tables do not yield the required precise quantities and compositions of the transformed coal products involved. What is more, the IPCC Guidelines provide neither methods nor default emission factors for such a comparison in this category.

3.3.1.5 Category-specific recalculations (1.B.1 all)

For the year 2014, the provisional figures for coke production from lignite were replaced with the relevant final data. This has led to a slight increase in carbon dioxide emissions (cf. in this regard Table 175). Otherwise, no recalculations were required.

3.3.1.6 Planned improvements, category-specific (1.B.1 all)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

3.3.2 Oil and natural gas and fugitive emissions from energy production (1.B.2)

This category is subdivided as follows:

Source category		Included emissions
1.B.2.		
Oil, natural gas and fugitive emissions from energy production		
a	Oil	
	i) Exploration	Total emissions from exploratory drilling for oil and gas
	ii) Production	Fugitive emissions from oil production and from oil processing (separation of water and accompanying gases)
	iii) Transport	Emissions from transport of crude oil via pipelines and inland-waterway tankers
	iv) Refining / storage	Emissions from oil desulphurisation and refining, from storage of crude oil and petroleum products and from cleaning of storage tanks
	v) Distribution of oil products	Emissions from distribution of petroleum products, from refueling processes and drip losses and from cleaning of tanks of transport vehicles
	vi) Other	No emissions in this category
b	Gas	
	i) Exploration	The emissions are assigned to category 1.B.2.a.i, since no differentiation is possible
	ii) Production	Fugitive emissions from natural gas production
	iii) Processing	Emissions from desulphurisation and processing of sour gas and from processing of town gas
	iv) Transport	Emissions from long-distance high-pressure pipelines and from underground gas storage (caverns and porous-rock reservoirs)
	v) Distribution	Emissions from natural-gas distribution lines, and from above-ground storage facilities, and fugitive leaks from tanks of vehicles for natural-gas transport
	vi) Other	Fugitive emissions from residential installations, and from institutional, commercial and industrial users – emissions from service lines (house connection lines) are listed under 1.B.2.b.v, while emissions from natural-gas ignition in appliances are listed under 1.A.4

Source category		Included emissions
c	Venting and flaring	
	i) Venting	
	Oil	The emissions are included in the categories 1.B.2.a.iii and 1.B.2.a.v
	Gas	The emissions are included in the categories 1.B.2.b.iv and 1.B.2.b.v
	Combined	No emissions in this category
	ii) Flaring	
	Oil	Flaring emissions related to oil production and refining
	Gas	Flaring emissions related to natural gas production and to processing of sour gas
	Combined	No emissions in this category
d	Other	
	i) Geothermal energy	No fugitive CO ₂ , CH ₄ or N ₂ O emissions occur in ongoing operations. Fugitive F-gas emissions are assigned to the category 2.F.9
1.C CO₂ – transport and storage		No emissions are being reported at present in this category, since no CCS measures are currently taking place in Germany.

3.3.2.1 Oil (1.B.2.a)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	1.B.2.a Fugitive Emissions from Fuels: Oil	Liquid fuels	CH ₄	404.3	0.03%	229.5	0.03%	-43.2%
-/-	1.B.2.a Fugitive Emissions from Fuels: Oil	Liquid fuels	CO ₂	282.7	0.02%	312.8	0.04%	10.7%

The category 1.B.2.a. "Oil" is not a key category.

3.3.2.1.1 "Oil, Exploration" (1.B.2.a.i)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂ , CH ₄	Tier 1	AS	D
NM VOC	Tier 2	AS	CS

3.3.2.1.1.1 Category description, "Oil, exploration" (1.B.2.a.i)

This category's emissions consist of emissions from activities of drilling companies and of other participants in the exploration sector. Gas and oil exploration takes place in Germany. The pertinent statistics do not differentiate between drilling solely for oil and drilling solely for natural gas.

Activity data

Table 109: Number of exploratory wells (sum total for oil and natural gas)

1990	1995	2000	2005	2010	2014	2015
12	17	15	23	16	24	18

(Statistical report of the WEG oil and gas industry association, 2015).

Table 110: Total length of all exploratory wells, in m (sum total for oil and natural gas)

1990	1995	2000	2005	2010	2014	2015
50,140	109,187	41,378	63,994	51,411	48,922	32,773

(Statistical report of the WEG oil and gas industry association, 2015).

Emission factors

Table 111: Emission factors used for category 1.B.2.a.i

Gas	Emission factor	Method	Source
CO ₂	0.48 kg / No	Tier 1	IPCC GPG 2000
CH ₄	64 kg / No	Tier 1	IPCC GPG 2000
NM VOC	576 kg / No	Tier 2	Expert estimate

The emission factors given in IPCC GL 2006 (Table 4.2.4) refer to production quantities and not to exploratory wells. Therefore, those factors cannot be used in the present context.

Emissions and trend

Table 112: Emissions in category 1.B.2.a.i

Gas	Total emissions			Trend		Remark
	1990	2014	2015	Since 1990	With respect to the previous year	
Methane	768 kg	1,536 kg	1,152 kg	100 %	9 %	The emissions have increased with respect to their level in 1990, as a result of increased drilling.
Carbon dioxide	5.76 kg	11.52 kg	8.64 kg	100 %	9 %	
NM VOC	6,912 kg	13,824 kg	10,368 kg	100 %	9 %	

3.3.2.1.1.2 Methodological aspects of the category "Oil, exploration" (1.B.2.a.i)

According to the WEG, 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 since old / decommissioned wells are backfilled and normally covered with concrete caps.

Since pertinent measurements are not available for the individual wells involved, a conservative approach is used whereby well emissions (WEG 2012) are calculated on the basis of the default factor pursuant to IPCC GPG 2000 for carbon dioxide and methane, using the Tier 1 method.

3.3.2.1.1.3 Uncertainties and time-series consistency, category "Oil, exploration" (1.B.2.a.i)

The uncertainties in the activity data for oil and gas exploration have been quantified as +/- 5 %. The emission factors are assigned the default uncertainties from the Good Practice Guidance 2000, +/- 25 %.

For the activity data and the emission factors, a consistent source is used throughout the entire time series.

3.3.2.1.1.4 Category-specific quality assurance / control and verification, category "Oil, exploration" (1.B.2.a.i)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Due to a lack of country-specific data, an external assessment (Müller-BBM, 2009a) was commissioned. In its source-category analysis, that assessment found that the default factors are applicable to Germany. It was not possible to carry out a comparison with the results for other countries, because the relevant data lack basic comparability – for example, they use a range of units that are not mutually convertible.

3.3.2.1.2 "Oil, production and preprocessing" (1.B.2.a.ii)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂ , CH ₄	Tier 2	AS	CS
NM VOC	Tier 2	AS	CS

3.3.2.1.2.1 Category description, "Oil, production and preprocessing" (1.B.2.a.ii)

This category's emissions are produced in the petroleum industry's extraction (crude oil) and pre-treatment of raw materials (petroleum). 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 purposes of removing gases, water and salt from the oil. Crude oil in the form in which it appears 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.

Activity data

Table 113: Extracted quantity of petroleum, in kt

1990	1995	2000	2005	2010	2014	2015
3,606	2,959	3,113	3,573	2,516	2,439	2,414

(Annual report of the WEG oil and gas industry association, 2014).

Emission factors

Table 114: Emission factors used for production and processing

Gas	Emission factor	Method	Source
CO ₂	88.4 g/m ³	Tier 2	Expert estimate
CH ₄	169.4 g/m ³	Tier 2	Expert estimate
NM VOC	21.4 g/m ³	Tier 2	Expert estimate

Emissions and trend

Table 115: Emissions in category 1.B.2.a.ii

Gas	Total emissions			Trend Since 1990	With respect to the previous year	Remark
	1990	2014	2015			
Methane	1,081 t	482 t	474 t	-56 %	-2 %	The emissions have decreased with respect to 1990, as a result of decreasing production and improved emissions-reduction technologies in the areas of production and preprocessing.
Carbon dioxide	460 t	250 t	247 t	-46 %	-1 %	
NM VOC	108 t	63 t	60 t	-44 %	-5 %	

3.3.2.1.2.2 Methodological aspects of the category "Oil, production and preprocessing" (1.B.2.a.ii)

The emissions from production and processing are measured, or calculated, by the operators, and the pertinent data are published in the annual reports of the WEG oil and gas industry association. The emission factors are determined from the reported emissions and the activity data shown in Table 113.

The emissions are calculated in keeping with the Tier 2 method.

3.3.2.1.2.3 Uncertainties and time-series consistency in the category "Oil, production and preprocessing" (1.B.2.a.ii)

In this category, the uncertainty for the activity data is given as 5 to 10 %. The figures are based on estimates of WEG experts and national experts.

The uncertainties for the emission factors in the category amount to 25 %.

3.3.2.1.2.4 Category-specific quality assurance / control and verification for the category "Oil, production and preprocessing" (1.B.2.a.ii)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The emission factors that have been used are of the same order of magnitude as those given in the 2006 IPCC Guidelines.

Table 116: Comparison of IEF with the relevant IPCC default values

Gas	CS emission factor used	IPCC GL 2006 (Table 4.2.4)	
	Units in [g/m ³]	Units in [Gg/1000m ³]	Units in [g/m ³]
CO ₂	88.1 g/m ³	1.1*10 ⁻⁰⁷ to 2.6*10 ⁻⁰⁴	0.11 – 260.00
CH ₄	169.4 g/m ³	1.5*10 ⁻⁰⁶ to 6.0*10 ⁻⁰²	1.50 – 60,000
NM VOC	21.4 g/m ³	1.8*10 ⁻⁰⁶ to 4.5*10 ⁻⁰³	1.80 – 4500.0

3.3.2.1.3 "Oil, transport" (1.B.2.a.iii)

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	Tier 2	AS	CS
NM VOC	Tier 2	AS	CS

3.3.2.1.3.1 Category description, "Oil, transport" (1.B.2.a.iii)

This category's emissions are tied to activities of logistics companies and of operators of pipelines and pipeline networks. Following first treatment, crude oil is transported to refineries.

Almost all transports of crude oil take place via pipelines. Pipelines are stationary and, normally, run underground. In contrast to other types of transports, petroleum transports are not interrupted by handling processes.

Activity data

Table 117: Transports of domestically produced crude oil, in kt

1990	1995	2000	2005	2010	2014	2015
3,606	2,959	3,113	3,573	2,516	2,439	2,414

(Statistical report of the WEG oil and gas industry association, 2015).

Table 118: Transports of imported crude oil, in kt

1990	1995	2000	2005	2010	2014	2015
84,043	86,063	89,280	97,474	98,084	102,061	102,061

(The figures for 2015 have been carried forward, since the relevant statistics have been discontinued).

Table 119: Crude-oil transports via inland-waterway tankers, in kt

1990	1995	2000	2005	2010	2014	2015
88.9	66.6	111.8	176.4	5.6	53.8	43.1

(Federal Statistical Office, Fachserie 8 / Reihe 4, Table 2.1).

Emission factors

Table 120: Activity data and emission factors used for category 1.B.2.a.iii, "Transport of crude oil"

Source category	Activity data	Units	Gas	Emission factor (EF)	Units
Transports of imported crude oil	102.06	Millions of t/a	NM VOC	0.0064	kg/t
			CH ₄	0.0064	
Transports of domestically produced crude oil	2.41		NM VOC	0.13	
			CH ₄	0.013	

Emissions and trend

Table 121: Emissions in category 1.B.2.a.iii

Gas	Total emissions			Trend		Remark
	1990	2014	2015	Since 1990	With respect to the previous year	
NM VOC	5,885 t	6,867 t	6,860 t	17 %	- 1 %	The increasing trend is driven primarily by increases in the quantities of transported oil.
CH ₄	588 t	687 t	686 t	17 %	- 1 %	

3.3.2.1.3.2 Methodological aspects of the category "Oil, transport" (1.B.2.a.iii)

The emissions are calculated in keeping with the Tier 2 method.

For pipelines, the emission factor for methane has been taken from the 2006 IPCC Guidelines, while for inland-waterway tankers that factor has been estimated by experts. The pertinent emission factors have been confirmed by the research project Theloke et al "Determination of emission factors and activity data in areas 1.B.2.a.i through vi" ("Ermittlung von Emissionsfaktoren und Aktivitätsraten im Bereich 1.B.2.a.i bis vi" (2013)). Since long-distance pipelines are continually monitored, and since disruptive incidents in such pipelines are very rare (CONCAWE – "Performance of European cross country oil pipelines"), 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 (connections, control units, measuring devices) along pipelines and transfer at refineries, and it has been determined on the basis of conservative assumptions. For imported quantities, only one transfer point (only the withdrawal station) is assumed, since the station for input into the pipeline network does not lie on Germany's national territory.

3.3.2.1.3.3 Uncertainties and time-series consistency in the category "Oil, transport" (1.B.2.a.iii)

The uncertainties for the emission factors have been quantified as +/- 20 %, while those for the activity data have been determined to be +/- 10 %. The emission factors and the activity data are consistent throughout the entire time series.

3.3.2.1.3.4 Category-specific quality assurance / control and verification for the category "Oil, transport" (1.B.2.a.iii)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The emission factors that have been used are of the same order of magnitude as those given in the 2006 IPCC Guidelines.

Table 122: Comparison of IEF with the relevant IPCC default values

Gas	CS emission factor used	IPCC GL 2006 (Table 4.2.4)	
	Units in [g/m ³]	Units in [Gg/1000m ³]	Units in [g/m ³]
CH ₄	6 g/m ³	5.4*10 ⁻⁰⁶	5.4
NM VOC	55 g/m ³	5.4*10 ⁻⁰⁵	54.0

3.3.2.1.4 "Oil, refining and storage" (1.B.2.a.iv)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 2	AS	CS
CH ₄	Tier 2	AS	CS
SO ₂	Tier 2	AS	CS
CO	Tier 2	AS	CS
NO _x	Tier 2	AS	CS
NM VOC	Tier 2	AS	CS

3.3.2.1.4.1 Category description, "Oil, refining and storage" (1.B.2.a.iv)

This category's emissions 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. 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.

Tanks are emptied and cleaned for purposes of tank inspections and repairs. In tank cleaning, a distinction is made between crude-oil tanks and product tanks. Because of the sediment deposits involved, cleaning of crude-oil tanks, in comparison to cleaning of product tanks, is a considerably more involved process. Product tanks contain no sedimentable substances and thus are cleaned only when the products they contain are changed. In keeping with an assessment of [Müller-BBM, 2009b], the emission factors for storage of crude oil and petroleum products may be assumed to take cleaning processes into account.

Activity data

Table 123: Quantity of crude oil refined, in kt

1990	1995	2000	2005	2010	2014	2015
107,058	96,475	107,632	114,589	95,398	91,307	92,870

(2016 annual report of the Association of the German Petroleum Industry (MWV)).

Table 124: Capacity utilisation in refineries, in kt

1990	1995	2000	2005	2010	2014	2015
106.2	92.1	95.3	99.5	81.1	88.3	91

(Internal calculation of the Federal Environment Agency (UBA); 2016 annual report of the Association of the German Petroleum Industry (MWV)).

Table 125: Crude-oil-refining capacity in refineries, in kt

1990	1995	2000	2005	2010	2014	2015
100,765	104,750	112,940	115,630	117,630	103,406	102,055

(2016 annual report of the Association of the German Petroleum Industry (MWV)).

Table 126: Tank-storage capacity in refineries and pipeline terminals, in millions of m³

1990	1995	2000	2005	2010	2014	2015
27.2	28.4	24.9	24.0	22.5	22.4	22.05

(2016 annual report of the Association of the German Petroleum Industry (MWV)).

Table 127: Storage capacity of tank-storage facilities outside of refineries, in millions of m³

1990	1995	2000	2005	2010	2014	2015
41.9	41.2	46.0	44.2	43.2	41.1	40.8

(2016 annual report of the Association of the German Petroleum Industry (MWV)).

Emission factors

Table 128: Emission factors used for category 1.B.2.a.iii, "Fugitive emissions at refineries"

Gas	Emission factor	Method	Source
CH ₄	0.647 g/t	Tier 2	Expert estimate
CO	0.598 g/t	Tier 2	Expert estimate
CO ₂	594.001 g/t	Tier 2	Expert estimate
SO ₂	0.439 g/t	Tier 2	Expert estimate
NMVOC	24.647 g/t	Tier 2	Expert estimate
NO _x	0.001 g/t	Tier 2	Expert estimate

Table 129: Emission factor used for category 1.B.2.a.iii, "Anode production at refineries"

Gas	Emission factor	Method	Source
CO ₂	200.7 kg/t	Tier 2	Expert estimate

Table 130: Emission factors used for category 1.B.2.a.iii, "Storage and cleaning of crude oil in tank-storage facilities of refineries"

Gas	Emission factor	Method	Source
CH ₄	0.016 kg/t	Tier 2	Expert estimate
NMVOC	0.144 kg/t	Tier 2	Expert estimate

Table 131: Emission factors used for category 1.B.2.a.iii, "Storage of liquid petroleum products in tank-storage facilities outside of refineries"

Gas	Emission factor	Method	Source
CH ₄	5 g/m ³	Tier 2	Expert estimate
NMVOC	100 g/m ³	Tier 2	Expert estimate

Table 132: Emission factors used for category 1.B.2.a.iii, "Storage of gaseous petroleum products in tank-storage facilities outside of refineries"

Gas	Emission factor	Method	Source
CH ₄	150 g/m ³	Tier 2	Expert estimate
NMVOC	500 g/m ³	Tier 2	Expert estimate

Emissions and trend

Table 133: Emissions in category 1.B.2.a.iv

Gas	1990	Total emissions 2014	2015	Since 1990	Trend With respect to the previous year	Remark
Carbon dioxide	282,240 t	289,460 t	312,583 t	11 %	8 %	The trend for CO ₂ is influenced by anode production. The falling trend for methane and NMVOC is driven by improved emissions-reduction technologies in refineries and in storage of refinery products.
Methane	14,502 t	7,904 t	8,020 t	- 45 %	1 %	
NMVOC	97,183 t	41,106 t	41,477 t	- 57 %	1%	

3.3.2.1.4.2 Methodological aspects of the category "Oil, refining and storage" (1.B.2.a.iv)

The emissions for all sub-areas are calculated in keeping with the Tier 2 method.

Refining

The emission factors used for NMVOC, CH₄, CO₂, CO, NO_x and SO₂ were obtained from evaluations, carried out by Theloke et. al. (2013), of the 2004 and 2008 emissions declarations.

Anode production

The activity data are calculated from the relevant quantity of petroleum coke, minus the own consumption (coke burn-off in catalyst regeneration – cf. 1.A.2). The data have been obtained from the Official Mineral Oil Statistics [BAFA 2014]. This "green coke" is processed via calcining. The emission factor is calculated from the pertinent activity data and from the emissions data of the EU Emissions Trading System (ETS).

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" ("Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV - Bereich Lageranlagen") [Müller-BBM, 2009b], the crude-oil-distillation capacity is used as the activity data for estimation of emissions from storage in refineries. The fugitive-VOC-emissions value specified in VDI Guideline 2440, 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 (2009b), no emission factors can be derived, via evaluation of emissions declarations for storage systems, that would be representative of individual systems. This is due, so the same source, to the clearly widely differing emissions behaviour 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 are suitably differentiated.

3.3.2.1.4.3 Uncertainties and time-series consistency in the category "Oil, refining and storage" (1.B.2.a.iv)

Uncertainties of +/- 20 % are assumed for the emission factors for refining of crude oil. The uncertainties for the activity data are assumed to be +/- 10 %. The total uncertainties for the emissions from the area of storage and cleaning are estimated at +/- 40 %. These figures are based on estimates of national experts, and on the research report of Müller-BBM (2009b) and Theloke et. al. (2013).

The emission factors and the activity data are consistent throughout the entire time series.

3.3.2.1.4.4 Category-specific quality assurance / control and verification for the category "Oil, refining and storage" (1.B.2.a.iv)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Due to the complexity of the category, the data cannot be cross-checked against those of other countries. This was confirmed at the 2014 EU Workshop in Dessau. To permit comparison with the IPCC Guidelines, the factors for refining and crude oil storage were summed.

Table 134: Comparison of IEF with the relevant IPCC default values

Source	Gas	CS emission factor used Units in [g/m ³]	IPCC GL 2006 (Table 4.2.4)	
			Units in [Gg/1000m ³]	Units in [g/m ³]
Storage	CH ₄	13.8		
Refining	CH ₄	0.56		
Total	CH₄	14.4	2.6*10⁻⁰⁶ - 41.0*10⁻⁰⁶	2.6 - 41.0
Storage	NM VOC	124.1		
Refining	NM VOC	21.5		
Total	NM VOC	145.6	0.0013	1,300

The emission factor for methane lies within the range of the default value given in the IPCC Guidelines. While the factor for NM VOC is an order of magnitude lower, the relevant default value has an uncertainty of +/- 100%. The factor in the EMEP Guidebook (Table 3-1) is 0.2 kg/t, which corresponds to 172 g/m³ and thus is of the same order of magnitude as the German emission factor.

3.3.2.1.5 "Oil, distribution of oil products" (1.B.2.a.v)

Gas	Method used	Source for the activity data	Emission factors used
NM VOC	Tier 2	AS	CS

3.3.2.1.5.1 Category description, "Oil, distribution of oil products" (1.B.2.a.v)

The category comprises transports and handling of petroleum products, via inland-waterway tankers, pipelines, railway tank cars and road tankers, as well as cleaning of transport vehicles.

Activity data

Table 135: Petrol stations in Germany (number)

1990	1995	2000	2005	2010	2014	2015
19,317	17,957	16,324	15,187	14,744	14,562	14,531

(MWV 2016).

Table 136: Distributed quantities of petroleum products, in kt

	1990	1995	2000	2005	2010	2014	2015
Diesel fuel	21,817	26,208	28,922	28,531	32,128	35,587	36,756
Jet fuel	4,584	5,455	6,939	8,049	8,465	8,526	8,537
Light heating oil	31,803	34,785	27,875	25,380	21,005	16,807	16,127
Gasoline	31,257	30,333	28,833	23,431	19,634	18,527	18,226

(MWV 2016).

Table 137: Petroleum transports via inland-waterway tankers, in kt

1990	1995	2000	2005	2010	2014	2015
3,000	3,000	3,000	2,783	6,358	4,839	4,756

(Federal Statistical Office, Fachserie 8, Reihe 4, Table 2.1; data for the period prior to 2001 are estimates of the Federal Environment Agency (UBA)).

Emission factors

The emission factors listed below have been verified by the study [Theloke et al. 2013]. The model used for calculation of petrol emissions is described in Chapter 3.3.2.1.5.2.

Petroleum products are transported by inland-waterway tanker ships, product pipelines, railway tank cars and road tankers, and they are transferred from tanks to other tanks. Experts consider the emissions from refueling of aircraft to be non-existent, since the equipment used for such refueling is fitted with dry couplings. The emissions from filling of private heating-oil tanks are also very low, thanks to high safety standards.

In this category, petroleum products are handled and distributed that have undergone fractional distillation in refineries, 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 138: NMVOC emission factors used for category 1.B.2.a.v "Distribution of petrol"

Process responsible for emissions	Emission factor [kg/t]	Method	Source
Drip losses in refueling at service stations	0.117 kg/t	Tier 2	Expert estimate
Transfers from road tankers to service stations (20th Ordinance Implementing the Federal Immission Control Act – vapour displacement)	1.4 ³⁹ kg/t	M (Tier 2)	Expert estimate
Ventilation in connection with transports with inland-waterway tankers	0.025 kg/t	Tier 2	Expert estimate
Transfers from service station tanks to vehicle tanks (21st Ordinance Implementing the Federal Immission Control Act – vapour recovery)	1.4 kg/t	M (Tier 2)	Expert estimate

Table 139: NMVOC emission factors used for category 1.B.2.a.v "Distribution of diesel fuels"

Process responsible for emissions	Emission factor [kg/t]	Method	Source
Drip losses in refueling at service stations	0.1 kg/t	Tier 2	Expert estimate
Transports from refineries to transport vehicles	0.008 kg/t	Tier 2	Expert estimate
Transfers from service station tanks to vehicle tanks	0.003 kg/t	Tier 2	Expert estimate

Table 140: NMVOC emission factors used for category 1.B.2.a.v "Distribution of light heating oil"

Process responsible for emissions	Emission factor [kg/t]	Method	Source
Drip losses in refueling at transfer stations	0.0011 kg/t	Tier 2	Expert estimate
Transports from refineries to transport vehicles	0.0053 kg/t	Tier 2	Expert estimate
Transfers from service station tanks to vehicle tanks	0.0063 kg/t	Tier 2	Expert estimate

Table 141: NMVOC emission factors used for category 1.B.2.a.v "Distribution of jet fuels"

Process responsible for emissions	Emission factor [kg/t]	Method	Source
Drip losses in refueling at transfer stations	0 kg/t	Tier 2	Expert estimate
Transports from refineries to transport vehicles	0.055 kg/t	Tier 2	Expert estimate
Transfers from service station tanks to vehicle tanks	0.02 kg/t	Tier 2	Expert estimate

Emissions and trend

Table 142: Emissions in category 1.B.2.a.v

Gas	Total emissions			Trend With respect to the previous year	Remark
	1990	2014	2015		
NMVOC	82.8 kt	13.2 kt	13.2 kt	- 75 %	- 1 %

The emissions decreases are due primarily to the introduction of the 20th and 21st Ordinances Implementing the Federal Immission Control Act (BImSchV), which phased in requirements for vapour-balancing and vapour-recovery systems.

3.3.2.1.5.2 Methodological aspects of the category "Oil, distribution of oil products" (1.B.2.a.v)

Transport

Inland-waterway tankers that transport petrol retain considerable quantities of petrol vapours in their tanks after their petrol has been unloaded. When the ships change loads or spend time in port, their tanks have to be ventilated. With such ships averaging 277 instances of ventilation per year, the quantity of NMVOC emitted in such operations amounts to 336 - 650 t [BIPRO 2010]. The highest value in the range is used for calculation of the relevant emissions.

About 13 million m³ of petrol fuels 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 [UBA 2004b]. The emissions situation points to the high technical standards that have been attained in railway tank cars and pertinent handling facilities.

³⁹ The factor does not include reduction measures – cf. Table 143

Petrol stations

Significant quantities of fugitive VOC emissions are released into the environment during transfers from tanker vehicles to storage facilities and during refueling of vehicles. For emissions determination, a standardised emission factor of 1.4 kg/t is used. This 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-law provisions of 1992 and 1993 (20th and 21st BImSchV – 20th and 21st Ordinances Implementing the Federal Immission Control Act), designed to limit such emissions at service stations, promoted relevant reduction measures. The relevant provisions cover the areas of both transfer and storage of gasoline (20th BImSchV) and of refueling of vehicles with gasoline at service stations (21st BImSchV).

Use of required emissions-control equipment, such as vapour-balancing (20th BImSchV) and vapour-recovery (21st BImSchV) systems, along with 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 143).

In emissions calculation, the two ordinances' degrees of application to the petrol stations in service, and their efficiencies, are taken into account. The following assumptions, based on the technical options currently available, are applied:

Table 143: Effectiveness of the 20th and 21st Ordinances Implementing the Federal Immission Control Act (BImSchV), and their resulting effects on petrol stations

Ordinance		Factor	
20th BImSchV	Vapour balancing	Level of use	98 %
		Efficiency	98 %
21st BImSchV	Vapour recovery	Level of use	98 %
		Efficiency	85 %

The emissions are calculated with the following formula:

$$\text{Emissions} = \text{activity data} * \text{unreduced emission factor (from Table 138)} * (\text{level of use} * (1 - \text{efficiency}) + (1 - \text{level of use}))$$

Cleaning of transport vehicles

Tank interiors are cleaned prior to tank repairs, prior to 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 tank cars' tanks after the tanks 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 petrol. The emissions released, via exhaust air, in connection with cleaning of tank cars' interiors amount to about 40,000 kg/a VOC [UBA 2004b, p.34].

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

petrol 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. 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 refueling.

Pursuant to the UBA text (2004b), 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 m³ escapes), along with more thorough treatment of exhaust from cleaning of tanks' 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/m³, exhaust concentration levels can be reduced by 99.5 %, to less than 5 g/m³. As a result, the remaining emissions amount to only 1.1 t. This is equivalent to a reduction of about 97 % [UBA, 2004b, p. 34] from the determined level of 36.5 t/a (without adsorption).

3.3.2.1.5.3 Uncertainties and time-series consistency in the category "Oil, distribution of oil products" (1.B.2.a.v)

The uncertainties in the category are quantified as follows: for the emission data, +/- 20% (95 % confidence interval, normal distribution); for the activity data, +/- 5% [Theloke et.al. 2013].

3.3.2.1.5.4 Category-specific quality assurance / control and verification for the category "Oil, distribution of oil products" (1.B.2.a.v)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The data cannot be compared with those of other countries, since the CRF tables do not indicate what factors influenced the reported emissions. What is more, in the 2013 submission only Spain and Sweden reported NMVOC emissions in this category. With regard to methane emissions, IEF can be derived only for Iceland and Croatia. No cross-checking against the 2006 IPCC Guidelines is possible, since those Guidelines do not list any default factors.

3.3.2.2 Natural gas (1.B.2.b)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	1.B.2.a Fugitive Emissions from Fuels: Natural gas	Gaseous fuels	CH ₄	7,939.9	0.65%	4,824.7	0.54%	-39.2%
-/-	1.B.2.a Fugitive Emissions from Fuels: Natural gas	Gaseous fuels	CO ₂	1,407.7	0.12%	1,152.2	0.13%	-18.1%

The category 1.B.2.b "Natural gas" is a key category of CH₄ emissions in terms of emissions level and trend.

3.3.2.2.1 "Natural gas, exploration" (1.B.2.b.i)

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	IE	IE	IE
NM VOC	IE	IE	IE

3.3.2.2.1.1 Category description, "Natural gas, exploration" (1.B.2.b.i)

Category 1.B.2.b.i is considered together with category 1.B.2.a.i (Oil, exploration). Consequently, the aggregated, non-subdivided data of 1.B.2.b.i are included in category 1.B.2.a.i.

3.3.2.2.1.2 Methodological aspects of the category "Natural gas, exploration" (1.B.2.b.i)

The possibility of breaking exploration down into oil exploration and natural gas exploration was reviewed [Öko 2014], but then abandoned due to a lack of statistics and to the very small emissions quantities involved. The emissions are thus listed completely, for both oil exploration and gas exploration, under 1.B.2.a.i.

3.3.2.2.1.3 Uncertainties and time-series consistency of the category "Natural gas, exploration" (1.B.2.b.i)

See 1.B.2.a.i for explanations of uncertainties and time-series consistency.

3.3.2.2.1.4 Category-specific quality assurance / control and verification, category "Natural gas, exploration" (1.B.2.b.i)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook. See 1.B.2.a.i for an explanation of the verification procedure.

3.3.2.2.2 "Natural gas, production" (1.B.2.b.ii)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂ , CH ₄	Tier 2	AS	CS
NM VOC	Tier 2	AS	CS

3.3.2.2.2.1 Category description, "Natural gas, production" (1.B.2.b.ii)

The emissions of this category consist of emissions related to production.

Activity data

Table 144: Extracted quantity of natural gas, in millions of m³

1990	1995	2000	2005	2010	2014	2015
15.3	19.1	20.1	18.8	12.7	9.2	8.6

(Statistical report of the WEG oil and gas industry association, 2015).

Emission factors

Table 145: Emission factors used for the year 2015

Gas	Emission factor	Method	Source
CO ₂	0.11 g/m ³	Tier 2	Expert estimate
CH ₄	0.12 g/m ³	Tier 2	Expert estimate
NM VOC	0.01 g/m ³	Tier 2	Expert estimate

Emissions and trend

Table 146: Emissions in category 1.B.2.b.ii

Gas	Total emissions			Since 1990	Trend With respect to the previous year	Remark
	1990	2014	2015			
Methane	5,799 t	1,581 t	1,027 t	- 82 %	- 35 %	The emissions have decreased with respect to 1990, as a result of decreasing production and improved emissions-reduction technologies.
Carbon dioxide	1,450 t	965 t	899 t	- 38 %	- 7 %	
NM VOC	580 t	110 t	77 t	- 87 %	- 30 %	

3.3.2.2.2 Methodological aspects of the category "Natural gas, production" (1.B.2.b.ii)

Since 1998, the WEG oil and gas industry association has determined the emissions from production and published the relevant data in its annual report. For the period prior to 1998, the emissions have been determined with the help of default factors from the 2006 IPCC Guidelines. The emissions are calculated in keeping with the Tier 2 method.

3.3.2.2.3 Uncertainties and time-series consistency of the category "Natural gas, production" (1.B.2.b.ii)

In this category, the uncertainty for the activity data is given as 5 %. The figures are based on estimates of WEG experts and national experts.

The uncertainties for the emission factors in the category amount to 25 %.

3.3.2.2.4 Category-specific quality assurance / control and verification, category "Natural gas, production" (1.B.2.b.ii)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The emission factors that have been used are of the same order of magnitude as those given in the 2006 IPCC Guidelines.

Table 147: Comparison of IEF with the relevant IPCC default values

Gas	CS emission factor used Units in [g/m³]	IPCC GL 2006 (Table 4.2.5)	
		Units in [Gg/106m³]	Units in [g/m³]
CO ₂	0.11 g/m³	1.4*10 ⁻⁰⁵ to 1.8*10 ⁻⁰⁴	0.014 – 0.18
CH ₄	0.12 g/m³	3.8*10 ⁻⁰⁴ to 2.4*10 ⁻⁰²	0.380 – 24.0
NM VOC	0.01 g/m³	9.1*10 ⁻⁰⁵ to 1.2*10 ⁻⁰³	0.091 – 1.20

3.3.2.2.3 Natural gas, processing (1.B.2.b.iii)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂ , CH ₄	Tier 2	AS	CS
CO	Tier 2	AS	CS
SO ₂ , NM VOC	Tier 2	AS	CS

3.3.2.2.3.1 Category description (1.B.2.b.iii)

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 [WEG 2008a⁴⁰, p. 25]. Natural gas dehydration systems are closed systems.

⁴⁰ WEG 2008a: Erdgas-Erdöl, Entstehung-Suche-Förderung, Hannover, 34 p.

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 [EXXON 2014]. 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. Such gas is transported via separate, specially protected pipelines (due to the hazardousness of hydrogen sulphide) 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 [WEG 2008].

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.

Activity data

Table 148: Sulphur production from natural gas production in Germany, in kt

1990	1995	2000	2005	2010	2014	2015
915	1,053	1,100	1,050	832	708	628

(Statistical report of the WEG oil and gas industry association, 2015).

Figures for natural gas production are presented in Chapter 3.3.2.2.1, in Table 144.

Emission factors

Table 149: Emission factors used for category 1.B.2.b.iii, "Processing"

Gas	Emission factor	Method	Source
NMVOC	0.01 kg / 1,000 m ³	Tier 2	Association data
CH ₄	0.11 kg / 1,000 m ³		
CO ₂	336 kg / 1,000 m ³		

Emissions and trend

Table 150: Emissions in category 1.B.2.b.iii

Gas	Total emissions			Since 1990	Trend With respect to the previous year	Remark
	1990	2014	2015			
Methane	5,340 t	404 t	377 t	- 93 %	- 7%	The air-pollution emissions of the exploration and production industry are determined in keeping with a procedure accepted throughout the industry ⁴¹ . For this reason, the annual emissions figures vary somewhat from year to year and do not yield a straight line. The sharp increase in NMVOC emissions is due to a change of methods.
Carbon dioxide	1,404 kt	1,265 kt	1,150 kt	- 18 %	- 9 %	
NMVOC	12 t	29 t	27 t	225 %	- 7%	

3.3.2.2.3.2 Methodological issues (1.B.2.b.iii)

The emissions were calculated in keeping with the Tier 2 method.

For processing of sour gas, the WEG data for the period since 2000 are used. Those data are the result of the WEG members' own measurements and calculations. For the period prior to 2000,

⁴¹ WEG: "Leitfaden zu Erfassung der Umweltdaten der WEG Mitgliedsfirmen", published in-house, and last revised in Sept. 2006

the average CO₂ emission factor reported by Austria, 0.23 t / 1,000 m³, is used, since, according to the WEG, the German desulphurisation plant is comparable to the Austrian plant.

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 WEG report on acid-gas processing (WEG, 2008a).

3.3.2.2.3.3 Uncertainties and time-series consistency (1.B.2.b.iii)

For the emissions data, the category uncertainties are given as 10 to 30 %. Those figures are based on estimates of national experts, and they lie within the range listed for relevant default emission factors [IPCC GPG 2000, Chapter 2.7.1.6.].

3.3.2.2.3.4 Category-specific quality assurance / control and verification (1.B.2.b.iii)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Table 151: Comparison of IEF with the relevant IPCC default values

Source	CS emission factor used Units in [g/m ³]	2006 IPCC GL (Table 4.2.4) ⁴²	
		Units in [Gg/10 ⁶ m ³]	Units in [g/m ³]
CO ₂	336	$7.9 \cdot 10^{-06} + 3.6 \cdot 10^{-3} + 6.3 \cdot 10^{-2}$	66.608
CH ₄	0.11	$9.7 \cdot 10^{-05} + 2.4 \cdot 10^{-6}$	0.099
NM VOC	0.01	$6.8 \cdot 10^{-05} + 1.9 \cdot 10^{-6}$	0.068

A comparison with the IPCC default factors [Table 4.2.4 in the 2006 IPCC GL] shows that the national emission factors for methane lie within the range given for the default factors. The factor for carbon dioxide greatly exceeds the relevant default factor, however. Nonetheless, Germany's value in this category is of the same order of magnitude as Austria's (cf. the following table). No cross-checking against the corresponding figures of other countries could be carried out, since the CRF tables do not indicate what shares of processed natural gas must be assigned to the "sour gas" category.

Table 152: Comparison of emission factors for carbon dioxide

Source	CS emission factor used Units in [g/m ³]
Austria	230
Germany	336

3.3.2.2.4 Gas, transmission (1.B.2.b.iv)

Gas	Method used	Source for the activity data	Emission factors used
CH ₄ (transmission)	Tier 3	AS	CS
CH ₄ (storage)	Tier 2	AS	CS

3.3.2.2.4.1 Category description (1.B.2.b.iv)

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 [DBI 2014a].

⁴² Addition of fugitive emissions, flare emissions and raw-CO₂ venting

Activity data

Table 153: Length of long-distance high-pressure pipelines, in km

1990	1995	2000	2005	2010	2014	2015
22,696	29,866	32,214	34,086	35,503	35,575	35,595

[BDEW data, and Internet research focusing on operators of long-distance pipeline networks]

Some of the natural gas is stored in underground reservoirs, to guard against the possibility of interruptions of pipeline transports (i.e. to assure the reliability of the gas supply).

Table 154: Volumes of underground gas-storage facilities; figures in billions of cubic metres

	1990	1995	2000	2005	2010	2012	2014	2015
Cavern reservoirs	2.8	4.8	6.1	6.8	9.2	12.1	14.3	14.3
Porous-rock reservoirs	5.2	8.5	12.5	12.4	12.1	10.8	10.3	9.8

[Statistical report of the WEG oil and gas industry association, 2015]

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 [GASUNIE 2014]. At present, the compressors involved have a total power output of about 2,550 MW [data from "Netzentwicklungsplan Gas 2012" ("2012 edition of the gas-network-development plan")]. 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.

Emission factors

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.

Table 155: Emission factors used for methane emissions in category 1.B.2.a.iv, "Transmission"

System or mechanism	Value	Method	Source
Long-distance high-pressure pipeline	159 kg/km	T3	Expert estimate
Compressor	30,229 m ³ /MW	T2	Expert estimate
Sliding sleeve hub	46,845 m ³ /No.	T2	Expert estimate
Systems for regulating and measuring gas pressure	764 m ³ /No	T2	Expert estimate
Cavern reservoirs	0.05 kg / 1,000 m ³ (Vn) ⁴³	T2	Expert estimate
Porous-rock reservoirs	0.05 kg / 1,000 m ³ (Vn) ⁴³	T2	Expert estimate

Table 156: Emission factors used for carbon dioxide emissions in category 1.B.2.a.iv, "Transmission"

System or mechanism	Value	Method	Source
Long-distance high-pressure pipeline	1.3 kg/km	T3	Expert estimate
Compressor	183 m ³ /MW	T2	Expert estimate
Sliding sleeve hub	271 m ³ /No.	T2	Expert estimate
Systems for regulating and measuring gas pressure	4.5 m ³ /No	T2	Expert estimate
Cavern reservoirs	0.6 g / 1,000 m ³ (Vn) ⁴³	T2	Expert estimate
Porous-rock reservoirs	0.6 g / 1,000 m ³ (Vn) ⁴³	T2	Expert estimate

⁴³ Available volume of working gas, normed to 273 K and 1013 hPa.

Emissions and trend

Table 157: Emissions in category 1.B.2.b.iv

Gas	Total emissions			Since 1990	Trend With respect to the previous year	Remark
	1990	2014	2015			
Methane	44.4 kt	76.3 kt	76.1 kt	71 %	0 %	The emissions have been increasing as a result of addition of new long-distance high-pressure pipelines, including the attendant compressors and measuring and safety mechanisms.
Carbon dioxide	210 t	313 t	313 t	71 %	0 %	

3.3.2.2.4.2 Methodological issues (1.B.2.b.iv)

The emissions from natural gas transmission were calculated in keeping with the Tier 3 method.

The emissions from natural gas storage, from compressor stations, from systems for regulating and measuring gas pressure and from sliding sleeve hubs were calculated in keeping with the Tier 2 method.

The emission factor for underground natural gas storage was derived via surveys of operators and analysis of statistics on accidents / incidents [Müller-BBM 2012], and it is valid for pore-storage and cavern-storage facilities. It is seen as very conservative. The emission factor for the compressor systems and the sliding sleeve hubs has been obtained from the research project DBI 2014b.

Results for above-ground gas storage facilities are reported in 1.B.2.b.v.

3.3.2.2.4.3 Uncertainties and time-series consistency (1.B.2.b.iv)

For the emissions data, the category uncertainties are given as 10 to 30 %. Those figures are based on estimates of national experts, and they lie within the range listed for relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.). For underground storage facilities, an uncertainty of -50% is assumed, since the factors used were obtained via a highly conservative approach.

3.3.2.2.4.4 Category-specific quality assurance / control and verification (1.B.2.b.iv)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

A comparison of the category with the relevant IPCC default factors (Table 4.2.8) indicates that the emission factors for methane lie within the range given. For comparison values are available for carbon dioxide.

Table 158: Comparison of IEF with the relevant IPCC default values

System or mechanism	CS emission factor	2006 IPCC GL – Table 4.2.8
Compressor	30,229 m ³ /MW	6,000 – 100,000 m ³ /MW
Shut-off devices (sliding sleeve hubs) ⁴⁴	46,845 m ³ /No.	1,000 – 50,000 m ³ /No

The emission factors for the compressors and the shut-off devices lie within the range for the pertinent IPCC factors. All of the emission factors used were verified via projects (DBI 2014a and

⁴⁴ The emission factor is calculated with regard to the components blow pump and valve (DBI 2014b); it is assumed that the listed IPCC default factor, due to its very high values, refers to sliding sleeves and not to measuring stations.

DBI 2014b). The factor for the sliding sleeve hubs is considered very conservative, since it was obtained in a study for the Russian transport network (Wuppertal Institute (Wuppertal Institut für Klima, Umwelt und Energie); Max Planck Institute for Chemistry, "Treibhausgasemissionen des russischen Erdgas-Exportpipeline-Systems" ("Greenhouse-gas emissions of the Russian pipeline systems for natural gas exports"), Wuppertal; Mainz, 2005).

3.3.2.2.5 Natural gas, distribution (1.B.2.b.v)

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	Tier 3	AS	CS

3.3.2.2.5.1 Category description (1.B.2.b.v)

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 2002; VDI-Richtlinie (VDI Guideline) 2440, 11-2000).

Activity data

Table 159: Gas distribution network; figures in km

Parameter	1990	1995	2000	2005	2010	2014	2015
Total length of pipeline network ⁴⁵	282,612	366,987	362,388	402,391	471,886	502,000	505,000

[135. 2013 gas statistics (Gasstatistik) of the German Association of Energy and Water Industries (BDEW); own survey]

Table 160: Number of natural-gas-powered vehicles in Germany

	1990	1995	2000	2005	2010	2014	2015
Number	0	0	7,500	28,500	90,000	99,621	97,804

[Federal Motor Transport Authority; own survey]

⁴⁵ The data given include building-connection lines.

Emission factors for methane

System or mechanism	Value	Method	Source
Low-pressure pipeline made of steel and ductile cast iron	372 kg/km	Tier 3	Expert estimate
Low-pressure plastic pipeline	51 kg/km	Tier 3	Expert estimate
Low-pressure grey-cast-iron pipeline	445 kg/km	Tier 3	Expert estimate
Medium-pressure pipeline made of steel and ductile cast iron	207 kg/km	Tier 3	Expert estimate
Medium-pressure plastic pipeline	28 kg/km	Tier 3	Expert estimate
High-pressure pipeline made of steel and ductile cast iron	62 kg/km	Tier 3	Expert estimate
High-pressure plastic pipeline	0.3 kg/km	Tier 3	Expert estimate
Above-ground storage facilities	5 kg / 1,000 m ³ (Vn) ⁴⁶	Tier 2	Expert estimate
Gas-pressure-regulation (measuring) equipment	256 kg / No	Tier 2	Expert estimate
Natural-gas-powered vehicles	0.33 kg / vehicle	Tier 2	Expert estimate

Emission factors for carbon dioxide

System or mechanism	Value	Method	Source
Low-pressure pipeline made of steel and ductile cast iron	3.1 kg/km	Tier 3	Expert estimate
Low-pressure plastic pipeline	0.4 kg/km	Tier 3	Expert estimate
Low-pressure grey-cast-iron pipeline	3.7 kg/km	Tier 3	Expert estimate
Medium-pressure pipeline made of steel and ductile cast iron	1.7 kg/km	Tier 3	Expert estimate
Medium-pressure plastic pipeline	0.2 kg/km	Tier 3	Expert estimate
High-pressure pipeline made of steel and ductile cast iron	0.5 kg/km	Tier 3	Expert estimate
High-pressure plastic pipeline	2.5 g/km	Tier 3	Expert estimate
Above-ground storage facilities	34 g / 1,000 m ³ (Vn) ⁴⁶	Tier 2	Expert estimate
Gas-pressure-regulation (measuring) equipment	1.7 kg / No	Tier 2	Expert estimate
Natural-gas-powered vehicles	2.3 g / vehicle	Tier 2	Expert estimate

Emissions and trend

Table 161: Emissions in category 1.B.2.b.v

Gas	Total emissions			Trend		Gas
	1990	2014	2015	Since 1990	With respect to the previous year	
Methane	232.9 kt	88.0 kt	88.8 kt	- 62 %	1 %	The emissions have been decreasing as a result of use of emissions-reducing materials in the pipeline network – and, especially, via replacement of grey cast iron pipes
Carbon dioxide	1.77 kt	0.6 kt	0.6 kt	- 62 %	1 %	

3.3.2.2.5.2 Methodological issues (1.B.2.b.v)*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) and of our 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

⁴⁶ Available volume of working gas, normed to 273 K and 1013 hPa.

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 for the distribution network were verified in 2012 [STOLLER, DBI 2012] and 2014 [DBI 2014].

The methane-emission factor used, 256 m³ / station for the gas-pressure-regulation (-measuring) systems in the distribution network, was determined by Federal Environment Agency experts on the basis of data from the DBI study 2014b.

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 [Müller-BBM 2012] 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.

Natural-gas-powered vehicles, and CNG fueling stations

Use of vehicles running on natural gas continues to increase in Germany. Such vehicles are refueled at CNG fueling stations connected to the public gas network. In such refueling, compressors move gas from high-pressure on-site tanks. Some 900 CNG fueling stations are now in operation nationwide [Müller-BBM 2012]. In keeping with the stringent safety standards applying to refueling operations and to the tanks themselves, the pertinent emissions are very low – about 30 t per year. In the main, emissions result via tank pressure tests and emptying processes. 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 has no LNG terminals at present [Müller-BBM 2012]. 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 [Müller-BBM 2012].

3.3.2.2.5.3 Uncertainties and time-series consistency (1.B.2.b)

For the emissions data, the category uncertainties are given as 20-30 %. Those figures are based on estimates of experts, and they lie within the range listed for relevant default emission factors [IPCC GL 2006, Table 4.2.4].

3.3.2.2.5.4 Category-specific quality assurance / control and verification (1.B.2.b.v)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

It was not possible to compare the results for this category with the corresponding results of other countries, due to a lack of convertibility of pertinent units.

Table 162: Comparison of IEF with the relevant IPCC default values

Method	EF	AD	EM
CS (only the distribution network)	99 kg/km ⁴⁷	505,000 km	50 kt
IPCC 2006	1.1 * 10 ⁻³ Gg / millions of m ³	75 billion m ³	83 kt

Both methods yield emissions on the same order of magnitude. The IPCC default factor is somewhat higher – presumably, since it includes the gas-pressure-regulation systems.

3.3.2.2.6 Natural gas, other leakage (1.B.2.b.vi)

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	Tier 2	AS	CS

3.3.2.2.6.1 Category description (1.B.2.b.vi)

The category describes emissions from leakage in the industrial sector and in the residential and institutional/commercial sectors. The activity data are based on results of the German Association of Energy and Water Industries (BDEW) ("Gasstatistik" – gas statistics) and of our own surveys. In part, the BDEW gas statistics appear at three-year intervals, with some delay. In interim periods between such sets of statistics, values of the AGEB are used.

Activity data

Table 163: Activity data used for category 1.B.2.b.vi, "Fugitive emissions at sites of natural gas use"

	1990	1995	2000	2005	2010	2014	2015
Number of gas meters in the residential, institutional and commercial category [millions]	10.3	12.7	12.8	13.3	12.9	13.0	13.0
Energy consumption of industry [TWh]	323	361	370	399	335	322	327

[BDEW, AGEB, own survey]

Emission factors

Table 164: Methane emission factors used for category 1.B.2.b.vi, "Fugitive emissions at sites of natural gas use"

Operational site	Gas	Value	Method	Source
Gas meters and fittings in the residential, institutional and commercial sectors	CH ₄	2 m ³ /No ⁴⁸	Tier 2	Expert estimate
Fittings in industrial facilities	CH ₄	0.4 m ³ / 1,000 m ³	Tier 2	Expert estimate

⁴⁷ Weighted EF

⁴⁸ Average factor with respect to natural gas loss per number of gas meters in residences

Emissions and trend

Table 165: Emissions in category 1.B.2.b.vi

Gas	Total emissions			Since 1990	Trend With respect to the previous year	Remark
	1990	2014	2015			
Methane	29.1 kt	26.6 kt	26.7 kt	- 9%	0 %	The decrease is due to a reduction in the number of gas-fired devices (especially gas stoves), as well as to use of equipment with lower emissions.

3.3.2.2.6.2 Methodological issues (1.B.2.b.v)

The emission factors are country-specific, and they were determined via the research project "Methanemissionen durch den Einsatz von Gas in Deutschland von 1990 bis 1997 mit einem Ausblick auf 2010" ("Methane emissions via gas use in Germany from 1990 to 1997, with an outlook for 2010"); Fraunhofer ISI, 2000. Pursuant to the regulations DIN EN 1359, 3376-1, 3376-2, and to the gas-tightness tests they require, a maximum permissible value of 1-5 l/h can be derived. The relevant values were obtained at a pressure of 1.5 times the operational pressure. National experts thus consider a value of 2 m³/year to be suitable. The emissions that occur during ignition of end-user devices have already been included under 1.A.4. Emissions resulting from leakages in end-user service (connecting) lines are included, for statistical reasons, in 1.B.2.b.iv.

The emissions are calculated in keeping with the Tier 2 method.

3.3.2.2.6.3 Uncertainties and time-series consistency (1.B.2.b)

For the emissions data, the category uncertainties are given as 20 %. That figure is based on estimates of experts, and it lies within the range listed for relevant default emission factors [IPCC GPG 2000, Chapter 2.7.1.6.].

3.3.2.2.6.4 Category-specific quality assurance / control and verification (1.B.2.b.v)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

VERICO SCE 2014 compared the results for this category with other countries' corresponding results. This comparison yielded considerable differences between Germany's results and those of neighbouring countries. While a number of countries have emissions in this category, other countries' results are, on average, two orders of magnitude smaller than the German results. While the 2006 IPCC Guidelines provide no method description for this category, their Table 4.2.8 presents a range for the expected emissions.

Table 166: Comparison of IEF with the relevant IPCC default values

System or mechanism	CS emission factor	2006 IPCC GL – Table 4.2.8
Losses at the point of use	2 m ³ /No. ⁴⁹	2 to 20 m ³ /No.

⁴⁹ It was not possible to include the emission factor for industry emissions within the comparison, since the relevant units cannot be converted.

3.3.2.3 Venting and flaring (1.B.2.c)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	1.B.2.c Venting and Flaring	0	CO ₂	543.5	0.04%	380.5	0.04%	-30.0%
-/-	1.B.2.c Venting and Flaring	0	CH ₄	1.6	0.00%	2.7	0.00%	65.3%
-/-	1.B.2.c Venting and Flaring	0	N ₂ O	1.1	0.00%	0.2	0.00%	-85.6%

The categories in the overarching group of fugitive emissions from 1.B.2.c "Venting and flaring" cover greenhouse-gas and air-pollutant emissions either vented or flared directly into the atmosphere. The emissions from venting processes are included in the category 1.B.2.a.iv for oil, and in categories 1.B.2.b.iii and 1.B.2.b.iv for natural gas.

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 2	AS	CS
CH ₄	Tier 2	AS	CS
N ₂ O	Tier 2	AS	CS
NM VOC	Tier 2	AS	CS

The category 1.B.2.c "Venting and flaring" is not a key category.

3.3.2.3.1.1 Category description, "Venting and flaring" (1.B.2.c)

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 CO₂ and H₂O. When a plant has such systems in operation, therefore, its flarehead will seldom show more than a small pilot flame.

Activity data

Table 167: Refined crude-oil quantity, in millions of t.

1990	1995	2000	2005	2010	2014	2015
107	96	108	115	95	91	93

(Annual report of the Association of the German Petroleum Industry (MWV), 2016).

Table 168: Flared natural gas, in millions of m³

1990	1995	2000	2005	2010	2014	2015
36	33	36	19	12	11	10

(Statistical report of the WEG oil and gas industry association, 2015).

Emission factors

Flaring takes place at extraction and pumping systems and in refineries. In refineries, flaring operations are subdivided into regular operations and start-up / shut-down operations in connection with disruptions.

Table 169: Emission factors used for category 1.B.2.c, "Flaring emissions in natural gas extraction"

Gas	Value	Method	Source
CO ₂	1.777 kg/m ³	Tier 2	Expert estimate
NO	2*10 ⁻⁸ kg/m ³	Tier 1	IPCC default value

Table 170: Emission factors used for category 1.B.2.c, "Flaring emissions at petroleum production facilities"

Gas	Value	Method	Source
CO ₂	9.1 kg/t	Tier 2	Expert estimate
N ₂ O	0.55 g/t	Tier 1	IPCC default value

Methane and NMVOC emissions are included under production. Pursuant to the WEG oil and gas industry association, the pertinent nitrous oxide emissions are extremely insignificant. In the interest of maintaining a conservative approach, the IPCC default value has been used in the relevant calculation.

Table 171: Emission factors used for category 1.B.2.c "Flaring emissions at refineries: normal flaring operations"

Gas	Value	Method	Source
CH ₄	0.29 g/t	Tier 2	Expert estimate
CO ₂	2.86 kg/t	Tier 2	Expert estimate
N ₂ O	0.01 g/t	Tier 2	Expert estimate
CO	0.33 g/t	Tier 2	Expert estimate
NMVOC	2.80 g/t	Tier 2	Expert estimate
SO ₂	8.43 g/t	Tier 2	Expert estimate
NO _x (as NO ₂)	0.41 g/t	Tier 2	Expert estimate

Table 172: Emission factors used for category 1.B.2.c "Flaring emissions at refineries: disruptions of flaring operations"

Gas	Value	Method	Source
CH ₄	0.08 g/t	Tier 2	Expert estimate
CO ₂	1.28 kg/t	Tier 2	Expert estimate
N ₂ O	0.3 mg/t	Tier 2	Expert estimate
CO	4.16 g/t	Tier 2	Expert estimate
NMVOC	2.27 g/t	Tier 2	Expert estimate
SO ₂	15.23 g/t	Tier 2	Expert estimate
NO _x (as NO ₂)	3.49 g/t	Tier 2	Expert estimate

The emission factors have been derived from the 2004 and 2008 emissions declarations (Theloke et al 2013).

Emissions and trend

Table 173: Emissions in category 1.B.2.c "Venting and flaring"

Gas	Total emissions			Trend		Remark
	1990	2014	2015	Since 1990	With respect to the previous year	
Methane	66 t	104 t	109 t	65 %	5 %	Emissions from flaring systems have decreased continuously as a result of improvements in gas-recovery methods.
Carbon dioxide	544 kt	367 kt	381 kt	-30 %	4 %	
NMVOC	522 t	408 t	428 t	-18 %	5 %	
Nitrous oxide	4 t	1 t	1 t	- 86 %	5 %	

3.3.2.3.1.2 Methodological aspects of the category "Venting and flaring" (1.B.2.c)

Venting emissions are taken into account in category 1.B.2.b.iii. The SO₂ emissions are determined from the activity data for the natural gas that is flared off [Table 168], and from an emission factor of 0.140 kg/ 1000 m³, a factor based on a mean H₂S 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).

The emissions are calculated in keeping with the Tier 2 method.

3.3.2.3.1.3 Uncertainties and time-series consistency, category "Venting and flaring" (1.B.2.c)

The quantitative uncertainties for the emission factors for flaring processes during normal operations are assumed to be +/-10 % (95 % confidence interval, normal distribution). The uncertainties for the activity data are assumed to be +/- 5 % (95 % confidence interval, normal distribution).

The uncertainties for the emission factors for disruption-related flaring processes (operations during disruptions; start-up / shut-down operations) are much larger, since the emissions quantities can vary widely from year to year. They are estimated to be -90 % / +300 % (95% confidence interval, log-normal distribution). The uncertainties for the activity data are assumed to be +/- 10 % (95 % confidence interval, normal distribution) (Theloke et. al. 2013).

3.3.2.3.1.4 Category-specific quality assurance / control and verification, category "Venting and flaring" (1.B.2.c)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

A comparison of the category with the IPCC Guidelines reveals considerable differences in individual factors. At the EU Workshop held in Dessau in 04/2014, the participating experts agreed that the default values are considerably higher than the emission factors currently used in Europe.

Table 174: Comparison of IEF with the relevant IPCC default values

Gas and system	CS emission factor used ⁵⁰	IPCC GL 2006 (Table 4.2.4)	
	Units in [g/m ³]	Units in [Gg/1000m ³]	Units in [g/m ³]
CO ₂ in refinery flares	3,569	$3.4 \cdot 10^{-02}$	34,000
CH ₄ in refinery flares	0.32	$2.1 \cdot 10^{-05}$	21
NMVOC in refinery flares	4.37	$1.7 \cdot 10^{-05}$	17
CO ₂ in oil production systems	7844	$4.1 \cdot 10^{-02}$	41,000
CO ₂ in natural gas production systems	1532	$1.2 \cdot 10^{-03}$	1,200

3.3.2.4 Geothermal energy (1.B.2.d)

3.3.2.4.1 Category description (1.B.2.d)

The category 1.B.2.d "Geothermal energy" is not a key category.

Geothermal energy is a renewable form of energy. Geothermal energy systems that tap geothermal heat to a depth of 400 metres are classified as "near-surface" geothermal energy systems. Near-surface geothermal systems generate heating and cooling energy by means of heat pumps. They are also used for heating service water. Geothermal energy systems that tap geothermal heat at depths greater than 400 metres are classified as "deep" geothermal energy systems. Geothermal heating stations use the heat in their thermal-water flows directly, and provide heating and cooling to end consumers, via district / local heating and cooling networks. Geothermal power stations convert the heat in their thermal-water flows into electricity. In most cases, they produce heat as well, via processes for combined heat/power (CHP) production.

As of the end of 2015, a total of 33 deep geothermal energy systems, with electricity output of 32.2 MW and thermal output of 280.7 MW, were in operation. A total of 3 systems, with electricity output of 5.3 MW and thermal output of 47.0 MW, are under construction. An additional 30 systems are planned.

Operation of geothermal power stations and heat stations in Germany produces no emissions of climate-relevant gases. 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. What is more, releases of the gases dissolved in their heat-carrying fluids – primarily H₂, CH₄, CO₂ and H₂S – would not produce concentrations that would require reporting (cf. "Umwelteffekte einer geothermischen Stromerzeugung, Analyse und Bewertung der klein- und großräumigen Umwelteffekte einer geothermischen Stromerzeugung" ("Environmental effects of geothermal power generation; analysis and assessment of small-scale and large-scale environmental impacts of geothermal power generation")), FKZ 205 42 110, Chapter A.2.3.5). For this reason, the emissions are reported as "NO". In 2015, all geothermal energy systems met their own power requirements (primarily power for operating pumps) by drawing electricity from the grid. In the report, that use is included in the relevant categories.

3.3.2.4.2 Methodological issues (1.B.2.d)

The IPCC Reference Manual does not describe any methods for category 1.B.2.d "Other" (IPCC, 1996: Volume 3, p. 1.132f)

No emission factors for greenhouse gases and pollutants that could escape in connection with drilling for tapping of geothermal energy (both near-surface and deep energy) are known for

⁵⁰ For refineries, determined as a mean value between normal operation and operation during disruptions

Germany at present. As is known from oil and gas exploration, however, it is clear that virtually any drilling will lead to releases of gases bound in underground layers – and the gases involved can include H₂, CH₄, CO₂, H₂S and Rn (cf. "Environmental effects of geothermal electricity production; analysis and assessment of the small-scale and large-scale environmental effects of geothermal electricity production", FKZ 205 42 110, Chapter A.2.1.5). Drilling to tap near-surface geothermal energy can be expected to produce only very slight emissions. In all drilling to tap deep geothermal energy, blow-out preventers are used to prevent gas releases. In addition, drilling fluids are used to drive any gases released into boreholes back into the rock layers traversed in drilling. THELOKE 2013 estimates that the fugitive emissions related to deep geothermal wells are on the order of kilograms. The emissions in this category are reported as NE, therefore, because their contribution to the total emissions is less than 0.05 % of the overall inventory or 500 kt CO₂ equivalents (pursuant to FCCC/SBSTA/2013/L.29/Add.1), and since it cannot be assured that annual inventories of such emissions (pursuant to FCCC/SBSTA/2013/L.29/Add.1, para 37) will be carried out. In Chapter 5, the pertinent emissions contribution to the overall inventory is presented (on a one-time basis). A compilation of all sources for which the entry "not estimated" is retained is presented in Annex 5 (Chapter 21).

3.3.2.4.3 Uncertainties and time-series consistency (1.B.2.d)

No explanations of uncertainties and time-series consistency are required.

3.3.2.4.4 Category-specific quality assurance / control and verification (1.B.2.d)

No explanations relative to source-specific quality assurance / control and verification are required.

3.3.2.5 Category-specific recalculations (1.B.2 all)

The figures for the past two years have been recalculated, because some of the statistics on which they had been based were provisional. This work led to the following inventory improvements, entailing recalculations:

Transports of imported crude oil

In the 2015 ESD Review, it was noted that the emission factors used had not been converted on the basis of the density of crude oil. In addition, it was noted that emissions from distribution via inland-waterway tankers had not been taken into account. The relevant conversion has now been carried out, and the emissions of inland-waterway tankers have been included. This has led to recalculations, throughout the entire time series, under 1.B.2.a.iii.

Processing of sour gas

The methane-emissions calculation was based on the applicable quantity of extracted natural gas, and not on the applicable quantity of sour gas. This led to a 60% overestimation of the emissions, throughout the entire time series.

Transmission, distribution and use of natural gas

In the 2015 ESD Review, it was noted that the carbon dioxide emissions are not negligible. Consequently, these emissions have been determined in light of the mean composition of natural gas, and the notation key *NE* has been replaced with suitable values. This is the main factor that led to the recalculations listed in Table 176.

Service stations (gas stations) – 21st BImSchV (Ordinance Implementing the Federal Immission Control Act)

For the year 2002, the efficiency has been reduced from 0.78 to 0.75. A review of the function of vapour recovery systems showed a total-failure rate of up to 30 %. The failure rate was not reduced until automatic monitoring equipment was introduced, under the 21st BImSchV. The amended 21st BImSchV entered into force on 18 May 2002, and new service stations were required to implement it by 1 April 2003. According to experts' assessments, these changes did not have an effect – and increase the systems' efficiency – until 2003.

In addition, the degree of utilisation of such systems was increased to 0.92 for the year 2010 and to 0.95 for 2011. EU Directive 2009/126/EC on Stage II petrol vapour recovery during refuelling of motor vehicles at service stations (STAGE II) entered into force in 2009. Its provisions were transposed via the 21st BImSchV. That ordinance was then amended in 2012. During preparation of the amendment, it emerged that nearly all service stations had already installed vapour-recovery equipment. A retrofit period lasting until the end of 2018 has been granted only to small service stations with annual throughputs of 100 to 1000 cubic metres of gasoline.

The recalculations for this category relate solely to NMVOC.

Table 175: Recalculations in category 1.B – methane emissions, in kt

	1990	1995	2000	2005	2010	2014
2016 Submission	1356	1121	920	529	338	314
2017 Submission	1355	1121	919	528	337	314
Difference	1	0	1	1	1	0

Table 176: Recalculations in category 1.B – carbon dioxide emissions, in kt

	1990	1995	2000	2005	2010	2014
2016 Submission	4065	3410	3313	3227	2848	2629
2017 Submission	4081	3424	3328	3243	2867	2709
Difference	16	14	15	16	19	80

3.3.2.6 Planned improvements, category-specific (1.B.2 all)

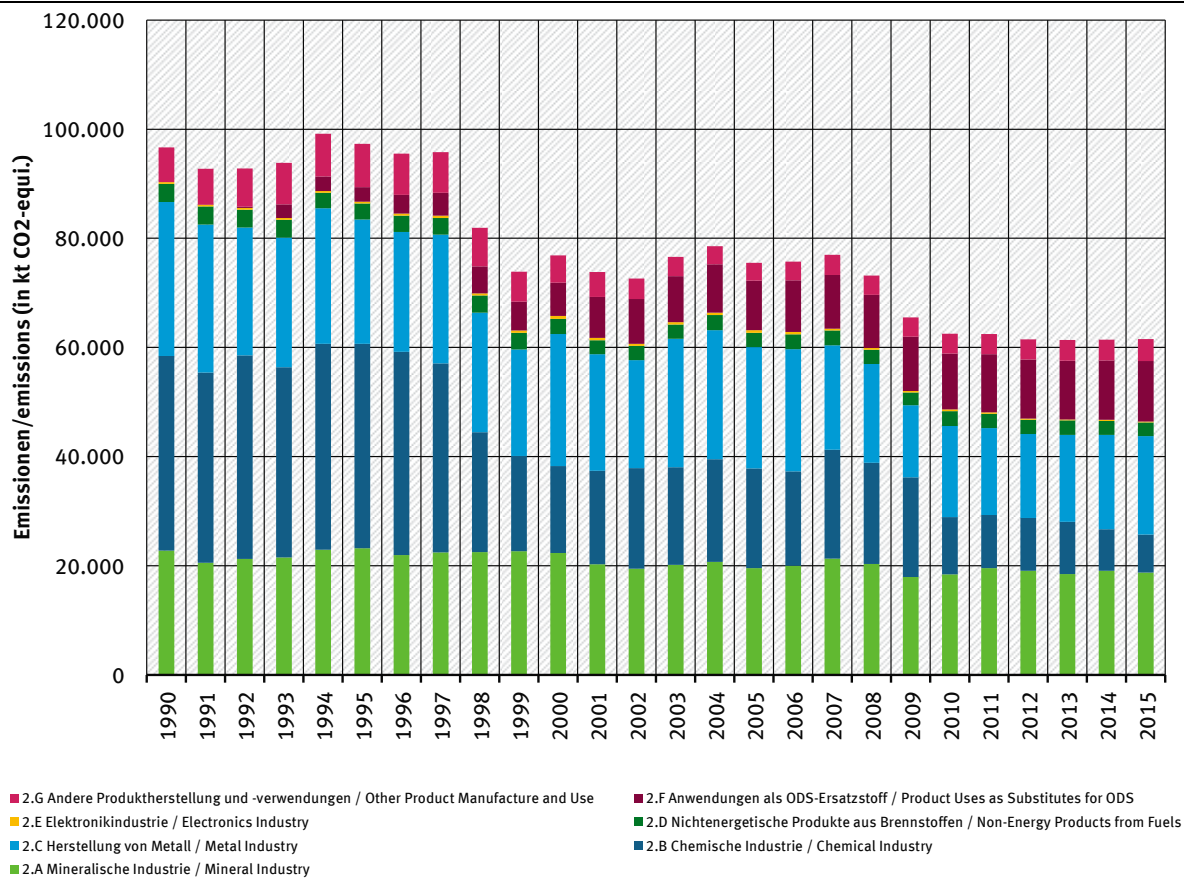
No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4 Industrial processes (CRF Sector 2)

4.1 Overview (CRF Sector 2)

Figure 43: Overview of greenhouse-gas emissions in CRF Sector 2



4.2 Mineral industry(2.A)

The CRF category 2.A Mineral industry is divided into sub-categories 2.A.1 through 2.A.4. These fields include:

- cement clinker production (2.A.1),
- lime burning (2.A.2),
- glass production (2.A.3),
- ceramics production (2.A.4.a)
- other soda ash use (2.A.4.b),
- production of non-metallurgic magnesium products (2.A.4.c),
- other limestone and dolomite use (2.A.4.d),

4.2.1 Mineral products: Cement production (2.A.1)

4.2.1.1 Category description (2.A.1)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	2.A.1. Mineral Products: Cement Production	Clinker Burning	CO ₂	15,145.8	1.24%	12,378.0	1.39%	-18.3%
Gas		Method used	Source for the activity data		Emission factors used			
CO ₂		Tier 2	AS		CS			
NO _x , SO ₂		Tier 1	AS		CS			

The category *Cement production* is a key category for CO₂ emissions in terms of emissions level and trend. The remarks below refer only to production of cement clinkers, because clinker grinding is not relevant as a dust source in the present context. In Table 177, cement production is included solely for reference purposes, without emissions relevance in this context.

The clinker-burning process emits climate-relevant gases. CO₂ accounts for the great majority of these emissions. The CO₂ emissions from pertinent raw materials are tied directly to the quantities of cement clinkers that are produced. Pursuant to the German Emissions Trading Authority (DEHSt, 2016), clinker production in 2015 amounted to 23,355 kt⁵¹. Raw-material-related CO₂ emissions are calculated with a country-specific emission factor, as determined by the *German Cement Works Association* (VDZ) from plant-specific data, of 0.53 t CO₂/t cement clinkers. Clinker production produced raw-material-related CO₂ emissions of 12,378 kt CO₂ in 2015.

Table 177: Production and CO₂ emissions in the German cement industry

Year	Clinker production [kt/a]	Emission factor [t CO ₂ /t]	Raw-material-related CO ₂ emissions [kt/a]	Cement production [kt/a]
1990	28,577		15,146	37,772
1991	25,670		13,605	34,341
1992	26,983		14,301	37,331
1993	27,146		14,387	36,649
1994	28,658		15,189	40,512
1995	29,072		15,408	35,862
1996	27,669		14,664	34,318
1997	28,535		15,124	34,148
1998	29,039		15,391	35,601
1999	29,462		15,615	37,438
2000	28,494		15,102	35,414
2001	25,227	0.53	13,370	32,118
2002	23,954		12,696	31,009
2003	25,233		13,373	32,749
2004	26,281		13,929	31,854
2005	24,379		12,921	31,009
2006	24,921		13,208	33,630
2007	26,992		14,306	33,382
2008	25,366		13,444	33,581
2009	23,232		12,313	30,441

⁵¹ Provisional value (rounded off).

Year	Clinker production [kt/a]	Emission factor [t CO ₂ /t]	Raw-material-related CO ₂ emissions [kt/a]	Cement production (kt/a)
2010	22,996		12,188	29,915
2011	24,775		13,131	33,540
2012	24,581		13,028	32,432
2013	23,128		12,258	31,308
2014	23,871		12,652	32,099
2015	23,355		12,378	31,160

Source: derived from BdZ 2005 (until 1994); VDZ, 2016 (as of 1995); DEHSt, 2016

4.2.1.2 Methodological issues (2.A.1)

Activity data

Activity data are determined via summation of figures for individual plants (until 1994, activity data were determined on the basis of data of the BDZ German cement-industry association). As of 1995, following optimisation of data collection within the association, activity data were compiled by the VDZ, and by its cement-industry research institute (located in Düsseldorf), via surveys of German cement works and use of BDZ figures. In the main, the data consist of data published in the framework of CO₂ monitoring, supplemented with data for plants that are not BDZ members (in part, also VDZ estimates). This corresponds to the Tier 2 approach of the IPCC Guidelines (IPCC, 2006, Volume 3, Chapter 2.2.1.1).

For internal reasons, the VDZ association was unable to provide the data for 2015. As a result, the cement-clinker figures are based on aggregated data of the DEHSt. A comparison covering the previous years 2005-2014 showed that the DEHSt's relevant emissions-trading figures and the VDZ's data on cement-clinker production differed by a constant percentage of about 1 %, meaning that a high degree of agreement between the two data sets may be assumed. In general, completeness is thus assured if one of the two data sets is used.

Table 177 summarises the activity data for cement clinkers and cement, and the raw-material-related CO₂ emissions as determined from clinker production, for the years 1990 through 2015.

Emission factors

The emission factor used for emissions calculation, 0.53 t CO₂ / t cement clinkers, is based on mass-weighted figures for individual plants, i.e. the VDZ determined the emission factor by aggregating plant-specific data relative to fractions of CaO and other metal oxides (MgO; in raw materials, and containing carbonate) in clinkers. The emission factor was determined in the framework of a research project (VdZ, 2009), and it was confirmed by the VDZ in subsequent years. The procedure is in keeping with the Tier 2 method given in the IPCC Guidelines (IPCC, 2006: Volume 3, Chapter 2.2.1.2), and it is considered to be more accurate than procedures using default emission factors.

In the German cement industry, dust separated from exhaust gas is returned to the burning process. As a result, carbonate release from clinker raw materials can be determined directly from clinkers' metal-oxide content, without any need to take account of significant losses via the exhaust-gas pathway.

The emission factor of 0.53 t CO₂ / t cement clinkers was applied to the entire time series.

Raw-material-related CO₂ emissions in the cement industry are determined, in accordance with the *IPCC Guidelines (IPCC, 2006: Volume 3, Equation 2.2)*, via the following equation:

$$\text{CO}_2 \text{ emissions} = \text{emission factor (EF}_{\text{clinkers}}\text{)} \times \text{clinker production}$$

(Table 177 shows calculated CO₂ emissions for the German cement industry for the years covered by the report.)

4.2.1.3 Uncertainties and time-series consistency (2.A.1)

For the activity data, time-series consistency is assured via the association's long history of data collection. For the year 2015, it is assured in that emissions-trading data has been proven, via excellent data agreement in previous years, to be a suitable alternative. For the emission factor, it is assured in that a consistent approach has been used for all years concerned.

The uncertainties given were determined via expert assessment.

Most companies are required to report clinker-production data within the framework of CO₂-emissions trading. The EU monitoring guidelines for emissions trading specify a maximum accuracy of 2.5 %. The uncertainties for the activity data used were thus estimated at -2.5 % and +2.5 %.

The uncertainty for the emission factor used was estimated at +/- 2 %. This was confirmed via surveys in the framework of a research project (VdZ, 2009).

4.2.1.4 Category-specific quality assurance / control and verification (2.A.1)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

For purposes of quality assurance, all data used, including data from the BDZ, from the VDZ and from emissions trading, and comparative data from the literature, were checked for plausibility. During the inventory review (ICR 2016), materials of the VDZ were used to demonstrate that QSE-conformal procedures are being used. Those materials were accepted by the review team as proof. The emission factor determined for raw-material-related CO₂ emissions has been compared with the relevant figures of other countries. The small deviation (about 1 %) from the IPCC Tier 1 default factor, 0.52 t CO₂ / t clinkers (IPCC 2006: Volume 3, Equation 2.4), results from the higher lime content found in some German clinkers.

The emission factor used differs only slightly (1 %) from the average emission factors used in connection with the ETS in Germany, emission factors that are checked by authorities and reviewed in light of companies' obligations to provide records. To date, no calculations relative to the emission factor prior to the year 2000 are available. The same figure – the result of an expert assessment – has been used for all relevant years in that period.

4.2.1.5 Category-specific recalculations (2.A.1)

No recalculations are required.

4.2.1.6 Planned improvements, category-specific (2.A.1)

Review is currently underway to determine whether the emissions-trading activity data can be used on a long-term basis in future.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.2.2 Mineral products: Lime production (2.A.2)

4.2.2.1 Category description (2.A.2)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/-	2.A.2. Mineral Products: Lime Production	burning of Limestone and Dolomite	CO ₂	5,986.6	0.49%	4,976.0	0.56%	-16.9%
Gas		Method used	Source for the activity data		Emission factors used			
CO ₂		Tier 2	AS		D			
NO _x , SO ₂		Tier 1	AS		CS			

The category *Lime production* is a key category for CO₂ emissions in terms of emissions level.

The statements made below regarding category 2.A.2 refer solely to the amounts of burnt lime and dolomite lime produced in German lime works. Additional relevant lime kilns, in addition to the lime-burning facilities covered by this chapter, have been identified in the iron and steel industry and sugar industry sectors. Those facilities are covered not in the present chapter, but in the sections for the relevant categories, 2.C.1 (Chapter 4.4.1) and 2.H.2 (Chapter 4.9.2). Information on other limestone-using sectors is provided in Chapter 4.2.7 (CRF 2.A.4d).

Because of the wide range of applications covered by the sector's products, lime production is normally more insulated from economic fluctuations than is production of other mineral products, such as cement. Production of burnt lime and dolomite lime was somewhat higher than it was in the previous year.

Table 178: Production and CO₂ emissions in the German lime industry

Year	Lime		Dolomite lime	
	Production [t]	CO ₂ emissions [Millions of t]	Production [t]	CO ₂ emissions [Millions of t]
1990	7,323,657	5.463	603,427	0.523
1991	6,474,897	4.830	605,186	0.525
1992	6,563,031	4.896	587,474	0.509
1993	6,852,841	5.112	526,799	0.457
1994	7,512,403	5.604	516,115	0.447
1995	7,611,109	5.678	555,927	0.482
1996	7,019,060	5.236	556,487	0.482
1997	7,114,649	5.308	541,893	0.470
1998	6,799,487	5.072	569,540	0.494
1999	6,814,898	5.084	490,745	0.425
2000	6,993,608	5.217	536,032	0.465
2001	6,665,136	4.972	522,778	0.453
2002	6,591,281	4.917	526,596	0.457
2003	6,731,929	5.022	445,625	0.386
2004	6,692,954	4.993	468,873	0.407
2005	6,535,470	4.875	473,632	0.411
2006	6,646,233	4.958	471,784	0.409
2007	6,873,539	5.128	468,593	0.406
2008	6,868,481	5.124	464,167	0.402
2009	5,500,965	4.104	341,713	0.296

Year	Lime		Dolomite lime	
	Production [t]	CO ₂ emissions [Millions of t]	Production [t]	CO ₂ emissions [Millions of t]
2010	6,124,382	4.569	341,779	0.296
2011	6,330,677	4.723	350,482	0.304
2012	6,035,949	4.503	241,833	0.210
2013	6,195,672	4.622	218,375	0.189
2014	6,400,977	4.775	227,701	0.197
2015	6,375,810	4.756	253,369	0.220

Because the applicable emission factor in this category is constant, CO₂ emissions and lime / dolomite-lime production depend linearly on each other; as a result, the above statements apply to CO₂ emissions mutatis mutandis.

4.2.2.2 Methodological issues (2.A.2)

In burning of limestone and dolomite, CO₂ is released, and it reaches the atmosphere via the exhaust gas of the process. The pertinent emissions level is obtained by multiplying the amount of product in question (lime or dolomite lime) and the relevant emission factor. Use of the emission factors explained below, together with country-specifically determined lime-production figures, is a Tier 2 method within the meaning of the *2006 IPCC Guidelines* (IPCC 2006: Volume 3, Chapter 2.3.1.1).

Emission factors

The pertinent CO₂ emissions are calculated with the following factors:

EF _{lime}	0.746 t CO ₂ /t lime (stoichiometric 0.785 * oxide fraction 0.95)
EF _{dolomite lime}	0.867 t CO ₂ /t dolomite lime (stoichiometric 0.913 * oxide fraction 0.95)

The emission factors used are based on the stoichiometric factors, as well as on the assumption that 95 % of the burnt lime consists of CaO, that 95 % of the dolomite lime consists of CaO • MgO and thus that 5 % of the total mass consists of impurities that are not CO₂-relevant. This approach is in line with the *2006 IPCC Guidelines* (IPCC 2006: Volume 3, Chapter 2.3.1.2).

Activity data

The German Lime Association (BVK) collects the production data for the entire time series, on a plant-specific basis, and makes them available for reporting purposes. The quantities produced by plants that are not included in the German Lime Association's association statistics are estimated on the basis of existing information (such as operator figures, and data published in the framework of emissions trading) and then added to the German Lime Association's figures. This ensures that all of German lime production is taken into account. Ever since the relevant method was changed to conform with the 2006 IPCC Guidelines, it is also being assumed that, in all years of the period covered by the report, as of the year 1990, 2 % of the burnt lime is being separated out as dust, via suitable waste-gas-scrubbing systems, and is not being returned to the production process. This is taken into account via a fictive 2 % increase in the pertinent activity data.

The manner in which the activity data are determined conforms with the Tier 2 approach of the *2006 IPCC Guidelines* (IPCC 2006: Volume 3, Chapter 2.3.1.3).

4.2.2.3 Uncertainties and time-series consistency (2.A.2)

The EU monitoring guidelines for emissions trading call for activity data to have an accuracy of 2.5 %. Since a) the German Lime Association's (BV Kalk's) lime-production data are based on operators' figures as provided in the framework of CO₂-emissions trading, b) those data have been obtained via two separate, parallel channels and thus are quality-assured, and c) the plants not

included in the association's statistics (and thus assessed after the fact) represent only a small share of the total number of plants concerned, the **uncertainties** for the **activity data** used are estimated to be 2.5 % and +2.5 %. These figures apply to both burnt lime and dolomite lime.

The uncertainties for the emission factors used for burnt lime were estimated to be -11 % and +5 %. The uncertainties for the emission factors used for dolomite lime were estimated to be -30 % and +2 %.

4.2.2.4 Category-specific quality assurance / control and verification (2.A.2)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The quality of the production-quantity data collected by the German Lime Association (BV Kalk) is assured via internal controls of the association, carried out with the help of separate surveys in the sector's technical and commercial areas (Tier 2).

The comparison with the available information from the ETS yielded discrepancies that can be explained as the result of differences in methods: on the one hand, as differences between the specifications in the ETS and on the part of the IPCC, and, on the other, as the result of methodological changes made between ETS trading periods. During the inventory review (ICR 2016), graphic comparisons were successfully used to show that the discrepancies, which are of methodological origin, provide no grounds to doubt the quality of the inventories' data.

The IPCC default factors used are suitable for the country-specific method.

The comparison with the emissions-trading figures for process-related emissions showed good agreement.

4.2.2.5 Category-specific recalculations (2.A.2)

No recalculations are required.

4.2.2.6 Planned improvements, category-specific (2.A.2)

No category-specific improvements are planned.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.2.3 Mineral products: Glass production (2.A.3)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.A.3. Mineral Products: Glass Production	Production of various types of glass	CO ₂	780.5	0.06%	919.8	0.10%	17.9%
Gas		Method used	Source for the activity data		Emission factors used			
CO ₂		Tier 2	AS		CS			
NO _x , NMVOC, SO ₂		Tier 2	AS		CS			

The category *Mineral products: Glass production* is not a key category.

4.2.3.1 Category description (2.A.3 Glass production)

Germany's glass industry produces a wide range of different glass types with different chemical compositions. Germany's glass sector comprises the following sub-sectors: container glass, flat glass, domestic glass, special glass and mineral fibres (glass and stone wool). The sub-sectors with

the highest production shares are container glass (accounting for about half of total glass production) and flat glass (about one-fourth of total glass production) (BV Glas, 2016a). The inventory calculations do not include the category "water-glass production". All relevant soda-ash quantities for water-glass production are taken into account in 2.A.4.b (Chapter 4.3.7).

In production, homogeneous glass mixtures combining primary and secondary raw materials are melted down at temperatures between 1,450 °C and 1,650 °C. The process-related CO₂ emissions under consideration here are released from the raw-material carbonates during the melting process in the furnace. CO₂ emissions – in small amounts – also occur in neutralisation of HF, HCl and SO₂ in exhaust gases, with the help of limestone or other carbonates. Because the amounts involved are so small, these emissions are not considered here.

The following table shows the trends, since 1990, in activity data, process-related CO₂ emissions and the implied emission factors resulting for all glass types overall.

Table 179: Activity data and process-related CO₂ emissions since 1990; IEF covering all glass types

Year	Activity data [t]	Process-related CO ₂ emissions [t]	IEF for all glass types [t CO ₂ / t Glas]
1990	6,561,849	780,480	0.119
1991	7,202,807	821,376	0.114
1992	7,228,752	810,610	0.112
1993	7,074,837	778,104	0.110
1994	7,760,000	747,225	0.096
1995	7,621,300	881,306	0.116
1996	7,519,600	853,395	0.113
1997	7,392,000	833,771	0.113
1998	7,314,000	803,411	0.110
1999	7,442,239	822,236	0.110
2000	7,505,000	846,300	0.113
2001	7,293,000	846,289	0.116
2002	7,084,000	800,501	0.113
2003	7,205,720	788,726	0.109
2004	7,088,900	791,150	0.112
2005	6,948,400	802,746	0.116
2006	7,285,600	842,228	0.116
2007	7,535,300	829,060	0.110
2008	7,513,900	824,868	0.110
2009	6,784,100	745,664	0.110
2010	7,163,600	828,828	0.116
2011	7,341,600	835,138	0.114
2012	7,079,700	823,341	0.116
2013	7,255,900	860,111	0.119
2014	7,458,900	891,901	0.120
2015	7,432,800	919,847	0.124

It is clear that emissions tend to follow the trend in activity data. At the same time, the implied emission factors indicate that the correlation is not rigid; some discrepancies do occur. The discrepancies are due to annual fluctuations in production quantities of various individual glass types, and in cullet inputs. They are thus logical and calculatory correct.

Emissions of "precursor substances," which also occur in connection with glass production, are not discussed in the present context. Due to limitations in the UNFCCC software, they cannot be reported in the present category, however; they are reported in Chapter 4.2.7.

4.2.3.2 Methodological issues (2.A.3 Glass production)

The CO₂ emissions (the main pollutant) are calculated via a Tier 2 method, because the detailed activity data are tied to specific emission factors (that are in keeping with the relevant carbonate concentrations). The following carbonates are taken into account as the main sources of CO₂ formation during the melting process: Calcium carbonate (CaCO₃), soda ash / sodium carbonate (Na₂CO₃), magnesium carbonate (MgCO₃) and barium carbonate (BaCO₃). In the present context, the CO₂ emissions from all carbonates are reported as a sum; inputs of raw-materials – soda ash – are considered under 2.A.4.b (cf. 4.2.5). Here, it should be noted that the calculated soda-ash-input quantities cannot be published, because data on soda ash production (cf. 4.2.5.2) are subject to statistical confidentiality and may not be derivable from balance sheets.

The production figures (**activity data**) are taken from the regularly appearing annual reports of the Federal Association of the German Glass Industry (Bundesverband Glasindustrie)(BV Glas, 2016a). "Production" refers to the amount of glass produced, which is considered to be equivalent to the amount of glass melted down. It must be remembered that a fraction of the molten glass, corresponding to the quantity of internal cullet, is not included in production statistics (see also the remarks below regarding cullet inputs). As a result, the figures given in the statistics correspond not to the actual quantities of molten glass involved, but to the molten-glass quantities consisting of primary raw materials and external cullet. Further processing and treatment of glass and glass objects are not considered.

The following activity data were determined for 2015:

Table 180: Glass: Activity data for the various industry sectors (types of glass)

Industry sector	Activity data for 2015 [t]
Container glass	3,934,100
Flat glass	2,138,700
Glass fibre and wool	349,400
Special glass	350,400
Stone wool	613,500
Domestic glass	46,700

Source: (BV Glas, 2016a)

The following sector-specific cullet percentages are assumed:

Table 181: Cullet percentages for the various types of glass

Industry sector	Cullet percentage [%] in the input raw material
Container glass	59 – 65 (annually varying)
Flat glass	10 (entire time series)
Domestic glass	5 (entire time series)
Special glass	5 (entire time series)
Glass fibre and wool	40 (entire time series)
Stone wool	40 (entire time series)

Source: (Gitzhofer, Bergmann, & Petermann, 2008) and surveys of BV Glas (BV Glas, 2016b)

The cullet percentage for container glass is known only for the western German Länder as of 1990. For Germany as a whole, it is known for the period since 1995. No data are available for the new German Länder for the period from 1990 to 1994. For that reason, an average cullet percentage

input was estimated on the basis of the various glass sectors' average percentages of total glass production. In 2007, the firm of Gesellschaft für Glasrecycling und Abfallvermeidung mbH (GGA) was forced to cease operations, under cartel law. As a result, no reliable cullet-input data have been available from that source since 2007. Since 2012, the Federal Association of the German Glass Industry (BV Glas) has provided data, from association surveys, on cullet inputs in the container-glass industry for the period as of 2007 (BV Glas, 2016b). The various sectors' cullet fractions contain only external cullet, since internal cullet is not included in production statistics, which are the basis for the relevant activity data. The total cullet fraction in vats can be considerably larger when internal cullet is involved.

Since the exhaust gases occurring during the melting process are drawn off together with combustion-related exhaust gases – i.e. as a collective exhaust-gas stream – measurements cannot be used to determine the CO₂ quantities produced by the German glass industry. For this reason, a calculation procedure is used that is based on the weight shares for the aforementioned carbonates and on cullet input in the container-glass and flat-glass industry. Figures on the chemical composition of the various types of glass produced in Germany have been taken from VDI-Richtlinie (guideline) 2578 (VDI, 1999) and from the ATV-DVWK Merkblatt (standards sheet of the German Association for Water, Wastewater and Waste) 374 (ATV, 2004).

The procedure used to determine **emission factors** for the various glass oxides involved and the pertinent emissions is described in detail in the 2007 NIR (Chapter 4.1.7.2, p. 251ff).

The emission factors below were calculated for the various industry sectors. The factors vary annually in keeping with variations in cullet inputs (ranges are given for container glass).

Table 182: CO₂-emission factors for various glass types (calculated in comparison with figures from the 2006 IPCC Guidelines)

Glass type	Calculated emission factor [kg CO ₂ / t molten glass] - stoichiometric / incl. cullet input-			Default emission factors [kg CO ₂ / t molten glass] – pursuant to 2006 IPCC Guidelines (Vol. 3, Tab. 2.6) –		
Container glass	193	/	49 – 86*			210
Flat glass	208	/	187			210
Domestic glass	120	/	114			100
Special glass	113	/	107	30	-	200
Glass fibre	198	/	119	190	-	250
Stone wool	299	/	179			-
Unspecified	174	/	139			-

* Most recently, 83 kg CO₂ per t of molten glass

4.2.3.3 Uncertainties and time-series consistency (2.A.3 Glass production)

The production data have been taken from the internal statistics of the Federal Association of the German Glass Industry (BV Glas). Since that association represents nearly all of Germany's container-glass and flat-glass manufacturers, the sectoral data it provides are highly accurate. An uncertainty of 5 % was thus assumed. The association's representation of all other glass sectors is incomplete, and thus the association cannot guarantee the completeness of the data for such other sectors. For this reason, an uncertainty of 10 % was assumed for those areas. Until about 2002, BV Glas also cross-checked the data against data of the *Federal Statistical Office*.

The uncertainty in the cullet figures for container glass lies within the customary range for statistical determinations. For the new German Länder, an uncertainty of 20 % has been assumed, because no statistical survey has been carried out; only an estimate is available. Use of data from

the association's own internal surveys, relative to cullet use as of 2007, increases the uncertainties. For example, surveys take account only of production sites' internal cullet and external container-glass cullet, and do not cover any quantities of flat glass that may be used in container-glass production.

The figures on cullet use for all other glass types are considerably less precise, however, since only estimates are available for those areas. An uncertainty of 20 % was thus assumed.

For the CO₂ emission factors, an uncertainty of 14 % is used in the case of container glass, and a figure of 22 % is used for all other types of glass.

4.2.3.4 Category-specific quality assurance / control and verification (2.A.3 Glass production)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The calculated emission factors were compared with several different sources, including the IPCC Guidelines (IPCC, 2006) and the "Baden-Württemberg 2004 emissions declaration" ("Emissionserklärung 2004 Baden-Württemberg"; UMEG 2004), an emission-factor manual. According to that comparison, the calculated emission factors may be considered accurate. In addition, the IEF was compared with those of the following countries, which also consider soda ash use only as an integrated part of glass production, i.e. do not consider such use separately: Austria (0.10), Italy (0.11) and the Netherlands (0.13). These values are comparable to the German IEF for the glass industry (which fluctuates around 0.1).

The calculated emissions were also cross-checked against the ETS data for Germany. This showed that the calculated emissions were about 3% higher than the emissions pursuant to ETS. This can be attributed to the incomplete sector coverage in the ETS.

The information provided regarding the chemical composition of the various glass types continues to be considered correct in the present context. The applicable rate of cullet input, for which the data still need to be improved (cf. Chapter 4.2.3.3), has considerable influence in this regard.

4.2.3.5 Category-specific recalculations (2.A.3 Glass production)

Minimal category-specific recalculations were carried out in the activity data for the year 2014, to take account of final production figures provided for that year by the Federal Association of the German Glass Industry (BV Glas).

4.2.3.6 Planned improvements, category-specific (2.A.3 Glass production)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.2.4 Mineral products: Ceramics (2.A.4.a)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.A.4. Mineral Products: Other process uses of carbonates	0	CO ₂	867.2	0.07%	465.4	0.05%	-46.3%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1	NS	CS
NO _x , NMVOC, SO ₂	Tier 1	NS	CS

The overarching category 2.A.4 – *Mineral products: Other uses of carbonates* is not a key category.

4.2.4.1 Category description (2.A.4.a Ceramics)

The process-related emissions determined for the ceramics industry originate in the following sub-categories:

1. "Production of ceramic products": This time series shows the production output (expressed as quantities) of the entire ceramics industry in Germany. The non-CO₂ emissions for the entire ceramics industry are calculated via these activity data. Process-related CO₂ emissions, on the other hand, are calculated only for the sub-quantities "roof tiles" and "masonry bricks" (see below).
2. "Brick production" (CO₂); "roof tile" product: Production of roof tiles is a subset of the aforementioned activity data for the entire ceramics industry. It is used only for calculation of process-related CO₂ emissions (with consideration of the applicable proportions for limestone and for organic impurities).
3. "Brick production" (CO₂); "masonry brick" product: Production of masonry bricks is also a subset of the aforementioned activity data for the entire ceramics industry. This production figure is also used only for calculation of process-related CO₂ emissions (with consideration of porosity agents, as well as of the applicable proportions for limestone and for organic impurities in the pertinent raw materials).

Table 183: Activity data and process-related CO₂ emissions in the ceramics industry (CRF 2.A.4.a)(rounded, and thus possibly with discrepancies between individual figures and the total)

	Total	Ceramics products		Process-related CO ₂ emissions		
		of which, masonry bricks	of which, roof tiles	Masonry bricks	Roof tiles	Total
				[kt]		
1990	21,595	16,524	1,758	481	50	531
1991	20,772	15,691	1,946	457	56	512
1992	22,769	17,302	2,216	503	63	567
1993	24,534	18,827	2,349	548	67	615
1994	30,458	23,925	2,611	696	75	771
1995	24,730	18,827	2,466	548	71	618
1996	22,663	16,965	2,598	494	74	568
1997	22,939	17,298	2,521	503	72	575
1998	22,798	17,048	2,658	496	76	572
1999	22,395	16,591	2,849	483	81	564
2000	21,199	15,383	2,924	448	84	531
2001	18,003	12,771	2,642	372	76	447
2002	16,500	11,686	2,381	340	68	408
2003	16,443	11,631	2,383	338	68	407
2004	16,796	11,697	2,601	340	74	415
2005	14,643	9,881	2,485	288	71	359
2006	16,019	10,883	2,648	316	76	392
2007	16,035	10,885	2,618	317	75	392
2008	13,867	9,302	2,254	271	64	335
2009	11,505	7,909	1,919	227	55	282
2010	12,653	8,463	2,179	246	62	308
2011	13,860	9,377	2,286	273	65	338
2012	13,409	9,233	2,118	269	61	330
2013	13,247	9,281	1,962	270	56	326
2014	13,074	9,082	2,001	264	57	321
2015	12,806	8,981	1,895	261	54	315

4.2.4.2 Methodological issues (2.A.4.a Ceramics)

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories 2006 contain information for calculation of process-related CO₂ emissions for the ceramics industry (IPCC 2006: Volume 3, Chapter 2.5.1 "Ceramics"). In general, the following product groups are normally allocated to this

industrial production sector: roof tiles and masonry bricks, stoneware pipes, refractory products, expanded clay, wall and floor tiles, household ceramics, sanitary ceramics, technical ceramics, inorganic bonded abrasives. For purposes of the national inventory, only estimates relative to production of roof tiles and masonry bricks have been carried out to date. This results from the important quantities of such products that are produced, and from the limited availability of data for the sector.

The CO₂ emissions in these sub-areas are calculated via a Tier 1 method, because no detailed data are available and because this category is not a key category.

Activity data

Official statistics are of limited use in determining actual production trends in the brick and tile industry, in terms of weights, since such statistics list masonry-brick production in cubic metres and roof tiles in numbers of tiles. Produced weight quantities can be determined only via conversion factors. The conversion factors used for masonry bricks and roof tiles consist of values obtained by the Bundesverband der Deutschen Ziegelindustrie (association of the German brick and tile industry) from experience.

Emission factors

Process-related CO₂ emissions originate in the raw materials for production of roof tiles and masonry bricks (normally, locally available loams and clays with varying concentrations of CaCO₃ (limestone) and, in some cases, with organic impurities). On the basis of information from the association of the German brick and tile industry (Bundesverband der deutschen Ziegelindustrie), an emission factor of 28.6 kg / t_{product} is assumed for process-related CO₂ emissions from CaCO₃ and organic impurities in raw materials. That figure corresponds to a mean CaCO₃ fraction of 65 kg/t in the raw meal.

Porous masonry bricks account for about half of all masonry bricks produced in Germany. They are produced by adding organic porosity agents to the raw materials. When the bricks are fired, these agents burn, creating hollows. Most of the porosity agents used are renewable resources (such as sludges from the paper industry, and spent liquors from pulp production). Non-renewable substances (especially polystyrene) are also used, however. The resulting CO₂ emissions are minimal by comparison to those from the limestone fractions in the raw materials. Nonetheless, they are taken into account in the inventory via a slightly higher CO₂-emission factor for masonry bricks (29.1 kg CO₂/t masonry bricks, as opposed to 28.6 kg CO₂/t for roof tiles).

The determined activity data and resulting CO₂ emissions are shown in Table 183. The process-related CO₂ emissions for this sub-category, at considerably less than one million tonnes of carbon dioxide, are not particularly important.

4.2.4.3 Uncertainties and time-series consistency (2.A.4.a Ceramics)

Due to the need for conversion of area and volume figures into produced quantities, the uncertainty for the three sets of activity data is estimated at +/- 20 %; no other uncertainty factors are relevant.

The uncertainties for the **CO₂-emission factors** used for production of masonry bricks and roof tiles are determined primarily by the uncertainty relative to the CaCO₃ quantities contained in the raw materials (+/- 30 %).

The time series are consistent for activity data for production of masonry bricks and roof tiles, and the related CO₂-emission factors are consistent as well. Some changes have occurred, throughout the time series, in availability of statistics for various product types. These changes accounted for

only about 1 % of the amounts of bricks produced, and for less than 0.5 % of total ceramics production, however.

The **activity data** for total ceramics production contain a methodological discontinuity that results from a substantial change in the available statistical data. For masonry bricks and roof tiles, figures in thousands of t were available until 1994. As of 1995, the figures are only in thousands of m³ or thousands of units (piece count). In the 2007 NIR, the relevant impacts are discussed in detail. On the other hand, the methods discontinuity is irrelevant with regard to CO₂ emissions.

4.2.4.4 Category-specific quality assurance / control and verification (2.A.4.a Ceramics)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The data from greenhouse-gas-emissions trading cannot be compared directly with relevant emissions data from the National Inventory. The reason for this is that, in emissions trading, installations (plants) are included and grouped in accordance with threshold values, and thus data are available for only part of the ceramics industry – and only for some brick and roof-tile producers.

4.2.4.5 Category-specific recalculations (2.A.4.a Ceramics)

No recalculations are required.

4.2.4.6 Planned improvements, category-specific (2.A.4.a Ceramics)

No category-specific improvements are planned.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.2.5 Non-metallic minerals industry: other soda ash use (2.A.4.b)

4.2.5.1 Category description (2.A.4.b)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1	NS	D

The overarching category 2.A.4 – *Mineral products: Other uses of carbonates* is not a key category.

Soda ash is used in a wide range of industrial applications. The most important areas of use include the glass industry, production of detergents and cleansers and the chemical industry. It is assumed that the carbon contained in soda ash is released sooner or later, regardless of the use involved, into the air as CO₂.

Emissions resulting solely from use of soda ash correlate in a fixed way to the pertinent calculated quantities used – in this context, outside of the glass industry (cf. the methodological issues in the following chapter):

Table 184: Activity data and use-related CO₂ emissions outside of the glass industry, since 1990

Year	Activity data [t]	CO ₂ emissions [kt]
1990	809,885	336.1
1991	587,756	243.9
1992	402,053	166.9
1993	379,687	157.6
1994	429,884	178.4

Year	Activity data [t]	CO ₂ emissions [kt]
1995	340,793	141.4
1996	336,440	139.6
1997	387,823	160.9
1998	452,848	187.9
1999	394,164	163.6
2000	411,281	170.7
2001	490,469	203.5
2002	437,769	181.7
2003	529,515	219.7
2004	500,956	207.9
2005	517,159	214.6
2006	484,871	201.2
2007	550,966	228.7
2008	538,477	223.5
2009	457,076	189.7
2010	528,885	219.5
2011	587,144	243.7
2012	516,444	214.3
2013	591,149	245.3
2014	584,961	242.8
2015	361,021	149.8

Source: Calculations of the Federal Environment Agency (UBA); for pertinent derivation, cf. the following chapter

4.2.5.2 Methodological issues (2.A.4.b)

Activity data

Since the 2010 inventory review, those soda ash inputs are determined that are not taken into account, for emissions calculations, in other categories. The relevant calculations are oriented to the greatest possible emissions from the applicable soda ash use. The total quantity of soda ash used in Germany is determined via balancing (quantity produced plus imports and less exports) (a). The relevant import and export quantities are taken from the foreign-trade statistics of the Federal Statistical Office (STATISTISCHES BUNDESAMT, 2015). Emissions from soda ash use in the glass industry are already taken into account, category-specifically, under category 2.A.3 (b). The soda ash quantities used in that category are deducted from the soda ash use of relevance in the present section. The activity data in the above table (c) have been obtained in accordance with the following formula:

$$c = a \text{ minus } b$$

Emission factor

Stoichiometrically, the emission factor for soda ash use is 415 kg CO₂ per tonne of soda ash, under the assumption that release is complete (a conservative approach).

4.2.5.3 Uncertainties and time-series consistency (2.A.4.b)

Activity data

The calculations of the relevant quantities of soda ash used exhibit large uncertainties (maximally, -18%/+18%), as a result of statistical fluctuations and of the calculatory assumptions on which the above derivation is based.

Emission factor

The emission factor for soda ash use is subject to small, explained uncertainties in the area of product purity and the completeness of the chemical transformations involved (-5%/+0%).

4.2.5.4 Category-specific quality assurance / control and verification (2.A.4.b)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook. Due to a lack of assigned expert resources, it was not possible to have source-category experts carry out QA/QC for the area "use of soda ash / sodium carbonate". Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

It is not possible at present to verify quantitatively the input quantities of soda ash that cannot be allocated to the glass industry. The pertinent estimates are conservative, however; they do not underestimate the quantities of relevance for the inventory. Qualitatively, the pertinent calculation results do not contradict the sales figures of soda-ash producers obtained on a sample basis.

The stoichiometric emission factor is in keeping with the default figures given in the IPCC Guidelines (IPCC, 2006: Volume 3, Chapter 2, Table 2.1).

4.2.5.5 Category-specific recalculations (2.A.4.b)

Only slight recalculations, for the year 2013, were required, as a result of changes in data rounding and of recalculations, for the year 2014, tied to updating of glass-industry production figures.

4.2.5.6 Planned improvements, category-specific (2.A.4.b)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.2.6 Production of non-metallurgical magnesium products (2.A.4.c)

4.2.6.1 Category description (2.A.4.c)

The greenhouse-gas emissions from this category amount to less than 0.05 % of the total inventory (not including LULUCF), and they are less than 500 kt CO₂-equivalents. What is more, relevant annual surveys cannot be assured (pursuant to FCCC/SBSTA/2013/L.29/Add.1, para 37). For this reason, we are not reporting on this area. The present chapter thus presents a one-time quantitative estimation of the emissions that are not covered by the inventory as a result. In addition, a compilation of all sources listed as "not estimated" is presented in Annex 5 in Chapter 21 of the present report.

4.2.6.2 Methodological issues (2.A.4.c)

It was not possible to identify any suitable activity data for this category segment in the official statistics. Some product types, such as refractory bricks, are already included in the activity data for the ceramics industry (CRF 2.A.4.a, Chapter 4.2.4). The additionally identified category "production of other carbonates" is a collective in which magnesium carbonates are a non-quantifiable sub-quantity. The resulting time series shows only production quantities less than 300,000 t. The lowest threshold for inclusion would be about one million tonnes of a product with large fractions of CaO and MgO. That production threshold is not achieved with any relevant product type. This also applies to the product types already included in other categories.

Because the pertinent statistics contain collective categories, the potential CO₂ emissions cannot be precisely calculated. They are estimated to be considerably less than 100,000 t of carbon dioxide.

4.2.6.3 Uncertainties and time-series consistency (2.A.4.c)

No conclusions relative to uncertainties and time-series consistency can be drawn.

4.2.6.4 Category-specific quality assurance / control and verification (2.A.4.c)

Due to resources limitations, and to the area's minimal relevance, no QC/QA has been carried out for reporting in this area.

An initial relevant estimate was made in the framework of a research project. It was then reviewed by the specialised contact person within the Federal Environment Agency (UBA) and confirmed in the above-described manner.

4.2.6.5 Category-specific recalculations (2.A.4.c)

Recalculations are not considered here, due to the fact that the relevant emissions are not listed.

4.2.6.6 Planned improvements, category-specific (2.A.4.c)

No further activities are planned.

4.2.7 Non-metallic minerals industry: other limestone and dolomite use (2.A.4.d)

4.2.7.1 Category description (2.A.4.d)

This category's carbon-dioxide emissions are not reported separately; instead, they are reported in the sections for the categories that use limestone and dolomite (they are thus included elsewhere – IE). In the relevant categories, they are also taken into account in key-category analysis.

Emissions of the precursor substances SO₂, NO_x and NMVOC are reported in this category whenever the UNFCCC's 'CRF Reporter Inventory Software' does not permit them to be entered in sub-categories. Specifically, the pertinent emissions include the following:

- NO_x and NMVOC from 2.A.1, 2.A.2 and 2.A.3,
- SO₂ from 2.A.2 and 2.A.3, including a statistical figure for the territory of the "New German Länder" (states) in 1990.
- As a result of this allocation, no figures for pertinent activities can be given in the CRF tables.

All other precursor substances are reported in the categories to which the emissions are assigned (no restrictions in the CRF-Reporter software apply).

Until the 2014 Submission, and in supplementation to the requirements set forth in the 1996 IPCC Guidelines, in this category all production and use of limestone and dolomite were considered in balance form, and the results were compared with the inventory categories. This "limestone balance" appeared most recently in the 2014 NIR.

No findings are available regarding use of limestone in emissions-relevant sectors other than the categories listed below.

4.2.7.2 Methodological issues (2.A.4.d)

The following section provides an overview of national limestone inputs (source-category references). Emissions calculations are carried out for those categories in which CO₂ emissions are produced via limestone use:

- 1.A.1.a Flue-gas desulphurisation in power stations (limestone inputs)
- 2.A.1 Cement-clinker production (limestone fraction in the relevant raw materials)
- 2.A.2 Limestone production (limestone inputs)
- 2.A.3 Glass production (limestone fraction in the relevant raw materials)
- 2.A.4.a Ceramic-brick production (limestone fraction in the relevant raw materials)
- 2.B.7 Soda ash production (limestone inputs)
- 2.C.1 Iron and steel production (limestone inputs and lime kilns)
- 2.H.2 Lime kilns in sugar production (limestone inputs)
- 3.G Soil liming in agriculture and forestry

The pertinent data are updated in the relevant categories (cf. the above list). In addition, pertinent methodological aspects are explained in the relevant category chapters.

4.2.7.3 Uncertainties and time-series consistency (2.A.4.d)

Information regarding uncertainties for activity data and emission factors for the relevant limestone uses is provided in the relevant category chapters.

4.2.7.4 Category-specific quality assurance / control and verification (2.A.4.d)

General quality control and quality assurance, in keeping with the requirements of the QSE manual and its associated documents, have been carried out in those categories into which category 2.A.4.d leads.

The activity data and the emission factors for the relevant limestone uses are verified and updated in the relevant categories.

4.2.7.5 Category-specific recalculations (2.A.4.d)

Recalculations have been carried out in the relevant categories.

4.2.7.6 Planned improvements, category-specific (2.A.4.d)

No improvements, and no annual updating of the limestone balance sheet, are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.3 Chemical industry (2.B)

Category 2.B is divided into the sub-categories 2.B.1 through 2.B.10. These include ammonia production (2.B.1), nitric acid production (2.B.2), adipic acid production (2.B.3), caprolactam, glyoxal and glyoxylic acid production, (2.B.4), carbide production (2.B.5), titanium dioxide production (2.B.6), soda ash production (2.B.7), petrochemical and carbon black production (2.B.8) and production of fluorinated chemicals (2.B.9).

In the category *Other* (2.B.10), only precursor substances from production of fertilisers and sulphuric acid are reported. Production of dodecanedioic acid is described in 2.B.10, while process-related N₂O emissions are reported under 2.G.3, for reasons of confidentiality.

4.3.1 Chemical industry: Ammonia production (2.B.1)

4.3.1.1 Category description (2.B.1)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/-	2.B.1 Chemical Industry	Ammonia production	CO ₂	6,025.0	0.49%	4,135.0	0.47%	-31.4%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 3	PS	PS
NO _x			D

The category *Chemical industry: ammonia production* is a key category for CO₂ emissions in terms of emissions level.

Ammonia is produced on the basis of hydrogen and nitrogen, using the Haber-Bosch process, which also forms CO₂. Hydrogen is produced from synthetic gas (usually) based on natural gas, via a highly integrated process, *steam reforming*, while nitrogen is produced via air dissociation.

The various plant types for the production of ammonia cannot be divided into individual units and be compared as independent process parts, due to the highly integrated character of the procedure. In *steam reforming*, the following processes 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*, carried out under mild conditions in a fired primary reformer, and with secondary splitting with excess air (sub-stoichiometric H/N ratio)
- 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 procedure is also used:

- Partial oxidation – gasification of natural gas, fractions of heavy mineral oil or vacuum residues in production of synthetic gas.

As of mid-2014, ammonia is being produced in Germany at only four locations. The production operations use both the steam-reforming and partial-oxidation processes.

The production decrease of more than 15 % (corresponding to an amount of nearly 300 kt) in the first year after German reunification was the result of a market shake-up, 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. It has not been possible to determine the reason for the renewed growth as of 1995, which returned production to the level seen in 1990. However, the growth could be due to resumption of production processes in the new German Länder, following extensive modernisations. Since 1995, production levels have fluctuated only slightly. The nearly 8% production decrease that occurred in 2009 was due to the global economic crisis. Until 2013, the IEF was higher than that of other countries, since in Germany heavy fuel oil is used for partial oxidation, in addition to natural gas. Heavy fuel oil produces significantly higher CO₂ emissions than natural gas does. Since mid-2013, partial oxidation has been carried out primarily with natural gas. In addition, sizable quantities of CO₂ are being captured and processed into urea for use in AdBlue, as well as for use as fertilizer. As a result, the IEF no longer differs significantly from those of other countries.

4.3.1.2 Methodological issues (2.B.1)

In keeping with this category's classification as a key category for CO₂ emissions, since the 2010 report the emissions data for this category have been collected and reported pursuant to Tier 3, apart from the data for one plant. Until 2012, those data were obtained pursuant to the Tier 2 method; a default figure for carbon content was used. As of 2013, all plant data have been obtained pursuant to the Tier 3 method. This is being carried out on the basis of a co-operation agreement with the relevant plant operators for delivery of plant-specific data.

The operators transmit their plant-specific data to the Industrieverband Agrar (IVA) agrochemical industry association. That association anonymises the data, for reasons of confidentiality, and then transmits it, in plant-specific form, to the Federal Environment Agency (UBA). The Federal Environment Agency carries out quality assurance and then aggregates the data.

The plant operators report:

- the ammonia quantities produced (**activity data**),
- the quantities of raw materials used in the process (natural gas, heavy mineral oil), less the pertinent fuel quantities used for energy purposes and so reported in the Energy Balance (TFR_i),
- the raw materials' carbon content factor (CCF_i) and carbon oxidization factor (COF_i),
- the quantity of CO₂ that undergoes further processing (R_{CO2}), and the purpose for which it is used.

CO₂ emissions:

The CO₂ emissions are calculated in keeping with Equation 3.3 in the 2006 IPCC Guidelines:

$$E_{CO_2} = \sum (TFR_i * CCF_i * COF_i * 44/12 - R_{CO_2})$$

The recovered quantity of CO₂ that is used in other production processes – such as urea production – (and is reported in connection with those other processes) is not included in the non-reported emissions.

The carbon content in natural gas and heavy fuel oil is determined by the four producers in the following manner:

As of 2013, all ammonia plants are subject to emissions trading requirements. As a result, all plants meet emission-trading requirements pertaining to determination of carbon content.

One producer uses a standard factor that has been obtained via ongoing operational analysis (C content = 86.1 % by weight). Until 2013, a second producer used the IPCC default value for natural gas. For the other gases – the gas mixtures used – that producer determined the applicable C content levels analytically, on the basis of the C content levels of the individual gases contained and their quantity shares of the mixtures. In two cases, producers use the data provided by the relevant natural gas suppliers.

Emission factor for NO_x:

For the NO_x emission factor, the default emission factor given in the *CORINAIR Guidebook*, 1 kg/t NH₃, is used (EMEP EEA Emission Inventory Guidebook, TFEIP-endorsed draft, May 2009).

4.3.1.3 Uncertainties and time-series consistency (2.B.1)

The uncertainties figures provided by the operators are aggregated by the Federal Environment Agency, in keeping with Equation 3.2 (2006 IPCC Guidelines, Vol. 1, Ch. 3), and entered into the system.

The uncertainty for the activity data is $\pm 0.6\%$. The uncertainty for the emissions is $\pm 1\%$.

4.3.1.4 Category-specific quality assurance / control and verification (2.B.1)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

4.3.1.5 Category-specific recalculations (2.B.1)

No recalculations have been carried out.

4.3.1.6 Planned improvements, category-specific (2.B.1)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.3.2 Chemical industry: Nitric acid production (2.B.2)

4.3.2.1 Category description (2.B.2)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	2.B.2. Chemical Industry	Nitric acid production	N ₂ O	3,258.5 ^e	0.27%	503.6 ^e	0.06%	-84.5%
Gas		Method used		Source for the activity data		Emission factors used		
N ₂ O		Tier 3		PS		PS		

The category *Chemical industry: Nitric acid production* is a key category for N₂O emissions in terms of emissions level and trend.

In production of nitric acid, nitrous oxide occurs in a secondary reaction. In Germany, there are currently nine nitric acid production plants.

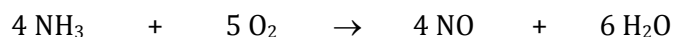
HNO₃ production occurs in two process stages:

- **Oxidation** of NH₃ to NO and
- **Conversion** of NO to NO₂ and **absorption** in H₂O.

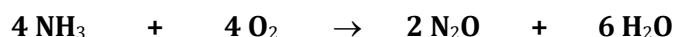
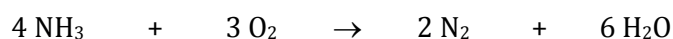
Details of the process are outlined below:

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 relevant reaction, according to the Ostwald 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.

4.3.2.2 Methodological issues (2.B.2)

In keeping with the 2006 IPCC Guidelines, nitric-acid production is now reported plant-specifically, in accordance with the Tier 3 standard. This is being carried out on the basis of a co-operation agreement with the relevant plant operators for delivery of plant-specific data. Through the 2014 reporting round, six operators sent data to the Industrieverband Agrar (IVA) industrial association. After carrying out quality assurance, the IVA aggregated the data, to protect confidentiality, and then transmitted the so-aggregated data to the Federal Environment Agency (AD and EF). One company sent its data (AD, EF, N₂O emissions and information about any reduction equipment used) directly to the Federal Environment Agency. After carrying out quality assurance, the Federal Environment Agency then aggregated that company's data with the data provided by the IVA and entered the resulting so-aggregated data into the CSE emissions database.

The relevant cooperation agreement was adapted for the new commitment period and in keeping with the new 2006 IPCC Guidelines. The Federal Environment Agency now receives the plant-specific data for the six operators, for a total of seven plants, in anonymised form, via IVA. The seventh operator continues to transmit his data directly to the Federal Environment Agency. Since 2000, an additional plant has been producing nitric acid. For the 2017 report, the activity data and the emissions for that one plant were estimated, since the work leading to a pertinent cooperation agreement has not yet been completed.

The plant operators report:

- the quantities of nitric acid produced (**activity data**);
- the EF;
- the N₂O emissions measured in the raw gas;
- where emissions-reduction equipment is used, the N₂O emissions measured in the emissions-reduced exhaust gas;
- the uncertainties for the activity data, the emission factor and emissions reductions.

The emissions-control technologies used include, in some cases, catalytic decomposition directly following ammonia combustion.

Until 2006, production quantities correlated with the N₂O emissions. Subsequently, a considerable decoupling of production quantities and N₂O emissions has become apparent that is due to use of emissions-reduction equipment.

NO_x emission factor:

For the NO_x emission factor, the default emission factor given in the *CORINAIR Guidebook*, 10 kg/t NH₃, is used (EMEP EEA Emission Inventory Guidebook, TFEIP-endorsed draft, May 2009).

4.3.2.3 Uncertainties and time-series consistency (2.B.2)

Activity data:

The activity-rate uncertainty has been determined by the Federal Environment Agency in keeping with Equation 3.2 (2006 IPCC Guidelines, Vol. 1, Ch. 3), on the basis of figures provided by the operators. The pertinent uncertainty is $\pm 1\%$.

Emission factor:

For the N₂O emission factor, the operators give an uncertainty of $\pm 5\%$.

4.3.2.4 Category-specific quality assurance / control and verification (2.B.2)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

4.3.2.5 Category-specific recalculations (2.B.2)

No recalculations have been carried out.

4.3.2.6 Planned improvements, category-specific (2.B.2)

In 2015, a new plant that produces nitric acid was identified. The Single National Entity is in the process of bringing that plant into the cooperation agreement.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.3.3 Chemical industry: Adipic acid production (2.B.3)

4.3.3.1 Category description (2.B.3)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	2.B.3. Chemical Industry	Adipic acid production	N ₂ O	18,076.7	1.48%	250.9	0.03%	-98.6%

Gas	Method used	Source for the activity data	Emission factors used
N ₂ O	Tier 3	PS	PS
NO _x , CO	NA	NA	NE

The category *Chemical industry: adipic acid production* is a key category for N₂O emissions in terms of emissions level and trend.

On an industrial scale, adipic acid is produced via oxidation of a mixture of cyclohexanol and cyclohexanone with nitric acid. In that reaction, considerable amounts of nitrous oxide (N₂O) are formed.

Until the end of 1993, the two sole German producers emitted all of their nitrous oxide directly into the atmosphere. One producer has since put into operation a system for thermal decomposition of nitrous oxide into nitrogen and oxygen. Decomposition takes place nearly completely. In 2009, a second, additional (i.e. redundant) thermal N₂O-decomposition facility was added. N₂O-decomposition rates of over 99% are now being achieved.

At the end of 1997, the other producer put a catalytic reactor system into operation that, in constant operation, achieves an N₂O-decomposition rate of 97-98 %. At the end of 2009, a second, redundant decomposition reactor was added.

Since 2010, N₂O emissions have decreased further, significantly, since the two producers have each installed a redundant waste-gas-treatment facility.

In March 2002, a third producer, with one plant, began production. That plant also uses the thermal N₂O-decomposition process. N₂O-decomposition rates of over 99% can now be achieved. That producer also has the option of using a redundant emissions-reduction system if his primary system should fail.

The overall fluctuations in the decomposition rates – and, thus, in the residual emissions – are the result of functional impairments in the emissions-control equipment, of planned interruptions in their operation and of variances in production volumes.

From 1990 to the present, production has nearly doubled, as a result of growth in demand.

4.3.3.2 Methodological issues (2.B.3)

Since 1990, N₂O emissions from adipic acid production have been calculated on the basis of plant-specific data.

In those years in which no systems for reducing nitrous oxide emissions were in operation, the two producers only provided production-quantity data. The nitrous oxide emissions for that period – until 1994, for one facility, and until 1997, for the second – were calculated with the IPCC default emission factor. The calculation of N₂O emissions for those years is in keeping with a Tier 2 approach. For the subsequent period, the producers continuously measured their nitrous oxide emissions and, in addition to providing data on production and on N₂O emissions, also provided the background information, on a confidential basis, that is needed to assess the precision of the reported data. The third producer has been measuring emissions continuously since 2013. Determination of N₂O emissions on the basis of continuous nitrous oxide measurement is in keeping with the Tier 3 method set forth in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Vol. 3, Ch. 3.4.2.1).

4.3.3.3 Uncertainties and time-series consistency (2.B.3)

For installations with thermal decomposition, the 2006 IPCC GL (Vol. 3, Tab. 3.4) give uncertainties for the N₂O-decomposition rate of +/- 0.5%; for installations with catalytic decomposition, they give uncertainties of +/- 2.5%.

According to producers' information, the uncertainties for the emissions, regardless of what reduction process is used, lie within a range of about +/-1 to 6%. The range for the uncertainties relative to production quantities is given as <0.1% to about 1%. The uncertainty for the EF is thus set at 6 %, while that for the production quantities is set at 2%.

4.3.3.4 Category-specific quality assurance / control and verification (2.B.3)

Due to a lack of relevant specialised staff, it was not possible to have quality control and quality assurance carried out, by category experts. This situation will be corrected as soon as the relevant person returns (normally, in connection with the next report). General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook. Data were collected, taken from previous years or determined on the basis of existing calculation routines.

Information provided by producers enjoys a high degree of confidentiality protection. For this reason, only emissions figures can be listed in the CRF tables. The reported emissions and activity data have been reviewed by a Federal Environment Agency expert and compared with industry figures and figures from other publications.

Two of the three producers have taken part in a JI project. The results of that project were compared with the inventory data, and the inventory data confirmed the project results.

4.3.3.5 Category-specific recalculations (2.B.3)

No recalculations are required.

4.3.3.6 Planned improvements, category-specific (2.B.3)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.3.4 Chemical industry: Caprolactam, glyoxal and glyoxylic acid (2.B.4)

4.3.4.1 Category description (2.B.4)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.B.4. Chemical Industry	Caprolactam, glyoxal and glyoxylic acid production	N ₂ O	221.8	0.02%	0.0	0.00%	-100.0%
Gas			Method used	Source for the activity data		Emission factors used		
N ₂ O			NA	NS		NA		

The category *Chemical industry: Caprolactam, glyoxal and glyoxylic acid* is not a key category.

Industrially, ε-caprolactam is the most important lactam. It is used primarily for production of PA 6. There are two producers in Germany.

Glyoxal is used in the production of a wide range of products. It serves to improve product properties. There is one producer. The process used by that producer for glyoxal production (oxidation of ethylene glycol during the gas phase) is not a source of process-related nitrous oxide emissions.

The producer reports that no glyoxal delivered to customers in Germany is processed into glyoxylic acid. We are not aware of any glyoxylic acid production in Germany from other raw materials.

4.3.4.2 Methodological issues (2.B.4)

Both producers use a synthesis pathway via hydroxylammonium sulfate (HAS), in the production of which ammonia is oxidised. Ammonia oxidation is the factor primarily responsible for the N₂O emissions in the production process.

Both producers also employ a thermal waste-gas treatment system to destroy nitrous oxide. Both producers' systems have a redundant design. The temperatures involved are much higher than the decomposition temperature of nitrous oxide. As a result, only very small quantities of emissions occur.

For one of the two producers, the pertinent N₂O emissions are assigned to nitric acid production (2.B.2), in the interest of consistency with emissions trading data. A Tier 3 reporting method is used. For that system, therefore, "IE" is entered under 2.B.4a in the CRF Table.

With regard to the other producer's installation, the Single National Entity has access to detailed information that indicates that the pertinent post-combustion system can be assumed to completely eliminate the nitrous oxide quantities involved. But since the operator of that system is not subject to measurement obligations, and in order to prevent any underestimation of nitrous oxide emissions from other emission sources, the N₂O emissions have been quantitatively estimated, on a one-time basis, using a Tier 2 method. For the estimate, the applicable production capacity was derived on the basis of press reports⁵², and the standard N₂O emission factor given

⁵² Inter alia BASF Press information P293/16 – "BASF richtet Caprolactam-Produktion in Europa" ("BASF sets up caprolactam production in Europe")

New in https://www.basf.com/documents/corp/de/news-and-media/news-releases/2016/09/P293_Neuausrichtung_Caprolactam_Produktion_Europa.pdf (Aufruf 15.03.2017)

by the 2006 IPCC-RL for caprolactam production (9 kg N₂O / t caprolactam, pursuant to Vol. 3, Chapter 3.5, Table 3.5), and standard factors for thermal waste-gas treatment in adipic acid production (98.5 % reduction rate, and 99.91 % capacity utilisation, pursuant to Vol. 3, Chapter 3.4, Table 3.4), were used. The capacity utilisation factor for the redundantly designed waste-gas-treatment system is obtained from the 97% capacity utilisation factor for the main installation, and the 97% factor for the second installation that is used for the 3% during which the main system cannot be used.

In using standard factors given by the IPCC-RL, Germany is following recommendations provided by the Expert Review Team for the 2016 In Country Review.

For the year 2015, the estimate is 10.7 kt CO₂ equivalents. Since the calculated N₂O emissions from the installation account for less than 0.05 % of the total inventory (not including LULUCF), and since they do not exceed 500 kt CO₂ equivalents (significance thresholds pursuant to FCCC/SBSTA/2013/L.29/Add.1), and since annual recording cannot be carried out (in keeping with FCCC/SBSTA/2013/L.29/Add.1, para 37), we opt not to report on this area (2006 IPCC Guidelines, 2006: Vol. 3, Ch. 3.5). In the CRF Table, the emissions from this installation are listed as "NE," under 2.B.4.a. In addition, a compilation of all sources listed as "not estimated" is presented in Annex 5 in Chapter 21 of the present report. In the CRF Table, the two installations are listed under 2.B.4.a, and marked as "IE" and "NE," respectively. That notation is in keeping with the information and recommendations provided in the In Country Review.

4.3.4.3 Uncertainties and time-series consistency (2.B.4)

For the activity data, an uncertainty of ± 30% is assumed. For the standard factors, the pertinent uncertainties given in the 2006 IPCC-GL apply.

4.3.4.4 Category-specific quality assurance / control and verification (2.B.4)

General quality control and quality assurance have been carried out by the Single National Entity. For the years 1995 through 2008, quantity data for ε-caprolactam production are available (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 3.1, Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe ("manufacturing industry, production in the manufacturing industry"). In 2009, the relevant product classification for production statistics – i.e. the classification on which the survey is based – was harmonised with the international NACE Rev.2 classification and the 2008 PRODCOM list. As a result, ε-caprolactam production quantities have not been listed individually since then. For this reason, as of the year 2009, the produced quantities of ε-caprolactam cannot be determined via statistical surveys. Consequently, no sources are available for verification of the information provided by producers in press reports. In foreign-trade statistics, ε-caprolactam continues to be listed separately. As a result, import-quantity data for the period since 1996, and export-quantity data for the period since 2009, are available. The import and export quantities have remained relatively stable.

4.3.4.5 Category-specific recalculations (2.B.4)

No recalculations are required.

4.3.4.6 Planned improvements, category-specific (2.B.4)

No further activities are planned.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.3.5 Chemical industry: Carbide production (2.B.5)

4.3.5.1 Category description (2.B.5)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.B.5. Chemical Industry	Carbide production	CO ₂	443.2	0.04%	7.2	0.00%	-98.4%
Gas		Method used		Source for the activity data		Emission factors used		
CO ₂		Tier 3		PS		PS (CaC ₂) NO (SiC)		

The category *Chemical industry: Carbide production* is not a key category.

During the reunification period, calcium carbide production took place primarily in the new German Länder. A short time later, production there was discontinued, while only one producer remained in the old German Länder. According to the responsible specialised association within the VCI, no silicon carbide has been produced in Germany since 1993. Emissions from this sector thus no longer occur.

4.3.5.2 Methodological issues (2.B.5)

Activity data:

Since Germany has only one producer, the relevant data must be kept confidential. The producer communicates the data directly to the Federal Environment Agency on an annual basis. The data, as of the data for 1997, were obtained from the operator's life cycle assessment and from his annual environmental declarations pursuant to the EMAS (the facility has been certified since 1997). The only published data consists of those for amounts produced in the former GDR. Those data were published, until 1989, by that country's central statistical authority. Those figures were used, in combination with existing estimates for 1991 and 1992, to interpolate production in the new German Länder in 1990.

Emission factor:

The stoichiometric emission factor for CO₂ is 688 kg per tonne of calcium carbide (44 g mol⁻¹ / 64 g mol⁻¹). Until 1992, this emission factor was used for production in the new German Länder.

Using covered furnaces, producers collect all of the carbon monoxide produced in the process and use it for energy generation. The resulting carbon dioxide serves as auxiliary material in production of calcium cyanamide and derived products. Reactions in these processes yield carbon dioxide in mineral form, as black chalk. In this form, it is used in agriculture. In 2012, carbide-furnace operations were smoothed out in a way that considerably reduced the amount of surplus furnace gas that had to be flared off. The new operational mode has also enabled the furnaces to run more "calmly", meaning that they produce fewer pressure surges that have to be buffered via raw-gas flares.

As a result, the emission factor for carbon dioxide from calcium carbide production is now substantially lower than it has been in previous years.

Upon request, the relevant producer provides the Federal Environment Agency with data on total emissions and on quantities produced. The emission factor is obtained as the product of activity data and emissions quantity.

4.3.5.3 Uncertainties and time-series consistency (2.B.5)

The uncertainties relative to the data provided by the producer are considered slight overall.

4.3.5.4 Category-specific quality assurance / control and verification (2.B.5)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Producers' relevant figures enjoy a high degree of confidentiality protection. For this reason, only emissions figures can be listed in the CRF tables. No calculations for verification could be carried out. It may be noted, however, that some of the figures have also been provided to licensing authorities and thus are considered trustworthy.

4.3.5.5 Category-specific recalculations (2.B.5)

No recalculations have been carried out.

4.3.5.6 Planned improvements, category-specific (2.B.5)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.3.6 Chemical industry: Titanium dioxide production (2.B.6)

There are several producers of titanium dioxide in Germany. One of the plants involved produces titanium dioxide via the chloride process. The others produce using the sulfate process, and emit no process-related CO₂. The estimate of the pertinent CO₂ emissions is an expert estimate. It has been made on the basis of the production capacity and of an emission factor that itself is based on an expert estimate. This estimate was made with confidential data that, by virtue of their confidentiality, cannot be presented here.

Since the greenhouse-gas emissions from the category titanium dioxide production account for less than 0.05 % of the total inventory (not including LULUCF), *and* since they would not exceed 500 kt CO₂ equivalents (significance thresholds pursuant to FCCC/SBSTA/2013/L.29/Add.1), and since annual recording cannot be assured (in keeping with FCCC/SBSTA/2013/L.29/Add.1, para 37), we opt not to report on this area (2006 IPCC Guidelines, 2006: Vol. 3, Ch. 3.7). In addition, a compilation of all sources listed as "not estimated" is presented in Annex 5 in Chapter 21 of the present report.

4.3.7 Chemical industry: Soda-ash production (2.B.7)

4.3.7.1 Category description (2.B.7)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.B.7. Chemical Industry: soda ash	production of soda ash	CO ₂	667.2	0.05%	456.2	0.05%	-31.6%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1	NS	CS

The category *Soda ash production* is not a key category.

In Germany, soda ash is produced only chemically. The country has 3 production facilities, all of which use⁵³ the Solvay process⁵⁴. In principle, the CO₂ contained within the calcium carbonate used in the process is bound within the product, soda ash (Na₂CO₃), and is released – if at all – only when that product is used. But since production via the Solvay process yields a CO₂ surplus, process-related CO₂ emissions result.

In the calcination part of the process, coke / anthracite is also used, and this produces additional (energy-related) carbon-dioxide emissions.

4.3.7.2 Methodological issues (2.B.7)

Activity data

The *Federal Statistical Office* determines the total amounts of soda ash produced in Germany. From 1995 to 2008, the sum total has comprised the categories of *light soda* (production number 2413 33 103, disodium carbonate in powder form, with a fill density of less than 700 g/l) and *heavy soda* (production number 2413 33 109, other disodium carbonate). Since 2009, light and heavy soda are reported in combination, in one position (notification number 2013 43 100). Of that quantity, only the portion "intended for sale" ("zum Absatz bestimmt") is taken into account. This prevents double-counting, since heavy soda is produced from light soda. Since Germany has only two producers, the production-quantity data, which are taken from official statistics, must be kept confidential.

Emission factor

The emission factor is calculated from the carbon dioxide emissions, as determined in keeping with the pertinent ETS-CO₂ balance, and from the production quantities involved. Since the production-quantity data, as taken from official statistics, has to be kept confidential, the relevant EF cannot be given here.

The coke quantity used in burning the relevant lime has already been included in the Energy Balance as a non-energy-related use (i.e. without inclusion of CO₂ emissions).

4.3.7.3 Uncertainties and time-series consistency (2.B.7)

Activity data

There are uncertainties regarding the production statistics given by the Federal Statistical Office, since – for example – the relation between light and heavy soda ash fluctuates widely, especially in the first years for which separate statistics are provided.

Emission factor

The uncertainty of the emission factor, with regard to production of soda ash, is calculated from the uncertainties for the ETS emission balance and the uncertainties for the pertinent production data.

4.3.7.4 Category-specific quality assurance / control and verification (2.B.7)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

⁵³ Other processes that are less important in terms of the production quantities involved are not considered here, because they use carbon dioxide from sources other than limestone.

⁵⁴ Ammonia-soda process pursuant to Ernst Solvay

The CO₂ balance for determination of the relevant emissions is produced with the help of data from emissions trading. Those data have been fully checked and verified in the framework of the EU Emissions Trading System (ETS).

4.3.7.5 Category-specific recalculations (2.B.7)

No recalculations are required.

4.3.7.6 Planned improvements, category-specific (2.B.7)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.3.8 Chemical industry: Petrochemical and carbon black production (2.B.8)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.B.8. Petrochemical and carbon black production	0	CO ₂	974.0	0.08%	972.7	0.11%	-0.1%
-/-	2.B.8. Petrochemical and carbon black production	0	CH ₄	333.7	0.03%	485.3	0.05%	45.4%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 2 (carbon black) CS (petrochemical industry)	NS	D (carbon black) CS (petrochemical industry)
CH ₄	Tier 1	NS	D
CO, SO ₂	Tier 1 (carbon black)	NS	D (carbon black)
NMVO	Tier 1 (petrochemical industry)	NS	C & CS (petrochemical industry)

The category *Chemical industry: Petrochemical and carbon black production* is not a key category. Carbon-black production predominates in this category, accounting for about 75% of its emissions.

4.3.8.1 Chemical industry: Petrochemicals (2.B.8 Petrochemicals)

4.3.8.1.1 Category description (2.B.8 Petrochemicals)

The petrochemicals sector produces basic organic chemicals, from natural gas and from petroleum fractions, that are processed into a great many different intermediate and end products (primarily polymers). Under 2.B.8, the 2006 IPCC Guidelines list production of the basic chemicals (a) methanol, (b) ethylene, (c) ethylene chloride and vinyl chloride, (d) ethylene oxide and (e) acrylonitrile on account of the carbon dioxide and methane emissions such production can entail.

Production of petrochemicals and derivatives, along with production of pharmaceuticals, production of fine and specialty chemicals and production of polymers, is one of the most important sectors of the chemical-pharmaceutical industry in terms of production value⁵⁵.

4.3.8.1.2 Methodological issues (2.B.8 Petrochemicals)

Activity data

No installation-related data are available with regard to production of the above products; only nationally aggregated production quantities are available. The data, for the period as of 1990, are provided by to the Federal Environment Agency by the Federal Statistical Office on the basis of its Fachserie 4, Reihe 3.1, "Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe"

⁵⁵ Chemiewirtschaft in Zahlen 2014, Verband der Chemischen Industrie e.V. (2015)

("Manufacturing industries, production in manufacturing industries"). They include confidential data.

In official production statistics, petrochemicals and derivatives are listed as "other basic organic substances and chemicals" ("sonstige organische Grundstoffe und Chemikalien") under WZ-Nummer (number within the German Classification of Economic Activities) 20.14.

The data on acrylonitrile-production quantities are subject to confidentiality requirements. The production-quantity data for methanol and ethylene dichloride are subject to confidentiality requirements in certain years. For these reasons, all production quantities for the products in groups a) through e) are aggregated and then reported, together with the pertinent CO₂ and CH₄ emissions, under 2.B.8.g.

For determination of NMVOC emissions, production of products that have to be reported under the CLRTAP is also taken into account, in addition to production of the products in groups a) through e). Detailed reporting on products that have to be reported under the CLRTAP is provided in the framework Informative Inventory Report pursuant to the CLRTAP.

CO₂ emission factors

Since 2013, pursuant to Annex 1 Part 2 Activity No. 27 German Greenhouse Gas Emission Allowance Trading Act (TEHG), all of the installations located in Germany for production of the aforementioned organic basic chemicals have been subject to the EU Emissions Trading System (ETS), because their production outputs are greater than 100 t/d (36,500 t/a).

A comparison of a) the total CO₂ emissions of the ETS installations pursuant to a) through e) that have been reported for purposes of the greenhouse-gas-emissions-trading system with b) the CO₂ emissions for the year 2013 as calculated with the new IPCC standard emission factors shows that the standard emission factors lead to higher emissions. And this proves to be the case even though the total installation-related emissions from emissions trading include both emissions from combustion processes and other process-related emissions. In the German greenhouse-gas inventory, most combustion-related emissions are already taken into account via the energy statistics for the energy sector. The standard emission factors thus cannot be used – their use would result in double-counting.

Along with combustion processes in boilers and cracking furnaces, the CO₂ emission sources to be considered include combustion processes in flares, decoking processes and other process-related emissions.

It would not be justified to quantify the other process-related emissions, since the installation-related CO₂ emissions of steam cracker units, which are far and away the largest group of emitters considered in this context, occur almost exclusively via combustion in cracking furnaces, auxiliary boilers or flares. With the exception of flares in the petrochemical industry, such combustion-related emissions are included in the energy-sector section in 1.A.2.c.

The CO₂ emissions from flaring losses are quantified, however, in order to fulfill the inventory aim of recording emissions as completely as possible. In future, decoking processes will also be included. Only that fraction of flare gases is considered that can be allocated to the aforementioned products in groups a) through e).

Since pre-2013 ETS data are not available for all of the aforementioned products, the CO₂ emissions are calculated on the basis of a CO₂ emission factor derived for 2013 and of the annually produced quantities of the relevant products.

Because residual gases and flare gases are often transported between installations (with different installations producing different products), it seems useful to use an emission factor that is aggregated over all of the products considered in this category. As a result of this aggregation, uncertainties in allocation of emissions of the aforementioned production processes to the products listed under a) through e) are taken into account, especially because CO₂ emissions from flares of the aforementioned installations are not necessarily tied to just one of the products in categories a) through e). At chemical industry sites, gases from various different production processes that need to be flared are often flared in a central flare that, in terms of its licensing, is allocated only to one production installation. As a result, in such cases, the emissions quantity allocated to a given product can be greater than the emissions quantity actually caused by the relevant production process. On the other hand, gases from processes a) through e) that need to be flared may be transported to a flare in an installation that is not considered in the present context, with the result that the emissions quantity considered is lower than the actual product-related emission quantity involved.

The flare emissions (ETS data) allocated to the various relevant chemical-industry installations for the year 2013 have been summed and then divided by the total production quantity for all products in a) through e) that were produced in 2013; this yields the emission factor for flaring losses (EF_{flaring}). The flare emissions of the steam cracker units are refinery sites have been determined via the units' known capacities. The resulting EF_{flaring} for the aforementioned petrochemicals is 28 kg/t product. That emission factor has been used to retroactively calculate annual emissions, using a Tier 1 method, back to 1990.

CH₄ emission factors

The IPCC Guidelines list all of the aforementioned installations as potential emission sources.

Pursuant to Point 5.2.5 of the TA Luft (Technical Instructions on Air Quality Control), German plants subject to the TA Luft must meet a standard of 50 mg/m³ (total carbon) for total mass concentration of organic substances (NMVOC and CH₄, but not including organic substances in particulate form). The current state of the art provides for thermal post-combustion of volatile organic substances from plants for production of primary organic chemicals.

A major German producer has reported that the methane emissions occurring in areas involving ethylene, methanol, ethylene dichloride and styrene are negligible, thanks to the thermal post-combustion processes employed since the 1980s.

No data from emissions trading can be used for reporting on methane emissions from chemical industry installations, since the currently valid German Greenhouse Gas Emission Allowance Trading Act (TEHG) of July 2011 does not mandate reporting on CH₄. Furthermore, since no information from other installation operators is available that could be used for quantification of CH₄ emissions, the methane emissions for all petrochemical industry installations as a whole are calculated via a Tier 1 method, with the IPCC 2006 standard emission factors (Vol. 3, Ch. 3.9.2.2).

NMVOC emission factors

The NMVOC EF have been obtained from the relevant BREF (Best Available Techniques Reference Document) and from confidential figures provided by German producers. Until 1994, the default factors in EMEP/CORINAIR Emission Inventory Guidebook were used. Relevant detailed reporting is provided in the Informative Inventory Report pursuant to the CLRTAP.

4.3.8.1.3 Uncertainties and time-series consistency (2.B.8 Petrochemical industry)

CO₂

The "backward projection" of the aforementioned production-related emission factor for flaring losses, from the 2013 emissions reports to earlier years (back through 1990) is subject to large uncertainties. On the one hand, in many cases the flare emissions reported in the ETS for report year 2013 were determined and reported on the basis of estimates. On the other, it must be assumed that CO₂ emissions from the flares allocated to the relevant installations, under licensing law, cannot be completely assigned to production of the products in groups a) through e). For example, gases (including waste gases) from other production processes are burned in the flares under consideration here. What is more, over time, installations can make local internal changes in routing of waste gases from various processes. Such changes further increase the uncertainty of "back-calculated" product-specific emissions. In addition, the ratios of production quantities to flare gases, for the installations considered, can differ considerably in various years from the corresponding ratios in 2013.

Due to limited data availability, the possibility that some energy-sector items are being double-counted cannot be completely ruled out. Extrapolation of flare emissions of steam cracker units also contributes to the uncertainty of the emission factor. An uncertainty of $\pm 50\%$ is thus being assumed.

Consistency of the time series is assured, because a consistent method was used to calculate the emissions back through 1990, and because there are no gaps in the activity data and no jumps (discontinuities) in the emission factor.

CH₄

In the 1980s, thermal post-combustion was introduced on a large scale. As a result, point-source emissions of organic substances from German plants are likely to be low. Use of standard emission factors is probably leading to overestimation of the emissions. Since the resulting uncertainties cannot be estimated, the Tier-1-method uncertainties given in Table 3.27 of the 2006 IPCC Guidelines (Vol. 3) are being used.

Consistency of the time series is assured, because a consistent method was used to calculate the emissions back through 1990, and because there are no gaps in the activity data and no jumps (discontinuities) in the emission factors.

Activity data

The activity data have been taken from official statistics for which inaccuracies of $\pm 20\%$ in statistical data collection are assumed.

4.3.8.1.4 Category-specific quality assurance / control and verification (2.B.8 Petrochemical industry)

Due to a lack of relevant specialised staff, it was not possible to have quality control and quality assurance carried out by category experts. This situation will be corrected as soon as the relevant person returns (normally, in connection with the next report). General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook. Data were collected, taken from previous years or determined on the basis of existing calculation routines.

Potentially suitable data sources are reviewed with regard to their suitability for verification of the data.

The quantity of ethylene produced in 2013, as reported by the Federal Statistical Office, was compared with capacity data provided by the Association of Petrochemical Producers in Europe (APPE; Petrochemicals Europe). The resulting national standard capacity-utilisation factor of

0.858 is comparable to the standard capacity-utilisation factor pursuant to Article 18 (2) of Commission Decision 2011/278/EU.

It is not possible to compare the national emission factor for CO₂ with the standard CO₂ emission factors given in the 2006 IPCC Guidelines, because the standard emission factors do not include any CO₂ emissions from flares.

4.3.8.1.5 Category-specific recalculations (2.B.8 Petrochemical industry)

No recalculations are required.

4.3.8.1.6 Planned improvements, category-specific (2.B.8 Petrochemical industry)

Plans call for improving the database.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.3.8.2 Chemical industry: Carbon black production (2.B.8 Carbon black)

4.3.8.2.1 Category description (2.B.8 Carbon black)

Carbon black is produced via incomplete combustion of gaseous or liquid hydrocarbons. Defined specifications for carbon black are achieved by carefully controlling and monitoring production processes. In Germany, carbon black is produced from hard-coal-tar oils (anthracene oils) and from oils produced by petroleum refineries (pyrolysis / cracking oils).

A total of 90 % of the carbon black produced in Germany is produced via the furnace black process. The remaining 10 % is produced via the flame-pressure and gas black processes.

4.3.8.2.2 Methodological issues (2.B.8 Carbon black)

CO₂ emissions

A comparison of the CO₂-emissions figures reported to date with the figures reported to the German Emissions Trading Authority (DEHSt) showed that the latter figures (the CO₂ emissions reported to the DEHSt) are considerably lower. An additional installation, which is not subject to emissions-trading requirements, has been considered in this regard, but its CO₂ emissions do not suffice to explain this difference. Consultations with the existing data supplier have suggested that sales figures – instead of production figures – are being reported in some cases for the production statistics being used. The activity data used to date was thus too high, to a considerable degree. As of the year 2005, therefore, the emissions-quantities figures of the DEHSt are being used, and the activity data are being back-calculated using the default emission factor in the 2006 IPCC Guidelines (Vol. 3, Table 3.23, Furnace Black Process (default process), primary feedstock). The unknown emissions of an additional installation not subject to emissions-trading requirements have been estimated. In all likelihood, that installation will be decommissioned in 2016.

CH₄ emission factors

The international guidelines give very little attention to this source category. The IPCC Guidelines list carbon black production as a potential emission source.

Pursuant to Point 5.2.5 of the TA Luft (Technical Instructions on Air Quality Control), German plants subject to the TA Luft must meet a standard of 50 mg/m³ (total carbon) for total mass concentration of organic substances (NMVOC and CH₄, but not including organic substances in particulate form). In keeping with these technical standards, the three German producers of

carbon black report an emission factor of 0.027 kg methane per tonne of carbon black. Since the relevant technology has been in service since the 1970s, this EF is rounded off to 0.03 kg/t and applied to the entire time series.

Emission factors for NMVOC, CO and SO₂

For pollutants other than the methane considered above, the emission factors listed in the following table were used for Germany.

Table 185: Emission factors used in Germany for other pollutants

	Carbon black [kg CO / t]	Carbon black [kg SO ₂ /t] ⁵⁶
1990	4.8/5	19.5/ ⁽⁵⁷⁾
1991	4.6/5	19/20
1992	4.4/5	18.5/20
1993	4.2	18
1994	4	17.5
1995	3.75	17
1996	3.5	16
1997	3.25	15
1998	3	14
1999	2.9	13.4
2000	2.8	12.8
2001	2.7	12.54
2002	2.65	12.28
2003	2.6	12.0
2004	2.55	11.7
2005	2.5	11.5
2006	2.5	11.2
2007	2.5	10.9
2008	2.5	10.6
2009	2.5	10.3
since 2010	2.5	10.0

The EF figures for CO and SO₂, for production of carbon black, are based on the BREF Large Volume Inorganic Chemicals - LVIC – S (EC, 2007) and are identical with the default values presented in the 2008 CORINAIR manual (first order draft).

Activity data

The production statistics of the Federal Statistical Office include the following products (cf. the following table).

Table 186: Reporting numbers (Meldenummern) from production statistics

Line	Carbon black
through 1994	4113 70
from 1995 through 2005	2413 11 300

The figure for carbon-black production in the new German Länder in 1990 was taken from the Statistical Yearbook (Statistisches Jahrbuch) for the Federal Republic of Germany (*FEDERAL STATISTICAL OFFICE*, 1992: p. 234); the figures for 1991 and 1992 were estimated, due to

⁵⁶ Where two EF are listed, the second figure refers to the new German Länder.

⁵⁷ No EF is listed for the new German Länder, since these SO₂ emissions can be taken account of only as a lump sum.

confidentiality requirements. The other data for carbon-black production as of 1990 were obtained from the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, Fachserie 4, Reihe 3.1, Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe ("manufacturing industry; production in the manufacturing industry"). For the period as of 2005, the activity data are back-calculated from the CO₂ emissions, using the default CO₂ emission factor.

4.3.8.2.3 Uncertainties and time-series consistency (2.B.8 Carbon black)

While the activity data are seen to fluctuate somewhat over time, their fluctuations are largely in keeping with global economic fluctuations.

4.3.8.2.4 Category-specific quality assurance / control and verification (2.B.8 Carbon black)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

4.3.8.2.5 Category-specific recalculations (2.B.8 Carbon black)

Recalculations are required, because the CO₂ emissions data reported by the German Emissions Trading Authority (DEHSt) as of 2015 had to be suitably adjusted, following their verification.

Year	CO ₂ emissions 2016 Submission [kt]	CO ₂ emissions 2017 Submission [kt]	CH ₄ emissions 2016 Submission [kt]	CH ₄ emissions 2017 Submission [kt]
2005	776.47	741.41	0.01188	0.01135
2006	815.69	772.39	0.01249	0.01182
2007	830.4	787.37	0.01271	0.01205
2008	757.43	717.56	0.01159	0.01098
2009	667.46	635.47	0.01022	0.00973
2010	761.54	783.88	0.01166	0.012
2011	745.05	709.68	0.0114	0.01086
2012	699.58	662.61	0.01071	0.01014
2013	711.18	680.21	0.01089	0.01041
2014	728.51	729.94	0.01115	0.01117
2015		732.34		0.01121

4.3.8.2.6 Planned improvements, category-specific (2.B.8 Carbon black)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.3.9 Chemical industry: Fluorochemical production (2.B.9)

KC	Category	Activity	EM of	1995 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1995-2015
-/-	2.B.9. Fluorochemical production	0	SF ₆	159.6	0.01%	96.7	0.01%	-39.4%
L/T	2.B.9. Fluorochemical production		HFCs	C	C	C	C	-98.9%
-/-	2.B.9. Fluorochemical production		PFCs	C	C	C	C	---

Gas	Method used	Source for the activity data	Emission factors used
HFC	Tier 3	PS	PS
SF ₆	Tier 3	PS	PS

The category *Fluorochemical production* is a key category for HFC emissions in terms of emissions level and trend. It is subdivided into 2.B.9.a By-product emissions and 2.B.9.b Fugitive emissions.

4.3.9.1 By-product emissions (2.B.9.a)**4.3.9.1.1 Category description (2.B.9.a)**

For process-related reasons, production of HCFC-22 produces up to 3 % HFC-23 as a by-product. For technical reasons, even when the HFC-23 is subjected to further processing (for example, to produce refrigerants) or is collected and then broken down into other substances, some HFC-23 is always released into the atmosphere.

Germany formerly had two production plants for HCFC-22. Those two plants, which were operated by a single company, were located in Frankfurt and Bad Wimpfen. In 1995, a CFC-cracking plant went into operation in Frankfurt that cracked, at high temperature, excess HFC-23 produced during production of HCFC-22 and that recovered hydrofluoric acid; i.e. no significant emissions were produced. HFC-23 produced at the second German production facility was captured in large amounts at the production system itself; the substance was then sold as a refrigerant or – following further distillative purification – as an etching gas for the semiconductor industry. Beginning in 1999, the excess amount that could not be sold was delivered to the cracking facility in Frankfurt. That measure substantially reduced emissions. In mid-2010, HCFC-22 production was terminated at one site. At the other site, it was significantly reduced, and all remaining production serves teflon production. The production quantities have remained at a constant low level since then. Since the installation is directly connected to a CFC-cracking plant, only very slight emissions occur.

4.3.9.1.2 Methodological issues (2.B.9.a)

In keeping with manufacturer information from 1996, HFC-23 emissions are assumed to have remained constant in the years 1990 to 1994.

Beginning in 1995, the producer calculated emissions, via a mass-balance procedure, on the basis of HCFC-22 production, HFC-23 concentrations in exhaust gas (as measured annually), sales of HFC-23 and quantities of HFC-23 delivered to the cracking plant. For reporting year 1995, emissions-reduction measures (the cracking plant) for the first production plant were assumed to have been in place since mid-year. Since report year 2011, the relevant production quantities have been estimated by experts, and the resulting estimates have been used to determine the emissions. The estimates are made in light of comparable production facilities in other European countries.

Activity data

There is only one HFC producer in Germany. That company's data, therefore, are subject to confidentiality. Until 2010, the emissions and production quantities were reported to the Federal Environment Agency, but only in aggregated form. Since 2011, data of the Federal Statistical Office have been used. The activity data for HFCs are reported together with those for PFCs and SF₆, as an "unspecified mix," in 2.B.9.

Emission factors

An emission factor of 0.05 is assumed for the period as of 2011.

Emissions

Until 2011, the relevant HFC-23 emissions were reported by the producer. Thereafter, experts' assessments were used.

Since there are fewer than three producers in Germany, the emissions data are confidential. The HFC-23 emissions are reported as an "unspecified mix" in 2.B.9, as an aggregate of 2.B.9a and 2.B.9b.

4.3.9.1.3 Uncertainties and time-series consistency (2.B.9.a)

The production data on which the emissions calculation is based have been obtained from the Federal Statistical Office, and may be assumed to be very precise.

4.3.9.1.4 Category-specific quality assurance / control and verification (2.B.9.a)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

4.3.9.1.5 Category-specific recalculations (2.B.9.a)

No recalculations are required.

4.3.9.1.6 Planned improvements, category-specific (2.B.9.a)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.3.9.2 Production-related emissions (2.B.9.b)**4.3.9.2.1 Category description (2.B.9.b)**

In Germany, one company produces these gases; its HFC und SF₆ production takes place at two locations. Emissions trends are tied to trends in amounts produced. While SF₆ and HFC-134a are produced in Germany, until 2008 no complete synthesis of HFC-227ea was carried out in Germany. Part of the HFC-227ea produced in Tarragona, Spain, undergoes subsequent distillation, in Germany, to pharmaceutical purity (use in dosing aerosols). That process produces emissions as a result of minor gas losses.

HFC-134a has been produced since 1994, while HFC-227ea has been produced since 1996.

Emissions of HFC-134a have remained relatively constant since 2011. The fluctuations seen result from slight differences in annual production quantities.

Emissions of HFC-227ea have been increasing since 2009, in parallel with increases in production quantities. An exception is seen in 2012, in which less HFC-227ea was sold, and thus the emissions level was lower.

4.3.9.2.2 Methodological issues (2.B.9.b)**Emission factors**

It is possible to calculate an emission factor from the emissions and production quantities reported by the producer until 2010. That emission factor is assumed to remain applicable – i.e. the emission factor is assumed to remain constant – in subsequent years. The emission factor is not published, however, because the underlying data are confidential.

Activity data

Because the HFC producer in Germany is the country's sole producer, that company's data are confidential. Until 2010, the emissions and production quantities were reported to the Federal Environment Agency, but only in aggregated form. Since 2011, data of the Federal Statistical Office have been used.

4.3.9.2.3 Uncertainties and time-series consistency (2.B.9.b)

The production figures used as a basis for emissions calculation may be considered highly accurate, since they come directly from the producer's internal records or from official statistical surveys.

4.3.9.2.4 Category-specific quality assurance / control and verification (2.B.9.b)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

4.3.9.2.5 Category-specific recalculations (2.B.9.b)

No recalculations are required.

4.3.9.2.6 Planned improvements, category-specific (2.B.9.b)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.3.10 Chemical industry – other: Emissions from other production processes (2.B.10)**4.3.10.1 Category description (2.B.10)**

The precursor substances from production of fertilisers and sulphuric acid are reported in this category. While N₂O emissions from production of dodecanedioic acid are described here, they are included in 2.G.3, for reasons of confidentiality. Among dicarboxylic acids, dodecanedioic acid ranks second, in terms in terms of the quantities involved. It is surpassed only by adipic acid in this regard. There is one producer in Germany. That producer's installation has a capacity of 18,000 t per year⁵⁸.

4.3.10.2 Methodological issues (2.B.10)**N₂O emissions**

The N₂O emissions are calculated via a Tier 2 method. The relevant production-quantity data were taken from a one-time query of the producer. The data are carried forward. The N₂O emissions have been greatly reduced, via waste-gas treatment in a treatment facility.

4.3.10.3 Uncertainties and time-series consistency (2.B.10)

Time-series consistency is assured, because the data set resulting from one-time data collection has also been applied to the other years involved. Since the figures are based on qualitative information provided by the manufacturer, and refer only to one year, large uncertainties, of + 300 % / - 20 %, have to be assumed.

4.3.10.4 Category-specific quality assurance / control and verification (2.B.10)

Due to a lack of relevant specialised staff, it was not possible to have quality control and quality assurance carried out, by category experts. This situation will be corrected as soon as the relevant person returns (normally, in connection with the next report). General quality control, and quality assurance in conformance with the requirements of the QSE manual and its associated applicable

⁵⁸ Source: Industrielle Organische Chemie, Hans-Jürgen Arpe, Wiley-VCH, 2007

documents, have been carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

4.3.10.5 Category-specific recalculations (2.B.10)

No recalculations are required.

4.3.10.6 Planned improvements, category-specific (2.B.10)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.4 Metal production (2.C)

Category 2.C is divided into the sub-categories 2.C.1 through 2.C.7. In the CSE emissions database, the sub-category Iron and steel production (2.C.1) includes sinter production, pig-iron production, production of direct-reduced iron (DRI), iron and steel production and production of tempered castings. Production of ferroalloys (2.C.2) has only minor importance in Germany. For this reason, it is not further subdivided in the present report. Aluminium production (2.C.3) is subdivided into primary aluminium and resmelted aluminium. Use of SF₆ in aluminium and magnesium production (2.C.4) is not further sub-divided. In the Central System of Emissions (CSE), sub-point (2.C.5) comprises lead production. (2.C.6) comprises zinc production. (2.C.7) includes copper production (2.C.7a), nickel production (2.C.7b) and other production (2.C.7c). No greenhouse-gas emissions result in Germany from these categories.

4.4.1 Metal production: Iron and steel production (2.C.1)

4.4.1.1 Category description (2.C.1)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/-	2.C.1. Metal Production: Iron and steel production	Steel (integrated production)	CO ₂	22,810.3	1.87%	16,731.1	1.89%	-26.7%
-/-	2.C.1. Metal Production: Iron and steel production	Steel (integrated production)	N ₂ O	26.5	0.00%	16.5	0.00%	-38.0%
-/-	2.C.1. Metal Production: Iron and steel production	Steel (integrated production)	CH ₄	4.7	0.00%	5.3	0.00%	13.6%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 2	NS	CS
CH ₄	Tier 2	NS	CS
N ₂ O	CS	NS	CS
NO _x , CO, NMVOC, SO ₂	Tier 2	NS	CS

The category *Iron and steel production* is a key category for CO₂ emissions in terms of emissions level. Along with carbon dioxide, slight emissions of methane and nitrous oxide also occur in this category. The methane emissions result from production of rolled steel and from production of iron, steel and malleable cast iron. The nitrous oxide originates in primary steel production, in connection with use of blast furnace gas in hot-blast stoves.

Since the CRF-Reporter software does not allow nitrous oxide to be allocated to 2.C.1, it is reported in 2.C.7 instead.

In 2015, a total of 30.1 million t of raw steel, from ore, was produced in Germany in six integrated steel works. Electric steel production amounted to 12.6 million t.

4.4.1.2 Methodological issues (2.C.1)

This sector comprises process-related emissions from primary steel production (via sinter plants, blast furnaces and oxygen-steel plants) and from electric steel plants.

Other structural elements in this category (foundries: iron and steel casting (including malleable casting); steel production: rolled-steel production) are used for calculation of other pollutant emissions (not greenhouse-gas emissions).

Process-related CO₂ emissions from primary steel production in integrated smelters result primarily from use of reducing agents in blast furnaces. CO₂ emissions from limestone inputs in sinter plants and in pig-iron production (including the CO₂ emissions from the lime kilns operated by the steel industry), and CO₂ emissions from electrode consumption in electric steel production, are added to process-related emissions in sector 2.C.1.

Very little direct-reduced iron (DRI; sponge iron) is produced in Germany (only about 0.5 million t. per year). Annual production-quantity data are available for the entire time series, but they are confidential, because they refer solely to a single installation.

The CO₂ emissions that occur in DRI production result from the use of natural gas, i.e. from use of a reducing-agent mixture, comprising H₂ and CO, obtained from natural gas. The relevant quantities of natural gas used are included, throughout the entire time series, in the natural-gas inputs in the steel industry that are reported under 1.A.2.a. Consequently, the CO₂ emissions resulting from DRI production are also included, throughout the entire time series, in the emissions reported under 1.A.2.a.

The process-related CO₂ emissions from DRI production cannot be listed separately under 2.C.1, because such disclosures could be used to derive the confidential production-quantity data for the relevant installation.

Method for calculating the CO₂ emissions resulting from use of reducing agents in blast furnaces

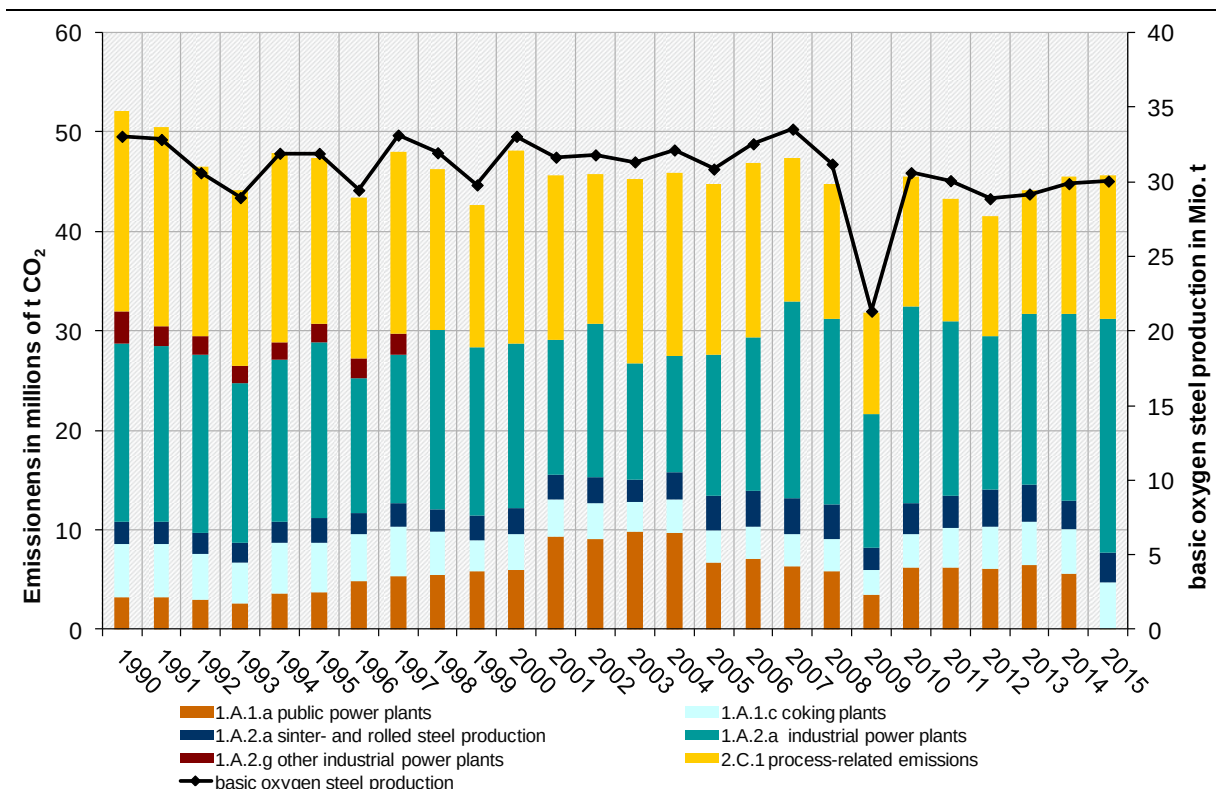
Pursuant to the IPCC Guidelines, the CO₂ emissions in category 2.C.1 are to be determined via a carbon balance. The reason for this requirement is that virtually all of the carbon used for primary steel production is subsequently released into the atmosphere, as CO₂, in later energy-related use, or in flaring, of the blast furnace gas that forms in the blast furnace or of the basic oxygen furnace gas that forms in the oxygen steel converter. The share of carbon that remains in produced steel, or in that portion of pig iron that is not processed into steel, is not important by comparison to the CO₂ emissions related to use of reducing agents⁵⁹.

The inputs of reducing agents in blast furnaces, and material inputs in converters, are statistically recorded in great detail. The Steel Institute VDEh provides the relevant data to the Federal Environment Agency annually. The carbon content in the various materials used is calculated from emissions trading data. CO₂ emission factors for use of blast furnace gas and basic oxygen furnace gas are also available from emissions trading. The input gas quantities are taken from energy statistics. Calculation on the basis of a) carbon inputs and of b) carbon removals via use of blast-furnace / basic oxygen furnace gas yields a difference. Those CO₂ emissions are reported in

⁵⁹ The average carbon fraction in the more than 2000 types of steel produced in Germany is normally considerably smaller than 2%. It is not recorded statistically, however. In any case, the pertinent deduction of non-energy-related carbon is extremely small (<1.5 %) in comparison to the total CO₂ emissions from primary steel production. Since only about 3% of the pig iron produced in Germany is not processed into oxygen steel, the pertinent deduction of non-energy-related carbon is also marginal (ca. 0.1%).

category 2.C.1. Only part of all energy-related use of blast furnace gas and basic oxygen furnace gas takes place in category 2.C.1 (this is the energy-related use in hot-blast stoves in blast furnaces). Such gas is also used for other process combustion in the iron and steel industry (1.A.2.a); in coking plants, for bottom heating of coking furnaces (1.A.1.c); and for electricity generation in public power stations (1.A.1.a) and industrial power stations (1.A.2.f). Energy statistics provide data on consumption of blast furnace gas and basic oxygen furnace gas in all of the aforementioned categories. Consequently, the CO₂ emissions resulting from reducing-agent inputs for primary steel production are divided among all categories in which blast furnace gas and basic oxygen furnace gas are burned and, thus, CO₂ is actually emitted (cf. the following figure).

Figure 44: Chronological trend and source-category allocation of the CO₂ emissions resulting from use of reducing agents for primary steel production and from use of top gas



The sum of the CO₂ emissions shown correlates well with the activity data reported for primary steel production (cf. the black line). Annual fluctuations in the individual categories are probably due to changes in allocation of individual plants within official statistics. Such fluctuations have practically no impact on the total sum of reported emissions, however.

Table 187: CO₂ emissions from primary steel production (including use of blast-furnace gas)

Mt CO ₂	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1.A.1.a Public power stations	3.244	3.291	3.015	2.631	3.647	3.764	4.816	5.305	5.465	5.808
1.A.1.c Coking plants	5.340	5.251	4.590	4.083	5.066	4.924	4.707	4.969	4.362	3.145
1.A.2.a Sinter and rolled-steel production	2.228	2.256	2.046	1.936	2.081	2.445	2.151	2.419	2.255	2.444
1.A.2.a Industry power stations	17.886	17.660	17.927	16.098	16.326	17.759	13.624	14.935	17.975	16.933
1.A.2.f Other industry power stations	3.206	2.025	1.942	1.707	1.720	1.770	1.932	2.144	0.000	0.000
2.C.1 Process emissions	20.228	19.961	16.942	17.693	19.074	16.736	16.204	18.194	16.215	14.317
Mt CO ₂	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1.A.1.a Public power stations	5.956	9.284	9.030	9.766	9.640	6.738	7.086	6.370	5.851	3.425
1.A.1.c Coking plants	3.652	3.741	3.684	3.029	3.356	3.247	3.281	3.226	3.226	2.500
1.A.2.a Sinter and rolled-steel production	2.520	2.487	2.629	2.265	2.788	3.461	3.603	3.642	3.437	2.315
1.A.2.a Industry power stations	16.573	13.627	15.406	11.709	11.695	14.164	15.351	19.748	18.675	13.429
1.A.2.f Other industry power stations	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.C.1 Process emissions	19.379	16.493	14.979	18.509	18.418	17.154	17.586	14.451	13.614	10.135
Mt CO ₂	2010	2011	2012	2013	2014	2015				
1.A.1.a Public power stations	6.276	6.258	6.080	6.465	5.533	0.013				
1.A.1.c Coking plants	3.245	3.895	4.289	4.341	4.554	4.702				
1.A.2.a Sinter and rolled-steel production	3.198	3.217	3.646	3.715	2.787	3.015				
1.A.2.a Industry power stations	19.705	17.553	15.512	17.173	18.890	23.538				
1.A.2.f Other industry power stations	0.000	0.000	0.000	0.000	0.000	0.000				
2.C.1 Process emissions	13.144	12.367	12.046	12.429	13.727	14.422				

In the iron and steel industry, secondary fuels are used only in pig iron production in blast furnaces. To date, these materials have not yet been included in national statistics and the Energy Balance. For this reason, the data used consisted of figures provided by the Wirtschaftsvereinigung Stahl steel-industry association. Since the secondary fuels are used solely as substitute reducing agents, in place of coke, the CO₂ emissions resulting from their use are also included in the CO₂ emissions determined via inputs of blast furnace gas and basic oxygen furnace gas and do not have to be calculated separately.

Determination of CO₂ emissions from limestone inputs in pig iron production

CO₂ emissions from limestone use are determined in accordance with Tier 1 (UBA 2006, FKZ 20541217/02). The steel industry uses limestone (CaCO₃) in sintering plants and in pig iron production in blast furnaces. In oxygen steel and electric steel mills, burnt lime for steel-mill applications (CaO) is used as a slag former (as a rule, it is purchased from the lime industry sector); the CO₂ emissions released in producing that burnt lime are thus already reported under 2.A.2. Only one steel mill meets its lime requirements with the help of lime kilns of its own whose production quantities, and related CO₂ emissions, are not included in the data reported under 2.A.2. The quantities produced by these lime kilns are estimated on the basis of available figures for the mill's crude-steel production (for a more precise description, cf. the 2016 NIR).

From the so-determined activity data, only the raw-material-related CO₂ emissions, calculated via a stoichiometric EF, are reported in 2.C.1 – in a procedure similar to that used for 2.A.2 (cf. Table 188). The CO₂ emissions from energy inputs in steel mills' own lime kilns, emissions which are not separately listed in the Energy Balance, are included in the emissions reported under 1.A.2.a.

Until 2004, limestone inputs in sinter and pig iron production were published as part of iron and steel statistics (*FEDERAL STATISTICAL OFFICE* Fachserie 4, Reihe 8.1). Since then, they have to be calculated from the production quantities of sinter and pig iron reported by the association, via specific input factors (i.e. kg of limestone per tonne of sinter or pig iron) (reported in the framework of the so-called "BGS form" (Fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants)). Multiplying the activity data for limestone inputs by the stoichiometric emission factor for limestone produces the CO₂-emissions figures given in Table 188.

Table 188: Limestone inputs in the steel industry; and the steel industry's own production of burnt lime, and the resulting CO₂ emissions

Year	Limestone input [t/a]		Own production		CO ₂ emissions [t/a]	
	Blast furnaces	Sinter plant	Burnt lime [t/a]	Limestone inputs	Lime production	Total
1990	755,737	4,680,775	153,918	2,392,065	114,823	2,506,888
1991	757,000	4,532,000	147,439	2,327,160	109,990	2,437,150
1992	666,000	4,198,000	136,560	2,140,160	101,874	2,242,034
1993	627,000	3,891,000	129,458	1,987,920	96,575	2,084,495
1994	733,000	4,173,153	140,003	2,158,707	104,443	2,263,150
1995	751,000	4,600,000	139,973	2,354,440	104,420	2,458,860
1996	686,000	4,350,000	129,177	2,215,840	96,366	2,312,206
1997	629,000	4,471,000	145,351	2,244,000	108,432	2,352,432
1998	677,000	4,588,000	140,157	2,316,600	104,557	2,421,157
1999	817,000	4,144,000	130,704	2,182,840	97,505	2,280,345
2000	924,000	4,273,000	144,991	2,286,680	108,163	2,394,843
2001	866,000	4,136,000	138,859	2,200,880	103,588	2,304,468
2002	831,000	3,940,000	139,538	2,099,240	104,096	2,203,336
2003	832,525	4,046,711	137,468	2,146,864	102,551	2,249,415
2004	847,689	4,209,871	140,977	2,225,326	105,169	2,330,495
2005	787,724	4,306,067	134,550	2,241,268	100,374	2,341,642
2006	822,920	4,410,408	162,500	2,302,664	121,225	2,423,889
2007	840,868	4,608,067	149,500	2,397,531	111,527	2,509,058
2008	790,216	4,541,174	136,500	2,345,812	101,829	2,447,641
2009	547,680	3,496,405	97,500	1,779,397	72,735	1,852,132
2010	799,679	4,045,042	130,000	2,131,677	96,980	2,228,657
2011	782,420	3,457,145	123,500	1,865,408	92,131	1,957,539
2012	757,355	3,912,824	117,000	2,054,879	87,282	2,142,161
2013	760,932	3,926,706	130,000	2,062,561	96,980	2,159,541
2014	782,447	3,945,838	130,000	2,080,446	96,980	2,177,426
2015	794,999	3,987,196	149,500	2,104,166	111,527	2,215,693

Source:

until 2004: Limestone inputs were calculated by the "limestone balance" project ("Kalksteinbilanz"; UBA 2006, FKZ 20541217/02);

as of 2005: calculations via the product-specific factors determined in the aforementioned project

Determination of CO₂ emissions from electrode consumption in production of electrical steel

In electrical steel production, CO₂ emissions occur directly via consumption of graphite electrodes. These emissions must also be allocated to process-related CO₂ emissions for steel production. They are calculated from the quantity of produced electric steel, via an emission factor (7.4 kg/t) that was updated in 2009, in a research project (UBA/BFI 2012), and that is based on the specific electrode consumption per tonne of electrical steel (2.06 kg/t), its carbon content (98%) and the relevant stoichiometric factor (3.667 t CO₂/t C). The contribution from electrode combustion in electrical steel production, at about 0.2% of total CO₂ emissions in iron and steel production, is insignificant.

Determination of the total CO₂ emissions from iron and steel production to be reported under 2.C.1

The total process-related emissions to be reported under 2.C.1 consist of the following:

1. the CO₂ emissions resulting from use of reducing agents in primary steel production, where the relevant blast furnace gas and basic oxygen furnace gas is not used in other categories and thus reported under other categories as CO₂ emissions,
2. the CO₂ emissions from limestone inputs in pig iron production and from the steel industry's own production of burnt lime, and
3. the CO₂ emissions from electrode consumption in electrical steel production.

The relevant so-determined emissions quantities are shown in Table 190.

Table 189: Total process-related emissions to be reported under 2.C.1

Year	CO ₂ emissions from use of reducing agents, where not reported in other categories [t/a]	CO ₂ emissions from limestone inputs and from the steel industry's own production of burnt lime [t/a]	CO ₂ emissions from electrode consumption [t/a]	2.C.1 total [t/a]
1990	20,228,163	2,506,888	75,242	22,810,293
1991	19,960,553	2,437,150	68,464	22,466,167
1992	16,942,152	2,242,034	64,358	19,248,544
1993	17,692,711	2,084,495	59,840	19,837,046
1994	19,074,282	2,263,150	65,783	21,403,215
1995	16,736,415	2,458,860	74,794	19,270,069
1996	16,204,219	2,312,206	76,291	18,592,716
1997	18,193,667	2,352,432	87,552	20,633,651
1998	16,255,161	2,421,157	89,196	18,765,514
1999	14,316,677	2,280,345	90,457	16,687,479
2000	19,378,699	2,394,843	98,251	21,871,793
2001	16,493,071	2,304,468	96,961	18,894,500
2002	14,978,738	2,203,336	97,381	17,279,455
2003	18,508,674	2,249,415	99,048	20,857,137
2004	18,418,361	2,330,495	104,984	20,853,840
2005	17,153,961	2,341,642	100,780	19,596,383
2006	17,586,218	2,423,889	108,206	20,118,313
2007	14,451,531	2,509,058	110,721	17,071,310
2008	13,614,398	2,447,641	107,945	16,169,984
2009	10,134,642	1,852,132	83,587	12,070,361
2010	13,144,493	2,228,657	97,446	15,470,596
2011	12,367,111	2,239,194	104,741	14,711,046
2012	12,046,280	2,142,161	101,675	14,290,116
2013	12,428,654	2,159,541	99,245	14,687,440
2014	13,726,939	2,177,426	96,314	16,000,679
2015	14,422,031	2,215,693	93,401	16,731,125

4.4.1.3 Uncertainties and time-series consistency (2.C.1)

The time series is consistent, since the activity data have been determined for all plants and since the same method has been used to determine the emissions for all years concerned.

Regarding CO₂ emissions from limestone inputs, a discontinuity in methods occurred from 2004 to 2005. It resulted because the data source used until 2004 was no longer available after 2004. The time-series trend seems plausible in spite of this discontinuity. In keeping with the required calculation, the uncertainty for the activity data here is $\pm 10\%$. The uncertainty is also relatively high for the activity data for the steel industry's own production of burnt lime, which production

has been estimated on the basis of several assumptions. The related CO₂ emissions are comparatively insignificant, however.

The uncertainty of the emission factor for electrode consumption is $\pm 3\%$, while the uncertainty for the other data is $\pm 5\%$. The uncertainties are due solely to imprecision in measurement and analysis.

4.4.1.4 Category-specific quality assurance / control and verification (2.C.1)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Determining emissions in categories 1.A.2.a and 2.C.1 is a complex task, since the Energy Balance, emissions reporting, emissions trading and association statistics differ widely in terms of their underlying methods. In the interest of data quality assurance, regular experts' discussions are carried out for the purpose of comparing and evaluating data. As a result of the methodological differences, plausibility checks of the determined emissions quantities, using data of the German emissions trading authority, are possible only at a highly aggregated level.

The implied emission factors (IEF) obtained by the Climate Secretariat cannot be used to carry out plausibility checks of the emissions determined for this category.

1. The reasons for this include the wide differences, from country to country, in primary steel production's (such production is highly CO₂-intensive) share of total steel production;
2. the differences in the ways that different countries allocate the resulting emissions to categories 1.A.2.a, 2.C.1, and to any other categories in which the process gases occurring in connection with iron and steel production are used for energy generation; and
3. addition of the activity data reported – in different ways, by different countries – under 2.C.1, addition which in some cases

is not justified. The aforementioned factors result in extreme scattering of the IEF obtained for the source categories mentioned, and thus those IEF do not support any conclusions regarding the "correctness" of the determined emissions.

4.4.1.5 Category-specific recalculations (2.C.1)

Slight recalculations have been carried out for the year 2014, to take account of updated statistical data and of replacement of data from the provisional Energy Balance with data from the final Energy Balance. The time series for the activity data for production of direct-reduced iron (DRI) has been completed. Since that time series is confidential, and since the figures yield no additional emissions to report (cf. the remarks made in Chapter 4.4.1.2), no pertinent further category-specific recalculations were required, however.

4.4.1.6 Planned improvements, category-specific (2.C.1)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.4.2 Metal production: Ferroalloys production (2.C.2)

4.4.2.1 Category description (2.C.2)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.C.2. Ferroalloys production	Ferroalloys	CO ₂	429.0	0.04%	6.0	0.00%	-98.6%
-/-	2.C.2. Ferroalloys production	Ferroalloys	CH ₄	8.6	0.00%	1.6	0.00%	-80.9%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS	IS	CS
NO _x , CO, NMVOC, SO ₂			NE

The category *Ferroalloys production* is not a key category. Ferroalloys are aggregates that are alloyed with steel. There are five ferroalloy producers in Germany; ferrochromium, ferrosilicon and silicon metal are each produced by only one company, and other ferroalloys are produced only in small quantities. According to data of the British Geological Survey, in 2014, 54,500 t of ferroalloys were produced in Germany in 2007. The only process in use since 1995 is the electric arc process, a process that releases only small amounts of process-related CO₂, with such releases occurring in electrode consumption.

Until 1995, the blast-furnace process, which produces relatively higher CO₂ emissions, was used to some extent.

4.4.2.2 Methodological issues (2.C.2)

The **emission factors** for the aforementioned two processes (blast-furnace and electric-arc processes) were determined in the research project "NEW CO₂" ("NEU-CO₂") (FKZ 203 41 253/02).

For the period since 1995, the **activity data** are determined via data of the British Geological Survey (BGS). The currently available data are from 2014. The activity data have been carried forward for 2015.

4.4.2.3 Uncertainties and time-series consistency (2.C.2)

The activity data provided by the British Geological Survey (BGS) are based partly on estimates and thus are subject to relatively large uncertainties.

The relevant data of the British Geological Survey (BGS) were compared with those of the U.S. Geological Survey (USGS). While the USGS data are of the same order of magnitude as the BGS data, they are less detailed and have a higher degree of aggregation. For this reason, we have chosen to use the BGS data.

For the period 2001 – 2006, data of the Federal Statistical Office on sales of ferroalloys are available. Those data are lower, by a factor of 0.7, than the production data of the BGS, however. In the interest of the consistency of the time series, the BGS data have thus also been used for those years.

The considerable decrease in the CO₂ emission factor that took place from 1994 to 1995 does not represent any inconsistency; it is the result of the change in the production process.

4.4.2.4 Category-specific quality assurance / control and verification (2.C.2)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The activity data used, which come from the BGS, have been verified with data of the Federal Statistical Office and the USGS (see above).

4.4.2.5 Category-specific recalculations (2.C.2)

Recalculations were required because the activity data carried forward last year have been updated. Those recalculations led to slight changes in last year's emissions. Such recalculations are carried out every year, since the underlying statistics are provided only at two-year intervals.

4.4.2.6 Planned improvements, category-specific (2.C.2)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.4.3 Metal production: Aluminium production (2.C.3)

4.4.3.1 Category description (2.C.3)

KC	Category	Activity	EM of	1990/1995 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990/1995- 2015
-/T	2.C.3. Aluminium production	Primary aluminium production	PFCs	1,800.7	0.15%	94.9	0.01%	-94.7%
-/-	2.C.3. Aluminium production	Primary aluminium production	CO ₂	1,011.9	0.08%	740.1	0.08%	-26.9%
-/-	2.C.3. Aluminium production	Secondary aluminium production	SF ₆	11.4	0.00%	15.8	0.00%	38.9%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 3	AS	CS
CH ₄	-	-	NE
PFC	Tier 3	AS	CS
SF ₆	CS	NS	CS
NO _x	-	-	NE
CO, SO ₂	-	AS	CS

Primary aluminium – by-product emissions

In keeping with its classification in category 2.C.3 Aluminium production, the category *Primary aluminium production* is a key category for PFC emissions in terms of trend.

In Germany, aluminium is produced at four foundries, in electrolytic furnaces with pre-burnt anodes. The principal emission sources are the waste gases from the electrolytic furnaces and fugitive emissions via the plant roofs. CO, CO₂, SO₂, CF₄ and C₂F₆ are among the most important climate-relevant substances and air pollutants that are emitted.

Production of primary aluminium continues to be the largest source of PFC emissions in Germany, in spite of the considerable reductions that have been achieved since 1990. Thanks to extensive modernisation measures in German aluminium foundries, and to decommissioning of production capacities, absolute emissions from this sector have fallen by more than 90 % since 1995. As to the future development of PFC emissions, stagnation at a low level can be expected.

Secondary aluminium – use of F gases in foundries

In keeping with its classification in category 2.C.3 Aluminium production, the category *Use of SF₆ in secondary aluminium production* (aluminium foundries) is not a key category for SF₆ emissions.

Generally speaking, inert gases without additives are sufficient for rinsing secondary molten aluminium. A purification system of inert gases, with added SF₆ at a concentration of 1 or 2.5 %, has been used in the past, however, in a few – usually smaller – aluminium foundries and in laboratories. Such purification systems were last used in 1999 (no sales have taken place in Germany since 2000). From 1990 to 1999, SF₆ consumption remained relatively constant, at 0.5 t/a.

Since 1999, pure SF₆ has been used again as a purification gas, in isolated cases.

4.4.3.2 Methodological issues (2.C.3)

Primary aluminium – by-product emissions

The relevant activity data are reported annually to the Federal Environment Agency by the Wirtschaftsvereinigung Metalle metal-industry association. The average anode consumption in production of primary aluminium is 430 kg of petrol coke per tonne of aluminium. Table 190 shows the process-related emission factors.

The total quantity of waste gas incurred per tonne of aluminium during the production of primary aluminium was multiplied by an average concentration value formed from several individual figures, from various different plants, with appropriate weighting. The emission factors also make allowance for fugitive emission sources, such as emissions via plant roofs. The emission figures used for CO are the results of emission measurements within the context of investment projects.

The emission factors for SO₂ and CO₂ were calculated from the specific anode consumption. The anodes consist of petrol coke; this material has specific sulphur concentrations of about 1.2 %, from which an SO₂ emission factor of 10.4 kg/t Al can be calculated. The CO₂-emission factor is calculated on the basis of the specific carbon content of petrol coke, 857 kg per t. (cf. Chapter 18.7). By multiplying the average anode consumption by the mean carbon content and carrying out stoichiometric conversion to CO₂, one obtains a CO₂-emission factor of 1367 kg/t aluminium. Theoretically, the CO₂-emission factor must be reduced by the proportion resulting from a CO fraction of 180 kg/t Al, since CO can also form only via consumption of anodes. The CO₂ factor listed below does not take this into account.

The emission factors shown in Table 190 were compared with the emission data in Best Available Techniques Reference Documents (BREF)⁶⁰ and other sources (such as VDI Guideline 2286 sheet 1).

Table 190: Activity data and process-related emission factors for primary aluminium production in 2013

	AD		Emission factors				
	Number of smelters	Production [t]	CO ₂ [kg/t]	NO _x [kg/t]	SO ₂ [kg/t]	C total [kg/t]	CO [kg/t]
Primary aluminium	4	492,368	1367	N. e.	10.4	N. e.	180

Emissions data are available for PFC emissions from primary aluminium smelters, thanks to a voluntary commitment on the part of the aluminium industry. Since 1997, the aluminium industry has reported annually on the development of PFC emissions from this sector. The measurement data are not published, but they are made available to the Federal Environment Agency.

⁶⁰ cf. <http://www.bvt.umweltbundesamt.de/kurzue.htm>

The measurements conducted in all German smelters in the years 1996 and 2001 form the basis for calculation of CF₄ emissions. In this context, specific CF₄ emission figures per anode effect⁶¹ were calculated, in keeping with the technologies used. The number of anode effects is recorded and documented in the foundries. The total CF₄ emissions were calculated by multiplying the total anode effects for the year by the specific CF₄ emissions per anode effect determined in 2001. The total emission factor for CF₄ is obtained by adding the CF₄ emissions of the smelters and then dividing the sum by the total aluminium production of the smelters. C₂F₆ and CF₄ occur in a constant ratio of about 1:10. The above-described method was applied to the time series through 2010, and the emissions for the years 1990 to 1996 were filled in via recalculations. For purposes of emissions trading, the aluminium industry has made a transition to the IAI method for calculating PFC emissions (the method is equivalent to UNFCCC default Tier 2). The default slope factor used with that method is used by all other European operators, and it is accepted in the framework of European emissions trading. In the interest of consistency, as of 2010 the aluminium industry has also used the IAI method to determine emissions data for purposes of emissions reporting.

Secondary aluminium – use of F gases in foundries

For aluminium foundries, the relevant emission factor has been established more reliably, via plant-specific measurements carried out in 2010. As a result, the relevant emissions figures have been established more reliably as well.

Reports and archived survey records from 1996 have been used as a basis for the reporting years 1990 through 1994.

Emission factor for secondary aluminium

On the basis of confidential measurement records certified by the pertinent permit authority, the SF₆ emission factor for aluminium foundries, for the period 1999 through 2008, has been reduced to 3 %. Via structural conversions, the emission factor has been further reduced, to 1.5%, as of 2009.

Activity data for secondary aluminium

SF₆-consumption data are obtained via surveys of gas sellers. At the same time, the survey for the 2000 reporting year revealed that there have been no sales of this gas mixture since 2000.

Data on the SF₆ used in pure form since 1999 have been obtained via direct surveys of users and have been compared with relevant data of gas sellers.

Since the 2007 reporting year, the data have been obtained by the *Federal Statistical Office* via surveys of gas sellers with regard to SF₆-sales figures.

4.4.3.3 Uncertainties and time-series consistency (2.C.3)

Primary aluminium – by-product emissions

The figures for PFC, CO, CO₂ and SO₂ emissions are in keeping with the Tier 3b approach and thus are considered very accurate. The time series for CO, CO₂ and SO₂ are consistent.

⁶¹ "...Organic fluorides occur only under certain conditions, and such conditions occur in the furnace repeatedly, at intervals of hours to several days. These conditions are referred to as the "anode effect". ... The gas at the anode changes in composition from CO₂ to CO and 5 to 20 % CF₄...." (ÖKO-RECHERCHE 1996)

On the other hand, in the framework of voluntary commitments no survey of the plant-specific number of anode effects in 1991, 1992, 1993 and 1995 was conducted, and no calculation was carried out for those years (cf. 4.4.3.6).

In addition, the years 1991 through 1994 were years of deep crisis for the German aluminium industry, due to sharp drops in the world-market prices for primary aluminium. For this reason, a number of plants were decommissioned. While all smelter types were affected, smelters that had recently been modernised, with point-feeder technology, were most strongly affected. Their capacity decreased by 43%, with regard to the relevant levels in 1990. This also explains the sudden increase and stagnation in the implied emission factor for CF_4 in these years. In absolute terms, the primary smelters emitted only 26 tonnes of CF_4 in 2007, while they emitted 45 tonnes in 2005. This drop was due to a decrease in production. With regard to 2006, production increased slightly, however, because partial shutdowns of furnaces in the Stade plant were more than offset by production increases at the Hamburg production site. In 2009, the economic crisis and other factors led to drastic reductions of production at the Rheinwerk Neuss site. In the period thereafter, all German primary smelters faced difficult economic situations and had to start up and shut down processes frequently, thereby incurring process instabilities. Those instabilities led to higher numbers of anode effects and, thus, to higher PFC emissions. The economic situation stabilised noticeably in 2010. That made it possible to run continuous, stable processes. As a result, the numbers of anode effects decreased to such a degree that absolute PFC emissions decreased, by comparison to their level in 2009, in spite of the production increases. That trend continued in subsequent years.

Secondary aluminium – use of F gases in foundries

As studies have shown, part of the SF_6 used in aluminium production is broken down during such use. For the aluminium industry, the emission factor has been applied to the highest measured emissions level, and an uncertainty of 50% has been assumed for lower levels, since measurements have shown that emissions are frequently considerably lower than the maximum levels.

4.4.3.4 Category-specific quality assurance / control and verification (2.C.3)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The activity data for primary aluminium production are based on surveys taken by the Wirtschaftsvereinigung Metalle metal-industry association. They are reported to the Federal Environment Agency annually. The relevant time series seems plausible and shows no inconsistencies. It is assumed that such data collection conforms to quality assurance criteria.

Specific PFC emissions during anode effects were determined via industry measurements carried out in 1996 and 2001 at all plants in Germany that produce primary aluminium. In each case, the amount of PFCs produced depends on the duration and frequency of the relevant anode effects. In recent years, the duration and frequency of anode effects have been considerably reduced via computer-aided process control. In 2010, the German emission factor for CF_4 , resulting from anode effects, was 0.044 kg/t aluminium. That factor is thus of the same magnitude as the average international factor, as reported by the International Aluminium Institute (IAI), of 0.034 kg/t for point-feeder systems. Therefore, the emission factor has been verified.

As to amounts consumed by Al foundries, for the 2002 reporting year, sales figures were compared for the first time with amounts used by industry, and this comparison revealed a discrepancy. That

discrepancy has since been corrected. Sales figures and industrial usage quantities were compared for reporting year 2004 and showed good agreement.

4.4.3.5 Category-specific recalculations (2.C.3)

No recalculations are required.

4.4.3.6 Planned improvements, category-specific (2.C.3)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.4.4 Metal production: Magnesium production (2.C.4)

4.4.4.1 Category description (2.C.4)

KC	Category	Activity	EM of	1995 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1995-2015
-/-	2.C.4. Magnesium foundries	0	SF ₆	176.6	0.01%	10.5	0.00%	-94.0%
-/-	2.C.4. Magnesium foundries	0	HFC 134a	0.0	0.00%	48.0	0.01%	---

Gas	Method used	Source for the activity data	Emission factors used
SF ₆	D	PS	D
HFC	D	PS	D

The category *SF₆ and HFC-134a in magnesium production* is not a key category.

No primary magnesium is produced in Germany. Only magnesium-alloy castings are produced.

No primary magnesium is produced in Germany. Only magnesium-alloy castings are produced.

In magnesium casting, since the mid-1970s, SF₆ has been used as a protective gas over molten magnesium to prevent the magnesium's oxidation and ignition. The amount of SF₆ used per tonne of magnesium (specific SF₆ coefficient) has decreased sharply from its level in 1995. This is due to the fact that HFC-134a has increasingly been used as a substitute since 2003. SF₆ is used in both a) the sand-casting process, for production of prototypes, individual parts and small series, and b) the pressure-casting process, in which it serves as a protective gas.

4.4.4.2 Methodological issues (2.C.4)

Use of SF₆ as a purification and protective gas in magnesium production is an open use, i.e. all of the SF₆ used in the process is emitted into the atmosphere. The practice of assuming the equivalence between consumption (activity data) and emissions conforms to the method in the 2006 IPCC Guidelines (Chapter 4.5).

For use of HFC-134a, the calculation method, emission factor used and figures for activity data in magnesium production are identical with the comparable figures for use of SF₆ in magnesium production.

Emission factors

For magnesium foundries, EF_{use} = 100% is assumed, due to a continuing lack of more precise decomposition-level data that would support a more precise estimate.

Activity data for magnesium production

In 1996, a survey was carried out, under commission to the Federal Environment Agency, of all domestic magnesium foundries that use SF₆. That survey determined the amounts consumed in the years 1990 to 1995.

Until report year 2007, data on the amounts used were obtained directly from users. Since report year 2006, the data have been obtained via surveys of gas sellers with regard to SF₆-sales figures. In report year 2006, the two methods were compared.

Since report year 2007, data of the *Federal Statistical Office* have been used.

4.4.4.3 Uncertainties and time-series consistency (2.C.4)

As studies have shown, part of the SF₆ used in magnesium production is broken down during such use. For this reason, the assumption that amounts used in magnesium production are emitted to a degree of 100 % probably overstates the emissions considerably.

4.4.4.4 Category-specific quality assurance / control and verification (2.C.4)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

Quality assurance / control for amounts consumed in Mg foundries was carried out via a one-time comparison of findings from foundry surveys with producers' total SF₆-sales figures – and with data of gas sellers. For report year 2007, additional findings resulting from a technical discussion held in December 2007 have been taken into account.

4.4.4.5 Category-specific recalculations (2.C.4)

No recalculations are required.

4.4.4.6 Planned improvements, category-specific (2.C.4)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.4.5 Metal production: Lead (2.C.5)

4.4.5.1 Category description (2.C.5)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.C.5. Lead production	0	CO ₂	157.9	0.01%	83.0	0.01%	-47.4%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1	AS	D/CS

The category *Metal production: Lead* is not a key category.

In Germany, lead is produced from primary lead concentrates and secondary raw materials such as lead-containing scrap and lead acid batteries.

All primary lead production in Germany takes place via the direct smelting (DS) process, either in bath smelting furnaces (Isasmelt-Ausmelt) or in QSL reactors. Process-related CO₂ emissions occur primarily via addition of carbon-containing reducing agents (such as coal dust). The imperial smelting process (in imperial smelting furnaces (ISF)) is no longer used in Germany.

Recycling of lead acid batteries is the key factor shaping secondary lead production in Germany. The relevant sector uses both short rotary furnaces and shaft furnaces. Process-related CO₂ emissions occur primarily via addition of carbon-containing reducing agents (for example, coke).

The relevant activity data are reported annually to the Federal Environment Agency by the Wirtschaftsvereinigung Metalle metal-industry association.

4.4.5.2 Methodological issues (2.C.5)

The **emission factors** that have been used have been taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (the values in Table 4.21). All primary lead production in Germany takes place via the direct smelting (DS) process. A separate process is used for secondary lead production (S). The DS/S production-quantity ratio in Germany is relatively constant, at about 1/ 1.5. The emission factor of 220 kg CO₂ / t lead was obtained by applying that ratio to the values in Table 4.21:

$$EF_{lead} = \frac{DS \cdot EF_{DS} + S \cdot EF_S}{DS + S} = \frac{1 \cdot 0.25 \frac{t \text{ CO}_2}{t \text{ lead}} + 1.5 \cdot 0.2 \frac{t \text{ CO}_2}{t \text{ lead}}}{2.5} = 0.22 \frac{t \text{ CO}_2}{t \text{ lead}}$$

DS: Quantity of primary lead produced using the direct smelting process

S: Quantity of secondary lead produced

DS/S: This production-quantity ratio is relatively constant in Germany, at 1/1.5

EF_{lead}: Overall CO₂-emission factor for lead

EF_{DS}: CO₂ emission factor for the direct smelting process as used in primary lead production – 0.25 t CO₂ / lead (pursuant to Table 4.21)

EF_S: CO₂ emission factor for secondary lead production – 0.20 t CO₂ / lead (pursuant to Table 4.21)

4.4.5.3 Uncertainties and time-series consistency (2.C.5)

The default uncertainties set forth in 2006 IPCC Guidelines for National Greenhouse Gas Inventories are used.

4.4.5.4 Category-specific recalculations (2.C.5)

No recalculations are required.

4.4.5.5 Category-specific quality assurance / control and verification (2.C.5)

The activity data are based on confidential surveys taken by the Wirtschaftsvereinigung Metalle metal-industry association. They are reported to the Federal Environment Agency annually. The relevant time series seems plausible and shows no inconsistencies. It is assumed that such data collection conforms to quality assurance criteria.

4.4.5.6 Planned improvements (category-specific) (2.C.5)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.4.6 Metal production: Zinc (2.C.6)

4.4.6.1 Category description (2.C.6)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.C.6. Zinc production	0	CO ₂	670.8	0.05%	293.7	0.03%	-56.2%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1	AS	D

The category *Metal production: Zinc* is not a key category.

In Germany, zinc is produced from primary zinc concentrates and secondary raw materials such as zinc-containing scrap and steel mill dust.

All primary zinc production in Germany takes place via the hydrometallurgical process. The imperial smelting process, a pyrometallurgical process, is not used.

In this sector in Germany, process-related greenhouse-gas emissions occur primarily in secondary zinc production. Process-related CO₂ emissions occur via use of coke as a reducing agent, especially in processing of zinc-containing secondary materials in rotary kilns.

The relevant activity data are reported annually to the Federal Environment Agency by the Wirtschaftsvereinigung Metalle metal-industry association.

4.4.6.2 Methodological issues (2.C.6)

The **emission factors** used have been taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (default factors), since no better figures are currently available.

4.4.6.3 Uncertainties and time-series consistency (2.C.6)

The default uncertainties set forth in 2006 IPCC Guidelines for National Greenhouse Gas Inventories are used. Category-specific recalculations (2.C.6)

No recalculations are required.

4.4.6.4 Category-specific quality assurance / control and verification (2.C.6)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The activity data are based on confidential surveys taken by the Wirtschaftsvereinigung Metalle metal-industry association. They are reported to the Federal Environment Agency annually. The relevant time series seems plausible and shows no inconsistencies. It is assumed that such data collection conforms to quality assurance criteria.

4.4.6.5 Planned improvements, category-specific (2.C.6)

Specific data for determination of emission factors will be collected in the next rounds of reporting. Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.4.7 Metal production: Other (2.C.7)

Since the CRF-Reporter software does not allow nitrous oxide to be allocated to 2.C.1, it is reported in 2.C.7 instead. Otherwise, no emissions are reported in category 2.C.7.

4.4.7.1 Category description (2.C.7)

In Germany, this category primarily includes copper production. The majority of that industry's greenhouse-gas emissions occur in process combustion; those emissions are reported under 1.A.2.b. The greenhouse-gas emissions that do not originate in process combustion are very low by comparison.

4.4.7.2 Methodological issues (2.C.7)

No emission factors are available. In addition, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories provide no pertinent default factor.

4.4.7.3 Uncertainties and time-series consistency (2.C.7)

No information.

4.4.7.4 Category-specific recalculations (2.C.7)

No recalculations are required.

4.4.7.5 Category-specific quality assurance / control and verification (2.C.7)

The activity data are based on confidential surveys taken by the WirtschaftsVereinigung Metalle metal-industry association. They are reported to the Federal Environment Agency annually. The relevant time series seems plausible and shows no inconsistencies. It is assumed that such data collection conforms to quality assurance criteria.

4.4.7.6 Planned improvements (category-specific) (2.C.7)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.5 Use of non-energy-related products from fuels and solvents (2.D)**4.5.1 Lubricant use (2.D.1)****4.5.1.1 Category description (2.D.1)**

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.D.1 Lubricant use	0	CO ₂	521.8	0.04%	589.8	0.07%	13.0%
Gas		Method used		Source for the activity data		Emission factors used		
CO ₂		Tier 1		NS		D		

The category *Lubricant use* is not a key category for CO₂ emissions.

Lubricants are used to reduce friction and wear in moving machine parts. They can also be used for transmission of power and heat. Furthermore, lubricants are used as sealants, and they are used to prevent build-up of deposits and to guard against corrosion. Consequently, special lubricants have been developed for many specific applications. The consumption of lubricants in Germany has remained at a relatively constant level since 1990, apart from a sharp decrease in 2009 that was related to the overall economic situation.

4.5.1.2 Methodological issues (2.D.1)

Lubricant use is divided into the two major areas of a) use in motor vehicles, including other mobile sources, and b) use in industry; this is due to the different calculation methods involved.

The German greenhouse-gas inventory covers CO₂ emissions from co-combustion of lubricants for all mobile sources. In keeping with emissions reporting requirements, emissions from two-stroke petrol engines are allocated directly to the pertinent emission sources, since in those cases lubricants are seen as part of the relevant fuels (fuel mixtures for two-stroke engines). On the other hand, all co-combustion emissions that are not caused by two-stroke engines are considered to result from product use and are reported in the present section, along with emissions from lubricant use in industrial sectors. The relevant calculation method is described here and in 19.1.4.

Activity data – lubricant use in industry

The activity data used for lubricant use in industry consist of the domestic-sales data (units of tonnes) as listed in the statistics in the "Official Mineral Oil Statistics for the Federal Republic of Germany" ("Amtliche Mineralölstatistik für die Bundesrepublik Deutschland") of the Federal Office of Economics and Export Control (BAFA) (Table 10j).

Emission factors – lubricant use in industry

The CO₂ emissions are calculated using a Tier 1 method, with a standard emission factors for the entire time series. The emission factor was derived using Equation 5.2 from Vol. 3 Chapter 5 of the 2006 IPCC Guidelines, as follows:

$$EF (CO_2) = NCV * CC * ODU * 44/12$$

The values for the default net calorific value (NCV) and the default carbon content (CC) have been obtained from Vol. 1, Chapter 1, Tables 1.2 and 1.3. The oxidised during use (ODU) factor has been obtained from Vol. 3, Chapter 5, Table 5.2.

An emission factor of 0.5896 t CO₂ / t lubricants results.

4.5.1.3 Uncertainties and time-series consistency (2.D.1)

A Tier 1 method and standard values from the 2006 IPCC Guidelines have been used, and thus that source's uncertainties for the activity data and emission factors apply (2006 IPCC Guidelines: Vol. 3, Ch. 5).

4.5.1.4 Category-specific recalculations (2.D.1)

No recalculations are required.

4.5.1.5 Category-specific quality assurance / control and verification (2.D.1)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The results of the emissions calculation cannot be compared with those obtained with other data sources for Germany, because no data sources relative to emission factors and emissions are available.

The emission factor for carbon dioxide was compared with the corresponding emission factors of other countries. The emission factor shows good agreement with the Danish emission factor of 0.6176 t CO₂ / t lubricants. The difference seen results in that the reference value for the emission factor was converted from TJ into t of lubricants.

4.5.1.6 Planned improvements, category-specific (2.D.1)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.5.2 Paraffin wax use (2.D.2)

4.5.2.1 Category description (2.D.2)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.D.2 Paraffin wax use	0	CO ₂	248.4	0.02%	586.7	0.07%	136.2%
-/-	2.D.2 Paraffin wax use	0	N ₂ O	0.6	0.00%	1.4	0.00%	136.2%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1	NS	D
N ₂ O	Tier 1	NS	D

The category *Paraffin wax use* is not a key category for CO₂ and N₂O emissions.

Within the European Union, Germany is an important market for candles. In 2013, its share of the market amounted to 35 % (source: "Verbrauch von Kerzen in der Europäischen Union (EU 28)" ("Consumption of candles in the European Union (EU 28)")) of the European Candle Association ASBL). In contrast to the overall European trend, candle consumption grew in Germany from 1990 through 2013. Production has remained at a constant level, and the country's growing additional requirements are being met via imports.

4.5.2.2 Methodological issues (2.D.2)

The calculation model is based on the assumption that all candles are consumed within a year of their purchase and are burned completely.

The CO₂ and N₂O emissions are calculated via a Tier 1 method.

Activity data

The data on charcoal production, and on the imported and exported quantities of candles, for the years as of 1996, were obtained from the Federal Statistical Office (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 3.1, Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe sowie der Außenhandelsstatistik ("manufacturing industry; production in the manufacturing industry and foreign-trade statistics")).

The quantities consumed are calculated in keeping with the formula Production + Imports – Exports.

For the years 1990 through 1995, the quantities consumed are calculated from the per-capita consumption, which has been derived from the data for the years 1996 through 2013. In the process, it is assumed that consumption also grew linearly in those (earlier) years.

Emission factors

The emission factor for CO₂ is 2.9467 t/t product; for N₂O, the factor is 0.024 kg/t product.

The emission factors, which are applied to the entire time series, were derived on the basis of standard values (IPCC-GL2006, Vol. 2 Chapter 1 Table 1.2 and IPCC, 2006: Vol. 2, Ch. 2 Tab. 2.4).

4.5.2.3 Uncertainties and time-series consistency (2.D.2)

A Tier 1 method and standard values from the 2006 IPCC Guidelines have been used, and thus that source's uncertainties for the activity data and emission factors apply (2006 IPCC Guidelines: Vol. 3, Ch. 5).

4.5.2.4 Category-specific recalculations (2.D.2)

No recalculations are required.

4.5.2.5 Category-specific quality assurance / control and verification (2.D.2)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

No other data, apart from the data provided by the Federal Statistical Office, are available for review of the relevant import, export and production quantities, for purposes of verification of the consumption-quantity data. For example, the European Candle Association (ECA) relies on data of EUROSTAT. A comparison with the data of EUROSTAT was carried out. Its figures show good agreement with the figures the Federal Statistical Office has provided to EUROSTAT.

The emission factors for carbon dioxide and nitrous oxide have been compared with the corresponding emission factors in the Danish inventory. The emission factors in the two greenhouse-gas inventories show excellent agreement.

4.5.2.6 Planned improvements (category-specific) (2.D.2)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.5.3 Other: Solvents – NMVOC (2.D.3 Solvents)

4.5.3.1 Category description (2.D.3 Solvents)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.D.3. Other		CO ₂	2,552.0	0.21%	1,317.1	0.15%	-48.4%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	D	NS	D
NMVOC	Tier 2	NS	CS

The category indirect CO₂ from NMVOC emissions, within the category *Solvent and other product use* (CRF 2.D.3), is not a key category, due to its inclusion within the overarching category 2.D.3 – *Other*.

The NMVOC emissions released through use of solvents and solvent-containing products all belong to sub-categories of this category.

The four reporting categories of this category vary widely in structure. To take account of this variation, inventory data were calculated in keeping with the UNECE/EMEP sub-structures based on the CORINAIR97 (CORINAIR: COordination d'INformation Environnementale; sub-project AIR) SNAP system⁶².

⁶² In the present area, this involves "SNAP Level 3" detailing.

The categories 2.D.3.a, d, e, f, g, h and i include the following applications and activities:

2.D.3.a: Household use of solvents, including fungicides

i) Residential use of solvents

- **Soaps**
- **Detergents, dishwashing agents and cleansers** (softeners; general-purpose detergents; detergents; auxiliary washing preparations; dishwashing detergents; cleansers for floors and carpets; cleansers for cars; window cleaners; cleaning agents for toilets and bathrooms);
- **Shoe polishes, shoe- and leather-care products, furniture and floor polishes; car-care washes and waxes**
- **Preparations for polishing metal**
- **Fragrances** (for rooms, perfumes, eau de toilette, aftershaves)
- **Cosmetics and make-up** (make-up; preparations for hand, nail and foot care; face-care products; body-care products; sunscreen products and other preparations)
- **Shampoos and hair-care products** (shampoos; perm-care products and hair straighteners; hairsprays; hair cremes and brilliantines; tinting shampoos, hair-colouring agents, hair-bleaching agents and other care products)
- **Other personal care products** (shaving creams; body deodorants and antiperspirants; bath essences; intimate-care products, hair removers, beauty products and other)
- **Anti-freezes for motor vehicles**

ii) Household use of pharmaceutical products

2.D.3.d: Use of paints and lacquers

i) Industrial coatings

- **Motor-vehicle repair**
- **Professional uses of paints and lacquers in structures and buildings** (emulsion paints for interiors; facade paints / silicate; polymer plasters / silicate; architectural paints / glazes; primers / coatings; other applications)
- **Do-it-yourself uses of paints and lacquers in structures and buildings** (emulsion paints for interiors; facade paints / silicate; polymer plasters / silicate; architectural paints / glazes; primers / coatings; other applications)
- **Wood coatings** (wooden interiors; carpentry and cabinet-making)

ii) Industrial coatings

- **Motor-vehicle manufacturing** (primers, fillers, topcoats and clearcoats)
- **Repair of utility vehicles and other vehicles**
- **Coil coatings**
- **Coatings for maritime applications**
- **Wood coatings** (furniture)
- **Other industrial coatings** (spray paints (without propellants); electrical fittings and appliances / household; machine tools; auto accessories/ metal; metal products, sheet metal packaging; wire enamels; impregnation and casting materials; structural elements without strip coatings; plastics; paper / foil; other processing)

iii) Other non-industrial colour coatings (marking paints; anti-corrosives; other)

2.D.3.e Degreasing

- **Metal degreasing**
- **Production of electronic components**
- **Other industrial cleaning** (precision mechanics, optics, watch-making)

2.D.3.f Chemical cleaning (dry cleaning)

- **Dry cleaning**

2.D.3.g Production and processing of chemical products

- **Processing of polyester**
- **Processing of polyvinyl chloride**
- **Processing of polyurethane**
- **Processing of polystyrene foam**
- **Rubber processing** (tyre manufacturing)
- **Production of pharmaceutical products**
- **Production of paints and lacquers**
- **Production of printing inks and dyes**
- **Production of glues**
- **Asphalt blowing**
- **Production of adhesives, magnetic tape, films and photographs**
- **Production of products containing solvents**
 - Production of wood preservatives
 - Production of building-material additives
 - Production of consumer goods containing solvents
 - Production of surface-cleaning agents
 - Production of anti-freezes and de-icing agents
 - Production of waxes and wax removers
 - Production of paint strippers

2.D.3.h Printing industry – printing applications

- **Coldset-offset printing** (newspaper printing)
- **Sheet-fed offset printing** (conventional, UV-bases)
- **Heatset-offset printing**
- **Endless-offset printing**
- **Book printing**
- **Flexographic printing for packaging** (solvent-based, water-based)
- **Gravure printing for packaging** (solvent-based, water-based)
- **Illustration gravure printing**
- **Screen printing**
- **Other printing applications**
- **Paints for artists, in sets**
- **Paints for artists, not in sets**
- **Inks for writing and drawing, etc., including inks in concentrate or solid form** (not including printing inks)

2.D.3.i: Other applications

- **Treatment of glass and rock wool**

- **Extraction of oils and fats**
- **Use of glues and adhesives** (paper and packaging; construction, wood; transport; shoes; do-it-yourself applications; other)
- **Use of wood preservatives**
- **Undersealing and wax treatments for automobiles**
- **Automobile-wax stripping**
- **Other**
 - Use of pesticides
 - Dichloroethane for paint stripping
 - Paint and varnish removal (improperly coated aluminium components, steel parts and steel hangers)
 - Concrete additives
 - De-icing (aircraft; working spaces; other)
 - Scientific laboratories
 - Cooling lubricants

"NMVOC" is defined in keeping with the VOC definition found in the EC solvents directive⁶³. For purposes of the definition of solvents, the term "solvent use" is also defined in keeping with the EC solvents directive⁶⁴.

It is important to note that some volatile organic compounds are used both as solvents and as chemical reactants – for example, toluene, which is used as a solvent in lacquers and glues and as a reactant for production of toluenediisocyanate (TDI), and methyl ethyl ketone (butanone), which is used as a solvent in printing inks and as a base material for synthesis of methyl ethyl ketone peroxide. Consequently, VOC (either substances or fractions of substances or products) used as chemical reaction components are not included in this category.

Delimitation of this category as outlined above takes a highly diverse range of emissions-causing processes into account. The factors considered with regard to such processes include:

- Concentrations and volatility of VOC used.
(The relevant spectrum includes use of volatile individual substances as solvents – for example, in cleansing; use of products with solvent mixtures – for example, in paints and lacquers; and applications in which only small parts of mixtures used (also) have solvent properties (as is the case, for example, in polystyrene-foam production)).
- The great differences in emissions conditions.

Solvent uses can be open to the environment – as is the case in use of cosmetics – or largely closed to the environment – as in extraction of essential oils or cleaning in chemical dry-cleaning systems.

4.5.3.2 Methodological issues (2.D.3 Solvents)

NMVOC emissions are calculated via an approach oriented to product consumption. In this approach, the NMVOC input quantities allocated to these source categories, via solvents or solvent-containing products, are determined and then the relevant NMVOC emissions (for each source

⁶³ In this definition, volatile organic compounds (VOC) include all organic compounds that are volatile at 293.15 K, at a vapour pressure of at least 0.01 kPa or under the usual conditions for their use.

⁶⁴ In this definition, an organic solvent is a volatile organic compound that, either by itself or in combination with other raw materials, products or waste substances, and without changing chemically, either dissolves or is used as a cleanser for dissolving dirt accumulations, as a solvent, as a dispersing agent, as an agent for adjusting viscosity or surface tension, or as a softener or preservative.

category) are calculated from those quantities via specific emission factors. This method is explicitly listed, under "consumption-based emissions estimating", as one of two methods that are to be used for emissions calculation for this category.

Use of this method is possible only with valid input figures – differentiated by source categories – in the following areas:

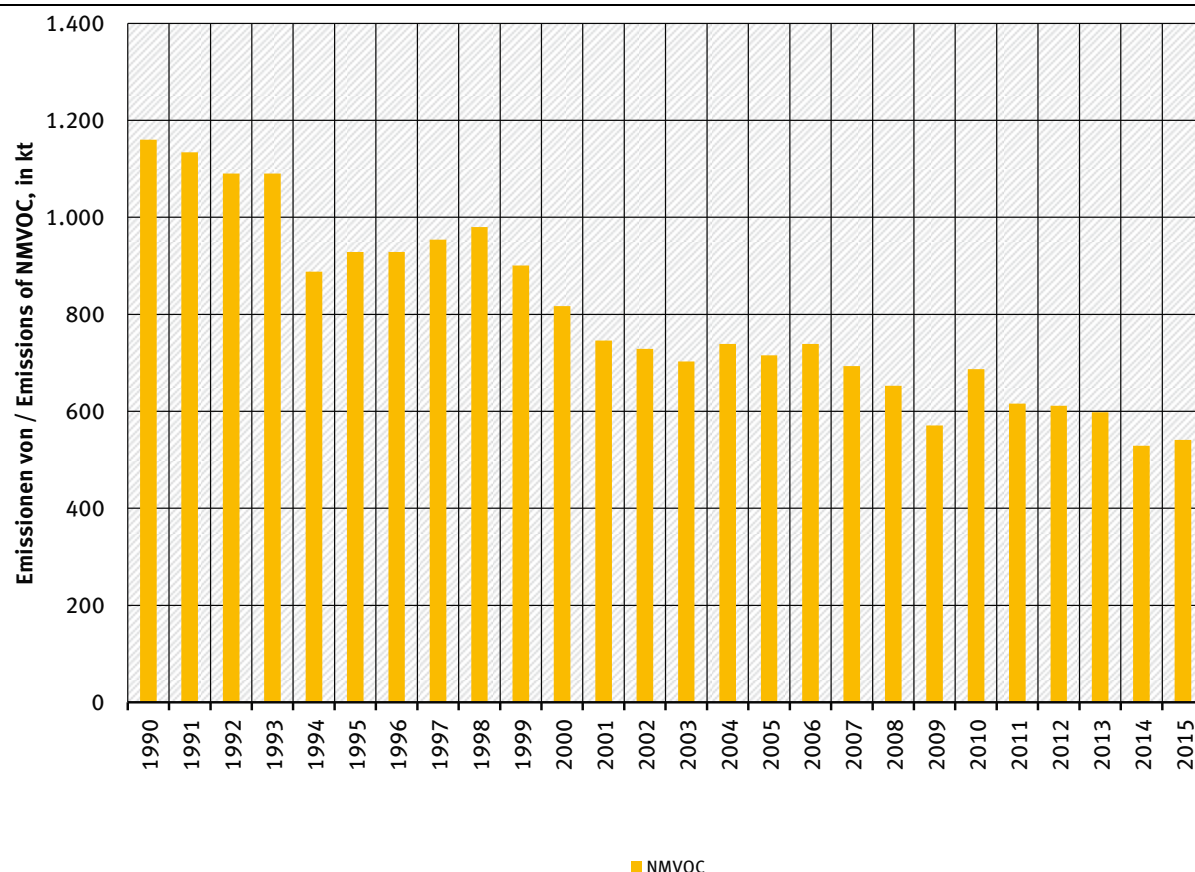
- Quantities of VOC-containing (pre-) products and agents used in the report year,
- The VOC concentrations in these products (substances and preparations),
- The relevant application and emission conditions (or the resulting specific emission factor).

To take account of the highly diverse structures throughout this category, these input figures are determined on the level of 37 differentiated emissions-causing processes (as noted above, in a manner similar to that used for CORINAIR SNAP Level 3), and the calculated NMVOC emissions 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 domestic-consumption quantities are then further verified via cross-checking with industry statistics.

The values used for the average VOC concentrations of the input substances, and the emission factors used, are based on experts' assessments (expert opinions and industry dialog) relative to the various categories and category areas. Not all of the necessary basic statistical data required for calculation of NMVOC emissions for the most current relevant year are available in final form; as a result, the data determined for the previous year are used as a basis for a forecast for the current report. The forecast for NMVOC emissions from solvent use for the relevant most current year is calculated on the basis of specific activity trends. As soon as the relevant basic statistical data are available for the relevant most current year, in their final form, the inventory data for NMVOC emissions from solvent use are recalculated.

Since 1990, NMVOC emissions from use of solvents and solvent-containing products have decreased by over 50%.

Figure 45: Total NMVOC emissions from solvents-based products and applications (2.D.3.a,d-i)



The greatest part of this emissions reduction has occurred in the years since 1999. This successful reduction has occurred especially as a result of regulatory provisions such as the *Ordinance, under chemicals law, for limiting emissions of volatile organic compounds (VOC) through limitations on the placing on the market of solvent-containing paints and varnishes (Chemikalienrechtliche Verordnung zur Begrenzung der Emissionen flüchtiger organischer Verbindungen (VOC) durch Beschränkung des Inverkehrbringens lösemittelhaltiger Farben und Lacke (Lösemittelhaltige Farben- und Lack-Verordnung - ChemVOCFarbV)*, the 31st Ordinance on the Implementation 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*), the 2nd such ordinance (*Ordinance on the limitation of emissions of highly volatile halogenated organic compounds – 2. BImSchV*) and the Technical Instructions on Air Quality Control (TA Luft). The German "Blauer Engel" ("Blue Angel") environmental quality seal, which is used to certify a range of products, including paints, lacquers and glues with low solvent concentrations, has also played an important role in this development.

While product sales increased in some areas – even over periods of several years – thereby adding to emissions, the above-described measures have largely offset this trend. These successes, which have occurred especially in recent years, are reflected in the updated emissions calculations – which, thanks to methods optimisation, now feature greater differentiation of VOC concentrations and emission factors.

Since the 2009 report, indirect CO₂ emissions are calculated from NMVOC.

Since compatibility with EU greenhouse-gas reporting is the primary methodological backdrop for conversion of NMVOC emissions into indirect CO₂ emissions, for the current report we have used the Reference Approach proposed in *Vol. 3 Chapter 7 Precursors and Indirect Emissions* of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories:

$$EM_{\text{Indirect CO}_2} = EM_{\text{NMVOC}} * \text{molar mass CO}_2 / \text{molar mass C} * 60 \%$$

In the framework of an expert assessment, and with the help of technical discussions with the affected sectors in the years 2013 and 2015, the solvent content levels of various paints and coatings have been adapted to the current state of the art – and, thus, reduced.

A more-detailed explanation of the methods used to determine and analyse trends for NMVOC emissions from solvents-based products and applications is available in the 2015 Informative Inventory Report (IIR)⁶⁵.

4.5.3.3 Uncertainties and time-series consistency (2.D.3 Solvents)

At the time of the report, errors had been estimated for NMVOC emissions; this was carried out using the error-propagation method and on the basis of experts' assessments for all input figures (in all 37 differentiated categories). The main source of current uncertainties consists of inadequate precision in separation of basic statistics (production and foreign-trade statistics), with regard to categorisation in VOC-containing and VOC-free products, and with regard to use in different categories with highly differing emissions conditions.

4.5.3.4 Category-specific quality assurance / control and verification (2.D.3 Solvents)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

4.5.3.5 Category-specific recalculations (2.D.3 Solvents)

The data used in the emissions inventory for the NMVOC emissions of the previous year are subjected to routine source-specific recalculations. That procedure, which is grounded in the methodology for the product-consumption approach, is required because the relevant final data from foreign-trade statistics do not become available until after the report for the pertinent reported year has been completed.

No corrections were required for the NMVOC emissions of 2014, since no adjustments in foreign-trade statistics resulted.

Updating of the data survey, and integration of sector-specific data for source category 2.D.3.h (printing industry / printing processes), for the years 2006 through 2015, led to a plausible emissions reduction in this area. The changes taken into account included changes in the area of printing inks (in connection with the reduced importance of book printing, for example) and lower emission factors tied to "greener" printing technologies.

The emission factors for de-icing agents, for the years 2006 through 2015, were lowered from 50% to 40%, since such agents have high concentrations of glycol derivatives, and the volatility of such agents decreases as their concentrations of glycol derivatives increase.

In keeping with a recent estimate of the mean solvent concentration in antifreezes, the assumed solvent-concentration levels in this product group have been gradually increased since 2010.

⁶⁵ Informative Inventory Report – Germany <http://iir.umweltbundesamt.de>

A new calculation was carried out on the basis of more-detailed data that were available for the year 2005.

The recalculations led to the following new total-quantity figures for NMVOC in category 2.D.3 (solvents).

Reference year	Total NMVOC emissions in 2.D.3 (solvents)		Difference, in kt
	PRIOR TO recalculations, in kt	AFTER recalculations, in kt	
2005	743	715	27
2006	747	739	8
2007	707	694	13
2008	669	653	16
2009	596	571	25
2010	705	687	18
2011	647	616	32
2012	637	611	26
2013	613	598	14
2014	550	529	21

4.5.3.6 Planned improvements, category-specific (2.D.3 Solvents)

Currently, the consistency of the data for the years 2005 through 2015 is being reviewed, and the plausibility of the emissions trends is being systematically checked.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.5.4 Other: Bitumen for roofing (2.D.3 Bitumen)

Gas	Method used	Source for the activity data	Emission factors used
NMVOC	Tier 1	AS	CS
CO ₂	NE	NE	NE

As far as is currently known, the category *Bitumen for roofing* produces no greenhouse-gas emissions⁶⁶ and thus is not a key category.

4.5.4.1 Category description (2.D.3 Bitumen)

Bitumen is used in production and laying of roof and sealing sheeting.

The quantities of roof and sealing sheeting that are produced and used in Germany are shown in Table 191. The discrepancy between the two figures (production and use) is due to an export surplus. In such production, liquid bitumen is applied, at temperatures of 150°C to 220°C, as a saturating or coating agent. This process produces emissions of organic substances (combined here as NMVOC).

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. Chapter 4.5.1.

Emissions from production of roof and sealing sheeting have been decreasing slightly, in keeping with decreasing production quantities. Emissions from laying of roof and sealing sheeting have remained about the same, although the quantities used have been decreasing.

⁶⁶ Cf. the discussion of indirect CO₂ emissions, under "Methodological aspects".

Substances other than NMVOC are of only subordinate relevance in terms of emissions (cf. footnote ⁶⁶).

4.5.4.2 Methodological issues (2.D.3 Bitumen)

Data on quantities of roof and sealing sheeting that are produced and used (**activity data**) are provided by the VDD association of the bitumen, roof sheeting and sealing sheeting industry (VDD, 2015), on the basis of a cooperation agreement dating from 2009. At present, no data supplementation or extrapolation is being carried out. To obtain internationally comparable figures, production quantities are converted into quantities of input bitumen (the conversion relationship, depending on the type of sheeting concerned, varies from 1.3 to 3.3 bitumen kg/m²).

Because of their predominating importance, only NMVOC emissions are considered and taken into account in the emissions inventory. In the process, a distinction is made between emissions from production and emissions from 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, 2009). The emission factor for laying of polymer bitumen sheeting has been taken from an ecological balance sheet ({Kreißig, 1996 #13}). That emission factor has also been adopted, by analogy, for sheeting glued primarily with hot bitumen. Thin sheeting is not glued; it is attached via nailing and produces no emissions. The implied emission factor for the category has been increasing slightly, as a result of the increasing importance of polymer bitumen sheeting.

NMVOC emissions are calculated in keeping with a Tier 1 method, since no pertinent detailed data are available.

Table 191: Production and laying of roof and sealing sheeting with bitumen, and relevant activity data and emission factors

	Produced or used area in 2015 [millions of m ²]	EF/ IEF
		[kg/ m ²]
Production of roof and sealing sheeting with bitumen	166	NMVOC 0.000358
Laying of roof and sealing sheeting with bitumen	142	NMVOC 0.000027 – 0.000040

The carbon dioxide emissions, which could be obtained by multiplying the NMVOC emissions by a carbon-content factor of 80% and then converting to CO₂, are negligible. For this reason, they are not listed as such; in the CRF tables, they are marked as "NE".

4.5.4.3 Uncertainties and time-series consistency (2.D.3 Bitumen)

Information relative to the uncertainty of the data of the VDD was obtained via consultation between the VDD and the Federal Environment Agency. The total uncertainty for the activity data for production and laying of sheeting is estimated to be about +/-1 %. That figure, in turn, leads to a higher uncertainty, of about +/-2.5 %, for the calculated bitumen consumption.

The uncertainty for the combined emission factors for production and laying of roof and sealing sheeting is estimated to be about +/-5 %.

4.5.4.4 Category-specific quality assurance / control and verification (2.D.3 Bitumen)

Due to resources limitations, and to the area's minimal relevance, no QC/QA is carried out for reporting relative to precursors. A QC/QA checklist was completed and confirmed in the framework of the agreement with the VDD.

The manner in which the activity data were determined is considered to be plausible. The emission factors accord with findings from pertinent Federal Environment Agency research projects and are plausible. In particular, the validity of the emission factors is justified in that no emissions from use of solvent-containing coatings and primers have to be taken into account in this section (that takes place in the solvents model, as noted above).

4.5.4.5 Category-specific recalculations (2.D.3 Bitumen)

No recalculations are required.

4.5.4.6 Planned improvements, category-specific (2.D.3 Bitumen)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.5.5 Other: Road paving with asphalt (2.D.3 Asphalt)

Gas	Method used	Source for the activity data	Emission factors used
NO _x , NMVOC, SO ₂	Tier 1	AS	CS
CO ₂	NE	NE	NE

As far as is currently known, the category *Road paving with asphalt* produces no greenhouse-gas emissions⁶⁷ and thus is not a key category.

4.5.5.1 Category description (2.D.3 Asphalt)

Currently, the report tables list produced quantities of mixed asphalt products and NMVOC, NO_x and SO₂ emissions (with regard to CO₂, cf. footnote 67).

In 2015, a total of about 39 million t of asphalt (DAV, 2016) was produced in Germany, in a total of about 660 asphalt-mixing plants. Asphalt is used primarily in road construction, where it competes directly with hydraulically bound concrete. In 1991, total production increased considerably; since 2000 it has been decreasing again.

The relevant emissions trends depend primarily on trends in production quantities. The production quantities continue to decrease, as a result of lacking investments in the road network.

4.5.5.2 Methodological aspects (2.D.3 Asphalt)

No special calculation procedure is available for calculating fuel inputs in category 1.A.2. Nonetheless, fuel inputs are taken into account via Energy Balance evaluation, and they are coupled with suitable emission factors.

The applicable quantity of mixed asphalt products produced (**activity data**) has been taken from communications of the Deutscher Asphaltverband (DAV; German asphalt association).

The **emission factors** were determined country-specifically, in accordance with Tier 2 criteria. Emission factors for substances other than CO₂ were determined on the basis of emissions measurements for over 400 asphalt-mixing plants, for the period 1989 to 2000. 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_x and SO₂ involved come from the mineral substances used (proportional process emissions). CO occurs

⁶⁷ Cf. the discussion of indirect CO₂ emissions, under "Methodological aspects".

primarily in incomplete combustion processes. CO emissions are calculated solely in connection with fuel inputs.

Table 192: Emission factors for production of mixed asphalt products

	NO _x	NM VOC	SO ₂
EF [kg/ t]	0.015	0.030	0.030

Only emissions from asphalt production are reported. Figures relative to emissions released during laying of asphalt have not yet been adequately reviewed.

The carbon dioxide emissions, which could be obtained by multiplying the NMVOC emissions by a carbon-content factor of 80 % and then converting to CO₂, are negligible. For this reason, they are not listed as such; in the CRF tables, they are marked as "NE".

4.5.5.3 Uncertainties and time-series consistency (2.D.3 Asphalt)

As the extensive measurement data show, the emissions lie within a comparatively narrow range. The large volume of measurement data available makes it possible to form highly reliable mean values. The only large uncertainties are found in breakdown of emissions amounts into fuel-related and process-related emissions.

The production-amount data may be considered very accurate, since the product in question is a sale-ready product, and operators report the relevant amounts to the DAV.

4.5.5.4 Category-specific quality assurance / control and verification (2.D.3 Asphalt)

Due to resources limitations, and to the area's minimal relevance, no QC/QA is carried out for reporting relative to precursors.

4.5.5.5 Category-specific recalculations (2.D.3 Asphalt)

No recalculations are required.

4.5.5.6 Planned improvements, category-specific (2.D.3 Asphalt)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.6 Electronics industry (2.E)

KC	Category	Activity	EM of	1995 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1995-2015
-/-	2.E. Electronics industry	0	PFCs	266.7	0.02%	150.7	0.02%	-43.5%
-/-	2.E. Electronics industry	0	SF ₆	47.3	0.00%	19.6	0.00%	-58.5%
-/-	2.E. Electronics industry	0	HFCs	17.1	0.00%	14.2	0.00%	-16.8%
-/-	2.E. Electronics industry	0	NF ₃	5.3	0.00%	11.9	0.00%	124.7%

Gas	Method used	Source for the activity data	Emission factors used
HFC	Tier 3	AS, NS	PS
PFC	CS	AS, NS	CS
SF ₆	CS	AS, NS	CS
NF ₃	CS	AS, NS	CS

The category *Electronics industry* is not a key category.

4.6.1 Semiconductor and circuit-board production (2.E.1)

4.6.1.1 Category description (2.E.1)

The semiconductor industry currently emits PFCs (CF_4 , C_2F_6 , C_3F_8 , $\text{c-C}_4\text{F}_8$), HFCs (CHF_3), nitrogen trifluoride (NF_3) and SF_6 from production processes. These gases are used for etching structures on thin layers and for cleaning reaction chambers following chemical vapour deposition (CVD). In the production process, some of the PFCs fed into plasma chambers are converted partly into CF_4 .

The semiconductor industry's emissions depend partly on the degree to which the industry uses waste-gas-scrubbing equipment. They also depend directly on semiconductor-production levels (in the present case, annual levels). As a result of these dependencies, emissions tend to fluctuate rather strongly from year to year.

4.6.1.2 Methodological issues (2.E.1)

Emission factors

During the etching process, only about 15 % of the added CF_4 reacts chemically. The emission factor, an inverse reaction quota, thus amounts to 85 % of the CF_4 consumption.

The emissions cannot be determined solely on the basis of input quantities (sales by gas vendors), however, because the difference between consumption and emissions depends on a number of factors – especially the effects of downstream waste-gas-scrubbing systems, in addition to only-partial chemical transformation in plasma reactors. The relevant figures are thus aggregated and reported on a plant-specific basis, by the pertinent industrial association.

Activity data

The quantities of SF_6 used (since report year 2006) and NF_3 use (since report year 2015) are determined by the Federal Statistical Office, via surveys of the gas trading industry. The usage-quantity data for the other substances are collected by the Federal Statistical Office, assigned to the semiconductor industry and confirmed by that industry.

Reliable emissions data are available for 1990 and 1995. Linear interpolation was carried out for the years 1991 to 1994.

Until report year 2000, emissions data were based on surveys carried out by the EECA-ESIA (European Electronic Component Manufacturers Association – European Semiconductor Industry Association). National manufacturers were queried regarding production capacities, amounts of substances used and waste-gas treatment equipment.

As the result of a voluntary commitment by the semiconductor industry, emissions figures are available for this sub- source category, for all individual substances, from the year 2001 onwards. In keeping with a standardised calculation formula (Tier 2c approach), the emissions data are calculated for each production site, from annual consumption, aggregated and then reported by the German Electrical and Electronic Manufacturers Association (Zentralverband Elektrotechnik- und Elektroindustrie eV. – ZVEI; Electronic Components and Systems Division) to the Federal Environment Agency.

4.6.1.3 Uncertainties and time-series consistency (2.E.1)

The uncertainties have been completely determined.

4.6.1.4 Category-specific recalculations (2.E.1)

No recalculations are required.

4.6.1.5 Category-specific quality assurance / control and verification (2.E.1)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The data have undergone the above association's internal quality assurance and quality control process.

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.6.1.6 Planned improvements, category-specific (2.E.1)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.6.2 TFT (2.E.2)

No TFT flat screens are produced in Germany.

4.6.3 Photovoltaics (2.E.3)**4.6.3.1 Category description (2.E.3)**

In wafer production in Germany, SF₆ and other fluorine compounds have been used for structure etching and for cleaning of reaction chambers during production processes. Since the purity of the process gas is lower than that of the gas used in the similar production process in the semiconductor industry, use for *photovoltaics* is reported separately. In Germany, use of SF₆ in solar technology began in 2002.

The time series shows a continuous emissions increase between 2002 and 2006; this is due to increases in production. A large jump occurred in 2007 and 2008, when quantities of produced wafers and, thus, the quantities of SF₆ used, increased sharply. In 2009, the opposite effect occurred.

Beginning 2008, NF₃ substituted for SF₆ in all new production lines for production of Si thin-film cells. Production of the substance was phased out by 2015.

In addition, in 2002/2003 the hydrocarbon CF₄ was introduced for "edge insulation" of crystalline solar cells. The procedure using that substance was soon supplanted by a different procedure that is easier to handle, however. Consumption of CF₄, which peaked in 2004, has been decreasing sharply since then. In 2014, production was largely discontinued.

4.6.3.2 Methodological issues (2.E.3)

Like emissions in the semiconductor industry, emissions in photovoltaics occur during production. The relevant production emissions cannot be determined solely on the basis of the quantities used (sales by the gas trade). The differences between consumption and emissions result from a) the fact that chemical conversion in plasma reactors is only partial and b) the effects of downstream waste-gas-scrubbing systems.

Emission factors

In 2009, only one producer in Germany did not have a waste-gas-scrubbing system. For this reason, the IPCC emission factor of 40 % is used only for the first year of pertinent use, 2003.

Thereafter, the emission factor decreases, as the percentage of wafer production connected to downstream waste-gas-scrubbing systems increases. In 2010, it was just under 6 %. Since then, it has dropped to 4 %.

Activity data

The annual consumption figures are obtained via surveys, carried out by the Federal Statistical Office, of gas suppliers, with regard to their domestic sales. In addition, the data were checked in a separate study entitled "SF₆ and NF₃ in the German photovoltaic industry" ("SF₆ und NF₃ in der deutschen Photovoltaik-Industrie") (ÖKO-RECHERCHE, 2009).

4.6.3.3 Uncertainties and time-series consistency (2.E.3)

The uncertainties have been completely determined.

4.6.3.4 Category-specific recalculations (2.E.3)

No recalculations are required.

4.6.3.5 Category-specific quality assurance / control and verification (2.E.3)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

4.6.3.6 Planned improvements, category-specific (2.E.3)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.6.4 Heat transfer fluids (2.E.4)

4.6.4.1 Category description (2.E.4)

The PFC C₆F₁₄ has been used as a heat transfer fluid in the semiconductor industry and in some ICE power cars. It has not been used since 2001, however. Emissions thus occur only from existing applications and in disposal. For reasons of confidentiality, this substance is reported under 2.H.3.

4.6.4.2 Methodological issues (2.E.4)

Because they are confidential, data on consumption and emissions of heat transfer fluids are reported under CRF 2.H.3. The emission factors are assumed to be 1 % for filling, 3 to 4 % for emissions from existing applications and 10 % for disposal.

4.6.4.3 Uncertainties and time-series consistency (2.E.4)

The uncertainties have been completely determined.

4.6.4.4 Category-specific recalculations (2.E.4)

No category-specific recalculations were carried out.

4.6.4.5 Category-specific quality assurance / control and verification (2.E.4)

General and category-specific quality control has been carried out, in conformance with the requirements of the QSE manual and its associated applicable documents. The person responsible for pertinent quality assurance was unable to carry out the quality assurance completely. The Single National Entity has carried out the additional quality control and quality assurance.

4.6.4.6 Planned improvements, category-specific (2.E.4)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.7 Product uses as substitutes for ODS (2.F)

KC	Category	Activity	EM of	1995 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1995-2015
L/T	2.F. Product uses as substitutes for ODS	0	HFCs	C	C	C	C	326.1%
-/-	2.F. Product uses as substitutes for ODS	0	PFCs	19.9	0.00%	11.8	0.00%	-40.9%

Gas	Method used	Source for the activity data	Emission factors used
HFC, PFC	cf. Table 193/Table 194	cf. Table 193/Table 194	cf. Table 193/Table 194

The category Product uses as substitutes for ODS is a key category for HFC emissions in terms of emissions level and trend.

Category 2.F includes Refrigeration and air conditioning systems (2.F.1), Foam production (2.F.2), Fire extinguishing agents (2.F.3), Aerosols (2.F.4), Solvents (2.F.5) and other applications; ODS substitutes fall under (2.F.6). In the interest of more precise data collection, these sub-categories are broken down further, as described in the following sub-chapters.

Use of relevant substances as refrigerants in stationary and mobile refrigeration applications, which accounts for over three-fourths of relevant emissions, is the largest source of HFC emissions in this category. The remaining emissions are distributed among the sources foams and aerosols and, in small amounts, fire extinguishers and solvents.

The PFC emissions originate in use of refrigerant blends in refrigeration and air-conditioning systems.

Table 193: Overview of methods and emission factors used for the current report year in category 2.F.1 – *Refrigeration and air-conditioning systems*.

	QG	Method	Gas		Lifetime	Production	Application	Waste management	
			HFC	PFC	[years]	Emission factor (dimensionless)	Emission factor (dimensionless)	Residual charge level (dimensionless)	Recovery rate (dimensionless)
Air-conditioning and refrigeration systems	2.F.1								
Commercial refrigeration	2.F.1a								
- Plug-in appliances		Tier 2a	HFC		10 (D)	0.005 (D)	0.01 - 0.014 (D)	0.90 (CS)	0.326 - 0.5 (D)
- Condensing units					12 (D)	0.01 (D)	0.060 - 0.097 (CS)	0.85 (D)	0.475 - 0.7 (D)
- Central systems			PFC	10 - 14 (D)	0.01 (D)	0.098 - 0.195 (D)	0.875 (D)	0.429 - 0.767 (D, CS)	
Household refrigeration	2.F.1b	Tier 2a	HFC		15 (D)	NO	0.003 (D)	0.955 (CS)	0.733 (CS)
Industrial refrigeration	2.F.1c								
- Plug-in appliances		Tier 2a	HFC		10 (CS)	0.005 (D)	0.01 - 0.014 (CS)	0.9 (D)	0.337 – 0.50(D)
- Large refrigeration systems				PFC	10 – 30 (CS, D)	0.01 (D)	0.055 - 0.088 (D)	0.85 (D)	0.45 – 0.775(D)
Refrigerated transports	2.F.1d								
- Refrigerated vehicles		Tier 2a	HFC	PFC	10 (CS)	5 g/system (CS, D)	0.15 - 0.3 (D)	0.875 (CS)	0.657 (D)
- Refrigerated containers					14 (CS)	NO	0.1 (CS)	0.875 (CS)	0.657 (D)
Mobile air conditioning systems	2.F.1e								
- Trucks		Tier 2a	HFC		15 (D)	5 g/system (CS, D)	0.15 (D)	0.34 (D)	0.38 - 0.433 (D)
- Automobiles					15 (D)	3 g/system (CS, D)	0.1 (D)	0.34 (D)	0.38 – 0.433(D)
- Buses					15 (D)	50 g/system (D)	0.15 (D)	0.34 (D)	0.38 (D)
- Ships					25 (CS)	0.01 (CS)	0.1 - 0.3 (CS)	NO	NO
- Railway vehicles					25 (CS)	0.005 (D)	0.06 (CS)	NO	NO
- Agricultural machines					10 (CS)	5 g/system (CS)	0.15 - 0.25 (CS)	0.34 (CS)	0.117 (CS)
- Aircraft					-	-	0.05 (CS)	NO	NO
Stationary air conditioning systems	2.F.1f								
- Large air conditioning systems		Tier 2a	HFC		15 - 25 (D)	0.005 (D)	0.034 - 0.06 (D)	0.9 (D)	0.658 - 0.775 (D)
- Heat pumps					15 (D)	0.005 (D)	0.02 - 0.025 (D)	0.75 (D)	0.5 - 0.575 (D)
- Heat-pump dryers					15 (CS)	0.005 (CS)	0.003 (CS)	NO	NO
- Mobile room air conditioners					10 (D)	NO	0.025 - 0.034 (D)	0.75 (D)	0.242 - 0.325 (D)
- Single-split units					10 (D)	0.1 (CS)	0.05 - 0.069 (D)	0.875 (CS)	0.379 - 0.50 (D)
- Multi-split units					13 (D)	0.01 (D)	0.051 - 0.079 (D)	0.875 (CS)	0.62 - 0.70 (D)
- VRF devices					13 (D)	0.01 (D)	0.060 - 0.081 (D)	NO	NO

Table 194: Overview of methods and emission factors used, for the current report year, in categories 2.F.2 (Foam blowing), 2.F.3 (Fire extinguishers), 2.F.4 (Aerosols), 2.F.5 (Solvents) and 2.F.6 (Other applications that use ODS substitutes)

	QG	Method	Gas		Lifetime	Emission factor (dimensionless)		
			HFC	PFC	[years]	Production	Application	Waste management
Foam production	2.F.2							
closed-cell	2.F.2a							
- PUR hard foam with 134a		Tier 2a	HFC		50 (D)	0.1 (D)	0.005 (D)	NO
- PUR hard foam with 227ea/245fa/365mfc					50 (D)	0.15 (D)	0.01 (D)	NO
- XPS foam with 134a/1234ze					50 (D)	C	0.0066 (CS)	NO
open-cell	2.F.2b							
- XPS foam with 152a		Tier 2a	HFC		-	1 (CS)	NO	NO
- PUR integral foam with 134a, 227ea, 245fa, 365mfc		Tier 2a			-	1 (CS)	NO	NO
- PU one-component foam (134a)		Tier 2a			-	0.5 g/can (CS)	1 (CS)	NO
- PU one-component foam (152a)					-	0.5 g/can (CS)	1 (CS)	NO
Fire extinguishers	2.F.3	CS	HFC			0.001 (CS)	0.01 – 0.08 (CS) 0.04 (D)	1.0 (D)
Aerosols	2.F.4							
Metered dose inhalers	2.F.4a	Tier 2a	HFC		-	0.01 (CS)	1 (CS)	NO
Other aerosols / novelties	2.F.4b/c	Tier 2a			-	0.015 (CS)	1 (CS)	NO
Solvents	2.F.5	Tier 2a	HFC		-	NO	1 (D)	NO
Other applications that use ODS substitutes	2.F.6					NO	NO	NO

Halocarbons are used in a number of different applications. Whereas in some, so-called "open" applications, consumed quantities are emitted completely, in the same year in question, in other applications large quantities are stored (stocks). The substances then are emitted, either partially or completely, from such "stocks" throughout the entire usage phase and in relevant waste management. Most of the EF used are either country-specific (CS) or IPCC default (D).

The emissions as listed in the inventory tables consist of the quantities of HFCs and PFCs that, during a report year, slowly escape from "stocks" and are emitted in production and waste management.

In general, the emissions data collected for the various product groups comprise emissions from production, use and waste disposal. Except where indicated otherwise in connection with the pertinent methods, these emissions are calculated as follows:

1. Production emissions are determined via new domestic consumption, as activity data:

Equation 1:

$$EM_{\text{production}} = \text{New domestic consumption} * EF_{\text{production}}$$

2. Application emissions are based on the final stocks of relevant pollutants (the activity data), and they are calculated via the following formula:

Equation 2:

$$EM_{\text{use}} = \text{Final stocks} * EF_{\text{use}}$$

The final stocks for the current year are calculated by summing annual new additions, from the first reporting year to the current one. The new additions for a given year consist of the new domestic consumption for that year, minus production emissions and losses from removals. The calculation thus requires consideration of foreign trade.

3. Disposal emissions refer to new additions for the year that is x years (depends on product lifetime) prior to the current reporting year n:

Equation 3:

$$EM_{\text{disposal}} = \text{New additions (n-x)} * EF_{\text{disposal}}$$

4. For refrigeration and air-conditioning systems, the disposal emissions are calculated in keeping with Vol. 3 Equation 7.14 of the 2006 IPCC Guidelines:

Equation 4:

$$EM_{\text{disposal}} = \text{new additions (n-x)} * \text{residual charge level} * (1 - \text{recovery factor})$$

In this chapter, the sections *Uncertainties and time-series consistency*, *Category-specific quality assurance / control and verification*, *Category-specific recalculations* and *Planned improvements* vary in their reference – some refer to the entire relevant category, some to the sub-category in question and some to only a part of a sub-category. In each case, the reference involved is apparent from the CRF number in the section heading.

4.7.1 Refrigeration and air conditioning systems (2.F.1)

4.7.1.1 Category description (2.F.1)

This category is divided into the sub-categories of commercial refrigeration, household refrigeration, industrial refrigeration, transport refrigeration, mobile air conditioning systems and stationary air conditioning systems (cf. Table 193).

In Germany, the leading pure-HFC refrigerants, far and away, are HFC-134a and the mixtures R404A, R407C, R410A, R422D and R507A.

For calculation of HFC emissions from the sub-categories of refrigeration and stationary air conditioning systems, individual data are collected, or refrigerant models are used. Any refrigerant models used are described in connection with the relevant method.

The emission factors used were obtained via surveys of experts. Disposal emissions in this category first occurred in 2000, in sub-categories 2.F.1.a (commercial refrigeration) and 2.F.1.e (mobile air-conditioning systems).

4.7.1.2 Methodological issues (2.F.1)

4.7.1.2.1 Commercial refrigeration (2.F.1.a)

Commercial refrigeration is the largest and most diverse area of (H)FC application. It is subdivided into the areas of plug-in devices, condensing units and central systems. The great diversity seen in the area of central systems, with regard to model, size, type of refrigerant and emissions-tightness, results from the fact that most relevant systems are customised systems. Less diversity is found in the areas of plug-in devices and condensing units.

Use of (H)FCs as refrigerants grew only gradually. For example, HFC-134a was not used on any significant scale until mid-1993. Use of the refrigerant mixtures R404A and R407C also did not begin until 1993. The various R422 mixtures, which are used as "drop-in" refrigerants in

conversions of HCFC-22 systems, have been used only since 2009. In addition, since 1993 small quantities of PFC-containing refrigerant mixtures, such as R403A/B, R413A, Isceon 89 and R508A/B, have also been used, as drop-in refrigerants. Since 2007, R410A has been used in small central systems. For conversions of central systems with R404A, the refrigerant mixture R449A has been used since 2013. R448A has also been used for such conversions since 2014. Since 2002, R744 has also been used as a halogen-free alternative. R290 has been used as such an alternative since 2010.

Today, the mixture R404A is the most important HFC refrigerant for stationary refrigeration systems, ranking ahead of even HFC-134a in this category. The mixtures R407C and R422D are now also of some significance.

In light of the extremely large number of companies specialising in refrigeration, detailed statistical surveys of refrigerant stocks are not practicable. Therefore, a different calculation method is used.

- For calculation of emissions from *central systems* for commercial refrigeration, in the food retail sector, the following refrigerant model is used (cf. SCHWARZ et al., n.y.):
- Foreign trade with locally installed refrigeration systems plays a negligible role, and thus annual HFC consumption for new systems is the same as new HFC additions in new systems.
- The starting point for the calculations is not the number of plants involved or the installed cooling capacity, but the sales floor area of the relevant food retail stores, since that figure is statistically recorded, on an annual basis. Discount stores in Germany have sales floor areas of about 800 m², and that figure is a relatively constant one. All such stores are assumed to have basically the same refrigeration requirements and, thus, use the same quantities of refrigerants. This is why in this case the number of discount stores involved serves as the basis for further calculations. The numbers of discount stores are also statistically recorded on an annual basis.
- On the basis of a study of the EPEE⁶⁸ (SKM Enviros, 2010), the coefficient "kilograms per square meter of sales floor area" is derived for a typical, average-size supermarket. It has the value 0.23 kg/m². For discount stores, the coefficient "kilograms per discount store" is determined. It has the value 80 kg / store. With the help of these coefficients, the annual refrigerant stocks are calculated for the three store classes discount stores, small supermarkets and large supermarkets.
- The refrigerant stocks for the various store formats, subdivided by refrigerant types, are determined with the help of applicable percentage shares for the types of refrigerants that are used. The refrigerant shares are derived with the help of statistical calculation models based on experts' assessments. For this purpose, the following store classes are differentiated: large supermarkets (with sales floor areas greater than 1,500 m²), small supermarkets (with sales floor areas between 400 and 1,500 m²) and discount stores.
- Division of refrigerant stocks by the systems' average lifetime (10 years for discount stores; 14 years for all other types of stores) yields the HFC additions via new systems.
- The production emissions and emissions from stocks are calculated with Equation 1 and Equation 2. Production normally takes place at the relevant sites.
- Replacement of CFCs and HCFCs in old systems is considered separately.

⁶⁸ EPEE: The European Partnership for Energy and the Environment.

- Disposal emissions occurred in connection with central systems for the first time in 2000. Removals of refrigerants are calculated with the help of the average lifetime – 10 years for central systems in discount stores, and 14 years for central systems in all other types of stores. In each case, the nominal quantity for disposal is equivalent to the added new quantity a system had when it was commissioned. In practice, however, the quantities of refrigerants that systems contain when they are disposed of are smaller than the corresponding nominal charges, since systems are normally not refilled before they are decommissioned. For this reason, the actual charge upon disposal, the "effective" quantity for disposal, is determined with the help of applicable percentage values for residual charges. The most important factor that enters into the determination of residual charges is the refrigerant-loss level at which a system has to be refilled in order to maintain its proper function. The effective charge at the end of a device's / system's service lifetime is larger, by half of the difference between that minimum "technical" charge and the nominal charge, than the minimum "technical" charge. For central systems, it amounts to 87.5 % of the nominal charge.
- The disposal emissions are calculated by multiplying the so-determined "effective" quantity for disposal by the inverse of the recovery factor, using Equation 4:
- Emissions of HFC-1234yf and HFC-1234ze from the refrigerant mixtures R448A and R449A, emissions which are not subject to reporting obligations, are voluntarily reported, pursuant to the recommendations of the 2014 UNFCCC Reporting Guidelines (FCCC/CP/2013/10/Add.3, Decision 24/CP.19), as "additional greenhouse gases." The emissions are aggregated with other emissions that are not subject to reporting obligations, and are listed in Chapter 4.9.3 under CRF 2.H.3.

Also in the case of *condensing units* for commercial refrigeration, the refrigerant stocks are the central point of reference for the refrigerant model for emissions calculation:

- The starting point for such calculations consists of the number of operation sites in the numerous sectors in which condensing units are used; the relevant sector selection is based on a study of the German Engineering Federation (VDMA) (2011). Such sectors include cash-and-carry beverage stores, service station shops, nurseries (garden centers), flower shops, flower wholesalers, cafeterias, caterers, hospitals, nursing homes, restaurants and hotels, butcher shops and franchise outlets for meat products, bakeries and franchise bakery outlets, discount stores, small food retailers and specialty food retailers. The number of sites involved is updated annually, from publicly accessible statistics.
- The refrigerant stocks for the various individual sectors are calculated as the product of the relevant number of operational sites, the sector-specific charges (as determined from the literature and via surveys of experts) and the percentage shares for the refrigerant types that are used. The percentage shares for the refrigerants are derived via a static calculation model (cf. SCHWARZ et al., n.y.).
- Division of total refrigerant stocks by the average lifetime of condensing units (12 years) yields the HFC additions via new systems.
- The production emissions and emissions from stocks are calculated with Equation 1 and Equation 2.
- The disposal emissions are calculated via Equation 4. The nominal quantity for disposal is identical, in terms of both quantity (amount) and refrigerant shares, with the corresponding initial-fill quantity from 12 years earlier. For condensing units, the effective charge at the end of units' service lifetime amounts to 85 % of the nominal charge.

The application sectors for hermetically sealed *plug-in appliances* are largely the same as those for condensing units. Emissions for such appliances are calculated in keeping with the refrigerant-model approach described for condensing units. Such appliances have an average lifetime of 10 years, and their residual charge upon disposal amounts to 90 % of the nominal charge.

Emission factors

The emission factors used are the result of surveys of experts and literature evaluations.

As a rule, filling of refrigeration systems produces only small quantities of emissions. For "initial emission" in Vol. 3, Table 7.9, the 2006 IPCC Guidelines give values of 0.5 to 3 percent of the initial charge for plug-in devices and for medium-sized and large commercial refrigeration systems. The country-specific $EF_{\text{production}}$, at 0.5 % for plug-in devices and at 1 % for central systems and condensing units, lie within this range.

Ongoing (H)FC emissions from stationary refrigeration systems in the *commercial refrigeration* category vary widely in keeping with the type of system concerned. The refrigerant loss ranges from 1 to 1.4 %, for plug-in individual units, to 6.0 to 9.7 %, for condensing units and to 9.8 to 19.5 % for central systems. The emission factors for application have decreased continuously since 1993 for all devices and systems in the area of commercial refrigeration (cf. Table 193), in keeping with the increasing degree of care taken in handling HFC refrigerants. Measured against the value ranges given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 1 for 15 % for individual units and 10 to 35 % for medium-sized and large commercial refrigeration systems, the emission factors either lie within low range sections (individual units and central systems, until report year 2014) or lie below the ranges (condensing units and central systems, as of report year 2015).

The average lifetimes prior to disposal are 10 years (individual units; central systems in discount stores), 12 years (condensing units) and 14 (central systems in all types of stores other than discount stores). The lifetimes used thus lie within the relevant ranges given in the 2006 IPCC Guidelines, 10 to 15 years (individual units) and 7 to 15 years (medium-sized and large commercial refrigeration systems).

The residual charges in the devices and systems, at the end of their lifetimes, and with respect to the initial charge in each case, are 90 % (individual units), 85 % (condensing units) and 87.5 % (central systems). The 2006 IPCC Guidelines give value ranges of 0 – 80 % (individual units) and 50 – 100 % (medium-sized and large commercial refrigeration systems). All of the values used are thus default values.

The recovery factors have been increasing continuously, and thus the losses occurring upon disposal, with respect to initial charge / residual charge, have been decreasing over the years concerned. For plug-in devices, the recovery factor was 32.6 % in 2003 and 50 % in 2015. For condensing units, the recovery factor was 47.5 % in 2005 and 70 % in 2015, while for central systems the recovery factor increased from 42.9 % in 2000 to 76.7 % in 2015. As a result, most of the recovery factors used lie within the value range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 0 to 70 %. The only recovery factor values used that are higher than the IPCC values are those used for central systems, as of report year 2009.

Activity data

The sales floor areas of grocery stores are surveyed annually, by two market-research institutes⁶⁹. The EHI Retail Institute also monitors the numbers of discount stores. In addition, the applicable

⁶⁹ EHI – EHI Retail Institute, Cologne; The Nielsen Company GmbH, Frankfurt am Main.

numbers of commercial sites are updated annually from various publicly available statistics (cf. SCHWARZ et al., n.y.).

The annual new additions of PFC-116 (C_2F_6), PFC-218 (C_3F_8), HFC-125 and HFC-23, which are contained in the refrigerant mixtures R508A, R508B, Isceon MO 89 and R413A (HFC-23 is also used as a single-component refrigerant), are obtained from the annual national survey pursuant to the Environmental Statistics Act (Umweltstatistikgesetz).

The quantities and types of refrigeration and freezer systems typically used by businesses are determined from the literature and via estimation by experts. The coefficients "kilograms per square meter of sales floor area" and "kilograms per discount store" have been determined semiempirically by experts, with the help of the relevant technical literature (SKM ENVIROS, 2010, CLODIC et al., 2011 und 2012). The charges for condensing units and plug-in appliances have been determined via technical discussions with German manufacturers of refrigeration / freezer systems and via study of the relevant literature.

4.7.1.2.2 Household refrigeration (2.F.1.b)

In 1994, domestic producers of household refrigerators and freezers made a changeover from CFC-12 to HFC-134a. In Germany, they then switched to isobutane a short time later. Small numbers of devices containing HFC-134a, representing a small share of all relevant appliances, were imported in between 1993 and 2014. Under the EU F-Gas Regulation (F-Gas R, 2014), imports of household refrigerators and freezers that use refrigerants with GWPs of 150 or higher are prohibited as of 2015.

Production losses and new consumption for domestic purposes do not have to be determined, since all filling with HFC took place abroad.

Equation 2 is used to calculate annual HFC emissions on the basis of final stocks. This is done by determining and aggregating the annual HFC new additions since 1993 and then subtracting the aggregated annual removals via disposal.

Disposal emissions occurring as of the year 2008, following an average lifetime of 15 years, are calculated with Equation 4.

Emission factors

Current HFC emissions from household refrigerators and freezers are estimated at 0.3 %, which is within the value range given by the 2006 IPCC Guidelines in Vol. 3, Table 7.9, 0.1 to 0.5 %

The average lifetime prior to disposal is 15 years. The system lifetimes used thus lie within the range given by the 2006 IPCC Guidelines, 12 to 20 years.

The residual charges in devices, with respect to initial charge, average 95.5 %. The relevant values given in the 2006 IPCC Guidelines range from 0 to 80 %. The value used is thus higher than the range given in the 2006 IPCC Guidelines. The value is justified in light of the low refrigerant losses that occur during the use phase (0.3 % per year; 4.5 % throughout the entire use phase); those losses do not substantiate use of lower values for the residual charge level.

The recovery factor is 73.3 %, which is slightly above the range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 0 to 70 %. The higher recovery factor has been brought about by legislation (the Electrical and Electronic Equipment Act – Elektrogesetz) (ElektroG, 2015) governing the disposal of household appliances.

Activity data

The annual additions figure of 1 % of new appliances is an estimate of leading refrigerator manufacturers.

4.7.1.2.3 Industrial refrigeration (2.F.1.c)

The industrial refrigeration included in this sector refers to refrigeration for production of products – mostly food and drink – that are refrigerated or frozen. Refrigeration systems in this category, as in the category of *commercial refrigeration*, are usually not purchased directly from series production. They tend to be customised systems, and thus emissions for this category have to be calculated with the help of a refrigerant model.

Use of fluorine-based refrigerants has not yet become standard practice in industry, especially the food industry. In addition, natural refrigerants – primarily ammonia – are used much more frequently in this sector than they are in other sectors. The fluorine-based refrigerants used in industrial refrigeration are R404A, HFC-134a, R407C, R507A and R422D. The last of these serves as a substitute refrigerant for converted HCFC-22 systems. HFC-23 and PFC-116 are also used, in low-temperature systems, while the refrigerant HFC-227ea, is used in air-conditioning systems for cranes and in high-temperature heat pumps.

Use of fluorine-based refrigerants began in Germany in 1993. Disposal emissions began occurring in 2002, from converted CFC-12 and HCFC-22 systems.

The following refrigerant model is used for *industrial refrigeration*:

- The refrigerant stocks serve as the central point of reference for the model. It is broken down into twelve major industrial refrigeration sectors: beer breweries, wine production, meat production, dairies, cold-storage facilities, chocolate production, production of frozen foods and of juices, skating rinks, milk refrigeration in the agricultural sector, other industry (80 % chemical industry) and hermetically sealed appliances in manufacturing. The basis for calculation of the refrigerant stocks consists of the quantities of produced goods. They are updated annually via publicly accessible merchandise statistics.
- In the three smaller sectors of industrial refrigeration, air-conditioning for cranes, high-temperature heat pumps and low-temperature refrigeration with HFC-23 (primarily in the plastics industry) and R508A/B, the annual new additions are used as the starting value for calculating stocks and all emissions.
- On the basis of the relevant production quantities, a conversion is made to the installed cooling capacity required for cooling goods and products in the twelve major sectors. The key factors required for that conversion, "installed cooling capacity per units of annual goods production", have been determined empirically, on the basis of the technical literature.
- The refrigerant quantities required for the resulting cooling capacity are estimated on the basis of refrigerant-use rates for plus and minus refrigeration and for direct and indirect refrigeration. The refrigerant-use rates were also determined via study of the literature, including CLODIC et al. 2011 & 2012. They range from 2 kg/kW for indirect plus refrigeration to 8.8 kg/kW for direct minus refrigeration. The typical charges per installed unit of cooling capacity are calculated, for the twelve sectors, by combining these values with the applicable sector-specific weightings for the four basic forms of refrigeration.
- Foreign trade with locally installed refrigeration systems plays a negligible role, and thus annual HFC consumption for new systems is the same as new HFC additions in new systems.

- The refrigerant stocks also provide the basis for calculating the quantity for disposal. For each sector, that quantity is calculated by dividing the stocks by devices' service lifetimes. For most sectors, the applicable service lifetime is 30 years. For dairy farms and skating rinks, it is 20 years, and for plug-in appliances, air conditioners for cranes, high-temperature heat pumps and low-temperature applications, it is 10 years.
- The percentage shares for the types of refrigerants that are used, which vary over time for stocks, new additions and quantities for disposal, are derived for each sector via a static calculation model (cf. SCHWARZ et al., n.y.).
- Replacement of CFCs and HCFCs in old systems is considered separately.
- The production emissions and emissions from stocks are calculated with Equation 1 and Equation 2.
- Disposal emissions are calculated with Equation 4. The nominal quantity for disposal is identical with the initial-fill quantity. The effective charge at the end of devices' service lifetimes is 85 % of the nominal charge, for all sectors except plug-in appliances, for which it is higher – 90 %.

Emission factors

The emission factors on which the emissions data are based are listed in Table 193.

The emission factors used are the result of surveys of experts and literature evaluations.

As a rule, filling of industrial refrigeration systems produces only small quantities of emissions. In Vol. 3, Table 7.9, the 2006 IPCC Guidelines give for "initial emission" values of 0.5 to 3 percent of the initial charge quantity. The country-specific $EF_{\text{production}}$ for the sectoral application areas is 1 %, while it is 0.5 % for plug-in appliances. The EF thus lie within the lower part of the range given by the Guidelines.

In all sectors except hermetically sealed appliances, ongoing HFC emissions from industrial refrigeration systems have been decreasing continually, changing from 8.8 % in 1993 to 5.5 % in 2015. The reason for this trend is that refrigeration systems' capacity for retaining their refrigerants has improved as a consequence of national and European legal regulations. Such emissions now lie within the lower part of the range, or even slightly below the range, given by the 2006 IPCC Guidelines in Vol. 3, Table 7.9 – 7 % to 25 %. For plug-in appliances, the decrease has been comparable to that seen in commercial refrigeration: from 1.4 % in 1994 to 1 % in 2015.

The average applicable lifetimes prior to disposal are as follows: 10 years (plug-in individual units, air-conditioners for cranes, high-temperature heat pumps, low-temperature applications and plastics industry); 20 years (dairy operations, skating rinks); and 30 years (food industry, cold-storage systems, chemical industry). The lifetimes used – with the exception of the 10-year lifetimes for certain application areas – thus lie within the value range given by the 2006 IPCC Guidelines (Vol. 3, Table 7.9), 15 to 30 years.

The residual charges in the devices and systems, at the end of their lifetimes, and with respect to the initial charge level in each case, are 90 % (individual units) and 85 % (sectoral application areas). The relevant values given in the 2006 IPCC Guidelines (Vol. 3, Table 7.9) for industrial refrigeration systems range from 50 to 100 %. All of the values used are thus default values.

The recovery factors have been increasing continuously, and thus the losses occurring upon disposal, with respect to initial charge / residual charge, have been decreasing over the years concerned. For plug-in individual units, the recovery factor was 33.7 % in 2004 and 50 % in 2015. For refrigeration systems of sectoral application areas, the recovery factor was 45 % in 2002 and

77.5 % in 2015. The recovery factors used thus lie within the range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 0 to 90 %.

Activity data

The statistics of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) contain numerous time series for food-production quantities. In addition, data are available from industrial associations such as the German association of cold-storage facilities and cold-chain logistics companies (VDKL) and the Association of the German Confectionary Industry (BDSI), as well as from specialised institutes, such as the German Wine Institute.

The unit-number figures for plug-in appliances have been taken from a study of the German Engineering Federation (VDMA) (2011) and provided by industry experts.

The annual new additions of HFC-227ea and HFC-23 (air-conditioning for cranes, high-temperature heat pumps and low-temperature cooling) are obtained from the annual national survey conducted pursuant to the Environmental Statistics Act (Umweltstatistikgesetz).

The "installed cooling capacity per units of annual goods production" indices, and the refrigerant-use rates for plus and minus cooling and for direct and indirect cooling, were determined on the basis of information provided in the relevant technical literature.

4.7.1.2.4 Transport refrigeration (refrigerated vehicles and containers) (2.F.1.d)

HFCs have been used as refrigerants in *refrigerated vehicles* since 1993. Today, HFC-134a, along with the refrigerant mixtures R404A and R410A, are most commonly used. Since 2015, R452A has also been in common use. The sizes and refrigerant charges of refrigeration systems vary in keeping with the load volumes of the refrigerated vehicles in question.

Refrigerated containers are used primarily for transports of perishable goods by ocean-going ships. Since their emissions take place primarily in international waters, their refrigerant emissions are divided, in each case, in keeping with the relevant country's share of world trade. Germany is assigned 10% of global emissions from refrigerated containers. Since 1993, the most commonly used refrigerant has been HFC-134a. Since 1997, R404A has also been used.

The following refrigerant model is applied to *refrigerated vehicles*:

- Refrigerated vehicles are divided into four weight-based size classes: 2-5 t, 5-9 t, 9-22 t and > 22 t of gross vehicle weight.
- Refrigerant types, and specific refrigerant fill amounts, are assigned to the various size classes. Each refrigerant is also assigned a percentage share of each size class. Since report year 2006, half of the small systems of up to 5 t gross vehicle weight have been filled with the refrigerant R404A and half have been filled with HFC-134a. From 1993 through 2005, only HFC-134a was used. Between 1993 and 2014, relevant charges consisted of 50 % HFC-134a and 50% R404A in the size class 5-9 t gross vehicle weight. As of 2015, that size class also includes small shares of R452A. In the size classes 9-22 t and > 22 t, HFC-134a, R404A, R410A and R452A are used. In these size classes, R404A predominates, with a share ranging from 77.5 to 95 %.
- The number of newly licensed refrigerated vehicles, and the number of refrigerated vehicles filled within the country (broken down by refrigerants), are determined for each year.
- The production emissions are calculated using Equation 1, on the basis of the new consumption required for filling domestically produced refrigerated vehicles.
- The annual new additions of refrigerants result from the numbers of newly licensed refrigerated vehicles and the above assumptions.

- From 1996 to 1999, HFCs were substituted for CFC-12 in a certain number of old systems. These amounts have to be included in the annual new additions.
- The year-end final stocks are obtained by aggregating the annual HFC new additions since 1993 and then subtracting the removals via disposal.
- Equation 2 is used to calculate annual HFC emissions on the basis of final stocks.
- Disposal emissions occurred in connection with refrigerated vehicles for the first time in 2003. They are calculated by means of Equation 4. The nominal quantity for disposal is identical to the new additions 10 years earlier (or 7 years earlier in the case of converted CFC-12 systems). The effective charge level at the end of units' service lifetimes amounts to 87.5 % of the nominal charge level.
- Emissions of HFC-1234yf from the refrigerant mixture R452A, emissions which are not subject to reporting obligations, are voluntarily reported, pursuant to the recommendations of the 2014 UNFCCC Reporting Guidelines (FCCC/CP/2013/10/Add.3, Decision 24/CP.19), as "additional greenhouse gases." The emissions are aggregated with other emissions that are not subject to reporting obligations and listed in Chapter 4.9.3 under CRF 2.H.3.

For *refrigerated containers*, the following refrigerant model is used:

- The number of refrigerated containers produced worldwide is determined for each year.
- The worldwide HFC additions for refrigerated containers are determined on the basis of annual unit figures from global production, in combination with the relevant charges and fill percentages for the various relevant refrigerants.
- Germany's HFC additions are determined from worldwide additions, in keeping with Germany's share of global trade, which amounts to 10 %.
- Since refrigerated containers are produced only outside of Germany, no emissions from filling occur in Germany.
- The year-end final stocks are obtained by aggregating the annual HFC new additions since 1993 and then subtracting the removals via disposal.
- Emissions from stocks are calculated with Equation 2.
- Refrigerated containers have an average lifetime of 14 years, and disposal emissions from such containers occurred for the first time in 2007. They are calculated by means of Equation 4.

Emission factors

The emission factors on which the emissions data are based are listed in Table 193.

The emission factors used are the result of surveys of experts and literature evaluations.

As a rule, filling of refrigerated vehicles produces only small quantities of emissions. The filling losses of refrigerant are estimated at 5 grams per system, regardless of system size. That is a standard value for hose losses during on-site filling. When emissions from filling are calculatory considered in relation to new consumption, emission factors between 0.06 and 0.25 % result. For "initial emission" in transport refrigeration, the 2006 IPCC Guidelines give figures, in Vol. 3, Table 7.9, of 0.2 to 1 percent of the initial charge. As a result, the great majority of the values used lie below the range recommended in the IPCC Guidelines.

Since no domestic production of refrigerated containers takes place, no emissions from filling occur.

Ongoing HFC emissions from new refrigeration units of refrigerated vehicles in the range 5-22 t gross vehicle weight are estimated to amount to 15 %. For units in vehicles up to 5 t gross vehicle weight, the emission factor is 30 %. For old units in refrigerated vehicles (converted CFC-12

systems), the emission factor for emissions from stocks is estimated to average 25 %, for all unit size classes. The emission factors for refrigerated vehicles thus lie at the lower end of the range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 15 to 50 %.

For refrigeration units, the figure for emissions from stocks is 10 %, which is slightly below the range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 15 to 50 %.

The lifetime of old systems in refrigerated vehicles is 7 years, while that of new systems in refrigerated vehicles is 10 years. The average lifetime for refrigerated containers prior to disposal is 14 years. The lifetimes used – with the exception of those for old systems in refrigerated vehicles – thus lie within the value range given by the 2006 IPCC Guidelines (Vol. 3, Table 7.9), 6 to 9 years.

The residual charges in refrigerated vehicles and refrigerated containers, with respect to initial charge, average 87.5 %. The relevant values given in the 2006 IPCC Guidelines (Vol. 3, Table 7.9) for transport refrigeration systems range from 0 to 50 %. All of the values used are larger than those given in the Guidelines, since it must be assumed that transport refrigeration systems that only have 50 % of their initial charges left no longer function properly and thus would compromise the cold chain, with the result that the chain would no longer be seamless. The act of allowing that to happen would violate German law.

The recovery factor for refrigerated vehicles and refrigerated containers is 65.7 %. The recovery factors used thus lie within the range given in the 2006 IPCC Guidelines, in Vol. 3, Table 7.9, 0 to 70 %, and thus are default values.

Activity data

Until 2008, and as of 2011, the registration figures for refrigerated vehicles, broken down by weight classes, were taken from statistical reports of the Federal Motor Transport Authority (KBA). Since in 2009 and 2010 the Federal Motor Transport Authority stopped carrying out separate surveys of refrigerated vehicles, the numbers of new refrigerated vehicles for those two years are determined via extrapolation from the registration figures for utility vehicles as determined by the KBA. Charges in refrigeration systems, information on refrigerants used, and details on CFC-12 replacement were provided by experts of the leading providers of refrigeration units for refrigerated vehicles.

New additions of refrigerants in the area of refrigerated containers are determined via a refrigerant model based on the numbers of refrigerated containers produced worldwide, with the numbers provided by the "World Cargo News" information service for the industry. A 10 % share is allocated to Germany.

4.7.1.2.5 Mobile air-conditioning systems (2.F.1.e)

The mobile air-conditioning systems category includes air-conditioning systems in/on automobiles, trucks and utility vehicles, buses, agricultural machinery (tractors, combines, field choppers), railway vehicles, ships, aircraft and helicopters. Hydrofluorocarbons (HFCs) have been used in mobile air-conditioning systems since 1991. HFC-134a is a commonly used HFC refrigerant. Since 2012, HFC-1234yf has also been used in automobile air-conditioning systems.

The time series show a significant emissions increase since 1995. This increase, which has occurred in spite of decreases in fill amounts, is a direct result of increased use of mobile air conditioning systems in vehicles.

- For *automobiles*, the following refrigerant model is applied:

- The production figures for German automobile production are available, on an annual basis, from the publicly accessible statistics of the German Association of the Automotive Industry (VDA). Those figures provide the database for calculating consumption data relative to filling.
- The annual percentages of automobiles equipped with air-conditioning systems are obtained via extensive surveys of manufacturers, since they are not provided by any official or publicly available statistics. This also applies to the average refrigerant (charge) quantities, which are determined from the technical data for the various automobile models and from information provided by industry experts.
- The quantities consumed in charging such air conditioners are calculated by multiplying the numbers of automobiles produced by the annual percentages of automobiles equipped with air-conditioning systems and by the average per-unit refrigerant (charge) quantities.
- Production emissions are computed with Equation 1.
- The annual numbers of new vehicle registrations as recorded by the Federal Motor Transport Authority (KBA) are not used in determining annual new additions and the refrigerant stocks in automobile air conditioning systems, since it is not possible to quantitatively estimate early departures of vehicles (i.e. prior to vehicles' reaching the end of their average lifetimes) from the registration cohorts that form the basic fleet.
- Instead, the refrigerant stocks are determined on the basis of the numbers of registered vehicles on the road, divided according to age since the initial registration. Relevant official data are available from the statistical communications (Statistische Mitteilung) of the KBA⁷⁰, for all required years, i.e. as of 1991. They make it possible to determine, on a continuous, chronological basis, the numbers of vehicles in the total fleet, divided by registration cohorts.
- The annual percentages of automobiles equipped with air conditioning systems, for newly registered vehicles, are also obtained via extensive surveys of manufacturers. Those numbers are not identical with the corresponding percentages of automobiles produced in Germany and equipped with air conditioning systems, since foreign cars also have to be taken into account. The necessary percentages are thus also obtained via surveys of foreign companies. This also applies to strategies for determining the average per-unit refrigerant (fill) quantities in newly registered vehicles.
- The refrigerant stocks in each registration cohort are calculated by multiplying the specific charges for the year in question by the numbers of automobiles equipped with air conditioners. The total stocks are equivalent to the sum of the refrigerant stocks for all registration cohorts since 1991.
- Emissions from stocks are calculated with Equation 2.
- Replacement of CFCs in old systems, and air-conditioner retrofits, are considered separately.
- In determination of quantities for disposal, only the old vehicles are taken into account that are handled each year by German dismantling facilities. Those numbers are obtained from the official data on old vehicles⁷¹ (cf. also UBA/BMUB, 2016). The refrigerant model does not take account of exports of used cars and old cars, since the relevant disposal emissions occur in the pertinent destination countries and double-counting has to be avoided.

⁷⁰ KBA "Fahrzeugzulassungen Bestand an Kraftfahrzeugen und Kraftfahrzeuganhängern nach Fahrzeugalter 1. Januar 2015."

⁷¹ Statistisches Bundesamt (Federal Statistical Office), Fachserie 19 / Reihe 1, Umwelt Abfallentsorgung ("environment – waste management").

- An average lifetime of 15 years is assumed for dismantled vehicles. The total quantity of refrigerants that are disposed of can be determined by multiplying the number of dismantled vehicles by the applicable percentage of vehicles equipped with air conditioning systems and the average per-unit refrigerant (fill) quantity for the relevant new-registration cohort of 15 years earlier.
- Disposal emissions occurred for the first time in 2002. They are calculated with Equation 4.
- Pursuant to the recommendations of the 2014 UNFCCC Reporting Guidelines (FCCC/CP/2013/10/Add.3, Decision 24/CP.19), Germany voluntarily reports emissions of HFC-1234yf, which are not subject to reporting obligations, under "additional greenhouse gases." The HFC-1234yf emissions are aggregated with other emissions that are not subject to reporting obligations, and are reported in Chapter 4.9.3 under CRF 2.H.3.

The refrigerant models for *utility vehicles and buses* are structured similarly to the model for automobiles. A detailed description of those models is provided by SCHWARZ et al. (n.y.).

The refrigerant model used for *agricultural machinery, ships and railway vehicles* is as follows:

- For ships and railway vehicles, refrigerant emissions are determined on the basis of annual new installations of air conditioning systems in ships (outset data: newly built ships for the German fleet) and in railway vehicles (outset data: new procurements by German Railways (DB) and private companies), as well as the relevant charges.
- The refrigerant model for air conditioning systems in agricultural machinery is based on the number of new vehicle registrations for each year, the average percentage of vehicles equipped with air conditioning systems and the average charges in the various types of agricultural machinery concerned.
- The annual new additions of HFC-134a, as well as the final stocks, are determined, for each area, from the relevant previous set of data.
- Emissions from stocks are obtained, using Equation 2, by multiplying the final stocks, for each area, by the relevant EF_{use} .
- Domestic consumption of HFC-134a, for production of mobile air conditioning systems, is determined on the basis of unit-number figures for production. Production emissions are computed with Equation 1.
- Disposal emissions in the agricultural machinery category occurred for the first time in 2004, at the end of the average lifetime for the category, 10 years. They are calculated by means of Equation 4. Due to the long lifetimes involved – 25 years – no air conditioning systems in ships and railway vehicles have been disposed of yet.

For *Aircraft and helicopters*, the following refrigerant model is applied:

- The refrigerant stocks in air-conditioning systems of medium-sized, multi-engine aircraft (registration class I) and helicopters (registration class H), and in the on-board refrigeration systems of passenger aircraft in registration classes A, B and C, are determined on the basis of the relevant numbers of aircraft and helicopters registered in Germany. The pertinent official figures are available, for all required years (i.e. as of 1993), in the statistics annually published by the German Federal Aviation Office (Luftfahrt-Bundesamt)⁷².
- In passenger aircraft of registration classes A, B and C, an average of three HFC-134a chillers, with per-unit charges of 500g, are used for on-board refrigeration during flights lasting longer than four hours.

⁷² http://www.lba.de/DE/Presse_POE/Statistiken/Statistik_Luftfahrzeuge.html?nn=700678.

- According to manufacturers, in aircraft of registration classes I and in helicopters, an average of 2 kg of HFC-134a are used, per aircraft/helicopter, for cooling instruments and for air-conditioning.
- The pertinent refrigerant stocks are calculated by multiplying the aircraft-specific charge by the number of registered air-conditioned / refrigerated aircraft involved.
- Emissions from stocks are calculated with Equation 2.
- To date, no disposal emissions have occurred, due to the long lifetimes of the aircraft involved.

Emission factors

The emission factors on which the emissions data are based are listed in Table 193.

The emission factors used have been obtained via evaluation of the relevant literature (e.g. ÖKO-RECHERCHE / ECOFYS 2003; SIEGL et. al., 2002; CLODIC et. al., 2011 und 2012; Öko-Recherche 2012, SCHWARZ et al., n.y.), measurements (automobiles), evaluations of service-center records, extensive surveys of experts and surveys of automobile service centers and dismantling facilities. In addition to regular emissions during operation, emissions also arise as a result of accidents and other external influences.

As a rule, charging of mobile air-conditioning systems produces only small quantities of emissions. For automobiles, the refrigerant losses upon charging are estimated as 3 grams per system. For utility vehicles and agricultural machinery, they are placed at 5 grams per system, and for buses they are considered to be 50 grams per system. These figures are standard values for hose leakage in connection with on-site charging. When the emissions from charging are seen, mathematically, in relation to new consumption, the following emission factors result: 0.25 - 0.63 % (automobiles), 0.42 - 0.66 % (utility vehicles), 0.28 - 0.35 % (agricultural machinery) and 0.42 - 0.45 % (buses). The ranges are the result of annual variations in initial charges. For railway vehicles, the emission factor for charging is 0.5 %, while for ships, it is 1 %. For "initial emission" for mobile air-conditioning systems (automobiles, utility vehicles, buses and railway vehicles), the 2006 IPCC Guidelines give figures, in Vol. 3, Table 7.9, of 0.2 to 0.5 percent of the initial charge. The Guidelines provide no values for agricultural machinery, ships and aircraft. The great majority of the values used for the vehicles described in the Guidelines thus lie within the relevant ranges proposed by the IPCC Guidelines.

Current HFC emissions are estimated at 10 % for automobiles; at 15 % for utility vehicles and buses; at 6 % for railway vehicles; for agricultural machinery, at 15 % (tractors) and 25 % (combines and field choppers); for ships, at 10 % (passenger ships on inland waterways), 20 % (ocean liners) and 30 % (ocean-going cargo ships); and at 5 % for aircraft. The EF_{use} used thus lie largely within the range proposed in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 10 to 20 % for air-conditioning systems in automobiles, utility vehicles, buses and railway vehicles. No proposals have been provided for agricultural machinery, ships and aircraft.

The average lifetimes prior to disposal are 15 years (automobiles, utility vehicles, buses), 10 years (agricultural machinery) and 25 years (railway vehicles, ships). For railway vehicles, disposal does not begin until 2017, while for ships it will not begin until 2022. With the exception of those for systems in railway vehicles and on ships, the lifetimes lie within the value range given by the 2006 IPCC Guidelines for systems in automobiles, utility vehicles, buses and railway vehicles, 9 to 16 years.

The residual charges remaining in air-conditioning systems, with respect to initial charge, average 34 % (automobiles, utility vehicles, buses, agricultural machinery). The 2006 IPCC Guidelines (Vol. 3, Table 7.9) give values ranging from 0 to 50 %. All of the values used are thus default values.

As a result of the disposal and recycling of end-of-life vehicles as required by the End-of-Life Vehicles Ordinance (Altfahrzeug-Verordnung) since 2002, the recovery factors for automobiles and utility vehicles have been increasing continuously, with the result that losses occurring upon disposal, with respect to initial charge or residual charge, have been decreasing over time. For automobiles and utility vehicles, the recovery factors amounted to 38 % in 2000, and to 43.3 % in 2015. For buses, the recovery factor is estimated at 38 %, and for agricultural machinery, at 11.7 %. The recovery factors used for automobiles, utility vehicles and buses thus lie within the range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 0 to 50 %. No recommendations have been provided for agricultural machinery.

Activity data

The Federal Motor Transport Authority (KBA) reports numbers of registered automobiles, utility vehicles and buses, and new registrations of agricultural tractors. The number of registered aircraft has been obtained from the German Federal Aviation Office (Luftfahrt-Bundesamt). The sources for production figures include the German Association of the Automotive Industry (VDA), the German Engineering Federation (VDMA), other statistics and surveys of manufacturers.

The charges in automobile air conditioners, and the annual percentages of automobiles equipped with air-conditioning systems, are determined via direct surveys of automobile companies. For systems in other types of vehicles, the charges and percentages are obtained by combining official statistics, information from surveys of manufacturers and experts' assessments.

4.7.1.2.6 Stationary air conditioning systems (2.F.1.f)

The area of stationary air conditioning systems includes room air conditioners, chillers for air conditioning of buildings and industrial refrigeration of liquids, heat-pump systems and heat-pump laundry dryers.

4.7.1.2.6.1 Room air conditioners

Room air conditioners are used to cool the interiors of individual rooms, entire floors or small-to-medium-sized buildings. Their performance levels tend to be lower than those of large air conditioning systems. The following refrigerants are in use: since 1998, the HFC mixture R407C; since 2001, the mixture R410A; and since 2014, HFC-32. Since 1997, R290 has also been used in mobile room air-conditioners, as a halogen-free alternative.

There is no domestic production of room air conditioners. Room air conditioners are normally already filled when imported. Installation of factory-manufactured single-split, multi-split and VRF-multi-split units involves installation of refrigerant pipes, and these have to be filled on site, however. Such filling of pipes is not required in connection with mobile, plug-in room air conditioners.

The following refrigerant model is used for room air conditioners:

- *Room air conditioners* are divided into four categories. The applicable numbers of new systems produced each year in each category are determined via surveys of manufacturers and via the data published in pertinent international publications. The categories are: small mobile units, single-split units, multi-split units with constant-volume refrigerant flow and VRF-multi-split systems with variable-volume refrigerant flow.

- For each category, the charges, and the percentage shares for the various types of refrigerants used, are determined in keeping with the numbers of new systems sold each year. The annual new consumption, which is identical to annual new additions of refrigerants, is obtained from sales statistics and the above assumptions. The year-end final stocks are obtained by aggregating the annual HFC new additions since 1993 and then subtracting the removals via disposal.
- No production emissions occur. Filling losses do occur, however, in installation of stationary single-split units, multi-split units and VRF multi-split systems. Surveys of experts have indicated that the applicable losses during installation are 5 g per unit (10 % of the initial charge) for single-split units, 20 g per unit (1 % of the initial charge) for multi-split units and 45 g per system (1 % of the initial charge) for VRF multi-split systems.
- Emissions from stocks are calculated with Equation 2.
- Disposal emissions occurred for the first time in 2008. The average lifetime of mobile units and single-split units is 10 years, while the average lifetime of multi-split units and VRF multi-split systems is 13 years. Disposal emissions are calculated with Equation 4.

Emission factors

The emission factors used have been obtained via surveys of experts and evaluations of the literature; they are listed in Table 193.

The country-specific $EF_{\text{production}} = 1\%$ for multi-split units and VRF multi-split units lies within the value range given by the 2006 IPCC Guidelines, in Vol. 3, Table 7.9 – 0.2 to 1 %. For single-split units, the emission factor is 10 %, which corresponds to a loss of 5 g of refrigerant per 50 g charge, and which is above the range given in the Guidelines.

For all devices, the emission factors for use decrease continually throughout the time series, beginning with the first year of use (cf. Table 193). For mobile room air conditioners, they range from 3.4 % (1999) to 2.5 % (2015); for single-split units, they range from 6.9 % (1998) to 5 % (2015); for multi-split units, they range from 7.9 % (1998) to 5.1 % (2015); and for VRF multi-split units, they range from 8.1 % (2003) to 6.0 % (2015). The emission factors for use thus lie within the range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 1 to 10 %.

The estimated lifetimes for such units, 10 years (mobile room air-conditioners, single-split units) and 13 years (multi-split units, VRF multi-split units), lie within the value range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 10 to 20 years. The 13-year lifetime for VRF multi-split units means that disposal of such units will not begin until 2016.

The residual charge upon disposal is 75 % for mobile room air-conditioners and 87.5 % for all other types of units. The 2006 IPCC Guidelines, in Vol.3, Table 7.9, recommend values ranging from 0 to 80 %. The residual-charge figure used for mobile room air-conditioners is thus a default value, while the values used for single-split units and multi-split units are above the Guidelines' range.

The recovery factors have been increasing continuously, and thus the losses occurring upon disposal, with respect to initial charge / residual charge, have been decreasing over the years concerned. For mobile room air-conditioners, the recovery factor was 24.2 % in 2009 and 32.5 % in 2015; for single-split units, it was 37.9 % in 2008 and 50 % in 2015; while for multi-split units, it was 62 % in 2011 and 70 % in 2015. The recovery factors used thus lie within the range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 0 to 80 %.

Activity data

The numbers of units sold in Germany, of the various types of units and systems involved, are determined on an annual basis via technical publications⁷³ and surveys of sellers.

4.7.1.2.6.2 Chillers

Chillers for air-conditioning of buildings and industrial refrigeration of liquids are divided into three performance categories: chillers with a cooling capacity of less than 100 kW, chillers with a cooling capacity of more than 100 kW and turbo-compressor systems (with cooling capacities above 1500 kW). The types of compressors used in chillers include piston, scroll and screw compressors.

In turbocompressor systems, only HFC-134a has been used since 1993. In the years 1995 through 1999, HFC-134a was also used for conversions of CFC-12 turbocompressor systems. The most important refrigerants used in chillers include HFC-134a (used as of 1993), R407C (as of 1998) and R410A (as of 2004). HFC-1234ze has also been used since 2013.

The following refrigerant model is applied to *chillers*:

- Chillers are divided into three categories. The number of new systems in each of the following categories is determined each year via surveys of experts and international sales statistics: chillers <100 kW cooling capacity; chillers >100 kW cooling capacity; and turbo-compressor systems in the performance range above 1500 kW.
- For each category, the average charge, and the percentage shares for the various types of refrigerants used, are determined. The applicable charges are 10 kg for chillers <100 kW, 95 kg for chillers >100 kW and 630 kg for turbo-compressor systems.
- Data on annual HFC additions to domestic stocks are obtained from the numbers of new systems, in connection with the above assumptions. Consumption for CFC replacements in old systems has to be taken into account.
- The year-end refrigerant stocks can be calculated from the previous-year stocks, the new additions and the removals.
- Production emissions are calculated by multiplying the quantities consumed in filling by the $EF_{\text{production}}$, pursuant to Equation 1.
- Emissions from stocks are calculated with Equation 2.
- Disposal emissions occurred for the first time in 2003 (in conversion of systems for CFC substitutes). They are calculated with Equation 4.
- Pursuant to the recommendations of the 2014 UNFCCC Reporting Guidelines (FCCC/CP/2013/10/Add.3, Decision 24/CP.19), emissions of HFC-1234ze, which are not subject to reporting obligations, are voluntarily reported under "additional greenhouse gases." The emissions are aggregated with other emissions that are not subject to reporting obligations, and they are listed in Chapter 4.9.3 under CRF 2.H.3.

Emission factors

The emission factors used were obtained via surveys of experts. They are listed in Table 193.

The losses from charging, at 0.5 %, are within the range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 0.2 to 1 %. To take account of the fact that large numbers of chillers are imported as pre-filled units, $EF_{\text{production}} = 1$ %, the actual $EF_{\text{production}}$, is not used.

⁷³ The trade journal JARN – Japan Air Conditioning, Heating & Refrigeration News, Tokyo 107-0052, Special Edition "World Air Conditioner Market".

The ongoing HFC emissions through 2000 are estimated at 6 % for all cooling-capacity classes / compressor models, age classes and refrigerant types. Thereafter, the EF_{use} decreases continuously, to 3.4 % (2015). All of the values used thus lie within the lower part of the range proposed by the 2006 IPCC Guidelines (Vol. 3, Table 7.9), 2 to 15 %.

The 2006 IPCC Guidelines, in Vol. 3, Table 7.9, give a service lifetime of 15 to 30 years for liquid chiller systems. The values used in the present case lie within that range: 15 years for chillers with cooling capacities either less or more than 100 kW, and 25 years for turbo-compressor systems.

The residual charge upon disposal is 90 %, for all chiller types. The 2006 IPCC Guidelines, in Vol. 3, Table 7.9, recommend values ranging from 80 to 100 %. The residual-charge figures used are thus default values.

The recovery factors have been increasing continuously, as a result of technical progress and greater care taken in handling refrigerants, and thus the losses occurring upon disposal, with respect to initial charge / residual charge, have been decreasing over the years concerned. The recovery factor for chillers, including units with cooling capacity less than 100 kW and greater than 100 kW, was 65.8 % in 2003 and 77.5 % in 2015, while the factor for turbo-compressor systems was 69.5 % in 2003 and 77.5 % in 2015. The recovery-factor figures used thus lie within the range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 0 to 95 %.

Activity data

The numbers of new systems are determined annually via surveys of experts and consultation of international sales statistics. The statistics are prepared by two market-research institutes⁷⁴.

The average charges, and the percentage shares for the various types of refrigerants used, were determined in the framework of expert consultations with industry representatives.

4.7.1.2.6.3 Heat-pump systems

Via a refrigeration cycle, heat pumps draw heat from the air, ground or groundwater and make it available for heating or cooling indoor areas or for heating water. Devices that directly use heat from the outdoor environment to warm indoor air fall within the category of room air conditioners. Since 1995, HFC-134a and the HFC mixtures R404A and R407C have been used as refrigerants in heat pumps; since 2001, R410A has been used as well.

Methodologically, the refrigerant model for *heat pumps* is structured like the model for room air conditioners.

- Three categories of heat pumps for heating are differentiated: air – water; ground (groundwater) – water; ground (brine) – water. Heat pumps for pumping hot process water are treated as a fourth category.
- The starting and reference point for calculations consists of the annual unit-number figures for newly installed heat pumps in all four categories. These data are published annually by the German heat-pump association (BWP). The numbers of newly installed heat pumps for hot process water are also used as production quantities. The produced quantities of heat pumps for heating are larger, by a factor of 2, than the numbers of newly installed pumps. On the basis of the data for new additions, the various heat-pump types are assigned average HFC charges and percentage shares of the various types of HFCs. The model also includes service-life and emissions-rate figures.

⁷⁴ BSRIA, the UK, and the European industry association EUROVENT, Brussels. Both companies break down the market for chillers by compressor types and cooling-capacity classes.

- Production emissions are calculated by multiplying the quantities consumed in filling by the $EF_{\text{production}}$, pursuant to Equation 1, while emissions from stocks are calculated with Equation 2.
- Heat pumps with HFCs have been produced and sold since 1995. Since the units have an average service life of 15 years, disposal-related emissions began occurring in 2010. They are calculated with Equation 4.

Emission factors

The emission factors (EF) on which the emissions data are based are listed in Table 193.

The emission factors used are the result of surveys of experts.

The filling loss is 0.5 %. Consequently, the $EF_{\text{production}}$ lies within the range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 0.2 to 1 %.

The annual HFC emissions for heating-system heat pumps are estimated at 2.5 %, while the emissions for water-heating heat pumps are placed at 2 %. The EF_{use} used thus lie within the range proposed by the 2006 IPCC Guidelines (Vol. 3, Table 7.9), 1 to 10 %.

The average lifetime prior to disposal is 15 years. The system lifetimes used thus lie within the range given in the 2006 IPCC Guidelines (Vol. 3, Table 7.9), 10 to 20 years.

The residual charges in heat pumps, with respect to initial charge, average 75 %. The 2006 IPCC Guidelines (Vol. 3, Table 7.9) give values ranging from 0 to 80 %. The value used is thus a default value.

The recovery factor for heat pumps has been increasing continuously, as a result of the greater care taken in handling refrigerants, and thus the losses occurring upon disposal, with respect to initial charge / residual charge, have been decreasing over the years concerned. The recovery factor was 50 % in 2010, and 57.5 % in 2015. As a result, all of the recovery-factor figures used lie within the range given in Vol. 3, Table 7.9 of the 2006 IPCC Guidelines, 0 to 80 %.

Activity data

Each year, the Bundesverband Wärmepumpe (BWP) national heat-pump association publishes the numbers of new domestic installations of heat pumps. Those figures serve as the basis for the relevant emissions calculation.

The production / installation ratio used is based on information provided by heat-pump producers.

4.7.1.2.6.4 Heat-pump clothes dryers

Heat-pump clothes dryers with HFC refrigerants have been sold on the German market since 2008. The refrigerants used by these household appliances are HFC-134a and the refrigerant mixture R407C. The charges in the units, which are hermetically sealed, range from 220 g to 485 g.

From 2008 to 2012, one company produced heat-pump clothes dryers using the refrigerant HFC-134a. At the end of 2012, that company transferred its production abroad.

The refrigerant model for *heat-pump clothes dryers* is structured similarly to the models for room air conditioners:

- The most important starting values are a) the unit-number figures for domestic sales and domestic production, and b) the split applied to the two refrigerants used (the refrigerant-use figures are tied to the domestic-sales figures). The total numbers of devices are calculated from the sums of new additions.
- Production emissions are calculated by multiplying the quantities consumed in filling by the $EF_{\text{production}}$, pursuant to Equation 1, while emissions from stocks are calculated with Equation 2.
- Heat-pump dryers with HFCs have been produced and sold since 2008. Since the units have an average service life of 15 years, disposal-related emissions will begin occurring in 2023.

Emission factors

The emission factors used are based on information from experts. They are listed in Table 193.

The charging loss is 0.5 %. The $EF_{\text{production}}$ is country-specific, since the IPCC Guidelines do not cover these appliances.

The ongoing HFC emissions of these hermetically sealed units are estimated at 0.3 %. In this area as well, the IPCC Guidelines provide no specifications.

Activity data

Heat-pump dryers are a relatively new product for which little statistical data and technical information are available. The pertinent refrigerant model is thus based almost exclusively on information provided by manufacturers (cf. SCHWARZ et al., n.y.).

4.7.1.3 Uncertainties and time-series consistency (2.F.1 all)

The emission factors are subject to considerable uncertainties. The broad range of emission factors found in the literature (see the refrigerant models) for identical applications is only partly a consequence of technical modifications, of how well systems are sealed or of national differences. To a large extent, it also results from real uncertainties, since too little solid empirical study of such factors has been carried out (ÖKO-RECHERCHE, 2007).

As a result of the aforementioned uncertainty with regard to emission factors, and to the large number of individual applications (systems) involved, the emissions data are considered to be too imprecise. In order to improve the quality of the data, the data were compared with manufacturers' (substance-oriented) sales data.

Until the 2001 reporting year, Germany reported only aggregated emissions, covering all sub-source categories. Within the context of emissions surveys for the years 1999 to 2001, and the emissions survey for the 2002 reporting year, the emissions for the reported years 1995 to 1998 were reviewed and updated on the basis of new findings on input quantities and emission factors. All data are thus being improved on an ongoing basis. A comprehensive review of the currentness of the refrigerant models, outset data and emission factors used was carried out in 2012.

The quality of the data on emissions from mobile air conditioning systems is good. The reason for this is that annual HFC consumption can be precisely determined via statistics on registered vehicles and new registrations, and on production, imports and exports of automobiles, which account for the largest part of this sector, as well as via annual model-specific figures on air-conditioner-installation rates and the pertinent charges. Only in the area of commercial vehicles are the data subject to major uncertainties.

The emission factors have been updated on the basis of the results of a study of the Federal Environment Agency (UBA) (SCHWARZ et al., n.y.). In many application areas, the factors show a

continuous development throughout the time series. Overall, the EF are considered to be accurate. In the study, the residual charges and recovery factors were determined for all areas of application of refrigeration and air-conditioning systems, in order to achieve conformance with the 2006 IPCC Guidelines.

The uncertainties for the entire sub-category of refrigeration and air conditioning systems have been quantified for the 2015 report.

4.7.1.4 Category-specific recalculations (2.F.1 all)

In the area of low-temperature applications in commercial refrigeration and of systems converted to HCFC-22 (sub- source category 2.F.1.a), data collected by the Federal Statistical Office, pursuant to the Environmental Statistics Act (UStatG), are used with regard to initial charges of new systems, and to initial charges of systems converted to R413A, R508A, R508B, Isceon 89 and R23. Since the UStatG data on HFC did not become available until December of the following year, the figures for 2014 had to be recalculated. This led to changes in the emissions of PFC-116, PFC-218, HFC-125 and HFC-23 in connection with production and use in 2014.

With regard to central systems in the food retail industry (sub- source category 2.F.1.a), the time period applying to use of HCFC and HFC refrigerants was reassessed on the basis of new scientific findings. In addition, the refrigerant model for central systems was adjusted to include utilisation of halogen-free refrigerants and of new HFC-refrigerant blends. This led to changes in the emissions of HFC-125, HFC-134a, HFC-143a and HFC-32 in connection with production and use in the years 1993 through 2014, and in connection with disposal in the years 2000 through 2014.

In the area of industrial refrigeration (sub- source category 2.F.1.c), the number of refrigeration units converted to R404A and R407C in 2014, in slaughterhouses and cold-storage systems, was downwardly corrected. The figures for new additions of HFC-227ea and HFC-23 in 2014 also had to be recalculated, since the relevant data collected pursuant to the Environmental Statistics Act (Umweltstatistikgesetz) did not become available until December of the following year. This led to changes in the emissions connected to use of HFC-125, HFC-134a, HFC-143a and HFC-32, and to changes in the emissions connected to production and use of HFC-227ea and HFC-23, in 2014.

In the area of refrigerated vehicles (sub- source category 2.F.1.d), the number of refrigerated vehicles produced in Germany with R404A, and with 2-5 t permissible total weight, was upwardly corrected for the years 2006 through 2014. This increased the emissions for production of HFC-125, HFC-134a and HFC-143a in the years 2006 through 2014.

In the area of buses (sub- source category 2.F.1.e), the percentage of newly registered buses with air-conditioning systems in 2014 was upwardly corrected. This increased the HFC-134a emissions from stocks in 2014.

In the area of utility vehicles (sub- source category 2.F.1.e), the percentage of domestically produced vehicles with air-conditioning systems, and the applicable charges, had to be upwardly corrected for the year 2013. This increased the HFC-134a emissions from production in 2013. In addition, with regard to utility vehicles newly registered in 2013 and 2014, the percentage of such vehicles with air-conditioning systems had to be increased, and the applicable charges had to be reduced. This led to an increase in the HFC-134a emissions from stocks in the years 2013 and 2014. Correction of an erroneously entered value for old vehicles disposed of domestically in 2014 led to an increase in the disposal emissions of HFC-134a in 2014.

In the area of automobiles (sub- source category 2.F.1.e), the percentage of domestically produced vehicles with air-conditioning systems, and the applicable charges, had to be downwardly

corrected for the year 2013, and upwardly corrected for the year 2014. As a result, the HFC-134a emissions from production decreased in 2013, and increased in 2014. In the area of vehicles newly registered in the years 2012 through 2014, the percentages of vehicles with air-conditioning systems, and the applicable charges for those systems, also required corrections. This led to a decrease in the HFC-134a emissions from stocks in the years 2012 through 2014. In addition, an erroneously entered value for the number of old vehicles disposed of domestically in 2014 was upwardly corrected. This led to an increase in the disposal emissions of HFC-134a in 2014.

In the area of room air-conditioners (sub- source category 2.F.1.f), the percentage shares for the various types of refrigerants used, for all unit types as of 1998, had to be corrected; in the past, the share of units with R407C was underestimated, and the share of units with R410A was overestimated. Furthermore, HCFC-22 was used for a longer period in room air-conditioners than had previously been assumed. In addition, the fact that R32 was used in single-split units as of 2014 had not previously been taken into account in the inventory. Use of R290, a halogen-free refrigerant, in mobile room air-conditioners had also not been taken into account. The reassessment of the applicable percentage shares for the various refrigerants led to changes in emissions from production and use of HFC-125, HFC-134a and HFC-32 in the years 1998 through 2014, as well as to changes in the emissions from disposal of those HFCs in the years 2010 through 2014.

With regard to chillers <100 kW and >100 kW cooling capacity (sub- source category 2.F.1.f), the applicable percentage shares for the various refrigerants, for the period as of 2005, were corrected as follows: the share for R407C units was increased, and the share for R410A units was decreased. The reassessment of the applicable percentage shares for the various refrigerants led to changes in emissions from production and use of HFC-125, HFC-134a and HFC-32 in the years 2005 through 2014.

In the area of heat pumps (sub- source category 2.F.1.f), the applicable percentage shares for the various HFC refrigerants used were corrected for the period as of 1996. Here as well, the share of units with R407C and HCFC-22 was underestimated in the past, and the share of units with R410A was overestimated. The reassessment of the applicable percentage shares for the various refrigerants led to changes in emissions from production and use of HFC-125, HFC-134a and HFC-32 in the years 1996 through 2014, as well as to changes in the emissions from disposal of those HFCs in the years 2011 through 2014.

The emissions changes in the sub-category refrigeration and air-conditioning systems (2.F.1), with regard to emissions from production, use and disposal of PFC-116, PFC-218, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea, HFC-23 and HFC-32, in the years 1993 through 2014, are listed in Table 195.

Table 195: Overview of the recalculation-related changes in emissions (EM) in the sub-category refrigeration and air-conditioning systems (2.F.1), with regard to emissions from production, use and disposal of PFC-116, PFC-218, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea, HFC-23 and HFC-32, in the years 1993 through 2014

	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
EM production, HFC-125												
2016 Submission	t CO ₂ eq	336.67	2401	4790	9975	10330	10862	10104	10019	10129	9112	9522
2017 Submission	t CO ₂ eq	337.39	2409	4824	9520	9848	10407	9667	10927	11716	10724	11047
Difference	t CO₂eq	+0.72	+8	+33	-454	-481	-455	-437	+908	+1588	+1613	+1525
EM production, HFC-134a												
2016 Submission	t CO ₂ eq	2921.6	5829.3	10392	18511	22236	27846	30802	30255	31592	30157	30826
2017 Submission	t CO ₂ eq	2920.9	5820.5	10357	17954	21649	27282	30255	29064	29884	28527	29266
Difference	t CO₂eq	-0.7	-8.7	-34	-557	-588	-564	-547	-1191	-1709	-1630	-1560
EM production, HFC-143a												
2016 Submission	t CO ₂ eq	168	673	2429	9263	9713	10958	12039	11742	11776	10349	10450
2017 Submission	t CO ₂ eq	170	702	2545	8793	9214	10530	11687	13975	15164	13687	13764
Difference	t CO₂eq	+3	+30	+117	-470	-500	-428	-353	+2232	+3388	+3338	+3314
EM production, HFC-32												
2016 Submission	t CO ₂ eq	2.8	12	43	159	169	211	284	361	408	395	466
2017 Submission	t CO ₂ eq	2.6	10	35	134	143	180	248	259	291	288	344
Difference	t CO₂eq	-0.2	-2	-8	-25	-27	-31	-36	-101	-117	-107	-122
EM use, HFC-125												
2016 Submission	t CO ₂ eq	9530	56554	141942	298973	454586	608669	730009	811909	889818	959017	1029778
2017 Submission	t CO ₂ eq	9544	56729	142735	301735	459379	614828	736433	829827	929366	1019247	1107088
Difference	t CO₂eq	+14	+175	+793	+2762	+4792	+6160	+6424	+17918	+39548	+60230	+77309
EM use, HFC-134a												
2016 Submission	t CO ₂ eq	67648	176854	340665	634237	980469	1397569	1827541	2212569	2544476	2853106	3153733
2017 Submission	t CO ₂ eq	67633	176673	339847	631373	975490	1390069	1817085	2183668	2490537	2777548	3059439
Difference	t CO₂eq	-15	-180	-818	-2865	-4979	-7500	-10456	-28901	-53939	-75558	-94294
EM use, HFC-143a												
2016 Submission	t CO ₂ eq	7990	22967	62761	199202	335761	483114	628349	720933	813252	890547	964607
2017 Submission	t CO ₂ eq	8039	23577	65531	208882	352571	506766	657908	780079	918834	1038374	1151665
Difference	t CO₂eq	+49	+610	+2771	+9680	+16810	+23652	+29558	+59146	+105582	+147827	+187058
EM use, HFC-32												
2016 Submission	t CO ₂ eq	26	177	874	3198	5532	8296	11724	15387	18939	22720	27954
2017 Submission	t CO ₂ eq	23	136	689	2550	4406	6608	9389	11614	13538	16012	19610
Difference	t CO₂eq	-3	-41	-185	-648	-1126	-1687	-2335	-3774	-5401	-6708	-8344

	Units	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
EM disposal, HFC-125												
2016 Submission	t CO ₂ eq								65355	62087	70383	84141
2017 Submission	t CO ₂ eq								62950	60718	68647	87140
Difference	t CO₂eq								-2405	-1370	-1736	+2999
EM disposal, HFC-134a												
2016 Submission	t CO ₂ eq								64668	61466	71999	85382
2017 Submission	t CO ₂ eq								59321	57115	67534	85776
Difference	t CO₂eq								-5347	-4351	-4465	+394
EM disposal, HFC-143a												
2016 Submission	t CO ₂ eq								86374	82056	93020	97840
2017 Submission	t CO ₂ eq								86469	83527	93745	104533
Difference	t CO₂eq								+94	+1472	+725	+6693
EM disposal, HFC-32												
2016 Submission	t CO ₂ eq								1442	1370	1553	1437
2017 Submission	t CO ₂ eq								1004	954	1160	1183
Difference	t CO₂eq								-438	-416	-393	-255

Continued

	Units	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
EM production, PFC-116												
2016 Submission	t CO ₂ eq											14.64
2017 Submission	t CO ₂ eq											20.76
Difference	t CO₂eq											+6.12
EM production, PFC-218												
2016 Submission	t CO ₂ eq											6.18
2017 Submission	t CO ₂ eq											7.41
Difference	t CO₂eq											+1.23
EM production, HFC-125												
2016 Submission	t CO ₂ eq	10011	10828	12216	13015	17381	21594	24650	23930	19624	18666	18959
2017 Submission	t CO ₂ eq	11619	12215	13495	14347	18194	21689	24386	23999	18761	16564	16350
Difference	t CO₂eq	+1608	+1387	+1279	+1332	+813	+95	-264	+69	-863	-2102	-2609
EM production, HFC-134a												
2016 Submission	t CO ₂ eq	31921	32996	33961	34902	35220	31525	35761	37325	33983	33930	36134
2017 Submission	t CO ₂ eq	30386	31625	32683	33680	34253	30344	34734	36543	33580	33954	35929
Difference	t CO₂eq	-1535	-1371	-1278	-1221	-967	-1181	-1027	-782	-403	+24	-205
EM production, HFC-143a												
2016 Submission	t CO ₂ eq	10627	10762	11226	11353	12297	13297	13988	13635	12472	11957	11781
2017 Submission	t CO ₂ eq	13991	14068	14446	14540	15358	15941	15844	15188	13110	10880	10074
Difference	t CO₂eq	+3364	+3305	+3220	+3187	+3061	+2643	+1856	+1553	+638	-1078	-1707

	Units	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
EM production, HFC-227ea												
2016 Submission	t CO ₂ eq											64
2017 Submission	t CO ₂ eq											46
Difference	t CO₂eq											-18
EM production, HFC-23												
2016 Submission	t CO ₂ eq											666
2017 Submission	t CO ₂ eq											776
Difference	t CO₂eq											+110
EM production, HFC-32												
2016 Submission	t CO ₂ eq	535	673	876	1010	1278	1157	1249	1393	1482	1576	1707
2017 Submission	t CO ₂ eq	422	523	713	861	1041	935	1042	1182	1228	1300	1412
Difference	t CO₂eq	-113	-150	-162	-149	-238	-222	-207	-211	-255	-276	-294
EM use, PFC-116												
2016 Submission	t CO ₂ eq											1539
2017 Submission	t CO ₂ eq											1620
Difference	t CO₂eq											+81
EM use, PFC-218												
2016 Submission	t CO ₂ eq											4276
2017 Submission	t CO ₂ eq											4292
Difference	t CO₂eq											+16
EM use, HFC-125												
2016 Submission	t CO ₂ eq	1084257	1114857	1155875	1218473	1317812	1461103	1610269	1735578	1769247	1779838	1816466
2017 Submission	t CO ₂ eq	1180583	1224743	1276022	1353865	1465249	1613949	1758909	1883191	1906764	1895992	1896768
Difference	t CO₂eq	+96326	+109886	+120147	+135392	+147437	+152846	+148640	+147613	+137517	+116154	+80302
EM use, HFC-134a												
2016 Submission	t CO ₂ eq	3453207	3753398	4056508	4015124	4218521	4433857	4599339	4752960	4854917	4926116	4989720
2017 Submission	t CO ₂ eq	3340729	3627844	3920705	3864864	4054485	4260024	4419816	4569249	4670514	4738033	4812704
Difference	t CO₂eq	-112478	-125554	-135804	-150261	-164036	-173833	-179523	-183711	-184403	-188083	-177015
EM use, HFC-143a												
2016 Submission	t CO ₂ eq	1048672	1115300	1184689	1270896	1363727	1431866	1485837	1525594	1533315	1522849	1516931
2017 Submission	t CO ₂ eq	1276157	1375568	1473810	1596987	1726550	1815556	1873347	1918417	1920668	1884088	1827198
Difference	t CO₂eq	+227485	+260267	+289121	+326091	+362824	+383691	+387510	+392822	+387353	+361239	+310267
EM use, HFC-227ea												
2016 Submission	t CO ₂ eq											3291
2017 Submission	t CO ₂ eq											3185
Difference	t CO₂eq											-106

	Units	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
EM use, HFC-23												
2016 Submission	t CO ₂ eq											61867
2017 Submission	t CO ₂ eq											62437
Difference	t CO₂eq											+570
EM use, HFC-32												
2016 Submission	t CO ₂ eq	34096	40995	49249	59158	70240	78946	87939	97847	106818	114909	123295
2017 Submission	t CO ₂ eq	24322	29676	36218	44356	53061	60164	67856	76391	84047	91253	99456
Difference	t CO₂eq	-9774	-11319	-13031	-14802	-17178	-18782	-20084	-21456	-22771	-23656	-23838
EM disposal, HFC-125												
2016 Submission	t CO ₂ eq	169262	229746	239045	221281	193166	109788	110478	130257	232442	260705	271226
2017 Submission	t CO ₂ eq	162894	229388	226875	220932	180022	104618	114358	130345	230069	247102	284368
Difference	t CO₂eq	-6368	-359	-12171	-349	-13144	-5170	+3880	+89	-2374	-13602	+13142
EM disposal, HFC-134a												
2016 Submission	t CO ₂ eq	100416	130077	160421	148601	161018	375295	203290	243651	301876	332973	361813
2017 Submission	t CO ₂ eq	93564	127225	146508	146244	146263	368346	203718	240731	294984	320306	332791
Difference	t CO₂eq	-6852	-2853	-13913	-2356	-14756	-6949	+428	-2920	-6892	-12667	-29022
EM disposal, HFC-143a												
2016 Submission	t CO ₂ eq	94922	105928	123542	105364	105321	109444	124153	149562	182031	183876	195805
2017 Submission	t CO ₂ eq	87240	108174	109748	107094	90131	104713	132152	155125	191086	193042	246911
Difference	t CO₂eq	-7683	+2246	-13794	+1730	-15190	-4731	+7999	+5563	+9054	+9166	+51106
EM disposal, HFC-32												
2016 Submission	t CO ₂ eq	1423	1908	2210	1919	1996	2442	3433	5323	10249	16702	21962
2017 Submission	t CO ₂ eq	1196	1580	1672	1654	1450	2081	3181	4684	8763	13141	17142
Difference	t CO₂eq	-227	-328	-538	-265	-546	-361	-252	-638	-1485	-3560	-4819

4.7.1.5 Planned improvements, category-specific (2.F.1 all)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.7.2 Foam blowing (2.F.2)

Since 1993, hydrofluorocarbons (HFCs) have also been used in foam blowing, as blowing agents substituting for ozone-depleting, climate-damaging CFCs and HCFCs.

A useful distinction can be made between open-cell and closed-cell foam products. In the case of open-cell foam products, the blowing-agent emissions occur only during the production process or immediately after it. The open-cell foam products that are produced and used in Germany include polyurethane integral foam, one-component polyurethane foam and extruded polystyrene hard foam (XPS) blown with HFC-152a. In the case of closed-cell foam products, emissions occur throughout products' entire lifetimes: in production, during use and upon disposal. The products in this category include rigid polyurethane foam, as well as extruded polystyrene hard foam (XPS) blown with HFC-134a or HFC-1234ze. Both types of closed-cell foam products are produced and used in Germany.

4.7.2.1 Closed-cell polyurethane hard foam products (2.F.2 PU hard foam)**4.7.2.1.1 Category description (2.F.2 PU hard foam)**

Closed-cell polyurethane (PU) hard foam products are used in many different kinds of products, including household appliances, refrigerated vehicles, insulating boards with flexible laminates and sandwich elements with rigid laminates. HFC-134a was used as a blowing agent from 1998 to 2003. Since 2002, HFC-365mfc (with small quantities of added HFC-227ea) has also been used as a blowing agent, and HFC-245fa has also been used as such an agent since 2004. HFC-245ca is not used in Germany. Use of HFC has been decreasing; it is being supplanted by hydrocarbons, such as pentane, and by CO₂ (in small amounts).

The time series, which does not begin until 1998, shows a small increase in emissions until 2003. A larger increase occurred in 2004. These results agree with the historical development of HFC use in this application area, an area which arose only slowly, as a result of the long period of utilisation of HCFCs. Emissions from PUR hard foam products decreased slightly again from 2005 through 2009. A slight increase occurred in 2010, and since then the emissions have remained at a relatively constant level.

4.7.2.1.2 Methodological aspects (2.F.2 PU hard foam)

The production emissions are calculated, using Equation 1, by multiplying the quantity of HFC that is emitted no later than one year after the time of production (the first-year loss) by the EF_{production}. The emissions from stocks are calculated with Equation 2.

Given the products' average lifetime of up to 50 years (sandwich elements), disposal of PU hard foam products will not begin until a few years from now.

Emission factors

The emission factors used are shown in Table 194.

The emission factor for production with HFC-134a is 10 %. That figure is equivalent to the standard value given in the 2006 IPCC Guidelines, in Vol. 3, Table 7.6, for "polyurethane continuous panels".

The emission factors for all other HFCs have been approved by national experts and adjusted where necessary. For example, the emission factor for production of PU hard foam, with use of HFC-365mfc/HFC-227ea as of 2004, was increased from 10 % to 15 %, because that HFC mixture has been used increasingly in open on-site applications, especially in spray foams. The emission factor for production with HFC-245fa is also 15 %. Those values lie within the standard-value range proposed in the 2006 IPCC Guidelines, in Vol. 3, Table 7.7, for the "first year loss" for the various PU hard-foam applications.

For PU hard foam blown with HFC-134a, the annual HFC emissions from the "stock" are estimated at 0.5 %. That figure is equivalent to the default value given in the 2006 IPCC Guidelines (Vol. 3, Table 7.6) for "polyurethane continuous panels". The products blown with HFC-365mfc/HFC-227ea and HFC-245fa emit 1 % annually, and thus lie within the default-value ranges given by the 2006 IPCC Guidelines, in Vol. 3, table 7.7, for various PU-hard-foam applications. The emission factor used for HFC-365mfc/HFC-227ea emissions from stocks was taken from an estimate based on test products.

Activity data

The figures for new domestic consumption, for each blowing agent and each product group, are based on the amounts of foam products produced in Germany. The data for products in service are based on the amounts of foam products used in Germany (sales in Germany) since the introduction of HFCs. Given a product lifetime of up to 50 years, removals from products in service do not yet play any significant role.

New domestic consumption and domestic sales of foam products are determined annually via surveys of manufacturers, users and blowing-agent suppliers, and via information from the relevant industry association (IVPU⁷⁵ – the polyurethane-foam industry association).

4.7.2.2 Closed-cell and open-cell XPS hard foam (2.F.2 XPS)

4.7.2.2.1 Category description (2.F.2 XPS)

Extruded polystyrene hard foam (XPS) is used in insulating boards that need to be highly moisture-resistant. HFC consumption and emissions from production of XPS insulation boards have occurred only since 2001, since HCFCs or CO₂ / ethanol were used in this area prior to that time. Since 2001, both HFC-152a and HFC-134a have been used as blowing agents, either singly or in mixtures. Since 2012, HFC-1234ze has also been used as a blowing agent. The emissions behaviour of XPS insulating boards varies in keeping with the blowing agents used to produce them. When HFC-152a is used, HFC emissions occur only during production, and thus the resulting XPS insulating boards can be considered "open-cell" products. When HFC-134a or HFC-1234ze are used, closed-cell XPS hard foam products result that also release HFC emissions during use and disposal.

⁷⁵ IVPU – Industrieverband Polyurethan-Hartschaum e. V.

The relevant time series, which begins in 2001, shows a slight emissions increase until 2005. As of 2006, the emissions decrease continuously; this is related to the increasing use of non-halogenated blowing agents in production of XPS hard foam products in Germany.

4.7.2.2.2 Methodological issues (2.F.2 XPS)

The production emissions are calculated by multiplying the production-related new HFC consumption by the $EF_{\text{production}}$, pursuant to Equation 1.

The use emissions are calculated, in keeping with Equation 2, from the domestic final HFC stocks in XPS insulating materials. Those stocks increase annually solely through new additions of insulating boards containing HFC-134a and HFC-1234ze. Given a product lifetime of 50 years, removals from products in service do not yet play any significant role. The new HFC additions are not equivalent to annual new consumption, minus production emissions. The reason for this is that, as a result of foreign trade, especially exports of XPS products with HFC-134a or HFC-1234ze, only 25 % (the complementary value for the export rate) of the HFC-134a or HFC-1234ze contained in products amounts to new additions to domestic HFC stocks.

Given that XPS insulating boards have an average lifetime of 50 years, disposal will not begin until 2051 at the earliest. Disposal emissions thus play no significant role to date.

HFC-1234ze is not subject to reporting obligations. Germany voluntarily reports emissions of this substance pursuant to the recommendations of the 2014 UNFCCC Reporting Guidelines (FCCC/CP/2013/10/Add.3, Decision 24/CP.19), under "additional greenhouse gases". For reasons of confidentiality, the HFC-1234yf emissions are aggregated with other emissions that are not subject to reporting obligations and are reported in Chapter 4.9.3 under CRF 2.H.3.

Emission factors

The emission factors used are shown in Table 194.

The production emissions (HFC first-year losses) for HFC-152a are practically 100 % ($EF_{\text{production}} = 1$), since the substance is used solely as a blowing agent in production. With HFC-134a, only part of consumption is emitted upon blowing; most of the substance enters into the product. The $EF_{\text{production}}$ for HFC-134a is determined empirically and communicated by the CEFIC⁷⁶ association or by its EXIBA⁷⁷ industry association. It is subject to confidentiality requirements. Until experimental measurements become available, the same $EF_{\text{production}}$ will be used for XPS insulating boards blown with HFC-1234ze that is used for insulating boards blown with HFC-134a.

Trials with HFC collection and recovery in the production process have been conducted, but to date no relevant systems have been implemented, for both technical and economic reasons.

The 2006 IPCC Guidelines give the following default values, in Vol. 3, Table 7.6, for insulating boards blown with HFC-134a and HFC-152a: The "first year loss" is 25 % for HFC-134a and 50 % for HFC-152a. The corresponding values used in Germany, especially that for HFC-152a, differ widely from these figures. At the same time, they are considered to be representative, since they are based on information provided by industry experts.

A representative of the FPX extruded-polystyrene-foam association estimated the annual releases from enclosed HFC-134a cell gas as being less than 1 % in 2002. That figure is based, inter alia, on an internal study of BASF regarding the half-lives of various cell gases, including HFC-134a (WEILBACHER 1987). The EF_{use} from that laboratory study has been used for HFC-134a. Fugitive

⁷⁶ CEFIC – The European Chemical Industry Council

⁷⁷ EXIBA – European Extruded Polystyrene Insulation Board Association

emissions from boards depend on board thickness, and they can be given only as average values, or as values for specific board thicknesses. The value used, $EF_{\text{use}} = 0.66 \%$, is based on average board thickness, and it lies below the value proposed in the 2006 IPCC Guidelines, in Vol. 3, Table 7.6, 0.75% . The 2006 IPCC Guidelines do not provide any default values for insulating boards blown with HFC-1234ze. The same EF_{use} is used for such boards as is used for boards blown with HFC-134a.

Activity data

The data on new domestic consumption of HFC-1234ze are obtained from data collected pursuant to the Environmental Statistics Act (Umweltstatistikgesetz) and from surveys of manufacturers.

The data on new domestic consumption of HFC-152a was obtained from data collected pursuant to the Environmental Statistics Act.

The data on new domestic consumption of HFC-1234ze are obtained from data collected via surveys pursuant to the Environmental Statistics Act (Umweltstatistikgesetz) and via information provided by the pertinent propellant manufacturer.

All of the data required for emissions calculation, including new domestic consumption, loss rate in production and the foreign trade balance for insulation boards containing HFC-134a, are provided by the relevant European industry association (CEFIC or EXIBA).

4.7.2.3 Open-cell polyurethane integral foam (2.F.2 PU integral foam)

4.7.2.3.1 Category description (2.F.2 PU integral foam)

Open-cell polyurethane (PU) integral foams are foams with a porous core and a compact, tough skin. They are produced via reaction injection moulding. In that process, the reaction mixture, including the blowing agent, is injected in liquid form into a cold injection mould. All of the blowing agent is emitted during the foaming action that ensues. PU integral foams are used in the soles of athletic and leisure shoes, in car-body parts and in window profiles. HFCs have been used as blowing agents for production of PU integral foams since 1996.

Along with HFC-134a, which has been used since 1996, the blowing agents used in Germany also include HFC-365mfc (since 2002; and with minor additions of HFC-227ea) and HFC-245fa (since 2004). HFC-245ca is not used in Germany.

The time series begins in 1996. From then until 2002, the emissions remained relatively constant. From 2002 through 2007, they then increased continuously. HCFCs were long used in production of PU integral foams in Germany, and this delayed the phasing-in of HFCs. A sharp emission reduction occurred beginning in 2008. It was due to intensified use of hydrocarbons (such as pentane), as blowing agents, in place of HFCs.

4.7.2.3.2 Methodological aspects (2.F.2 PU integral foam)

Pursuant to the 2006 IPCC Guidelines (page 7.34, equation 7.8), the emissions in this open application are considered to be the same as the HFC quantity used in production (new HFC consumption).

The production emissions are calculated by multiplying the production-related new HFC consumption by the $EF_{\text{production}}$, pursuant to Equation 1.

No use emissions or disposal emissions occur, since all of the blowing agent is emitted completely in production.

Emission factors

The emission factor used is shown in Table 194.

For PU integral foams blown with HFC-134a, HFC-245fa or HFC-365mfc (with additions of HFC-227ea), the 2006 IPCC Guidelines give a default value of 95 % for the first-year loss. The annual loss is given as 2.5 %, with the result that emissions occur over three years.

According to the in-country experts consulted, all of the blowing agent – except for small residual quantities – escapes during the blowing process. The small residual quantities are then emitted over a period of no longer than two years. For this reason, in a departure from the IPCC Guidelines, Germany considers an emission factor of 100 % to be suitable for production.

Activity data

The figures for new domestic consumption, for each blowing agent and each product group, are based on the amounts of integral foam products produced in Germany.

The new domestic consumption is determined annually via surveys of manufacturers, users and blowing-agent suppliers, and via information from the relevant industry association (IVPU – the polyurethane-foam industry association).

4.7.2.4 Open-cell one-component polyurethane foam (2.F.2 one-component PU foam)

4.7.2.4.1 Category description (2.F.2 one-component PU foam)

The term "one-component foam" refers to open-cell polyurethane foam (PU foam) that is sprayed, on site, from pressurised containers (cans). Such foam is used, for example, in installation of windows and doorframes. The blowing agents now used for such foam, following the prohibition of HCFCs, include mixtures of HFCs and propane, butane or dimethyl ether (DME). At the same time, the HFC quantities in such cans have been continually reduced since 1996.

HFC-134a has been used in Germany since 1992, in production of PU one-component foam (in cans). HFC-152a was used from 2002 to 2004. Imported cans of PU foam sealant used in Germany contain HFC-134a (since 1992) or HFC-152a (since 1995).

Emissions from PU one-component foams increased sharply from 1992 through 1997. Thereafter, they decreased continuously, until 2010. Since then, they have remained at a low, relatively constant level. Since 4 July 2008, a ban has been in force in the EU, with a few permitted exceptions, on sale of one-component-foam products filled with fluorinated greenhouse gases with a global warming potential (GWP) greater than 150. For that reason, future emissions can be expected to remain relatively constant, at low levels.

4.7.2.4.2 Methodological aspects (2.F.2 one-component PU foam)

The production emissions are calculated from the number of cans filled per year in Germany and the blowing-agent loss per can.

Pursuant to the 2006 IPCC Guidelines (page 7.34, equation 7.8), the emissions in this open application are considered to be the same as the HFC quantity sold in the relevant cans. Emissions from use are calculated, with Equation 2, via the HFC quantities sold in cans.

No disposal emissions occur, since all of the HFCs in cans of one-component foam are emitted when the cans are used.

Emission factors

The emission factors used are shown in Table 194.

The $EF_{\text{production}}$ was determined via surveys of experts and of manufacturers. From 1992 to 2002, it amounted to 1.5 g/can, while since 2003 it has been only 0.5 g/can, since the total fill quantities in cans have decreased.

The 2006 IPCC Guidelines, in Vol. 3, table 7.6, give a first-year loss of 95 % and an annual loss of 2.5 % for one-component foams, with the result that the relevant emissions are distributed over a total of three years in each case. In contrast to the IPCC method, for the German inventory, it is assumed that all emissions occur in the year of sale ($EF_{\text{use}} = 100 \%$), since use and disposal occur promptly. At the same time, used cans are not completely empty when they go to waste management; they still contain about 8 % of their original foam contents, including the relevant blowing agent. The majority of that blowing agent eventually also enters the atmosphere, after a certain delay.

Activity data

The data required for determination of losses from charging (production emissions) – the numbers of cans filled annually in Germany with HFC-134a or HFC-152a; the quantity of HFC per can, in grams; and the specific loss from charging – are obtained via surveys of experts and from information provided by manufacturers.

The data required for determination of the emissions from use – the numbers of cans sold annually in Germany with the propellants HFC-134a or HFC-152a, and the HFC quantity per can, in grams – are obtained from the manufacturers of spray cans with one-component-foam.

The pre-1995 data for foam sealants were obtained via discussion, in 2006, with leading foreign sellers of one-component foam products and from older publications.

4.7.2.5 Uncertainties and time-series consistency (2.F.2 all)

The uncertainties for the "foams" sub-category have been systematically quantified.

The emissions data for prior years, for PU foam products, are considered fairly accurate, since the quantities of HFCs used are still rather small at present. In future, however, it will become more difficult to obtain a good market overview in view of the anticipated product diversity.

Because it includes only a small number of manufacturers, the German XPS market is not complex. Since the EF and AD were prepared in co-operation with manufacturers, they are considered sufficiently precise.

Since 2001, the relevant industry association has determined, via research, the input quantities of HFC-152a and HFC-134a in production of XPS hard foams. Since 2006, data collected pursuant to the Environmental Statistics Act (Umweltstatistikgesetz) have also been available. Since only three manufacturers use HFC for XPS blowing, there is little reason to doubt the reliability of the activity data. This also applies to the export rate and the HFC production emissions determined for use of HFC-134a.

The production emissions in use of HFC-152a, 100 %, do not agree with the existing IPCC estimates. Nonetheless, the industry association considers them to be realistic.

The value for the emissions rate from current stocks, as determined by a laboratory study, will be used as long as no reliable measurements with insulation boards in actual service have been carried out; such measurements would be considered more conclusive than laboratory values.

4.7.2.6 Category-specific recalculations (2.F.2 all)

The figure for domestic consumption of HFC-152a for production of XPS hard foam, for the year 2014, was corrected on the basis of data collected pursuant to the Environmental Statistics Act (data which did not become available until December 2015). For reasons of confidentiality (there is only one manufacturer of XPS insulating boards produced with HFC-152a), the applicable emissions change in 2014 is not quantified in this context.

4.7.2.7 Planned improvements, category-specific (2.F.2 all)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.7.3 Fire extinguishers (2.F.3)

4.7.3.1 Category description (2.F.3)

Halons, which until 1991 were permitted fire extinguishing agents, have since been largely supplanted by ecologically safe substances – especially inert gases, such as nitrogen and argon, for systems for flooding rooms; and by powder, CO₂ and foams in handheld fire extinguishers.

In 1998, HFC-227ea was certified in Germany as a halon substitute. In 2001, HFC 236fa also received such certification. That substance is used solely in the military sector, however. HFC-23, while certified since 2002, did not begin to be used until 2005. Today, certification of fire extinguishing agents is no longer required. Nonetheless, the list of fire extinguishing agents in use has not grown, since all application areas can be covered with halogen-free agents and with the aforementioned HFCs (especially 227ea and 236fa).

HFC-based fire extinguishing agents are imported and filled into fire extinguishing systems in Germany. Virtually no foreign trade with filled systems takes place. The time series do not begin until after 1995.

4.7.3.2 Methodological issues (2.F.3)

The annual new HFC additions in domestic systems are identical with the amounts added to new systems within the country (new HFC consumption).

Since activity data are available in Germany for HFC-227ea and 236fa, a bottom-up approach is used. Unlike the top-down approach of the 2006 IPCC Guidelines (Vol. 3, Chapter 7.6), the bottom-up approach takes emissions from charging into account.

Due to a lack of pertinent data, the installed quantities of HFC-23 are estimated by the Federal Environment Agency. As of report year 2015, it has been assumed that, as a result of the provisions of Regulation (EU) 517/2014, no further new systems have been installed.

The figure used for the average lifetime of fire extinguishing systems has been increased from 15 years (2006 IPCC Guidelines: Vol. 3, Table 7.9) to 20 years, in keeping with a consensus of experts.

Emission factors

The EF_{production} are based on experts' assessments.

For HFC-236a, the EF_{production}, according to experts' assessments, has to increase from 1 % to 4 % by the year 2007, in order to take account of the greater probability of leaks in older systems. The 4 % figure conforms to the 2006 IPCC Guidelines. The emission factor for use of HFC-23 has also

been set at 4 %. With regard to HFC-227ea, concrete figures are available relative to installed and refilled quantities. They were obtained via up-scaling from the pertinent company's market share (as estimated by the company) to the German market as a whole.

The emission factor for disposal is 100 % for all HFCs, although it must be noted that no disposal has yet occurred.

Activity data

The emission figures for HFC 227ea are based on statistical surveys by one company, covering the aspects of input quantities, refill quantities, accidental releases, releases in cases of fire, and flooding tests in Germany (by analogy to Tier 2). Up-scaling was carried out on the basis of the market shares estimated by the company. The data for HFC-236fa are based on company information provided on a voluntary basis. The figures for HFC-23 are based on estimates of the Federal Environment Agency.

4.7.3.3 Uncertainties and time-series consistency (2.F.3)

The uncertainties for the "fire extinguishing agents" sub-category have been systematically quantified.

4.7.3.4 Category-specific recalculations (2.F.3)

No recalculations are required.

4.7.3.5 Planned improvements, category-specific (2.F.3)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.7.4 Aerosols (2.F.4)

This area includes metered-dose inhalers (MDI), which are used in medical applications, as well as general-purpose aerosols and so-called "novelty aerosols".

4.7.4.1 Metered-dose inhalers (2.F.4.a)

4.7.4.1.1 Category description (2.F.4.a)

Metered-dose inhalers are used in the medical sector, primarily for treatment of asthma. Metered-dose inhalers with an HFC propellant first reached the German market in 1996. They contained the propellant HFC-134a. Beginning 1999, metered dose inhalers with the propellant HFC-227ea were also sold. Since then, the number of available preparations has grown continually. Charging of inhalers with HFC-134a has taken place in Germany since 2001.

From 1996 through 2002, the time series shows a sharp emissions increase that correlates with increasing use of HFCs as CFC substitutes. A large change occurred in 2001. As of that year, CFCs were prohibited for the largest group of active ingredients, the short-acting betamimetics. Since 2003, the emissions have remained at a relatively constant high level.

4.7.4.1.2 Methodological issues (2.F.4.a)

Since 98 % of the contents of metered dose inhalers consist of propellant, their contents are considered to consist solely of HFCs.

The production emissions are calculated from the number of metered dose inhalers charged per year in Germany and the propellant loss per can. Part of the propellant emissions are collected with cold traps and then incinerated. Without such collection, the emissions would be higher.

Emissions from use are calculated, with Equation 2, via the HFC quantities sold in metered dose inhalers. The great majority of metered dose inhalers used in Germany are sold in pharmacies. An estimated 10 percent are used by hospitals, for their own needs, while 3 percent are samples, "not for sale", for doctors and pharmaceutical representatives. These two shares are taken into account by adding 13 % to sales by pharmacies.

The time period between pharmacy sales and use is short. The reference figure for the emissions from use – in contrast to the recommendation in the 2006 IPCC Guidelines (Vol. 3, Equation 7.6) – is thus not the sum of half the purchases (sales) of the previous year and half the purchases (sales) of the current year, but all purchases (sales) for the current year. The approach in the IPCC Guidelines would be a useful choice if the available data covered produced inhalers – rather than sold inhalers – since considerable time, for transport and storage, indeed can pass between production and use.

No disposal emissions occur, since all of the HFCs in metered dose inhalers are emitted when the cans are used.

Emission factors

The emission factors used are shown in Table 194.

The $EF_{\text{production}}$ on which production-emissions data are based is itself based on very precise determination of charging emissions, in actual operations, by the only German company that charges such inhalers. These amount to about 1 %, with respect to new consumption for charging. This translates to about 0.15 g per 10 ml inhaler.

In agreement with IPCC specifications (2006 IPCC Guidelines, Vol. 3, p. 7.28), a 100 % emissions level in use ($EF_{\text{use}} = 1$) is assumed. Inhaled HFCs are not broken down in bronchial passages; they are released into the atmosphere, without undergoing any changes, upon exhalation. In a departure from the Guidelines, Germany uses a lifetime of only one year for metered dose inhalers. The emission factor has thus been classified as "country-specific".

Activity data

The emissions data for the period until reporting years 2005 (production) and 2006 (use) are based on sales figures (sales in pharmacies) for metered-dose inhalers in Germany, as obtained via surveys of producers. The total unit numbers, the average fill quantity in ml and the propellant used have all entered into relevant calculations. As of report year 2006, the activity data for production are based on experts' estimates. As of report year 2007, the activity data for use are also based on such estimates. In the category "metered dose inhalers", the results of the *Federal Statistical Office's* annual surveys of certain climate-relevant substances normally do not become available on time for the corresponding current report year. Retroactive data cross-checking is carried out when necessary, however.

4.7.4.2 Other aerosols (2.F.4.b)

4.7.4.2.1 Category description (2.F.4.b)

In Germany, six types of general-purpose aerosols (includes neither medical metered dose inhalers nor novelties) containing HFC are sold:

- Compressed-air sprays,

- Cooling sprays,
- Drain-opener sprays,
- Lubricating sprays,
- Insecticides, and
- Self-defence sprays.

Production and use of general-purpose aerosols with HFC-134a began in 1992; production and use of such aerosols with HFC-152a began in 1995. Since 2013, HFC-1234ze has also been used as a propellant in cooling sprays and cleaning sprays. From 1992 through 1996, the time series shows a sharp emissions increase that correlates with increasing use of HFCs as CFC substitutes. The emissions remained at a constant level between 1996 and 2005. The emissions then jumped sharply in 2007. Since then, emissions from general-purpose aerosols have been decreasing slightly.

Other aerosols include "novelty" aerosols (artificial snow, "silly string", etc.). Such products are not produced in Germany, however. Use of novelty sprays with HFC-134a began in 1995, while use of sprays with HFC-152a began in 2000. As of 2004, the emissions from such sprays decreased sharply. Since 2010, they have remained at a constant low level. That trend is the result of a EU ban, in force as of 4 July 2009, on sale of novelty aerosols filled with hydrofluorocarbons (HFCs) with a Global Warming Potential (GWP) greater than 150. Producers were quick to respond by choosing other propellants for their products.

4.7.4.2.2 Methodological issues (2.F.4.b)

In the case of general-purpose aerosols, imports and exports are roughly in balance, and thus the domestic market can be considered equivalent to consumption for domestic filling. Domestic consumption refers to spray cans filled in Germany, regardless of where the cans are ultimately used. The production emissions are calculated, pursuant to Equation 1, from the HFC consumption for in-country filling of general-purpose aerosols and the propellant loss in production.

No novelty aerosols are produced in Germany. The basis for calculating the HFC quantities sold in novelty-aerosol cans consists of the German market's share of the EU market.

Emissions from use are calculated, using Equation 2, via the HFC quantities sold in "other aerosols".

Since the calculations are oriented to the numbers of aerosol cans sold – and not to the numbers produced – the average time period between the sale and use of such cans may be assumed to be very short. The reference figure for calculating the emissions from use – in contrast to the recommendation in the 2006 IPCC Guidelines (Vol. 3, Equation 7.6) – is thus not the sum of half the purchases (sales) of the previous year and half the purchases (sales) of the current year, but all purchases (sales) for the current year.

Since the HFCs contained in such aerosols are emitted completely when the aerosols are used, no disposal emissions have to be reported.

HFC-1234ze is not subject to reporting obligations. Germany voluntarily reports emissions of this substance pursuant to the recommendations of the 2014 UNFCCC Reporting Guidelines (FCCC/CP/2013/10/Add.3, Decision 24/CP.19), under "additional greenhouse gases". For reasons of confidentiality, the HFC-1234yf emissions are aggregated with other emissions that are not subject to reporting obligations and are reported in Chapter 4.9.3 under CRF 2.H.3.

Emission factors

The $EF_{\text{production}} = 1.5 \%$ on which production-emissions data for other aerosols are based is itself based on experts' assessments.

A 100 % emissions level in use of other aerosols ($EF_{\text{use}} = 1$) is assumed. This assumption is appropriate, and it accords with IPCC specifications (2006 IPCC Guidelines, Vol. 3, p. 7.28). In a departure from the Guidelines' relevant proposal, it is assumed that all of the cans sold in Germany are used completely in the same year in which they are sold. The emission factor has thus been classified as "country-specific".

Activity data

The data for the period prior to 1995 are based on estimates of experts. In keeping with a bottom-up approach, all quantity data as of 1995 are provided directly by producers, fillers and operators, propellant manufacturers and the relevant industry association. Emissions data for general-purpose aerosols also include filling emissions (= production emissions). Estimates are based on EU-wide data.

4.7.4.3 Uncertainties and time-series consistency (2.F.4 all)

The uncertainties for the "aerosols" sub-category have been systematically quantified.

In the case of metered dose inhalers, the surcharge factor for hospitals and doctors' samples can vary, by $\pm 3 \%$, from the above-cited 13%.

In comparison to the emissions data for metered dose inhalers, the data for other aerosols are considered to be not as good, since the large number of products involved makes it difficult to obtain an overview of the market. Large quantities of imports, especially in the area of "novelties", also complicate the situation. The uncertainties are thus considerably higher (more than 20 %).

Since the shift from CFCs to chlorine-free propellants had already been completed by the beginning of the 1990s, the time series for the period 1995-2005 showed virtually no changes. Slight emissions decreases have been seen since 2006.

4.7.4.3.1 Category-specific recalculations (2.F.4 all)

No recalculations are required.

4.7.4.3.2 Planned improvements, category-specific (2.F.4 all)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.7.5 Solvents (2.F.5)

4.7.5.1 Category description (2.F.5)

Use of HFCs as solvents was banned in Germany until the year 2001 (2nd Ordinance on the Implementation of the Federal Immission Control Act – 2. BimSchV) and remains heavily restricted to this day. A separate permit has to be applied for for every surface-treatment facility that uses HFCs either in a pure form or in mixtures with trans-1,2-dichloroethene, and such permits are granted only in special cases. In addition to HFC-43-10mee, which has already been reported, the following substances are now also used, in very small quantities: HFC-365mfc (since 2013), and C_6F_{14} (since 2006). HFC-245fa was used only from 2010 through 2014. Usage, in terms

of quantity, of C₆F₁₄ is decreasing. Usage, in terms of quantity, of HFC-43-10mee and HFC-365mfc is either constant or slightly increasing.

In addition, hydrofluoroethers (HFE) are also used, in various applications. Emissions of the HFE involved (HFE-7100/7200/7300) are not subject to reporting obligations. Germany voluntarily reports HFE emissions pursuant to the recommendations of the 2014 UNFCCC Reporting Guidelines (FCCC/CP/2013/10/Add.3, Decision 24/CP.19), under "additional greenhouse gases". The emissions are aggregated with other emissions that are not subject to reporting obligations, and they are listed in Chapter 4.9.3 under CRF 2.H.3.

4.7.5.2 Methodological issues (2.F.5)

Emissions are calculated in keeping with Tier 2a as described in the 2006 IPCC Guidelines (Vol. 3, Chapter 7.2).

Emission factors

Emissions in use are assumed to be completed within 2 years. For HFE, an emission factor of 100 % is assumed.

Activity data

The consumption figures for HFC-43-10mee are based on the sales data of an authorised dealer. The quantities of HFC-245fa, HFC-365mfc, C₆F₁₄ and HFE used are based on information provided by industry experts. Since the data are confidential, they are reported under CRF 2.H.

4.7.5.3 Uncertainties and time-series consistency (2.F.5)

All of the uncertainties for the sub-category *solvents* have been identified.

4.7.5.4 Category-specific recalculations (2.F.5)

No recalculations have been carried out.

4.7.5.5 Planned improvements, category-specific (2.F.5)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.7.6 Other applications that use ODS substitutes (2.F.6)

Germany reports no emissions in this category.

4.7.7 Category-specific QA/QC and verification (2.F all)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The data for the 2003 report year, like the data for most of the previous years, were collected by an external expert working in the framework of a research project under commission to the Federal Environment Agency.

For the most part, quality assurance was carried out by an external expert. In addition, the data are checked by the relevant Federal Environment Agency specialists upon receipt.

In 2011, the entire sector of F-gas emissions was subjected to voluntary trilateral review. Experts from England, Germany and Austria reviewed "each other's" F-gas inventories. The aims of the review were to exchange information regarding country-specific methods for preparing F-gas inventories; to learn about the institutional and legal regulations for F-gas inventories in each country; to identify obstacles for the preparation of complete, precise inventories; and to discuss differences and similarities between the various methods used to prepare F-gas inventories. The meeting helped all three countries to review their methods for relevant emission calculation. In addition, the transparency, completeness and precision of the various inventories were assessed. That review had a positive outcome, namely that Germany has a good F-gas inventory. As a result, no recommendations were issued for improvements of the German F-gas inventory.

4.8 Other product manufacture and use (2.G)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	2.G. Other product manufacture and use		HFCs	C	C	C	C	---
L/T	2.G. Other product manufacture and use		SF₆	C	C	C	C	-43.7%
-/-	2.G. Other product manufacture and use		CH ₄	4.5	0.00%	36.5	0.00%	706.4%
-/-	2.G. Other product manufacture and use		PFCs	0.0	0.00%	20.8	0.00%	---
-/T	2.G. Other product manufacture and use	Other N-Dodecanedioic acid⁷⁸	N₂O	2,029.5	0.17%	392.7	0.04%	-80.7%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂ , CH ₄ , N ₂ O, SF ₆ , PFC, HFC	cf. Table 196	cf. Table 196	cf. Table 196

The category *Other product manufacture and use* is a key category for SF₆ emissions in terms of level and trend. For N₂O emissions, it is a key category only in terms of trend.

The category 2.G includes SF₆ from electrical equipments (2.G.1), SF₆ and PFC from other product use (2.G.2), use of N₂O (2.G.3), other ORC systems (2.G.4 ORC) and CO₂, CH₄, N₂O and particulate emissions from use of charcoal (2.G.4 Charcoal). With regard to use of cigarettes (2.G.4) and fireworks (2.G.4), emissions of particulates, precursor substances and heavy metals are reported. In the interest of more-precise data collection, these sub-categories are further divided, to some extent, in the following section.

The methods, emission factors and applicable lifetimes on which the emission calculation is based are listed in Table 194.

⁷⁸ includes 2.B.10.

Table 196: Overview of the methods and emission factors used, for the current report year, in the categories 2.G.1 (Electrical equipments), 2.G.2 (SF₆ and PFC from other product use) and 2.G.4 (ORC systems & charcoal use)

	QG	Method	Gas			Lifetime	Emission factor (dimensionless)		
			SF ₆	HFC	PFC	[years]	Production	Application	Waste management
Electrical equipments	2.G.1								
Switchgear and controlgear	2.G.1a	Tier 3	SF ₆				0.02 (CS)	0.001 – 0.01 (CS)	0.015 (CS)
SF ₆ and PFC from other product use	2.G.2								
AWACS	2.G.2a	CS	SF ₆				NO	C	NO
Particle accelerators	2.G.2b	CS					0.15 - 1 (CS)	0.006 – 0.003 (CS)	NO
Insulated glass windows	2.G.2c	Equ. 3.24 ff					0.33 (D)	0.01 (D)	1 (D)
Adiabatic behaviour	2.G.2d								
- Automobile tyres		Equ. 3.23	SF ₆				NO	NO	1 (D)
- Athletic shoes		Equ. 3.23	SF ₆		PFC		NO	NO	1 (D)
Other	2.G.2e								
- Trace gases		Equ. 3.22	SF ₆				NO	1 (D)	NO
- Welding		CS	SF ₆				NO	1 (CS)	NO
- Optical glass fibre		CS	SF ₆				0.7 (CS)	NO	NO
- Medicines and cosmetics		CS			PFC	-	NO	1 (CS) 0.95 – 0.998 (CS)	NO
Semiconductor manufacturing		D					C		
Narcotic applications		D						1	
Explosives		D						0.1036 kg/t	
Spray cans		D						1	
Other	2.G.4								
ORC systems	2.G.4a	CS		HFC	PFC	20 – 30 (CS)	0.02 (CS)	0.04 (CS)	0.2 (CS)
Charcoal use	2.G.4b	Tier 1	CO ₂ -, CH ₄ -, N ₂ O- and particulates				C	C	

4.8.1 Electrical equipments (2.G.1)

This category consists primarily of use of electrical equipments (2.G.1), which is further subdivided into high-voltage (HS – Hochspannungs-), medium-voltage (MS – Mittelspannungs-) and other electrical equipments.

4.8.1.1 Category description (2.G.1)

In electricity transmission and distribution, SF₆ is used primarily in switchgear and controlgear and equipment in high-voltage (52-380 kV) and, increasingly, medium-voltage (10-52 kV) networks. It serves as an arc-extinguishing and insulation medium (in the latter function, in place of air). In addition, it is used in production of components installed in gas-insulated indoor switchgear and controlgear (instrument transformers, bushings) or supplied directly to operators (high-voltage instrument transformers for outdoor installations).

As a result of first-time inclusion, in report year 2002, of additional SF₆ applications, the time series shows a marked jump in emissions in 2002. In report year 2005, new companies were included in reporting, especially in the new category "Other electrical equipments." For reasons having to do with the economy as a whole, more systems were sold in 2005 and 2006. Nonetheless, absolute emissions are falling overall, due to considerable reductions in the area of "other" equipments and as a result of again-lower emissions rates in switchgear and controlgear. In 1996, industry, represented by producers' and operators' associations and the SF₆ producer, committed itself to reducing emissions in life cycles of switchgear and controlgear and to provide annual progress reports. In 2005, this voluntary commitment was extended, in co-operation with the

Federal Environment Agency and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), to include additional energy-transmission and energy-distribution installations above the 1 kV level. In addition, specific reduction targets were added to the commitment. The scope of voluntary reporting was enlarged and refined accordingly. In subsequent years, manufacturers and the gas producer made further investments in reduction measures. Substitutes for SF₆ foams were introduced in some sub-areas of bushings. This brought about further reductions in specific emissions rates and absolute emissions, even though production continued to increase.

4.8.1.2 Methodological issues (2.G.1)

The emissions figures are based largely on a mass balance. Increasingly, they are also being combined with emission factors for sub-areas in which the technical measurement limits for mass-balancing have been reached or in which mass-balancing would necessitate unreasonably high costs.

The methods used are based on the new "2006 IPCC Guidelines for National Greenhouse Gas Inventories; Volume 3", Chapter 8. For further information, the reader is referred to "Tier 3, Hybrid Life-Cycle Approach" in sub-chapter 8.2.

Usage emissions

Ongoing emissions from products in service include the amount of SF₆ in service, as accumulated since 1970 via annual additions of switchgear and controlgear; they are given as the average for year n.

The final amount of SF₆ in all electrical equipments for a given year n changes annually by the balance of new additions and removals. Some removals (high voltage) have been registered since 1997; large-scale removals of first-generation high-voltage switchgear and controlgear and equipment cannot be expected until after 2015, in light of the products' estimated service lifetime of at least 40 years.

Three special aspects must be taken into account in reporting relative to switchgear and controlgear:

- Calculation of the final stocks for a given year n is based on the final stocks for the previous year (n-1); this does not extend back to the first year of service, however. Such backward extension, an otherwise customary procedure, is not used for switchgear and controlgear, because operators/manufacturers estimated the SF₆ stocks in service for 1995. Their estimate was broken down into high-voltage and medium-voltage categories (770 t and 157.6 t, respectively).
- In the area of high-voltage switchgear and controlgear, stocks and emissions are determined via direct surveys of the some 100 operators. In such surveys, the operators are asked to provide data on their current stocks of SF₆ in electrical equipments (gas-insulated HV switchgear (GIS), circuit breakers, outdoor instrument transformers). Emission factors determined on the basis of reference systems are then applied to such stocks data.

- The group of operators of medium-voltage switchgear is very numerous and highly diverse. It is thus not feasible to conduct direct surveys. Manufacturers of medium-voltage switchgear have themselves taken responsibility for updating their domestic stock data on the basis of their sales data. The emissions can be determined in that the systems are practically maintenance-free and, by definition (IEC 62271-1), require no refilling throughout their entire lifetimes. The emissions are minimal (usually, they occur only as a result of external influences), and they can be accounted for via a lump-sum emission factor (resulting from survey of experts): the emissions rate has been set at a constant 0.1 % since 1998, since virtually all of the systems added to domestic stocks since the mid-1990s are systems that are "sealed for life" (hermetically sealed pressurised systems pursuant to IEC). In their voluntary commitment of 2005, the operators also promised to use only such systems. As a result, the impact of the few older systems that have emissions rates greater than 0.1 % has diminished. The stocks are calculated on the basis of the previous year's stocks, plus new deliveries and less decommissioned systems.

Disposal emissions

Because switchgear and controlgear have long service lifetimes (40 years), and because the first use of SF₆ dates from the late 1960s, disposal emissions were very low until 2004. For the period until 2004, therefore, the quantities of SF₆ (AD), in old switchgear and controlgear (high-voltage and medium-voltage), that were slated for disposal have been roughly estimated (at a constant 3 t/a). As of the 2005 report year, amounts for disposal from systems removal were determined precisely for the first time, by the relevant associations. This also applies to emissions from disposal, which prior to 2005 were estimated at 0.06 t.

Activity data

In the framework of the manufacturers' voluntary commitment, annual consumption by manufacturers of electrical equipments, and stocks of medium-voltage switchgear and controlgear, are reported to the Federal Environment Agency by the German Electrical and Electronic Manufacturers' Association (ZVEI), while stocks of high-voltage switchgear and controlgear, outdoor-mounted instrument transformers, gas-insulated lines and transformers are reported by the Forum network technology / network operation (FNN) in the Association for Electrical, Electronic & Information Technologies (VDE) and, since 2004, by the Association of the Energy and Power Generation Industry (VIK). Participants in the voluntary commitment jointly determine quantities of decommissioned units.

Table 197 shows the inventory data for the current year, broken down by sub-categories and with explanatory remarks. The sum total for electrical equipments for energy transmission and distribution agrees with the data in Table 2 (II)F, Sheet 2, category 2.G.1 in the CRF.

Table 197: 2015 inventory data for category 2.G.1, including relevant sub-categories

Category 2.G.1: Electrical equipments for energy transmission and distribution	Activity data			Emissions	
	Annual consumption , production	Stocks	Decommissioned (tonnes of SF ₆)	Production	Operation
Electrical equipments for energy transmission and distribution 2.G.1 (total), including:	910	2546	5.8	10.7	6.5
MV switchgear and controlgear *	168	1144	0.8	0.4	1.1
HV switchgear and controlgear **	684	1142	5.0	3.5	4.6
Other electrical equipments ***	57	259	0	6.9	0.7

IE= included in "HV switchgear and controlgear; marginal

Explanatory remarks:

- * Hermetically sealed pressurised systems pursuant to IEC 62271-1 for the range 1kV through 52 kV; also known as "sealed for life" systems
- ** Sealed pressurised systems pursuant to IEC 62271-1 for the range above 52 kV
- *** Gas-insulated transformers: marginal residual stocks in the network; (no production emissions) + high-voltage instrument transformers for outdoor installation (all emissions categories) + gas-insulated lines (GIL) (all emissions categories) + high-voltage bushings (only production emissions) + medium-voltage cast-resin instrument transformers (only production emissions) + testing of medium-voltage components (only production emissions) + 1000V capacitors (only production emissions)

4.8.1.3 Uncertainties and time-series consistency (2.G.1)

Since there are only about ten different manufacturers of electrical equipments (including bushings and instrument transformers), the consumption data, and the new-additions and decommissioned-units figures, are highly reliable. This holds all the more in that such data and figures are based on internal accounting, and that fill amounts are determined with great precision and then noted on devices' name plates. The pertinent uncertainty is in the area of ± 5 %.

Determination of emissions is more difficult, since the plants typically concerned have several different emissions sources, each quite small. Gas losses occur in filling of devices, in testing, in opening of products that fail to pass quality inspections, in product development, etc.. On the other hand, all domestic plants proceed in accordance with a standardised questionnaire that lists all possible emissions sources and that is checked for correctness during surveys. For this reason, and because there are few manufacturers (see above), the precision of data collection ultimately depends on the precision of the relevant measurements. The resulting figures lie within ± 10 % of estimates.

Emissions from operations in the high-voltage sector are determined by selected operators, via monitoring of annual refilling of reference systems (refills are carried out when levels fall below 90 % of the desired charge, and the devices themselves normally display such fill requirements as soon as they occur). This method can be considered very reliable, i.e. the deviations from the actual value are about ± 5 %. All surveys to date have produced similar results for emissions rates; all results are within a range from 0.55 to 0.88 %. The one-time emissions-rate peak for high-voltage switchgear and controlgear that occurred in 2004 is the result of special events. In the main, it was due to simultaneous refilling of old, older-model systems that were less well-sealed.

In the year 2000, a decrease with respect to the previous year occurred in high-voltage in-service stocks and, thus, in emissions, both of which had been increasing since 1995. For in-service stocks,

the decrease amounted to over 25 t, while for emissions it amounted to 0.85 t. That decrease, which was due to trends in gas-insulated HV switchgear (GIS) (600 to 567 t), cannot be explained as the result of decommissioning removals, since the role of such removals is still insignificant. According to the association of network operators (VDN), which carried out the surveys at the time, the underlying problem is both statistical and organisational in nature. At the end of the 1990s, electricity-market liberalisation led to profound operator regrouping (through mergers and changes in ownership of various parts of companies). Along with those changes, personnel assignments relative to electrical equipments in service were repeatedly changed. As a result, it is possible that double-counting occurred in 1999, and that some operating equipment was not counted in 2000. In light of experience gained in recent years, the uncertainty today can be assumed to lie in the range of $\pm 5\%$ for high-voltage stocks.

Pursuant to the IEC, the emissions rate of 0.1 % in the medium-voltage sector is a normal rate for hermetically sealed pressurised systems.

4.8.1.4 Category-specific recalculations (2.G.1)

No recalculations have been carried out.

4.8.1.5 Category-specific quality assurance / control and verification (2.G.1)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The data for the 2003 report year, like the data for most of the previous years, were collected by an external expert working in the framework of a research project under commission to the Federal Environment Agency.

For the most part, quality assurance was carried out by an external expert. In addition, the data are checked by the relevant Federal Environment Agency specialists upon receipt.

In 2011, the entire sector of F-gas emissions was subjected to voluntary trilateral review. Experts from England, Germany and Austria reviewed "each other's" F-gas inventories. The aims of the review were to exchange information regarding country-specific methods for preparing F-gas inventories; to learn about the institutional and legal regulations for F-gas inventories in each country; to identify obstacles for the preparation of complete, precise inventories; and to discuss differences and similarities between the various methods used to prepare F-gas inventories. The meeting helped all three countries to review their methods for relevant emission calculation. In addition, the transparency, completeness and precision of the various inventories were assessed. That review had a positive outcome, namely that Germany has a good F-gas inventory. As a result, no recommendations were issued for improvements of the German F-gas inventory.

4.8.1.6 Planned improvements, category-specific (2.G.1)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.8.2 SF₆ and PFC from other product use (2.G.2)

This category comprises the applications *Military AWACS* (2.G.2.a), *Particle accelerators* (2.G.2.b), *Sound-proof glazing* (2.G.2.c), *Adiabatic properties: Automobile tyres* and *athletic shoes* (2.G.2.d), *Other: Trace gas, welding, optical glass fibres* and medical and cosmetic applications (2.G.2.e).

4.8.2.1 Military AWACS maintenance (2.G.2.a)**4.8.2.1.1 Category description (2.G.2.a)**

SF₆ is used as an insulating medium for radar in Boeing E-3A (NAEWF; formerly, AWACS) aircraft, which are large military surveillance aircraft. It is used to prevent electrical arcing, towards the antenna, in waveguides with high voltages in excess of 135 kV. Ongoing emissions are relatively high, since SF₆ is released to equalize pressure as aircraft climb.

4.8.2.1.2 Methodological issues (2.G.2.a)

The emissions data for report years until 2001 are based on estimates that are themselves based on a survey from the year 1996. For this reason, the precision of the emissions data for the years 1997 to 2001 is lower than it is in subsequent years. For report year 2002, a new survey of consumed quantities was carried out. This showed a significant increase over relevant quantities in report year 2001. As of report year 2006, the quantities used are determined by the Federal Statistical Office, via surveys. The pertinent quantities are added to aircraft, in Germany.

To date, 50% of the SF₆ emissions of AWACS aircraft have been applied to Germany. This year, an emission factor of 100% of consumption is being assumed. A recalculation on this basis, covering the period back through 1990, has been carried out.

The pertinent emissions have been decreasing in recent years.

Data on AWACS maintenance are reported under CRF 2.H.3, since the data are confidential.

4.8.2.2 Particle accelerators (2.G.2.b)**4.8.2.2.1 Category description (2.G.2.b)**

The insulating gas SF₆ is used to protect human safety and to safeguard equipment parts (to guard against burning of insulators). In relevant applications, high-voltage parts are insulated by being enveloped with the gas (which guards against electrical arc flashes between high-voltage parts and equipment walls).

In some cases, such protection can also be achieved by using other gases (such as nitrogen, nitrogen/CO₂ mixtures), by providing adequate physical distance (air insulation) or by enclosing equipment in concrete walls. The criteria entering into decisions for or against SF₆ as an insulating gas for equipment (either by itself or as an additive) include technical circumstances, design considerations and voltage levels. For this reason, the quantities of SF₆ that non-standardised equipment and components require will vary. The SF₆ charge in any given unit or system thus depends on the unit's/system's setup, and not on its size class (measured in MV, for example).

The SF₆-insulated particle accelerators in use differ in terms of size, design and function. High-voltage accelerator systems (0.3 to more than 23 MV) are used by university institutes, research groups and industry. In such high-voltage systems, the accelerator and the high-voltage source (Van de Graaff generator, or a more-compact high-voltage generator with cascaded diodes) sit within a tank that is insulated with SF₆ or an SF₆-containing mixture. In some cases, such tanks are also pressurised. Such tanks often have to be opened when equipment has to be adjusted or repaired. In such cases, the insulating gas is pumped into reserve tanks. SF₆ losses occur during such pumping, and they occur whenever overpressure valves of accelerator or reserve tanks are activated. Research accelerators, which are operated under varying conditions, have to be opened more frequently than industrially used electron accelerators do.

In industry, low-voltage devices with less than 0.3 MV are also used. In low-voltage systems, the depth to which electrons penetrate materials being processed is considerably lower than the

depths occurring in connection with high-voltage systems. In industry, "electron-beam tools" are used for cross-linking of polymers, primarily polymers in cable and wire insulation. Low-voltage systems, with lower accelerator voltages, require less shielding (= smaller quantities of SF₆) than high-voltage systems do.

Yet another relevant category consists of radiation-therapy devices in medical facilities. In cancer treatments with electron or photon radiation, industrially pre-set particle accelerators are used. Such accelerators accelerate particles within waveguides that are filled with the insulating gas SF₆, which guards against electrical flashovers. Prior to 1996, CFCs were used in such equipment.

SF₆ is also used as an insulating gas in large electron microscopes (with accelerator voltages >100 kV) and in electron-beam lithography systems. Such devices, which are combined within the category "other equipment, have now been covered for the first time – for the year 2010.

In general, the following applies: The SF₆ consumption tied to initial charging and recharging of equipment, and to replacements of emission, depends on equipment size, pressure conditions and operating conditions.

4.8.2.2.2 Methodological issues (2.G.2.b)

In early 2004, Öko-Recherche, working under commission to the Federal Environment Agency, carried out a complete survey of particle accelerators within the country, with the aim of updating pertinent data, some of which date from 1996. In the process, both users and producers of the devices/systems were queried. The questions posed had to do with the quantities of SF₆ in their devices and with refills of SF₆ carried out during the last seven years.

The CSE assumes responsibility for structuring the survey. For all five relevant categories, it contains annual data on SF₆ stocks and on replacements to compensate for emissions. The emissions in question include both ongoing emissions and filling and disposal losses.

For the 2011 report year, another exhaustive survey was carried out. For the first time, data on electron microscopes were gathered. (SCHWARZ et al., n.y.) Only small numbers of equipment changes – additions or removals, depending on the application – were seen. For this reason, constant levels of usage are assumed. Radiation therapy is an exception. In this area, the quantities used have been increasing slightly.

Table 198: SF₆ stocks in particle accelerators, in 5 application sectors, 1995-2010, in t

User category	1995	1997	1999	2001	2003	2010	Type of equipment 1995→2003	Equipment, 2010
(1) University institutes	30.571	30.571	28.467	28.067	28.317	32.090	13→11	10
(2) Research institutions	19.555	19.305	19.305	19.305	19.555	13.531	10→9	20
(3) Industry (high-voltage)	13.750	19.700	22.700	24.422	24.422	26.575	12→19	22
Subtotal (1-3)	63.876	69.826	70.722	72.044	72.044	72.196	35→39	52
(4) Industry (low-voltage)	1.600	1.600	1.600	1.600	1.600	1.425	14→14	23
(5) Institutions for radiation therapy	0.156	0.162	0.168	0.173	0.157	0.106	350→401	545
Subtotal (4-5)	1.756	1.762	1.768	1.773	1.757	1.531	364→415	568
Total (1-5)	65.632	71.588	72.490	73.817	73.801	73.727	399→455	620

In most high-volume particle accelerators used for research or industrial purposes (the first three user categories), the recharge quantities, which serve as indicators of the ongoing emissions, amounted to 4.1-4.5 t per year in the years 1995 through 2003. The ongoing emissions were considerably lower in 2010. That decrease is more pronounced than is the decrease in the charges.

Table 199: SF₆ emissions from particle accelerators, broken down by five areas of application, from 1995 through 2010, in t

User category	1995	1997	1999	2001	2003	2010	Type of equipment 1995→2003	Equipment, 2010
(1) University institutes	1.853	1.853	1.703	1.508	1.558	1.582	13→11	10
(2) Research institutions	1.259	1.259	1.246	1.246	1.196	0.886	10→9	20
(3) Industry (high-voltage)	0.958	1.291	1.548	1.722	1.710	1.155	12→19	22
Subtotal (1-3)	4.070	4.403	4.497	4.476	4.464	3.623	35→39	52
(4) Industry (low-voltage)	0.020	0.020	0.020	0.020	0.020	0.017	14→14	23
(5) Institutions for radiation therapy	0.345	0.359	0.372	0.384	0.395	0.491	350→401	545
Subtotal (4-5)	0.365	0.379	0.392	0.404	0.415	0.508	364→415	568
Total	4.435	4.782	4.889	4.880	4.879	4.131	399→455	620

When tanks of high-volume high-voltage systems are opened, the SF₆ in the tanks is pumped out and then later returned to the tanks. This can entail considerable gas losses. The reported recharges also include compensations for emissions due to accidents. As a result, the emission factors in lines 1-3 fluctuate.

Table 200: SF₆ emission factors of particle accelerators, in five areas of application, 1995-2010, in % of SF₆ stocks

User category	1995	1997	1999	2001	2003	2010
(1) University institutes	6.1	6.1	6.0	5.4	5.5	4.9
(2) Research institutions	6.4	6.4	6.2	6.2	6.2	6.5
(3) Industry (high-voltage)	7.0	6.6	6.8	7.1	7.0	4.3
Subtotal (1-3)	6.4	6.3	6.3	6.2	6.2	5.0
(4) Industry (low-voltage)	1.3	1.3	1.3	1.3	1.3	1.2
(5) Institutions for radiation therapy	222	222	222	222	252	463
Total (1-5)	6.8	6.7	6.7	6.6	6.6	5.6

According to information provided by producers, the emissions rate for small low-voltage systems in industry, in the years 1995-2003, was 1.3%. Producers also report that the emissions rate was 1.2% in 2010, meaning that it had changed very little.

From 1995 through 2003, the radiation therapy units used in medical settings had annual emissions rates of 220 – 250%. The high recharge requirements for such units result in that such units are opened an average of two to four times per year, for maintenance and repairs by producers, and the insulating gas escapes every times the units are opened. Service personnel regularly recharge the units in connection with maintenance and repairs. The differences in the emissions rates (annual losses per unit), for the three producers, form a factor-of-10 spread. The smaller the charge, the greater the recharge requirements – and, thus, the greater the emissions rate. For units of two of the three producers, the per-unit recharge rate remained constant between 2003 and 2010, while the rate decreased considerably for the third producer's units. In keeping with the fact that the share of small, highly emissive units, with respect to the overall unit pool, has increased markedly, the total loss rate for radiation therapy units increased considerably between 2003 and 2010, from about 250% to about 460%. One maker of radiation therapy units has reported having introduced a service tool, in 2006, for recycling SF₆ in the maker's units (for pumping SF₆ out of units, storing it temporarily and then re-adding it to units). According to that producer, this has considerably reduced SF₆ consumption.

4.8.2.3 Sound-proof glazing (2.G.2.c)

4.8.2.3.1 Category description (2.G.2.c)

Since 1975, SF₆ has been used to enhance the soundproofing properties of multi-pane windows. In such use, the gas is inserted into the spaces between the panes. The disadvantages of such use are that it reduces windows' thermal-insulation performance and that SF₆ is a potent greenhouse gas. The higher priority given to thermal insulation – e.g. by the Thermal Insulation Ordinance (Wärmeschutzverordnung) – along with improved SF₆-less window technologies, have led to a reduction in use of SF₆ in this application since the mid-1990s.

In Germany, sound-proof windows have been produced by numerous companies and filled with gas. Exports of assembled windows play no significant role.

Since 4 July 2007, a ban has been in force in the EU on sale of windows, for residential uses, that are filled with fluorinated greenhouse gases. As of 4 July 2008, that ban also applies to other windows. Current and future emissions in this category thus come primarily from open waste management of old windows, which is assumed to occur an average of 25 years after the windows were filled. For this reason, total emissions are expected to continue growing until the year 2020.

4.8.2.3.2 Methodological issues (2.G.2.c)

Emissions occur during filling of spaces between panes, as a result of overfilling (production emissions), during use (use emissions) and in disposal (disposal emissions). Emissions are calculated in keeping with equations 3.24 – 3.26 of IPCC-GPG (2000) on the basis of new domestic consumption, average annual stocks and remaining stocks 25 years ago.

The time series for sound-proof glazing begin in 1975, since the filling quantities of the year 1975 are of relevance for emissions from stocks in 1995. These data, which were reconstructed with the help of industry experts in 1996, were published in 2004 for the first time.

Emission factors

According to expert-level information from manufacturers of windowpanes and gas-filling equipment, provided to industry experts and to a scientific institute, one-third of the SF₆ used in the process of pumping SF₆ into spaces between windowpanes escapes. The EF_{production} is thus 33 %, with respect to new annual consumption.

This emission factor is obtained in the following manner: In use of both manual filling devices and automatic gas-filling presses, gas-swirling in the space between the panes cannot be avoided. As a result, the escaping gas consists not only of the air originally between the panes, it also includes an air-SF₆ mixture. More and more mixed gases escape as the filling process progresses. The gas loss, the "overfill", ranges from 20 to 60 % of the amount filled. The smaller the window concerned, the greater the overfill's relative importance. On average, i.e. throughout the entire spectrum of filled windows, of all shapes and sizes, the overcharge amounts to 50 % of the amount actually contained between the panes. This corresponds to one-third (33 %) of the relevant consumed amounts. This emission factor continues to be used, since neither filling technologies nor the range of window geometries have changed.

A DIN standard (DIN EN 1279-3, DIN 2003) specifies an upper limit of 10 per mil for annual losses of filled gas from panes' peripheral seals. This value also takes account of gas losses resulting from glass breakage in transport, installation and use, as well as from age-related increasing leakage from peripheral seals. The result is an emission factor EF_{use} of 1 % with respect to the average SF₆ stocks that have accumulated since 1975 and that are in place in year n.

Finally, disposal losses are incurred at the end of windows' service lifetimes (utilisation periods), or an average of 25 years after the windows were filled. For this reason, emissions from disposal do not have to be taken into account until the year 2000.

Since each year a window loses 1 % of its gas, with respect to the previous year's value, only part of a window's original quantity of gas is emitted when the window undergoes disposal. Since no gas collection upon disposal takes place, however, the emissions level is 100% ($EF_{\text{disposal}} = 1$).

Activity data

The new annual consumption was determined via top-down survey (domestic sales by the gas industry).

4.8.2.4 Adiabatic behaviour – Automobile tyres (2.G.2.d)

4.8.2.4.1 Category description (2.G.2.d)

Beginning in 1984, automobile tyres were filled with SF_6 for reasons of image (the resulting improved pressure constancy is not relevant in practice). The peak consumption year was 1995. In that year, over 500 of the some 3,500 tyre-sales outlets in Germany had equipment for filling tyres with SF_6 gas. Because SF_6 is a powerfully acting greenhouse gas, many tyre dealers began filling tyres with nitrogen instead. This practice led to a considerable reduction in use of SF_6 . Since 4 July 2007, a ban has been in force in the EU on sale of new automobile tyres filled with fluorinated greenhouse gases. No further emissions occur.

4.8.2.4.2 Methodological issues (2.G.2.d)

For the sake of simplicity, gas emissions during tyres' service lifetimes are not taken into account; as a result, emissions occur only when tyres are dismantled. Given an intended service lifetime of about 3 years, and the fact that there is no foreign trade with filled types, emissions follow domestic consumption for filling with a three-year time lag (ÖKO-RECHERCHE, 1996). The emissions are calculated using equation 8.9 of the 2006 IPCC Guidelines (Vol. 3).

Emission factors

The very small losses incurred in filling of tyres are not taken into account. Since SF_6 escapes completely when tyres are dismantled, $EF_{\text{disposal}} = 1$.

Activity data

Annual sales have been determined via surveys, carried out by the Federal Statistical Office, of gas suppliers, regarding their domestic sales to tyre dealers and automobile service centres.

4.8.2.5 Adiabatic behaviour – Athletic shoes (2.G.2.d)

4.8.2.5.1 Category description (2.G.2.d)

SF_6 was inserted into the soles of sport shoes in order to enhance cushioning. 2003 was the last year in which this practice occurred anywhere in Europe. As of 2004, PFC-218 (C_3F_8) was used in this application. Use of that gas was then discontinued in 2006. Today, nitrogen is usually used for this purpose. Sale of footwear produced with fluorinated greenhouse gases has been prohibited in the EU since 4 July 2006. No further emissions occur.

4.8.2.5.2 Methodological issues (2.G.2.d)

The emissions were calculated using equation 8.9 of the IPCC Guidelines (2006). Production emissions occurred only in foreign countries. Current emissions were not determined. In keeping

with a commitment to maintain confidentiality, data relative to sport-shoe soles are reported under CRF 2.H.3.

Emission factors

Manufacturers have not reported production emissions.

It is assumed that no emissions occur during use.

In disposal, emissions may be equated with input quantities ($EF_{\text{disposal}} = 1$). In addition, in a procedure similar to the IPCC method for automobile tyres, a time lag of three years is assumed.

Activity data

The filled quantities are based on manufacturers' European-wide sales figures. These figures are broken down, on the basis of Germany's population, to obtain figures for Germany. While such data have been available to the Federal Environment Agency since the 2001 report year, for reasons of confidentiality they are reported only in aggregate form, under CRF 2.H.3.

4.8.2.6 Other: Trace gas (2.G.2.e)

4.8.2.6.1 Category description (2.G.2.e)

SF₆, as a stable and readily detectable trace gas, even at extremely low concentrations, is used by research institutions to investigate a) ground-level and atmospheric airflows and gas dispersions and b) water currents.

As of report year 2007, use of SF₆ as a trace gas was reduced considerably with respect to earlier years.

4.8.2.6.2 Methodological issues (2.G.2.e)

The quantities used have been estimated by experts.

Emission factors

An "open use" is assumed, i.e. annual new inputs are completely emitted in the same year and are treated as consumption for production ($EF_{\text{production}} = 1$). No recovery takes place.

Activity data

In 1996, total domestic use was estimated by experts of all relevant research institutions. Since then, use levels have been estimated by one expert at three-year intervals. These assessments indicate that the quantities used vary only slightly.

4.8.2.7 Other: Welding (2.G.2.e)

4.8.2.7.1 Category description (2.G.2.e)

According to gas suppliers, use of SF₆ in welding began in 2001. SF₆ is used as a protective gas in welding of metal. Since there is only one user in Germany, the pertinent data are subject to confidentiality protection.

4.8.2.7.2 Methodological issues (2.G.2.e)

Because they are confidential, data on consumption and emissions in connection with welding are reported under CRF 2.H.3.

Emission factors

No reliable data are available on SF₆ decomposition during use. Experts presume that the entire relevant input SF₆ quantities are emitted completely into the atmosphere during use. For this reason, consumption and emissions are considered equal for welding applications. The emission factor for welding is specified as EF_{use} = 1.

Activity data

The annual amounts consumed are determined via enquiry of the company that uses SF₆ for welding purposes.

4.8.2.8 Other: Optical glass fibre (2.G.2.e)

4.8.2.8.1 Category description (2.G.2.e)

Use of SF₆ in production of special optical glass fibre began in 2002. In such production, SF₆ is used for fluorine doping. Only a few production operations are in place in Germany.

4.8.2.8.2 Methodological issues (2.G.2.e)

Emissions occur in production of optical glass fibre cable.

Emission factors

The 2006 IPCC Guidelines⁷⁹ contain no information on use of SF₆ in production of optical glass fibre. According to experts, 70 % of the input SF₆ quantities escape. For this reason, an emission factor of EF_{production} = 0.7 is used.

Activity data

The annual consumption figures are obtained via surveys, carried out by the Federal Statistical Office, of gas suppliers, with regard to their domestic sales. They have been increasing since 2001, with slight fluctuations.

4.8.2.9 Other: Medical and cosmetic applications (2.G.2.e)

4.8.2.9.1 Category description (2.G.2.e)

In Germany, fluorinated greenhouse gases, in addition to being used in medical metered dose inhalers (source category 2.F.4), are also used in various medical and cosmetic applications.

Since 2000, perfluorodecalin (C₁₀F₁₈, PFC-9-1-18) has been used, in pure form, in ophthalmology and in research. In ophthalmology, perfluorodecalin is used in retinal surgery within the eye, especially in treatment of retinal detachments, retinal tears, proliferative vitreoretinopathy, etc.. Perfluorodecalin is also used, in considerably smaller quantities, in research into organ preservation during transplants, as a contrast agent in diagnostic imaging techniques (magnetic resonance tomography, ultrasound) and as an oxygen carrier in cell cultivation.

Since 2012, perfluorodecalin has also been used as an ingredient in cosmetic products (skin care; nail care). In such products, it serves as a carrier or storage medium for oxygen. The perfluorodecalin concentrations used in such products, according to manufacturers, amount to 0.1 %.

In Germany, hydrofluoroethers (HFE) are the standard anaesthetic gases used for inhalative anaesthesia. They are used in some 9 million operations annually. Isoflurane, a halogenated ether (HCFE-235da2, CHF₂-O-CHCl-CF₃), has been used since 1985. Desflurane (HFE-236ea2, CHF₂-O-

⁷⁹ IPCC GL 2006: Vol. 6, Ch. 6: Electronics Industry

CHF-CF₃) and sevoflurane (HFE-347mmz1, CH₂F-O-CH(CF₃)₂), which have been used since 1995, currently have a combined market share of about 90 %. In relevant uses, the hydrofluoroethers are vaporized in special equipment. They are administered in concentrations of 1 % to 6 % in a carrier gas consisting of oxygen and nitrous oxide (N₂O). On average, 8.2 g of isoflurane, 32.6 g of desflurane or 11.4 g of sevoflurane are used per operation. The quantities of the various hydrofluoroethers that are used per operation vary, because the concentrations of narcotic gases – as provided through respirators, and along with carrier gases – needed to ensure proper anaesthetic effects differ widely.

As recommended by the 2006 IPCC Guidelines, medical and cosmetic applications of PFCs are placed in source category 2.G.2.

4.8.2.9.2 Methodological issues (2.G.2.e)

In ophthalmological and research applications in which it is used in pure form, all of the perfluorodecalin used is emitted. The perfluorodecalin in cosmetic products is also emitted completely when the products are used ($EF_{use} = 1$).

Hydrofluoroethers used as inhalation anaesthetics are collected during operations and then vented into the atmosphere from central points. During operations, the various hydrofluoroethers that patients inhale are not exhaled in unchanged form; to some extent, and to varying degrees, they are metabolised in patients's bodies. In each case, the gas-specific emission factors amount to 100 % minus the applicable metabolism rate.

No production emissions occur in the case of medical and cosmetic applications, since no relevant products are produced in Germany.

In the case of perfluorodecalin, the emissions from use are calculated, using Equation 2, via the quantities of perfluorodecalin sold in bulk and in cosmetic products. In a departure from the method proposed by the 2006 IPCC Guidelines for calculation of "prompt emissions" (equation 8.23), it is assumed that all of the quantities sold in a given year are emitted completely in the same year, i.e. the emissions are not calculated as the sum of half the purchases (sales) of the previous year and half the purchases (sales) of the current year. This approach is justified in that the time between sale and use tends to be very short.

Emissions from use of hydrofluoroethers used as anaesthetic gases are calculated with Equation 2, via the quantities used in Germany. The 2006 IPCC Guidelines provide no instructions for calculating such emissions.

Since the perfluorodecalin and the hydrofluoroethers are emitted completely when used, no disposal emissions have to be reported.

Because they are confidential, data on consumption and emissions in connection with perfluorodecalin are reported under CRF 2.H.3.

Emissions of hydrofluoroethers are not subject to reporting obligations. Germany voluntarily reports HFE emissions pursuant to the recommendations of the 2014 UNFCCC Reporting Guidelines (FCCC/CP/2013/10/Add.3, Decision 24/CP.19), under "additional greenhouse gases". The emissions are aggregated with other emissions that are not subject to reporting obligations, and they are listed in Chapter 4.9.3 under CRF 2.H.3.

Emission factors

The emission factors used have been obtained from opinions provided by experts; they are listed in Table 195.

The EF_{use} for all medical and cosmetic applications of perfluorodecalin is 100 %.

With regard to the hydrofluoroethers used as inhalation anaesthetics, the EF_{use} for isoflurane and desflurane is 99.8 %, and for sevoflurane it is 95 %.

In agreement with the IPCC specifications (2006 IPCC Guidelines, p. 8.32), a 100 % emissions level for use of perfluorodecalin ($EF_{\text{use}} = 1$) is assumed. In a departure from the Guidelines, Germany applies a product lifetime of only one year in this area. The emission factor has thus been classified as "country-specific".

The IPCC Guidelines do not provide any instructions relative to the use of hydrofluoroethers as inhalation anaesthetics.

Activity data

The annual imports of $C_{10}F_{18}$ to Germany, for use in ophthalmology and research, were disclosed by the manufacturer F2 Chemicals, UK, on a confidential basis.

The quantities of cosmetic products containing $C_{10}F_{18}$ that are imported to Germany were disclosed, on a confidential basis, by the trading enterprise P2 cosmetics, which sells the products in Germany.

The quantities of hydrofluoroethers that are used as inhalation anaesthetics were determined via surveys of industry experts (hospitals, manufacturers of anaesthesia equipment), and with the help of literature references, in the framework of a research project (cf. ÖKO-RECHERCHE 2015).

4.8.2.10 Uncertainties and time-series consistency (2.G.2 all)

The uncertainties for this source category have been systematically quantified.

In the case of sound-proof glazing, since 2006 data from the top-down survey of annual new consumption, carried out on the basis of commercial sales data, have been compared with data from the *Federal Statistical Office's* pertinent annual surveys. This procedure, which may be considered reliable and complete, has increased data reliability. Due to the wide range of influencing factors, the $EF_{\text{production}}$ cannot be measured reliably. Estimates resulting from a survey of ten industry experts, conducted in 1996 and 1999 (the experts represented window manufacturers, suppliers of filling devices and one scientific institute), indicate, virtually conclusively, that the mean filling loss ranges between 30 % and 40 %. A 1 % rate is considered realistic for ongoing gas losses.

With regard to sport shoes, in spite of the good quality of the data for the EU, the filled-quantities breakdown, by Member States, is subject to considerable uncertainties.

In the case of medical applications, the data on the quantities of perfluorodecalin used is considered to be of good quality, since they were obtained directly from the manufacturer (F2 Chemicals Ltd, UK), and that manufacturer is the sole exporter of perfluorodecalin to Germany. The uncertainties relative to cosmetic products are larger, since Germany's market for cosmetics is extremely dynamic, with the result that no reliable statistics for this purpose are available.

4.8.2.11 Category-specific quality assurance / control and verification (2.G.2 all)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The data for the 2003 report year, like the data for most of the previous years, were collected by an external expert working in the framework of a research project under commission to the Federal Environment Agency.

For the most part, quality assurance was carried out by an external expert. In addition, the data are checked by the relevant Federal Environment Agency specialists upon receipt.

In 2011, the entire sector of F-gas emissions was subjected to voluntary trilateral review. Experts from England, Germany and Austria reviewed "each other's" F-gas inventories. The aims of the review were to exchange information regarding country-specific methods for preparing F-gas inventories; to learn about the institutional and legal regulations for F-gas inventories in each country; to identify obstacles for the preparation of complete, precise inventories; and to discuss differences and similarities between the various methods used to prepare F-gas inventories. The meeting helped all three countries to review their methods for relevant emission calculation. In addition, the transparency, completeness and precision of the various inventories were assessed. That review had a positive outcome, namely that Germany has a good F-gas inventory. As a result, no recommendations were issued for improvements of the German F-gas inventory.

4.8.2.12 Category-specific recalculations (2.G.2 all)

For medical and cosmetic products (sub- source category 2.G.2.e), the quantities of hydrofluoroether used in the period 1990 through 2014 as inhalation anaesthetics (hydrofluoroether is not subject to reporting requirements), were upwardly corrected, since the values assumed – erroneously – to apply in the last survey year were too low. Since the pertinent substances are not subject to reporting requirements, they are not described quantitatively in the present context. The recalculated emissions are aggregated with other emissions that are not subject to reporting requirements and are reported in Chapter 4.9.3 under CRF 2.H.3.

4.8.2.13 Planned improvements, category-specific (2.G.2 all)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.8.3 Use of N₂O (2.G.3)

4.8.3.1 Category description (2.G.3)

The German nitrous oxide market is dominated by Air Liquide, Linde AG and Westfalen AG, all of which are leading producers as well as importers. No nitrous oxide emissions occur in nitrous oxide production and in filling of the gas into gas bottles. Emissions occur solely in use of the gas. Medical applications represent the most important N₂O-emissions source. Other emissions sources include use of laughing gas as a propellant in whipped-cream aerosol cans and use in the semiconductor industry. N₂O is also released, in small amounts, in blasting. Nitrous oxide emissions in anaesthesia, a predominant emissions source since 1990, have been decreasing sharply, due to increasing use of intravenously administered anaesthetics instead of nitrous oxide. This trend is expected to continue.

Medicine – anaesthesia

In medicine, nitrous oxide, a gas with analgesic properties, is used for anaesthetic purposes. In such applications, nitrous oxide is mixed with pure oxygen, to produce an active gas mixture consisting of 70 % nitrous oxide and 30 % oxygen. In modern anaesthesia, the effects of nitrous oxide are enhanced through addition of other anaesthetics. While medical use of N₂O is not prohibited, there is strong resistance – especially in the German medical sector – against

widespread, general use of the substance. Medical use of laughing gas has thus been decreasing continuously since 1990.

Food industry – whipped-cream aerosol cans

In the food industry, nitrous oxide is used as an additive known as "E 942". Foods sold in pressurised containers are extracted from such containers with the help of propellants. As it exits such a container, a food takes on either a foamy or a creamy consistency, depending on what type of food it is. Examples of relevant foods with added N₂O include whipped cream (from spray cans), quark, and various desserts such as ready-to-eat puddings (DIE VERBRAUCHER INITIATIVE E.V, 2005; LINDE GAS GMBH, 2005).

Semiconductor manufacturing

A wide range of different chemicals and gases is used in semiconductor production. Argon, ultra-pure oxygen, hydrogen, ultra-pure helium and nitrogen account for the lion's share of the gases used. Special process gases, such as nitrous oxide (dinitrogen monoxide), ammonia and hexafluorethane, are used only in relatively small amounts, and the amounts involved have remained nearly constant over the past few years (AMD Saxony LLC&Co. KG, Dresden, Umweltbericht (environmental report) 2002/2003, page 16).

Explosives

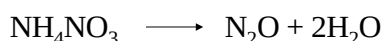
Explosives are used in both military and industrial contexts. Civil and commercial explosives are used in mining, in construction in rocky terrain, in demolition, in geology and in fireworks.

Nitrous oxide emissions occur primarily in detonation of explosives that contain ammonium nitrate, such as ANFO (ammonium nitrate / fuel oil) and emulsion explosives. In general, commercial / civil explosives consist to some 60 to 80 % of ammonium nitrate (AN). By contrast, Analex, an ANFO explosive, contains up to 94 % ammonium nitrate.

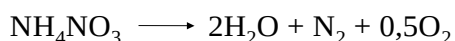
In Germany, two companies produce explosives for civil use: Orica Mining (formerly Dynamit Nobel) and Westpreng GmbH (Wasag Chemie).

While no nitrous oxide emissions occur in manufacturing of explosives, nitrous oxide can form in thermal decomposition of explosives. The reason for this is that ammonium nitrate (AN) forms nitrous oxide (laughing gas) and water as it decomposes thermally.

Under careful warming to a temperature above the melting temperature, the reaction is as follows:



But in a fast, detonative reaction of an AN-containing explosive, the reaction occurs as follows:



This means that under high pressure and temperature AN primarily forms nitrogen, oxygen and water as it reacts. Only a small concentration of primarily formed N₂O remains intact in the detonation process. For example, detonation clouds of amatols⁸⁰, which contain some 80 % AN, have only 0.1 mole N₂O per mole of ammonium nitrate. From this figure, a theoretical maximum of about 68 g (this figure was provided by an explosives expert; the stoichiometric value would be 44 g/mole amatol (80%-AN)) per kilogramme AN can be calculated (ORELLAS, D.L., 1982; VOLK,

⁸⁰ Amatol x/y : military explosives – pourable mixtures, generally consisting of x % TNT and y % ammonium nitrate

F., 1997, page 74). According to experts, this AN-content figure can be used as a basis for assumptions regarding N₂O emissions for other explosives.

N₂O in automobile tuning

In automotive technology, nitrous oxide is used to improve combustion in gasoline / petrol engines, via so-called "laughing-gas injection". In the process, laughing gas is broken down into nitrogen and oxygen. The nitrogen cools the combustion process, and the oxygen increases combustion power. This "tuning" tactic can quickly increase engine performance. To date, one company in Germany offers such tuning measures. Research has shown that the equipment used for such tuning is designed to consume the input laughing gas completely, without producing significant emissions.

4.8.3.2 Methodological issues (2.G.3)

Anaesthesia

The 1990 figure for N₂O emissions from medical applications is based on an extrapolation of a statistical plant survey conducted in 1990 in the territory of the former GDR. At the time, it was ascertained that one plant for the production of N₂O for anaesthetic purposes had existed in the former GDR. Also at the time in question, the plant had not yet been operational for long (it was constructed in 1988). The annual production capacity was approximately 1,200 t. Research indicated that there were no exports or imports of this substance, and thus it was assumed that all of the substance was used for domestic consumption. Via the per-capita emissions calculated from this for the former GDR, and assuming identical conditions, N₂ emissions of 6,200 t were estimated, as a rough approximation, for Germany in 1990. The N₂O figure for 2001 was obtained via a written memorandum, dating from 2002, of the Industriegaseverband e.V. (IGV) industrial-gas association. That figure was tied to a range of 3,000 ~ 3,500 t/a. The mean value from that range (3,250 t/a) was then used for generation of an N₂O-emissions time series.

Since 2005, the Industriegaseverband (IGV) industrial-gas association has carried out surveys of N₂O sales for all applications in Germany. In addition, the IGV has made the data from those surveys available to the Federal Environment Agency for reporting purposes. In 2010, the IGV entered into a voluntary agreement, with the Federal Ministry of Economics and Technology (BMWi), regarding annual provision of N₂O-sales data for purposes of emissions reporting.

The gaps in the data relative to uses in anaesthesia are closed via interpolation and extrapolation.

The pertinent emission factor is 100%.

Whipped-cream aerosol cans

Use of N₂O in aerosol cans for whipped cream, in Germany, has to be carefully differentiated. In Germany, there is one maker of aerosol cans for whipped cream. That maker also fills the cans in Germany. In emissions calculations, it is assumed, on the basis of the above-described research, that that company accounts for a share of about 3 % of the laughing-gas sales of the IGV industrial-gas association. Most of the companies who deal with such aerosol cans have them filled abroad and then import them into Germany. The relevant sales of such companies are thus not included in the data of the IGV industrial-gas association. The MIV dairy-industry association has reported to the Federal Environment Agency the results of a one-time survey that showed that 50.2 million units of whipped-cream aerosol cans were sold in 2008. At the same time, the MIV association reported that the units involved vary in size, and that it is not possible to break the figures down by can sizes. Internet research showed that pressurized cartridges for this area are sold in Germany: cartridges with 8g of N₂O, for 0.5l (whipped-cream) cans, and cartridges with 16g of

N₂O, for 1.0l cans. Comparison calculations have shown that 8g of N₂O is a safe approximation, for purposes of calculation, for the amount of laughing gas contained per sold unit (whipped-cream aerosol can). That, in turn, leads to an input figure of 401.6 t N₂O for whipped-cream aerosol cans in 2008 in Germany. Since no pertinent data are available for the years prior to 2008, that value is assumed to be constant.

The emission factor for whipped-cream aerosol cans is assumed to be 100%.

Semiconductor manufacturing

On a one-time basis, the German Electrical and Electronic Manufacturers' Association (ZVEI) has provided information on quantities of laughing gas used (**activity data**) in the years 1990, 1995, 2000, 2001 and 2008. Values between those points are obtained via interpolation.

A wide range of different chemicals and gases is used in semiconductor production. Argon, ultra-pure oxygen, hydrogen, ultra-pure helium and nitrogen account for the lion's share of the gases used. Special process gases, such as nitrous oxide (dinitrogen monoxide) and ammonia, are used only in relatively small amounts, and the amounts involved have remained nearly constant over the past few years (AMD Saxony LLC&Co. KG, Dresden, Umweltbericht (environmental report) 2002/2003, page 16).

The **emission factor** is confidential and is thus not described here in detail.

Explosives

In 2003, a total of 59 kt of explosives was produced in Germany. Of that figure, 13 kt were exported abroad, and 5.8 kt were imported into Germany⁸¹. Those figures, in turn, yield a figure of 51.8 kt for the amount of explosives used in Germany. Of that amount, ANFO accounts for a share of 60 %, emulsion explosives account for 25 % and dynamite explosives account for 15 %. ANFO explosives consist of 94 % ammonium nitrate and 6 % fuels. The corresponding relationship for emulsion explosives is 80 % to 20 %; for dynamite explosives, it is 50 % to 50 %.

At present, nitrous oxide amounts in detonation clouds are not determined, while amounts of NO and NO₂ are determined.

Normally, N₂O formation plays a significant role only in explosives that contain ammonium nitrate (AN). That said, no precise analyses of detonation clouds of ANFO explosives have been carried out. For this reason, it must be assumed that the N₂O concentrations formed upon detonation of ANFO are similar, with regard to AN content, to those formed upon detonation of amatols and ammonites⁸², for which analyses have been carried out that support relevant estimates. The following result has been obtained: upon detonation, amatols and ammonites form about 0.1 mole N₂O per mole of ammonium nitrate (AN).

According to the *Federal Office for Material Research and Testing* (BAM), levels of explosives use in Germany remained constant from 1990 to 2005.

The emission factor for use of explosives is 0.1036 kg N₂O/t explosives. That emission factor was determined, via measurement, by the BAM in February 2010. As a result, the emission factor has been corrected downward, considerably, with respect to the 2010 Submission.

⁸¹ Personal communication: Federal Office for Material Research and Testing (BAM).

⁸² Ammonite: Composition: 70-88 % ammonium nitrate, with 5-20 % nitroaromates, 1-6 % vegetable flour and, in some cases, 4 % nitroglycerine, aluminium powder and potassium perchlorate

For anaesthesia, whipped-cream aerosol cans and the semiconductor industry, the pertinent emissions are reported in aggregation with confidential emissions data from 1,12-dodecanedioic acid production (2.B.10).

4.8.3.3 Uncertainties and time-series consistency (2.G.3)

Since 2005, activity data for anaesthetic uses have been obtained from association information. For that reason, the uncertainty is estimated to be 20 %. The data on consumption for whipped-cream aerosol cans and explosives are subject to a very high level of uncertainty (75 %), since the relevant calculations are based on several assumptions and since a definite figure is available only for one year. The uncertainty of the activity data for the semiconductor industry is estimated at 10 %, since the data have been obtained from facility operators themselves. For the uncertainties applying to the explosives, the IPCC default value of +/- 75% is used.

The uncertainty in the emission factors for anaesthesia and whipped-cream aerosol cans is set as 0 %, since at present it is assumed that N₂O undergoes no transformation in use, and that the gas thus escapes completely into the atmosphere following its use. The emission factor for use in semiconductor manufacturing is estimated to have an uncertainty of 15 %, since the data have been obtained from facility operators themselves. The emission factor for explosives is estimated to have an uncertainty of 5 %, since the emission factor has been determined via an official measurement.

With these results, the time series can be considered to show a normal distribution (distribution type).

4.8.3.4 Category-specific quality assurance / control and verification (2.G.3)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

With regard to use in anaesthesia, a comparison with other countries shows that most other countries use an emission factor of 1.0, as Germany does. That factor is equivalent to the default value given in the IPCC GL 2006: Vol. 3, p. 8.36.

With regard to nitrous oxide emissions from use of explosives, no comparisons with other comparison or data sources are possible, since Germany is the only country that reports such emissions.

The quantities of nitrous oxide used cannot be verified via other data sources, since no other data are available that would support such verification. A special survey was carried out in order to obtain the data for the present report.

4.8.3.5 Category-specific recalculations (2.G.3)

No recalculations are required.

4.8.3.6 Planned improvements, category-specific (2.G.3)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.8.4 Other – ORC systems (2.G.4 ORC systems)

4.8.4.1 Category description (2.G.4 ORC systems)

Fluorinated greenhouse gases have been used in ORC systems in Germany since 2003. They are reported in category 2.G.4.

The Organic Rankine Cycle (ORC) is used for generating electricity from heat sources with temperatures and pressures that are too low for steam-powered generation. ORC systems are used especially in geothermal power generation and in harnessing of waste heat from combined heat and power (CHP) stations and biogas plants.

The working media used in the ORC cycle are certain organic substances, such as HFCs, PFCs, hydrocarbons and silicone oils, that evaporate at lower temperatures than water does. In ORC systems, such working media evaporate and drive turbines, just as steam drives turbines in conventional power stations. The largest fill quantities, far and away – up to 75 tonnes of fluorinated working media in each case – are used in geothermal applications. Considerably smaller fill quantities (0.2 to 0.6 tonnes) are used in systems that harness waste heat from biogas plants and in compact combined heat-and-power (CHP) generating systems.

In Germany, C₅F₁₂ was first used as a working medium – in an ORC pilot system – in 2003. That system was decommissioned in 2010. HFC-134a was used for the first time in an ORC system in 2008. In 2010, HFC-245fa was used for the first time as a working medium. Beginning 2011, several systems were commissioned that operate with HFC-245fa and with the working medium "Solkatherm", which consists of HFC-365mfc (65 %) and a perfluorinated polyether (PFPE) with the trade name "Galden" (35 %).

4.8.4.2 Methodological issues (2.G.4 ORC systems)

Emissions from ORC systems occur during filling, operation and disposal.

Production emissions are determined via new domestic consumption – the activity data – and calculated pursuant to Equation 1.

Emissions from use are determined on the basis of final quantities (i.e. in systems) of working media – the activity data – and via multiplication by the EF_{use}, in keeping with Equation 2.

Disposal emissions refer to new additions for the year that is x years (depends on product lifetime) prior to the current reporting year n. They are calculated pursuant to Equation 3.

Apart from one exception, disposal emissions have not begun playing any role yet, since most systems are new. Large ORC systems in geothermal applications are expected to have a useful lifetime of 30 years, while smaller systems are expected to have lifetimes of 20 years.

Emissions of the perfluorinated polyether "Galden" are not subject to reporting obligations. Germany voluntarily reports emissions of this substance pursuant to the recommendations of the 2014 UNFCCC Reporting Guidelines (FCCC/CP/2013/10/Add.3, Decision 24/CP.19), under "additional greenhouse gases." The emissions are aggregated with other emissions that are not subject to reporting obligations, and they are listed in Chapter 4.9.3 under CRF 2.H.3.

Emission factors

The emission factors used have been obtained from opinions provided by experts; they are listed in Table 196.

The filling loss is 2 %. It is country-specific, since ORC systems have not yet been covered by the IPCC Guidelines and thus no default factors are yet available.

The emissions from use are estimated to be 4 %. In this area as well, the IPCC Guidelines provide no specifications.

Under the current technological state of the art, the emission factor for disposal is 20 %. That value is also country-specific.

Activity data

ORC systems are a new area of application for fluorinated greenhouse gases, an area for which little data and technical information has been gathered to date. Almost all of the data used, therefore, are based on information provided by producers and operators of ORC systems. The data have been determined via discussions with experts (cf. ÖKO-RECHERCHE 2015).

4.8.4.3 Uncertainties and time-series consistency (2.G.4 ORC systems)

The uncertainties for the "ORC systems" sub-category have been systematically quantified.

The data on the quantities used are considered to be of good quality overall. Germany has only a small number (fewer than 10 companies) of manufacturers and sellers of ORC systems with fluorinated working media, and the country's market is relatively small. The data on the quantities of HFC-245fa and Solkatherm (HFC-365mfc and PFPE) that are used annually are of good quality, since the data come directly from the manufacturers of these working media (Honeywell und Solvay Solexis), and these companies are the only sellers who export to Germany.

The emission factors are subject to considerable uncertainties. Since sales of ORC systems in Germany began only a few years ago, no pertinent, solid empirical studies have been carried out to date. The values are based on estimates provided by operators of such systems.

4.8.4.4 Category-specific quality assurance / control and verification (2.G.4 ORC systems)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The data for the 2003 report year, like the data for most of the previous years, were collected by an external expert working in the framework of a research project under commission to the Federal Environment Agency.

For the most part, quality assurance was carried out by an external expert. In addition, the data are checked by the relevant Federal Environment Agency specialists upon receipt.

4.8.4.5 Category-specific recalculations (2.G.4 ORC systems)

No recalculations are required.

4.8.4.6 Planned improvements, category-specific (2.G.4 ORC systems)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.8.5 Other product manufacture and use: Other, charcoal use (2.G.4 Charcoal)

4.8.5.1 Category description (2.G.4 Charcoal)

In this category, CO₂, CH₄, N₂O and particulate emissions from use of charcoal for barbecuing are reported.

Only small quantities of charcoal are produced in Germany – by one major charcoal-factory operator and in a number of demonstration charcoal kilns. The pertinent quantities are determined by the Federal Statistical Office (STBA) and are subject to confidentiality requirements. Use of charcoal is reported under 1.B.1b.

Use of charcoal increased in the years 1990 through 2012. The great majority of the charcoal used is imported.

4.8.5.2 Methodological issues (2.G.4 Charcoal)

The calculation model is based on the assumption that all calculation method is consumed within a year of its purchase and is burned completely.

The CO₂, CH₄ and N₂ emissions are calculated via a Tier 1 method.

Activity data

The data on charcoal production, and on the imported and exported quantities, for the years as of 1996, were obtained from the Federal Statistical Office (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 3.1, Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe sowie der Außenhandelsstatistik ("manufacturing industry; production in the manufacturing industry and foreign-trade statistics")).

The quantities consumed are calculated in keeping with the formula Production + Imports – Exports.

For the years 1990 through 1995, the quantities consumed are calculated from the per-capita consumption, which has been derived from the data for the years 1996 through 2013. In the process, it is assumed that consumption also grew linearly in those (earlier) years.

Emission factors

Since import and export data are published, no exact emission factors for CO₂, CH₄ and N₂O may be given, for reasons of confidentiality. It may be disclosed, however, that the relevant emission factors are comparable to the emission factors that can be derived from the 2006 IPCC Guidelines.

Each emission factor is applied to the entire time series.

4.8.5.3 Uncertainties and time-series consistency (2.G.4 Charcoal)

A Tier 1 method, with emission factors similar to those provided by the 2006 IPCC Guidelines, has been used, and thus that source's relevant uncertainties for the activity data and emission factors apply (2006 IPCC Guidelines: Vol. 3, Ch. 5).

4.8.5.4 Category-specific quality assurance / control and verification (2.G.4 Charcoal)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

No other data, apart from the data provided by the Federal Statistical Office, are available for review of the relevant import, export and production quantities, for purposes of verification of the consumption-quantity data. The import and export figures were compared with the corresponding data of EUROSTAT. Its figures show good agreement with the figures the Federal Statistical Office has provided to EUROSTAT. It was not possible to compare production quantities, because EUROSTAT also lists them as confidential.

The emission factors were compared with the corresponding emission factors of other countries. For reasons of confidentiality, the result of that comparison can be documented only internally. The emission factors are comparable.

4.8.5.5 Category-specific recalculations (2.G.4 Charcoal)

No recalculations are required.

4.8.5.6 Planned improvements, category-specific (2.G.4 Charcoal)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.9 Other production (2.H)

The category *Other production* is not a key category.

In the CSE, process-related emissions from production of particle board and from pulp production are reported under 2.H.1 Pulp and paper.

Process-related emissions from production of alcoholic beverages, and from production of bread and other foods, are listed under 2.H.2 Food and drink.

Confidential data on emissions of fluorinated greenhouse gases are reported under 2.H.3. Data on F gases subject to voluntary reporting are reported in that section as well, in aggregated form.

4.9.1 Other production: Pulp and paper (2.H.1)

4.9.1.1 Category description (2.H.1)

Gas	Method used	Source for the activity data	Emission factors used
NO _x , CO			CS
NM ₁₀ OC, SO ₂			D

The category *Other production – pulp and paper* is not a source of greenhouse-gas emissions and is thus not a key category.

All emissions of climate-relevant gases from the pulp and paper industry, and from particle-board production, in Germany result from combustion of fuels; for this reason, they are reported in Chapter 3.2 as energy-related emissions. The pulp and paper industry does not produce any process-related emissions of climate-relevant gases within the meaning of the *2006 IPCC Guidelines*.

Two of the six pulping plants in Germany carry out sulphate-process **pulp production** via caustification. For these plants, fuel-related CO₂ emissions in lime ovens are already taken into account, as energy-related emissions, via the pertinent fuel statistics. The remaining four plants use the sulphite process.

No attempt was made to take account of country-specific CO emission factors in energy-related emissions from pulp production, since that would have required conversion of product-based emission factors into fuel-based emission factors. Such conversion is an extremely involved process. Compared to the relevant CO emissions from paper mills, the CO emissions from the six pulping plants are of insignificant quantities.

The sulphate and sulphite pulp-production processes can both be a source of SO₂ emissions. In sulphate pulp production, NO_x, CO and NMVOC emissions are also released from recovery boilers, lime ovens, bark boilers and auxiliary boilers.

Particle board is produced from wood chips, with added binders, in a process that applies heat and pressure. The main source of NMVOC emissions in such production are the wood chips used, which release NMVOC during drying via heating. NMVOC can also be emitted from wood and binders during the pressing process.

Particle board is produced in a total of 18 plants in Germany. Some 6,000 employees work in particle-board plants nation-wide. The particle-board industry tends to be dominated by larger companies.

4.9.1.2 Methodological issues (2.H.1)

The **pulp and paper industry** produces no process-related emissions of climate-relevant gases within the meaning of the *IPCC Good Practice Guidance* (IPCC, 2000). For indirect greenhouse gases, the IPCC-Guidelines emission factors listed in Table 201 were used until the reported year 2004.

Table 201: IPCC default emission factors for SO₂, NO_x, CO and NMVOC from pulp production

	NO _x	CO	NMVOC	SO ₂
	[kg / t ADt*]			
Sulphate pulp	1.5	5.6	3.7	7
Sulphite pulp				30

* ADt = Air-dried tonne

As of reported year 2005, plant operators have provided updated emission factors.

Table 202: Real emission factors, for German plants, from pulp production. (German contribution to revision of the BAT reference (BREF) document for the pulp and paper industry, 2007)

	NO _x	CO	NMVOC	SO ₂
	[kg / t ADt*]			
Sulphate pulp	1.75	0.16	3.7	0.03
Sulphite pulp	2			2

In 2015 the following quantities were produced, in a total of 162 plants:

Table 203: Pulp and paper production, produced quantities

Product	Quantities produced in 2014	
Production of paper, cardboard and carton (PCC):	22.60	million t
Raw-material production:		
Paper pulp	1,608,849	t
of this, sulphite pulp	604,091	t
of this, sulphate pulp	1,004,758	t
Wood pulp	945,952	t
Recycled paper	13,980,000	t
Quantity of recycled paper used for this purpose	(16,722,000	t)

Source: Verband Deutscher Papierfabriken, Leistungsbericht 2016 (VDP, various years)

These figures, which the German Pulp and Paper Association (VDP) collects annually and publishes in a production report, are available back to the reference year, 1990.

Particle board

Emission factors

The emission factors have been determined on the basis of experts' assessments.

Activity data

The activity data were obtained from national statistics (STATISTISCHES BUNDESAMT (FEDERAL STATISTICAL OFFICE): Fachserie 4, Reihe 3.1).

Table 204: Updated activity data for the particle-board industry

Year	2010	2011	2012	2013	2014	2015
Activity data for the particle-board industry [in t]	4,561,000	4,488,000	4,429,000	4,488,000	4,446,000	4,402,000

Source: Federal Statistical Office, Fachserie 4, Reihe 3.1.4

4.9.1.3 Uncertainties and time-series consistency (2.H.1)

Pulp and paper

Until report year 2004, the IPCC default values (IPCC, 1996b: Vol. 3) were used for emissions calculation. As of reported year 2005, updated, Germany-specific emission factors were entered into the CSE emissions database, following consultation with German plant operators. Such updating was required because German sulphate pulp plants had undertaken considerable modernisation measures, in the previous five years, that had led to sharp emissions reductions. The updating was completed as of 2005. In sulphite pulp plants, continual improvements led to considerable SO₂-emissions reductions with respect to corresponding emissions levels in 1990.

The uncertainties in the activity data are estimated to amount to 5 %. The uncertainties in the emission factors are estimated to amount to 20 %.

Particle board

The uncertainties in the activity data for the particle-board industry are ± 5 % (expert assessment).

4.9.1.4 Category-specific quality assurance / control and verification (2.H.1)

Due to resources limitations, and to the area's minimal relevance, no QC/QA is carried out for reporting relative to precursors.

4.9.1.5 Category-specific recalculations (2.H.1)

No recalculations are required.

4.9.1.6 Planned improvements, category-specific (2.H.1)

Since plant operators have confirmed the emission factors from the international guidelines, no further inventory improvements for this category are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.9.2 Other production: Food and drink (2.H.2)

4.9.2.1 Category description (2.H.2)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	NA	NA	NA
NM VOC	CS	NS	CS/D

The category *Other production – food and drink* is not a source of greenhouse-gas emissions and is thus not a key category.

The food and beverage industry's emissions of direct climate gases in Germany result from fuel combustion; for this reason, they are reported under CRF 1.A.2. The food and beverage industry's important process-related emissions include non-methane volatile organic compounds (NMVOC) (IPCC 1996c: p. 2.41). Carbon dioxide emissions from food inputs that occur during certain production processes are not reported in CRF 2.D.2., since they result from use of biological carbon and do not contribute to net CO₂ emissions. Solvent emissions related to production of margarine and vegetable oils are reported in category 3.D. Animal fats are thus included in the source category "Margarine and solid and hardened fats". CO₂ used in sugar production, which is obtained from burning of limestone, is bound during the production process. Therefore, that process is not emissions-relevant (cf. UFOPLAN research project FKZ 205 41 217/02); UBA, 2006).

Emissions of the food and drink industry are reported, in summary form, in the inventory in "Table2(I)s2" of the sectoral report for industrial processes. In the table "Background data of the sectoral report for industrial processes" ("Hintergrunddaten des sektoralen Reports für Industrielle Prozesse"), "Table2(I).A-G", the IEF is listed as NE, since the pertinent CO₂ emissions are reported under CRF 1.A.2.

Pursuant to the IPCC, emissions reporting for the food and drink category covers the following products:

Alcoholic beverages

- Wine
- Beer
- Spirits

Bread and other foods

- Meat, fish and poultry
- Sugar
- Margarine and solid and hardened fats
- Cake, cookies and breakfast cereals
- Bread
- Animal feedstuffs
- Coffee roasting

Default emission factors for NMVOC emissions relative to these products are listed (IPCC, 1996c: p. 2.41f).

4.9.2.2 Methodological issues (2.H.2)

For emissions calculations, national emission factors were used where available. Otherwise, the emission factors recommended by IPCC and CORINAIR were used. The basis for selection of emission factors consists of the research report "Emissions from the food industry" ("Emissionen

aus der Nahrungsmittelindustrie") (FKZ 206 42 101/01; IER, 2008). The procedure is in keeping with that described in the NIR 2013.

For category 2.H.2, a total of 14.5 kt of NMVOC emissions result for 2015. Of those, 4.0 kt NMVOC are from sugar production and 3.5 kt NMVOC are from production of spirits.

4.9.2.3 Uncertainties and time-series consistency (2.H.2)

The uncertainties in the activity data are estimated to amount to 5-20 %. Further information about the relevant uncertainties is provided in the NIR 2013.

4.9.2.4 Category-specific quality assurance / control and verification (2.H.2)

Due to resources limitations, and to the area's minimal relevance, no QC/QA is carried out for reporting relative to precursors.

Other countries' reports contain very little information about 2.H.2, and thus no comparisons are possible at present. No comparison with ETS data is possible, since no emissions subject to emissions trading occur in 2.H.2.

4.9.2.5 Category-specific recalculations (2.H.2)

Recalculations for the year 2014 were carried out, to take account of minor updating of statistical data in the area of production of spirits.

NMVOC	2014 [t]	new, 2014 [t]	Change
Spirits	3,372	3,456	+ 3%
Total	14,708	1.4793	+ 1%

4.9.2.6 Planned improvements, category-specific (2.H.2)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

4.9.3 Other (2.H.3)

Gas	Method used	Source for the activity data	Emission factors used
HFC, PFC, SF ₆	cf. Table 194/Table 196	cf. Chapter 4.7.5 / Chapter 4.8.2	cf. Table 194/Table 196

Emissions of SF₆ from use in *Athletic shoes* (2.G.2.d. Adiabatic properties – Athletic shoes), use in *AWACS maintenance* (2.G.2.a Military uses) and use in *welding* (2.G.2.e Other – Welding) are reported 2.H.3, for reasons of confidentiality.

HFC emissions from use of the solvents HFC-43-10mee, HFC-245fa, HFC-365mfc and C₆F₁₄ (2.F.5) are also reported under 2.H.3.

PFC emissions from use in athletic shoes (2.G.2.d Adiabatic properties – Athletic shoes), and the use of perfluorodecalin in *medical and cosmetic applications* (2.G.2.e Other – Medical and cosmetic applications), are also reported under 2.H.3.

In keeping with a recommendation of the Expert Review Team, it is noted that all information relative to the emissions reported under 2.H.3 – including category description, methodological issues, uncertainties & time-series consistency, category-specific recalculations & verification and planned improvements – is presented in the pertinent category chapters.

In addition to reporting on greenhouse gases subject to reporting obligations, Germany has decided to report on the greenhouse gases shown in Table 205, which are not subject to reporting obligations. This reporting covers the applications of relevance in Germany, which are also listed as such in the table. For reasons of confidentiality, Table 206 shows the emissions of these greenhouse gases, which are not subject to reporting obligations, in aggregated form.

Table 205: Overview of voluntarily reported fluorinated greenhouse gases, their global warming potentials (GWP) and their areas of application

Greenhouse gas	Formula	GWP	Area of application	QG
HFC-1234yf		4 ¹	Commercial refrigeration Refrigerated transports Mobile air conditioning systems	2.F.1.a 2.F.1.d 2.F.1.e
HFC-1234ze		7 ¹	Commercial refrigeration Stationary air conditioning systems XPS foams General-purpose aerosols	2.F.1.a 2.F.1.f 2.F.2.a 2.F.4.b
HCFE-235da2 (isoflurane)	CHF ₂ OCHClCF ₃	350	Inhaled anaesthetic	2.G.2.e
HFE-236ea2 (desflurane)	CHF ₂ OCHF ₂ CF ₃	989	Inhaled anaesthetic	2.G.2.e
HFE-347mmz1 (sevoflurane)	CH ₂ FOCH(CF ₃) ₂	216 ²	Inhaled anaesthetic	2.G.2.e
PFPE/PFPMIE	CF ₃ (OCF(CF ₃)CF ₂) _n (OCF ₂) _m OCF ₃	10,300	ORC systems	2.G.4

Unless indicated otherwise, the GWP figures come from the 4th IPCC Assessment Report.

¹ GWP value pursuant to Regulation (EU) No. 517/2014 ²GWP value pursuant to information provided by producers

Table 206: Aggregated greenhouse emissions of the additional greenhouse gases – which are not subject to reporting requirements – HFC-1234yf, HFC-1234ze, HCFE-235da2, HFE-236ea2, HFE-347mmz1 and PFPE/PFPMIE

Year	Emissions, in t CO ₂ equivalents
1990	3,038
1991	3,795
1992	4,619
1993	5,512
1994	6,474
1995	7,504
1996	13,874
1997	20,026
1998	26,671
1999	33,809
2000	41,439
2001	47,758
2002	54,433
2003	61,463
2004	68,849
2005	76,591
2006	88,534
2007	95,727
2008	101,095
2009	108,838

Year	Emissions, in t CO ₂ equivalents
2010	116,013
2011	122,420
2012	129,802
2013	129,984
2014	120,964
2015	120,835

No other sources of emissions of fluorinated greenhouse gases are known.

5 Agriculture (CRF Sector 3)

5.1 Overview (CRF Sector 3)

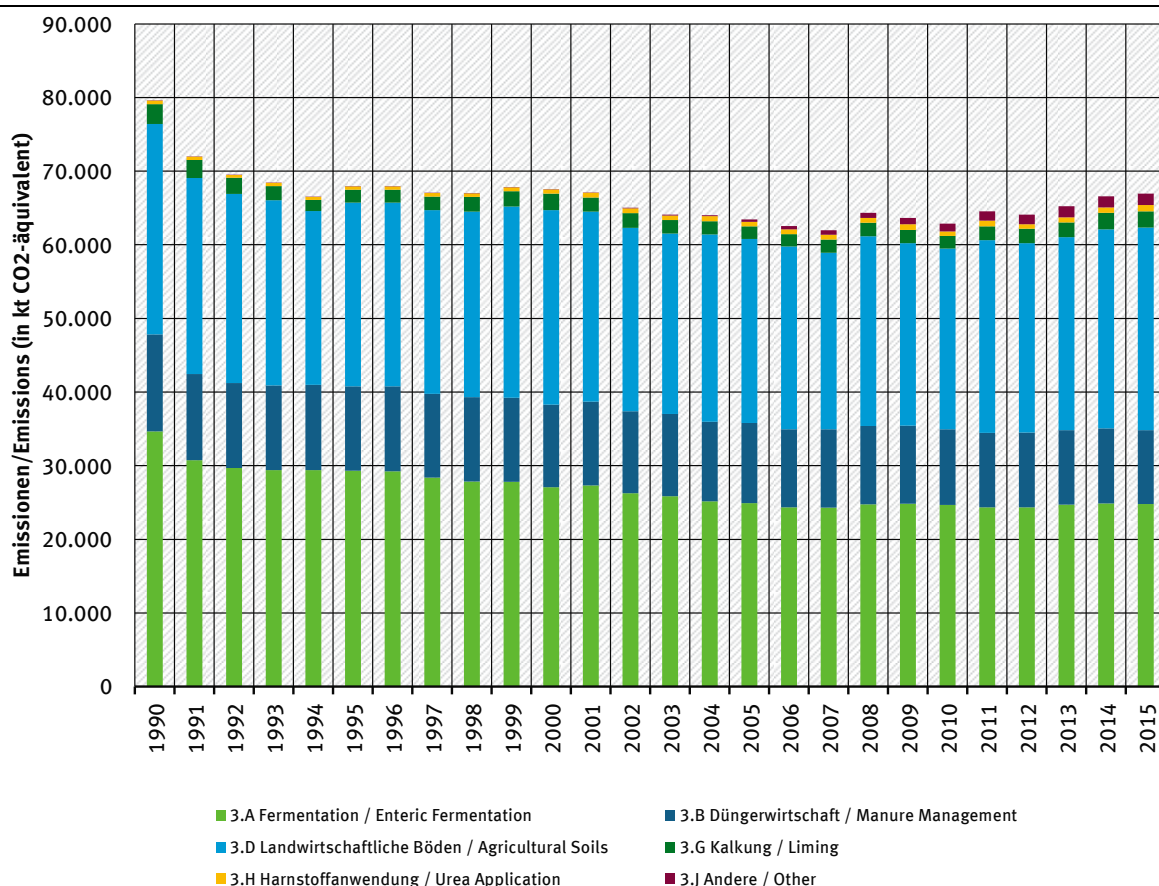
5.1.1 Source categories and total emissions, 1990 –2015

In source category 3, "Agriculture", Germany reports on emissions from enteric fermentation (3.A), from manure management (including manure digestion and storage of digestates of manure) (3.B), from use of agricultural soils (3.D) and from liming (3.G) and from use of urea (3.H). The NIR also reports on emissions occurring in connection with digestion of energy crops (3.J: Emissions from digestion of energy crops and from storage of digestates; 3.D: Emissions from application of digestates).

Emissions from rice cultivation (3.C) do not occur in Germany, while clearance of land by prescribed burning (3.E) is not practiced in Germany (NO). Field burning of crop residues (3.F) is prohibited in Germany (NO). The CO₂ emissions to be reported in sector 3.I (other lime fertilizers) are included in 3.G; for this reason, "IE" is listed under 3.I.

For the present 2017 NIR, Figure 46 provides an overview of the development of greenhouse-gas emissions, since 1990, in the areas 3.A, 3.B, 3.D, 3.G, 3.H and 3.J. The pertinent data have been calculated with the GAS-EM inventory model (cf. Chapter 5.1.2).

Figure 46: Overview of greenhouse-gas emissions in CRF Sector 3



5.1.2 The GAS-EM emissions-inventory model

5.1.2.1 Guidelines applied, and detailed report

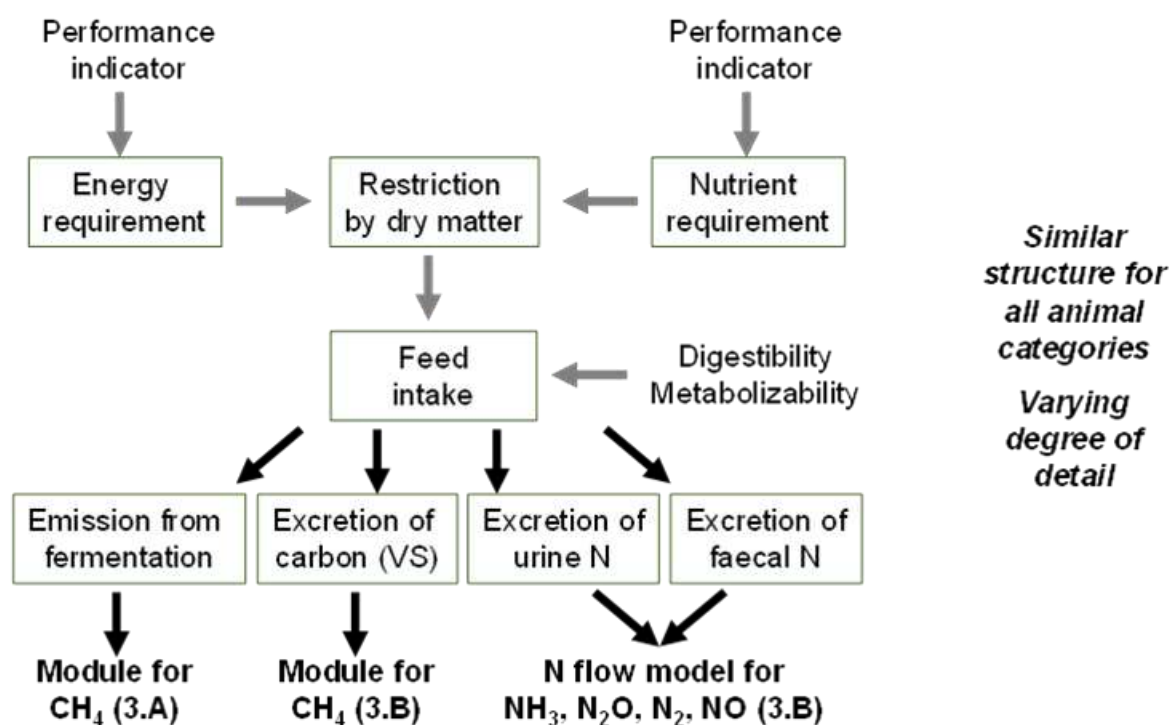
The GAS-EM emissions-inventory model is based primarily on the relevant sets of guidelines (greenhouse gases: IPCC 2006a, 2006b; air pollutants, especially NH_3 : EMEP, 2007; EMEP, 2009; EMEP, 2013). The aforementioned guidelines present no methods for calculation of emissions from digestion of energy crops.

Over the past few years, many of the methods described in the guidelines have been refined for purposes of the GAS-EM model. And a national method has been developed for calculation of emissions from digestion of energy crops. A comprehensive description of the GAS-EM inventory model, including listings of relevant additional sources, is presented in the pertinent detailed report (RÖSEMANN et al., 2017)⁸³. The following remarks summarize that detailed report.

5.1.2.2 Basic structure of the GAS-EM emissions-inventory model

Feed intake serves as the basis for emissions calculations in the animal husbandry sector. It is calculated as a function of basic and yield-related energy requirements, as Figure 47 shows with the example of dairy cows. That approach provides the CH_4 emissions from enteric fermentation (3.A), as well as the carbon and nitrogen excretions data needed to calculate emissions from management of manure and digested slurry (3.B). The latter, in turn, enter into calculations of nitrogen discharges into agricultural soils (3.D).

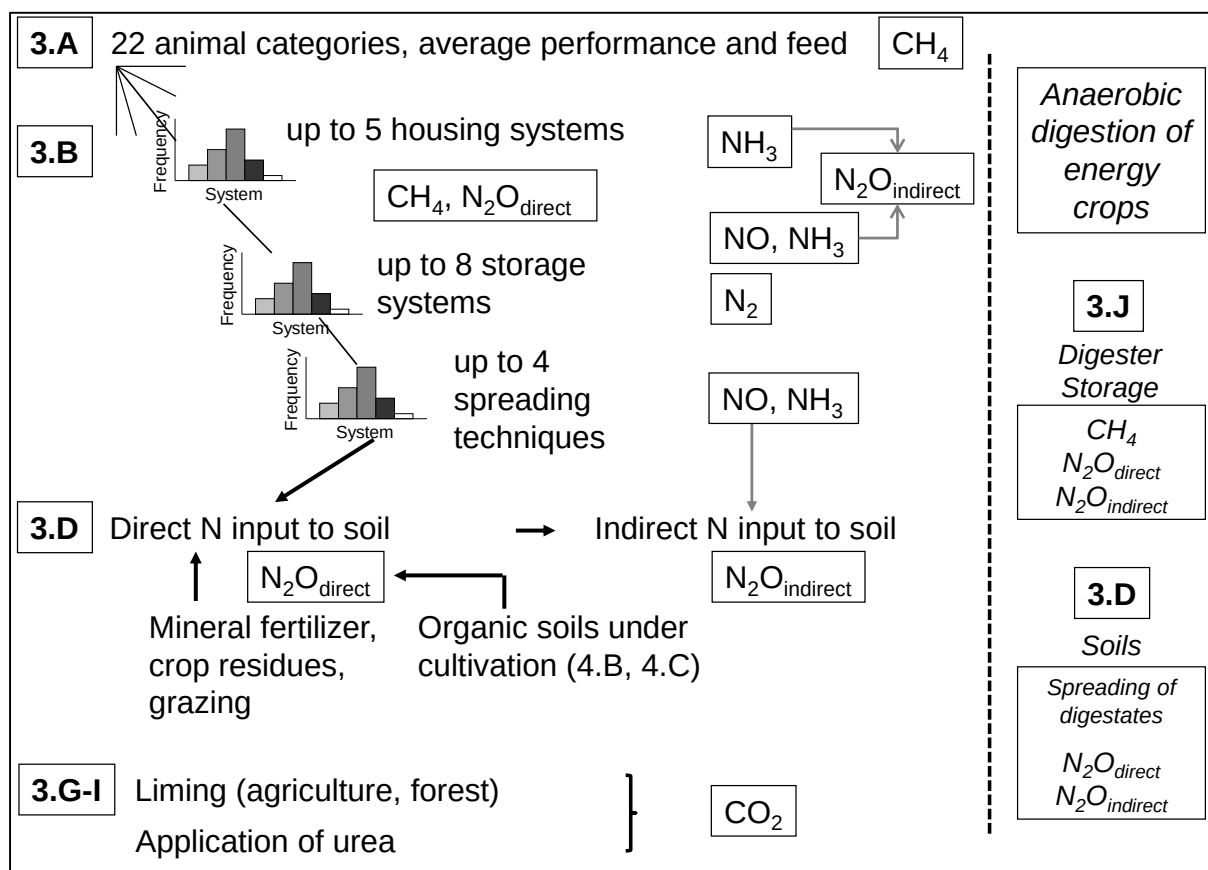
Figure 47: Logical structure behind national methods for calculating emissions from animal husbandry, illustrated with the example of dairy cows. ("Performance indicator" stands for the sum of basic and performance-related requirements.)



⁸³ An electronic version of the detailed report is available from: dieter.haenel@thuenen.de, claus.roesemann@thuenen.de.

Figure 48 shows how the GAS-EM model, for purposes of calculations in categories 3.A and 3.B, first differentiates between animal categories and sub-categories and then further subdivides those categories into housing systems, storage systems (with digestion as a separate storage system) and procedures for spreading of manure and digestates. CH₄ emissions are calculated separately for each animal sub-category in 3.A and 3.B. For categories 3.B and 3.D, N₂O emissions are calculated on the basis of an N-flow concept (cf. Chapter 5.1.2.4). In categories 3.G-I, CO₂ emissions are calculated for liming and urea application. In conformance with the IPCC's guidelines, these calculations also include the area of liming in forests. Emissions from digestion of energy crops are calculated in two separate sections: Emissions from digesters and storage of digestates, in 3.J; and emissions from soils, as a result of spreading of digestates, in 3.D.

Figure 48: Concept and thematic content behind the GAS-EM model



5.1.2.3 Treatment of CH₄ within the emissions inventory

The GAS-EM inventory model is used to calculate CH₄ emissions from enteric fermentation and VS excretions of agricultural livestock (cf. Chapters 5.2 and 5.3.2), taking account of slurry-based and straw-based systems and their typical forms of storage. Anaerobic digestion of manure and energy crops, in biogas plants, is included in the calculations (cf. Chapters 5.1.3.6.5 and 5.1.4).

5.1.2.4 The nitrogen-flow concept (3.B, 3.D)

With the GAS-EM model, N-species emissions are calculated on the basis of the N-flow concept (DÄMMGEN & HUTCHINGS, 2005, RÖSEMAN et al., 2017).

To make it possible to apply the concept, the N amounts excreted in animal husbandry have to be determined. For dairy cows, heifers, male beef cattle, swine, laying hens, pullets, broilers, ducks and turkeys, males and hens, N excretions are calculated as the difference between the amount of

N taken in with feed and basic and yield-based N requirements (animal weight, weight gain, annual milk production or egg production (i.e. numbers of eggs) and, if relevant, numbers of young). The N intake with feed is determined on the basis of animal energy requirements and the energy and N content of the feed. For other animals, N-excretion data are taken from the pertinent German technical literature (cf. in this regard RÖSEMANN et al., 2017).

In the case of N excretions, a distinction is made between the two fractions "organic N" and "TAN readily converted into NH_3 " (TAN – "total ammoniacal nitrogen"). TAN is present in the urine of mammals; in the GAS-EM model, in each case TAN is considered to be equivalent to the N content of urine. Poultry excrete "UAN" (uric acid nitrogen); in the inventory, UAN is treated as TAN. As a result of the manner in which the relevant emission factors are defined, NH_3 emissions are calculated primarily in proportion to the available TAN quantity, while N_2O emissions, NO emissions and N_2 emissions are calculated in proportion to the available N quantity. For this reason, the calculations take account of two parallel N pools. These are (1) the entire N quantity available at the relevant stage being considered, i.e. the sum of organic N and TAN, and (2) TAN by itself.

The N excretions determined for a given animal category are divided into stable emissions and pasture emissions. This division is made in accordance with the percentages of time the relevant animals spend in the stable and in pasture.

In the case of solid-manure systems, N inputs from bedding material are also taken into account, along with N excretions.

For each animal category, the amounts of N occurring in housing systems are divided in accordance with the relative shares of the animal-housing systems commonly used in Germany. N losses via NH_3 emissions are subtracted from the TAN pool and from the total N pool. The remaining N and TAN amounts for all stables are combined separately, for slurry-based systems and then for straw-based systems, and are transferred into the correspondent storage systems.

The N removed via air-scrubbing systems is treated as TAN, as if it were directly applied with manure (see below).

The total N and TAN amounts (for solid-manure systems, including the N inputs from straw bedding) accruing to the storage systems are divided, separately for the categories solid manure and slurry, among the different storage systems commonly used in Germany, in keeping with the applicable percentage shares. Anaerobic digestion of manure in biogas plants is included in the calculations (cf. Chapter 5.1.3.6.5). From storage, NH_3 emissions from the TAN pool and the total N pool occur. The N losses occurring via emissions of N_2O , NO and N_2 are calculated as a total, for housing systems and for storage systems, and then subtracted from the total N pool. At the same time, these N losses are subtracted from the TAN pool, in a manner in keeping with the ratio of the TAN quantity to the total-N quantity. The remaining N / TAN quantities are spread, with the N removed via air-scrubbing systems being added to the TAN pool.

The amount of N applied is divided among the different application techniques commonly used in Germany, taking account of the different durations of manure incorporation commonly observed. This is carried out in accordance with the different application techniques' relative proportions of the total amount of manure applied, differentiated by animal category and by the categories of solid manure and liquid manure. The N_2O emissions released from agricultural soils as a result of application of manure, and of digestates of manure, are calculated in proportion to the N quantity applied.

The total-N quantity excreted during grazing yields the N quantity available in the soil that is used for calculation of N₂O emissions from grazing.

The N flows that occur in connection with digestion of energy crops, and with storage and spreading of the resulting digestates, are treated separately from the N flows for animal husbandry. The former are calculated on the basis of the N quantity in the digested energy crops (cf. Chapter 5.1.4.2), via a procedure analogous to that described above for animal N excretions.

In a procedure analogous to that used for manure application, the N₂O emissions from agricultural soils, resulting from application of mineral fertilizer, are calculated in proportion to the N quantity applied.

5.1.3 Characterization of animal husbandry

5.1.3.1 Animal categories (3.A, 3.B)

For calculation of emissions from animal husbandry in German agriculture, animal stocks are divided into sub-categories, to permit description of sub-stocks that are homogeneous with regard to yield and to housing systems. Table 207 compares the animal categories to be reported on in the in CRF tables with the animal categories used in the German inventory.

The CRF categories "mules and asses" and "buffalo" are reported as "IE", since the numbers of animals in those categories are included in the figures for "horses" and "other cattle" (cf. Chapter 5.1.3.2.2).

The categories deer, rabbits, ostriches and fur-bearing animals are not reported in the CRF tables under IPCC (2006a), because their contribution to the total emissions is less than 0.05 % of the overall inventory or 500 kt CO₂ equivalents (pursuant to FCCC/SBSTA/2013/L.29/Add.1), and since it cannot be assured that annual inventories of such emissions (pursuant to FCCC/SBSTA/2013/L.29/Add.1, para 37) will be carried out. The emissions contributions from those categories are estimated in Chapter 19.3.1. All those sources for which no emissions are reported ("NE" is entered) are listed in Chapter 21.

Table 207: CRF animal categories, and the subdivisions used for purposes of German emissions reporting (3.A, 3.B)

CRF animal categories		Animal categories in the German inventory
1	Dairy cows	"Dairy cows" ^a
	Other cattle	"Calves" (to 4 months old) ^a Young female cattle as of 4 months old ("heifers") ^a Young male cattle as of 4 months old ("male beef cattle") ^a "Suckler cows" ^a "Male cattle older than 2 years"
2	Sheep	"Mature sheep" "Lambs"
3	Swine	"Sows" (incl. suckling piglets to 8 kg) "Weaners" "Fattening pigs" "Boars"

CRF animal categories	Animal categories in the German inventory
4	Buffalo
	Camels
	Deer
	Goats
	Horses
	Mules and asses
	Poultry
	Rabbits
	Reindeer
	Ostriches
	Fur-bearing animals

^a In the years through 2012, the German inventory included buffalo with suckler cows; as of 2013, the official animal-population figures for the categories "other cattle" and "dairy cows" include buffalo. The buffalo data cannot be separated out from those figures.

^b These animals do not occur in Germany.

^c These animals are not reported on, since their emissions contribution is insignificant; cf. Chapter 19.3.1.

^d In the years through 2009, the German inventory included mules and asses with light horses and ponies; as of 2010, the official animal-population figures for horses include mules and asses. The data for those animals cannot be separated out from the horse figures.

5.1.3.2 Animal place data (3.A, 3.B)

The terms "animal place" and "place" (as units: pl) as used in the German inventory are in keeping with the definition of "average annual population" (AAP) in EMEP (2013), p. 13, and IPCC (2006a)-10.8, equation 10.1. The term refers to an average animal place that is continuously occupied for production purposes. This definition of animal place is consistent with the assumption, used in the German inventory, that the numbers of animals determined by official statistics, as of a specific reference date (cf. Chapter 5.1.3.2.1), are constant throughout the year.

In the following, "numbers of animals" and "animal population" / "animal-population figures" are used interchangeably with "animal places".

5.1.3.2.1 Surveys of the Federal and Länder statistical offices

The Federal Statistical Office and the statistical offices of the Länder (German states) carry out agricultural-structure surveys⁸⁴ that, in addition to collecting other data, carry out censuses of cattle, swine, sheep, horses (as of 2010: equids) and poultry. In the periods 1990 – 1996 and 1999 – 2007, such agricultural structural surveys were carried out every other year. In 2010, they were then carried out in the framework of the 2010 agricultural census (Landwirtschaftszählung 2010 – LZ 2010)⁸⁵, a more extensive census. Thereafter, they were not carried out again until 2013.

⁸⁴ <https://www.destatis.de/DE/Meta/AbisZ/Agrarstrukturhebung.html>

⁸⁵

<https://www.destatis.de/DE/ZahlenFakten/Wirtschaftsbereiche/LandForstwirtschaft/Landwirtschaftszaehlung2010/Ergebnisse.html>

The 1990, 1992, 1994 and 1996 surveys were each carried out on 3 December. Surveys during the years 1999 –2007 were referenced to 3 May, while the 2010 and 2013 surveys were referenced to 1 March.

In addition to agricultural-structure surveys, annual livestock censuses are carried out (STATISTISCHES BUNDESAMT, Fachserie 3, Reihe 4.1). Through 1998, such surveys were carried out semiannually for cattle and sheep (June, December), every four months for swine (April, August, December), and every two years, in even-numbered years (in December), for all animal species, i.e. also for horses and poultry. In each case, the reference date was the third calendar day of the pertinent month. Since 1999, the livestock census for cattle and swine has been carried out twice annually, as of the reference dates 3 May and 3 November. For the sheep census, the reference date was 3 May in the period 1999 through 2009. As of 2011, it has been 3 November, while in 2010 it was 1 March.

Census data from official surveys are thus available for cattle, swine and sheep for all years since 1990. In the inventories through 1998, the December data were used (for sheep, the June data). Thereafter, through 2010, the May data were used. As of 2011, by agreement with the Federal Statistical Office, the November reference date is to be used (EU Regulation No 1165/2008, Article 4). These figures are in keeping with the figures the Federal Statistical Office has provided to EUROSTAT. The change in the reference date, to 3 November, does not significantly affect the population figures in the case of cattle and swine. Among the figures for sheep, livestock-population figures had to be corrected; cf. Chapter 5.1.3.2.2.

The numbers of goats in Germany were not surveyed between the years 1977 and 2010. Until 2004, the Federal Ministry of Food and Agriculture (BMEL) estimated goat populations at the national level. As of 2005, the pertinent time series was continued via estimation by the Federal Statistical Office. In 2010, the total number of goats (reference date: 1 March) was officially determined for the first time, in the framework of the 2010 agricultural census (LZ 2010). The resulting figure is considerably lower than the estimates used in for earlier years. By agreement with the Federal Statistical Office, those estimates, which are also reported to EUROSTAT, continue to be used in the inventory. An official goat-population figure obtained by the Federal Statistical Office is available for 2013 (reference date: 1 March). The Federal Statistical Office has not collected poultry-census data for 2014 and 2015.

For horses / equids, and for poultry, population figures are available only at intervals of two to three years, from agricultural-structure surveys (reference dates: through 1998, 3 December; 1999 –2007, 3 May; 2010 and 2013, 1 March). By agreement with the Federal Statistical Office, the population figures have not been adjusted to take account for the variations in reference dates.

The 2013 poultry counts carried out by the Federal Statistical Office and the statistical offices of the Länder were tied to a revision of the relevant reporting groups. The revision was carried out because previous surveys (most recently, in 2010) had failed to take account of a number of large poultry flocks, due to the then-applicable rules for selection of the farms to be surveyed. The poultry counts obtained in 2013 are thus considerably higher than the surveys from prior years would have led one to expect. The Federal Statistical Office has not corrected the official poultry counts for relevant earlier years through 2010. As a result, while the counts used in the inventory for the period 2010 through 2013 show a marked increase, that increase cannot be interpreted as a meaningful trend in actual poultry populations. The Federal Statistical Office has not collected poultry-census data for 2014 and 2015.

For purposes of inventory calculations, and in the interest of conformance with emissions-reporting requirements, a number of data gaps had to be closed, and some of the animal-place

figures had to be adjusted. These changes, and the manner in which buffalo, mules and asses are taken into account, are discussed in Chapter 5.1.3.2.2.

5.1.3.2.2 Special aspects of animal-place figures in the inventory

Since 2008, cattle-population figures have been taken from the HIT database (Herkunftssicherungs- und Informationssystem für Tiere ("origin-tracing and information system for animals"; <http://www.hi-tier.de>) of the Bavarian State Ministry for Food, Agriculture and Forestry (Bayerische Staatsministeriums für Ernährung, Landwirtschaft und Forsten –StMELF), in which all cattle are individually registered. Via the new survey method, systematically higher population figures result for years as of 2008 than result for earlier years in which not all animals were counted, due to the survey thresholds applied. A comparison carried out by the Federal Statistical Office for 2007 reveals that the population figures for cattle shown in HIT are 2.9 % higher than those resulting via the conventional survey method (for dairy cows alone, the population figures are 2.8 % higher). The Federal Statistical Office reports that the cattle time series for the period prior to 2008 will not be adjusted in this regard. As a result, emissions from keeping of cattle are slightly underestimated for the years 1990 to 2007. In the interest of obtaining maximally homogeneous animal categories, some of the cattle categories used in official surveys have been modified for purposes of the inventory (RÖSEMANN et al., 2017).

As of the time-series year 2013, the cattle population data provided by the Federal Statistical Office also include bison and buffalo. The buffalo numbers cannot be extracted from such aggregate cattle data. As a result, as of the time-series year 2013 the buffalo emissions are included in the cattle emissions. Consequently, as of the 2015 submission buffalo are no longer treated as a separate category in the inventory (included elsewhere, IE). The emissions produced by buffalo in the time-series years 1990 through 2012 are taken into account in the inventory by adding the buffalo populations to the numbers of suckler cows. On the other hand, the Federal Statistical Office has not published any buffalo counts. For this reason, figures of the Deutscher Büffelverband (German buffalo association) have been used for the period as of 2000. In keeping with a recommendation in the final report for the "Initial Review under the Kyoto Protocol and Annual 2006 Review under the Convention", for the years prior to 2000 the time series for the buffalo population at the national level was completed via linear extrapolation. For the years 1990 through 1995, mathematically negative population figures result; they are replaced with zeros.

For swine as well, several of the categories used in official surveys have been modified with a view to obtaining maximally homogeneous animal categories. The official numbers of animals for piglets weighing up to 20 kg animal⁻¹, and for young pigs and fattening pigs weighing at least 20 kg animal⁻¹, have been converted, using the procedure described in HAENEL et al. (2011), into numbers of animals for the inventory categories "weaners" and "fattening pigs". Because this conversion is based partly on weight data, updating of such data normally leads to some shifting of animal-number data between the two categories "weaners" and "fattening pigs." The current submission includes a pertinent case; cf. Chapter 5.1.3.3. This conversion of numbers of animals has no impact on the total number of swine, however. For purposes of emission calculation, the number of piglets weighing up to 8 kg is deducted from that total number, however. This is done for the reason –conceptually based –that piglets weighing up to 8 kg are considered suckling piglets that, with regard to their emissions, are implicitly included in calculations for sows.

The official population numbers for sheep have been corrected for all years as of 2010 (RÖSEMANN et al., 2017). This has been done to take account of the change in the relevant survey date from spring (until 2009, May / June) to 1 March (2010) and to 3 November (since 2011). The

correction compensates for the apparent reduction in the number of lambs that this change entails (as well as the corresponding reduction in the total number of sheep).

Official goat-population figures are available for 2010 and 2013. Those figures were used as a basis for calculating, via linear interpolation, (otherwise unavailable) goat-population figures for 2011 and 2012. The goat figures lacking for 2014 and 2015 have been estimated via extrapolation of the trend prevailing between 2010 and 2013.

In the inventory, population figures for horses are subdivided into the two categories "heavy horses" and "light horses and ponies", to take account of the differences in emissions behaviour between the two categories.

In the 2010 and 2013 agricultural censuses, "numbers of equids", rather than numbers of horses, were counted. The equid figures include the counts for mules and asses. The numbers for mules and asses cannot be separated out of the equid data (included elsewhere, IE). As of the 2015 submission, therefore, the inventory no longer includes "mules and asses" as a separate category. Until the year 2009, the counts for mules and asses were added to the counts for light horses and ponies. In keeping with data of the INTERESSENGEMEINSCHAFT FÜR ESEL UND MAULTIERE (INTEREST ASSOCIATION FOR MULES AND ASSES –(IGEM), the applicable number for mules and asses has been estimated at 8,500 mules and asses per year. Gaps within the time series for horses have been filled in via linear interpolation. The goat figures lacking for 2014 and 2015 have been estimated via extrapolation of the trend prevailing between 2010 and 2013.

Until 2007, in contrast to actual housing practice (placement in stalling systems, as laying hens, as soon as they complete their 18th week of life; this is also the practice taken into account in the inventory) pullets were officially counted until they reached the age of 6 months. In the inventory, therefore, a fraction of the pullets was shifted into the laying-hen category, while the sum total for pullets and laying hens was not changed (RÖSEMANN et al., 2017). The next poultry count, after 2007, took place in 2010. As of that count, shifting of figures between the pullet and laying-hen categories is no longer required, since the relevant populations have been counted in keeping with actual housing practice. No survey figures are available for 2014 and 2015. The figures for that year have been estimated on the basis of the value for 2013, since the 2010 figure is unsuited, due to a decline in animal populations (as a result of the ban on cage housing applying as of 2010), for trend estimates followed by extrapolation for 2014 and 2015.

The animal-population figures lacking for 2014 and 2015, for the other poultry categories, have been estimated on the basis of the relevant figures for 2013, as well as of the trend prevailing between 2007 and 2010. The trend prevailing between 2010 and 2013 was not suitable for this purpose, because that trend is considerably distorted as a result of a revision in reporting groups that led to the inclusion of numerous previously uncounted animal populations (cf. Chapter 5.1.3.2.1).

In the inventory, the official census data for turkeys were broken down by the categories "turkeys, males" and "turkeys, females", for all years since 1990, to take account of the pertinent differences in growth.

5.1.3.2.3 Animal place data used in the inventory (3.A, 3.B)

Table 208 presents a compilation of the animal-place figures on which German reporting is based. With regard to the uncertainties for the animal numbers, cf. Table 249 in Chapter 5.1.6.

Table 208: Animal-place figures used in German reporting (3.A, 3.B), in thousands

[in thousands]	Dairy cows	Other cattle	Swine	Sheep	Goats	Horses	Poultry
1990	6,355	13,133	26,502	3,266	90	499	113,879
1995	5,229	10,661	20,387	2,991	100	634	111,228
2000	4,570	9,969	21,768	2,743	140	500	120,180
2005	4,236	8,800	22,743	2,643	170	508	120,560
2006	4,082	8,668	22,418	2,561	180	529	124,512
2007	4,071	8,617	22,985	2,538	180	550	128,463
2008	4,218	8,754	22,678	2,437	190	521	128,608
2009	4,205	8,742	23,022	2,350	220	491	128,754
2010	4,183	8,629	22,244	2,245	150	462	128,900
2011	4,190	8,340	22,788	1,980	143	462	145,044
2012	4,190	8,319	23,648	1,966	137	461	161,189
2013	4,268	8,418	23,391	1,877	130	461	177,333
2014	4,296	8,447	23,667	1,892	124	461	180,421
2015	4,285	8,351	22,979	1,867	117	461	183,508

5.1.3.2.4 Comparison with livestock-population figures of the FAO (3.A, 3.B)

The United Nations Food and Agriculture Organization (FAO) publishes global livestock-census data in its FAOSTAT Internet database (<http://faostat3.fao.org>). In general, the German figures in FAOSTAT come from the German Federal Statistical Office, which is also the data source for the livestock-population figures in the German inventory. Nonetheless, a comparison of the data in FAOSTAT (as of 20 June 2016: time series through 2014) and the inventory shows numerous discrepancies. Minor differences can be attributed to rounding errors. In the comparison, such errors were considered to be not relevant, and the relevant data were classified as being "in agreement." The main reasons for the differences between the FAOSTAT data and the German data are that FAOSTAT has placed a number of entries under the wrong years, and that it is inconsistent in its choice of methods for closing data gaps. In the following section, the most important results of the data comparison are listed.

Cattle (including buffalo): For the years 2011 –2013, the two sources differ in that FAOSTAT contains May-census data, while the inventory contains November-census data. For the period prior to 2000, the FAO figures have been entered in a year that is one year off the correct year (for example, the cattle-census figures listed for 1999 are actually figures for 1998).

Swine: In general, the swine-census figures listed by the FAO cannot be compared with the corresponding inventory figures, since the inventory always deducts the numbers of piglets that weigh less than 8 kg (cf. Chapter 5.1.3.2.2). A comparison of a) the FAOSTAT figures and b) figures of the Federal Statistical Office without deduction of suckling piglets shows that the FAOSTAT figures, like the FAOSTAT cattle-census figures for the period prior to 2000, are shifted by one year. The FAOSTAT data for the period 2011 –2013 are taken from May censuses, while the inventory data are taken from November censuses.

Sheep: In the periods 1993 –2000 and 2005 –2009, the two sets of figures show good agreement. In the periods 1990 –1992 and 2001 –2004, there are discrepancies –some of them large –that cannot be explained with the available information. As of 2010, the FAO's sheep-census figures cannot be compared with the corresponding inventory figures, since the inventory figures are corrected figures (cf. Chapter 5.1.3.2.2).

Goats: FAOSTAT does not list goat counts explicitly, as such; it includes them in a "sheep & goats" time series. By subtracting from those figures the figures in the FAOSTAT "sheep" time series, one obtains the time series for the goat counts. For the years prior to 2003, those figures are shifted by one year with respect to the relevant German statistics (the FAOSTAT goat count for 1991 is the same as the German goat count for 1990, etc.). For the years 2003, 2005, 2007, 2010 and 2013,

the FAOSTAT figures agree with the corresponding German figures. For the years in between, there are discrepancies, resulting –on the FAOSTAT side –from carry-forwards of old data and use of uncorrected estimates. The origins of the FAOSTAT goat counts for 2011 and 2012, in particular, are unclear.

Horses (including mules and asses): The FAOSTAT figures for the period prior to 2010 list horse-only counts, i.e. do not include mules and asses. If one subtracts, for purposes of comparison, the added figures for mules and asses (cf. Chapter 5.1.3.2.2) from the inventory figures, one obtains good agreement for the years 1994, 2003 and 2007, and approximate agreement for the years 1996 and 2005. The FAOSTAT figure for 2013 agrees with the German figure. Because that figure, implicitly, already includes mules and asses, the FAOSTAT figure also includes those animal categories. Discrepancies –considerable, in some cases –occur between the FAOSTAT figures and the German figures in all of the post-1990 years not mentioned in this context. The reasons for the discrepancies include one-year shifts in the FAOSTAT figures. Other discrepancies, especially those occurring in the years between 2008 and 2013, cannot be explained with the available information. The sharp disagreement seen in the FAOSTAT estimate for 2014 can be explained as the result of continuation of a trend that had already been incorrect in earlier years.

Poultry: The poultry counts largely agree for nearly all years with animal censuses (1994, 1999, 2003, 2005, 2007, 2010 and 2013). It seems clear that in FAOSTAT the results of the censuses of the years 1990, 1996 and 2001 have been erroneously entered in the following year in each case. The manner in which FAOSTAT has closed the gap in the data between 2010 and 2013 does not seem at all systematic, nor does FAOSTAT seem to have used any systematic approach to obtain its estimate for 2014. The relevant FAOSTAT figures differ considerably from the inventory data as a result.

5.1.3.3 Yield, energy and feed data (3.A, 3.B)

To calculate emissions in accordance with a Tier 2 method, one requires data on animal yield (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 feed (phase feeding, feed components, protein and energy content, energy metabolizability and digestibility of organic matter). To divide the total numbers of turkeys, as reported by the Federal Statistical Office, into cocks and hens, one must know the applicable sex ratio. For the most part, such data are not available from official statistics. In the present case, such data were obtained from the open literature, from association publications, from regulations for agricultural consulting in Germany and via surveys of experts.

Table 209 shows the mean animal weights for dairy cows, other cattle, swine and poultry. In the cattle and swine categories, updating of animal weights has led to slight discrepancies with respect to the 2016 Resubmission. For details on calculation of average animal weights, cf. RÖSEMANN et al. (2017).

Table 209: Average animal weights (3.A, 3.B)

[kg animal ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	607.9	618.7	641.9	646.7	648.6	651.2	642.6	641.9	646.8	647.8	646.1	645.7	645.2	649.7
Other cattle	338.7	351.1	367.7	365.4	369.4	371.8	365.7	366.0	367.8	365.6	365.2	367.1	367.0	369.6
Swine	66.7	69.0	67.3	67.0	66.9	66.9	66.6	66.7	65.3	64.1	63.7	63.6	63.7	63.3
Poultry	1.63	1.60	1.69	1.78	1.79	1.78	1.76	1.79	1.78	1.74	1.72	1.69	1.69	1.68

The animal weights for sheep, goats and horses (cf. RÖSEMANN et al., 2017) do not enter into the emissions calculations, but they have been estimated for the purposes of CRF-3.B (average weights

for sheep and horses, to take account of the inclusion of both large and small animals): Sheep, 50 kg animal⁻¹; goats, 40 kg animal⁻¹; and horses, 490 kg animal⁻¹.

Table 210 shows the mean daily milk yield for dairy cows; it is obtained by dividing the annual milk yield by 365 days.

Table 210: Mean daily milk yield for dairy cows (3.A)

[kg d ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Milk yield	12.93	14.80	16.65	18.53	18.77	19.03	18.69	19.11	19.41	19.84	20.06	20.12	20.66	20.90

For dairy cows, heifers, male beef cattle, sows, weaners and fattening pigs, the gross energy (GE) intake is calculated as a function of yield. Such calculations are tied to the condition that feeding exactly meets animal net-energy-for-lactation (NEL) and metabolizable energy (ME) requirements⁸⁶. The quantity of feed, of a given composition, required to meet NEL and ME energy requirements is calculated on the basis of the energy requirements and the mean NEL and ME energy content of the feed (RÖSEMANN et al., 2017). The GE intake for a given animal is calculated on the basis of the feed quantity ingested and the mean GE content of the feed. The GE intake for calves, suckler cows, male cattle older than 2 years, boars, goats, sheep and horses are calculated with the help of standard values. No GE intake is calculated for poultry.

With respect to the 2016 Resubmission, the following yield data have been changed (cf. also RÖSEMANN et al., 2017):

- **Dairy cows, heifers, male beef cattle:** The initial and final weights were updated for several years.
- **Swine:** In some German Länder (states), the data for initial and final weights, growth rates and piglets per sow were updated, for several time-series years.
- **Broilers:** The data item "total gross meat quantity obtained at slaughter" has been updated for 2013.

Table 211 shows the daily GE intake for dairy cows, other cattle and swine. In all three animal categories, slight discrepancies with respect to the 2016 Resubmission have occurred, in some years, as a result of the aforementioned changes in yield data.

Table 211: Mean daily GE intake (3.A)

[MJ place ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	259.9	277.8	295.1	310.3	311.8	314.7	310.2	314.1	317.5	320.3	321.9	321.9	326.0	328.4
Other cattle	103.3	105.5	107.0	105.5	105.8	105.6	105.1	105.5	105.3	104.8	104.3	104.4	103.8	103.8
Swine	30.2	31.8	32.6	33.0	33.1	33.2	33.3	33.8	33.8	34.0	34.3	34.5	34.8	34.9

Table 212 through Table 214 show, for dairy cows, other cattle and swine, the input data for the VS calculation on which the calculation of CH₄ emissions from manure management is based (cf. Chapter 5.3.2.2.1). The data include dry-matter (DM) intake, digestibility of organic matter and ash content of feed. The DM intake is obtained from the feed intake, taking account of the DM content of the various feed components (for details, cf. RÖSEMANN et al., 2017). The digestibility of organic matter, and the ash content of feed, are given as feed-property data (BEYER et al., 2004; information from producers); where the data are not available, suitable substitute values are used (cf. RÖSEMANN et al., 2017). The aforementioned changes in the yield data lead to slight discrepancies with respect to the 2016 Resubmission.

⁸⁶ The energy requirements for dairy cows are given in terms of the "net energy for lactation (NEL)" (cf. KIRCHGESSNER et al., 2008), while the term "metabolizable energy (ME)" is used for other animals for which the German inventory includes energy-requirements calculations (for example, cf. GfE, 2006).

Table 212: Daily DM intake

[kg ⁻¹ place ⁻¹ d ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	14.17	15.07	15.96	16.74	16.81	16.96	16.73	16.93	17.10	17.24	17.32	17.32	17.53	17.66
Other cattle	5.52	5.64	5.72	5.64	5.65	5.64	5.61	5.64	5.63	5.59	5.57	5.57	5.54	5.54
Swine	1.83	1.93	1.98	2.00	2.01	2.02	2.02	2.05	2.05	2.06	2.08	2.10	2.11	2.12

Table 213: Digestibility of organic matter in feed (3.A)

[%]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	72.9	73.4	73.9	74.4	74.5	74.5	74.4	74.5	74.6	74.6	74.7	74.6	74.8	74.8
Other cattle	72.7	72.7	72.6	72.7	72.7	72.8	72.8	72.8	72.8	72.8	72.9	72.9	72.9	72.9
Swine	84.7	84.7	84.7	84.8	84.8	84.8	84.8	84.8	84.8	84.8	84.9	84.9	84.9	84.9

Table 214: Ash content of feed

[kg kg ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	0.096	0.093	0.091	0.089	0.089	0.088	0.089	0.088	0.088	0.087	0.087	0.087	0.087	0.087
Other cattle	0.089	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091
Swine	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056

The following chapters present further information relative to animal husbandry –for example, excretion data (N, VS).

None of the animal models used call for mean percentages of pregnant animals as input figures. For cattle, they are reported in CRF Table 3.A, however, in the interest of completeness.

5.1.3.4 N excretions (3.B)

For dairy cows, heifers, male beef cattle, swine, laying hens, pullets, broilers, ducks and turkeys, males and turkeys, females, N excretions are calculated as a function of yield. For other animals, N-excretion data are derived from the pertinent German literature (cf. RÖSEMANN et al., 2017).

Calculation of N excretions as a function of yield is based on the assumption that feeding precisely meets energy requirements (cf. Chapter 5.1.3.3). The N quantity ingested by an animal is obtained from the ingested quantity of feed and the mean N quantity of the feed ration that conforms to relevant national feeding recommendations. Growth-related N retention, N output via products (milk/eggs) and N losses via pregnancy/young are all deducted from the ingested N quantity. The remaining N quantity is the N excretions figure.

The following parameters enter into calculation of N excretions:

- Dairy cows: milk production, milk-protein content, milk-fat content, animal weight, weight gain, numbers of births per year, feed characteristics
- Heifers and male beef cattle: weight gain, final weight and feed characteristics;
- Swine: animal weight; for sows, also number of piglets per year; for weaners and fattening pigs, also weight gain and feed characteristics;
- Laying hens, pullets, ducks, turkeys: weight gain, final weight, and feed characteristics; for laying hens, also egg production and egg weights;
- Broilers: gross meat quantities at slaughter, feed characteristics.

For animal categories with grazing, calculated N excretions per animal place and year are broken down into in-pasture and in-stable excretions, since only in-stable excretions can enter into calculation of N₂O emissions in 3.B. Such division of excrements into in-stable and in-pasture categories is based on the relative time proportions for time in stable and time in pasture (cf. also Chapter 19.3.1, Table 506).

Table 215 shows the time series for N excretions. For goats, the N excretions are constant over time (11.0 kg place⁻¹ a⁻¹). The changes in the yield data (cf. Chapter 5.1.3.3) lead to only slight discrepancies with respect to the 2016 Resubmission.

Table 215: N excretions per animal place and year (3.B(b))

[kg place ⁻¹ a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	97.6	102.9	109.9	115.3	115.9	116.9	114.2	115.4	116.4	117.3	117.6	117.3	119.2	120.4
Other cattle	41.2	43.0	43.8	43.3	43.4	43.1	43.0	43.2	43.1	42.9	42.7	42.7	42.5	42.5
Swine	12.1	12.6	12.7	12.8	12.8	12.8	12.8	12.9	12.9	12.9	12.9	13.0	13.0	13.0
Sheep	7.7	7.7	7.8	7.8	7.8	7.7	7.7	7.8	7.8	7.8	7.8	7.8	7.8	7.8
Horses	48.2	48.1	49.0	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
Poultry	0.70	0.67	0.69	0.74	0.73	0.74	0.74	0.75	0.77	0.75	0.73	0.70	0.70	0.69

Table 216 shows the annual N excretions for the four manure management systems "slurry-based (without digestion)", "straw-based (without deep bedding and without digestion)", "deep bedding (without digestion)" and "digestion"; as well as for "grazing".

Table 216: Annual N excretions, broken down by manure management systems (3.B(b)) and grazing systems (3.D)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	1611.4	1382.9	1346.1	1297.4	1274.4	1286.1	1290.8	1301.2	1286.4	1291.3	1309.4	1324.8	1343.1	1335.3
Slurry-based ^a	898.6	848.0	823.7	766.2	733.6	719.4	706.5	692.9	656.6	635.6	635.8	622.7	626.5	617.7
Straw-based ^b	447.7	310.0	297.4	284.5	282.7	287.4	287.8	288.4	287.0	289.6	294.9	299.3	303.0	303.4
Deep bedding ^a	51.6	53.1	57.4	70.7	70.4	71.5	74.1	75.1	74.5	71.6	71.3	71.9	72.0	70.5
Digestion	0.04	0.56	4.8	32.3	48.1	69.5	83.6	106.3	132.2	161.4	175.0	197.1	206.2	207.7
Grazing	213.4	171.3	162.8	143.7	139.5	138.4	138.8	138.5	136.1	133.0	132.3	133.8	135.4	135.9

^a Without digestion

^b Without deep bedding and without digestion

5.1.3.5 VS excretions (3.B)

The VS excretions for dairy cows, other cattle, swine and poultry (exception: geese) are calculated using the national procedure of DÄMMGEN et al. (2011):

Equation 5: Calculation of VS excretions

$$VS_i = m_{\text{feed, DM, } i} \cdot (1 - X_{\text{DOM, } i}) \cdot (1 - x_{\text{ash, feed}})$$

VS_i	VS excretions for animal category i (in kg place ⁻¹ d ⁻¹)
$m_{\text{feed, DM, } i}$	DM intake, animal category i (in kg place ⁻¹ d ⁻¹)
$X_{\text{DOM, } i}$	Digestibility of organic matter, animal category i (in kg kg ⁻¹)
$x_{\text{ash, } i}$	Ash content of feed, animal category i (in kg kg ⁻¹)

The VS excretions for geese are estimated on the basis of the VS excretions for ducks (RÖSEMANN et al., 2017): 0.023 kg pl⁻¹ d⁻¹.

The input data for the VS calculation include: dry-matter intake, digestibility of organic matter and ash content of feed; for a pertinent overview for dairy cows, other cattle and swine, cf. Chapter 5.1.3.3.

The VS excretions, calculated with national input data, for dairy cows, other cattle, swine and poultry are shown in Table 217. As a result of the changes in the yield data (cf. Chapter 5.1.3.2.4), the VS figures differ slightly from the pertinent values given in the 2016 Resubmission (the differences cannot be represented in the number format used in Table 217).

Table 217: Daily VS excretions, for dairy cows, other cattle, swine and poultry (without geese) (3.B(a))

[kg place ⁻¹ d ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	3.47	3.63	3.78	3.90	3.91	3.94	3.90	3.94	3.97	3.99	4.01	4.01	4.04	4.06
Other cattle	1.37	1.40	1.43	1.40	1.40	1.40	1.39	1.39	1.39	1.38	1.37	1.38	1.37	1.37
Swine	0.26	0.28	0.28	0.29	0.29	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.30	0.30
Poultry	0.023	0.022	0.023	0.026	0.026	0.026	0.026	0.026	0.027	0.026	0.025	0.024	0.024	0.024

Table 218 shows the daily VS excretions for sheep, goats and horses. For mature sheep, goats and heavy horses, the default VS values pursuant to IPCC (2006a), Table 10A-9, have been used. The VS excretions for lambs are set at 40 % of those for mature sheep, in keeping with the relevant lower energy requirements in the lamb category (i.e. in comparison to those for mature sheep) (RÖSEMANN et al., 2017). Similarly, the VS excretions for light horses and ponies have been derived from the VS excretions for heavy horses, in keeping with the energy requirements ratio between the two categories (RÖSEMANN et al., 2017).

Table 218: Daily VS excretions for sheep, goats and horses (3.B(a))

[kg place ⁻¹ d ⁻¹]	VS
Mature sheep	0.40
Lambs	0.16
Goats	0.30
Heavy horses	2.13
Light horses and ponies	1.38

The mean-VS-excretions figure for sheep and horses is not a constant, due to variance in the numbers of large and small animals –as shares of the overall population –in the two categories. The annual variation is small, however. The daily VS excretions for all sheep combined, averaged over the relevant years, amount to 0.31 kg place⁻¹ d⁻¹, while those for all horses combined amount to 1.95 kg place⁻¹ d⁻¹.

5.1.3.6 Housing systems, storage systems and application procedures (CRF 3.B, 3.D)

5.1.3.6.1 Frequency distributions (3.B, 3.D)

The German inventory uses annual frequency distributions for the various husbandry systems (proportions for grazing / housing; proportions for different housing systems), manure-storage systems and manure-application techniques, and time allotted to grazing, by animal sub-categories. The data for manure digestion and storage of digestates are discussed in Chapter 5.1.3.6.5.

For the years 1990 through 1999, the frequency distributions for the various housing systems, storage systems and application techniques, and the various time periods allotted to grazing, were obtained with the help of the RAUMIS (Regionalisiertes Agrar- und UmweltInformationssystem für Deutschland –Regionalized Agricultural and Environmental Information System for Germany) agricultural sector model⁸⁷. The data that entered into RAUMIS included specialized national statistics at the sectoral and district levels, standardization data of the Association for Technology and Structures in Agriculture (KTBL-Normdaten) relative to description of production processes, data from the Economic Accounts for Agriculture (EAA), special evaluations of the Federal Ministry of Food and Agriculture (population-size-class distribution) and survey data. Where relevant statistical data were missing, models were formulated with the aid of experts.

⁸⁷ RAUMIS is operated by the Institute for Rural Studies of the Thünen Institute (TI; until 2008: Federal Agricultural Research Centre (FAL)). For a pertinent introduction, cf. WEINGARTEN (1995); a detailed description is provided in HENRICHSMEYER et al. (1996).

Updating of the aforementioned RAUMIS data was no longer possible after 1999. The first subsequent year for which it was possible to obtain current data was 2010. Those data were provided by the 2010 agricultural census (Landwirtschaftszählung 2010; LZ 2010), as well as by surveys, for calendar year 2010, of agricultural production methods and of manure application. In most cases, gaps between those data and the RAUMIS data of 1999 have been closed via linear interpolation. In some cases, LZ 2010 data were used in the inventory for the period beginning in 1990, however, instead of comparatively uncertain RAUMIS data or data based on comparatively uncertain assumptions. The 2010 agricultural census collected a first set of official data on grazing of sheep, for example; those data have been used for the years as of 1990, in place of earlier assumptions.

For laying hens, data on distribution of housing systems are available for every year as of 1993. The data are provided, on request and annually, by the Federal Statistical Office (Section G 105). No data were yet available for the time-series year 2015, however, at the time the emissions calculations for the 2017 Submission were being carried out. The gap in the data from 1990 through 1992 has been closed by using the relevant value for 1993. For 2015, the values from 2014 have been carried forward.

In addition, the following determinations have been made on the basis of assessments by experts of KTBL:

- Until 2002, 50 % of all calves were housed in tied systems with solid floors and bedding material and 50 % were housed in deep bedding systems; as of 2003, as a result of a ban on tied systems, 100 % were housed in deep bedding systems.
- For housing of heifers, all straw-based systems are deemed to have solid floors and bedding material, since such systems are the systems most commonly used in Germany.
- For suckler cows, all straw-based systems –except tied systems –are deemed to be deep bedding systems, since such systems are the systems most commonly used in Germany.
- For the years 2011 through 2015, no data are available on the frequency distributions of housing, storage and application procedures. For this reason, the LZ 2010 data are also used for those years. In an exception, the applicable incorporation periods for liquid manure have been updated for the period as of 2012, to reflect the fact that implementing regulations now specify that liquid manure (including liquid digestates) applied to bare soil has to be worked into the soil within 4 hours (cf. RÖSEMANN et al., 2017).
- The numbers of air-scrubbing systems in swine-housing facilities, through 2012 (this applies to the NH₃ emissions of relevance for 3.D), have been obtained from surveys of KTBL. Apart from new data for Lower Saxony for 2014, no data were available for the period 2013 through 2015. As a result, for all other Länder the relevant 2012 figures were used for the period 2013 through 2015. For Lower Saxony, the lacking value for 2013 was estimated via linear interpolation between 2012 and 2014, and the value for 2014 was carried forward for 2015.
- The applicable shares for anaerobic digestion of slurry and manure of cattle, swine and poultry in biogas plants, and the applicable frequencies for gas-tight systems for storage of digested slurry, were provided by KTBL (KTBL, 2016). The data were updated, with respect to the 2016 Resubmission, for all relevant years.

Table 506, Table 507 and Table 508 in Annex Chapter 19.3.1 show the applicable distributions of housing systems, storage systems and application techniques, and they provide data on grazing. These tables also include data on digestion of manure from cattle, swine and poultry husbandry, as well as data on application of digestates (cf. Chapter 5.1.3.6.5).

The following tables show, for the important animal categories "dairy cows," "other cattle," "swine," and "poultry," how the pertinent animal populations break down with respect to the various categories of manure management systems.

Table 219: Slurry-based systems without digestion, in % of excreted VS (3.B(a))

[%]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	54.5	70.9	72.1	70.3	68.4	66.2	64.9	62.6	60.0	56.9	55.7	53.7	53.1	52.9
Other cattle	59.2	56.8	53.4	47.0	45.2	43.3	41.5	39.4	37.0	35.6	35.2	34.5	34.0	33.9
Swine	80.6	87.2	89.0	88.4	87.7	86.5	85.8	84.8	82.8	81.3	80.8	79.2	78.8	78.3

Table 220: Straw-based systems without digestion, in % of excreted VS (3.B(a))

[%]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	27.8	15.7	14.8	15.4	15.5	15.5	15.5	15.5	15.5	15.4	15.3	15.2	15.2	15.2
Other cattle	19.6	18.3	18.5	18.4	18.7	18.9	19.3	19.7	20.2	20.1	19.8	19.7	19.8	19.9
Swine	17.3	10.9	9.1	7.8	7.6	7.3	7.0	6.6	6.4	6.2	5.9	5.9	5.8	5.8
Poultry	100.0	99.9	99.6	96.8	95.6	94.6	93.8	92.2	90.2	89.1	88.7	87.3	87.1	87.1

Table 221: Deep bedding systems without digestion, in % of excreted VS (3.B(a))

[%]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other cattle	6.7	8.7	10.2	15.0	15.4	16.0	16.7	17.2	17.5	17.4	17.5	17.4	17.4	17.3
Swine	2.2	1.9	1.6	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.2

Table 222: Digestion systems, in % of excreted VS (3.B(a))

[%]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	0.003	0.051	0.49	3.1	5.2	7.6	9.2	11.6	14.4	17.5	18.7	20.6	21.3	21.4
Other cattle	0.003	0.033	0.28	2.0	2.9	4.0	4.6	5.8	7.2	8.9	9.7	10.6	10.9	10.9
Swine	0.003	0.042	0.33	2.4	3.3	4.8	5.9	7.4	9.5	11.2	12.0	13.7	14.1	14.6
Poultry	0.004	0.056	0.43	3.2	4.4	5.4	6.2	7.8	9.8	10.9	11.3	12.7	12.9	12.9

Table 223: Grazing, in % of excreted VS (3.B(a))

[%]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	17.7	13.2	12.5	11.1	10.8	10.6	10.5	10.3	10.1	10.2	10.3	10.4	10.4	10.5
Other cattle	14.4	16.2	17.6	17.7	17.7	17.9	17.9	18.0	18.1	18.0	17.8	17.8	17.9	18.1

5.1.3.6.2 Bedding material in solid-manure systems

In solid-manure systems, additional nitrogen enters the system via the bedding material. In the inventory, this nitrogen is taken into account in calculation of N₂O and NO emissions from manure management. Table 506 in Chapter 19.3.1 lists the applicable bedding-material quantities, as fresh matter, for the various different animal-housing procedures. With a dry-matter content of 86 %, and an N quantity of 0.58 % in dry matter (cf. RÖSEMANN et al., 2017), the bedding-material N quantities listed in Table 224, for the various animal categories, result. The noticeable decrease seen in the swine category, from 2014 to 2015, is the result of decreases in the numbers of swine.

Table 224: Annual totals for N inputs via bedding material, in straw-based systems

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	17.1	7.6	7.1	6.7	6.5	6.5	6.7	6.7	6.7	6.7	6.7	6.8	6.9	6.9
Other cattle	23.9	21.1	21.3	20.3	20.2	20.4	21.1	21.3	21.3	20.6	20.5	20.7	20.8	20.6
Swine	3.18	1.78	1.58	1.41	1.36	1.35	1.28	1.26	1.18	1.18	1.19	1.17	1.18	1.13
Sheep	0.83	0.75	0.70	0.68	0.65	0.64	0.62	0.60	0.58	0.51	0.50	0.48	0.48	0.47
Goats	0.04	0.05	0.07	0.08	0.09	0.09	0.09	0.11	0.07	0.07	0.07	0.06	0.06	0.06
Horses	6.54	8.30	6.65	6.75	7.02	7.30	6.91	6.51	6.12	6.12	6.12	6.12	6.11	6.11
Poultry	0.80	0.91	1.10	1.27	1.31	1.35	1.39	1.46	1.52	1.62	1.72	1.83	1.88	1.92

5.1.3.6.3 Maximum methane-producing capacity B_0 (3.B(b))

For purposes of emission calculation (cf. Chapter 5.3.2.2.1), the methane formation related to manure storage is characterized via the animal-specific maximum methane-producing capacity B_0 and the storage-specific methane conversion factor MCF . With regard to the MCF , cf. Chapter 5.1.3.6.4.

Table 225 shows the B_0 values used and the origins of the relevant data. For cattle and swine, the data are national data. For other animals (apart from pullets and geese), IPCC default values have been used. No IPCC (2006a) default values are available for pullets and geese. In a conservative approach, the IPCC (2006a) default value for laying hens has been adopted for pullets. For the B_0 for geese, a value of $0.36 \text{ m}^3 \text{ kg}^{-1}$ has been adopted, in keeping with RÖSEMANN et al. (2017). Owing to variations in the population fractions for the various poultry categories, the mean B_0 for poultry is not a constant, as Table 226 illustrates.

Table 225: Maximum methane-producing capacity B_0 (3.B(b))

[m ³ kg ⁻¹]	B_0	Source
Cattle	0.23	DÄMMGEN et al. (2012a)
Swine	0.30	DÄMMGEN et al. (2012a)
Sheep	0.19	IPCC (2006a), 10.82
Goats	0.18	IPCC (2006a), 10.82
Horses	0.30	IPCC (2006a), 10.82
Laying hens	0.39	IPCC (2006a), 10.82
Broilers	0.36	IPCC (2006a), 10.82
Ducks	0.36	IPCC (2006a), 10.82
Turkeys	0.36	IPCC (2006a), 10.82
Pullets	0.39	Assumption (see text)
Geese	0.36	RÖSEMANN et al. (2017)

Table 226: Maximum methane-producing capacity B_0 for poultry (3.B(b))

[m ³ kg ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Poultry	0.380	0.377	0.375	0.372	0.372	0.372	0.371	0.371	0.370	0.370	0.371	0.371	0.371	0.371

5.1.3.6.4 Methane conversion factors MCF (3.B)

In CRF 3.B(a), the MCF values for the various national manure management categories are to be reported under "Additional Information." In Germany, the pertinent categories are "slurry-based without digestion", "straw-based without digestion" (heap), "deep bedding without digestion", "digestion" and "pasture". The values are weighted average values, overall all animal categories, based on the MCF values described below. The category "slurry-based without digestion" includes all animals housed in slurry-based systems with no digestion of the animals' manure. The categories "straw-based without digestion (solid-manure storage systems)" and "deep bedding without digestion" should be understood in the same way. The "digestion" category includes all animals whose manure is digested.

Table 227 shows the MCF values for cattle, broken down by the storage systems commonly used in Germany. The national values proposed by DÄMMGEN et al. (2012a) are in boldface type. In a conservative approach, chosen due to a lack of IPCC default values or national values, the MCF applying to "slurry without natural crust" was used for "slurry with solid cover" (including tent structures), "slurry with floating chopped-straw cover" and "slurry with floating cover foil". The values for deep bedding and pasture were taken from IPCC (2006)-10.44ff.

Table 227: Methane-conversion factors *MCF* (in percent of B_0) for cattle (3.B(a))

	MCF [%]
Slurry	Open tank, without natural crust
	17
	Solid cover
	17
	Natural crust
	10
Slurry	Floating cover (chopped straw)
	17
	Floating cover (cover foil)
	17
Slurry	Below slatted floor > 1 month
	17
Solid manure	Deep bedding
	17
Solid manure	Heap
	2
Pasture	1

Table 228 lists the methane conversion factors MCF for manure storage in swine husbandry. As was the case for the cattle data, the values are national values (DÄMMGEN et al., 2012a, boldface), default values from IPCC (2006a) -10.44ff or conservative assumptions in cases in which no MCF is known. For cattle, the MCF for "deep bedding" is the same as that for slurry without natural crust, and thus the same relationship has been assumed to hold for swine. Free-range management of swine ("pasture") plays a very insignificant role in Germany and is thus not taken into account in the inventory (not occurring, NO).

Table 228: Methane-conversion factors *MCF* (in percent of B_0) for swine (3.B(a))

	MCF [%]
Slurry	Open tank, without natural crust
	25
	Solid cover
	25
	Natural crust
	15
Slurry	Floating cover (chopped straw)
	25
	Floating cover (cover foil)
	25
Slurry	Below slatted floor > 1 month
	25
Solid manure	Deep bedding
	25
Solid manure	Heap
	3

The average methane conversion factors for slurry-based systems without digestion, for dairy cows, other cattle and swine, depend on the frequency of the various applicable housing procedures and thus are not constant, as Table 229 shows.

Table 229: Average methane conversion factors *MCF* (in percent of B_0) for slurry-based systems without digestion (3.B(a))

[%]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	14.3	14.0	14.0	14.4	14.5	14.7	14.8	14.9	15.1	15.2	15.2	15.3	15.3	15.3
Other cattle	14.5	14.4	14.6	14.9	15.0	15.0	15.1	15.2	15.3	15.3	15.3	15.4	15.4	15.4
Swine	24.7	23.7	23.6	22.8	22.6	22.5	22.4	22.2	22.1	22.1	22.1	22.1	22.1	22.2

For storage of manure from other animals (goats, sheep, horses and poultry), the default values from IPCC (2006a)-10.44ff have been used (cf. Table 230).

Table 230: Methane-conversion factors MCF (in percent of B_0) for goats, sheep, horses and poultry (3.B(a))

MCF [%] ^a	
Heap	2
Poultry manure	1.5
Pasture	1

For systems in which manure is digested, a variable MCF results, when the various contributions from pre-storage systems, digesters and systems for storage of digestates are taken into account (cf. Chapter 5.1.3.6.5).

5.1.3.6.5 Manure digestion and storage of digestates (3.B)

Pursuant to IPCC (2006a), Table 10.17, anaerobic digestion of manure, and storage of the resulting digestates, is a separate storage-system type. In keeping with the German situation, it is included for cattle, swine and poultry (HAENEL und WULF, 2016; RÖSEMANN et al., 2017). The time series for the activity data have been provided by KTBL, which prepared them especially on the basis of data of the Deutsches Biomasseforschungszentrum (DBFZ; German biomass research centre) (cf. KTBL (2016)).

Equation 6, using the example of slurry, describes the concept used by the KTBL (2016) to determine the relevant relative fractions of manure that undergoes digestion. Equation 6 is used in a similar manner for solid manure and deep bedding (including the N from the bedding material). The aggregation into "manure, total" is carried out on the basis of numbers of animals and of animal-specific manure production.

Equation 6: Concept for calculation of the percentage shares of digested manure with respect to total manure production

$$pct_{SL, dig, i}(y) = 100 \cdot \frac{SL_{dig, i}(y)}{SL_{total, i}(y)} = 100 \cdot \frac{W_{el, dig}(y) \cdot s_i}{SL_{total, i}(y)}$$

Where

$pct_{SL, dig, i}$	Quantity of digestion residues, as a fraction of the total slurry production for animal category i (in %)
i	Index of the pertinent animal category
y	Year (1990, 1991, ...)
$SL_{dig, i}$	Quantity of nitrogen in digestates in animal category i (in kg a ⁻¹)
$SL_{total, i}$	Total slurry production (nitrogen quantity) of animal category i (in kg a ⁻¹)
$W_{el, dig}$	Annual electrical work of German biogas plants (in GWh _{el} a ⁻¹)
s_i	Work-specific substrate input (nitrogen quantity) in animal category i (in kg GWh _{el} ⁻¹)

KTBL (2016) derived the applicable annual electrical work $W_{el, dig}$, differentiated by German Länder (states) and plant-performance classes, from data of the registry of biogas plants (Biogasanlagenregister) (as of 31 Dec. 2013, 9129 plants). In the process, consideration of the factor "equivalent electrical work" makes it possible to take account also of those biogas plants that solely feed biomethane into the gas network, i.e. without producing any electricity. The work-specific substrate input s_i was calculated separately for cattle slurry, cattle manure, swine slurry and poultry manure, using data from 1,664 biogas plants. The nitrogen quantities $SL_{total, i}$ were

derived from the numbers of animals and from the animal-specific slurry and manure production (including bedding material). The data have been updated with respect to the 2016 Resubmission.

Table 231 shows the resulting updated fractions for digestion of cattle slurry, cattle solid manure, swine slurry and poultry manure, expressed as percentages of the N quantities entering into storage systems. For swine solid manure, no digestion is taken into account, since the relevant data are of uncertain reliability, due to the small quantities of solid manure involved.

Table 231: Relative shares of manure undergoing digestion (in % of the N quantities entering storage)

[%]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	0.003	0.042	0.38	2.6	4.0	5.6	6.8	8.8	11.1	13.7	14.9	16.5	17.1	17.3
Cattle slurry	0.004	0.056	0.52	3.6	5.8	8.4	10.2	13.3	16.8	21.1	23.2	25.6	26.6	26.7
Cattle solid manure	0.001	0.012	0.11	0.8	1.2	1.6	1.8	2.3	2.9	3.6	4.1	4.4	4.5	4.6
Swine slurry	0.003	0.044	0.35	2.5	3.4	4.9	6.0	7.7	10.0	12.0	13.0	14.8	15.2	15.7
Poultry manure	0.004	0.052	0.40	3.0	4.1	5.1	5.9	7.6	9.6	10.7	11.2	12.6	12.9	12.8

The data in Table 231 are also used to calculate the share of stored VS quantities that undergo digestion.

The total MCF for digestion of manure and slurry in biogas plants, including pre-storage systems and systems for storage of digestates, is calculated in accordance with a national method; cf. Equation 7. Regarding the derivation of this equation, see RÖSEMANN et al. (2017).

Equation 7: Calculation of total MCF for digestion of manure and slurry in biogas plants, including pre-storage of substrate and storage of digestates

$$MCF\% = MCF\%_{ps} + (100\% - MCF\%_{ps}) \cdot \left((1 - \mu_{rg}) \cdot L_{dig} + \mu_{rg} \cdot \frac{MCF\%_{residues}}{100\%} \right)$$

Where

$MCF\%$	Total MCF for the system "pre-storage system + digester + system for storage of digestates" (in %)
$MCF\%_{ps}$	MCF for the pre-storage system (in %)
μ_{rg}	Potential for residual gas production, with respect to B_0 (with $0 \leq \mu_{rg} \leq 1 \text{ m}^3 \text{ m}^{-3}$)
L_{dig}	Relative leakage rate of the digester, with respect to the quantity of CH_4 produced in the digester (with $0 \leq L_{dig} \leq 1 \text{ m}^3 \text{ m}^{-3}$)
$MCF\%_{residues}$	MCF for the system for storage of digestates (in %)

Table 232 shows the methane conversion factors $MCF\%_{ps}$ for pre-storage systems. Regarding the derivation, see RÖSEMANN et al. (2017).

Table 232: Methane conversion factors for pre-storage systems (in percent of B_0)

$MCF\%_{ps}$ [%]	
Cattle slurry	1.7
Cattle solid manure	0.2
Swine slurry	2.5
Poultry manure	0.15

On the basis of KTBL (2016), the potential CH_4 off-gas quantity μ_{rg} with respect to B_0 is considered to be 4.6 % (or $0.046 \text{ m}^3 \text{ m}^{-3}$); cf. RÖSEMANN et al. (2017).

In keeping with BACHMAIER & GRONAUER (2007), BÖRJESSON & BERGLUND (2007), GÄRTNER et al. (2008) and ROTH et al. (2011), the leakage rate of the digester, L_{dig} , is set at 1 %, or $0.01 \text{ m}^3 \text{ m}^{-3}$ (KTBL, 2016). In a 2016 study, UBA also applied a leakage rate of 1 % (UBA, 2016).

A leakage rate is assumed even for a gas-tight system for storage of residues from slurry digestion; that leakage rate is assumed to be the same as that of the digester. Taking account of the relative share of gas-tight storage systems, with respect to all storage of digestion residues, one obtains Equation 8.

Equation 8: Calculation of MCF for systems for storage of digestates

$$MCF\%_{\text{residues}} = x_{\text{gts}} \cdot (100 \cdot L_{\text{sto, gt}}) + (1 - x_{\text{gts}}) \cdot MCF\%_{\text{ngts}}$$

Where

$MCF\%_{\text{residues}}$	MCF for the system for storage of digestates (in %)
x_{gts}	Relative share of gas-tight storage of digestion residues (in kg kg^{-1})
$L_{\text{sto, gt}}$	Relative leakage rate for gas-tight storage of digestion residues ($L_{\text{sto, gt}} = L_{\text{dig}}$)
$MCF\%_{\text{ngts}}$	MCF for non-gas-tight systems for storage of digestates (in %)

In general, digestates are in a liquid state. For non-gas-tight storage of digestion residues, it is assumed that a natural floating crust forms, as a result of co-digestion of energy crops, which increases the dry-matter content in the digestion residues. This type of storage is thus similar to open storage of undigested cattle slurry with a natural floating crust. For this reason, the relevant MCF for undigested cattle slurry is used for $MCF\%_{\text{ngts}}$: 10 % (cf. Chapter 5.1.3.6.4).

Table 233 shows the fraction of gas-tight storage of residues from manure digestion, as a percentage share of all storage of residues from manure digestion, and in percent of N inputs. The data were derived by KTBL (2016) from the pertinent input quantities of digestion substrates, broken down by German Länder and by plant-output classes, as well as by the percentage shares of biogas plants with gas-tight, covered storage of digestion residues, with respect to the output classes prevailing in Germany. The sharp increase, from 2011 to 2012, in the use of gas-tight storage of digestion residues is attributed to the 2012 German act on electricity feed-in (Energieeinspeisegesetz, EEG), which mandates gas-tight covers for all digestion-residue storage systems that went into operation on or after 1 January 2012. The percentage values for gas-tight covers were updated for 2013 and 2014. Since no data on use of such covers were available for 2015, the relevant figures for 2014 were retained for that year.

Table 233: Percentage shares for storage of digestates in gas-tight and non-gas-tight storage systems (in percent of the N inputs in biogas plants)

[%]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
gas-tight	0.0	4.5	9.1	15.2	20.3	25.3	30.4	35.5	40.6	45.6	57.0	59.6	62.1	62.1
non- gas-tight	100.0	95.5	90.9	84.8	79.7	74.7	69.6	64.5	59.4	54.4	43.0	40.4	37.9	37.9

The total MCF values resulting from Equation 7, for the systems "pre-storage systems + digester + system for storage of digestates", for dairy cows, other cattle, swine and poultry, are listed in the following table.

Table 234: Average methane conversion factors *MCF* (in percent of B_0) for manure management systems with digestion (3.B(a))

[%]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	3.00	3.02	3.00	2.97	2.95	2.93	2.92	2.90	2.87	2.85	2.81	2.80	2.79	2.79
Other cattle	2.99	2.91	2.87	2.81	2.79	2.77	2.74	2.72	2.69	2.67	2.62	2.61	2.60	2.60
Swine	3.88	3.86	3.84	3.82	3.80	3.78	3.75	3.73	3.71	3.69	3.65	3.64	3.63	3.63
Poultry	1.56	1.54	1.53	1.50	1.48	1.46	1.44	1.42	1.40	1.38	1.33	1.33	1.32	1.32

The reduction of CH_4 emissions from manure management that is related to digestion depends on the fraction of manure that is digested, as well as on the relative frequency of gas-tight systems for storage of digestates. The pertinent reductions resulting in Germany are given in Chapter 5.3.2.2.3.

Table 235 lists the N_2O emissions that the inventory takes account of for the various relevant sub-systems and manure types. For details, cf. RÖSEMANN et al. (2017). N_2O and NO emissions from agricultural soils, resulting from application of digestion residues, are described in Chapter 5.5.

Table 235: Calculation of N_2O emissions from anaerobic digestion

	Slurry	Solid manure / poultry manure
Pre-storage systems	0	Equation 9
Digester	0	0
System for storage of digestion residues	0	0
gas-tight	0	0
non- gas-tight	Equation 10	Equation 10

Equation 9: Calculation of N_2O emissions from systems for pre-storage of solid manure and poultry manure

$$E_{N_2O-N, \text{dig,ps}} = (N_{\text{excr, dig}} + N_{\text{straw, dig}}) \cdot EF_{N_2O-N, \text{dig,ps}}$$

Where

$E_{N_2O-N, \text{dig, ps}}$	N losses via N_2O emissions from pre-storage of solid manure or poultry manure (in kg a^{-1})
$N_{\text{excr, dig}}$	Fraction of annual in-stable N excretions that goes to digestion (in kg a^{-1})
$N_{\text{straw, dig}}$	Fraction of annual N inputs from bedding material that goes to digestion (in kg a^{-1})
$EF_{N_2O-N, \text{dig, ps}}$	N_2O -N emission factor for pre-storage of manure or poultry manure (in $\text{kg } N_2O\text{-N pro kg N}$)

Equation 10: Calculation of N_2O emissions from non-gas-tight storage of digestates

$$E_{N_2O-N, \text{dig,ngts}} = (1 - x_{\text{gts}}) \cdot N_{\text{tot, dig, ferm}} \cdot EF_{N_2O-N, \text{dig,ngts}}$$

Where

$E_{N_2O-N, \text{dig, ngts}}$	N losses via N_2O emissions from non-gas-tight storage of digestates (in kg a^{-1})
x_{gts}	Relative share of gas-tight storage of digestates (in kg kg^{-1})
$N_{\text{tot, dig, ferm}}$	Total N quantity from digestates that leaves the digester (in kg a^{-1})
$EF_{N_2O-N, \text{dig, ngts}}$	N_2O -N emission factor for non-gas-tight storage of digestates (in $\text{kg } N_2O\text{-N per kg N}$)

The N_2O emission factors used in the inventory are listed in Table 236. For details on their derivation, see RÖSEMANN et al. (2017).

Table 236: N₂O-N emission factors for manure pre-storage and for storage of digestates

	[kg kg ⁻¹]	Manure	Poultry manure
Pre-storage systems	$EF_{N_2O-N, \text{ dig, ps}}$	0.001	0.0001
Systems for storage of digestates, non-gas-tight	$EF_{N_2O-N, \text{ dig, ps}}$	0.005	0.005

The N quantity in digestates at the beginning of storage ($N_{\text{tot, dig, ferm}}$) is calculated with inclusion of the N losses from pre-storage. It is assumed that no N losses from digesters occur.

The procedure for calculating NO emissions occurring in connection with manure digestion is similar to that for calculating N₂O emissions. As is customary in the German inventory's sections on manure management (cf. RÖSEMANN et al., 2017), the NO-N emission factor is assumed to be one-tenth of the N₂O-N emission factor.

To calculate the N₂O emissions that result indirectly from agricultural soils, as a result of deposition of reactive nitrogen (cf. Chapter 5.5.2.1.2), one must also calculate the NH₃ emissions that occur in connection with digestion of manure. NH₃ emissions are calculated for pre-storage of solid manure and poultry manure, for non-gas-tight storage of digestates and for application of digestates. In other cases, it is assumed that NH₃ emissions either do not occur or can be neglected. For details on the extensive subject of NH₃-calculation methods, see RÖSEMANN et al. (2017).

5.1.4 Digestion of energy crops: Concept and activity data

5.1.4.1 The concept, and the manner in which it is taken into account in the CRF tables

The inventory covers the six energy-crop categories that are the most important in Germany in terms of quantities: maize silage, grass silage, whole-plant silage, wheat grain, rye grain and Corn Cob Mix (CCM). They differ only slightly in terms of their key characteristics (N and VS content in dry matter, maximum methane formation potential B_0 ; cf. KTBL (2016)). This makes it possible to treat the total dry matter for all included energy crops as a single energy-crop category. The procedure for calculating the pertinent emissions is similar to that for calculating emissions from digestion of solid manure (cf. Chapter 5.1.3.6.5), with the exception that no pre-storage is included.

In practice, manure and energy crops are normally digested together. Nonetheless, the emissions occurring in connection with digestion of these two substrate categories are calculated separately, with a view to highlighting the contribution that energy-crop digestion makes to the greenhouse-gas balance.

For further details on emission calculation in connection with digestion of energy crops, see RÖSEMANN et al. (2017).

The following emissions are calculated that result, directly or indirectly, from digestion of energy crops, as well as from storage and application of digestates:

Digester

- CH₄ (via leakage)

Storage

- CH₄ (via leakage)
- Direct N₂O
- N₂O resulting indirectly from deposition of NH₃ and NO from storage
- NO

Application

- Direct N₂O
- N₂O resulting indirectly from deposition of NH₃ and NO via application
- N₂O resulting indirectly from leaching / surface runoff of the nitrogen applied via spreading of digestates
- NO

The emissions from digesters and systems for storage of digestates (CH₄, N₂O, indirect N₂O from deposition of NH₃ and NO from storage) are described in Chapter 5.9 and reported under 3.J in CRF Table 3s2. The direct and indirect N₂O emissions occurring as a result of spreading of digestates are described in Chapter 5.5 and reported under 3.D (CRF 3.D: a.2.c, b.1 and b.2). The NO emissions from storage of digestates and from application of digestates are reported separately, as NO_x emissions, under 3.J in CRF Table 3s2.

5.1.4.2 Activity data and parameters

The activity data used in calculation of the pertinent emissions consist of the total quantities of dry matter that are input into digestion; cf. Table 237. The underlying substrate quantities were derived by KTBL (2016) in connection with digestion of manure / slurry (cf. Chapter 5.1.3.6.5). The relevant value for 2014 has been updated with respect to the 2016 Resubmission.

Table 237: Total dry matter in the energy crops input into biogas plants

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	3.4	43.2	374.2	3,175	4,457	6,095	7,105	9,115	11,461	14,295	15,657	18,862	19,795	19,911

A weighted average B_0 value of 0.36 m³ kg⁻¹ was derived from the B_0 values for the six energy-crop categories (KTBL, 2014) (cf. Chapter 5.1.4.1), using the IPCC default value for the density of methane (0.67 kg m⁻³). The following weighted averages for the VS and N content resulted (with respect to dry matter): VS content, 0.947 kg kg⁻¹; N content, 0.0148 kg kg⁻¹.

The VS quantity required for calculation of the CH₄ emissions is obtained by multiplying the dry matter by the average VS content; cf. Table 238.

Table 238: Total VS quantity in the energy crops input into biogas plants

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	3.2	40.9	354.3	3,007	4,221	5,772	6,729	8,632	10,854	13,538	14,827	17,862	18,745	18,856

The N quantities required for calculation of the N emissions are obtained with the help of the relevant N content; cf. Table 239.

Table 239: Total N quantity in the energy crops input into biogas plants

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	0.05	0.64	5.5	47.0	66.0	90.2	105.2	134.9	169.6	211.6	231.7	279.2	293.0	294.7

In keeping with KTBL (2016), the leakage rates for digesters and gas-tight systems for storage of digestates are considered to be the same as those used in connection with manure digestion (cf. Chapter 5.1.3.6.5).

Table 240 shows the fractions of gas-tight storage of digestates from energy-crop digestion, as percentages of the pertinent input fresh matter (KTBL, 2016). The data were updated, with respect to the 2016 Resubmission, for 2013 and 2014. Since no data on use of such covers were available for 2015, the relevant figures for 2014 were retained for that year. The sharp increase, from 2011 to 2012, in the use of gas-tight storage of digestion residues is attributed to the 2012 German act on electricity feed-in (Energieeinspeisegesetz, EEG), which mandates gas-tight covers

for all digestion-residue storage systems that went into operation on or after 1 January 2012. The data differ somewhat from those for storage of manure digestates (cf. Table 233). This is due to the fact (KTBL, 2016) that the total fraction of energy crops, with respect to the manure / energy-crop substrate mix, increases with plant (i.e. facility) size (a relationship that also holds for the covered-system fraction of systems for storage of digestates).

Table 240: Percentage shares for systems for gas-tight and non-gas-tight storage of digestates of energy crops (in percent of the fresh matter inputs in biogas plants)

[%]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
gas-tight	0.0	4.7	9.4	15.8	21.1	26.4	31.7	37.0	42.2	47.5	59.4	63.1	66.8	66.8
non- gas-tight	100.0	95.3	90.6	84.2	78.9	73.6	68.3	63.0	57.8	52.5	40.6	36.9	33.2	33.2

A range of different application methods, and different incorporation periods for cropland and grassland, are used. The available relative-frequency data were obtained from a survey that the Federal Statistical Office conducted in 2011, for the year 2010; cf. Chapter 19.3.1, Table 508. Owing to a lack of other data, those data have been used for all years of the time series, with the following exception for application: as of 2012, application –like application of manure –is assumed to take place within 4 hours (cf. Chapter 5.1.3.6.1 and RÖSEMANN et al., 2017).

5.1.5 Activity data for emissions from agricultural soils and crops

5.1.5.1 N₂O emissions from agricultural soils (3.D)

5.1.5.1.1 The N quantities behind direct N₂O emissions (3.D)

Table 241 shows the N quantities, from various sources, that have been used as a basis for calculating direct N₂O emissions pursuant to IPCC (2006a)-11.7 (cf. Chapter 5.5.2.1.1).

Since no data on mineral-fertiliser application are collected, the inventory considers the N quantities from mineral-fertiliser application to be the same as the N quantities given by official statistics, at the German Länder (states) level, on sales of mineral fertilisers. The delay in the relevant surveys amounts to half a year. For purposes of the inventory, it is assumed that all of the mineral fertilizer sold in the second half of year j-1, and all of the mineral fertilizer sold in the first half of year j, is applied (spread) in year j.

The N quantity applied with manure and digestates from manure digestion is equivalent to the total N quantity excreted in housing systems, plus any N quantity introduced via bedding material, and minus the losses via N emissions from housing and storage as given by the N-flow concept (manure: Chapter 5.1.2.4; digestates from manure digestion: Chapter 5.1.3.6.5)

The N quantity that is applied with digestates from digestion of energy crops is obtained as the N quantity in the energy crops input into digestion, minus the N losses via emissions from the system for storage of digestates.

For each Land (state) in Germany, N quantities from sewage-sludge application are taken from data of the Federal Environment Agency (Section III 3.3) and (since 2009) of the Federal Statistical Office (Section G 202).

The direct N₂O emissions from N excretions during grazing are calculated in proportion to the N quantity excreted in pasture (cf. Chapter 5.1.3.4).

The quantities of N remaining in the soil in crop residues are obtained from the relevant areas under cultivation, yields and crop-specific N content data. The data on areas under cultivation and on fresh-matter yields are reported by the FEDERAL STATISTICAL OFFICE (STATISTISCHES BUNDESAMT; Fachserie 3, Reihe 3). The data are converted into dry-matter yields with the help

of dry-matter-content data given by the Fertiliser Ordinance (Düngeverordnung (DüV, 2007)). The relative N quantities contained in crop residues are taken from the Fertiliser Ordinance (DüV, 2007) and from a list prepared by the Institute of Vegetable and Ornamental Crops (IGZ, 2007). The quantities of N removed from relevant areas, for bedding material in animal husbandry, are deducted. With regard to the relevant input data and calculation methods, cf. RÖSEMANN et al. (2017).

The changes in the N quantities (apart from those for mineral fertilizer), with respect to the 2016 Resubmission, result from updating of the following activity data:

- **Manure, including digestates from manure digestion:** The N quantities have changed slightly, in some years, as a result of updates of input data (animal yield, relative shares of digested manure, frequency distribution of gas-tight storage of digestates) (cf. Chapters 5.1.3.3 and 5.1.3.6.5).
- **Digestion of energy crops:** The time series for the relevant amounts of fresh matter, and for the frequency distribution of gas-tight storage of digestates, have been updated. This has led to changes in the N quantities in application (cf. Chapter 5.1.4.2).
- **Sewage sludge:** The quantities of applied sewage sludge have been updated for some years.
- **Grazing:** Slight changes have occurred in the excreted N quantities, as a result of updating of animal yield data (cf. Chapter 5.1.3.3).
- **Crop residues:** The activity data for leek crops have been updated for the years 2012, 2013 and 2014.

An interesting feature of the time series for N quantities from crop residues is that it shows a sharp increase from 2013 to 2014 that results directly from a very good harvest in 2014.

Table 241: The N quantities behind direct N₂O emissions from agricultural soils (3.D)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mineral fertiliser	2163.7	1787.4	2014.4	1778.4	1783.7	1599.8	1807.2	1550.6	1569.0	1786.5	1640.4	1648.8	1675.3	1822.8
Manure, including digestates from manure digestion	1152.2	1001.9	973.9	943.1	927.6	938.1	942.9	952.5	945.5	953.1	969.1	982.7	998.0	992.3
Digestates from digestion of energy crops	0.0	0.6	5.3	45.2	63.6	87.2	101.9	131.0	165.1	206.5	227.4	274.4	288.4	290.1
Sewage sludge	27.4	35.3	33.0	27.4	27.0	26.0	25.6	25.5	26.0	25.1	25.0	21.5	21.3	21.3
Grazing	213.4	171.3	162.8	143.7	139.5	138.4	138.8	138.5	136.1	133.0	132.3	133.8	135.4	135.9
Crop residues	484.3	497.6	559.5	586.5	548.7	551.3	614.6	643.8	571.5	559.5	604.4	604.5	688.0	604.8

5.1.5.1.2 Area of organic soils under cultivation (3.D)

Table 242 shows the applicable land areas of segments of cultivated land with organic soils, broken down by cropland and grassland. The data have been provided by the LULUCF sector. The values for grassland differ from those for the grassland areas that the LULUCF sector reports, since LULUCF includes both the drained-grassland areas shown in Table 242 and undrained wet-grassland areas.

Table 242: Areas of organic soils under cultivation (3.D)

[thousands of ha]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	1307.6	1303.1	1298.6	1279.3	1275.2	1271.1	1267.0	1264.3	1261.6	1258.9	1256.2	1252.0	1247.7	1243.5
Cropland	301.5	306.1	310.7	315.5	326.5	337.5	348.4	355.5	362.5	369.6	376.6	378.0	379.3	380.7
Grassland (drained)	1006.1	997.0	987.9	963.8	948.7	933.7	918.6	908.8	899.1	889.3	879.6	874.0	868.4	862.9

5.1.5.1.3 Deposition of reactive nitrogen (3.B, 3.D, 3.J)

Deposition of reactive nitrogen is derived from the NH_3 and NO emissions from the German agricultural sector, as calculated in the inventory. This is carried out for the NH_3 and NO sources "housing and storage" (3.B), "storage of digestates of energy crops" (3.J) and "application and grazing" (3.D). In addition to spreading of manure and digestates from manure digestion, "application" also includes spreading of mineral fertilizer and digestates of energy crops.

Table 243 shows, for sectors 3.B and 3.J, the quantities of reactive nitrogen on which the calculations of indirect N_2O from N deposition are based. Similar data for the sector 3.D are provided in Table 244. The marked increase in the sum total, from 2014 to 2015, results from a strong increase in NH_3 emissions from application of mineral fertilizer. That increase, in turn, is due to a marked increase in the relevant quantities of mineral fertilizer, as well as to a simultaneous increase in the relative share of urea fertilizers.

Table 243: Sectors 3.B and 3.J: Reactive nitrogen from deposition of NH_3 and NO

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
3.B, Manure, including digestates from manure digestion	265.4	223.3	222.3	222.6	219.5	222.1	222.0	222.8	217.4	217.6	220.7	221.4	223.0	220.3
3.J, Digestates from digestion of energy crops	0.0	0.0	0.1	1.0	1.3	1.7	1.8	2.2	2.5	2.9	2.4	2.7	2.5	2.6

Table 244: Sector 3.D: Reactive nitrogen from deposition of NH_3 and NO

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
3.D, Total	403.6	336.2	345.7	331.8	338.0	336.1	347.3	360.2	343.1	380.2	361.9	382.7	389.0	412.2
3.D, Manure, digestates from manure digestion, mineral fertilizer, grazing	403.5	336.0	344.6	323.0	325.3	319.0	327.5	334.7	310.7	339.6	319.3	331.9	335.8	358.7
3.D, Residues from digestion of energy crops	0.0	0.1	1.0	8.8	12.7	17.2	19.8	25.6	32.4	40.6	42.6	50.8	53.2	53.5

Discrepancies in the total quantity of reactive nitrogen (sum of values in Table 243 and Table 244), with respect to the 2016 Resubmission, result from changes in animal yield data (cf. Chapter 5.1.3.3) and in the activity data for digestion of manure and energy crops (cf. Chapter 5.1.3.6.5 and Chapter 5.1.4).

5.1.5.1.4 Leaching and surface runoff (3.D)

As was already the case in the 2016 Resubmission, and in conformance with IPCC (2006a), the activity data used for calculating N_2O emissions from leaching and surface runoff consist of the total nitrogen in the applied quantities of mineral fertilizer, manure, digestates (including digestates of energy crops) and sewage sludge, as well as of the N quantities in crop residues. With this procedure, Germany is following a recommendation made by the Expert Review Team in connection with the In Country Review of the 2016 Submission. For details, cf. RÖSEMANN et al. (2017).

Only part of the available N quantity is leached out. That fraction is expressed via the quantity $\text{Frac}_{\text{LEACH}}$ (cf. IPCC (2006a)-11.21). For $\text{Frac}_{\text{LEACH}}$, Germany uses the IPCC default value 0.30 kg kg^{-1} (IPCC (2006a)-11.24, Table 11.3). The criterion for use of that default value is that the soil's water-

retention capacity is exceeded; cf. IPCC (2006a) 11.24, Table 11.3. This criterion must be assumed to be fulfilled, on a yearly average, throughout all Germany, since new groundwater formation takes place everywhere in Germany (NEUMANN & WYCISK, 2002). The calculated quantities of leached nitrogen are shown in Table 245.

Table 245: Leached N quantity (including surface runoff) (3.D)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	1212.3	1048.3	1124.7	1057.3	1047.1	1002.2	1089.3	1032.6	1024.0	1099.1	1079.6	1099.7	1141.9	1160.2

5.1.5.2 CO₂ emissions from liming and urea application (3.G-I)

The calculated CO₂ emissions from liming also include –as is called for in reporting on the agricultural sector (cf. IPCC (2006a), Chapter 11.3, and CRF Table 3.G-I) –the emissions from the quantities of lime fertilizer used in forests. Emissions are calculated and listed separately for a) limestone use and b) dolomite use, because the emission factors for those two categories differ (cf. Chapter 5.8.2). (The ERT's call for separate calculation of limestone use and dolomite use, expressed in connection with the 2016 In Country Review, was already fulfilled in the 2016 Resubmission.)

No data on applied quantities of lime fertilizer are available. For this reason, the applied quantities are considered to be equal to the product quantities sold within the country (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 8.2). The delay in the relevant surveys amounts to half a year. For purposes of the inventory, it is assumed that all of the lime fertilizer sold in the second half of year j-1, and all of the lime fertilizer sold in the first half of year j, is applied (spread) in year j. Calcium carbonate, compound lime, carbolic lime ("Carbokalk"), residual lime and calcium ammonium nitrate are all taken into account. For purposes of emissions calculations, product quantities reported in units of CaO or N are converted into units of CaCO₃, for limestone, and of CaMg(CO₃)₂, for dolomite.

Dolomite's share of the total quantity of fertilizer lime is not recorded statistically. For purposes of the inventory, that share has been calculated on the basis of the expert assessment (personal communication) of R. Müller of the Düngekalk-Hauptgemeinschaft group (a department within the BV Kalk lime industry association), Cologne, 25 August 2016), according to which the lime fertilizer used in the forestry sector consists of one-third MgCO₃, and the use of dolomite in the agricultural sector is negligible. For calculation of the 2016 Resubmission, the activity data for the new German Länder (states), for the years 1990 through 1993, were already updated with respect to the 2016 Submission (RÖSEMANN et al., 2017).

Table 246 shows the limestone and dolomite quantities –combined for the agricultural and forestry sectors –on which the emissions calculations are based (RÖSEMANN et al., 2017).

Table 246: Lime-fertilizer quantities (3.G)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Limestone [in CaCO ₃]	5318.9	3505.2	4688.5	3713.8	3567.5	3849.7	4005.3	3874.0	3768.6	4086.4	4239.7	4339.0	4894.2	4855.2
Dolomite [in CaMg(CO ₃) ₂]	763.0	425.0	339.8	195.7	187.7	193.8	151.8	190.5	166.7	184.0	174.8	198.0	186.1	164.6

The CO₂ emissions from urea application are calculated in proportion to the quantities of applied urea listed in Table 247 (including applied urea ammonium nitrate solution). These quantities were derived stoichiometrically (via multiplication by the molar ratio 60/28) from the urea-N quantities reported in official statistics.

Table 247: Urea application, including application of urea ammonium nitrate solution (3.H)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	654.0	650.8	788.9	815.4	891.5	874.1	883.5	1084.1	801.0	1022.6	852.0	947.8	951.6	1167.6

5.1.5.3 NMVOC emissions from agricultural crops

Table 248 shows the input data for agricultural crops for which NMVOC emissions are calculated pursuant to EMEP (2013)-3D-32 ff (cf. Chapter 5.5.2.1.5). The beginning and end years of the time series are listed, by way of example, for the relevant areas under cultivation and the fresh-matter yields. The data on areas under cultivation and on fresh-matter yields are reported by the FEDERAL STATISTICAL OFFICE (STATISTISCHES BUNDESAMT; Fachserie 3, Reihe 3). The data are converted into dry-matter yields with the help of dry-matter-content data given by the Fertiliser Ordinance (Düngeverordnung (DüV, 2007)). The relative emission duration for wheat, rye, rape and grass have been taken from EMEP (2013)-3D-34, Table A3-2, and applied, analogously, to the other crops involved.

Table 248: Input data for calculation of NMVOC emissions from agricultural crops (overview)

Crop	Area under cultivation [ha]		Fresh matter yield [kg ha ⁻¹]		Dry matter content [kg kg ⁻¹]	Relative emission duration [a a ⁻¹]
	1990	2015	1990	2015		
Wheat	2419.9	3263.8	6.3	8.1	0.86	0.3
Rye	1067.1	616	3.8	5.7	0.86	0.3
Barley	2612.5	1621.7	5.4	7.2	0.86	0.3
Oats	533.5	140	4.5	4.5	0.86	0.3
Triticale	77.4	401.6	5.1	6.5	0.86	0.3
Grain maize	228.4	455.9	6.8	8.9	0.86	0.3
Silage maize	1365.4	2100.3	40.4	41.4	0.28	0.3
Rape	557.5	1281.6	3.0	3.9	0.91	0.3
Root crops	1249.6	549.4	40.6	60.0	0.22	0.3
Grass clover ley, alfalfa, forage grass	856.6	526.6	34.0	35.4	0.20	0.5
Legumes	121.2	160.3	3.6	3.5	0.86	0.3
Pastures and meadows	5417.2	4495.2	31.6	31.4	0.20	0.5

5.1.6 Total uncertainty of all GHG emissions in sector 3

Along with calculation of emissions, the total uncertainty for all GHG emissions in Sector 3 was calculated. This was done in accordance with the "Approach 1" procedure described in IPCC (2006b), Chapter 3, a procedure based on Gaussian error propagation calculation. By way of convention, it is ignored that such error propagation calculations assume a normal distribution, a distribution requirement that some of the activity data and emission factors that enter into the calculation do not meet or cannot be verified to meet. For asymmetric distributions, the larger of the two intervals [2.5 percentile; average] and [average; 97.5 percentile] was used, as required by IPCC (2006b) for the "Approach 1" procedure. (For uncertainties calculations by the Federal Environment Agency, using the "Approach 2" procedure, the upper and lower bound of the 95 % confidence interval and the type of distribution involved are provided for all uncertainties.) Further details on uncertainties calculation for the German inventory are presented in RÖSEMANN et al. (2017).

Table 249 shows, for the year 2015, the total uncertainty, as calculated with the "Approach 1" procedure, for all emissions of the "agriculture" sector (Sector 3), including emissions from digestion of energy crops and from storage and application of residues from digestion of energy crops. Table 249 also shows the uncertainty for the overall trend since 1990. All emissions values are given in CO₂ equivalents, as obtained using the greenhouse warming potential (GWP) conversion factors specified in IPCC (2006a), 25 kg kg⁻¹ for CH₄ und 298 kg kg⁻¹ for N₂O.

In the interest of clarity, the presentation in Table 249 uses the collective animal categories "other cattle", "swine", "horses" and "poultry", and includes pertinent representative uncertainties for activity data and emission factors. The calculations for Table 249 were carried out using the sub-categories (for example, for swine: sows (including suckling piglets), weaners, fattening pigs, boars) and their specific uncertainties, however; cf. RÖSEMANN et al. (2017).

The uncertainties for the emission factors tend to be considerably higher than those for the activity data, and thus they predominate in the combined uncertainty in the column "Combined uncertainty as % of total national emissions".

The total uncertainty for the emissions in sector 3 (animal husbandry, use of agricultural soils, digestion of energy crops) is 38.1 % (valid for the year 2015). It is caused, to a large extent, by the uncertainties for the N₂O emissions from agricultural soils, as the column "Combined uncertainty as % of total national emissions" indicates. The uncertainty for the trend for the period 1990 – 2015 is 12.9 %.

Table 249: Total-uncertainties calculation for emissions from Sector 3 (animal husbandry, agricultural soils), including digestion of energy crops

Source category	Gas	Base year emissions, in CO ₂ equivalents	Year 2015 emissions, in CO ₂ equivalents	Activity data uncertainty (half the 95 % confidence interval)	Emission factor uncertainty (half the 95 % confidence interval)	Combined uncertainty (half the 95 % confidence interval)	Auxiliary calculations ^A	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Square of "Uncertainty introduced into the trend in total national emissions" ^B
		(GWP _{CH₄} = 25, GWP _{N₂O} = 298)										
		kt a ⁻¹	kt a ⁻¹									
EntFer, dairy cows	CH ₄	19,089.1	14,579.1	4	20	20.4	19.7	0.02	0.18	0.37	1.04	1.21
EntFer, other cattle	CH ₄	14,163.3	9,045.4	4	20	20.4	7.6	0.04	0.11	0.72	0.64	0.93
EntFer, swine	CH ₄	677.7	654.6	4	20	20.4	0.0	0.00	0.01	0.02	0.05	0.00
EntFer, sheep	CH ₄	518.2	297.0	10	30	31.6	0.0	0.00	0.00	0.05	0.05	0.01
EntFer, goats	CH ₄	11.3	14.6	20	30	36.1	0.0	0.00	0.00	0.00	0.01	0.00
EntFer, horses	CH ₄	204.6	190.9	10	30	31.6	0.0	0.00	0.00	0.01	0.03	0.00
MM, dairy cows	CH ₄	2,646.8	2,225.6	4	20	20.4	0.5	0.00	0.03	0.00	0.16	0.03
MM, other cattle	CH ₄	2,602.9	1,445.5	4	20	20.4	0.2	0.01	0.02	0.19	0.10	0.05
MM, swine	CH ₄	2,684.7	2,341.8	4	20	20.4	0.5	0.00	0.03	0.02	0.17	0.03
MM, sheep	CH ₄	17.0	9.7	10	30	31.6	0.0	0.00	0.00	0.00	0.00	0.00
MM, goats	CH ₄	0.5	0.6	20	30	36.1	0.0	0.00	0.00	0.00	0.00	0.00
MM, horses	CH ₄	31.7	29.6	10	30	31.6	0.0	0.00	0.00	0.00	0.01	0.00
MM, poultry	CH ₄	89.4	148.2	10	20	22.4	0.0	0.00	0.00	0.02	0.03	0.00
MM, direct N ₂ O, dairy cows	N ₂ O	1,565.6	993.9	4	100	100.1	2.2	0.00	0.01	0.41	0.07	0.17
MM, direct N ₂ O, other cattle	N ₂ O	1,456.2	1,000.3	4	100	100.1	2.2	0.00	0.01	0.28	0.07	0.08
MM, direct N ₂ O, pigs	N ₂ O	548.7	546.7	4	100	100.1	0.7	0.00	0.01	0.11	0.04	0.01
MM, direct N ₂ O, sheep	N ₂ O	74.2	42.3	10	300	300.2	0.0	0.00	0.00	0.08	0.01	0.01
MM, direct N ₂ O, goats	N ₂ O	4.2	5.5	20	300	300.7	0.0	0.00	0.00	0.01	0.00	0.00
MM, direct N ₂ O, horses	N ₂ O	156.1	145.9	10	300	300.2	0.4	0.00	0.00	0.05	0.03	0.00
MM, direct N ₂ O, poultry	N ₂ O	37.5	67.0	10	100	100.5	0.0	0.00	0.00	0.04	0.01	0.00

Source category	Gas	Base year emissions, in CO ₂ equivalents	Year 2015 emissions, in CO ₂ equivalents	Activity data uncertainty (half the 95 % confidence interval)	Emission factor uncertainty (half the 95 % confidence interval)	Combined uncertainty (half the 95 % confidence interval)	Auxiliary calculations ^A	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Square of "Uncertainty introduced into the trend in total national emissions" ^B
		(GWP _{CH₄} = 25, GWP _{N₂O} = 298)										
		kt a ⁻¹	kt a ⁻¹									
EntFer = Enteric Fermentation MM = Manure Management DEC = Digestion of Energy Crops												
MM, indirect N ₂ O, all animals	N ₂ O	1,242.9	1,031.7	10	400	400.1	38.0	0.00	0.01	0.07	0.18	0.04
Soils, mineral fertilizers	N ₂ O	10,132.1	8,535.9	1	200	200.0	650.1	0.00	0.11	0.03	0.15	0.02
Soils, spreading of manure	N ₂ O	5,395.7	4,647.0	20	200	201.0	194.6	0.00	0.06	0.27	1.65	2.80
Soils, sewage sludge	N ₂ O	128.4	99.8	20	200	201.0	0.1	0.00	0.00	0.02	0.04	0.00
Soils, crop residues	N ₂ O	2,267.8	2,832.4	50	200	206.2	76.1	0.01	0.04	2.32	2.52	11.73
Soils, organic soils	N ₂ O	2,594.2	2,836.7	1	200	200.0	71.8	0.01	0.04	1.64	0.05	2.70
Soils, grazing	N ₂ O	1,909.0	1,211.7	20	200	201.0	13.2	0.00	0.02	0.99	0.43	1.17
Soils, indirect N ₂ O (deposition)	N ₂ O	1,889.8	1,679.7	50	400	403.1	102.3	0.00	0.02	0.45	1.49	2.43
Soils, indirect N ₂ O (leaching, run-off)	N ₂ O	4,257.8	3,769.1	170	230	286.0	259.2	0.00	0.05	0.54	11.39	129.94
DEC, digester and storage	CH ₄	0.3	1,296.0	10	20	22.4	0.2	0.02	0.02	0.33	0.23	0.16
DEC, storage, direct N ₂ O	N ₂ O	0.1	233.0	10	100	100.5	0.1	0.00	0.00	0.29	0.04	0.09
DEC, storage, indirect N ₂ O (deposition)	N ₂ O	0.0	12.0	10	400	400.1	0.0	0.00	0.00	0.06	0.00	0.00
DEC, soils, direct N ₂ O	N ₂ O	0.2	1,358.7	10	200	200.2	16.5	0.02	0.02	3.41	0.24	11.71
DEC, soils, indirect N ₂ O (deposition)	N ₂ O	0.0	250.5	10	400	400.1	2.2	0.00	0.00	1.26	0.04	1.59
DEC, soils, indirect N ₂ O (leaching, run-off)	N ₂ O	0.0	305.7	10	230	230.2	1.1	0.00	0.00	0.88	0.05	0.78
Liming, calcium fertilizers without dolomite	CO ₂	2,340.3	2,136.3	3	3	4.2	0.0	0.00	0.03	0.01	0.11	0.01
Liming, dolomite	CO ₂	363.7	78.5	100	3	100.0	0.0	0.00	0.00	0.01	0.14	0.02
Application of urea	CO ₂	479.6	856.3	1	1	1.4	0.0	0.01	0.01	0.01	0.02	0.00
Total		79,581.6	66,955.2									
					Percentage uncertainty in total inventory:		38.1			Trend uncertainty (percentage):		12.9

^A The data in this column describe auxiliary data needed to derive the percentage uncertainty in total inventory in the bottommost cell of this column. In order to calculate the data the calculation procedure provided by IPCC (2006b) 3.31, Table 3.2, column H, has been used. Note, however, that the head of column as prescribed by IPCC (2006)-3.31, Table 3.2, column H ("Contribution to Variance by Category") does not correctly describe the data in column H. Hence the head of column has been modified.

^B The head of this column as prescribed by IPCC (2006b)-3.31, Table 3.2, column M („Uncertainty introduced into the trend in total national emissions“), has been modified in order to match the formula provided by IPCC (2006b) and applied in the table above to calculate the data in this column.

5.1.7 Quality assurance and control

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

5.1.7.1 The Thünen Institute's quality management for emissions inventories

The Thünen Institute's quality management for emissions-inventory preparation has been developed in conformance with the IPCC guidelines and the QSE (Chapter 1.6.1). The framework for the quality management, and the process for carrying it out, are described in detail in the relevant concept (BMEL, 2016) and in the provisions for implementation of the concept (TI, 2016). Documents of importance for quality control are added to the inventory description that is archived by the Single National Entity. The requirements and procedures set forth by the provisions for implementation of the concept were fully complied with. The following sections discuss important aspects of the quality control for the present submission.

5.1.7.2 Input data, calculation procedures and emissions results

Checking of the emissions calculations and of the NIR has included checking for the following:

- The calculation methods agree with those used for the 2016 Resubmission. A detailed description of the calculation methods is provided by RÖSEMANN et al. (2017).
- The input data and calculation results for all relevant emission sources in agricultural-sector emissions reporting are provided, as background for the results presented in the NIR 2017 and the CRF tables, in the CD Annex of RÖSEMANN et al. (2017).
- Every single time series of the emissions results for the 2017 Submission was checked for consistency with the corresponding time series in the 2016 Resubmission. The few discrepancies that have occurred are primarily the result of updating of some input data (cf. Chapter 5.1.3.3, 5.1.3.6.5 and 5.1.4.2). For pertinent documentation, cf. RÖSEMANN et al. (2017).
- The LULUC (Chapters 4.B, 4.C) and Agriculture (3.D) sections agree in their reporting regarding the areas of the organic soils used for cropland or as managed grassland.
- The fluctuations and trends in the time series can be explained, and the most important of these are described in the NIR.
- The activity data and emissions results were compared with corresponding data of central European countries that are either direct neighbors of Germany or that have comparable agricultural practices. In most cases, the German data fall within the middle range, or are at the level found in one or more of the countries being compared, or are at the level of an IPCC (2006a) standard value. Any important departures from these criteria discrepancies can be justified, in each individual case. For pertinent documentation, cf. RÖSEMANN et al. (2017).
- To ensure that the activity data and emission factors (IEF) were correctly entered into the Central System of Emissions (CSE) database, on which the CRF tables are based, the emissions as calculated with the CSE were compared with the emissions as calculated with the GAS-EM inventory model.
- The data in the NIR 2017 text were checked for consistency, via comparison with the calculation results.

5.1.7.3 Verification

The national emissions results calculated with the GAS-EM inventory model cannot be compared with other pertinent data from Germany, since no such data are available. Consequently, as described in Chapter 5.1.7.2, the input data and emissions results were compared with

corresponding data of other countries and with IPCC (2006a) default values. That process is discussed in the present NIR, in the relevant sub-chapters.

In the framework of a verification project for the 2014 NIR, an external expert (Zsolt Lengyel, Verico SCE) reviewed the German emissions calculations. That review found that the input data are consistent, and that the calculations are consistent and have been carried out in keeping with the methodological requirements set forth in the IPCC Guidelines.

The GAS-EM model is continuously validated and verified, in the framework of the European Agricultural Gaseous Emission inventory Research network (EAGER) group, and via review of modules, by KTBL. For the present 2017 Submission, modeling of feeding of fattening pigs was checked, by KTBL, for consistency with the practice-relevant information of the Deutsche Landwirtschaftliche Gesellschaft (German Agricultural Society) (DLG, 2014).

5.1.7.4 Reviews and reports

The recommendations from the Individual Review for the 2013 Submission, regarding improved transparency, and justification of the activity data and parameters in the biogas calculations, as well as of the national N₂O emission factor for solid manure, were fulfilled by adding the comprehensive detailed report (current version: RÖSEMANN et al., 2017) to the NIR and by including references to further relevant documents. As of the 2015 Submission, the sheep figures for the period as of 2010 have been corrected in response to a call for greater consistency in the time series for numbers of animals, a call issued as a result of the change in the survey key date. The ERT's recommendation that the activity data for mineral-fertiliser application be explicitly presented in the NIR was implemented in the 2015 Submission.

The recommendations for the Agriculture sector in the draft ERT report of the Centralized Review of the 2014 Submission were implemented in the 2015 Submission.

The recommendations made by the Expert Review Team in the 2016 In Country Review have been implemented in full. This applies especially to the aspects on which the 2016 Resubmission was based:

- An increase of the Tier 1 emission factor for CH₄ from enteric fermentation of lambs, from 3.2 kg place⁻¹ a⁻¹ to 3.6 kg place⁻¹ a⁻¹;
- Adjustment of the method for calculation of indirect N₂O emissions from leaching and surface runoff, to bring the calculation into line with the IPCC (2006a) methods;
- Calculation of CO₂ emissions from liming carried out separately for dolomite and limestone.

In its draft report, a national quality audit carried out by the firm of Verico SCE (auditor for the agricultural sector: Markus Helm), in April 2016, confirmed that the reporting system's Quality System for Emission Inventories (QSE) –and thus its emissions reporting for the agricultural sector –are in conformance with the requirements of the IPCC (2006a) Guidelines. The report is currently being prepared for publication.

5.2 Enteric fermentation (3.A)

5.2.1 Source category description (3.A)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	3.A.1. Enteric fermentation	Dairy cows	CH ₄	19,089.1	1.56%	14,579.1	1.64%	-23.6%
L/T	3.A.1. Enteric fermentation	Other cattle	CH ₄	14,163.3	1.16%	9,045.4	1.02%	-36.1%
-/-	3.A.2.-4. Enteric fermentation	Other animals (sheep, goats, horses, swine)	CH ₄	1,411.8	0.12%	1,157.1	0.13%	-18.0%

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	CS/Tier1/Tier2/Tier3	M/Q/AS/RS/NS	CS/D

The category *Dairy cows* is the most important emissions source within the source category *Enteric fermentation*. For methane, it is a key category in terms of emissions level and trend. This is due to the large numbers of animals and the high yields involved. The source category *Other cattle* is also a key category in terms of emissions level and trend.

CH₄ from enteric fermentation occurs via microbial conversions in animals' digestive tracts. The quantities released per animal and unit of time depend on the animal species in question, individual-animal yield and feed composition.

Germany reports on CH₄ emissions from enteric fermentation of dairy cows, other cattle (calves, heifers, bulls, suckler cows, male cattle older than 2 years), swine (sows, including suckling piglets weighing up to 8 kg per animal, weaner piglets, fattening pigs and boars), sheep, goats and horses.

The CH₄-emissions trend is shaped by decreasing animal populations –for cattle especially, throughout the entire period, and for all animal categories in the early 1990s –and by improved feed digestibility, which is partly offset by increasing GE intake levels in connection with increases in milk production and animal weights.

CH₄ emissions from enteric fermentation, as a percentage of total CH₄ emissions from the German agricultural sector (including CH₄ emissions from digestion of energy crops and storage of digestates from digestion of energy crops), have decreased slightly over the years (1990: 81.1 %; 2015: 76.8 %). Overall, CH₄ emissions from enteric fermentation decreased by 28.5 % between 1990 and 2015.

5.2.2 Methodological issues (3.A)

5.2.2.1 Methods (3.A)

The CH₄ emissions from enteric fermentation of dairy cows are calculated using a national method (Tier 3); see below. For other cattle and swine, the calculations are carried out with a Tier 2 method (IPCC, 2006a, 10.24 ff); see below. For sheep, goats and horses, calculations are carried out with a Tier 1 method that employs default emission factors (cf. Chapter 5.2.2.2).

In the national method for calculation of CH₄ emissions from enteric fermentation of dairy cows (DÄMMGEN et al., 2012b), the emission factor is calculated, pursuant to KIRCHGESSNER et al. (1994), as a function of intake of raw fibre, N-free extracts, raw protein and fat:

Equation 11: Calculation of the CH₄ emission factor for dairy cows (national method)

$$EF_{CH_4, ent} = a \cdot M_{XFi} + b \cdot M_{NFE} + c \cdot M_{XP} + d \cdot M_{XF} + e$$

Where

$EF_{CH_4, ent}$ Emission factor for CH₄ from enteric fermentation (in kg place⁻¹ a⁻¹ CH₄)

<i>a</i>	Coefficient ($a = 0.079 \text{ kg kg}^{-1}$)
M_{XFI}	Raw-fibre intake (in $\text{kg place}^{-1} \text{ a}^{-1}$)
<i>b</i>	Coefficient ($b = 0.010 \text{ kg kg}^{-1}$)
M_{NFE}	Intake of N-free extracts (in $\text{kg place}^{-1} \text{ a}^{-1}$)
<i>c</i>	Coefficient ($c = 0.026 \text{ kg kg}^{-1}$)
M_{XP}	Intake of raw protein (in $\text{kg place}^{-1} \text{ a}^{-1}$)
<i>d</i>	Coefficient ($d = -0.212 \text{ kg kg}^{-1}$)
M_{XF}	Intake of fat (in $\text{kg place}^{-1} \text{ a}^{-1}$)
<i>e</i>	Constant ($e = 365 \cdot 0.063 \text{ kg place}^{-1} \text{ a}^{-1}$)

The intake of raw fibre, N-free extracts, raw protein and fat is determined from the basic feed-composition data and from the pertinent quantities of ingested feed (cf. Chapter 5.1.3.3).

The methane conversion factor is calculated from those figures, with the help of the GE intake (cf. Chapter 5.1.3.3):

$$x_{\text{CH}_4, \text{GE}} = \frac{\eta_{\text{CH}_4} \cdot EF_{\text{CH}_4, \text{ent}}}{GE}$$

Where

$x_{\text{CH}_4, \text{GE}}$	Methane conversion factor for dairy cows (in MJ MJ^{-1})
η_{CH_4}	Energy content of methane ($\eta_{\text{CH}_4} = 55.65 \text{ MJ (kg CH}_4\text{)}^{-1}$)
$EF_{\text{CH}_4, \text{ent}}$	Emission factor for CH_4 from enteric fermentation (in $\text{kg place}^{-1} \text{ a}^{-1} \text{ CH}_4$)
GE	GE intake (in $\text{MJ place}^{-1} \text{ a}^{-1} \text{ GE}$)

While the methane conversion factor for dairy cows decreased from 0.071 MJ MJ^{-1} in 1990 to 0.063 MJ MJ^{-1} in 2015, the emission factor increased, as a result of continual increases in yield, from 120.2 kg CH_4 per animal place and year in 1990 to 136.1 kg CH_4 per animal place and year in 2015 (cf. Chapter 5.2.2.2).

The Tier 2 method that is used for other cattle and swine calculates the emission factor from the gross energy intake (cf. Chapter 5.1.3.3) and the methane conversion factor, in accordance with the following formula:

Equation 12: Calculation of the CH_4 emission factor (Tier 2 method, IPCC (2006), p. 10.31)

$$EF_{\text{CH}_4, \text{ent}} = GE \cdot \frac{x_{\text{CH}_4, \text{GE}}}{\eta_{\text{CH}_4}}$$

Where

$EF_{\text{CH}_4, \text{ent}}$	Emission factor for CH_4 from enteric fermentation (in $\text{kg place}^{-1} \text{ a}^{-1} \text{ CH}_4$)
GE	GE intake (in $\text{MJ place}^{-1} \text{ a}^{-1} \text{ GE}$)
$x_{\text{CH}_4, \text{GE}}$	Methane conversion factor (in MJ MJ^{-1})
η_{CH_4}	Energy content of methane ($\eta_{\text{CH}_4} = 55.65 \text{ MJ (kg CH}_4\text{)}^{-1}$)

In keeping with IPCC (2006a), Table 10.12, a methane conversion factor of 0.065 MJ MJ^{-1} is used for all other cattle, with the exception of calves. Pursuant to DÄMMGEN et al. (2013) a methane conversion factor of 0.041 MJ MJ^{-1} is used in the calculations for calves. For 1990 and 2015, the average methane conversion factor for other cattle is $0.0637 \text{ MJ MJ}^{-1}$. It varies slightly from year to year, however, as a result of changes in the composition of the total population of other cattle.

Table 250 shows the national category-specific methane conversion factors for swine (DÄMMGEN et al., 2012c). For 1990, the average methane conversion factor for all swine is $0.0052 \text{ MJ MJ}^{-1}$, while for 2015 it is $0.0050 \text{ MJ MJ}^{-1}$. The change from 1990 to 2015 is a result of changes in the composition of the total population of swine.

Table 250: Methane conversion factors for swine; DÄMMGEN et al. (2012c) (3.A)

	MJ MJ ⁻¹
Sows	0.0071
Weaners	0.0044
Fattening pigs	0.0046
Boars	0.0071

With regard to the emission factors calculated with Equation 12, cf. Chapter 5.2.2.2.

A detailed description of calculation of CH₄ emissions from enteric fermentation is provided by RÖSEMANN et al. (2017).

5.2.2.2 Emission factors (3.A)

Table 251 shows the CH₄ emission factors calculated per animal place for enteric fermentation of dairy cows, other cattle and swine.

Table 251: Animal-place-based CH₄ emission factors, enteric fermentation (3.A)

[kg ⁻¹ place ⁻¹ a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	120.2	124.4	128.4	131.8	132.1	132.8	131.9	132.8	133.6	134.3	134.7	134.7	135.5	136.1
Other cattle	43.1	44.1	44.7	44.1	44.2	44.1	43.9	44.1	44.0	43.7	43.5	43.6	43.3	43.3
Swine	1.02	1.07	1.09	1.10	1.10	1.10	1.10	1.11	1.12	1.12	1.12	1.13	1.14	1.14

The changes with respect to the 2016 Resubmission result from the changes, as mentioned in Chapter 5.1.3.3, in animal-yield data.

Table 252 shows the inventory's Tier 1 emission factors for sheep, goats and horses. The values shown have been used for the entire time series. The emission factor for goats has been taken from IPCC (2006a), Table 10.10. The emission factors for sheep and horses that are listed in that IPCC table have been adopted for mature sheep and heavy horses, respectively (RÖSEMANN et al., 2017). The emission factors for lambs and light horses / ponies have been derived from the Tier 1 emission factors for adult sheep and heavy horses, respectively (RÖSEMANN et al., 2017). In keeping with results of the 2016 In Country Review, the emission factor for lambs has been increased, with respect to the 2016 Submission, from 3.2 to 3.6 kg place⁻¹ a⁻¹. (For the 2016 Resubmission, calculations were carried out with this lamb emission factor of 3.6 kg place⁻¹ a⁻¹.)

Table 252: Tier 1 emission factors for CH₄ from enteric fermentation in sheep, goats and horses (3.A)

Animal category	EF [kg place ⁻¹ a ⁻¹]
Mature sheep	8.0
Lambs	3.6
Goats	5.0
Heavy horses	18.0
Light horses / ponies	12.0

Because the compositions of the small-animal / large-animal populations do not remain constant, the emission factors reported in the CRF tables vary slightly, from year to year, for sheep overall and for horses overall. For the period 1990 through 2015, the average factor for sheep is 6.4 kg place⁻¹ a⁻¹, while for horses it is 16.5 kg place⁻¹ a⁻¹.

5.2.2.3 Emissions (3.A)

The calculated CH₄ emissions from enteric fermentation, for all German animal husbandry, are listed in Table 253.

Table 253: CH₄ emissions from enteric fermentation (3.A)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	1386.6	1172.5	1082.9	997.3	973.3	972.3	990.5	993.5	986.2	974.0	973.8	988.7	995.4	991.3
Dairy cows	763.6	650.7	586.9	558.1	539.3	540.5	556.2	558.3	559.0	562.7	564.3	575.1	582.2	583.2
Other cattle	566.5	470.1	445.6	387.9	383.3	380.3	384.3	385.3	379.7	364.8	362.2	367.0	366.0	361.8
Swine	27.1	21.9	23.8	25.0	24.8	25.4	25.1	25.7	24.8	25.5	26.5	26.4	26.9	26.2
Sheep	20.7	18.9	17.6	16.9	16.3	16.1	15.4	15.0	14.3	12.6	12.5	11.9	12.0	11.9
Other mammals ^a	8.6	10.9	9.0	9.3	9.7	10.0	9.6	9.2	8.4	8.4	8.3	8.3	8.3	8.2

^a Other mammals: goats and horses

The emissions chronology since 1990 has been shaped primarily by

- trends in animal populations (inter alia, with a sharp decrease in 1990/1991 following German reunification, followed by a gradual further reduction; swine populations increased again as of the mid-1990s, however, as did dairy-cow populations as of 2011);
- continual increases in yields (milk production, animal weights, weight gains).

5.2.3 Uncertainties and time-series consistency (3.A)

With regard to the uncertainties in the area of methane emissions from enteric fermentation, the reader's attention is called to Table 249 in Chapter 5.1.6 (total uncertainty of the German GHG inventory).

The emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and complete.

5.2.4 Source-specific quality assurance / control and verification (3.A)

With regard to quality control and quality assurance, we refer to Chapter 5.1.7.

As part of verification, the German animal husbandry data for dairy cows, other cattle and swine were compared with the corresponding IPCC default values and with relevant data of neighboring countries, including data of the UK (Table 254 and Table 255). At the time the German 2017 emissions report was being prepared, the results of the other countries' 2017 emission reporting were not yet known. For this reason, data from 2016 reports are being used for those countries, although the German data have been taken from the current 2017 report. The international comparison is being carried out for 2014 (the last time-series year in the 2016 report).

Table 254 shows, for dairy cows, the national mean figure for animal-place-related emission factor (implied emission factor, IEF), GE intake and milk yield (which is the key factor affecting emissions levels). The CH₄-conversion factor is also included. It is used to calculate the fraction of GE intake that is converted into methane energy that is lost with emitted methane (cf. the method description in Chapter 5.2.2.1).

Of the ten countries included in the comparison, Denmark has the highest IEF, while Poland has the lowest. Germany's IEF falls into the middle of the ranking. This also applies to its GE-intake and milk yield figures. As to methane conversion factors, a number of countries have used the IPCC default value of 6.5 %. The values used by Denmark, France and Germany are lower than the IPCC default value, with the German value coming closest to the IPCC default value.

The IPCC default values for IEF and milk yield, when compared with the corresponding 2014 average figures for the countries under consideration, are seen to be too low. In 1990, the German IEF was already higher than the IPCC IEF, however, although the average daily milk yield, at 12.9 kg pl⁻¹ d⁻¹, was considerably lower than the level it reached in 2014, 20.7 kg pl⁻¹ d⁻¹.

Table 254: Methane emissions from enteric fermentation of dairy cows, in various countries –a comparison of Implied Emission Factors (IEF) for the time-series year 2014

	IEF _{CH₄} [kg place ⁻¹ a ⁻¹]	CH ₄ -conversion factor Y _m [MJ MJ ⁻¹]	GE intake [MJ place ⁻¹ d ⁻¹]	Milk yield [kg place ⁻¹ d ⁻¹]
Austria	130.12	0.0650	305.2	17.92
Belgium	139.78	0.0600	355.2	21.27
Czech Republic	140.54	0.0650	329.7	21.11
Denmark ^a	154.70	0.0600	393.1	24.94
France	122.18	0.0615	302.7	19.10
Germany	135.54	0.0635	326.0	20.66
Netherlands	127.20	n/a	281.1	NA
Poland	119.86	0.0650	281.1	n/a
Switzerland	136.92	0.0690	302.5	22.87
UK	130.85	0.0650	306.9	21.69
IPCC(2006a)-10.15 through 10.21, 10.29, 10.72	117	0.065	Equation 10.3-10.16	16.44 ^b

Source: Germany: Submission 2017; other countries: UNFCCC 2016

n/a: not available

^a Denmark, including Greenland, but not including the Faroe Islands

^b calculated from the annual milk yield assumed in IPCC (2006a), 6,000 kg place⁻¹ a⁻¹

Table 255 shows the IEF and the GE intakes for the group of other cattle and for all swine combined.

In the "other cattle" category, Denmark, among the ten countries chosen for comparison, has the lowest IEF, while the UK has the highest. Germany's IEF falls into the lower section of the ranking. Since the country's methane conversion rate is at about the same level seen in other countries (cf. RÖSEMANN et al., 2017), this is due directly to Germany's GE intake figure, which marks the lower end of the scale for all countries being compared. It should be noted, in this regard, that the German GE-intake figure has been calculated in light of feed characteristics specified in the technical literature, and based on the assumption that typical feeds have been used.

For swine, all of the countries involved, except for Denmark, Germany, France and Switzerland, use the IPCC default value for CH₄ from enteric fermentation. The four countries that calculate the IEF obtain results that are lower than the IPCC default value. The German value is substantiated in that Denmark and Switzerland obtain relatively similar results. The number of values reported for the GE intake for swine is too low for any meaningful comparison. Germany's value lies somewhat above the average of the reported values.

For both the "other cattle" and swine categories, the IEF default values in IPCC (2006a) seem too high for the circumstances prevailing in central Europe.

Table 255: Methane emissions from enteric fermentation of other cattle and swine, in various countries –a comparison of Implied Emission Factors (IEF) for the time-series year 2014

	Other cattle		Swine	
	IEF _{CH4} [kg place ⁻¹ a ⁻¹]	GE intake [MJ place ⁻¹ d ⁻¹]	IEF _{CH4} [kg place ⁻¹ a ⁻¹]	GE intake [MJ place ⁻¹ d ⁻¹]
Austria	59.92	140.55	1.50	NA
Belgium	50.14	132.27	1.50	NE
Czech Republic	55.33	129.78	1.50	NA
Denmark ^a	37.64	130.24	1.12	39.95
France	50.77	119.40	0.79	n/a
Germany	43.33	103.81	1.14	34.82
Netherlands ^b	37.29	n/c	1.50	NE
Poland	49.78	116.77	1.50	n/a
Switzerland ^b	46.90	114.68	1.07	27.15
UK ^c	64.67	NE	1.50	n/a
IPCC (2006a)-10.15 through 10.21, 10.28/29	57	Equation 10.3-10.16	1.5	Equation 10.3-10.16

Source: Germany: Submission 2017; other countries: UNFCCC, 2016;

n/a: not available; n/c: no calculation

^a Denmark, including Greenland, but not including the Faroe Islands^b Other cattle: calculated from CRF data^c UK, other cattle:: cattle, not including dairy cows, and not including dairy replacements (including calves going on to be dairy cows)

5.2.5 Source-specific recalculations (3.A)

Table 256 and Table 257 show, for dairy cows, other cattle and swine, GE intake and emission factors in comparison to the corresponding data in the 2016 Resubmission. The differences are slight; in the decimal representation chosen here, they are apparent only for swine in the years 2010 and 2014. They are due to the changes in yield-determining data described in Chapter 5.1.3.3.

Table 256: Comparison of the mean daily GE intake for dairy cows, other cattle and swine (3.A), as reported in 2016 and 2017

(MJ/animal)	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows, 2017	259.9	277.8	295.1	310.3	311.8	314.7	310.2	314.1	317.5	320.3	321.9	321.9	326.0	328.4
Dairy cows, 2016	259.9	277.8	295.1	310.3	311.8	314.7	310.2	314.1	317.5	320.3	321.9	321.9	326.0	
Other cattle, 2017	103.3	105.5	107.0	105.5	105.8	105.6	105.1	105.5	105.3	104.8	104.3	104.4	103.8	103.8
Other cattle, 2016	103.3	105.5	107.0	105.5	105.8	105.6	105.1	105.5	105.3	104.8	104.3	104.4	103.8	
Swine, 2017	30.2	31.8	32.6	33.0	33.1	33.2	33.3	33.8	33.8	34.0	34.3	34.5	34.8	34.9
Swine, 2016	30.2	31.8	32.6	33.0	33.1	33.2	33.3	33.8	33.7	34.0	34.3	34.5	34.6	

Table 257: Comparison of the CH₄ emission factors (enteric fermentation) for dairy cows, other cattle and swine (3.A), referenced to animal place, and as reported in 2016 and 2017

[kg place ⁻¹ a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows, 2017	120.2	124.4	128.4	131.8	132.1	132.8	131.9	132.8	133.6	134.3	134.7	134.7	135.5	136.1
Dairy cows, 2016	120.2	124.4	128.4	131.8	132.1	132.8	131.9	132.8	133.6	134.3	134.7	134.7	135.5	
Other cattle, 2017	43.1	44.1	44.7	44.1	44.2	44.1	43.9	44.1	44.0	43.7	43.5	43.6	43.3	43.3
Other cattle, 2016	43.1	44.1	44.7	44.1	44.2	44.1	43.9	44.1	44.0	43.7	43.5	43.6	43.3	
Swine, 2017	1.02	1.07	1.09	1.10	1.10	1.10	1.10	1.11	1.12	1.12	1.12	1.13	1.14	1.14
Swine, 2016	1.02	1.07	1.09	1.10	1.10	1.10	1.10	1.11	1.11	1.12	1.12	1.13	1.13	

Table 258 compares emissions from enteric fermentation, for the aforementioned animal categories, for sheep and for all mammal categories. In a trend similar to that seen for the emission

factors, the emissions for dairy cows, other cattle and swine have changed only slightly. In the decimal representation chosen here, the changes are apparent only in the swine category for 2014. The emission factor for lambs, which has been increased from 3.2 to 3.6 kg place⁻¹ a⁻¹, as a result of the 2016 In Country Review, has already been used in its new form in the 2016 Resubmission. For sheep, the 2016 Resubmission and the 2017 Submission show the same emissions results.

Table 258: Comparison of the CH₄ emissions (enteric fermentation) for all mammals, dairy cows, other cattle, swine and sheep (3.A), as reported in 2016 and 2017

[Tg a ⁻¹ CH ₄]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Mammals, 2017	1.387	1.172	1.083	0.997	0.973	0.972	0.991	0.993	0.986	0.974	0.974	0.989	0.995	0.991
Mammals, 2016	1.387	1.172	1.083	0.997	0.973	0.972	0.991	0.993	0.986	0.974	0.974	0.989	0.995	
Dairy cows, 2017	0.764	0.651	0.587	0.558	0.539	0.541	0.556	0.558	0.559	0.563	0.564	0.575	0.582	0.583
Dairy cows, 2016	0.764	0.651	0.587	0.558	0.539	0.541	0.556	0.558	0.559	0.563	0.564	0.575	0.582	
Other cattle, 2017	0.567	0.470	0.446	0.388	0.383	0.380	0.384	0.385	0.380	0.365	0.362	0.367	0.366	0.362
Other cattle, 2016	0.567	0.470	0.446	0.388	0.383	0.380	0.384	0.385	0.380	0.365	0.362	0.367	0.366	
Swine, 2017	0.0271	0.0219	0.0238	0.0250	0.0248	0.0254	0.0251	0.0257	0.0248	0.0255	0.0265	0.0264	0.0269	0.0262
Swine, 2016	0.0271	0.0219	0.0238	0.0250	0.0248	0.0254	0.0251	0.0257	0.0248	0.0255	0.0265	0.0264	0.0267	
Sheep, 2017	0.0207	0.0189	0.0176	0.0169	0.0163	0.0161	0.0154	0.0150	0.0143	0.0126	0.0125	0.0119	0.0120	0.0119
Sheep, 2016	0.0207	0.0189	0.0176	0.0169	0.0163	0.0161	0.0154	0.0150	0.0143	0.0126	0.0125	0.0119	0.0120	

5.2.6 Planned improvements (3.A)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

5.3 Manure management (3.B)

5.3.1 Source category description (3.B)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	3.B.1 Manure management	Dairy cows	CH ₄	2,646.8	0.22%	2,225.6	0.25%	-15.9%
-/-	3.B.1 Manure management	Dairy cows	N ₂ O	1,565.6	0.13%	993.9	0.11%	-36.5%
-/-	3.B.1 Manure management	Other cattle	CH ₄	2,602.9	0.21%	1,445.5	0.16%	-44.5%
-/-	3.B.1 Manure management	Other cattle	N ₂ O	1,456.2	0.12%	1,000.3	0.11%	-31.3%
-/-	3.B.2. and 3.B.4. Manure management	Other animals (sheep, goats, horses, poultry)	N ₂ O	272.0	0.02%	260.7	0.03%	-4.2%
-/-	3.B.2. and 3.B.4. Manure management	Other animals (sheep, goats, horses, poultry)	CH ₄	138.6	0.01%	188.2	0.02%	35.7%
-/-	3.B.3. Manure management	Swine	CH ₄	2,684.7	0.22%	2,341.8	0.26%	-12.8%
-/-	3.B.3. Manure management	Swine	N ₂ O	548.7	0.04%	546.7	0.06%	-0.4%
-/-	3.B.5. Indirect N ₂ O emissions	Manure (atmospheric deposition)	N ₂ O	1,242.9	0.10%	1,031.7	0.12%	-17.0%

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	Tier 2	M/Q/AS/RS/NS	CS/D
N ₂ O direct	Tier 2	M/Q/AS/RS/NS	CS/D
N ₂ O indirect	Tier 1	M/Q/AS/RS/NS	D
NO _x	Tier 2	M/Q/AS/RS/NS	CS
NM VOC	Tier 1	RS/NS	D

The source category *Manure management* is not a key category.

In sector 3.B, Germany reports on CH₄, N₂O, NO and NMVOC from manure management.

CH₄ occurs when methanogenic bacteria break down organic substances in anaerobic environments. Direct N₂O emissions are produced by nitrification and denitrification processes that take place during storage of manure and of digestates. NO is produced via nitrification in surface layers of manure storage facilities. NMVOC emissions are released from silage fodder and from manure storage facilities.

Reporting on manure management also covers indirect N₂O emissions. Such emissions can occur in connection with decomposition processes in the soil, and they are generated from reactive nitrogen originating via deposition of NH₃ and NO from management of manure and of digestates, as well as via nitrogen leaching and surface runoff from management of manure and of digestates. For reasons of water protection, seeping/leachage and uncontrolled above-ground runoff from management of manure and of digestates are to be prevented (1991 EU Nitrates Directive). For this reason, no indirect N₂O emissions from leachage / surface runoff have been calculated. This procedure has been followed for all years as of 1990. With regard to total N₂O emissions from the German agricultural sector, this amounts to a conservative assumption, since the nitrogen that is not lost via N₂O from leaching / surface runoff is applied to fields, thereby causing higher N₂O emissions as a result.

The relevant emissions are calculated in relation to a range of factors, including animal category; animal excretions (which, in turn, are a function of animal yield and of diet); the amounts of time spent by relevant animals in various defined areas (pastures, stables); the types of stables used; nitrogen inputs from bedding material (straw); and the type of manure storage involved.

The CH₄ emissions from manure management (including manure digestates) and grazing decreased by 23.2 % between 1990 and 2015. This decrease is due primarily to changes in animal populations and to emissions reductions achieved via manure digestion (cf. Table 262). In 1990, the CH₄ emissions from Sector 3.B accounted for 18.9 % of total CH₄ emissions from the German agricultural sector. The corresponding percentage in 2015 was 19.5 %.

The total direct N₂O emissions from manure management (including manure digestates) decreased by 27.1 % between 1990 and 2015. The reasons for this decrease are largely the same as those for the decrease in CH₄ emissions; see above. In 1990, the N₂O emissions from Sector 3.B accounted for 11.4 % of total N₂O emissions from the German agricultural sector. The corresponding percentage in 2015 was 8.9 %.

The indirect N₂O emissions assigned to manure management (including manure digestates) decreased by 17.0 % from 1990 to 2015. Their share of total N₂O emissions from the German agricultural sector decreased slightly: 1990: 3.7 %; 2015: 3.3 %.

The total NMVOC emissions from manure management amounted to 271.4 kt a⁻¹ in 1990. In 2015, they decreased by 26.8 %, to 198.6 kt a⁻¹.

5.3.2 Methane emissions from manure management (3.B, CH₄)

5.3.2.1 Source category description (3.B, CH₄)

Cf. Chapter 5.3.1.

5.3.2.2 Methodological issues (3.B, CH₄)

5.3.2.2.1 Methods (3.B, CH₄)

For all animal categories, CH₄ emissions are calculated in accordance with the Tier 2 method:

Equation 13: Calculation of total CH₄ emissions from manure management

$$E_{\text{CH}_4, \text{MM}} = \sum_{i,j} n_i \cdot EF_{i,j} = \sum_{i,j} n_i \cdot \alpha \cdot \rho_{\text{CH}_4} \cdot VS_i \cdot B_{o,i} \cdot MS_{i,j} \cdot MCF_{i,j}$$

Where

$E_{\text{CH}_4, \text{MM}}$	Total methane emissions from manure management (in kg a ⁻¹ CH ₄)
n_i	Number of animal places in animal category i (in places)
$EF_{i,j}$	Methane emission factor for animal category i in manure management system j (in kg place ⁻¹ a ⁻¹ CH ₄)
α	Factor for conversion of time units ($\alpha = 365 \text{ d a}^{-1}$)
ρ_{CH_4}	Density of methane ($\rho_{\text{CH}_4} = 0.67 \text{ kg m}^{-3}$)
VS_i	VS excretions for animal category i (in kg place ⁻¹ d ⁻¹)
$B_{o,i}$	Maximum methane-producing capacity for animal category i (in m ³ kg ⁻¹ CH ₄)
$MS_{i,j}$	Relative proportion of housing places, for animal category i, whose excrement occurs in manure management system j (in place place ⁻¹)
$MCF_{i,j}$	Methane-conversion factor for manure management system j (in m ³ m ⁻³) ⁸⁸

With regard to the number of animal places n_i , the reader's attention is called to Chapter 5.3.2.2.1. The VS excretions are described in Chapter 5.1.3.5. With regard to the relative percentages of storage systems for solid manure, slurry and digestates, and to time allotted to grazing, cf. Chapters 5.1.3.6.1 and 19.3.1. The methane-producing capacity B_o and the methane conversion factors MCF are discussed in Chapters 5.1.3.6.3 and 5.1.3.6.4. According to IPCC, manure digestion, including storage of manure digestates, is a separate storage type. The B_o and MCF values for it are covered in Chapter 5.1.3.6.5.

5.3.2.2.2 Emission factors (3.B, CH₄)

Table 259 shows the time series for the emission factors referenced to animal place. They have been calculated using Equation 13 in Chapter 5.3.2.2.1. The emission factors include the emissions reduction effects resulting via manure digestion. Discrepancies with respect to the 2016 Resubmission result from changes in animal-yield data (cf. Chapter 5.1.3.3) and in the activity data for manure digestion (cf. Chapter 5.1.3.6.5).

Table 259: Animal-place-based CH₄ emission factors; manure management (3.B(a))

[kg place ⁻¹ a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	16.7	21.3	22.5	23.4	23.2	22.9	22.6	22.4	22.0	21.4	21.2	20.7	20.7	20.8
Other cattle	7.9	8.0	8.1	8.0	7.9	7.8	7.6	7.5	7.4	7.2	7.1	7.0	7.0	6.9
Swine	4.1	4.4	4.5	4.4	4.4	4.3	4.2	4.2	4.1	4.1	4.1	4.1	4.1	4.1
Sheep	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
Goats	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Horses	2.5	2.5	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Poultry	0.031	0.030	0.032	0.035	0.035	0.036	0.036	0.036	0.037	0.035	0.034	0.033	0.033	0.032

5.3.2.2.3 Emissions (CRF 3.B, CH₄)

Table 260 shows the calculated total CH₄ emissions from manure management.

Table 260: CH₄ emissions from manure management (3.B(a))

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
[kt a ⁻¹]	322.92	291.42	287.18	275.08	266.88	265.55	265.12	263.86	253.87	249.62	251.85	250.22	251.76	248.05

Overall, emissions decreased by 74.9 kt a⁻¹ (23.2 %) from 1990 through 2015. The progression over time is tied largely to trends in the sizes of animal populations (cf. Chapter 5.1.3.2), with the

⁸⁸ IPCC gives MCF in percent (of B_o); in the German inventory, the less-ambiguous units m³ m⁻³ are used.

effects of such trends modified via emissions-increasing growth in yields (cf. Chapter 5.1.3.2.4) and via increasing emissions reductions as a result of manure digestion; cf. Table 262 below.

Table 261 shows the emissions contributions of dairy cows, other cattle and swine. These animal categories account for 98.3 % (1990) to 97.0 % (2015) of emissions from manure management. The ratio between the emissions of cattle husbandry and those of swine husbandry is about 2:1 for 1990 and 1.6:1 for 2015.

Table 261: CH₄ emissions from manure management for dairy cows, other cattle and swine

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	105.9	111.1	102.7	99.0	94.6	93.4	95.3	94.0	92.2	89.7	88.7	88.4	88.9	89.0
Other cattle	104.1	85.3	80.4	70.1	68.4	67.0	66.9	66.0	63.6	59.8	59.0	59.3	58.8	57.8
Swine	107.4	89.3	98.3	99.9	97.6	98.5	96.4	97.4	91.7	93.3	97.0	95.1	96.6	93.7

The CH₄-emissions reductions achieved via manure digestion are shown in Table 262. Without digestion, the so-saved emissions would have been emitted in addition to the quantities shown in Table 260. Such findings lead to the additional time series, shown in Table 262, of the reductions –expressed as percentages –achieved via digestion.

Table 262: Absolute and percentage changes in CH₄ emissions achieved as a result of manure digestion, in comparison to a situation with no digestion and no storage of digestates

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
[kt a ⁻¹]	0.01	0.1	0.7	6.5	9.5	13.7	16.6	21.3	26.6	32.7	35.8	40.1	41.9	42.0
[%]	0.0	0.0	0.2	2.3	3.4	4.9	5.9	7.5	9.5	11.6	12.4	13.8	14.3	14.5

5.3.2.3 Uncertainties and time-series consistency (3.B, CH₄)

With regard to the uncertainties in the area of methane emissions from manure management, the reader's attention is called to Table 249 in Chapter 5.1.6 (total uncertainty of the German GHG inventory).

The emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and complete.

5.3.2.4 Source-specific quality assurance / control and verification (3.B, CH₄)

With regard to quality control and quality assurance, we refer to Chapter 5.1.7.

In the framework of verification, and in an approach similar to that used in Chapter 5.2.4, the results and input data obtained for 2014 were compared with those (for 2014) of neighbouring countries and of the UK (2016 Submission 2016 for 2014, UNFCCC 2014).

Table 263 shows, for dairy cows, the IEF for CH₄ from manure management, and a number of important influencing factors. In keeping with the CRF requirements, the percentage shares for slurry systems, and the corresponding MCF values, refer only to slurry systems whose slurry is not digested in biogas plants.

Germany's IEF is in the order of the range for the IPCC default values. It also falls into the middle of the range defined by the values of countries being compared, although the daily VS excretions per animal place calculated for Germany mark the lower end of the relevant scale. The main reasons for this apparent discrepancy include the fact that Germany's MCF for slurry systems is considerably higher than the average value for the comparison countries. Only Poland and Belgium have still higher MCF values, as a result of their use of IPCC default values.

Table 263: CH₄ emissions from storage of manure from dairy cows, in various countries –a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters for the year 2014

	IEF _{CH₄}	VS excretions	Slurry systems (without digestion)	
	[kg place ⁻¹ a ⁻¹]	[kg place ⁻¹ d ⁻¹]	Frequency [%]	Mean MCF [%]
Austria	11.86	4.91	32.20	8.72
Belgium	28.35	5.09	46.15	19.00
Czech Republic	21.78	6.19	27.00	NO
Denmark ^a	30.40	6.66	79.99	6.97
France	23.30	4.15	n/a	n/a
Germany	20.70	4.04	52.77	15.28
Netherlands	41.55	4.70	83.42	NA
Poland	11.64	5.71	10.53	17.00
Switzerland	26.93	4.80	66.08	13.67
UK	17.52	4.51	37.02	11.40
IPCC (2006a)-10.38, 10.77, Western Europe, cool region 10°C/11°C	21 to 23	5.1	35.7	17 to 19

Source: Germany: Submission 2017; other countries: UNFCCC, 2016;

n/a: not available

^a Denmark, including Greenland, but not including the Faroe Islands

Table 264 shows, for other cattle, the IEF for CH₄ from manure management, and a number of important influencing factors. The German IEF is about at the level of the average value for all of the countries concerned. The primary reason for the large fluctuation range seen in the IEF values –apart from differences in VS excretions and MCF values –is that the frequency of use of slurry systems differs very widely. Germany also falls within the middle of the range in this category. Here, as in the dairy cows category, the German VS-excretions figure marks the lower bound of the value range for the countries being compared.

As Table 265 shows, Germany's IEF for CH₄ from manure management also falls into the middle of the range in the swine category, although it is slightly lower than the mean value for all of the countries being compared.

Table 264: CH₄ emissions from manure storage in the other cattle category, in various countries –a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters, for the year 2014

	IEF _{CH₄}	VS excretions	Slurry systems (without digestion)	
	[kg place ⁻¹ a ⁻¹ CH ₄]	[kg place ⁻¹ d ⁻¹]	Frequency [%]	Mean MCF [%]
Austria	5.01	2.17	24.73	8.47
Belgium	3.49	1.69	18.84	19.00
Czech Republic	9.09	2.82	42.00	NO
Denmark ^a	12.83	3.28	31.12	6.97
France	5.20	1.91	n/a	n/a
Germany	6.96	1.37	31.73	15.36
Netherlands ^b	8.60	n/c	66.43	n/c
Poland	2.16	2.09	5.06	17.00
Switzerland ^b	7.99	2.48	44.74	13.67
UK ^c	8.83	2.95	10.06	11.40
IPCC (2006a)-10.38, 10.77, Western Europe, cool region 10°C/11°C	6 to 7	2.6	25.2	17 to 19

Source: Germany: Submission 2017; other countries: UNFCCC, 2016;

n/a: not available; n/c: cannot be calculated

^a Denmark, including Greenland, but not including the Faroe Islands

^b Calculated from CRF data

^c UK: cattle, not including dairy cows, and not including dairy replacements (including calves going on to be dairy cows)

Table 265: CH₄ emissions from storage of manure from swine, in various countries –a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters, for the year 2014

	IEF _{CH₄}	VS excretions	Slurry systems (without digestion)	
	[kg place ⁻¹ a ⁻¹ CH ₄]	[kg place ⁻¹ d ⁻¹]	Frequency [%]	Mean MCF [%]
Austria	1.18	0.27	75.28	3.39
Belgium	4.48	0.22	96.79	19.00
Czech Republic	6.00	NA	76.00	NO
Denmark ^a	4.36	0.19	NO	16.66
France	4.74	n/a	n/a	n/a
Germany	4.08	0.30	78.22	22.17
Netherlands	6.77	3.70	99.01	NA
Poland	1.99	0.50	24.81	17.00
Switzerland	4.33	0.31	89.31	13.67
UK	5.21	n/a	n/a	n/a
IPCC (2006a)-10.80, 10.81, Western Europe, cool region 10°C/11°C	Sows, boars: 9 to 10 Other: 6	Sows, boars: 0.46 Other: 0.30		17 to 19

Source: Germany: Submission 2017; other countries: UNFCCC, 2016;

n/a: not available

^a Denmark, including Greenland, but not including the Faroe Islands

Table 266 shows, for poultry, the average IEF, the average VS excretions and –as an indicator for energy requirements, and thus for feed intake and excretions –the average animal weight. Data on VS excretions and average animal weight are available for only a few countries, however. Germany's VS excretions figure, realistically enough, is at the level of the corresponding figures for Denmark and the Netherlands. Germany's average-weight figure for poultry weight lies between the values reported by a) Belgium and b) the Czech Republic / Denmark.

Table 266: CH₄ emissions from manure storage in the poultry category, in various countries –a comparison of Implied Emission Factors (IEF) and important emissions-relevant parameters for the year 2014

	IEF _{CH₄} [kg place ⁻¹ a ⁻¹ CH ₄]	VS excretions [kg place ⁻¹ d ⁻¹]	Mean animal weight [kg animal ⁻¹]
Austria	0.026	NA	NA
Belgium	0.024	NE	1.56
Czech Republic	0.173	NA	2.00
Denmark	0.028	0.02	2.00
France	n/a	n/a	n/a
Germany	0.033	0.024	1.69
Netherlands	0.027	0.022	n/a
Poland	0.028	NA	NA
Switzerland	0.017	0.01	NA
UK	0.020	0.01	NE
IPCC (2006a)-10.82, W-Europe, cool region, developed countries	0.02 to 0.09	0.01 to 0.07	0.9 to 6.8

Source: Germany: Submission 2017; other countries: UNFCCC, 2016;

n/a: not available

5.3.2.5 Source-specific recalculations (3.B, CH₄)

Table 267 and Table 268 show the VS excretions and emission factors for dairy cows, other cattle, swine and poultry. The changes with respect to the 2016 Resubmission, resulting from changes in animal-yield data (cf. Chapter 5.1.3.3) and in activity data for manure digestion (cf. Chapter 5.1.3.6.5) are so slight that, as a result of the number format chosen, they appear only in a few cases in the following tables.

Table 267: Comparison of VS excretions as reported in 2017 and in 2016 (3.B(a))

[kg place ⁻¹ d ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows, 2017	3.47	3.63	3.78	3.90	3.91	3.94	3.90	3.94	3.97	3.99	4.01	4.01	4.04	4.06
Dairy cows, 2016	3.47	3.63	3.78	3.90	3.91	3.94	3.90	3.94	3.97	3.99	4.01	4.01	4.04	4.06
Other cattle, 2017	1.37	1.40	1.43	1.40	1.40	1.40	1.39	1.39	1.39	1.38	1.37	1.38	1.37	1.37
Other cattle, 2016	1.37	1.40	1.43	1.40	1.40	1.40	1.39	1.39	1.39	1.38	1.37	1.38	1.37	1.37
Swine, 2017	0.264	0.278	0.284	0.287	0.289	0.289	0.290	0.294	0.294	0.295	0.297	0.299	0.302	0.302
Swine, 2016	0.264	0.278	0.284	0.288	0.289	0.289	0.290	0.294	0.293	0.295	0.297	0.299	0.300	0.300
Poultry, 2017	0.0225	0.0218	0.0233	0.0255	0.0255	0.0261	0.0262	0.0264	0.0271	0.0263	0.0254	0.0242	0.0243	0.0241
Poultry, 2016	0.0225	0.0218	0.0233	0.0255	0.0255	0.0261	0.0262	0.0264	0.0271	0.0263	0.0254	0.0242	0.0242	0.0242

Table 268: Comparison of the animal-place-based CH₄ emission factors, as reported in 2017 and in 2016, for manure management (3.B(a))

[kg place ⁻¹ a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows, 2017	16.7	21.3	22.5	23.4	23.2	22.9	22.6	22.4	22.0	21.4	21.2	20.7	20.7	20.8
Dairy cows, 2016	16.7	21.3	22.5	23.4	23.2	22.9	22.6	22.4	22.0	21.4	21.2	20.7	20.6	20.6
Other cattle, 2017	7.93	8.01	8.07	7.97	7.89	7.78	7.65	7.55	7.37	7.17	7.09	7.04	6.96	6.92
Other cattle, 2016	7.93	8.01	8.07	7.97	7.89	7.78	7.65	7.55	7.37	7.17	7.09	7.04	6.93	6.93
Swine, 2017	4.05	4.38	4.52	4.39	4.35	4.29	4.25	4.23	4.12	4.09	4.10	4.07	4.08	4.08
Swine, 2016	4.05	4.38	4.52	4.39	4.35	4.28	4.25	4.23	4.12	4.09	4.10	4.06	4.03	4.03
Poultry, 2017	0.0314	0.0302	0.0321	0.0348	0.0348	0.0355	0.0356	0.0358	0.0366	0.0354	0.0341	0.0325	0.0325	0.0323
Poultry, 2016	0.0314	0.0302	0.0321	0.0348	0.0348	0.0355	0.0356	0.0358	0.0366	0.0354	0.0341	0.0325	0.0324	0.0324

Table 269: Comparison of CH₄ emissions from manure management as reported in 2017 and in 2016 (3.B(a))

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
All animals, 2017	322.9	291.4	287.2	275.1	266.9	265.6	265.1	263.9	253.9	249.6	251.8	250.2	251.8	248.0
All animals, 2016	322.9	291.4	287.2	275.2	266.8	265.5	265.1	263.9	253.7	249.6	251.8	250.2	249.8	249.8
Dairy cows, 2017	105.9	111.1	102.7	99.0	94.6	93.4	95.3	94.0	92.2	89.7	88.7	88.4	88.9	89.0
Dairy cows, 2016	105.9	111.1	102.7	99.0	94.6	93.4	95.3	94.0	92.2	89.7	88.7	88.4	88.5	88.5
Other cattle, 2017	104.1	85.3	80.4	70.1	68.4	67.0	66.9	66.0	63.6	59.8	59.0	59.3	58.8	57.8
Other cattle, 2016	104.1	85.3	80.4	70.1	68.4	67.0	66.9	66.0	63.6	59.8	59.0	59.3	58.5	58.5
Swine, 2017	107.4	89.3	98.3	99.9	97.6	98.5	96.4	97.4	91.7	93.3	97.0	95.1	96.6	93.7
Swine, 2016	107.4	89.3	98.3	100.0	97.6	98.5	96.4	97.4	91.5	93.3	97.0	95.1	95.4	95.4
Poultry, 2017	3.58	3.36	3.86	4.20	4.34	4.56	4.57	4.61	4.71	5.13	5.49	5.77	5.86	5.93
Poultry, 2016	3.58	3.36	3.86	4.20	4.34	4.56	4.57	4.61	4.71	5.13	5.49	5.76	5.85	5.85

5.3.2.6 Planned improvements (3.B, CH₄)

CH₄ emissions from manure use are also reported in sector 5.B.2 "Biowaste treatment –digesters." To rule out the possibility of double-counting of emissions in the waste and agricultural sectors, the data in these two sectors, and the substance streams between them, are being analyzed in detail for the 2018 Submission.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

5.3.3 NMVOC emissions from manure management

5.3.3.1 Source category description (NMVOC)

Cf. Chapter 5.3.1.

5.3.3.2 Methodological aspects (NMVOC)

5.3.3.2.1 Methods (NMVOC)

IPCC (2006a) does not provide any method for calculating NMVOC emissions from manure management. EMEP (2013) provides methods and the relevant parameters. Germany uses the

Tier 1 method (EMEP (2013)-3B-13 ff). The calculation is carried out separately for the various animal categories.

Equation 14: Tier 1 method for calculation of annual NMVOC emissions from manure management

$$E_{\text{NMVOC, MM, } i} = n_i \cdot EF_{\text{NMVOC, MM, } i}$$

Where

$E_{\text{NMVOC, MM, } i}$	NMVOC emissions from manure management for animal category i (in kg a ⁻¹)
n_i	Number of animal places in animal category i (in places)
$EF_{\text{NMVOC, MM, } i}$	NMVOC emission factor for animal category i (in kg place ⁻¹ a ⁻¹)

5.3.3.2.2 Emission factors (NMVOC)

EMEP (2013)-3B-16, Table 3.3, provides different emission factors for feeding with and without silage. For cattle and horses, the German inventory applies the relevant emission factors for feeding with silage; for other animals, it uses the factors for feeding without silage.

In a conservative approach, the emission factor for sows is used for boars, and the factor for fattening pigs is used for weaners.

The emission factor for sheep listed in EMEP (2013) has been interpreted as applying to mature sheep. Pursuant to RÖSEMANN et al. (2017), the emission factor for lambs is to be set at 40 % of the emission factor for mature sheep.

The emission factor for horses listed in EMEP (2013) has been interpreted as applying to heavy horses. For light horses and ponies, the emission factor given in EMEP (2013) for mules and asses has been used.

Due to the similarity in the applicable housing systems, the emission factor for broilers has been used for pullets.

Table 270 presents a list of the emission factors used in the inventory.

Table 270: NMVOC emission factors pursuant to EMEP (2013) that are used in the inventory

[kg place ⁻¹ a ⁻¹]	EF_{NMVOC}
Dairy cows	17.937
Other cattle	8.902
Sows, boars	1.704
Fattening pigs, weaners	0.551
Mature sheep	0.169
Lambs	0.068
Goats	0.542
Heavy horses	7.781
Light horses and ponies	3.018
Laying hens	0.165
Broilers, pullets	0.108
Geese, ducks and turkeys	0.489

5.3.3.2.3 Emissions (NMVOC)

Table 271 lists the NMVOC emissions from manure management that are to be reported under CRF 3s1. In keeping with the Tier 1 method used (cf. Chapter 5.3.3.2.1), the time series directly reflect the trends in numbers of animals (cf. Chapter 5.1.3.2.3).

The total emissions decreased by 26.8 %, from 271.4 kt a⁻¹ in 1990 to 198.6 kt a⁻¹ in 2015. The cattle contribution to the total emissions decreased from 85.1 % in 1990 to 76.1 % in 2015, while

the poultry contribution increased from 6.8 % to 14.7 %. With this result, the contribution of all other animal categories taken together has remained at a low level (1990: 8.2 %; 2015: 9.2 %).

Table 271: NMVOC emissions from manure management

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	271.4	225.6	209.3	193.9	190.5	191.0	194.3	193.9	191.7	191.7	194.1	198.4	199.7	198.6
Dairy cows	114.0	93.8	82.0	76.0	73.2	73.0	75.7	75.4	75.0	75.2	75.2	76.5	77.1	76.9
Other cattle	116.9	94.9	88.7	78.3	77.2	76.7	77.9	77.8	76.8	74.2	74.1	74.9	75.2	74.3
Swine	18.4	14.2	15.0	15.5	15.3	15.6	15.3	15.4	14.9	15.1	15.5	15.3	15.4	15.0
Sheep	0.43	0.39	0.36	0.35	0.34	0.33	0.32	0.31	0.30	0.26	0.26	0.25	0.25	0.25
Goats	0.05	0.05	0.08	0.09	0.10	0.10	0.10	0.12	0.08	0.08	0.07	0.07	0.07	0.06
Horses	3.2	4.1	3.3	3.4	3.5	3.7	3.5	3.3	3.1	3.1	3.1	3.1	3.1	3.1
Poultry	18.3	18.1	19.8	20.3	20.9	21.5	21.5	21.6	21.6	23.8	26.0	28.2	28.7	29.1

5.3.3.3 Uncertainties and time-series consistency (NMVOC)

Pursuant to EMEP (2013)-3B-33, the calculation procedure must be considered solely a first approach to the task of estimating NMVOC emissions from animal husbandry. The pertinent uncertainty, which EMEP (2013) does not quantify, is considered very high.

The emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and complete.

5.3.3.4 Source-specific quality assurance / control and verification (NMVOC)

With regard to quality control and quality assurance, we refer to Chapter 5.1.7.

5.3.3.5 Source-specific recalculations (NMVOC)

The method used for calculating the NMVOC-emissions shown in Chapter 5.3.3.2.3 is the same as that used in the 2016 Resubmission. The NMVOC-emissions figures for the years 1990 through 2014 agree with the corresponding figures given in the 2016 Resubmission.

5.3.3.6 Planned improvements (NMVOC)

No improvements are planned at present.

5.3.4 Direct N₂O and NO emissions from manure management (3.B, N₂O & NO)

5.3.4.1 Source category description (3.B, N₂O_{direct} & NO)

Cf. Chapter 5.3.1.

5.3.4.2 Methodological issues (3.B, N₂O_{direct} & NO)

5.3.4.2.1 Methods (3.B, N₂O_{direct} & NO)

N₂O emissions from manure management are calculated separately for all animal categories, taking account of the management systems in use (and including manure digestion; cf. Chapter 5.1.3.6.5):

Equation 15: Calculation of N₂O emissions from manure management

$$E_{N_2O-N} = \sum_{i,j} [(N_{excr,i} + N_{straw,i,j}) \cdot MS_{i,j}] \cdot EF_{N_2O-N,j}$$

where:

E_{N_2O-N}	Total N ₂ O-N emissions from manure management (kg a ⁻¹ N ₂ O-N)
$N_{excr,i}$	Total N excretions of animal category i (kg a ⁻¹ N)
$N_{straw,i,j}$	N input via bedding material, for animal category i and manure management system j (kg a ⁻¹ N)
$MS_{i,j}$	Relative share of manure management system j in animal category i (place place ⁻¹)
$EF_{N_2O-N,j}$	N ₂ O-N emission factor for manure management system j (kg kg ⁻¹ N ₂ O-N)

With regard to total N excretions and total N inputs via bedding material, cf. Chapters 5.1.3.4 and 5.1.3.6.2. With regard to the relative frequencies of manure management systems, cf. Chapters 5.1.3.6.1 and 19.3.2.

NO emissions from manure management are calculated using a method similar to that used to calculate the relevant N₂O emissions.

N₂O and NO emissions from manure application and grazing are reported under 3.D.

5.3.4.2.2 Emission factors (3.B, N₂O_{direct} & NO)

For slurry storage, the default emission factors given in IPCC (2006a)-10.62 are used where possible (outdoor storage without cover = open tank without natural crust; outdoor storage with natural crust; storage below slatted floor). In a conservative approach, for slurry storage with solid cover, or with artificial floating cover (chaff) –both of which are not mentioned in IPCC (2006a) – the emission factor for outdoor storage with natural crust is used. For slurry storage under a plastic film cover, which is also not mentioned in IPCC (2006a), it is assumed that the emission factor for outdoor storage without natural crust can be used.

Systems for storage of solid manure are broken down into the categories tied systems / pens allowing free movement (with storage in heaps) and deep bedding. For storage of solid manure from tied systems / pens allowing free movement the emission factor derived by VANDRÉ et al. (2013) is used: 0.013 kg N₂O-N (kg N)⁻¹. With regard to housing with deep bedding, Germany's agricultural sector does not practice active mixing of the bedding (expert judgment of Brigitte Eurich-Menden, KTBL, 2016; cf. RÖSEMANN et al., 2017). For this reason, the IPCC default value for "Cattle and swine deep bedding/no mixing" is used: 0.010 kg N₂O-N (kg N)⁻¹ (IPCC(2006a)-10.63).

The inventory calculations for poultry manure are based on the IPCC (2006a) default emission factor: 0.001 kg N₂O-N (kg N)⁻¹ (IPCC(2006a)-10.63).

Manure digestion, including storage of digestates, is treated in IPCC (2006a)-10.63 as a separate storage type. The German inventory does not use the IPCC default value for the N₂O emission factor (0 kg kg⁻¹), however, since it calculates the relevant N₂O emissions separately for the various types of manure and storage of digested manure; cf. Chapter 5.1.3.6.5.

Table 272 provides an overview of the N₂O-N emission factors used in the present 2017 Submission.

Table 272: Emission factors for emissions of N₂O-N from manure management, not including digestion (in relation to total excreted N and straw-bedding N) (3.B(b))

Manure	Emission factor [kg kg ⁻¹]
Slurry	Open tank, without natural crust ^a
	Solid cover ^b
	Natural crust cover ^a
	Floating cover (chaff) ^b
	Floating cover (plastic film) ^c
	Below slatted floor ^a
Leachate ^d	Solid cover
Solid manure ^e	
Deep bedding ^a	
Poultry, solid manure or faeces ^a	

^a Source: IPCC (2006a)

^b Worst-case assumption: Like natural crust, since no information is available.

^c Assumption: With floating plastic film covers, no N₂O formation occurs.

^d Assumption: Comparable to storage of slurry under a solid cover^e Source: VANDRÉ et al. (2013)

IPCC (2006a) does not give any emission factors for NO. The Tier 1 emission factors given in EMEP (2009)-4B-16 (cf. also EMEP (2013)-3B-15) refer to animal places and thus cannot be used in the GAS-EM inventory model, which, in the framework of the N-flow concept (cf. Chapter 5.1.2.4), requires emission factors that are related to N amounts. At the same time, comparative calculations show that the German total NO emissions from Sector 3.B as calculated with the Tier 1 method pursuant to EMEP (2009) can be reproduced with GAS-EM when the NO-N emission factor oriented to N is smaller than the N₂O-N emission factor by an order of magnitude. For this reason, in the inventory, the NO-N emission factor has been set at a level of 10 % of the N₂O-N emission factor. This approach yields NO emissions that are directly proportional to the relevant N₂O emissions.

Neither IPCC nor EMEP gives emission factors for N₂ (which must also be taken into account in the N-flow concept; cf. Chapter 5.1.2.4). JARVIS & PAIN (1994) obtained 3:1 as the ratio of N₂ emissions to N₂O-N emissions. Therefore, for purposes of the inventory, it has been assumed that N₂ emission factor is three times as large as the N₂O-N emission factor.

Table 273 shows the time series for the average N₂O-N emission factors for the four manure management systems "slurry-based (without digestion)", "straw-based (without deep bedding and without digestion)", "deep bedding (without digestion)" and "digestion" (of manure). In the interest of clarity, we have used the units g kg⁻¹, instead of the kg kg⁻¹, the common units for emission factors. These emission factors are defined as the ratio of total N₂O-N emissions from a management system to the sum of animal N excretions in the same management system. Under this perspective, the total N₂O emissions of systems with bedding also include fractions tied to bedding-N. For this reason, the resulting emission factor for deep bedding that is listed in Table 273 is higher than the factor given in Table 272. The same holds, in principle, for straw-based systems without deep bedding and without digestion, although the effect is not perceived, because the relevant values in Table 273 also include the considerably lower emission factor for poultry (cf. Table 272). The N₂O-N emission factors for straw-based systems show a negative trend in the first half of the 1990s, while those for systems with digestion show a negative trend throughout almost the entire time series. For straw-based systems, this results from decreases in N₂O contributions from solid-manure systems in cattle and swine husbandry. Those decreases, in turn, result from changes in numbers of animals in the various housing systems. For digestion systems, the negative trend in the emission factors is due primarily to increasing use of gas-tight storage of digestates (cf. Chapter 5.1.3.6.5). The data in Table 273 differ from those in the 2016 Resubmission, for the years 1990 through 2014, as the result of correction of an error in the derivation of the N₂O IEFs for the four different manure-management categories. This has masked changes resulting from updating of activity data. The error correction has not affected the magnitude of the total N₂O emissions.

Table 273: Average N₂O-N emission factors, by manure management systems (3.B(b))

[g kg ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Slurry-based ^a	3.15	3.45	3.41	3.44	3.44	3.45	3.47	3.48	3.50	3.50	3.50	3.50	3.50	3.50
Straw-based ^b	10.65	10.14	9.63	9.25	9.19	9.09	9.04	8.95	8.94	8.64	8.46	8.32	8.30	8.24
Deep bedding ^a	11.71	12.03	12.25	12.27	12.29	12.21	12.22	12.28	11.84	11.76	11.70	11.62	11.56	11.53
Digestion	5.81	5.45	5.25	4.94	4.67	4.40	4.14	3.88	3.61	3.33	2.71	2.58	2.44	2.44

^a Without digestion^b Without deep bedding and without digestion

5.3.4.2.3 Emissions (3.B, N₂O_{direct} & NO)

Table 274 shows the direct total N₂O emissions from manure management (including storage of digested manure), broken down by system categories. Between 1990 and 2015, the annual emissions from manure management decreased by 27.1 %, from about 12.9 kt N₂O to about 9.4 kt N₂O. The sharp emissions decrease in the first half of the 1990s is due primarily to reductions of livestock populations following German reunification. Additional influencing factors include shifts, over time, in the distributions of management systems (cf. Chapters 5.1.3.6.1 and 19.3.1), and gradually (over the years) increasing emissions reductions achieved via manure digestion (cf. Chapter 5.1.3.6.5).

Table 274: Direct N₂O emissions from manure management (MM), total and by system categories (3.B(b))

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MM total	12.894	10.552	10.064	9.886	9.769	9.863	9.908	9.951	9.784	9.597	9.470	9.446	9.495	9.402
Slurry-based ^a	4.451	4.603	4.420	4.137	3.971	3.905	3.854	3.795	3.614	3.496	3.496	3.424	3.445	3.397
Straw-based ^b	7.493	4.941	4.500	4.135	4.084	4.106	4.086	4.058	4.033	3.933	3.919	3.911	3.952	3.929
Deep bedding														
^a	0.950	1.004	1.105	1.364	1.360	1.372	1.423	1.451	1.386	1.323	1.311	1.313	1.308	1.278
Digestion	0.000	0.005	0.040	0.251	0.353	0.480	0.545	0.648	0.751	0.845	0.744	0.798	0.791	0.798

^a Without digestion

^b Without deep bedding and without digestion

Table 275 shows the corresponding contributions from the three most important animal categories (dairy cows, other cattle and swine). Cattle account for the largest shares: 78.6 % in 1990 and 71.2 % in 2015. Cattle and swine together have accounted for 92.9 % (1990) and 90.7 % (2015).

Table 275: Direct N₂O emissions from manure management for dairy cows, other cattle and swine (3.B(b))

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Dairy cows	5.25	3.92	3.65	3.57	3.45	3.46	3.47	3.46	3.42	3.38	3.29	3.28	3.32	3.34
Other cattle	4.89	4.15	3.99	3.61	3.57	3.55	3.63	3.65	3.62	3.46	3.39	3.41	3.40	3.36
Swine	1.84	1.46	1.53	1.78	1.80	1.87	1.87	1.93	1.88	1.89	1.92	1.88	1.90	1.83

Table 276 shows the absolute and percentage reductions in N₂O emissions achieved via manure digestion, in comparison to a situation with no digestion and storage of digestates. Negative values denote an emissions increase. The primary reason for the increase is that storage of digestates, if it is not gas-tight, generates higher N₂O emissions than does conventional storage of manure. What is more, storage of digested poultry manure generally produces higher N₂O emissions than does storage of undigested poultry manure. Only as of 2006/2007, when the fraction of storage systems with gas-tight storage has increased significantly (cf. Chapter 5.1.3.6.5), are reductions in N₂O achieved.

Table 276: Absolute and percentage changes in direct N₂O emissions as a result of manure digestion, in comparison to a situation with no digestion and storage of digestates (negative values: emissions increase)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
[kt a ⁻¹]	-0.0001	-0.0006	-0.003	-0.02	0.00	0.03	0.08	0.14	0.22	0.33	0.51	0.60	0.67	0.68
[%]	-0.001	-0.005	-0.03	-0.2	0.0	0.3	0.8	1.4	2.2	3.3	5.1	6.0	6.6	6.7

Table 277 shows the total NO emissions in source category 3.B.. Because the NO and N₂O emission factors are proportional to each other, the trends for NO are identical to those for N₂O.

Table 277: NO emissions from manure management

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	1.758	1.439	1.372	1.348	1.332	1.345	1.351	1.357	1.334	1.309	1.291	1.288	1.295	1.282

5.3.4.3 Uncertainties and time-series consistency (3.B, N₂O_{direct} & NO)

With regard to the uncertainties in the area of N₂O emissions from manure management, the reader's attention is called to Table 249 in Chapter 5.1.6 (total uncertainty of the German GHG inventory).

With regard to uncertainties in the area of N₂O emissions, cf. also RÖSEMANN et al. (2017).

The emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and complete.

5.3.4.4 Source-specific quality assurance / control and verification (3.B, N₂O_{direct} & NO)

With regard to quality control and quality assurance, we refer to Chapter 5.1.7.

In the framework of verification, and in an approach similar to that used in Chapter 5.2.4, the 2014 N-excretions and N₂O-emissions figures for Germany (current 2017 Submission) were compared with those of neighboring countries and the UK (2016 Submission, UNFCCC 2016); cf. Table 278 and Table 279.

Germany's N-excretions figure falls about within the middle range for dairy cows, while its value for other cattle falls more within the lower range. This is due at least in part to the (unknown) differences between the different countries' herd compositions. The German N-excretions figure for swine is the second-highest, after the Czech Republic's very high value, which is more in keeping with the excretions of a sow. These results bring up the question of how to define the average value for the entire swine population. Germany calculates the average value in conformance with the rules for an AAP place that is occupied 365 days of the year –cf. RÖSEMANN et al. (2017). The lower N-excretions values given by the other countries may be due to some inclusion of vacancy periods.

In the poultry category, Germany has the highest N excretions of all countries compared. As is the case in the swine category, direct comparisons are hampered by a lack of data regarding the composition of the total populations in the various countries.

Table 278: N excretions per animal place, for dairy cows, other cattle, swine and poultry of various countries, for the year 2014

	Dairy cows [kg place ⁻¹ a ⁻¹]	Other cattle [kg place ⁻¹ a ⁻¹]	Swine [kg place ⁻¹ a ⁻¹]	Poultry [kg place ⁻¹ a ⁻¹]
Austria	101.38	45.93	9.43	0.54
Belgium	117.92	54.31	9.38	0.60
Czech Republic	149.69	73.58	27.92	0.61
Denmark ^a	143.07	41.74	7.95	0.51
France	113.21	59.03	n/a	n/a
Germany	119.17	42.47	13.02	0.70
Netherlands ^b	n/a	n/c	n/a	n/a
Poland	n/a	n/a	10.36	0.53
Switzerland ^b	115.17	39.00	9.20	0.53
UK ^c	127.84	53.70	n/a	0.57
IPCC (2006a)-10.59, 10.72, 10.78,10.80, 10.81, 10.82	105.1 ^d	50.6 ^d	9.3 / 30.4 ^d	0.52 ^{d, f}
EMEP (2013)-3B-27	105	41	12.1 / 34.5 ^e	0.36 to 1.64

Source: Germany: Submission 2017; other countries: UNFCCC 2016

^a Denmark, including Greenland, but not including the Faroe Islands

^b Netherlands and Switzerland, other cattle: calculated from CRF data

^c UK: Cattle data differentiate between dairy cows (dairy cows and dairy replacements, including calves going on to be dairy cows) and the remaining "other cattle"

^d IPCC weights: calculated pursuant to IPCC (2006a), with the IPCC's standard values for weight and N excretions and, in the case of poultry, with the German animal counts in the various poultry sub-categories (2017 Submission)

^e IPCC (2006a): Sows and boars: 30.4, other: 9.3; EMEP (2013): Sows: 34.5, fattening pigs: 12.1

^f Poultry: Assumptions for lacking values: Weight of geese = 1/2 standard weight of turkeys (IPCC 2006a); N excretions of geese = standard N excretions of turkeys (IPCC 2006a); weight of pullets = 1/2 standard weight of laying hens (IPCC 2006a); N excretions of pullets = standard N excretions of laying hens (IPCC 2006a)

Table 279 shows a comparison of the IEFs for direct N₂O emissions from manure management for dairy cows, other cattle, swine and poultry. The values of the Czech Republic, France, the Netherlands and Switzerland are either extreme or missing (except for the Swiss value for poultry); presumably, they are due to transfer errors. When those countries are not included, the German IEFs for dairy cows, other cattle and swine are each somewhat higher than the average value, while Germany's value for poultry is the highest in its category. Germany's high value for poultry can be explained in that the German poultry IEF also includes N₂O emissions from digestion of poultry manure, and from related storage of digestates; the effective emission factor for such digestion and storage is considerably higher than the emission factor for conventional storage of poultry manure.

Table 279: IEFs of various countries for direct N₂O emissions from manure management for dairy cows, other cattle, swine and poultry, in 2014

	Dairy cows [kg place ⁻¹ a ⁻¹]	Other cattle [kg place ⁻¹ a ⁻¹]	Swine [kg place ⁻¹ a ⁻¹]	Poultry [kg place ⁻¹ a ⁻¹]
Austria	0.70	0.36	0.045	0.00080
Belgium	0.76	0.57	0.037	0.00094
Czech Republic	3.35	0.95	0.374	0.00872
Denmark ^a	1.04	0.35	0.071	0.00081
France	0.15	0.09	0.004	n/a
Germany	0.77	0.40	0.080	0.00123
Netherlands ^b	IE	n/c	IE	n/a
Poland	0.58	0.24	0.081	0.00083
Switzerland ^b	0.16	0.10	0.004	0.00081
UK ^c	0.52	0.26	0.078	0.00088

Source: Germany: Submission 2017; other countries: UNFCCC 2016

n/a: not available; n/c: cannot be calculated

^a Denmark, including Greenland, but not including the Faroe Islands^b Netherlands and Switzerland, other cattle: calculated from CRF data^c UK: Cattle data differentiate between dairy cows (dairy cows and dairy replacements, including calves going on to be dairy cows) and the remaining "other cattle"

5.3.4.5 Source-specific recalculations (3.B, N₂O_{direct} & NO)

Table 280 shows the N₂O emissions in Sector 3.B in comparison to the corresponding results in the 2016 Resubmission.

Table 280: Comparison of total direct N₂O emissions from manure management, as calculated in 2016 and in 2017

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2017	12.894	10.552	10.064	9.886	9.769	9.863	9.908	9.951	9.784	9.597	9.470	9.446	9.495	9.402
2016	12.894	10.552	10.064	9.887	9.768	9.862	9.908	9.951	9.782	9.597	9.470	9.463	9.531	

Discrepancies in the N₂O emissions, with respect to the 2016 Resubmission, result from changes in animal-yield data (cf. Chapter 5.1.3.3) and in the activity data for manure digestion (cf. Chapter 5.1.3.6.5). The changes in the N-excretions figures –cf. Table 281 –are due to updating of animal-yield data.

Table 281: Comparison of total N excretions, as calculated in 2016 and in 2017 (cf. Chapter 5.1.3.4)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2017	1611.4	1382.9	1346.1	1297.4	1274.4	1286.1	1290.8	1301.2	1286.4	1291.3	1309.4	1324.8	1343.1	1335.3
2016	1611.4	1382.9	1346.1	1297.6	1274.4	1286.0	1290.8	1301.2	1286.1	1291.3	1309.4	1324.8	1341.8	

The NO emissions, because they are directly proportional to N₂O emissions (cf. Chapter 5.3.4.2.2), have changed with respect to the corresponding figures in the 2016 Resubmission in the same manner that the N₂O emissions have changed. Table 282 presents a comparison of the time series for total NO emissions.

Table 282: Comparison of total NO emissions from manure management, as calculated in 2016 and in 2017

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2017	1.758	1.439	1.372	1.348	1.332	1.345	1.351	1.357	1.334	1.309	1.291	1.288	1.295	1.282
2016	1.758	1.439	1.372	1.348	1.332	1.345	1.351	1.357	1.334	1.309	1.291	1.290	1.300	

5.3.4.6 Planned improvements (3.B, N₂O_{direct} & NO)

N₂O emissions from manure use are also reported in sector 5.B.2 "Biowaste treatment –digesters." To rule out the possibility of double-counting of emissions in the waste and agricultural sectors, the data in these two sectors, and the substance streams between them, are being analyzed in detail for the 2018 Submission.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

5.3.5 Indirect N₂O emissions as a result of manure management (3.B)

5.3.5.1 Source category description (3.B, N₂O_{indirect})

Cf. Chapter 5.3.1.

5.3.5.2 Methodological issues (3.B, N₂O_{indirect})

5.3.5.2.1 Methods (3.B, N₂O_{indirect})

The indirect N₂O emissions resulting from deposition of NH₃ and NO from manure management (including storage of digestates of manure; not including application) are calculated, in keeping with IPCC (2006a)-11.21, in proportion to the deposited N quantity:

Equation16: indirect N₂O emissions from manure management

$$E_{\text{N}_2\text{O indirect, MM}} = \frac{44}{28} \cdot (E_{\text{NH}_3\text{-N, MM}} + E_{\text{NO-N, MM}}) \cdot EF_4$$

where:

$E_{\text{N}_2\text{O, indirect, MM}}$	Indirect N ₂ O emissions from deposition of NH ₃ -N and NO-N from manure management (kg a ⁻¹)
$E_{\text{NH}_3\text{-N, MM}}$	Total NH ₃ -N emissions from manure management (kg a ⁻¹)
$E_{\text{NO-N, MM}}$	Total NO-N emissions from manure management (kg a ⁻¹)
EF_4	N ₂ O-N emission factor; cf. Chapter 5.3.5.2.2

With regard to calculation of NH₃ and NO emissions from housing systems and from manure storage, cf. RÖSEMANN et al. (2017).

Indirect N₂O emissions via leaching from manure management are not reported for Germany; cf. Chapter 5.3.1.

5.3.5.2.2 Emission factor (3.B, N₂O_{indirect})

The emission factor EF_4 for indirect N₂O emissions resulting from deposition of NH₃ and NO via manure management and management of digestates of manure (not including application) amounts to 0.01 kg N₂O-N (kg N)⁻¹ (IPCC (2006a)-11.24, Table 11.3).

5.3.5.2.3 Emissions (3.B, N₂O_{indirect})

Table 283 shows the indirect N₂O emissions resulting from deposition of reactive nitrogen via NH₃ and NO emissions from manure management –as reported in the present 2017 Submission and, with reference to Chapter 5.3.5.5, in the 2016 Resubmission. In general, the trend for indirect N₂O emissions follows the trend for direct N₂O emissions; cf. Chapter 5.3.4.2.3. With regard to the underlying quantities of reactive nitrogen, cf. Chapter 5.1.5.1.3.

Table 283: Indirect N₂O emissions as a result of deposition of NH₃ and NO from manure management (2017 Submission and 2016 Resubmission)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2017	4.171	3.509	3.493	3.498	3.449	3.489	3.487	3.500	3.415	3.418	3.469	3.479	3.504	3.462
2016	4.171	3.509	3.493	3.498	3.449	3.489	3.487	3.500	3.414	3.418	3.468	3.479	3.500	

5.3.5.3 Uncertainties and time-series consistency (3.B, N₂O_{indirect})

With regard to the uncertainties for the indirect N₂O emissions resulting from deposition of NH₃ and NO from manure management, we call attention to Table 249 in Chapter 5.1.6 (total uncertainty of the German GHG inventory).

The emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and complete.

5.3.5.4 Source-specific quality assurance / control and verification (3.B, N₂O_{indirect})

With regard to quality control and quality assurance, we refer to Chapter 5.1.7.

5.3.5.5 Source-specific recalculations (3.B, N₂O_{indirect})

For the 2017 Submission, animal-yield data (cf. Chapter 5.1.3.3), and activity data for manure digestion, have been updated (cf. Chapter 5.1.3.6.5). To take account of these differences, the time series for deposition-related indirect N₂O emissions from manure management has been recalculated for all years as of 1990. Table 283 in Chapter 5.3.5.2.3 presents a comparison of the relevant time series in the 2017 Submission and the 2016 Resubmission. The changes are slight.

5.3.5.6 Planned improvements (3.B, N₂O_{indirect})

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

5.4 Rice cultivation (3.C)

No rice is cultivated in Germany (not occurring –NO).

5.5 Agricultural soils (3.D)

5.5.1 Source category description (3.D)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	3.D. Agricultural soils		N ₂ O	28,575.0	2.34%	27,527.1	3.10%	-3.7%

Gas	Method used	Source for the activity data	Emission factors used
N ₂ O	Tier 1 / Tier 2	M/AS/RS/NS	D, CS
NO _x	Tier 1	RS/NS	D
NM VOC	Tier 1	RS/NS	D

The source category *Agricultural soils* is a key category for *N₂O emissions*, in terms of both emissions level and trend.

Microbial transformations of N compounds (nitrification and denitrification) lead to emissions of N₂O from soils. A distinction is made between direct and indirect N₂O emissions. The direct emissions in sector 3.D include N₂O emissions resulting from:

- application of mineral fertilizer
- application of manure (including manure digestates)
- application of digestates of energy crops
- application of sewage sludge
- grazing
- crop residues
- cultivation of organic soils

In mineral soils in Germany that are in continuing use as cropland, or as grassland (in a strict sense), no changes of carbon stocks occur (cropland: Chapter 6.5.2.2, CRF 4.B.1; grassland (in a strict sense): Chapter 6.6.2.3, CRF 4.C.1). Consequently, no mineralization / immobilization of nitrogen, in combination with increases / losses of organic substance in mineral soils in continuing agricultural use, takes place. For mineral soils, therefore, N₂O is being reported as zero (NA).

The indirect N₂O emissions in Sector 3.D result from deposition of reactive nitrogen and from leaching and surface runoff.

In 2015, the total N₂O emissions of Sector 3.D were 3.7 % lower than they were in 1990. At 87.1 %, their share of total N₂O emissions from German agriculture was somewhat higher in 2015 than it was in 1990, when it was 84.9 %. In 1990, the greenhouse-gas emissions in Sector 3.D (in CO_{2eq}) accounted for a 35.9 % share of greenhouse-gas emissions from the agricultural sector as a whole. By 2015, that share had increased to 41.1 %. In addition, the greenhouse-gas emissions resulting solely from application of residues from digestion of energy crops were negligible in 1990, while in 2015 they accounted for 2.9 % of the entire agricultural sector's greenhouse-gas emissions.

The German inventory takes account of NMVOC emissions from agricultural crops. As a result of increasing harvests, those emissions increased by 28.0 % from 1990 to 2015 –from 7.7 kt (1990) to 9.8 kt (2014).

5.5.2 Methodological aspects, and emissions (3.D)

5.5.2.1 Methods and emission factors (3.D)

5.5.2.1.1 Direct N₂O emissions (3.D.a)

Direct N₂O emissions resulting from application of N-containing substrates, and from crop residues, are calculated, with a Tier 1 method pursuant to IPCC (2006a)-11.7, in proportion to the

pertinent applied N quantities (cf. Chapter 5.1.5.1). Pursuant to IPCC(2006a)-11.11, Table 11.1, the relevant emission factor is 0.01 kg N₂O-N per kg of applied nitrogen.

Emissions from N excretions during grazing are calculated, pursuant to IPCC (2006a)-11.7, in proportion to the N quantity excreted on pasture (cf. Chapter 5.1.5.1). The relevant emission factor for cattle is EF = 0.02 kg N₂O-N per kg of excreted nitrogen. For sheep, goats and horses, the N₂O-N emission factor is 0.01 kg kg⁻¹. (For swine and poultry, the inventory assumes that there are no N excretions outdoors.)

Direct N₂O emissions from cultivation of organic soils are calculated in proportion to the relevant area, which is broken down into the categories of cropland and grassland (cf. Chapter 5.1.5.1.2). Pursuant to RÖSEMANN et al. (2017), the national emission factor for cropland, as derived from the German data, is 10.7 kg N₂O-N per ha, while the so-derived national EF for drained grassland is 2.3 kg N₂O-N per ha. As a result, for drained grassland, a lower EF is being used than was used in the 2016 Resubmission (2.7 kg N₂O-N per ha). As a result of the year-to-year variance in the cropland and grassland areas, the average emission factor varies over time; cf. Table 284.

Table 284: Average N₂O-N emission factors for cultivated organic soils

[kg kg ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
N ₂ O-N	4.2	4.3	4.3	4.4	4.5	4.5	4.6	4.7	4.7	4.8	4.8	4.8	4.9	4.9

5.5.2.1.2 Indirect N₂O emissions resulting from deposition of reactive nitrogen via agricultural soils (3.D)

Indirect N₂O emissions resulting from deposition of reactive nitrogen are calculated, pursuant to IPCC (2006a)-11.21, in proportion to the pertinent N quantity deposited. The method used is basically in keeping with the approach described in Chapter 5.3.5.2.1. With regard to the emission factor, cf. Chapter 5.3.5.2.2 (0.01 kg N₂O-N (kg N)⁻¹). The total deposited N quantity of relevance for the calculations in Sector 3.D comprises the N quantities of the following NH₃ and NO emissions (cf. Chapter 5.1.5.1.3):

- NH₃ and NO emissions from application of mineral fertilizer,
- NH₃ and NO emissions from application of manure (including manure digestates),
- NH₃ and NO emissions from application of residues from digestion of energy crops,
- NH₃ and NO emissions from grazing.

These emissions are obtained by multiplying the relevant applied N quantity or N excretions during grazing by the pertinent emission factor. The NH₃ emission factors for the various fertilizer categories are obtained from EMEP (2013)-3D. With regard to the NH₃ emission factors for spreading of manure and digestates, we refer to RÖSEMANN et al. (2017). The NH₃ emission factors for grazing are differentiated by type of animal; cf. EMEP (2013)-3B-27. With regard to the NO emission factor, cf. Chapter 5.5.2.1.4.

A detailed description of calculation of indirect N₂O emissions from agricultural soils is provided by RÖSEMANN et al. (2017).

5.5.2.1.3 Indirect N₂O emissions resulting from leaching and surface runoff (3.D)

In keeping with the Tier 1 method pursuant to IPCC (2006)-11.21, indirect N₂O emissions resulting from leaching and surface runoff are calculated as the product of the N₂O-N conversion factor 44/28, the N quantity leached (cf. Chapter 5.1.5.1.4) and the emission factor (0.0075 kg N₂O-N (kg N)⁻¹; IPCC (2006a)-11.24, Table 11.3).

A detailed description of calculation of indirect N₂O emissions from agricultural soils is provided by RÖSEMANN et al. (2017).

5.5.2.1.4 NO emissions

The procedure for calculating NO emissions is similar to that for calculating N₂O emissions (cf. Chapter 5.5.2.1.2). The following table shows the NO emission factors used. Neither EMEP (2013) nor EMEP (2009) provides a procedure for calculating NO emissions resulting from grazing. For this reason, we use the emission factor given in EMEP(2007)-B1020-12, Chapter 4.3.

Table 285: Emission factors EF_{NO} for NO-N emissions from agricultural soils

	EF_{NO-N} kg kg ⁻¹	Remark
Application of mineral fertiliser, manure and digestion residues	0.012	EMEP (2013)-3D-11, pursuant to STEHFEST & BOUWMAN (2006) (converted from NO into NO-N)
grazing	0.007	EMEP (2007), B1020-12

5.5.2.1.5 NMVOC emissions

IPCC (2006a) does not provide any method for calculating NMVOC emissions from agricultural crops. In keeping with EMEP (2013)-3D-32 ff, Germany calculates the pertinent NMVOC emissions separately by crops:

Equation 17: EMEP method for calculation of annual NMVOC emissions from agricultural crops

$$E_{NMVOC, cult, i} = \beta \cdot A_i \cdot m_{FM, i} \cdot x_{DM, i} \cdot t_i \cdot EF_{NMVOC, cult, i}$$

Where

$E_{NMVOC, cult, i}$	NMVOC emissions from agricultural crop i (in kg a ⁻¹)
β	Conversion factor for time units (8760 h a ⁻¹)
A_i	Area under cultivation with crop i (in ha)
$m_{FM, i}$	Average fresh-matter yield from crop i (in kg ha ⁻¹)
$x_{DM, i}$	Dry-matter content of crop i (in kg kg ⁻¹)
t_i	Fraction of the year during which crop i emits NMVOCs (in a a ⁻¹)
$EF_{NMVOC, cult, i}$	NMVOC emission factor for crop i (in kg kg ⁻¹ h ⁻¹)

With regard to areas under cultivation, fresh-matter yields, dry-matter content and relative duration of emissions, cf. Chapter 5.1.5.3. The emission factors for wheat, rye, rape and grass were obtained from EMEP (2013)-3D-34, Table A3-2; cf. Table 286. For the crop categories "grass clover ley, alfalfa, forage grass" and "pastures and meadows", the EMEP emission factor for grass has been used. For the remaining crops, the EMEP emission factor for wheat has been used.

Table 286: NMVOC emission factors for agricultural crops

Crop	Emission factor [kg kg ⁻¹ h ⁻¹]
Wheat	$2.60 \cdot 10^{-8}$
Rye	$1.41 \cdot 10^{-7}$
Rape	$2.02 \cdot 10^{-7}$
Grass (15 °C)	$1.03 \cdot 10^{-8}$

5.5.2.2 Frac values (3.D)

Germany reports on $Frac_{GASF}$, $Frac_{GASM}$ and $Frac_{leach}$.

In the German inventory, $F_{\text{FracLEACH}}$ is an input value. It shows the relative fraction of N inputs into the soil that is lost via leaching and surface runoff. The German inventory uses the IPCC default value $F_{\text{FracLEACH}} = 0.30 \text{ kg kg}^{-1}$ (IPCC (2006a)-11.24, Table 11.3); cf. Chapter 5.1.5.1.4.

The quantities F_{FracGASF} and F_{FracGASM} , on the other hand, are not used in the inventory. They are determined, however, for purposes of reporting input and output data for completed emission calculations.

Pursuant to IPCC (2006a)-11.21, Equation 11.9, F_{FracGASF} denotes the fraction of the N quantity applied via mineral fertiliser that is emitted as $\text{NH}_3\text{-N}$ and NO-N ; cf. Table 287. In such emissions, NH_3 is the predominant influencing factor. Because different NH_3 emission factors are used for different mineral fertilizer types, the F_{FracGASF} value depends on the mineral-fertilizer mix prevailing in the year in question. Because urea has a relatively high emission factor (EMEP, 2013), F_{FracGASF} correlates very well with the ratio of urea-N to total-mineral-fertilizer-N ($R^2 = 99.3 \%$). The average value of F_{FracGASF} over the entire time series is 0.073 kg kg^{-1} .

Table 287: F_{FracGASF} (3.D)

[kg kg ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
F_{FracGASF}	0.061	0.064	0.068	0.073	0.077	0.081	0.077	0.094	0.078	0.084	0.080	0.085	0.085	0.091

Pursuant to IPCC (2006a)-11.21, Equation 11.9, F_{FracGASM} denotes the fraction of the N quantity applied via manure (including digestates from manure digestion), digestates from digestion of energy crops, sewage sludge and grazing that is emitted as $\text{NH}_3\text{-N}$ and NO-N ; cf. Table 288. (The F_{FracGASM} definition in CRF Table 3.D does not conform to this definition.) The average value of F_{FracGASM} over the entire time series is 0.179 kg kg^{-1} .

Table 288: F_{FracGASM} (3.D)

[kg kg ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
F_{FracGASM}	0.195	0.183	0.178	0.174	0.174	0.173	0.173	0.172	0.173	0.175	0.170	0.172	0.171	0.172

5.5.2.3 Emissions (3.D)

Table 289 presents an overview of the contributions of the various individual sub-sources to overall N_2O emissions from agricultural soils. The indirect emissions also include the contributions resulting from application of digestates from digestion of energy crops.

Table 289: Overview of N_2O emissions from agricultural soils (3.D)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total emissions^a	95.9	83.7	88.7	83.8	83.3	80.5	86.5	83.1	82.4	87.8	86.3	88.0	90.8	92.4
Total of direct emissions^a	75.3	66.0	70.0	66.2	65.7	63.5	68.2	65.3	64.9	68.9	67.9	69.0	71.3	72.2
Total indirect emissions^a	20.6	17.6	18.7	17.7	17.7	17.1	18.3	17.8	17.5	18.9	18.4	19.0	19.6	20.2
Mineral fertiliser	34.0	28.1	31.7	27.9	28.0	25.1	28.4	24.4	24.7	28.1	25.8	25.9	26.3	28.6
Manure	18.1	15.7	15.3	14.8	14.6	14.7	14.8	15.0	14.9	15.0	15.2	15.4	15.7	15.6
Digestates from digestion of energy crops	0.0	0.0	0.1	0.7	1.0	1.4	1.6	2.1	2.6	3.2	3.6	4.3	4.5	4.6
Sewage sludge	0.4	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
Grazing	6.4	5.1	4.8	4.2	4.1	4.1	4.1	4.1	4.0	4.0	3.9	4.0	4.0	4.1
Crop residues	7.6	7.8	8.8	9.2	8.6	8.7	9.7	10.1	9.0	8.8	9.5	9.5	10.8	9.5
Organic soils	8.7	8.8	8.8	8.8	8.9	9.0	9.2	9.3	9.3	9.4	9.5	9.5	9.5	9.5
Indirect; deposition; not including EC ^b	6.3	5.3	5.4	5.1	5.1	5.0	5.1	5.3	4.9	5.3	5.0	5.2	5.3	5.6
Indirect; deposition, EC ^b	0.0	0.0	0.0	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.8	0.8
Indirect; leaching; not including EC ^b	14.3	12.4	13.2	12.3	12.1	11.5	12.5	11.7	11.5	12.2	11.9	12.0	12.4	12.6
Indirect; leaching, EC ^b	0.0	0.0	0.0	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.0	1.0

^a The discrepancies between the listed sum totals and the sums resulting from addition of individual sources are due to rounding.

^b EC: Digestates of energy crops

The total N₂O emissions decreased in the first half of the 1990s. In subsequent years, through 2013, no clear trend emerges. A marked increase occurred from 2013 to 2014/2015.

The annual fluctuations in total emissions are shaped largely by fluctuations in N₂O emissions from application of mineral fertilizer. Those fluctuations, in turn, result from year-to-year variations in the N quantity contained in the mineral fertilizers used (cf. Table 241 in Chapter 5.1.5.1.1). In the last ten years of the time series, quantity increases in application of digestates of manure and of digestates of energy crops have an impact. Most of the marked increase seen from 2013 to 2014 is due to an increase of N₂O emissions from crop residues and leaching. That increase, in turn, is the result of exceptionally large harvests in 2014 (cf. Chapters 5.1.5.1.1 and 5.1.5.1.4). Although in 2015 N₂O emissions from crop residues returned to their 2013 level, total N₂O emissions increased from 2014 to 2015, due to a considerable increase in mineral fertilizer use.

The fractional contributions to the total emissions in 2015 included the following: application of mineral fertiliser, 31.0 %; application of manure (including digestates from manure digestion) and digestates from digestion of energy crops, 21.8 %; crop residues, 10.3 %; cultivation of organic soils, 10.3 %; grazing, 4.4 %; and sewage sludges, 0.4 %. The remaining 21.8 % are indirect emissions.

The results of the NO-emissions calculations are shown in Table 290. In keeping with the remarks made in Chapter 5.5.2.1.2, those calculations cover the NO emissions resulting from application of mineral fertilizer and manure (including digestates of manure) and from grazing (both emissions categories are summarized under "animal husbandry, mineral fertilizer"), while the NO emissions resulting from application of digestates of energy crops are listed separately. The trend for the total emissions largely follows that for the N₂O emissions. (For purposes of reporting in CRF 3s2, the NO values are converted into NO₂, via multiplication by the molar ratio 46/30.)

Table 290: NO emissions from agricultural soils

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	88.5	74.3	79.4	73.3	73.4	69.6	75.4	69.8	70.9	77.8	74.9	76.7	78.2	81.9
Animal husbandry, mineral fertiliser	88.5	74.3	79.3	72.1	71.8	67.3	72.8	66.4	66.7	72.4	69.1	69.7	70.8	74.4
Digestates from digestion of energy crops	0.0	0.0	0.1	1.2	1.6	2.2	2.6	3.4	4.2	5.3	5.8	7.1	7.4	7.5

Table 291 shows the chronological course of NMVOC emissions, which increased nearly by half (47.4 %) from 1990 to 2014, as a result of increases in harvests since 1990 (cf. Chapter 5.1.5.3).

Table 291: NMVOC emissions from agricultural crops

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	7.69	8.19	8.79	9.17	8.83	9.19	9.83	10.63	9.49	8.99	10.02	10.32	11.34	9.85

5.5.3 Source-specific quality assurance / control and verification (3.D)

With regard to quality control and quality assurance, we refer to Chapter 5.1.7.

In an approach similar to that of Chapter 5.2.4, and for purposes of verification, Table 292 and Table 293 present the N₂O-IEFs, and the Frac values Frac_{GASF}, Frac_{GASM} and Frac_{LEACH}, as determined for Germany, in a comparison with the corresponding data of countries that either are neighboring countries or have agricultural practices comparable to those prevailing in Germany. For the reasons given in Chapter 5.2.4, the year chosen for the comparison is the time-series year 2014.

Table 292: Comparison of the N₂O-N-IEF values used in the German inventory with those of neighboring countries, 2014

N ₂ O-N	Mineral fertilizer	Manure	Crop residues	Organic soils	Grazing	Deposition	Leaching
	[kg kg ⁻¹]	[kg kg ⁻¹]	[kg kg ⁻¹]	[kg ha ⁻¹]	[kg kg ⁻¹]	[kg kg ⁻¹]	[kg kg ⁻¹]
Austria	0.0100	0.0100	0.0100	NO	0.0159	0.010	0.0075
Belgium	0.0099	0.0100	0.0100	8.0000	0.0196	0.010	0.0031
Czech Republic	0.0100	0.0100	0.0100	NO	0.0183	0.010	0.0075
Denmark ^a	0.0100	0.0100	0.0100	11.3818	0.0180	0.010	0.0047
France	0.0100	0.0101	0.0100	8.0335	0.0189	0.010	0.0075
Germany	0.0100	0.0100	0.0100	4.8537	0.0190	0.010	0.0075
Netherlands	0.0130	0.0087	0.0117	7.4725	0.0330	0.011	0.0075
Poland	0.0100	0.0100	0.0100	8.0000	0.0191	0.010	0.0075
Switzerland	0.0100	0.0100	0.0100	8.0000	0.0190	0.026	0.0075
UK	0.0093	0.0046	0.0100	8.0000	0.0044	0.010	0.0075
IPCC(2006a)-11.11, 11.24, IPCC (2013) ^b	0.0100	0.0100	0.0100	8.00 (13 / 4.3 / 8.2 / 1.6) ^b	0.02 (cattle, swine, poultry); 0.01 other animals	0.0100	0.0075

Source: Germany: Submission 2017; other countries: UNFCCC 2016

^a Denmark, including Greenland, but not including the Faroe Islands

^b IPCC (2013) Wetlands Supplement, Table 2.5 (cropland, drained/ grassland, drained, nutrient-poor/ grassland, deep-drained, nutrient-rich / grassland, shallow-drained, nutrient-rich)

For application of mineral fertilizer and manure, and for crop residues, and apart from a few exceptions (primarily the Netherlands and the UK), the N₂O-N IEFs of the ten countries being compared –and thus, that of Germany –are in keeping with the IPCC (2006) default value of 0.01 kg kg⁻¹.

As to the IEFs for N₂O-N from organic soils, most of the countries that report this figure use the IPCC (2006) default value of 8 kg ha⁻¹. The Danish value is considerably higher and thus stands apart. While the German value, at 4.85 kg ha⁻¹, marks the lower end of the scale, it is based on national emission factors; cf. Chapter 5.5.2.1.1.

Clearly enough, most of the IEFs for N₂O-N resulting from grazing are based on a combination of the two default values of IPCC (2006). The share for "other animals," which has the lower EF, varies from country to country, and thus its effects vary from country to country. The German value, at 0.019 kg kg⁻¹, is close to the default value for cattle, swine and poultry. This fact makes it clear that the population fractions for the other animals are relatively small.

All countries except for Switzerland –i.e. including Germany –use the IPCC (2006) default value in calculating indirect N₂O-N resulting from deposition of reactive nitrogen. In the case of indirect N₂O-N from leaching and surface runoff, most countries, including Germany, use the figure recommended in IPCC (2006).

Table 293: Comparison of Germany's Frac values with those of neighboring countries, for 2014

[kg kg ⁻¹]	$\text{Frac}_{\text{GASF}}$	$\text{Frac}_{\text{GASM}}$	$\text{Frac}_{\text{LEACH}}$
Austria	0.04	0.17	0.15
Belgium	0.08	0.19	0.30
Czech Republic	0.10	0.20	0.30
Denmark ^a	0.04	0.08	0.28
France	0.10	0.20	0.30
Germany	0.08	0.17	0.30
Netherlands	NO	NO	NO
Poland	0.10	0.20	0.30
Switzerland	0.05	0.21	0.22
UK	0.03	0.07	0.22
IPCC(2006a)-11.24	0.10	0.20	0.30

Source: Germany: Submission 2017; other countries: UNFCCC 2016

^a Denmark, including Greenland, but not including the Faroe Islands

The scattering seen in the $\text{Frac}_{\text{GASF}}$ data can be attributed to the variation, among the neighboring countries, seen in the relative shares of different fertilizer types (with their different NH_3 emission factors). The values thus hardly lend themselves to comparison. The German value, 0.08 kg kg⁻¹, is smaller than the IPCC (2006) default value of 0.10 kg kg⁻¹. With the exception of the Netherlands, those countries that do not use the IPCC default value calculate considerably lower $\text{Frac}_{\text{GASF}}$ quantities (0.03 to 0.05 kg kg⁻¹).

A considerable range is also seen in the $\text{Frac}_{\text{GASM}}$ values. The range extends from the low values of the UK and Denmark (0.07 and 0.08 kg kg⁻¹, respectively) to Switzerland's figure, 0.21 kg kg⁻¹, which is only slightly higher than the IPCC (2006a) default value. The German IEF is at the level of the average value for all of the countries being compared.

With $\text{Frac}_{\text{LEACH}}$, it is worthy of note that most neighboring countries use the IPCC default value, as Germany does.

5.5.4 Uncertainties and time-series consistency (3.D)

With regard to the uncertainties in the area of N_2O emissions from agricultural soils, the reader's attention is called to Table 249 in Chapter 5.1.6 (total uncertainty of the German GHG inventory).

For NO , EMEP (2013)-3D-18, with reference to Stehfest and Bouwman (2006), gives a 95 % confidence interval of -80 % to +406 % (with respect to the emission factor). In contrast to the interpretation provided in EMEP (2013)-3D-18, that result is equivalent to an uncertainty factor of about 5.

The NMVOC emissions result is subject to large uncertainties (EMEP (2013)-3D-5, EMEP (2013)-3D-7, EMEP (2013)-3D-34). The Tier 1 emission factors in EMEP (2013)-3D-11, Table 3-1, have an uncertainty factor of 4.

The emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and complete.

5.5.5 Source-specific recalculations (3.D)

In general, the N_2O emissions from agricultural soils are lower than the levels reported in the 2016 Resubmission; cf. Table 294:

Table 294: Total N₂O from agricultural soils, in 2016 and in 2017 (3.D)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2017	95.9	83.7	88.7	83.8	83.3	80.5	86.5	83.1	82.4	87.8	86.3	88.0	90.8	92.4
2016	96.5	84.3	89.3	84.4	83.9	81.1	87.0	83.7	82.9	88.4	86.9	88.5	91.5	

As Table 295 shows, the differences with respect to the 2016 Resubmission, for the years through 2013, are due almost exclusively to the changes in organic soils that result from the change in the emission factor for drained grassland (cf. Chapter 5.5.2.1.1). As a result of updating of activity data for digestion of energy crops (cf. Chapter 5.1.4.2), in time-series year 2014 leaching and surface runoff, and spreading of digestates, contribute significantly to the differences with respect to the 2016 Resubmission. During the 2016 In Country Review, the ERT called for changes in the method used to calculate indirect N₂O emissions from leaching and surface runoff. The requested changes were already implemented in the 2016 Resubmission.

Table 295: Differences from 2016 to 2017 in data reported on total N₂O emissions from agricultural soils, as well as on relevant sub-sources (3.D)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	-0.63	-0.63	-0.62	-0.61	-0.60	-0.59	-0.58	-0.58	-0.56	-0.56	-0.55	-0.54	-0.70	
Leaching, including EC ^a	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
Organic soils	-0.63	-0.63	-0.62	-0.61	-0.60	-0.59	-0.58	-0.57	-0.57	-0.56	-0.55	-0.55	-0.55	
Application of digestates of EC ^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	-0.12
Other sources	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.01	-0.01	

^a Leaching including leaching as a result of application of digestates of energy crops

^b Direct N₂O emissions as a result of application of digestates of energy crops

Table 296 compares the total NO emissions with the corresponding data from the 2016 Resubmission. The slight differences seen are the result of the changes –which work in opposite directions, to some extent –in the animal-yield data (cf. Chapter 5.1.3.3) and the activity data for digestion of manure and energy crops (cf. Chapters 5.1.3.6.5 and 5.1.4.2).

Table 296: Comparison of data for total-NO emissions from agricultural soils (3.D)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2017	88.5	74.3	79.4	73.3	73.4	69.6	75.4	69.8	70.9	77.8	74.9	76.7	78.2	81.9
2016	88.5	74.3	79.4	73.3	73.4	69.6	75.4	69.8	70.9	77.8	74.9	76.7	78.4	

The NMVOC emissions have not changed with respect to the 2016 Resubmission.

5.5.6 Planned improvements (3.D)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

5.6 Prescribed burning of savannas (clearance of land by prescribed burning) (3.E)

Land clearance by prescribed burning is not practiced in Germany (NO).

5.7 Field burning of agricultural residues (3.F)

Burning of agricultural residues is prohibited in Germany (NO).

5.8 CO₂ emissions from liming and urea application (3.G-I)

5.8.1 Source category description

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/-	3.G. Liming		CO ₂	2,704.0	0.22%	2,214.7	0.25%	-18.1%
-/-	3.H. Urea application		CO ₂	479.6	0.04%	856.3	0.10%	78.5%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 1	NS	D

The source category *CO₂ from liming* is a key category for CO₂ emissions in terms of emissions level.

Liming, i.e. addition of carbonates to the soil, reduces the soil's acidity. It enhances plant growth, releasing CO₂ in the process. Lime fertilisers include all carbonates of calcium and magnesium, either as pure substances or as additives. Under CRF 3.G, Germany reports all CO₂ emissions that result from application of calcium carbonate, compound lime, carbolic lime and residual lime. CRF 3.G also includes CO₂ emissions resulting from application of calcium ammonium nitrate. For this reason, "IE" is reported in CRF 3.I ("Other carbon-containing fertilizers"). In keeping with the requirements in IPCC (2006a), Chapter 11.3, and CRF Table 3.G-I, the reported CO₂ emissions include both emissions from the agricultural sector and emissions from the forestry sector, and they are broken down into the separate categories of limestone (CaCO₃) and dolomite (CaMg(CO₃)₂).

Nitrogen fertilization with urea leads to CO₂ emissions via reactions involving urease and water. Germany reports such CO₂ emissions in Sector 3.H, without consideration of CO₂ bound via industrial production of urea fertilizer.

From 1990 through 2015, the calculated CO₂ emissions from liming decreased from 2,704.0 kt a⁻¹ to 2,214.7 kt a⁻¹, or by 18.1 %. In 2015, the CO₂ emissions from urea application, at 856.3 kt a⁻¹, were 78.5 % above their value in 1990 (479.6 kt a⁻¹).

5.8.2 Methods and emissions

Although they have been classified as a key category, CO₂-C emissions from liming are calculated with the Tier 1 method given in IPCC (2006a)-11.27. The Tier 2 method given in IPCC (2006a)-11.27 makes use of a Tier 1 equation (Equation 11.12 in IPCC (2006a)-11.27) and of national emission factors. Because such emission factors are not available for Germany, the inventory uses the Tier 1 method, along with the default emission factors given in IPCC (2006a)-11.27, which are the highest-possible emission factors. This approach is a conservative one; as a result of it, the CO₂ emissions from liming that Germany has calculated and is reporting amount to the highest emissions that are possible.

Pursuant to Equation 11.12 in IPCC (2006a)-11.27, CO₂-C emissions from liming are calculated as the product of the relevant lime quantity (cf. Chapter 5.1.5.2) and the CO₂-C emission factor. For limestone, the IPCC Tier 1 emission factor is 0.12 kg CO₂-C per kg CaCO₃, while for dolomite it is 0.13 kg CO₂-C per kg CaMg(CO₃)₂ (IPCC (2006a)-11.27).

For purposes of entry into the CRF tables, the so-calculated CO₂-C emissions are converted into CO₂ units via multiplication by the molar ratio 44/12 (IPCC (2006a)-11.27).

Table 297 shows the CO₂ emissions from liming over time, broken down by emissions for limestone and those for dolomite.

Table 297: CO₂ emissions from liming (3.G)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	2704.0	1744.9	2224.9	1727.4	1659.2	1786.3	1834.7	1795.4	1737.6	1885.7	1948.7	2003.5	2242.2	2214.7
Limestone	2340.3	1542.3	2062.9	1634.1	1569.7	1693.9	1762.4	1704.6	1658.2	1798.0	1865.5	1909.1	2153.5	2136.3
Dolomite	363.7	202.6	162.0	93.3	89.5	92.4	72.4	90.8	79.4	87.7	83.3	94.4	88.7	78.5

The Tier 1 method for CO₂-C emissions from urea application (IPCC (2006a)-11.32) calculates the emissions in proportion to the quantity of urea applied (cf. Chapter 5.1.5.2). The proportionality factor used in the procedure is the CO₂-C emission factor, which is to be stoichiometrically derived. IPCC (2006a)-11.32 gives it as 0.2 kg CO₂-C per kg of urea. Conversion into units of CO₂, as required for the CRF tables, is analogous to the conversion for CO₂ from liming; see above. Table 298 presents the resulting time series.

Table 298: CO₂ emissions from urea application (3.H)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	479.6	477.2	578.5	598.0	653.8	641.0	647.9	795.0	587.4	749.9	624.8	695.0	697.8	856.3

5.8.3 Source-specific quality assurance / control and verification

With regard to quality control and quality assurance, we refer to Chapter 5.1.7.

5.8.4 Uncertainties and time-series consistency

With regard to the uncertainties in the area of CO₂ emissions from liming and urea application, the reader's attention is called to Table 249 in Chapter 5.1.6 (total uncertainty of the German GHG inventory). For details, cf. RÖSEMANN et al. (2017).

Normally, not all of the carbon applied is converted into CO₂, but this fact cannot be taken into account, since it is not possible to quantify the C quantity that is actually converted into CO₂. The calculated emissions thus represent the maximum possible emissions in the framework of the uncertainties listed in Table 249 in Chapter 5.1.6.

The emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and complete.

5.8.5 Source-specific recalculations

In the 2016 In Country Review, the Expert Review Team called for limestone-related CO₂ emissions to be calculated separately for limestone and dolomite. That request was already fulfilled in the 2016 Resubmission. Similarly, the activity data for the new German Länder were updated for the years 1990 through 1993 (cf. Chapter 5.1.5.2). For this reason, no recalculations in the area of liming were required for the present 2017 Submission.

In addition, the activity data and methods for calculation of CO₂ emissions from urea application have also not been changed, and thus no recalculations were required in this area as well.

5.8.6 Planned improvements

The CO₂ emissions from use of calcium ammonium nitrate are to be reported separately as of the 2018 Submission (CRF 3.I, Other carbon-containing fertilizer).

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

5.9 CH₄ and N₂O from digestion of energy crops (digesters and systems for storage of digestion residues) (3.J)

5.9.1 Source category description

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/T	3.J. Other	0	CH ₄	0.3	0.00%	1,296.0	0.15%	477864.4%
-/-	3.J. Other	0	N ₂ O	0.1	0.00%	245.0	0.03%	200157.6%

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	Tier 2	Q/RS/NS	CS/D
N ₂ O direct	Tier 2	Q/RS/NS	CS/D
N ₂ O indirect	Tier 1	Q/RS/NS	D
NO _x	Tier 2	Q/RS/NS	CS

The source category "CH₄ and N₂O from digestion of energy crops (digesters and systems for storage of digestates)" is not a key category.

Digestion of energy crops is carried out primarily for purposes of energy generation. For this reason, the emissions occurring during digestion itself (digester) and in storage of digestates (CH₄, N₂O and NO; cf. Chapter 5.1.4.1) are reported on as a separate source category (CRF 3s2/J). The emissions resulting via use of digestion residues as fertilizer are reported in conjunction with reporting on emissions from application of other fertilizers, under 3.D.2.c.

In a procedure analogous to that used for manure, the indirect N₂O emissions connected to storage of digestates of energy crops are calculated as a result of deposition of reactive nitrogen. In addition, it is assumed, as in the case of manure, that no indirect N₂O emissions result from leaching / surface runoff from storage systems.

From 1990 to 2015, the annual GHG emissions from digestion of energy crops increased from 0.4 kt CO_{2eq} to 1,541.0 kt CO_{2eq}, i.e. to a level that amounts to 2.3 % of the entire agricultural sector's GHG emissions for 2015. Also from 1990 through 2015, the relative N₂O contribution to the total GHG emissions from digestion of energy crops decreased from 31.1 % to 15.9 %, as a result of increasing use of gas-tight storage.

5.9.2 Methodological issues

The procedure for calculating CH₄ emissions and direct N₂O emissions is analogous to that for calculation of emissions from manure digestion (cf. Chapter 5.1.3.6.5), with the exception that it does not take pre-storage into account.

As for manure (cf. Chapter 5.3.5), indirect N₂O emissions from storage of digestates of energy crops are calculated as a result of deposition of reactive nitrogen. In the case of energy crops, such nitrogen originates in NH₃ and NO emissions from systems for storage of digestates of energy crops. Also as for the manure category, NO emissions from systems for storage of digestates are calculated via a procedure similar to that for calculation of N₂O emissions (cf. Chapter 5.3.4.2). With regard to calculation of NH₃ emissions from storage of digestates of energy crops, we refer to RÖSEMANN et al. (2017).

5.9.3 CH₄ emission factor and emissions (3.J, CH₄)

Table 299 shows the chronological sequence for the CH₄ emission factor for digestion of energy crops (digesters and systems for storage of digestates), related to the dry-matter quantities that are input into the digestion process along with energy crops (cf. Chapter 5.1.4.2). In the interest of clarity, we have used the units g kg⁻¹, instead of the kg kg⁻¹, the common units for emission factors.

The decrease in the emission factor over time results from increasing use of gas-tight storage for digestion residues (cf. Chapter 5.1.4.2). For such storage, only the CH₄ leakage rate has to be taken into account, instead of the higher emission factor for open storage.

Table 299: CH₄ emission factor for digestion of energy crops (digesters and systems for storage of digestates), related to the dry-matter quantities input into digestion along with energy crops

[g kg ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	3.23	3.19	3.14	3.08	3.03	2.98	2.93	2.88	2.83	2.78	2.67	2.64	2.60	2.60

The CH₄ emissions from digestion of energy crops (digesters and systems for storage of digestates) are shown in Table 300. The markedly increasing trend results from a sharp increase in the quantities of energy crops that are digested (cf. Chapter 5.1.4.2) –especially since 2005. That trend has been offset somewhat by growing use of gas-tight storage of digestion residues (cf. Chapter 5.1.4.2), especially for the transition from 2011 to 2012.

Table 300: CH₄ emissions from digestion of energy crops (digesters and systems for storage of digestates)

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	0.01	0.14	1.18	9.78	13.51	18.17	20.82	26.25	32.44	39.75	41.77	49.71	51.54	51.84

5.9.4 N₂O emission factors and emissions (3.J, N₂O)

The emission factors for direct N₂O emissions from digestion of energy crops (systems for storage of digestates) are shown in Table 301. These data represent the average values for gas-tight and open storage. In their decreasing trend, they represent the increasing use that has occurred, over the years, of gas-tight storage, which emits no N₂O. In the interest of clarity, we have used the units g kg⁻¹, instead of the kg kg⁻¹, the common units for emission factors. The emission factors in Table 301 are to be applied to the N quantities that are input, along with energy crops, into the digestion process (cf. Chapter 5.1.4.2).

Table 301: Implied N₂O-N emission factor for direct N₂O emissions from digestion of energy crops (systems for storage of digestates), related to the N quantities input via energy crops

[g kg ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	5.00	4.77	4.53	4.21	3.95	3.68	3.41	3.15	2.89	2.63	2.03	1.86	1.69	1.69

The emission factor for indirect N₂O emissions as a result of deposition of NH₃ and NO from storage of digestates from digestion of energy crops, like that for the comparable process in connection with manure, is EF = 0.01 kg kg⁻¹ (IPCC (2006a)-11.24, Table 11.3). To obtain the relevant emissions, this emission factor has to be multiplied by the N quantities that are deposited –which are given in Chapter 5.1.5.1.3.

The calculated direct and indirect N₂O emissions are presented in Table 302. The trend reflects the sharp increase that has occurred in digested quantities of energy crops (cf. Chapter 5.1.4) – especially since 2005. The marked emissions decrease seen from 2011 to 2012 results from a disproportional increase in use of gas-tight storage; cf. Chapter 5.1.4.2.

Table 302: N₂O emissions from storage of digestates of energy crops

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	0.000	0.005	0.041	0.327	0.431	0.549	0.593	0.702	0.810	0.918	0.777	0.856	0.818	0.822
N ₂ O _{direct}	0.000	0.005	0.039	0.311	0.410	0.522	0.564	0.668	0.770	0.873	0.739	0.815	0.778	0.782
N ₂ O _{indirect}	0.000	0.000	0.002	0.016	0.021	0.027	0.029	0.034	0.040	0.045	0.038	0.042	0.040	0.040

5.9.5 NO emission factors and emissions (3.J, NO)

As for the case of manure (cf. Chapter 5.3.4.2.2), the relevant NO emissions are calculated in proportion to the direct N₂O emissions, via use of the NO-N emission factor, which is to be applied to the input N quantity; that factor is set to 10 % of the N₂O-N emission factor.

Table 303 shows the trend in NO emissions from digestion of energy crops (systems for storage of digestion residues).

Table 303: NO emissions from storage of digestates from digestion of energy crops

[kt a ⁻¹]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	0.000	0.001	0.005	0.042	0.056	0.071	0.077	0.091	0.105	0.119	0.101	0.111	0.106	0.107

5.9.6 Source-specific quality assurance / control and verification (3.J)

With regard to quality control and quality assurance, we refer to Chapter 5.1.7.

5.9.7 Uncertainties and time-series consistency (3.J)

With regard to the uncertainties relative to the CH₄ and N₂O emissions from digestion of energy crops (digesters and systems for storage of digestates), we refer to Table 249 in Chapter 5.1.6 (total uncertainty of the German GHG inventory).

The emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and complete.

5.9.8 Category-specific recalculations (3.J)

In keeping with updating, with respect to the 2016 Resubmission, of the time series for the activity data (quantities of energy crops, gas-tight storage: cf. Chapter 5.1.4.2), the entire time series for CH₄ and N₂O emissions (cf. Chapters 5.9.3 and 5.9.4) have been recalculated, with the same method used for the 2016 Resubmission. Table 304 compares the results. Discrepancies occur only in the years 2013 and 2014. They are due to updating of activity data (cf. Chapter 5.1.4.2).

Table 304: GHG emissions from digestion of energy crops (digesters and systems for storage of digestates), 2016 and 2017 (3.J)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2017 [kt CO ₂ eq]	0.39	4.94	41.7	341.9	466.3	617.7	697.1	865.4	1052.3	1267.4	1275.7	1497.9	1532.3
2016 [kt CO ₂ eq]	0.39	4.94	41.7	341.9	466.3	617.7	697.1	865.4	1052.3	1267.4	1275.7	1516.5	1639.0

5.9.9 Planned improvements (3.J)

No improvements are planned at present.

6 Land Use, Land Use Changes and Forestry (CRF Sector 4)

6.1 Overview (CRF Sector 4)

6.1.1 Categories and total emissions and sinks, 1990 – 2015

In the sub-category "Forestry and other land use" within the LULUCF sector (Common Reporting Framework sector 4), Germany reports on positive (source) and negative (sink) CO₂ emissions from carbon pools⁸⁹

- above-ground and below-ground biomass
- dead wood, litter
- organic and mineral soils,

for the land-use categories

- Forest Land (4.A.1)
- Cropland (4.B.1)
- Grassland (4.C.1)
- Wetlands (4.D.1)
- Settlements (4.E.1)

as well as the relevant land-use changes between these use categories (CRF 4.A.2 - 4.E.2). In the category Other Land (4.F), no anthropogenic emissions occur, since the relevant land areas are not used. No land-use changes to Other Land occur, since, by definition, land, once it is in use, cannot be returned to the category "unused land".

The following are also inventoried:

- CO₂ emissions from
 - wood products (4.G)
 - industrial peat extraction (4.D.1)
- N₂O emissions from
 - drained organic soils in land-use categories 4.A, 4.D, 4.E (emissions from the categories 4.B Cropland and 4.C Grassland are reported under Agriculture in CRF 3.D.a.6)
 - direct (CRF 4.(III)) and indirect (CRF 4.(IV)) emissions from humus mineralisation in mineral soils as a result of land-use changes and / or land cultivation.
 - industrial peat extraction (4.(II))
 - wildfires (4.(V))
- CH₄ emissions from
 - organic soils (4.(II))
 - drainage ditches of organic-soil areas (4.(II))
 - industrial peat extraction (4.(II))
 - wildfires (4.(V))
- In reporting on emission/removals of greenhouse gases in the various land-use categories, a distinction is made between areas that, during the report period,
- undergo no land-use changes, and thus are assigned, in unchanged form, to a land-use category ("remaining" categories 4.A.1 - 4.F.1)

⁸⁹ CO₂ emissions from forest fires are taken into account implicitly, via carbon-stock changes in Forest Land.

- undergo conversion: From this time on (the time at which they undergo conversion), these areas are reported in the category to which they were converted. Within those land-use categories, the converted areas are then reported in transition categories (4.A.2 - 4.F.2) for a total of 20 years. After spending 20 years in their transition categories, the areas are then added permanently to the relevant "remaining" categories.

Figure 49, Figure 50 and Figure 51 provide an overview, for the present 2017 Submission, of the development over time of greenhouse-gas emissions (sum of CO₂, CH₄ and N₂O emissions, as CO₂ equivalents) in categories 4.A-4.E, differentiated by sub-categories, pools and greenhouse gases. The x axis consists of all the years covered by the report, while the y axis consists of a scale for emissions (positive values) and removals (negative values), expressed in kilotonnes of CO₂ equivalents (kt CO₂-eq.).

The marked changes in emissions in the years 2002 and 2008 result from changes in emission factors for forest biomass and wood use. Wood use increased in the inventory period 2002 through 2008 and then decreased in the period 2008 through 2012 (cf. Chapter 6.4.2.2.1). The time series reflect the changes in forest biomass and the trends in land-use changes (cf. Chapter 6.3.5). The land-use changes have been determined on the basis of data sets for the reference years 1990, 2000, 2005, 2008, 2012 and 2014 (cf. Chapter 6.3). Between the reference years, the land-use changes have been linearly interpolated. As a result, constant, average land-use changes emerge for the periods between reference years (cf. Table 337). The values for the year 2015 were extrapolated from those for 2014. This method conforms with the IPCC guidelines. Between the periods, land-use changes can vary in their intensity and direction.

The course of net emissions from 1990 through 2015 shows that, without exception, the sector functioned as a sink during that period. The main reason for this is found in the land-use category Forest Land. The predominant pool is forest biomass, although forest soils also contributed significantly to the sink effect. Harvested wood products, via their function as carbon stocks, share in the sink function. The sink is offset primarily by emissions from agriculturally used areas in the land-use categories Cropland and Grassland. Over the years, these two categories were a constant source, with little variation, as a result of continuing high emissions from drained organic soils. The land-use category Wetlands contributes to emissions primarily via industrial peat extraction. The category Settlements, with an emissions increase of 80.1 %, exhibits the most pronounced trend of all land-use categories. The predominant greenhouse gas is carbon dioxide (CO₂), and it functions as a significant net sink. Releases of methane (CH₄) and nitrous oxide (N₂O), by contrast, are relatively low. Detailed descriptions of the pertinent emissions and their time series are presented in the relevant specialized chapters (Chapter 6.4.1, Chapter 6.5.1, Chapter 6.6.1, Chapter 6.7.1, Chapter 6.8.1 and Chapter 6.10.1).

Figure 49: Time series for greenhouse-gas emissions and removals (sum of CO₂, CH₄ and N₂O) [kt CO₂ equivalents] in the LULUCF sector since 1990, broken down by sub-categories

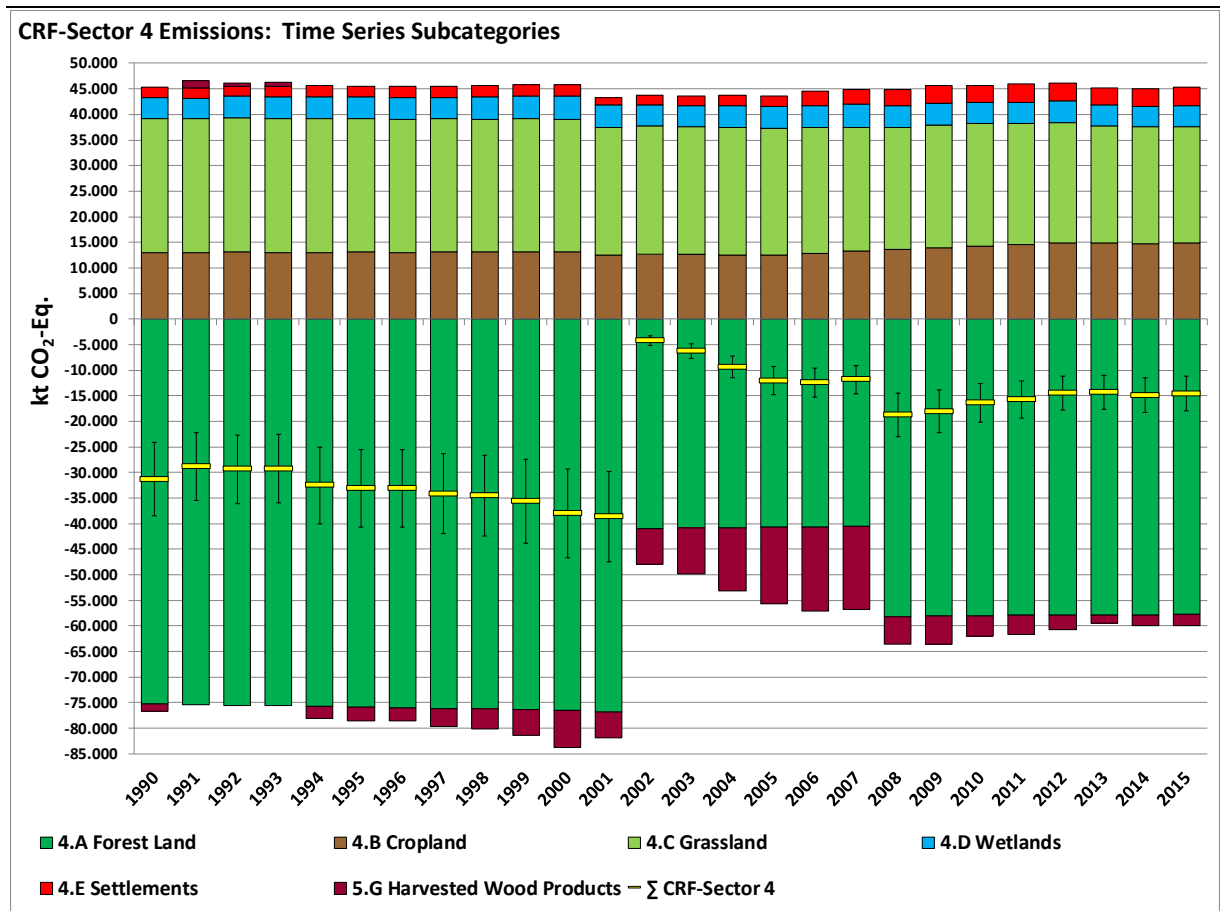


Figure 50: Time series for greenhouse-gas emissions and removals (sum of CO₂, CH₄ and N₂O) [kt CO₂ equivalents] in the LULUCF sector since 1990, broken down by source categories

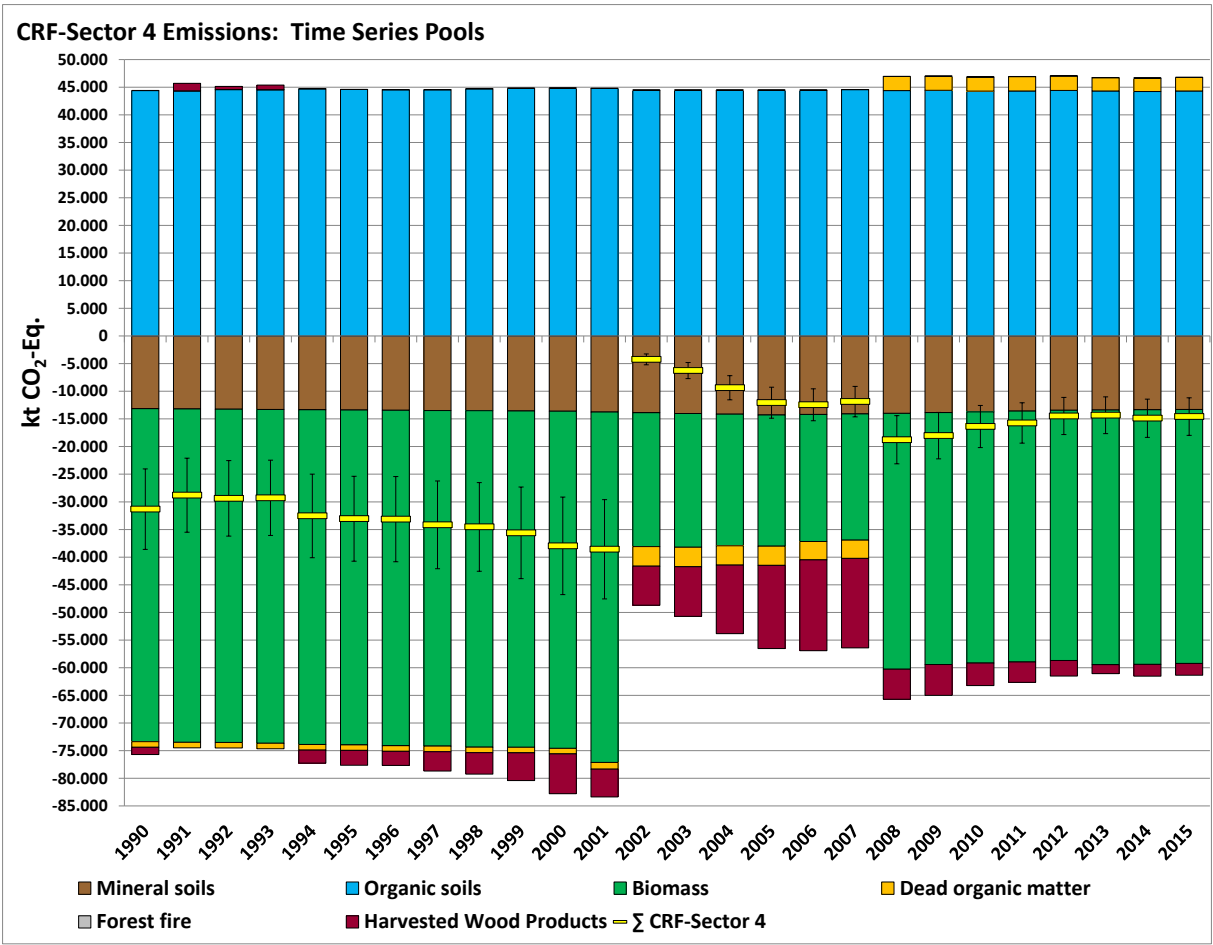
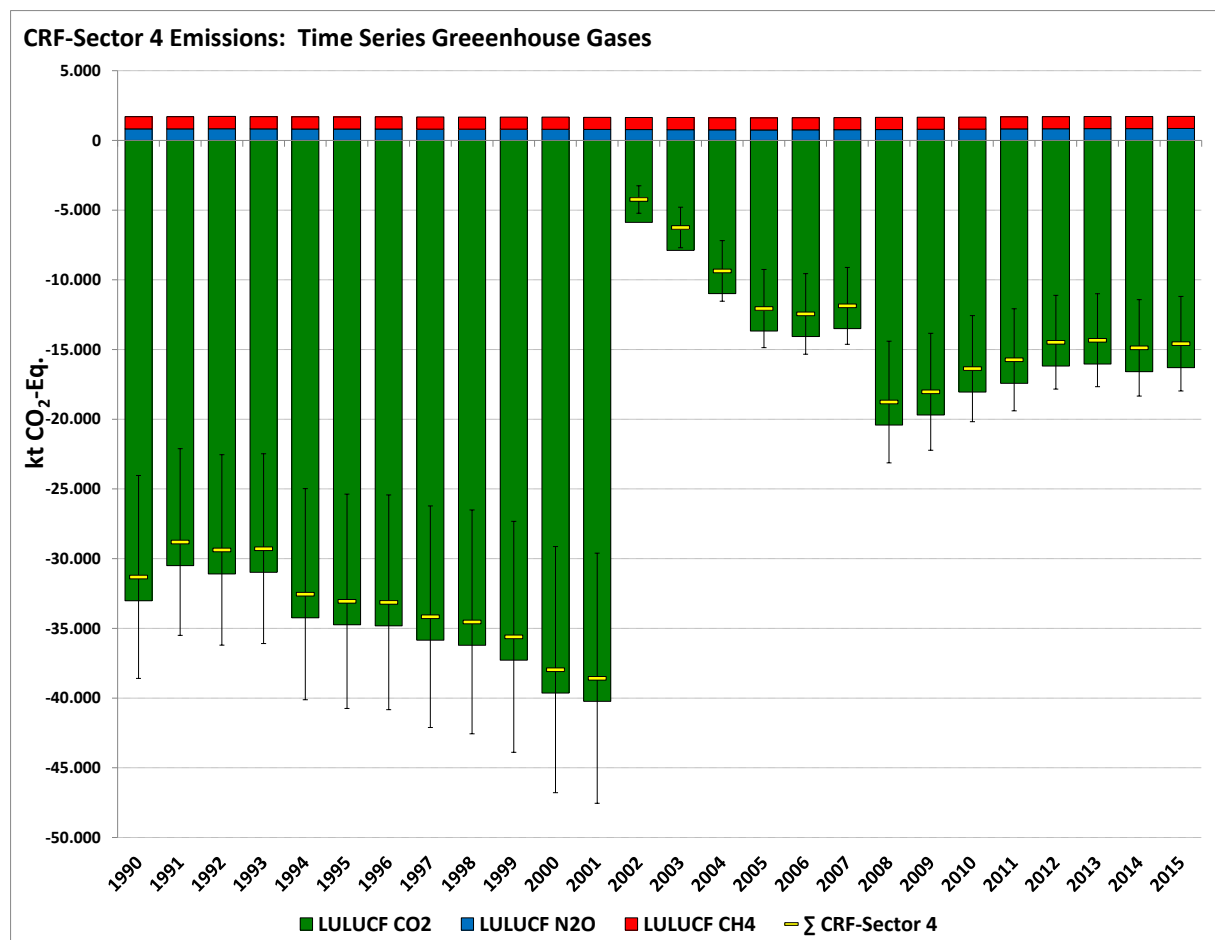


Figure 51: Time series for greenhouse-gas emissions and removals (sum of CO₂, CH₄ and N₂O) [kt CO₂ equivalents] in the LULUCF sector since 1990, broken down by greenhouse gases (GHG)



The pertinent calculation shows that the total uncertainty for the German LULUCF inventory (not including harvested wood products) is 23.26 %. The relevant details are presented in the relevant chapters for the individual categories and in Chapter 19.4.3.

6.1.2 Methodological issues

Germany has extensively adopted the land-use-system scheme that the 2006 IPCC Guidelines require for CRF Sector 4. The relevant implementation is outlined in Table 305, while precise relevant definitions and descriptions are provided in Chapter 6.2 (cf. also Chapter 6.3).

Table 305: Correlation of the German reporting categories with the IPCC land-use categories

IPCC category	German LULUCF categories
4.A Forest Land	Forest land
4.B Cropland	Cropland
4.C Grassland	Grassland (in the strict sense) Woody grassland
4.D Wetlands	Terrestrial wetlands Peat extraction Waters
4.E Settlements	Settlements
4.F Other Land	Other land
4.G Harvested wood products	Harvested wood products

Basic elements of the LULUCF inventory, and the steps required to prepare it

1. **Land-use matrix_{annual} [*Area_{ann}*]:** Annual calculation of the total areas for the sub-categories "final land use" and "land-use change", in each of the categories Forest land, Cropland, Grassland (in a strict sense), Woody grassland, Terrestrial wetlands, Waters, Peat extraction, Settlements and Other land, and, for all time series, with differentiation by mineral and organic soils. The relevant land uses, and the specific areas assigned to them, were explicitly determined for the years 1990, 2000, 2005, 2008, 2012 and 2014. For the time periods between those years, the applicable areas were linearly interpolated (cf. Chapter 6.3), while for 2015 the areas were extrapolated. **This approach is in conformance with the IPCC Guidelines.**
2. **Emission factors for total carbon stocks in a year of a land-use change [*EF_{ann}*]:** The emission factors for the various pools have been differentiated by land-use categories. They are shown in Table 306 (mineral soils), Table 315 (biomass), Table 316 (forest biomass (deforestation), dead wood and litter) and in Chapter 6.1.2.2.2 (organic soils). Except in the Forest Land and Cropland categories, carbon stocks per area unit remain constant over time. As a result, carbon stocks change constantly when land use changes.
3. **Carbon-stock changes for annual land-use changes [*E_{ann}*]** are calculated using the formula $E_{ann} [kt\ C] = EF_{ann} [Mg\ C/ha] * Area_{ann} [kha]$, under the assumption that, in each case, the entire carbon-stock change occurs in the year of the land-use change.
4. **Introduction of a twenty-year transition period [*Area_{20y}*]:** The land-use-matrix calculation is referenced to 1970, to make it possible to determine land-use-change areas for years prior to the period covered by the report (cf. Chapter 6.3.4). Identified transition areas are assigned to the relevant land-use-change category, in the year in which the land-use change takes place, and they remain in that category for 20 years. Consequently, as of the second reporting year, the areas in the "remaining" categories are smaller, in each case, than the corresponding areas in the annual land-use matrix, while the areas in the transition categories are larger than those areas. The relevant areas are shown in the CRF tables Table 335 and Table 336.
5. **Emission factors [*EF*] and implied emission factors [*IEF*] for the twenty-year transition period [*IEF_{20y}*]:** These factors are listed in the CRF tables. Annual emission factors are converted into emission factors, and implied emission factors, that are

appropriate for the land-use-matrix areas with 20-year transition periods. The calculations can be checked, step-by-step, in the relevant spreadsheet-program worksheets. Conversion of EF_{ann} to IEF_{20y} , following inclusion of the mineral-soil and organic-soil areas for emissions from pools, yields adjusted EFs, i.e. implied emission factors (IEFs). Although the absolute emissions remain unchanged as this occurs, the IEFs are influenced by the annual net changes in the areas in the transition categories. In the process, the following formulae are used:

- **Mineral soils:** The entire carbon-stock change as a result of a land-use change is linearly distributed, using the formula $IEF_{20y} = EF_{ann} / 20$, over the 20-year transition period; i.e. only one twentieth of the total emissions are added annually.
 - **Organic soils:** The same quantity of CO₂ is emitted each year – both in the transition categories and in the "remaining" categories for the new land uses; $IEF_{20y} = EF_{ann}$.
 - **Net carbon-stock change, carbon-stock increases and decreases in biomass and in dead organic matter, except in the case of land-use changes leading to forest land:** All emissions are taken account of completely in the year of the land-use change, in keeping with the formula $IEF_{20y} = E_{ann} / Area_{20y}$. The emissions that occur in a specific report year are thus adjusted in accordance with the larger area of the relevant transition category.
 - **Net carbon-stock change, carbon-stock increase in biomass and in dead organic matter in connection with land-use changes to forest land:** The entire carbon-stock change resulting from land-use change is calculated with the formula $IEF_{20y} = EF_{ann}$; i.e. the relevant carbon sink is applied to the entire land-use-change area each year.
 - **N₂O from loss of organic matter in mineral soils, as a result of land-use changes to cropland:** The method used is the same as that used for calculation of carbon-stock losses in mineral soils. The entire carbon-stock change as a result of a land-use change is linearly distributed over the 20-year transition period, in keeping with the formula $IEF_{20y} = E_{ann} / Area_{20y}$; i.e. only one twentieth of the total emissions are added each year.
6. For purposes of the the UN Framework Convention on Climate Change, **total carbon-stock changes for areas with 20-year transition periods** are also calculated using the following formula: $E_{20y} [kt C] = IEF_{20y} [t C/ha] * Area_{20y} [kha]$.
 7. **Calculation of CO₂ emissions** on the basis of the carbon-stocks figures for the NIR, via multiplication of carbon-stock changes by the factor -44/12.
 8. The 2017 Submission was compiled in accordance with the following provisions:
 - 2006 IPCC Guidelines
 - 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC 2014a)
 - 2013 Supplement to the IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (IPCC 2014b)

. The key inventory-improvement measures that were carried out for the present submission and that led to recalculations:

- First estimation of the carbon-stock changes in phytomass in the category Cropland remaining Cropland
- With regard to official statistics regarding Germany's use of areas for perennial crops in the sub-category "Cropland remaining Cropland" (cf. Chapter 6.5.2.1)
- Introduction of emission factors for phytomass of perennial and annual crops in the sub-category "Cropland remaining Cropland" (cf. Chapter 6.5.2.1).
- Correction and methods changes in determination of emission factors for the biomass of annual cropland and grassland plants (Chapter 6.1.2.3)

Apart from these changes, the methods, data sources and emission factors used in the previous submission were again used.

6.1.2.1 Greenhouse-gas emissions from mineral soils (4.A to 4.F)

6.1.2.1.1 Carbon

The area of the mineral soils was calculated as the difference between the relevant total areas and the areas covered by organic soils (Chapter 6.1.2.2).

Changes in carbon and nitrogen stocks in mineral soils are calculated, pursuant to Equation 2.25 in the 2006 IPCC Guidelines (IPCC 2006), as the difference between the relevant stocks prior to, and after, relevant land-use changes. The emission factors have been derived on a country-specific basis. In land-use categories 4.B – 4.F (Cropland, Grassland (in the strict sense), Woody grassland, Wetlands, Settlements and Other land), representative carbon stocks, weighted by area, were defined for mineral soils with depths to 30 cm, from usage-differentiated profile data for soils in Germany. Those carbon stocks were differentiated by parent substrate, soil type, climate region (only topsoils) and land use. The manner in which the relevant values, and their uncertainties, are derived is described Chapter 19.4.2. The values for forest soils were obtained from the Forest Soil Inventories (cf. Chapter 6.4.2.5.3). The reporting on mineral soils thus applies a Tier 2 method.

In the framework of the Forest Soil Inventories, an annual carbon-stock change of $0.41 \pm 0.11 \text{ t C ha}^{-1} \text{ a}^{-1}$ was determined for category 4.A.1, Forest Land remaining Forest Land (cf. Chapter 6.4.2.5.4 and Chapter 19.4.2.1). On an annual basis, that quantity is added to the previous year's stocks and reported as a removal.

For mineral soils with no use change, in land-use categories 4.B, 4.C, 4.D, 4.E and 4.F, it is assumed that the pertinent carbon inputs into the soil and carbon extractions from the soil are equal in size, so that the systems are in balance. The reasons for this assumption are described in Chapters 6.5.2.3 and 6.6.2.3.

The category Grassland (4.C) has two sub-categories: grassland (in a strict sense), and grassland areas with woody plants and shrubs that do not fall within the Forest land category as it is defined. The transition areas between these sub-categories are treated like land-use changes.

The category Wetlands (4.D) has three sub-categories: terrestrial wetlands, peat-extraction areas (only as a non-transfer category) and waters (flooded land). The area transitions between those two sub-categories are treated like land-use changes. Mineral soils occur only in the two sub-categories "terrestrial wetlands" and "waters". No carbon-stock changes are applied in connection with land-use changes from and to waters. As a result, no carbon-stock changes in mineral soils occur in connection with land-use changes between the relevant sub-categories (NO).

For each transition category, the carbon-stock changes in mineral soils as a result of land-use changes are calculated as the difference between the carbon stocks of the final-use category and

the carbon stocks of the original category. Since the carbon stocks in forest soils (4.A) change annually, the relevant inventory calculations are based on the valid annual values for all years in question. Pursuant to IPCC Default (IPCC 2006), the total changes are linearly distributed over a period of 20 years. The sum of all carbon-stock changes resulting from land-use changes in Germany's mineral soils is calculated, for a 20-year period, as follows:

$$\Delta C = \sum_{n=1}^7 (C_{final} - C_{initial})$$

ΔC : Change in carbon stocks as a result of land-use changes in mineral soils of an IPCC land-use category [t C (20*a)⁻¹]

C_{final} : Final soil-carbon stocks [t C]

$C_{initial}$: Initial soil-carbon stocks [t C]

n: Transition categories

The carbon stocks of mineral soils in the various land-use categories, and the carbon-stock changes derived from those stocks and used as emission factors, are shown for 2015 in Table 306; the pertinent derivations are described in Chapter 19.4.2.

Table 306: Mean carbon stocks in Germany's mineral soils, by land use [t C ha⁻¹], and derived (e.g. therefrom) carbon-stock changes, as a result of land-use changes, for 2015

Mean carbon stocks in Germany's mineral soils in 2015								
	Forest land	Cropland	Grassland (in a strict sense)	Woody grassland	Terrestrial wetlands	Waters	Settlements	Other land
[t C ha ⁻¹]	65.49	60.03	77.43	73.18	74.00		58.67	55.60
Carbon-stock change in 20 years [t C ha ⁻¹ (20 a) ⁻¹]								
Initial\final	Forest land	Cropland	Grassland (in the strict sense)	Woody grassland	Terrestrial wetlands	Waters	Settlements	Other land
Forest land		-5.46	11.94	7.69	8.51	0	-6.82	-9.89
Cropland	5.46		17.40	13.15	13.97	0	-1.35	NO
Grassland (in the strict sense)	-11.94	-17.40		-4.25	-3.43	0	-18.76	NO
Woody grassland	-7.69	-13.15	4.25		0.82	0	-14.51	NO
Terrestrial wetlands	-8.51	-13.97	3.43	-0.82		0	-15.32	NO
Waters	0	0	0	0	0		0	NO
Settlements	6.82	1.35	18.76	14.51	15.32	0		NO
Other land	9.89	4.42	21.83	17.58	18.39	0	3.07	

Values in italics: Changing from year to year

Negative: Carbon losses; positive: Carbon sequestration; NO: not occurring

To take account of the 20-year transition period, the total stock change for each transfer category in question (EF_{ann}, cf. Table 306) is divided by 20 (cf. also Chapter 6.1.2). This yields the implied emission factors for the transition categories (IEF_{20y}; cf. Table 307). In the case of land-use changes to and from Forest Land, and because carbon stocks in mineral forest soils change from year to year, an implied emission factor (IEF) has to be derived for each transition category. Such IEF, which vary from year to year, are obtained in each case from the contributions of the land-use changes of the 20 previous years, weighted by emissions. The emissions are calculated as the product of IEF_{20y} and the areas of the 20-year transition categories (cf. Chapter 6.1.2).

Table 307: Implied emission factors [$\text{t C ha}^{-1} \text{a}^{-1}$] for determination of annual carbon-stock changes in Germany's mineral soils, following land-use changes, for the year 2015

Initial\final	Emission factors _{mineral soils} [$\text{t C ha}^{-1} \text{a}^{-1}$] for the year 2015							
	Forest land	Cropland	Grassland (in the strict sense)	Woody grassland	Terrestrial wetlands	Waters	Settlements	Other land
Forest land		-0.009	0.813	0.575	0.689	0	-0.156	0
Cropland	0.037		0.870	0.658	0.699	0	-0.068	NO
Grassland (in the strict sense)	-0.801	-0.870		-0.213	-0.172	0	-0.938	NO
Woody grassland	-0.598	-0.658	0.213		0.041	0	-0.725	NO
Terrestrial wetlands	-0.672	-0.699	0.172	-0.041		0	-0.766	NO
Waters	0	0	0	0	0		0	NO
Settlements	0.116	0.068	0.938	0.725	0.766	0		NO
Other land	0.220	0.221	1.091	0.879	0.920	0	0.154	

Values in italics: Changing from year to year

Negative: Carbon losses; positive: Carbon sequestration; NO: not occurring

6.1.2.1.2 Nitrous oxide

The direct (CRF Table 4.III) and indirect (CRF Table 4.IV) N_2O emissions tied to losses of organic soil substance resulting from land-use changes and land cultivation have been determined in keeping with the 2006 IPCC Guidelines. To that end, the carbon-stock changes determined for the various individual land-use-change areas were divided by the mean, area-weighted C/N ratios for the pertinent soils; this yielded the absolute changes in soil nitrogen stocks (Equation 11.8 in the 2006 IPCC Guidelines). The C/N ratios were derived from the estimated profile data of the BÜK 1000 n 2.3 soil map (BGR 2011).

For determination of the direct emissions, the absolute N-stocks differences were multiplied by the IPCC standard value of $0.01 \text{ kg N}_2\text{O-N (kg N)}^{-1}$, in keeping with Equation 11.1 in the 2006 IPCC Guidelines. The so-determined N_2O emissions are listed in CRF Table 4.III, while the relevant emission factors are listed in Table 308 and the uncertainties are presented in Chapters 6.4.3, 6.5.3, 6.6.3, 6.7.3 and 6.8.3.

For estimation of the indirect nitrous oxide emissions, the N-stocks differences pursuant to Equation 11.10 of the 2006 IPCC Guidelines were multiplied by the standard factors $\text{Frac}_{\text{Leach-(H)}}$ ($0.3 \text{ kg N}_2\text{O-N (kg N)}^{-1}$) and EF_5 ($0.0075 \text{ kg N}_2\text{O-N (kg N)}^{-1}$) (2006 IPCC Guidelines). The emission factors for the indirect nitrous oxide emissions, for the year 2015, are listed in Table 309. They are also listed, along with the pertinent uncertainties, in Chapters 6.4.3, 6.5.3, 6.6.3, 6.7.3 and 6.8.3. The figures presented also include the results entered in CRF Table 4.IV.

The nitrous oxide emissions are also subject to transition-time considerations; like the carbon-stock changes, they are distributed over 20 years.

Table 308: Emission factors for direct nitrous oxide emissions [$\text{kg N}_2\text{O ha}^{-1} \text{a}^{-1}$] caused by losses of organic matter from Germany's mineral soils, following land-use changes, for the year 2015

Initial\final	Emission factors _{mineral soils} [$\text{kg N}_2\text{O ha}^{-1} \text{a}^{-1}$] for the year 2015							
	Forest land	Cropland	Grassland (in the strict sense)	Woody grassland	Terrestrial wetlands	Waters	Settlements	Other land
Forest land		0.040	0	0	0	0	0.135	0
Cropland	0.041		0	0	0	0	0.087	NO
Grassland (in the strict sense)	0.993	1.078		0.263	0.213	0	1.162	NO
Woody grassland	0.769	0.845	0		0	0	0.932	NO
Terrestrial wetlands	0.684	0.711	0	0.042		0	0.780	NO
Waters	0	0	0	0	0		0	NO
Settlements	0.012	0	0	0	0	0		NO
Other land	0	0	0	0	0	0	0	

Values in italics: Changing from year to year

Positive: Nitrous oxide emissions

Table 309: Emission factors for indirect nitrous oxide emissions [$\text{kg N}_2\text{O ha}^{-1} \text{a}^{-1}$] caused by losses of organic matter from Germany's mineral soils, following land-use changes, for the year 2015

Initial\final	Emission factors _{mineral soils} [$\text{kg N}_2\text{O ha}^{-1} \text{a}^{-1}$] for the year 2015							
	Forest land	Cropland	Grassland (in the strict sense)	Woody grassland	Terrestrial wetlands	Waters	Settlements	Other land
Forest land		0.009	0	0	0	0	0.030	NO
Cropland	0.009		0	0	0	0	0.019	NO
Grassland (in the strict sense)	0.223	0.243		0.059	0.048	0	0.261	NO
Woody grassland	0.173	0.190	0		0	0	0.210	NO
Terrestrial wetlands	0.154	0.160	0	0.009		0	0.175	NO
Waters	0	0	0	0	0		0	NO
Settlements	0.002	0	0	0	0	0		NO
Other land	0	0	0	0	0	0	0	

Values in italics: Changing from year to year

Positive: Nitrous oxide emissions

6.1.2.2 Greenhouse gas emissions from organic soils (4.A through 4.F; 4.(II))

CO_2 , N_2O and CH_4 emissions from organic soils are reported in the land-use categories Forest land, Cropland, Grassland (in the strict sense), Woody grassland, Terrestrial wetlands (industrial peat extraction) and Settlements (N_2O from drained organic soils is reported under Cropland and Grassland in CRF Sector 3.D.a.6). Reporting also covers methane emissions from drainage ditches, as well as carbon losses in connection with dissolved organic carbon (DOC). The majority of organic soil areas in Germany consists of drained areas.

The emissions are calculated by multiplying the bog areas per sub-category by pertinent use-specific emission factors. For land-use changes, the emission factor for the final category is used right away:

$$EC_{orgsoil} = \sum_{n=1}^7 (A_n * EF_n)$$

$EC_{orgsoil}$: Carbon emissions from organic soils in a land-use category [Gg C]

A_n : Bog area subject to a certain land use [kha]

EF_n : Land-use-specific emission factor [$\text{t C ha}^{-1} \text{a}^{-1}$]

n : Transition categories or "remaining" categories

The present inventory is based on highly detailed maps showing the locations and drainage of organic soils. In addition, the submission makes use of extensive measurement data on greenhouse-gas emissions from organic soils in Germany that have been generated, using standardised measurement protocols, in the "Organic Soils" ("Organische Böden") project (www.organische-boeden.de), a collaborative research project of the Johann Heinrich von Thünen Institute (Federal Research Institute for Rural Areas, Forestry and Fisheries), as well as in predecessor projects (a small quantity of the data was obtained from the relevant national literature). The database for the activity data and emission factors, and the relevant derivations, meet the criteria for an IPCC Tier 3 method. In the interest of transparency, and in order to maintain consistency with other activity data and carbon pools, the database and the derivations have been turned into a national Tier 2 method for the inventory.

6.1.2.2.1 Activity data (3.D, 4.A- 4.E; 4.(II))

Under commission to the Thünen Institute, until 2013 an "Organic Soils Map" ("Karte organischer Böden") (Parametrized area data on the organic soils in Germany) was prepared that is fully in keeping with the IPCC definition of organic soils (ROSSKOPF et al. 2015):

- Spatial resolution / scale: heterogenous, for process-related reasons, ~1:10,000 – 1:200,000; grid width 25 m.
- Temporal resolution: regionally varying, depending on the database involved (from the beginning of the 20th century to the present).
- Data records: in close cooperation with government agencies of the German Länder (states), the existing soil data, bog cadastres and data records available from geological, silvicultural and agricultural maps were harmonised, and then incorporated in the inventory process as extensively as possible, and at the highest level of resolution possible.
- Data selection (minimal criterion): In keeping with the "Bodenkundliche Kartieranleitung" soil mapping instructions (KA 5, ARBEITSGRUPPE BODEN 2005) and the IPCC 2006 instructions for reporting on organic soils, among map sheets with legend units based on digital (vector-form) outset data, map data were chosen that primarily describe soils with a 9 % minimum content of organic carbon (15 % organic soil matter) in a mixed sample of the upper 20 cm.

The new organic-soils area encompasses a total of 1.824 million ha. The new organic soils map supplants the previously used overview soil map, which was drawn to a coarse scale of 1:1,000,000 (BGR 1997), and which did not include any shallow peat soils or peats mixed with mineral soils (old total area: 1.725 million ha). Because the area allocations in the new organic soils map are much more precise than those in the old map, the area fractions for the various land-use categories have changed with respect to the submissions prior to 2015. Grassland in the strict sense is now far and away the predominant use (Table 310). In order to take account of small-scale structures, the resolution of the grid for determining land-use categories on organic soils has been greatly increased (cf. Chapter 6.3). This makes it possible to report a highly precise time series of land uses and land-use changes on organic soils.

Table 310 shows the organic soils areas, by land-use categories, along with the applicable drained-area fractions, for the year 2015. The drained fractions of organic soils areas, by land-use categories, were derived from the regional distribution of water levels in Germany's organic soils (BECHTOLD et al. 2014). Those levels have been obtained, inter alia, from the map of organic soils and from long-term measurements of water levels in organic soils. The drained fraction of organic soils consists of those areas that have an average annual water level lower than 0.1 m below ground level.

For determination of CH₄ from drainage ditches, a ditch-area fraction (Fracditch) of 1.3 % was determined, using the ATKIS-Basis-DLM Basic Digital Landscape Model. That figure applies for all land-use categories.

Table 310: Organic soils areas, by land-use categories, and drained-area fractions, for the year 2015 (3.D, 4.A- 4.E; 4.(II))

	Areas of land with organic soils [ha]	Drained fraction [%]
Forest land	146,078	77.00
Cropland	380,664	100
Grassland (in the strict sense)	934,259	92.36
Woody grassland	150,508	76,82 (like forest land)
Terrestrial wetlands	98,991	76.37
Waters	19,559	0
Peat extraction	19,857	100
Settlements	74,006	100
Other land	0	0
Σ	1,823,922	

6.1.2.2.2 Emission factors for greenhouse gases from drained organic soils, in all land-use categories (3.D, 4.A-4.E; 4(II))

The emission factors have been developed in keeping with the guidelines in the 2013 IPCC Wetlands Supplement (IPCC 2014). The emission factors for CO₂ from soils (CO₂-C on-site), CH₄ from soils (CH₄_{land}) and N₂O were developed from national annual measurements. For CO₂ from dissolved organic carbon (CO₂-C_{DOC}) and CH₄ from drainage ditches (CH₄_{Ditch}), the standard values in the 2013 IPCC Wetlands Supplement (IPCC 2014) have been used.

CO₂ from soils (CO₂-C_{on-site}):

The database consists of representative, quality-checked, national annual measurements (208 measurement years, 95 sites, 13 different bog areas) obtained on areas with an average annual water level of 0 cm or more below ground level (no overflow). This data set exhibits a linear correlation, across all land-use categories, with average annual water levels. Via linear regression, it is thus possible, for each 25 x 25 m pixel of the map of the regional distribution of water levels in Germany's organic soils (BECHTOLD et al. 2014), to calculate CO₂ emissions from soil (CO₂-C_{on-site}) with an average annual water level lower than 0.1 m below ground level. The uncertainty of the water-level map was taken into account in the uncertainties calculation. The mean value, the emission factor, was derived from the map of the results, while the 95th percentile was derived from the uncertainties calculation. Table 311 provides an overview of the national emission factors. In each case, it shows both the nationally derived portion of the CO₂ emission factor and the fully aggregated emission factor as used in the inventory.

Table 311: Emission factors for CO₂-C_{organic_drained} from drained organic soils, in all land-use categories (4.A-4.E; 4(II))

Land use	NIR 2017 Soil-CO ₂ -C _{onsite} t CO ₂ -C ha ⁻¹ a ⁻¹	NIR 2017 CO ₂ -C _{total_organic_drained} t CO ₂ -C ha ⁻¹ a ⁻¹	IPCC Wetlands Supplement CO ₂ -C _{total_organic_drained} t CO ₂ -C ha ⁻¹ a ⁻¹
Forest land / Woody grassland	IPCC	2.9 (2.3 - 3.6)	2.9 (2.3 - 3.6)
Cropland	7.8 (4.1 - 4.9)	8.1 (4.4 - 9.5)	8.2 (6.8 - 9.7)
Grassland, Settlements	7.1 (3.0 - 9.2)	7.4 (3.3 - 9.5)	6.4 (5.3 - 7.6)
Terrestrial wetlands	6.2 (2.3 - 9.2)	6.5 (2.5 - 9.5)	/
Peat-extraction areas	1.2 (1.2 - 1.4)	1.6 (1.5 - 1.8)	3.1 (1.4 - 4.5)

CH₄ from soil (CH₄_{land}):

The database consists of representative, quality-checked, national annual measurements (197 measurement years, 97 sites, 15 different bog areas) obtained on areas with an average annual water level of 0 cm or more below ground level (no overflow). The emission factor was derived in a manner similar to that used for the emission factor for CO₂ from soil (CO₂-C on-site). Because methane emissions grow exponentially with rising water levels, an exponential function was used. Land-use-dependent exponential functions for Forest Land, Grassland and Wetlands were developed. Cropland and peat-extraction areas proved to be too dry for achievement of any correlation with water levels. For this reason, the average values of the measurements were adopted for these two land-use categories. Table 312 provides an overview of the national emission factors. In each case, it shows both the nationally derived portion of the CH₄ emission factor and the fully aggregated emission factor as used in the inventory.

Table 312: Emission factors for CH₄-organic from drained organic soils, in all land-use categories (4.A- 4.E; 4(II))

Land use	NIR 2017 CH ₄ _{land} kg CH ₄ ha ⁻¹ a ⁻¹	NIR 2017 CH ₄ _{organic (land+ditch)} kg CH ₄ ha ⁻¹ a ⁻¹	IPCC Wetlands Supplement CH ₄ _{land} kg CH ₄ ha ⁻¹ a ⁻¹
Forest land / Woody grassland	3.7 (-2.1 - 70)	6 (0.3 - 72)	2.5 (-0.6 - 6)
Cropland	11.4 (-2.7 - 73)	26 (8.8 - 88)	0 (-2.8 - 3)
Grassland, Settlements	10.4 (3.6 - 69)	23 (12 - 81)	16 (2.4 - 29)
Terrestrial wetlands	17 (1.5 - 150)	20 (4.1 - 151)	/
Peat-extraction areas	4.2 (-0.4 - 13)	11 (3.9 - 22)	6.1 (1.6 - 11)

N₂O:

The database consists of representative, quality-checked, national measurements that cover at least a year in each case (94 sites, 20 different bog areas) and were obtained on areas with an average annual water level of 0.1 m or more below ground level (no overflow). The national database is part of the European data records in LEPPELT et al. (2014). Since no functional interrelationships were identified, the average measurement values for the various land-use categories were defined as the emission factors. Table 313 provides an overview of the national emission factors for N₂O.

Table 313: Emission factors for N₂O from drained organic soils, in all land-use categories (3.D, 4.A- 4.E; 4(II))

Land use	NIR 2017	IPCC Wetlands Supplement
	kg N ₂ O-N ha ⁻¹ a ⁻¹	kg N ₂ O-N ha ⁻¹ a ⁻¹
Forest land / Woody grassland	1.8 (0.1 - 5.3)	2.8 (-0.6 - 6.1)
Cropland	10.7 (1.6 - 41.4)	13 (8.2 - 18)
Grassland, Settlements	2.7 (0 - 8.9)	8.2 (4.9 - 11)
Terrestrial wetlands	0.4 (-0.1 - 1.6)	/
Peat-extraction areas	0.9 (0.3 - 1.4)	0.3 (0 - 0.6)

6.1.2.2.3 Implied emission factors (IEF) for greenhouse gases from organic soils (4.A-4.E; 4(II))

In the framework of inventory preparation, the emissions from organic soils are calculated with implied emission factors – including specific factors for each greenhouse gas and for each land-use category. The emission factors shown in Chapter 6.1.2.2.2 apply for drained organic soils. In determination of emissions from a specific land-use category, undrained, wet areas also have to be taken into account, however, and thus the IEF for peat-extraction areas also has to take account of emissions from peat that has been extracted and applied. This perspective leads to the implied emission factors shown in Table 314 as the factors for calculation of greenhouse-gas emissions from organic soils. In some cases, these factors differ considerably from the factors presented in Chapter 6.1.2.2.2.

Table 314: Implied emission factors for CO₂-C, CH₄ and N₂O-N from organic soils (4.A- 4.E; 4(II)), for the year 2015

Land use	CO ₂ -C	CH ₄	N ₂ O-N
	t CO ₂ -C ha ⁻¹ a ⁻¹	kg CH ₄ ha ⁻¹ a ⁻¹	kg N ₂ O-N ha ⁻¹ a ⁻¹ CH ₄
Forest land	-2.233	4.620	1.386
Cropland	-8.100	26.000	10.700
Grassland	-6.834	21.242	2.494
Woody grassland	-2.233	4.620	1.386
Terrestrial wetlands	-4.964	15.275	0.305
Peat-extraction areas	-29.991	11.191	1.339
Settlements	-7.400	23.000	2.700

6.1.2.3 Biomass (4.B through 4.F)

6.1.2.3.1 General information

In preparation of the German inventory, emissions from the pool of above-ground and below-ground biomass are listed for

- the "remaining" category Cropland (with usage changing between annual, herbaceous and perennial woody crops),
- and for the transition categories of Forest Land, Cropland, Grassland, Woody Grassland, Wetlands, Waters, Settlements and Other Land.

For the "remaining" categories of Cropland, Grassland, Woody Grassland, Wetlands and Settlements, no carbon-stock changes are listed in cases in which crops (annual or perennial) do not change, since,

- pursuant to the IPCC Guidelines (2006 IPCC Guidelines), an equilibrium condition is assumed, in these sub-categories, for the carbon fluxes of the annual phytomass pool. With the gain-loss method, therefore, $\Delta C = 0$ (Equation 2.7 in the 2006 IPCC Guidelines). Consequently, "NO" (not occurring) has been entered in CRF Tables 4.D.1 – 4.F.1 under the pools "living biomass" and "dead organic matter."
- For the woody perennial plants on these areas, this is based on the representative "equilibrium carbon stocks" determined for Germany. On the basis of the work of PÖPKEN (2011), these stocks were determined for hedges and field copses, and for all areas with cultivated woody crops, such as orchard and vineyard areas, tree nurseries, Christmas tree plantations and short-rotation plantations. This was done by summing over all different age classes, types and compositions of the various woody crop areas (Chapter 6.1.2.3.4 and Chapter 6.1.2.3.5). For example, the mean carbon stocks in fruit trees are calculated on the basis of a complete tree count with differentiation by tree type and age ($< 1 - > 25$ years); cf. Chapter 6.1.2.3.4.1. In each case, when these stocks are set in relation to the area concerned, as a function of rotation period, this leads to the mean emission factor for the woody crop concerned. As a rule, annual growth increments in cultivated woody plants are completely pruned away. Since the rotation periods for woody crops tend to be relatively short (about 10 – 15 years for fruit trees), such plantations tend to rejuvenate frequently. Such rejuvenation occurs from the source category used to derive the pertinent emission factors, however. The processes of planting, growth, pruning, harvest and rejuvenation reach a state of dynamic equilibrium. This also applies to the woody-crop biomass of vineyards, tree nurseries, Christmas tree plantations, short-rotation plantations, hedges and field copses (Chapter 6.1.2.3.4). In connection with land-use changes, therefore, the carbon stocks from planting of woody-crop biomass are credited completely in the year of the land-use change.

At present, the existing system for listing land-use changes does not make it possible to list annual and perennial crops in a spatially explicit and complete manner. As a result,

1. the Cropland category currently cannot be subdivided into two sub-categories ($\text{Cropland}_{\text{annual}}$, $\text{Cropland}_{\text{perennial}}$, and use changes within the Cropland land-use category, between annual and perennial crops, and to other land-use categories, can be reported as "normal land-use changes" (similar to the situation with Grassland);
2. in the case of land-use changes to and from Cropland, an area-weighted emission factor has to be derived for the entire cropland phytomass, since it is unclear whether annual or perennial Cropland is the outset use or the final use.

For this reason, the carbon-stocks change for perennial crops can be estimated only on the basis of area changes determined statistically for all of Germany, under the assumption that the annual area differences for permanent crops solely represent use changes within the Cropland land-use category (cf. Chapter 6.5.2.1.2). Connections to other land-use categories cannot be proven, and thus they cannot be reported. As a result, the first-time estimation of the carbon-stock changes of phytomass in the Cropland "remaining" category uses the methods described below, although it does so on the basis of the spatially and qualitatively non-specific area differences shown in official statistical data, i.e. without relating the changes to other land-use classes (cf. Table 315).

6.1.2.3.2 Calculation methods

The carbon-stock changes resulting from land-use changes are determined, and reported, for both annual and perennial biomass. In the process, removals and emissions of CO_2 are determined via the relevant carbon-stock changes, on the basis of national data, and separately for above-ground

and below-ground biomass. In each case, a carbon-stock change takes place completely in the year of the relevant land-use change (cf. also Chapter 6.1.2).

The carbon-stock changes in biomass are estimated by subtracting the biomass carbon stock before the land-use conversion from the stock after the conversion, with reference to the area affected by the change (in keeping with Equation 2.16, 2006 IPCC Guidelines):

$$\Delta C_{Bio} = \sum_{n=1}^7 (A_n * EF_{final} - A_n * EF_{initial})$$

ΔC_{Bio} :	Change in the biomass carbon stock for a given land-use category [Mg]
A_n :	Area on which the land-use change has occurred [ha]
EF_{final} :	Plant-specific biomass carbon stock [Mg ha ⁻¹]
$EF_{initial}$:	Plant-specific biomass carbon stock [Mg ha ⁻¹]
n :	Transition categories

The biomass-stocks changes are calculated in keeping with the gain-loss method (2006 IPCC Guidelines). Chapter 6.3 outlines the determination of the relevant activity data, while the derivation of the country-specific emission factors and their uncertainties is described in Chapter 6.1.2.3.3, Chapter 6.1.2.3.4 Chapter 6.1.2.3.5 and in the chapters for the individual land-use categories. The reporting on biomass is equivalent to a Tier 2 method.

The annual-biomass carbon stocks of cropland and grassland plants vary annually and are calculated for each year on the basis of harvest statistics, with the same data sources and algorithms as are used for calculating crop residues in CRF Sector 3.D. The pertinent differences obtained in the above-described manner lead to the emission factors shown in Table 315. For Cropland, Grassland, Wetlands and Settlements, the factors differ slightly from those of the previous year, since the emission factors for the annual phytomass have been slightly modified (cf. Chapter 6.5.5 and Chapter 6.6.5), in the Cropland category,

- in connection with correction of an error
- via improved derivation, in the Grassland (in the strict sense) category.

Table 315: Emission factors [$\text{t C ha}^{-1} \text{ a}^{-1}$] for determination of carbon-stock changes in the year of the change, in above-ground and below-ground biomass, by type of land-use change, for the year 2015

Mean carbon stocks in above-ground and below-ground biomass										
	Forest land ⁹⁰	Cropland	Grassland (in the strict sense)	Woody grassland	Terrestrial wetlands	Waters	Settlements	Other land	Cropland _{annual}	Cropland _{perennial}
[t C ha^{-1}]	54.66	6.55	6.81	43.16	18.93	0	12.49	0	6.48	11.66
2015 emission factors for biomass [$\text{t C ha}^{-1} \text{ a}^{-1}$]										
Initial\final	Forest land ⁹¹	Cropland ⁹²	Grassland (in the strict sense) ⁹²	Woody grassland ⁹²	Terrestrial wetlands ⁹²	Waters ⁹²	Settlements ⁹²	Other land	Cropland _{annual} ⁹³	Cropland _{perennial} ⁹³
Forest land		-48.11	-47.85	-11.5	-35.73	-54.66	-42.17	NO		
Cropland	3.47		0.26	36.61	12.38	-6.55	5.94	NO		
Grassland (in a strict sense)	3.25	-0.26		36.35	12.12	-6.81	5.68	NO		
Woody grassland	2.04	-36.61	-36.35		-24.23	-43.16	-30.67	NO		
Terrestrial wetlands	3.49	-12.38	-12.12	24.23		-18.93	-6.44	NO		
Waters	3.64	6.55	6.81	43.16	18.93		12.49	NO		
Settlements	3.41	-5.94	-5.68	30.67	6.44	-12.49		NO		
Other land	3.64	6.55	6.81	43.16	18.93	0	12.49			
Cropland _{annual} ⁹³										5.18
Cropland _{perennial} ⁹³									-5.18	

Remark: The carbon stocks for forest land and cropland are chronologically variable (values in italics), while those for the other land-use categories are constant

⁹⁰ Carbon stocks of deforestation areas

⁹¹ Annual carbon-stock change over 20 years

⁹² One-time carbon-stock change

⁹³ only the "remaining" category of Cropland

For calculation relative to conversion of forest land into other land uses (deforestation), the average value determined for deforestation areas in Germany, in the National Forest Inventories of 2002 and 2012, was used as a basis for the relevant reporting years. For the relevant methods and value derivation, cf. Chapter 6.4.2.2. New values for dead wood were also determined via the BWI 2012.

Table 316: Time series for mean carbon stocks in phytomass of deforestation areas [t C ha⁻¹]

Year	Phytomass – carbon [t C ha ⁻¹] (EF 1)					Σ deforestation
	Bio _{total}	Bio _{above}	Bio _{below}	Litter	Dead wood	
1990	28.93	24.53	4.39	19.00	1.88	49.81
1995	28.93	24.53	4.39	18.94	1.88	49.75
2000	28.93	24.53	4.39	18.88	1.88	49.69
2005	54.66	46.48	8.18	18.81	1.82	75.29
2006	54.66	46.48	8.18	18.80	1.82	75.28
2007	54.66	46.48	8.18	18.79	1.82	75.26
2008	54.66	46.48	8.18	18.78	1.99	75.42
2009	54.66	46.48	8.18	18.76	1.99	75.41
2010	54.66	46.48	8.18	18.75	1.99	75.39
2011	54.66	46.48	8.18	18.74	1.99	75.38
2012	54.66	46.48	8.18	18.73	1.99	75.37
2013	54.66	46.48	8.18	18.71	1.99	75.36
2014	54.66	46.48	8.18	18.70	1.99	75.34
2015	54.66	46.48	8.18	18.69	1.99	75.33

The uncertainty for the tree biomass is 24.95 % (half of the 95 % confidence interval). The distribution is normal. This also applies for the values for the dead organic matter; for dead wood, half of the 95 % confidence interval is 56.76 %, while for litter it is 3.15 %. The uncertainties for the emission factors listed in Table 315 are set forth in the chapters for the relevant land-use categories (Chapter 6.4.3, Chapter 6.5.3, Chapter 6.6.3, Chapter 6.7.3, Chapter 6.8.3 and Chapter 521).

On-site burning of biomass is prohibited by law in Germany (Art. 3 German Ordinance on direct payments (DirektZahlVerpflV); Federal Law Gazette (BGBl) 2004) and thus is not reported. In the CRF tables, NO (not occurring) is entered for that category.

Emissions from dead organic matter are reported only for land-use changes from forest land to one of the categories 4.B – 4.E. In the land-use-change categories 4.B – 4.E, emissions from dead organic matter are included with emissions from living biomass, since estimates of emissions from living biomass are always oriented to entire plants. To prevent double counting, therefore, in these transition categories, emissions from dead organic matter are marked IE (included elsewhere) in the CRF tables. In category 4.F, NO (not occurring) is used, since, by definition, the areas in this category have no vegetation cover.

6.1.2.3.3 Derivation of the emission factors for phytomass of annual crops and herbaceous plants

The carbon stocks of the above-ground and below-ground phytomass of herbaceous plants of a) cropland and grassland crops and b) grassland (in the strict sense) are derived annually, on the basis of harvest surveys of the Federal Statistical Office. From those stocks, area-weighted and harvest-weighted mean carbon stocks are calculated, with respect to the relevant areas, and the

area-weighted means are used as emission factors. This approach is in keeping with the methods set forth in the 2006 IPCC Guidelines.

The mean carbon stocks of cropland and horticultural crops are determined on the basis of data on harvests and area under cultivation for a total of 65 field crops. These include:

- Winter wheat, spring wheat, rye, triticale, maslin, winter barley, spring barley, oats, mixed grains other than maslin, grain maize;
- Field peas, broad beans;
- Potatoes, sugar beets, fodder beets;
- Winter oilseed rape;
- Clover, alfalfa, grass, silage maize; and
- Cauliflower, broccoli, Chinese cabbage, kale, kohlrabi, Brussels sprouts, red cabbage, white cabbage, savoy, oak-leaf lettuce, iceberg lettuce, endive, lamb's lettuce, head lettuce, lollo lettuce, radicchio, romana lettuce, arrugula, other lettuce types, spinach, rhubarb, asparagus, celery, fennel, celeriac, horseradish, carrots, radishes, (larger) radishes, red beets, pickling cucumbers, slicing cucumbers, edible pumpkins, zucchini, sweet corn, bush beans, broad beans, runner beans, split peas, peas, bunching onions, onions, parsley, leeks and chives.

For Grassland (in the strict sense), the data consists of harvest and cultivation-area data for all statistically recorded

- meadows
- mowed pastures
- pastures
- mountain pastures and rough pastures

The dry biomass of individual plant parts is derived from harvest data, pursuant to ROESEMANN et al. (2015), using relevant ratios and water-content data (obtained from various sources). The data and methods used are consistent with those used to calculate nitrogen in crop residues (CRF 3.D.a.4).

For calculation of biomass carbon stocks, an average carbon content of 45 % by weight was assumed – and used instead of the IPCC standard value (50 % by weight) – since OSOWSKI et al. (2004) give carbon contents of 44 to 48 % by weight for plants in central Europe and since PÖPKEN (2011), in her studies of cultivated trees (carried out for the German inventory), also found average values of 45 to 46 % by weight.

The results for herbaceous plants of cropland and horticultural areas are shown in Table 317, while those for Grassland (in the strict sense) are shown in Table 318.

As Table 317 shows, the values for phytomass of herbaceous cropland and horticultural land plants

- exhibit a positive, significant trend over time. For this reason, the calculations of carbon-stock changes due to land-use changes are always based on the current pertinent value for the year in question.
- The values for the years 1990 – 2014 differ from the corresponding values in the previous year's submission. This is due to correction of a calculation error tied to a lacking field reference in the calculation program. In the current Submission, the correction led to emission factors that are insignificantly lower than the corresponding figures for the previous year.

Table 317: Area-based carbon stocks [$\text{t C ha}^{-1} \pm$ half of the 95 % confidence interval] of herbaceous phytomass on cropland and horticultural land, and the percentage changes in such stocks with respect to the previous year's submission

Year	Cropland ^{annual}					
	Carbon stocks [t C ha^{-1}]			Change with respect to the 2016 Submission [%]		
	Phytomass _{total}	Phytomass _{above-ground}	Phytomass _{below-ground}	Phytomass _{total}	Phytomass _{above-ground}	Phytomass _{below-ground}
1990	5.17 $\pm$ 0.61	3.72 $\pm$ 0.51	1.45 $\pm$ 0.33	-0.34	-0.34	-0.34
1995	5.54 $\pm$ 0.65	4.12 $\pm$ 0.57	1.42 $\pm$ 0.32	-0.33	-0.33	-0.33
2000	5.89 $\pm$ 0.69	4.40 $\pm$ 0.60	1.49 $\pm$ 0.33	-0.32	-0.32	-0.32
2005	6.08 $\pm$ 0.71	4.58 $\pm$ 0.63	1.50 $\pm$ 0.34	-0.29	-0.29	-0.29
2006	5.74 $\pm$ 0.67	4.36 $\pm$ 0.60	1.39 $\pm$ 0.31	-0.28	-0.28	-0.28
2007	5.81 $\pm$ 0.68	4.35 $\pm$ 0.60	1.46 $\pm$ 0.33	-0.30	-0.30	-0.30
2008	6.30 $\pm$ 0.74	4.78 $\pm$ 0.66	1.51 $\pm$ 0.34	-0.31	-0.31	-0.31
2009	6.46 $\pm$ 0.76	4.89 $\pm$ 0.67	1.57 $\pm$ 0.35	-0.31	-0.31	-0.31
2010	5.96 $\pm$ 0.70	4.51 $\pm$ 0.62	1.45 $\pm$ 0.32	-0.30	-0.30	-0.30
2011	6.09 $\pm$ 0.71	4.55 $\pm$ 0.62	1.54 $\pm$ 0.35	-0.30	-0.30	-0.30
2012	6.43 $\pm$ 0.75	4.84 $\pm$ 0.66	1.59 $\pm$ 0.36	-0.30	-0.30	-0.30
2013	6.32 $\pm$ 0.74	4.81 $\pm$ 0.66	1.51 $\pm$ 0.34	-0.30	-0.30	-0.30
2014	7.21 $\pm$ 0.84	5.45 $\pm$ 0.75	1.76 $\pm$ 0.40	-0.31	-0.31	-0.31
2015	6.48 $\pm$ 0.76	4.95 $\pm$ 0.68	1.53 $\pm$ 0.34	/	/	/

For Grassland (in the strict sense), Table 318 and Table 319 make it clear that the carbon stocks in the phytomass of herbaceous plants

- do not show a significant trend in the time series, and that the annual changes are considerably smaller than the uncertainties. For this reason, mean carbon stocks for the phytomass of Grassland (in the strict sense) are estimated and, in a consistent manner, used as a basis for the calculations for all the years concerned.
- The values used in the current submission differ slightly from those of the previous year's submission. This is due to changes in the procedures used to calculate the emission factor. The mean carbon stocks over time were determined via bootstrapping. Bootstrapping is resampling procedure in which statistical indexes are calculated on the basis of samples (in the present case, the mean carbon stocks of the above-ground and below-ground phytomass of herbaceous grassland plants for the years 1990 – 2015). This procedure is especially useful in cases in which the theoretical distribution of the statistics is not known, and one parameter (in the present case, the mean) of the basic whole (i.e. not the sample), and its average divergence from the true parameter, has to be estimated. The so-calculated values for herbaceous plants of Grassland (in the strict sense) are shown in Table 319. They serve as a basis for all relevant calculations in the inventory. The standard error of the calculated means for the basic whole is 2.3 % (half of the 95 % confidence interval).

Table 318: Area-related carbon stocks [t C ha⁻¹] of phytomass on Grassland (in the strict sense) (± half of the 95 % confidence interval)

Grassland (in the strict sense)	Carbon stocks [t C ha ⁻¹]		
	Biomasse _{total}	Biomasse _{above-ground}	Biomasse _{below-ground}
1990	6.63 ± 2.00	3.68 ± 1.33	2.95 ± 1.50
1995	6.74 ± 2.04	3.75 ± 1.35	3.00 ± 1.52
2000	7.26 ± 2.19	4.03 ± 1.46	3.22 ± 1.64
2005	7.08 ± 2.14	3.94 ± 1.42	3.15 ± 1.60
2006	6.62 ± 2.00	3.68 ± 1.33	2.94 ± 1.49
2007	7.00 ± 2.12	3.89 ± 1.41	3.11 ± 1.58
2008	6.67 ± 2.01	3.71 ± 1.34	2.96 ± 1.51
2009	6.81 ± 2.06	3.78 ± 1.37	3.03 ± 1.54
2010	6.74 ± 2.04	3.75 ± 1.35	3.00 ± 1.52
2011	6.84 ± 2.07	3.80 ± 1.37	3.04 ± 1.54
2012	7.18 ± 2.17	3.99 ± 1.44	3.19 ± 1.62
2013	6.80 ± 2.05	3.78 ± 1.37	3.02 ± 1.54
2014	7.67 ± 2.32	4.26 ± 1.54	3.41 ± 1.73
2015	6.62 ± 2.00	3.68 ± 1.33	2.94 ± 1.49

Table 319: Area-related carbon stocks [t C ha⁻¹] of Grassland (in the strict sense) (± half of the 95 % confidence interval)

Grassland (in the strict sense)	Carbon stocks [t C ha ⁻¹]			Change with respect to the 2016 Submission [%]		
	Biomasse _{total}	Biomasse _{above-ground}	Biomasse _{below-ground}	Biomasse _{total}	Biomasse _{above-ground}	Biomasse _{below-ground}
Grassland (in the strict sense)	6.81 ± 2.06	3.78 ± 1.37	3.03 ± 1.54	-0.73 %	-0.79 %	-0.66 %

6.1.2.3.4 Derivation of emission factors for perennial woody crops

In the framework of the research project "Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth" ("Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Waldflächen"), country-specific carbon-stock data were collected for the above-ground and below-ground biomass of orchards, vineyards and Christmas-tree plantations in Germany. The mean carbon stocks of the plants in tree nurseries were then estimated on the basis of these data, and of results of the National Forest Inventory. Mean tree biomass values for short-rotation plantations were derived from literature data, on a country-specific basis.

6.1.2.3.4.1 Fruit trees

In the framework of the aforementioned research project, with trees taken from Germany's two main fruit-growing regions (Altes Land ("Old country"): northern Germany, and Lake Constance region: southern Germany), a total of 100 fruit trees (91 apple trees, 6 cherry trees and 3 plum trees), of differing ages and types, were destructively tested. In addition, the following data was collected from 210 living apple trees:

- Diameter at stem base
- Diameter at breast height
- Height

A regression procedure applied to all collected data yielded a highly significant relationship between tree age and mean stem diameter ($=(\text{diameter at stem base} + \text{diameter at breast height})/2$), for each age class:

Equation 18: Regression equation for estimating mean stem diameter [cm] of apple trees, as a function of tree age [a]

$$S_{\text{mean apple}} = 14.2986 * (1 - e^{(-0.0528x)})$$

$S_{\text{mean\_apple}}$: Mean stem diameter, apple tree [cm]

x: Tree age [a]

Statistical indexes / uncertainties:

$r^2 = 0.9768$

$p < 0.0002$

Standard error of estimation = $0.5625 \pm 8.44 \%$

The total uncertainty in the estimation of the mean stem diameter of apple trees as a function of tree age amounts to 23.59 % (half of the 95 % confidence interval).

Equation 19: Regression equation for estimating mean stem diameter [cm] of cherry and plum trees, as a function of tree age [a]

$$S_{\text{mean cherry/plum}} = 53.8165 * (1 - e^{(-0.0252x)})$$

$S_{\text{mean\_cherryplum}}$: Mean stem diameter, cherry/plum tree [cm]

x: Tree age [a]

Statistical indexes:

$r^2 = 0.9486$

$n = 9$

$p < 0.0001$

Standard error of estimation = $1.2963 \pm 11.14 \%$

The estimation of the stem diameter of cherry and plum trees as a function of tree age is subject to a total uncertainty of 25.68 % (half of the 95 % confidence interval).

Via destructive testing, the masses, water content and carbon content of the fruit trees were separately determined for the compartments above-ground biomass (trunk and branches) and below-ground biomass (roots). The ages of the so-tested apple trees were 6 and 9, while the ages of the cherry and plum trees were 4, 12 and 14.

The trees' biomasses were adjusted to take account for the water content measured during drying at 105°C and then, to determine the carbon stocks of the trees' parts / whole trees, were multiplied by the carbon-content percentage of the biomass_{dry}.

From the resulting data, highly significant relationships were derived between mean trunk diameter and carbon stocks of the entire plant [(apple); Equation 22 (cherry/plum)] and between mean trunk diameter and carbon stocks of the above-ground biomass [Equation 20 (apple); Equation 23 (cherry/plum)]. The carbon stocks in the below-ground biomass of cherry and plum trees was determined by subtracting the above-ground biomass from the total stocks, while the relevant stocks for apple trees were determined via the equation of MOKANY et al. (2006) (Equation 21). In a survey, they derived, for numerous types of vegetation, root / shoot ratios as a function of biomass, climatic parameters and local site parameters. Their results were then adopted as default values in the 2006 IPCC Guidelines (IPCC 2006).

Equation 20: Regression equation for estimating carbon stocks in the above-ground biomass of apple trees, as a function of mean stem diameter

$$\ln C_{above\ apple} = -2.7521 + 1.9533 * \ln x$$

$\ln C_{above\_apple}$: Logarithm for carbon stocks in above-ground plant parts [kg plant⁻¹]

$\ln x$: Logarithm for mean stem diameter [cm]

Statistical indexes:

$$r^2 = 0.8273$$

$$n = 90$$

$$p < 0.0001$$

$$\text{Standard error of estimation} = 0.044 \pm 2.83 \%$$

Equation 21: Regression equation for estimation of the carbon stocks in below-ground biomass of apple trees as a function of above-ground biomass (MOKANY et al. (2006)):

$$C_{below\ apple} = 0.489 * x^{0.89}$$

C_{below_apple} : Carbon stocks in below-ground plant parts [kg plant⁻¹]

x : Carbon stocks in above-ground biomass [kg plant⁻¹]

Statistical indexes:

$$r^2 = 0.93$$

$$n = 301$$

$$\text{Standard error of the estimation} = 13.6 \% \text{ (derived from MOKANY et al. (2006))}$$

Equation 22: Regression equation for estimating carbon stocks of the entire biomass of cherry and plum trees, as a function of mean stem diameter

$$C_{total\ cherry/plum} = 0.0369 x^{2.2725}$$

$C_{total\_cherryplum}$: Carbon stocks of entire cherry/plum tree biomass [kg plant⁻¹]

x : Mean stem diameter, cherry/plum tree [cm]

Statistical indexes:

$$r^2 = 0.9608$$

$$n = 9$$

$$p < 0.0001$$

$$\text{Standard error of estimation} = 1.7382 \pm 14.04 \%$$

Equation 23: Regression equation for estimating carbon stocks in the above-ground biomass of cherry and plum trees, as a function of mean stem diameter

$$C_{above\ cherry/plum} = 0.0238 x^{2.3586}$$

$C_{above\_cherryplum}$: Carbon stocks of above-ground cherry/plum tree biomass [kg plant⁻¹]

x : Mean stem diameter, cherry/plum tree [cm]

Statistical indexes:

$$r^2 = 0.9442$$

$$n = 9$$

$$p < 0.0001$$

$$\text{Standard error of estimation} = 2.025 \pm 18.76 \%$$

The root C stocks of cherry / plum trees are obtained as the difference between the carbon stocks of the entire plant and the stocks of its above-ground parts (cf. Equation 24).

Equation 24: Estimation of the carbon stocks in the root mass of cherry/plum trees

$$C_{below} = C_{total} - C_{above}$$

C_{below}: Below-ground carbon stocks [kg plant⁻¹]C_{total}: Carbon stocks of entire plant [kg plant⁻¹]C_{above}: Above-ground carbon stocks [kg plant⁻¹]

The absolute carbon stocks of all fruit trees in Germany were calculated on the basis of the results of the exhaustive statistical surveys for the fruit cultivation sector that were carried out in the years 2002, 2007 and 2012 (STATISTISCHES BUNDESAMT, various years). On the basis of that survey's results, the Federal Statistical Office determined total numbers of apple, pear, sweet cherry / sour cherry, plum / prune, mirabelle and greengage trees, in different age classes, as well as the areas under cultivation with trees in the various age classes. Examples of the pertinent results, for the year 2007, are shown in Table 320.

Table 320: Results of the exhaustive statistical survey of fruit trees carried out in 2007 by the Federal Statistical Office, 2007

Age class		Fruit trees, total	Apple	Pear	Sweet cherry	Sour cherry	Plum, prune	Mirabelle, greengage
1	Area [ha]	6,337	2,610	558	1,669	569	561	89
	Number [n]	77,908,784	1,959,650	374,357	349,898	309,888	174,950	25,268
1-4	Area [ha]	1,314	1,283	30	125	9	142	8
	Number [n]	3,493,397	3,460,242	51,926	92,723	6,720	98,538	4,372
5-9	Area [ha]	7,403	5,159	252	859	330	713	90
	Number [n]	15,410,632	13,645,705	466,895	563,239	234,410	452,011	48,372
10-14	Area [ha]	10,606	7,275	350	783	866	1,186	146
	Number [n]	19,740,123	17,334,084	581,720	458,483	579,748	722,909	63,179
15-19	Area [ha]	10,321	7,603	454	763	372	1,057	71
	Number [n]	19,602,081	17,527,552	831,342	322,364	260,231	632,286	28,306
20-24	Area [ha]	8,599	5,995	338	764	791	621	91
	Number [n]	12,899,071	11,365,689	443,150	219,989	543,127	290,899	36,217
>25	Area [ha]	3,333	1,837	119	519	507	284	66
	Number [n]	3,348,345	2,569,271	126,438	143,442	351,826	130,916	26,452

To determine the total carbon stocks in fruit trees, the carbon stocks – either measured or determined via regression – in the above-ground and below-ground biomass of individual trees of each age class were multiplied by the relevant total numbers of trees. In the process, the values obtained for apple trees were also assigned to pear trees, while those obtained for cherry and plum trees were also assigned to prune, mirabelle and greengage trees.

The area-related emission factors for the various tree varieties were calculated, in each case, via division by the relevant area under cultivation.

Table 321: Area-related carbon stocks [t C ha⁻¹] (range, or ± half of the 95 % confidence interval) in the biomass of Germany's fruit trees

Fruit-tree survey, 2002				
Fruit tree	Carbon stocks [t C ha ⁻¹]			Area [ha]
	Bio _{above}	Bio _{below}	Bio _{total}	
Apple	3.53 ± 0.85	1.55 ± 0.56	5.08 ± 2.20	32,406
Pear	2.93 ± 0.71	1.24 ± 0.45	4.18 ± 1.81	2,189
Sweet cherry	7.53 ± 1.39	1.33 ± 0.15	8.86 ± 1.25	5,505
Sour cherry	14.08 ± 2.74	2.67 ± 0.32	16.74 ± 2.5	4,230
Plum/prune	6.52 ± 1.36	1.28 ± 0.16	7.79 ± 1.25	4,562
Mirabelle/greengage	6.70 ± 1.26	1.25 ± 0.14	7.95 ± 1.14	473

Fruit-tree survey, 2007				
Fruit tree	Carbon stocks [t C ha ⁻¹]			Area [ha]
	BiO _{above}	BiO _{below}	BiO _{total}	
Apple	4.56 ± 1.10	1.97 ± 0.71	6.53 ± 2.83	31,762
Pear	3.95 ± 0.95	1.66 ± 0.60	5.61 ± 2.43	2,101
Sweet cherry	7.71 ± 1.50	1.39 ± 0.17	9.09 ± 1.36	5,482
Sour cherry	15.24 ± 2.98	2.83 ± 0.34	18.07 ± 2.71	3,444
Plum/prune	7.71 ± 1.59	1.53 ± 0.19	9.24 ± 1.47	4,565
Mirabelle/greengage	7.28 ± 1.41	1.38 ± 0.16	8.66 ± 1.29	561

Fruit-tree survey, 2012				
Fruit tree	Carbon stocks [t C ha ⁻¹]			Area [ha]
	BiO _{above}	BiO _{below}	BiO _{total}	
Apple	5.31 ± 1.28	2.27 ± 0.82	7.58 ± 3.29	31,739
Pear	4.91 ± 1.19	2.04 ± 0.73	6.95 ± 3.02	1,933
Sweet cherry	8.44 ± 1.65	1.57 ± 0.19	10.01 ± 1.49	5,258
Sour cherry	17.31 ± 3.53	3.13 ± 0.39	20.45 ± 3.19	2,292
Plum/prune	9.60 ± 1.93	1.9 ± 0.24	11.51 ± 1.78	3,870
Mirabelle/greengage	8.25 ± 1.62	1.51 ± 0.18	9.76 ± 1.47	501

6.1.2.3.4.2 Grapevines (wine)

In the project "Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth" ("Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Waldflächen") (PÖPKEN 2011), a total of 74 grapevines were destructively tested for the purpose of deriving a country-specific mean value for carbon stocks of grapevines. The ages of the vines tested were 15 and 25 (years). In the testing, the vines' weights, and the water and carbon content of the above-ground and below-ground plant parts, were determined (PÖPKEN 2011). The carbon stocks of grapevines and of parts of vines are calculated via Equation 58.

Equation 25: Calculation of the carbon stocks in grapevines

$$C_{vine} = C_{cont\ above} * M_{105\ bio\ above} + C_{cont\ below} * M_{105\ bio\ below}$$

C_{vine} : Carbon stocks of one grapevine [kg]

$C_{cont\ above}$: Carbon content of the above-ground vine [by weight]

$M_{105\ bio\ above}$: Dry biomass of the vine [kg]

$C_{cont\ below}$: Carbon content of below-ground biomass [by weight]

$M_{105\ bio\ below}$: Dry biomass of below-ground biomass [kg]

The annual quantity of cut wood was not taken into account in determination of the biomass of grapevines, since the annual growth is basically the same as the quantity cut, and thus a temporary equilibrium occurs.

Since vineyards in Germany contain an average of 4,000 grapevines per ha (PÖPKEN 2011), the carbon stocks per area unit (ha) were calculated by multiplying the C stocks of individual plant compartments / total plants by 4,000. The absolute carbon stocks are calculated by multiplying the pertinent emission factors by the total vineyard area. The vineyard area figures are obtained from official German statistics (Statistisches Bundesamt, FS 3, R 3.1.5, various years). The resulting values are shown in Table 322.

Table 322: Area-related carbon stocks [t C ha^{-1}] ($\pm$ half of the 95 % confidence interval) in grapevine biomass in Germany

Woody plant	Carbon stocks [t C ha^{-1}]			Area [ha]
	Bio _{above}	Bio _{below}	Bio _{total}	
Grapevines (wine)	1.12 ± 0.06	0.54 ± 0.04	1.66 ± 0.09	102,425

6.1.2.3.4.3 Christmas-tree plantations

In 2015 in Germany, Christmas trees were cultivated on a total of 20,100 ha of agricultural land outside of forests (STATISTISCHES BUNDESAMT, 2015). With an average planting density of 6,000 plants per ha, about 50 t of biomass_{dry} are produced per ha (PÖPKEN 2011). Of that quantity, about 28 % is root mass. That value was derived via the regression of root biomass as a function of above-ground biomass (Equation 21) pursuant to MOKANY et al. (2006) (cf. Chapter 6.1.2.3.4.1).

Table 323: Area-related carbon stocks [t C ha^{-1}] ($\pm$ half of the 95 % confidence interval) in Christmas tree biomass in Germany

Woody plant	Carbon stocks [t C ha^{-1}]			Area [ha]
	Bio _{above}	Bio _{below}	Bio _{total}	
Christmas trees	8.10 ± 4.1	3.15 ± 1.6	11.25 ± 4.4	15,800

6.1.2.3.4.4 Tree nurseries

In 2015, the total area occupied by tree nurseries in Germany amounted to 19,900 ha (STATISTISCHES BUNDESAMT 2015). An exhaustive tree-nursery survey carried out at 4-year intervals by the FEDERAL STATISTICAL OFFICE (STATISTISCHES BUNDESAMT, various years) provides information about the tree species cultivated in tree nurseries. The last such survey, carried out in 2012, showed that German tree nurseries cultivate primarily ornamental and other trees and shrubs (86.7 %); only 13.3 % of their area was used for cultivation of forest plants. The species composition of the cultivated trees and shrubs has varied widely over the years (STATISTISCHES BUNDESAMT 2013). Unfortunately, no studies have been carried out of the average biomass stocks in the trees and shrubs cultivated in tree nurseries in Germany. For this reason, the average carbon stocks per unit of tree-nursery area were derived from country-specific biomass-stock values for trees and shrubs. To this end, the following assumptions were made:

- Two-thirds of the trees and shrubs in tree nurseries are ornamental plants, and one-third are forest trees (this share was increased to 33 %, because although the recent survey showed that forest trees were being cultivated on only 13.3 % of the available area, that cultivation percentage has varied widely over the years (share of forest plants in 2004: 19.8 %, STATISTISCHES BUNDESAMT 2005), and ornamental-plant cultivation includes conifers (to a considerable extent) and "forest trees" such as oak and beech.
- The cultivation period for ornamental trees and shrubs is no more than 10 years, while that for forest plants is no more than 5 years.
- The age classes within the various tree/shrub groups are evenly distributed.

The carbon stocks determined via the project "Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth" (PÖPKEN 2011) were also applied to ornamental trees and shrubs, in a representative approach. For half of the larger trees and shrubs, the carbon stocks determined for cherry and plum trees were applied; for half of the smaller trees and shrubs, the stocks determined for apple trees were used (cf. Chapter 6.1.2.3.4.1).

For calculation of the biomass of forest trees, the methods were used that were developed by KÄNDLER & BÖSCH (2013) for calculation of forest biomass. Those methods are described in Chapter 6.4.2.2. For spruce, pine, beech and oak, the above-ground biomass stocks per individual tree, up to a tree age of 5 years, were determined using Equation 27 and the coefficients shown in Table 340 in Chapter 6.4.2.2.4. The carbon-conversion factor 0.45 was used for conversion of units to t C ha^{-1} , and a total of 6,000 plants per ha was assumed (this corresponds to an average plant density, with a planting distance of about 120/130 cm). The below-ground biomass was estimated on the basis of the so-calculated shoot mass, using the formula of MOKANY et al. (2006) (cf. Chapter 6.1.2.3.4.1), while the total biomass stocks were obtained by adding the above-ground and below-ground stocks.

This derivation approach then yields, via determination of average values, the mean, area-based carbon stocks shown in Table 324 for the various trees and shrubs concerned, along with the resulting mean carbon stocks, which the inventory presents as the dynamic equilibrium values for the biomass in Germany's tree nurseries.

Table 324: Derivation of average area-based carbon stocks [mixed value_{tree nurseries} in $\text{t C ha}^{-1} \pm$ half of the 95 % confidence interval] in the biomass of tree nurseries.

Woody plant	C stocks _{total} [t C ha^{-1}]	C stocks _{above} [t C ha^{-1}]	C stocks _{below} [t C ha^{-1}]
Apple ₁₀	6.69 ± 1.34	4.8 ± 1.16	1.89 ± 0.68
Cherry ₁₀	21.52 ± 1.88	16.83 ± 1.92	4.69 ± 0.33
Forest trees ₅	7.7 ± 0.82	5.54 ± 0.71	2.15 ± 0.42
Mixed value _{tree nurseries}	11.97 ± 0.82	9.06 ± 0.78	2.91 ± 0.29

6.1.2.3.4.5 Short-rotation plantations

In Germany, pursuant to Art. 2 of the Federal Forest Act (BWaldG) (2015), short-rotation plantations are not forest land. In the German inventory, therefore, they are reported solely in the land-use category Cropland. Since short-rotation plantations are also listed as Cropland in the framework of the National Forest Inventory, there is no possibility of double-counting in this area.

To obtain country-specific, mean carbon stocks in the biomass of short-rotation plantations, pertinent data were derived from the relevant literature. Key work in this regard included the overviews produced by WALTER et al. (2014), HORN (2013), GURGEL (2011), KERN et al. (2010), BIERTÜMPFEL et al. (2009), BOELCKE (2007), STOLZENBURG (2006) and MAIER & VETTER (2004).

This work includes the results obtained on 23 test sites, oriented to short-rotation plantations, distributed throughout Germany (Bavaria, Baden-Württemberg, Thuringia, Saxony, Brandenburg, Mecklenburg – West Pomerania and Lower Saxony). As a group, the sites covered all of the country's relevant climate zones (precipitation: 550 – 1550 mm), average annual temperatures 6.8 – 10.1°C, soil types (light to heavy soils) and geographic regions (lowlands to mid-elevation mountains). Short-rotation plantations were established on a total of 62 test areas. The main tree types included were poplars (58 %) and willow (34 %), although birch (3 %), alder, black locust (robinia) and foxglove tree (paulownia) (5%) were also planted. The rotation periods ranged from one to ten years, and averaged 4.2 years. Since these studies cover all relevant aspects of operation of short-rotation plantations in Germany, including spatial distribution, site conditions, vegetation and management practices, they are representative.

From the results of these studies, an average annual dry yield of $9.05 (-6.0 \% / +9.9 \%) \text{ t ha}^{-1} \text{ a}^{-1}$ of above-ground biomass was derived for short-rotation plantations in Germany.

The average total yield short-rotation plantations, as a function of plantation-operation duration, was obtained by multiplying the average annual dry yield by the number of years of plantation operation. An average plantation-operation duration of 20 years was assumed. In addition, it was assumed that the short-rotation plantations have even distributions throughout the various operational age classes (initialization class, and class_{1_a} – class_{20_a}). For the initialization phase, it was assumed that 10,000 cuttings, each with 20 g of biomass, were planted per hectare (± 0.2 t biomass ha⁻¹). The below-ground biomass was determined on the basis of the average dry yield, as a function of the operational duration and the formula provided by MOKANY et al. (2006). Via addition of above-ground and below-ground biomass, the total stocks in short-rotation plantations were determined for each different operational-age class. Via multiplication by 0.45, those stocks were then converted into carbon stocks. The average values of these carbon stocks, for all operational age classes, serve as the dynamic equilibrium values for the average, area-based carbon stocks in the biomass of short-rotation plantations, the values on which the pertinent inventory calculations are based. These values are shown in Table 325.

Table 325: Average, area-based carbon stocks [t C ha⁻¹] and 97.5 and 2.5% percentile values [%] in the biomass of short-rotation plantations

	Carbon stocks in the biomass of short-rotation plantations		
	Bio _{total}	Bio _{above}	Bio _{below}
Carbon stocks [t C ha ⁻¹]	53.71	40.75	12.96
97.5 percentile [%]	10.30	9.93	29.13
2.5 percentile [%]	8.16	6.02	28.04

6.1.2.3.4.6 Mean carbon stocks in the biomass of woody plants cultivated on cropland

As Chapter 6.1.2.3.1 explains, the existing system for listing land-use changes does not make it possible to list annual and perennial crops in a spatially explicit and complete manner. Consequently, in connection with land-use changes from/to Cropland, it will not be known which woody crop is the object of the land-use change. This fact is taken into account by deriving an emission factor, weighted by area in accordance with type and use, for the entire woody biomass of the relevant perennial cropland.

To this end, the absolute carbon stocks of the various crop types were calculated, by compartments, as follows: the cultivation areas were multiplied by the average crop-based carbon stocks, summed, and then divided by the area sum. These calculations were carried out for the years 2002, 2007 and 2012 (Table 326). The intervals are tied to the survey dates for the fruit-tree census, which the Federal Statistical Office carries out only at five-year intervals. The census has been carried out in its current form only since 2002. The values between the individual surveys have been linearly interpolated. For the years 1990 – 2002, the data for the year 2002 have been used, while for the years 2013 and 2015 the data for 2012 have been used. The latter set of data will be corrected via the next exhaustive survey, which is to take place in 2017.

Table 326: Determination of area-weighted carbon stocks [t C ha⁻¹] for woody plants cultivated on cropland in Germany, as of the years for the relevant statistical surveys (carbon stocks $2 \pm$ half of the 95 % confidence interval)

Fruit trees	Carbon stocks [t C ha ⁻¹]		
	Bio _{total}	Bio _{above}	Bio _{below}
2002	5.04 $\pm$ 0.41	3.72 $\pm$ 0.38	1.31 $\pm$ 0.17
2007	5.19 $\pm$ 0.43	3.83 $\pm$ 0.39	1.36 $\pm$ 0.18
2012	6.55 $\pm$ 0.48	4.85 $\pm$ 0.43	1.70 $\pm$ 0.21

Since in Germany woody plants cultivated on cropland are always mixed with grass, the total biomass carbon stocks per area unit for such areas are calculated via Equation 26:

Equation 26:

$$C \text{ stocks}_{\text{Biomass\_perennial\_crops}} = C \text{ stocks}_{\text{perennial\_woody plants}} + C \text{ stocks}_{\text{Grassland}} * 0.75$$

The factor for grassland biomass arises in that only the areas directly under the woody plants concerned are kept free of vegetative cover; in orchards and vineyards, grass is allowed to grow between the rows of trees/vines. The value for grassland ("in the strict sense") is used as a basis for determining such biomass. Table 327 shows the time series for the biomass carbon stocks of perennial woody plants cultivated on cropland in Germany. The large changes in the above-ground and below-ground biomass are due to the use of outdated C-stocks figures for grassland (only in connection with this calculation). The changes with respect to total biomass are very small, however. For this reason, this error's impact on the mixed value for cropland is virtually invisible (a difference of about 0.02 %).

Table 327: Area-weighted mixed value for biomass carbon stocks [t C ha⁻¹] of perennial woody plants cultivated on cropland in Germany (C stocks of above-ground and below-ground biomass, and total C stocks ± half of the 95 % confidence interval), and its change [%] with respect to the previous year's submission

Year	Cropland _{perennial}					
	Carbon stocks [t C ha ⁻¹]			Change with respect to the 2016 Submission [%]		
	Phytomass _{total}	Phytomass _{above-ground}	Phytomass _{below-ground}	Phytomass _{total}	Phytomass _{above-ground}	Phytomass _{below-ground}
1990	10.15 ± 1.62	6.56 ± 1.08	3.59 ± 1.15	0.93	-6.22	17.28
1995	10.15 ± 1.62	6.56 ± 1.08	3.59 ± 1.15	0.93	-6.22	17.28
2000	10.15 ± 1.62	6.56 ± 1.08	3.59 ± 1.15	0.93	-6.22	17.28
2005	10.24 ± 1.63	6.62 ± 1.09	3.62 ± 1.16	0.92	-6.17	17.11
2006	10.27 ± 1.64	6.64 ± 1.10	3.63 ± 1.17	0.91	-6.15	17.06
2007	10.30 ± 1.64	6.66 ± 1.10	3.64 ± 1.17	0.91	-6.13	17.00
2008	10.57 ± 1.69	6.87 ± 1.13	3.70 ± 1.19	0.96	-5.89	16.71
2009	10.85 ± 1.73	7.08 ± 1.17	3.77 ± 1.21	1.00	-5.66	16.43
2010	11.12 ± 1.77	7.28 ± 1.20	3.84 ± 1.24	1.04	-5.46	16.15
2011	11.39 ± 1.82	7.48 ± 1.23	3.91 ± 1.26	1.06	-5.27	15.88
2012	11.66 ± 1.86	7.68 ± 1.27	3.98 ± 1.28	1.08	-5.10	15.62
2013	11.66 ± 1.86	7.68 ± 1.27	3.98 ± 1.28	1.08	-5.10	15.62
2014	11.66 ± 1.86	7.68 ± 1.27	3.98 ± 1.28	1.08	-5.10	15.62
2015	11.66 ± 1.86	7.68 ± 1.27	3.98 ± 1.28	/	/	/

6.1.2.3.5 Derivation of the emission factors for hedges and field copses

In order to determine carbon stocks in hedges, PÖPKEN (2011) has studied 50 hedges to date, working in the framework of the research project "Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Waldflächen" ("Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth"). The hedges studied to date vary widely in terms of:

1. **Age**
 - About 4 – 20 years old
2. **Size**
 - Height, about 2 - 9 m

- Depth, about 1 – 6 m
- Length, about 100 – 500 m

3. Species composition

- Typical hedge plants, such as dog rose (*Rosa canina*), blackthorn/sloe (*Prunus spinosa*), common hazel (*Corylus avellana*), elder (*Sambucus spec.*), hawthorn (*Crataegus spec.*), honeysuckle (*Lonicera spec.*) and willow (*Salix spec.*).
- Trees, such as field maple (*Acer campestre*), common hornbeam (*Carpinus betulus*), willow (*Salix spec.*), beech (*Fagus sylvatica*), linden (*Tilia spec.*) and elm (*Ulmus spec.*),

As a result, the study has included a representative spectrum of relevant field trees and shrubs. Laboratory analysis of samples taken of the various species in question included measurement of weight, water content and carbon content. That, in turn, made it possible, in connection with size data for the relevant fields, to determine absolute and area-related carbon stocks (cf. Table 328). Via regression, carried out on the basis of these data, a highly significant correlation between the average carbon stocks of the above-ground biomass of hedges and the ages of hedges was found:

$$C_{\text{above}} = 1.5506 * X^{1.6015}$$

$R^2 = 0.843$; half of the 95 % confidence interval: $\pm 65.7 \%$

C_{above} : Average carbon stocks of above-ground biomass in hedges [t C ha^{-1}]

X:

X: Hedge age [a]

With this equation, the average carbon stocks in the above-ground biomass of hedges was determined for each year of the rotation period (12 years). For reasons of nature conservation, the study carried out by PÖPKEN (2011) was able to survey only above-ground biomass. For this reason, the below-ground biomass was estimated via the formula that MOKANY et al. (2006) derived via regression. That then made it possible, for each of the age classes in question, to determine below-ground biomass on the basis of above-ground biomass.

$$\text{Bio}_{\text{below}} = 0.489 * \text{Bio}_{\text{above}}^{0.890} \text{ (MOKANY et al. 2006)}$$

$R^2 = 0.93$

$\text{Bio}_{\text{below}}$: Below-ground biomass in t C ha^{-1}

$\text{Bio}_{\text{above}}$: Above-ground biomass in t C ha^{-1}

The total stocks per age class are then obtained via

$$C_{\text{total\_AK}} = C_{\text{above\_AK}} + C_{\text{below\_AK}}$$

$C_{\text{total\_AK}}$: Average carbon stocks in the total biomass of hedge plants of a single age class [t C ha^{-1}]

$C_{\text{above\_AK}}$: Average carbon stocks in the above-ground biomass of hedge plants of a single age class [t C ha^{-1}]

$C_{\text{below\_AK}}$: Average carbon stocks in the below-ground biomass of hedge plants of a single age class [t C ha^{-1}]

The average value for all age classes, for an assumed rotation period of 12 years, then yields the average equilibrium carbon stocks in Germany's hedges. That figure, in turn, is used, as an emission factor, as a basis for the inventory calculations; cf. Table 319.

Table 328: Area-based carbon stocks [t ha^{-1} (95 % confidence interval)] in the biomass of woody grassland

Woody grassland	Carbon stocks [t C ha^{-1}]		
	Bio _{above-ground}	Bio _{below-ground}	Bio _{total}
Woody grassland	32.69 (10.46-55.27)	10.47 (3.16-18.11)	43.16 (19.77-67.00)

6.1.3 Quality assurance and control

General quality control (for 4(I) through 4 (V), Wetlands & Other land) and, for all other areas, general and category-specific quality control, and quality assurance, have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

In the QA, detailed checklists were used, and individual checks carried out, for review and documentation of the results in keeping with the quality management guidelines of the Thünen institute (THÜNEN-INITIUT 2016). The Single National Entity archives the Thünen checklists, as well as other documents of importance for quality control. All these documents are thus also available for purposes of external review.

6.1.3.1 The Thünen Institute's quality management for emissions inventories

The Thünen Institute's quality management for emissions-inventory preparation has been developed in conformance with the IPCC guidelines and the QSE manual (Chapter 1.3.3). The framework for the quality management, and the process for carrying it out, are described in detail in the relevant concept (BMELV, 2012) and in the provisions for implementation of the concept (THÜNEN-INITIUT, 2016). All pertinent documents and data are added to the inventory description that is archived by the Single National Entity. The requirements and procedures set forth by the provisions for implementation of the concept were fully complied with. The following section describes the special additional quality controls carried out for the present Submission.

6.1.3.2 Input data, calculation procedures and emissions results

In a first step, the land-use matrix was checked for quality and then approved for emissions calculation. Such checking covered the decision trees and the results of the annual land-use matrix and of the 20-year transition period. The following section lists key test criteria, for the land-use matrix, that were applied in this year's tests. These criteria exceed the requirements set forth by the provisions for implementation of the concept. They apply for the entire land-use matrix and for the two sub-matrixes for mineral soils and organic soils:

- The national area is constant.
- The national area is the same as that used in the previous year.
- The areas of the land-use categories are the same, or almost the same, as the corresponding areas used in the previous year; if there are any discrepancies, they can be explained.
- The areas and area trends are consistent with the relevant statistical data; if and where they are not consistent, the discrepancies can be explained.
- The sums of the total areas, consisting of remaining areas and areas with land-use changes, are correct.
- Other land areas have remained the same or have decreased; no land-use changes to "Other land" have occurred.
- Peat-extraction areas have been listed separately.
- Consistency between LULUCF and KP-LULUCF is assured with regard to forest-land areas and afforestation/reforestation/deforestation (ARD) areas.

The emissions calculations have been carried out using the quality-assured land-use matrix. Emissions calculations relative to annual land-use changes, and to the transition period, are gradually being carried out in suitable tables, using the area data and emission factors / implied emission factors (IEF). The tables have been reviewed with regard to:

1. Correctness of the calculations,
2. Consistency of the time series,
3. Consistency with the calculations of the previous year.

The following test criteria have also been applied:

Emission factors:

- The calculations of the emission factors and implied emission factors (IEF) are correct.
- The time series for the emission factors is consistent; any changes from year to year can be explained.
- The emission factors are the same as those of the previous year, except in cases in which data and methods have changed; any new emission factors are plausible. Any differences with respect to those of the previous year can be explained and have been completely documented.
- Uncertainties have been correctly reported and are consistent with those of the previous year.
- Data consistency between the Convention (LULUCF) and Kyoto-Protocol-reporting (KP-LULUCF) frameworks is assured.

Calculations:

- The basic calculations, and the calculations for the annual land-use changes and the transition period, are correct.
- The overview tables, which serve as the basis for the CRF tables and the text, are correct.
- The emissions results are consistent with those of the previous year; any discrepancies can be explained as the result of use of new data and methods.
- The consistency of the calculations, between the Convention (LULUCF) and Kyoto-Protocol-reporting (KP-LULUCF) frameworks, is assured.

Results of quality controls:

1. All calculations are correct.
2. The time series are consistent. Any major year-to-year changes result solely from the periodicity of data and from linear interpolation between pertinent periods.
3. No unexplainable outliers were found in the relative differences with regard to the emissions of the previous year. All changes with respect to the previous year have been correctly documented and are included in the National Inventory Report.
4. In the 2015 Submission, and with regard to annual biomasses in the Cropland (4.B.2) and Grassland (in the strict sense) (4.C.2) categories, a small number of items requiring updating in the agricultural sector (3.D) were not updated. That omission has been corrected in the present submission, via the QC process.

After the relevant activity data and implied emission factors (IEF) were entered into the Central System of Emissions (CSE) database, the emissions as calculated in the CSE were compared, for quality control purposes, with emissions results obtained via calculations made outside of the database environment. All quality control steps and their results are fully recorded in the inventory description that is also archived by the Single National Entity.

6.1.3.3 Verification

The results relative to IEF, differentiated by carbon source categories and land-use categories, have been compared with those of neighbouring countries. Details relative to such comparison are provided in the relevant sub-chapters.

6.1.3.4 Reviews and reports

In September 2016, an In-Country Review was carried out by an expert panel of the Climate Secretariat. Its recommendations have been implemented in the present submission:

- Estimation of the carbon-stock changes in (woody plant) phytomass in the land-use category "Cropland remaining Cropland"
- Inclusion of additional, more-detailed remarks designed to improve the transparency of the report, with regard to
 - the mineral soils pool in the category "Cropland remaining Cropland": proof that mineral soils are not a carbon source
 - proof that the mean carbon stocks of mineral soils under Settlement areas are country-specific and rules-conformal, and that the method used is indeed a Tier 2 method
 - emission factors HWP CRF Table4.Gs2
 - Forest land: Stock change method
 - Proof with regard to land use, and preparation of the land-use matrix
 - KP-LULUCF (some remarks are redundant with those of UNFCCC)

6.1.4 Planned improvements

The following measures to improve the inventory are planned:

- Development of new, country-specific emission factors for mineral soils, via a major inventory (Agricultural Soil Inventory); the process is to be completed by the NIR 2020 at the earliest.
- Derivation of country-specific emission factors, and development of models for determination of the impacts of cultivation on cropland and grassland areas, using data from the Agricultural Soil Inventory, data from long-term soil monitoring and mathematical models (by 2020 at the earliest).
- The time frame for implementation of these measures will depend on the results of the research projects being carried out for these purposes, as well as on the projects' schedules for completion and publication. In addition, it will be subject to quality checks for reporting purposes. In keeping with the "provisions for preparation and quality management of emissions and carbon inventories for the area of category 4" (THÜNEN-INSTITUT 2016), new activity data and emission factors will be approved for reporting purposes only following quality-checking in keeping with defined criteria.

6.2 Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories

With the introduction of the sample-point grid system, the various land-use definitions from the underlying data sources (Basis-DLM of ATKIS® and CORINE Land Cover; cf. Chapter 6.3.2 and CIR data) had to be correlated with the LULUCF reporting categories.

In the Basis-DLM, the catalogue of object types changed in connection with the introduction of the new AAA model. For this reason, a new correlation table is being used for the period as of 2013. The six IPCC land-use categories are directly correlated with the object types used in the Basis-DLM (AAA levels) of ATKIS®. (Table 329).

In preparation of the land-use matrix, grid-point allocation is computerized; it is carried out fully automatically via dedicated programmes. In support of that purpose, the allocation keys for these classification systems are included in digital form, with the result that any given grid point can always be unambiguously allocated to an object-type-key number and, thus, to a specific land use and land-use category, regardless of the data source being used. The scripts for these programmes are maintained in the inventory description.

Table 329: Allocation of main object-type index numbers and attributes in ATKIS® to IPCC land-use categories

ATKIS Object-type catalog					CORINE LAND COVER
Object number, AAA levels	Attribute, AAA levels	Object number, levels	Object type	Description / attributes pursuant to ATKIS object-type catalog	Nomenclature code
IPCC category: Forest land					
43002	VEG, all	4107	Forest land	Deciduous, coniferous and mixed forest	311; 312; 313; 324
IPCC category: Cropland					
43001	VEG 1010	4101	Agriculture: Cropland	Area for cultivation of field crops (such as grain, legumes, root crops) and berries (such as strawberries) Cropland also includes rotational set-asides, permanent set-asides and areas set aside to achieve eligibility for EU compensation payments.	211; 212
43001	VEG 1011		Agriculture: Streuobstacker – silvoarable form of traditional <i>Streuobst</i> orchards	A Streuobstacker is a cropland area on which fruit trees are allowed to grow (often, in dispersed, irregular patterns).	211; 212
43001	VEG 1012	4109	Agriculture: Hops	Hops	211; 212
43001	VEG 1021		Agriculture: Streuobstwiese – Meadow orchard, the silvopastoral form of traditional <i>Streuobst</i> orchards	A meadow orchard is a grassland area on which fruit trees are allowed to grow (often, in disperse, irregular patterns).	211; 212
43001	VEG 1030	4103	Agriculture: Horticultural land	Horticultural land is land for cultivation of vegetables, fruit and flowers, and for growing of cultivated plants	211; 212
43001	VEG 1031	4109	Agriculture: Tree nursery	Tree nursery	211; 212
43001	VEG 1040	4109	Agriculture: Vineyard	Vineyard	211; 212
43001	VEG 1050	4109	Agriculture: Fruit plantation	Fruit plantation	211; 212
IPCC category: Grassland					
43001	VEG 1020	4102	Agriculture: Grassland	Grassland is a grassy area that is mowed or grazed.	231; 321
43004		4104	Heath	A heath area is a sandy area (typically) with certain typical shrubs and grasses, and with sparse, scrub tree cover.	322; 421
43006		4106	Marsh	Grassland (in the strict sense) A marsh area is a waterlogged area that is covered with water for part of the year. Areas that are wet for brief periods, after rainfall, are not considered marsh areas.	411
43007	FKT 1300		Wasteland and vegetation-free areas: Semi-natural area	A semi-natural area is an area that is not used for crop cultivation and that is covered with grass, wild herbs and other plants.	No allocation
43003		4108	Woody grassland	Area covered with individual trees, groups of trees, bushes, hedges and shrubs.	243
43007	FKT 1200		Wasteland and vegetation-free areas: Succession area	A succession area is an area that has been permanently set aside from agricultural or other existing	No allocation

ATKIS Object-type catalog					CORINE LAND COVER
Object number, AAA levels	Attribute, AAA levels	Object number, levels	Object type	Description / attributes pursuant to ATKIS object-type catalog	Nomenclature code
					use and that is allowed to revert to its original condition – for example, as woody grassland, a bog or a heath.
IPCC category: wetlands					
43005		4105	Bog	Terrestrial wetlands	412
41005	AGT 4010	2301	Open-pit mine: Peat extraction		No allocation
43001 to 44007		5101 - 5203, 3402	Waters	For example, dammed reservoirs, rivers at least 12 m wide, canals, storage basins, shifting shorelines and banks. 3402 refers to harbour basins – and, thus, to waters and not settlements (in AAA 44005).	511; 512; 423; 521; 522; 523
IPCC category: Settlements					
41001 to 41010		2101-2352	Settlements	Settlements refer to areas, either with or without buildings and structures, that have been shaped by human occupation or that support human occupation.	111; 112; 121; 131; 132; 133; 142; 141; 142
42001 to 42016		3101-3543	Transport	Transport areas consist of areas, either with or without buildings and structures, that serve and support transports.	122; 123; 124
42007	FKT 1100		Wasteland and vegetation-free areas: Area accompanying a water body	An area accompanying a water body is an area, either with or without buildings and structures, that is allocated to a watercourse.	122; 123; 124
IPCC category: Other land					
42007	FKT 1000	4120	Wasteland and vegetation-free areas: Areas without vegetation	Areas without significant vegetation cover, as a result of special soil characteristics such as unprotruding rocks, sand or ice areas.	331; 332; 333; 334; 335
43008		4199	Area currently undefined	Areas whose characteristics cannot currently be determined, in terms of allocation to object types.	No allocation

6.2.1 Forests

The definition of Forest land used in the German inventory is in keeping with that given in the 2006 IPCC Guidelines (Vol. 4, Chapter 2.2). The manner in which areas defined by national land-use systems are allocated to this category is shown in Table 329.

The basis for reporting consists of the definition of forest used by the National Forest Inventory (Bundeswaldinventur (BWI); BMVEL, 2001):

"Forest" within the meaning of the BWI is any area of ground covered by forest vegetation, irrespective of the information in the relevant cadastral survey or similar records. The term "forest" also refers to cutover or thinned areas, forest tracks, firebreaks, openings and clearings, forest glades, feeding grounds for game, timber yards / lumberyards, forest aisles for conduction, further areas linked to and serving the forest including areas with recreation facilities, overgrown heaths and moorland, overgrown former pastures, alpine pastures and rough pastures, as well as areas of dwarf pines and green alders. Heaths, moorland, pastures, alpine pastures and rough pastures are considered to be overgrown if the natural forest cover has reached an average age of five years and if at least 50 % of the area is covered by forest. Forested areas of less than 1,000 m² located in farmland or in developed regions, narrow thickets less than 10 m wide, Christmas tree and decorative brushwood cultivations and parkland belonging to residential areas do not

constitute forest within the meaning of the BWI. Watercourses up to 5 m wide do not break the continuity of a forest area.

At the same time, in a departure from the BWI definition of "forest", areas that the BWI counts as forest, but places in the forest category "non-forest ground", i.e. because they are not wooded, are treated as "non-forest" in the BWI's calculation of carbon stocks and carbon-stock changes. While short-rotation plantations are recorded separately in the BWI, they are not forest within the meaning of the Forest Inventory, the Federal Forest Act and the present inventory. They are thus reported under Cropland.

Pursuant to the 2006 IPCC Guidelines, Land converted to Forest Land remains in that conversion category for at least 20 years and is only then included in Forest Land remaining Forest Land. For afforestation areas, data for the period as of 1970 are taken into account.

6.2.2 Cropland

The definition of Cropland used in the German inventory is in keeping with that given in the 2006 IPCC Guidelines (Vol. 4, Chapter 3.2). The manner in which areas defined by national land-use systems are allocated to this category is shown in Table 329.

For purposes of emissions calculations, such land-use systems are stratified by specific pools:

- Calculation of biomass stocks: Annually variable stratification relative to 65 annual crops (Chapter 6.1.2.3.3) and permanent crops. Permanent crops are grouped into the following categories: various fruit-tree categories (Chapter 6.1.2.3.4.1), wine grapes (Chapter 6.1.2.3.4.2), Christmas trees (Chapter 6.1.2.3.4.3), tree nurseries (Chapter 6.1.2.3.4.4) and short-rotation plantations (Chapter 6.1.2.3.4.5). Permanent crops accounted for a 1.36% share of the total cropland area in 2015.
- Calculation of the emissions from soils: Chronologically constant stratification in accordance with the categories of organic soils and mineral soils. The mineral soils category is subdivided by usage, soil type / soil-parent-rock groups and climate region (cf. Chapter 19.4.2.2).
- The total area of open drainage ditches is determined along with the area of organic soils under cropland.
- Calculation of the emissions from land-use changes: Annually updated stratification in accordance with the categories "Cropland remaining Cropland" and "Land converted to Cropland". The relevant data are taken annually from the pertinent land-use information (Chapter 6.3; Chapter 6.4).

6.2.3 Grassland

Grassland as defined in the German inventory is in keeping with the definition given in the 2006 IPCC Guidelines (Vol. 4, Chapter 3.2). The manner in which areas defined by national land-use systems are allocated to this category is shown in Table 329.

Grassland is divided into two sub-categories: a) areas covered with grasses and herbs (Grünland im engeren Sinn / Grassland in a strict Sense) and b) areas that are covered with trees and shrubs (Gehölze / Woody Grassland) but do not fall within the definition of "forest". It also includes object type 4106 "swamp, reeds" from the Basic Digital Landscape Model (Digitales Basis-Landschaftsmodell; Basis-DLM) (Chapter 6.3.2.1), which consists of undrained organic soils under grassland. In the following, such areas are also referred to as "wet grassland". In 2015, Grassland (in the strict sense) accounted for 88.6 % of the total grassland area, while woody grassland accounted for 11.4 % of that total area.

The sub-categories in this area include the following types of land use and plants:

- Meadows, pastures, alpine pastures, rough pastures, heath areas, natural-condition grassland, recreational areas and swamp/reeds are grouped under "grassland (in a strict sense)".
- Hedges, field copses and shrubbery make up the sub-category "woody grassland".

Changes between these two sub-categories are treated like land-use changes.

For purposes of emissions calculation, the two grassland sub-categories have been stratified by pools. To that end, area-weighted mean carbon stocks are determined, and the resulting figures are used in the inventory:

- Calculation of biomass stocks: Stratification within the sub-categories, by crop types. For grassland (in a strict sense), the stratifications include above-ground and below-ground biomass of grasses and herbaceous plants (Chapter 6.6.2.2). For woody grassland, mean carbon stocks have been determined for hedge plants and field copses, stratified by species combinations, age, growth density and growth height (Chapter 6.6.2.2). Those carbon stocks may be understood as the values for long-term equilibrium.
- Calculation of the emissions from soils: Chronologically constant stratification in accordance with the categories of organic soils and mineral soils.
 - The organic soils are subdivided into wet areas (depth to water table < 0.1 m) and drained areas (depth to water table > 0.1 m) (cf. Chapter 6.1.2.2). In addition, the total area of drainage ditches has been estimated.
 - The mineral soils category is subdivided by usage, soil type / soil-parent-rock groups and climate region (cf. Chapter 19.4.2.2).
- Calculation of emissions from land-use changes: Annually updated stratification, by the categories "grassland (in a strict sense) remaining as grassland (i.s.s.)", "woody grassland remaining as woody grassland" and "land converted to grassland". The relevant data are taken annually from the pertinent land-use information (Chapter 6.2; Chapter 6.3).

6.2.4 Wetlands

Pursuant to the 2006 IPCC Guidelines, the "Wetlands" land-use category must subsume all those land areas whose soils are intermittently or constantly waterlogged, or covered with water, and that do not fall within the land-use categories 4.A, 4.B, 4.C and 4.E. In the German inventory, these areas are combined in the sub-categories "terrestrial wetlands" (IPCC: Other Wetlands) and "waters" (IPCC: Flooded Land). In addition, all areas that are related to peat extraction and combined within an additional sub-category under the land-use category Wetlands (IPCC: Peat Extraction; cf. the 2006 IPCC Guidelines).

The majority of Germany's former wetlands areas have been drained and are used mainly for agriculture and forestry (1,614 kha $\triangleq$ 89 %). Those areas are reported in the relevant land-use categories (4.A - 4.C) pursuant to the 2006 IPCC Guidelines. The sub-category "terrestrial wetlands" thus includes Germany's few remaining undrained, semi-natural (i.e. subject to very little anthropogenic influence) bogs, along with certain other wetlands on mineral soils and peat-extraction areas. In the "waters" sub-category, a distinction is also made in terms of degree of anthropogenic influence – between a) "flooded land"⁹⁴ and b) "natural water bodies," including "non-regulated" and "regulated" water bodies (which are not covered by reporting obligations).

⁹⁴ Water bodies that are regulated via human activities and that exhibit wide fluctuations in water level and/or changes in the area they cover (dammed reservoirs, etc.) (2006 IPCC Guidelines)

Table 330 shows how Germany's wetlands areas have been classified, for the year 2015, in accordance with these provisions.

Table 330: Breakdown of the Wetlands land-use category pursuant to the 2006 IPCC Guidelines, and allocation of water-body and terrestrial-wetlands areas [ha], in Germany, to the relevant sub-categories for 2015

4.D Wetlands [728,681 ha]						
Terrestrial wetlands [111,857 ha]				Peat extraction [19,857 ha]	Waters [598,068 ha]	
Mineral soils [12,866 ha]		Organic soils [98,991 ha]		Organic soils [19,857 ha]		
Undrained [12,866 ha]		Drained [75,604 ha] / Undrained [23,387 ha]		Drained [19,857 ha]		
"remaining" [7,686 ha]	Changed [5,179 ha]	"remaining", including all undrained [77,098 ha]	Changed (drained) [21,902 ha]	"remaining" [19,857 ha]		
Natural and semi-natural wetlands (such as swamps, rivers and streams)		Natural and semi- natural bogs (such as peat areas, fens)	Semi-natural bogs	Peat-extraction areas	No emissions	Emissions from biomass
No emissions	Emissions from mineral soils, biomass	Emissions from organic soils, biomass	Emissions from organic soils, biomass	Emissions from on-site, off-site		

The sub-categories "peat extraction", "terrestrial wetlands" and "waters" differ in terms of their emissions behaviour. For this reason, they are listed as separate sub-categories and reported separately in the CRF tables (4.D and 4.(II)) (for details, cf. Chapter 6.3. In the Wetlands land-use category, land areas are calculated with the help of annually updated stratification by terrestrial wetlands and waters remaining as such, as well as by land converted into waters or terrestrial wetlands. The relevant data are taken annually from the pertinent land-use information (Chapter 6.3; Chapter 6.4). With regard to the peat-extraction area, a constant value of 19,857 ha is assumed (cf. Chapter 6.7.2.4.1); that area is reported only in the "remaining" category. Conversions of waters into terrestrial wetlands and vice versa are treated like land-use changes from other land-use categories.

For purposes of emissions calculation, the sub-categories peat extraction, terrestrial wetlands and waters are stratified by pools. To that end, area-weighted mean carbon stocks are determined, and the resulting figures are used in the inventory:

Non-transition ("remaining") category:

- Calculation of biomass stocks: No biomass occurs in the sub-category "waters". The biomass of the sub-category "terrestrial wetlands" has been derived from the relevant figures for grassland (in a strict sense) and woody grassland (Chapter 6.7.2.2).
- Calculation of the emissions from mineral soils: No anthropogenic emissions occur in any of the sub-categories, since the areas are undrained. In the tables, the emissions are listed as "not occurring" (NO).
- Calculation of the emissions from organic soils: For peat-extraction areas, both on-site and off-site emissions are calculated (Chapter 6.7.2.4.1), in keeping with the 2006 IPCC Guidelines and the 2013 IPCC Supplement on Wetlands. The terrestrial wetlands sub-category is divided into wet (depth to water table < 0.1 m) and drained areas (depth to water table > 0.1 m) (cf. Chapter 6.1.2.26.1.2.2); on-site emissions are reported, but no emissions are reported for the sub-category waters (Chapter 6.7.2.4).

Transition categories

- Calculation of biomass stocks: In the case of land-use changes to waters, the biomass stocks are set to "zero." The biomass of the sub-category "terrestrial wetlands" has been derived from the relevant figures for grassland (in the strict sense) and woody grassland (Chapter 6.7.2.2; cf. Chapter 6.6.2.2).
- Calculation of the emissions from soils: No emissions occur in the sub-category "waters". The "terrestrial wetlands" sub-category is divided, in a constant manner over time, into "organic soils" and "mineral soils." For organic soils, on-site emissions are reported, following subdivision of such soils into wet (depth to water table < 0.1 m) and drained areas (depth to water table > 0.1 m) (Chapter 6.7.2.4). The mineral soils category is subdivided by usage, soil type / soil-parent-rock groups and climate region (cf. Chapter 19.4.2.2).

6.2.5 Settlements

The categories used by national land-use systems in connection with the categories Settlements and Transport, and the manner in which those categories are allocated to the IPCC's Settlements land-use category, are shown in Table 329. The definition of Settlements used in the German inventory is in keeping with that given in the 2006 IPCC Guidelines (Vol. 4, Chapter 2.2). All settlement lands have been combined within a single category.

- For purposes of emissions calculations, the land-use category is stratified by specific pools. To that end, area-weighted mean carbon stocks are determined, and the resulting figures are used in the inventory:
- Calculation of biomass stocks: The biomass of the "settlements" category has been derived from the relevant figures for grassland (in a strict sense) and woody grassland (Chapter 6.8.2.2; cf. Chapter 6.6.2.2).
- Calculation of the emissions from soils: Chronologically constant differentiation in accordance with the categories of organic soils and mineral soils. The mineral soils category is subdivided by usage, soil type / soil-parent-rock groups and climate region (cf. Chapter 19.4.2.2). For organic soils, the values for Grassland (in the strict sense) are used, on a proxy basis (Chapter 6.1.2.26.1.2.2).
- Calculation of the emissions from land-use changes: Annually updated stratification in accordance with the categories "settlements remaining settlements" and "land converted to settlements." The relevant data are taken annually from the pertinent land-use information (Chapter 6.2; Chapter 6.3).

6.2.6 Other land

The following object types defined in ATKIS® are assigned to the "Other land" category within the German reporting system, in keeping with the 2006 IPCC Guidelines: "area currently not classifiable" (object number 4199), and "vegetation-free areas" (object number 4120). The relevant areas are described and allocated in keeping with Table 329 in Chapter 6.2 and the algorithms described in that section.

6.3 Information on approaches used for determining relevant land areas and on the sources of land-use data used

6.3.1 Introduction

The method for determining land-use changes in the LULUCF sector takes account of all land uses and land-use changes in a chronologically and spatially consistent manner. A sample-based system

is used. The basis for that system consists of a regular grid of sample points laid over the entire surface area of Germany. The grid, which is randomly distributed, is based on the grid for the 2012 National Forest Inventory (BWI 2012), and it assigns points an average area of 1.4 km². Since the method used is based on spatially explicit observations, the 2006 IPCC Guidelines require it to be categorised as an "approach 3". The reasons why this sample-based system was chosen are listed in Chapter 19.4.1.

In the 2016 Submission, a change was made within this sample-based approach. The number of samples provided by the National Forest Inventory's grid proved to be too small for spatially precise, reliable identification of land uses and land-use changes on areas with organic soils. To address this issue, the entire area of Germany (35,779,633 ha) was divided into two area systems: a "mineral soils system" (33,955,711 ha) and an "organic soils system" (1,823,922 ha) (cf. also Table 331). The stratification basis for the "organic soils" system consists of the "map of Germany's organic soils" ("Karte organischer Böden Deutschlands"), which has a scale of 1:25,000 (Roskopf et al. 2015). The area of the "mineral soils system" is obtained as the difference between the total area and the area taken up by organic soils. In the "mineral soils system", the standard point density of the National Forest Inventory (BWI), which has 243,454 sample points, is used. The resolution of the point grid in the "organic soils system" was increased, to take better account of the small areas and great spatial diversity of wetlands in the landscape, to an average area of 64 m² per point (284,769 sample points). The relevant land areas are calculated separately, in the two systems, using the same methods and algorithms for both systems (Chapter 6.3.2 ff.), and then the results from the two systems are combined to produce a unified land-use matrix (Chapter 6.3.5). This procedure considerably improves precision in the identification and demarcation of land uses and land-use changes on organic and mineral soils, in all land-use categories.

Table 331: Comparison of the strata "mineral soils" and "organic soils"

Land area	Sampling network	Number of sample points	Area [ha]	Average area per sample point
Mineral soils	BWI grid (Netz)	243,454	33,955,711	1.4 km ²
Organic soils	BWI grid (with resolution increased)	284,769	1,823,922	64 m ²
Germany	BWI grid (with resolution partly increased)	528,223	35,779,633	0.68 km ²

6.3.2 Database and data processing

The land-use matrix (LUM) is derived on the basis of all available geographically explicit data sets. For a data source to be usable, its land-use classes – as assigned via interpretation or modelling – have to lend themselves to translation into the IPCC land-use categories. In each case, not every data set has to show all land-use classes; it suffices if at least one of the six main land-use classes is shown. The land-use information in the various data records is correlated with the sample points, via geographic location. When this is done, information is then available for each sample point – information that is distributed over time, and that can differ in terms of numbers of data items and in terms of quality with regard to errors of location, preparation and interpretation.

The aims with this flexible survey system thus do not include recording land-use changes as often as possible. The aims instead are

- to identify the most reliable land-use information, from the wealth of available information,
- to filter out and detect land-use changes, and
- to eliminate any possible uncertainties and sources of error.

The quality of the available data records differs in terms of usefulness for classification of land-use categories. For this reason, a clear hierarchy was introduced for sorting (ranking) the data records, from the most precise data – the 1st quality level – to the poorest quality level. A land use is recorded in the year in which the pertinent data source is surveyed. If, for a given year and one given sample point, several different land-use data items are available, from different data sources, then the data record with the highest quality level (QL) is used to define the pertinent land-use category. Where data sources with the same quality level show different land-use categories, additional rules for applicable decision-making have been defined and documented. Such rules can be oriented to references such as verification data – for example, trends shown in agricultural statistics – that are not available in georeferenced form.

6.3.2.1 Data sources

The following data sources / records have been used:

- Information relative to the forest-oriented categories from the National Forest Inventory (Bundeswaldinventur) 1987 and 2002, for the period 1987 to 2002 for the old German Länder; data of the National Forest Inventory 2002 and the Inventory Study (Inventurstudie) 2008 (Oehmichen et al. 2011), for 2002 to 2008 for all Germany, and data of the Inventory Study 2008 and the National Forest Inventory 2012 for the period 2008 through to the present submission,
- Maps, derived from CIR data, from the mapping of biotopes and use types carried out for 1990,
- The Basic Digital Landscape Model (Digitales Basis-Landschaftsmodell; Basis-DLM) for the years 2000, 2005, 2008, 2012 and 2015,
- The LBM-DE digital land cover model (Digitales Landbedeckungsmodell) for the year 2009,
- Corine Land Cover 1990, 2000, 2006,
- 1990 GSE data for the new German Länder.

A total of 99.97 % of all land-use information is obtained from the BWI, the CIR data or the Basis-DLM (for 1990, from the Corine Land Cover). Land-use information from the "Digitales Landbedeckungsmodell LBM-DE zum Zeitpunkt 2009" ("LBM-DE digital land-cover model for 2009) and the "GSE-Daten 1990" ("1990 GSE data") accounts for very little – only 0.03 % – of the data used in land-use determination.

1st quality level: BWI data

Details relative to the National Forest Inventory (BWI) are described in Chapter 6.4.2.1.1. The BWI is a permanent, systematic cluster sample that is collected periodically. At present, BWI data are available referenced to 1987, 2002 and 2012 and, in a sub-sample, to 2008 (Inventory Study 2008). The data of the BWI 2012 provide precise information, as of the end of the first Kyoto-Protocol commitment period in 2012 and as of the beginning of the second Kyoto-Protocol commitment period in 2013, relative to land use (forest land remaining forest land) and land-use changes to forest land (afforestation) or from forest land (deforestation). Land uses, and land-use changes to forest land (afforestation) or from forest land (deforestation), are determined for each sample point, with the help of aerial photographs, country-specific map sets and in situ inspections. The basis for relevant reporting, pursuant to the UN Framework Convention on Climate Change, consists of the definition of "forest" used by the National Forest Inventory (BMVEL, 2001); cf. Chapter 6.2.1.

The first German report under the Kyoto Protocol uses the following definition of "forest", which accords with the relevant definition of the UN Food and Agriculture Organization (FAO):

- Land with tree crown cover of more than 10% of the area;

- The minimum land area to be taken into consideration is 0.1 ha;
- The potential tree height is at least 5 meters.

Within the limits defined by the Marrakesh Accords⁹⁵, that definition is the one that comes closest to the definition used in the National Forest Inventory. Studies (TOMTER et al., 2010) comparing activity-data calculations using the aforementioned definitions have found that the resulting discrepancies are negligible. For that reason, the same area-estimation algorithms have been used for purposes of both the UN Framework Convention on Climate Change and the Kyoto Protocol. At the same time, in a departure from the BWI definition of "forest", areas that the BWI counts as forest, but places in the forest category non-woodland, i.e. because they are not permanently non-wooded, were not taken into account in the forestry sector in calculation of carbon stocks and carbon-stock changes.

For the new German Länder, no forest / non-forest information was available for the year 1987 at the relevant BWI points. In the interest of obtaining a maximally consistent database for the new German Länder, the individual-tree data of the BWI 2002 were used in the following manner: for 1987, the sample points were retroactively assigned to the land-use class Forest Land for those cases in which the BWI 2002, at the pertinent forest cluster points, listed trees that were more than 15 years old.

2nd quality level: The CIR data are thematic maps prepared from color-infrared (CIR) aerial photos. The aerial photos have a resolution of about 40 cm and thus provide a considerably better data framework than the CORINE Land Cover data offer. The thematic-map data, in terms of time precision (the data include precise records of when the photographs were taken) and degree of detail, are superior even to those of the Basic Digital Landscape Model (Digitales Basis-Landschaftsmodell; Basis-DLM). The action plan addressing the problems identified in the 2010 In Country Review is being implemented via use of the CIR data for improvement of the 1990 land-use data. In the years 1989 through 1992, the German Länder (states) Schleswig-Holstein, Saxony, Saxony-Anhalt, Brandenburg, Mecklenburg – West Pomerania and Thuringia used legally mandated biotope-type-mapping programmes as an opportunity to map their entire territories. As of report year 2014, all CIR data in the 1990 base year are being used. Each such data set has been used with the help of an individualised table for conversion into the Basis-DLM format.

3rd quality level: Basis-DLM data

The Basic Digital Landscape Model (Basis Digitale Landschaftsmodell; Basis-DLM) is the basis for Germany's Official Topographical-Cartographical Information System (Amtliches Topographisch-Kartographisches Informationssystem; ATKIS®), which is managed by the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV). The ATKIS® system describes Germany's topography in terms of digital landscape and terrain models. "The Basis-DLM uses a vector format to describe topographic objects of the landscapes and the relief of the earth's surface. Each object is assigned to a specific object type and defined in terms of its spatial position, geometric type, descriptive attributes and relations to other objects. Each object has an identification number (identifier) that is unique throughout all objects for Germany. In the Basis-DLM, spatial position is given true to scale, and independently of any representations, within the coordinate system used for land surveying. The object types contained in the DLM, and the manner in which the objects are to be formed, are defined in the ATKIS® object-type catalogue (ATKIS®-OK)" (AdV). The informational spectrum of the Basis-DLM is oriented to the contents of standard 1:25,000 topographic maps. At the same time, the Basis-DLM features greater precision

⁹⁵ A set of rules and guidelines pertaining to specific aspects of the Kyoto Protocol.

of position ($\pm 3\text{m}$) for the most important point-shaped and line-shaped objects. Data of the Basis-DLM systems of the Länder are adopted by the Federal Agency for Cartography and Geodesy (BKG) and then checked, harmonised, georeferenced and processed, without any overlapping, for use within a nationally standardised Basis-DLM. The BKG also manages the data, within a special database, for purposes of provision to federal authorities and other agencies.

The purpose of ATKIS® is to provide a landscape model (land-cover model that is maximally up-to-date and has the highest resolution possible) of Germany, with regularly updated and expanded geometries and content. The surveying administrations of the Länder collect the pertinent data on an ongoing basis; they do not collect data as of a given key date, nor do they collect on a national basis. As a result, new surveying results are continuously transmitted to the Federal Agency for Cartography and Geodesy (BKG) and integrated within ATKIS®. While five years is given as time period within which a complete revision should be accomplished, that specification is applied very differently from state to state (states = German Länder). In practice, the data for areas with vegetation cover are between one and seven years old. For areas of very high current interest, especially with regard to area changes – such as settlement and transport areas – a period of three to twelve months is prescribed for transfer into ATKIS®. The Basis-DLM version maintained and managed by the BKG is always the latest version. No pertinent history data are recorded, nor are old versions archived.

For the reporting by Thünen institutes, this means:

- Basis-DLMs are obtained on an annual basis; the Basis-DLM for a given report year is obtained in September of that year;
- In each case, the version for the current year is archived within the institute.

Basis-DLM data sets have been available on an annual basis to the Thünen institutes only since 2005. One data set is available for the year 2000. No ATKIS® data exist for years prior to 2000. Due to the multi-year revision cycles involved, multi-year intervals in the Basis-DLM data records are used, however, to prevent the regional artifacts that can occur via seemingly sudden massing of land-use changes in updating years.

As of 2009, the Basis-DLM is being converted to a new data model, referred to in the following as "AAA levels", to distinguish it from the "levels" referred to under the old model. In the years 2009 through 2012, some German Länder (states) provided data in the old model and some provided data in the new model. As of 2013, the Basis-DLM (AAA levels) is being used for all of Germany.

Each data set in the Basis-DLM (levels) comprises some 800 individual layers of differing degrees of detail. For example, polygons with relatively low resolution (such as those showing settlement areas) are found on the lowest level, while polygons with very high resolution and rich detail (such as those showing residential areas) are found on the highest level. A single record thus will contain numerous superimposed polygons that, in terms of content, can be assigned to the same LULUCF categories. All such related content, with all overlays, is read into the system as a whole. As a result, data gaps occur only where the entire pertinent Basis-DLM data record contains no data. In a subsequent step, the areas so defined are merged with the points of the BWI network. Where a point touches several stacked areas, only a single value is chosen, with the help of a priority list. Where the same priorities overlap (for example, vegetation with vegetation), then that area with the lower ATKIS® identification value is selected. The procedure has been carried out for the Basis-DLM (levels) from the years 2000, 2005, 2008 and 2012. The Basis-DLM categories (levels) are assigned to the LULUCF categories with the help of a key table (cf. also Table 329).

The new data model (Basis-DLM AAA levels) includes a layer designated "actual use" ("Tatsächliche Nutzung"). "All object types of this object-type area participate in seamless, non-overlapping and complete-coverage description of the earth's surface (land areas)". As a result, problems due to overlapping and gaps are now a thing of the past. Additional attributes emerge in additional layers. The Basis-DLM categories (AAA levels) are assigned to the LULUCF categories with the help of a key table (cf. also Table 329).

4th quality level: CORINE Land Cover (CLC) data

CORINE Land Cover (CLC) is a European remote-sensing project for standardising classification of land use and land-use changes. It was initiated by the EU Commission in the mid-1980s. In the CLC framework, digital satellite images of European countries are collected, via standardised procedures, and analysed with regard to land-use changes. Image data recorded in three different years, 1990, 2000 and 2006, are currently available. These data have been entered into the database with the help of a script. The CORINE classes have been allocated to the LULUCF categories with the help of a translation table (cf. also Table 329).

5th quality level: GSE data

The GSE Forest Monitoring project is part of the Global Monitoring for Environment and Security (GMES) programme, which was established in 1998 by the European Commission and the European Space Agency (ESA). In the framework of the GSE Forest Monitoring project, the service "Forest Monitoring: Inputs for national greenhouse-gas reporting (GSE FM-INT; "Wald Monitoring: Inputs für die Nationale Treibhausgasberichterstattung") has been introduced for the Federal Ministry of Food and Agriculture (BMEL). The products of that service have included maps of forest cover, land use and land-use changes, for 1990 and for pertinent changes through 2002 and 2005/06; area statistics; and error analyses for the new German Länder (GSE 2003, GSE 2006, GSE 2007, GSE 2009). Further information about the GSE FM-INT project is provided in Oehmichen et al. (2011b).

6.3.2.2 Derivation of LULUCF information

Each sample point is assigned information, from the available data sources, with regard to land use per year. Then, classification in keeping with the LULUCF categories can begin. This is achieved via retrospective and prospective comparison – with reference to the year under consideration – to determine the time for each point at which land-use information on the highest available quality level is available (QL-MAX retrospective and QL-MAX prospective). This means, for example, that for a sample point to which a land-use class is to be assigned for 2001, data on the 1st quality level are available – the BWI information. Retrospectively, the point's first survey-time point, 1987, lies in forest land. Prospectively, the next survey-time point, 2002, also lies in forest land. From the two land-use classes, the classes as seen at the times 1987 and 2002, the relevant land-use category is then derived. For the point in the example, the resulting land-use category would be "Forest Land remaining Forest Land."

Sample points at which BWI information on land use (forest land remaining forest land), and on categories of land-use change to forest land (afforestation) or from forest land (deforestation), are available were validated via on-site inspections during the forest inventories and may be considered correct. A similar status may be assumed for the CIR data (which contain information about all land uses), since those maps were prepared to a very large scale and were validated via field surveys. The Basis-DLM data for the period as of 2013 (complete-coverage AAA model) are also considered current and quality-assured, since that project used a strictly hierarchical nomenclature (and was the first to do so). All other records have been reviewed for plausibility of

the assigned land-use categories, for a given year, on the basis of additional data, and in keeping with the following criteria:

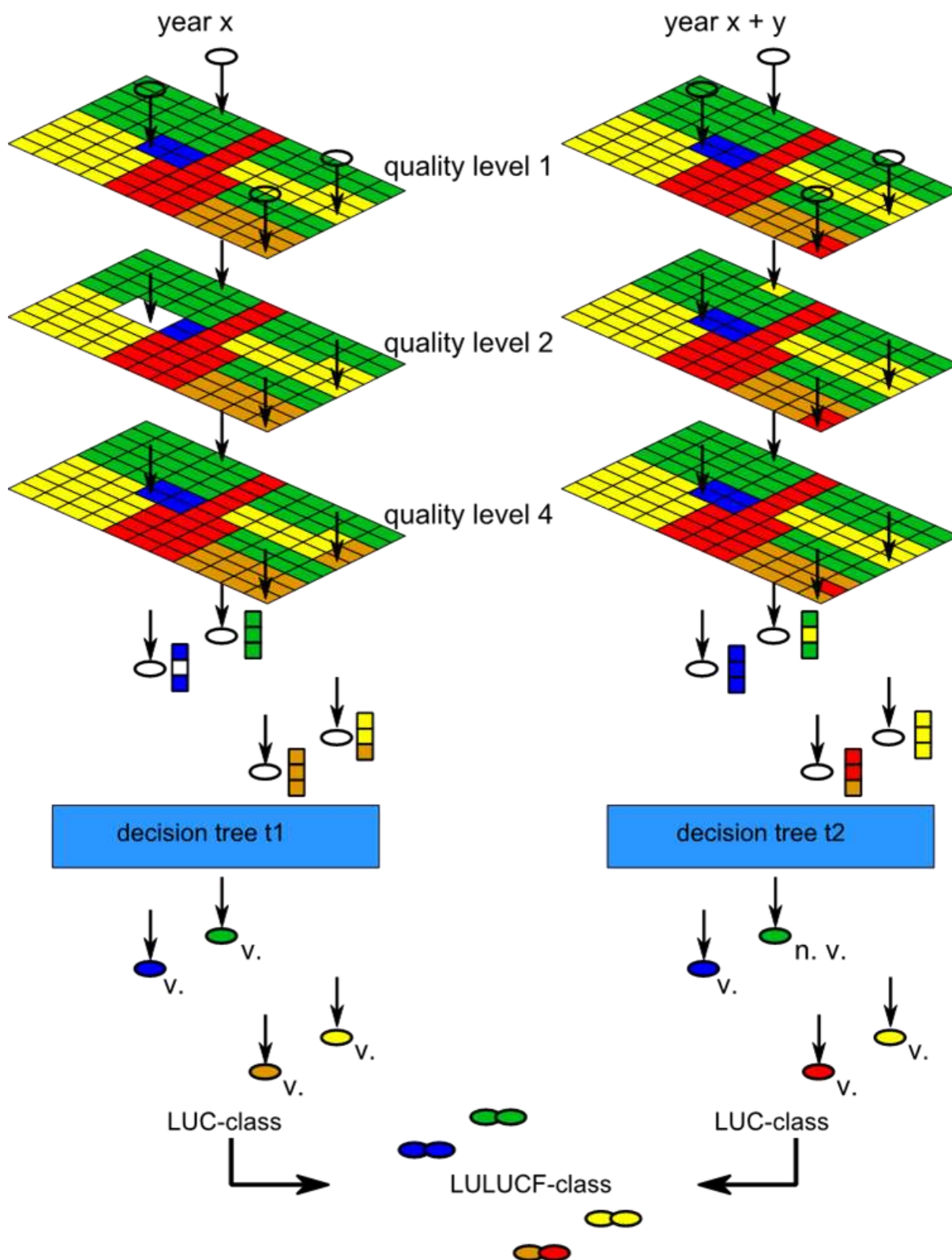
- Can the classification into a specific land-use category be substantiated with pertinent data from a lower quality level?
- Following placement in a land-use category, cases involving land-use changes were reviewed to determine whether data of lower quality levels could be used to narrow down the time period in which the change must have occurred.
- To provide an additional criterion, the national trend in land-use changes (except for those changes to and from forest land) was compared with the national net land-use-change rates obtained via the periodic land inventories and agricultural-structural inventories of the Federal Statistical Office. Those inventories use land-use-category definitions that differ – widely, in some cases – from those used in the present system.

In the following, an example is provided to illustrate the manner in which the time period in which a land-use change occurs is narrowed down: Let us assume that, on the basis of BWI data, a sample point was classified as forest land in 1987 and as settlements in 2002. If no additional data were available, the land-use change would be linearly interpolated between those two years, meaning that 1/15 of the represented area would change from forest land to settlements each year. If Basis-DLM data are available for the point, and those data also show the category "forest land" for 2000 and also show the category "settlements" for 2005, then placement in the land-use-change category "Forest Land converted to Settlements" would be logical and justified, and the change period could be narrowed down to two years (2000 = forest land in the Basis-DLM and 2002 = settlements pursuant to BWI) (cf. also Figure 52).

For each sample point and time, the process of selecting a land-use category – i.e. of carrying out relevant review and decision-making – has been carried out transparently, on the basis of a decision tree (cf. Chap. 6.3.4.1).

In keeping with the provisions of the 2006 IPCC Guidelines, land-use changes as of 1970 are already being taken into account in reporting under the UN Framework Convention on Climate Change. As a result, the transition categories are already being filled with areas in a manner that enables them, as of 1990, to reach a stable dynamic state comprising additions of new change areas and transfers of areas into relevant final-use categories. At present, the earliest georeferenced data available for Germany date from the BWI 1987; and, in general, for the period prior to 1990, no complete and internally consistent (the latter aspect is even more important) national data sets are available. Consequently, the changes in all land-use categories in the period 1990 – 2000 were extrapolated retroactively to 1970. That approach is in keeping with that used, for example, by the Czech Republic and by Austria for the land-use matrix.

Figure 52: Schematic representation of allocation of sample points to a land-use category



6.3.3 Validation and error assessment

With the sampling method used, various sources of error, such as

- additional sampling errors,

- differences in definitions, and
- discrepancies between Minimum Mapping Units,

can be quantified. On the other hand, error determination is hampered by the impossibility of achieving 100% accuracy in georeferencing of data sets.

Still, the three error sources mentioned immediately above can be eliminated, over time, via this flexible, sample-based system, for the following reason: Pursuant to the decision tree that has been introduced, placement within a land-use category is assumed correct only if such placement can be derived from suitably precise data sets on the 1st quality level, or if data from a lower quality level confirm the placement. In every other case – i.e. whenever different data sources disagree about land use at a given time – the relevant sample point has to be evaluated with the help of aerial photos (whenever such photos are available). Such evaluation was carried out for several German Länder (states) for the year 1990, for example. In the small numbers of cases, regarding the nature of specific points, in which even aerial photos did not make a decision possible, or in which no aerial photos are available, the points are inspected on-site, if possible. Time-series inconsistencies resulting from use of data sets with differing definitions, or different Minimum Mapping Units, and inconsistencies tied to imprecise geographic locations, do not occur, thanks to such additional validation.

6.3.4 Step-by-step implementation

Complete implementation of this above-described new system for determining land uses and land-use changes throughout Germany, over time, will necessitate extensive preliminary work and continuous supporting efforts. For example, the following have to be carried out:

- The various data materials, for different points in time, have to be acquired,
- Geometric corrections (of erroneous geometries, etc.) and checks have to be carried out,
- Conversion functions have to be written for converting the original classifications into the categorisation used here,
- The sample points have to be merged with the maps,
- The decision tree has to be programmed and adjusted as necessary, in keeping with data quality and availability, and
- The "transition-time" procedures have to be programmed and adjusted as necessary, in keeping with data quality and availability.

The decision to use this flexible, sample-based system was made in spring 2011, in consultation with the Single National Entity (Federal Environment Agency – UBA) and the Federal Ministry of Food and Agriculture (BMEL), which is responsible for the forest inventories.

Programming of the decision tree for each classification year, and of the "transition-time" procedures, has been adapted in keeping with this current data structure.

6.3.4.1 Derivation of land uses

Each sample point can be assigned to a land-use category for the years in question (1990, 2000, 2005, 2008, 2012 and 2015), on the basis of the available data (cf. Chapter 6.3.2), and in keeping with the relevant quality levels. The basic table (cf. Table 332) is structured as follows (shown here with the example of a sampling point):

Table 332: Basic table for derivation of land uses

Cluster	Cluster point	BWI 1987	BWI 2002	BWI 2008	DLM 2000	DLM 2005	DLM 2008	DLM 2012	DLM 2015	CORIN E 1990	CORIN E 2000	CORIN E 2006	GSE 1990	GSE 2005
xya	1	forl	sett	sett	forl	sett	sett	sett	sett	forl	gra1	sett	gse0	gse0

The following codes are used for the land-use classes in the data records:

Table 333: Codes in the basic table

Code	Category	Sub-category
crop	Cropland	Cropland
gra1	Grassland	Grassland (in the strict sense)
gra2	Grassland	Woody grassland
forl	Forest land	Forest land
wet1	wetlands	Terrestrial wetlands
wet2	wetlands	Waters
sett	Settlements	Settlements
othl	Other land	Other land
nofo	Non-forest land ⁹⁶	
bwi0	No information ⁹⁷	
dln0	No information ⁹⁸	
clc0	No information ⁹⁹	
gse0	No information ¹⁰⁰	

For the years 1990, 2000, 2005, 2008, 2012 and 2015, the decision trees were applied to the relevant year. Figure 53 shows, by way of example, the decision tree for 2012. In reading the decision trees, it must be noted that all lines consist of "IF - ELSE IF - ELSE" structures, rather than simple "IF - THEN - ELSE" structures. In other words, when a condition applies, it is implemented. All subsequent conditions are then irrelevant. This structure considerably simplifies the query logic.

⁹⁶ The information is from BWI data, needs to be further specified with the help of other data sources and must be non-forest land.

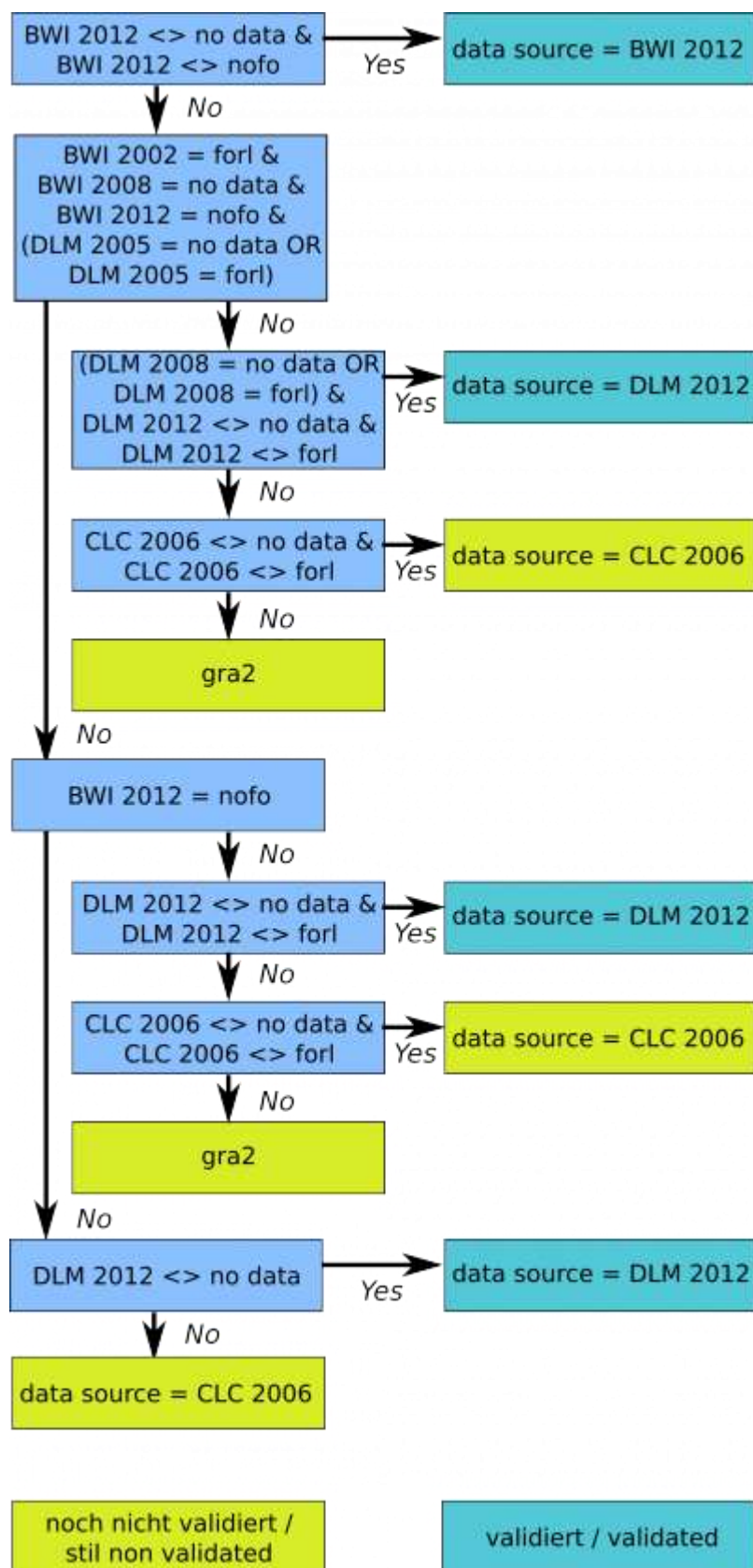
⁹⁷ No land-use information at this point in BWI data

⁹⁸ No land-use information at this point in Basis-DLM data

⁹⁹ No land-use information at this point in CORINE data

¹⁰⁰ No land-use information at this point in GSE data

Figure 53: Decision tree for the year 2012, presented by way of illustration (for abbreviations, cf. Table 333)



Use of the decision trees yields a further table (cf. Table 334), with the most probable land uses per sample point and year (1990, 2000, 2005, 2008, 2012 and 2015) and the best data source in each case. The BWI data are cited only for actual forest areas. Where the BWI shows "non-forest", other data sources are always used to define the land use, and such other sources must not show "forest land" as the land use:

Table 334: Most probable land use (LU) and pertinent data sources (DB)

Cluster	Cluster point	LU 1990	LU 2000	LU 2005	LU 2008	LU 2012	LU 2015	DB 1990	DB 2000	DB 2005	DB 2008	DB 2012	DB 2015
xya	1	forl	forl	sett	sett	sett	sett	bwi	d1m	d1m	d1m	d1m	d1m

(For abbreviations, see Table 333)

6.3.4.2 Derivation of annual land-use changes

Subsequently, the relevant land-use-change categories were derived for each change period (1990-2000, 2000-2005, 2005-2008, 2008-2012 and 2012-2015) and each sample point. To that end, an SQL script was programmed; it is documented in the inventory description.

The process of developing a land-use matrix that takes account of the required 20-year transition period following a land-use change takes place in several sub-steps:

- For all land-use changes that occur within a transition period covered by the included observations (1990-2015), processing is first carried out on a point-oriented basis. At the same time, the land-use changes have been spatially correlated with the individual observation points.
- Land-use changes that occurred prior to that period (1970-1990) are extrapolated retroactively from observations carried out during the first measurement period (1990-2000). In those cases, spatial correlation with the observation points is not possible, but it is no longer required. As a result, for those cases a change is made from point-based processing to calculation on the basis of area sums.
- The observation period is divided into transition periods of differing lengths (1990-2000, 2000-2005, 2005-2008, 2008-2012, 2012-2015), and the annual changes in those change periods are calculated on a proportional basis, via linear interpolation.

6.3.5 Land-use changes pursuant to the Convention and the KP

The method described here for determining land-use changes, and the resulting land-use matrix (cf. Table 335), including a 20-year "transition time" beginning in 1970, are compliant with reporting requirements pursuant to the UN Framework Convention on Climate Change, as set forth in the 2006 IPCC Guidelines. Table 336 shows the complete detailed land-use matrix for 2015 by way of example.

For determination of land-use changes pursuant to the Kyoto Protocol, the same set of annual data is used (cf. Table 337), but only land-use changes since 1990 are taken into account and, in the change categories of afforestation and deforestation, they are accumulated for more than 20 years (cf. Table 446 in Chapter 11.2.2).

Table 335: Land-use changes (LUC), including 20-year transition time, pursuant to reporting under the Convention

Category	4.A.1 Forest land remaining forest land	4.A.2 ... LUC to forest land	4.B.1 Cropland remaining cropland	4.A.2 ... LUC to cropland	4.C.1 Grassland remaining grassland	4.A.2 ... LUC to grassland	4.D.1 Wetlands remaining wetlands	4.A.2 ... LUC to wetlands	4.E.1 Settlements remaining settlements	4.A.2 ... LUC to settlements	4.F.1 Other land remaining other land	4.F.2 ... LUC to other land
Units	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
1990	10,376,246	552,374	12,587,710	1,045,088	6,378,432	966,821	616,711	92,953	2,396,776	684,463	82,060	0
1995	10,451,644	552,374	12,529,098	1,045,088	6,274,232	966,821	612,016	92,953	2,500,987	684,463	69,959	0
2000	10,527,042	552,374	12,470,486	1,045,088	6,170,032	966,821	607,320	92,953	2,605,198	684,463	57,857	0
2005	10,618,033	491,033	12,381,063	893,694	6,210,648	938,749	609,812	102,349	2,717,210	787,273	29,769	0
2006	10,634,337	478,462	12,382,137	924,047	6,155,508	924,577	612,675	102,695	2,738,447	798,784	27,965	0
2007	10,650,641	465,890	12,383,211	954,399	6,100,368	910,405	615,538	103,041	2,759,683	810,296	26,161	0
2008	10,666,944	453,319	12,384,285	984,752	6,045,228	896,232	618,401	103,387	2,780,919	821,807	24,357	0
2009	10,683,558	442,258	12,384,373	1,015,414	5,987,639	875,696	621,387	101,574	2,806,860	837,544	23,330	0
2010	10,700,171	431,196	12,384,461	1,046,075	5,930,050	855,160	624,373	99,760	2,832,801	853,282	22,303	0
2011	10,716,784	420,135	12,384,549	1,076,737	5,872,461	834,624	627,359	97,946	2,858,742	869,019	21,277	0
2012	10,733,397	409,074	12,384,637	1,107,398	5,814,873	814,088	630,345	96,133	2,884,683	884,756	20,250	0
2013	10,753,207	395,526	12,384,320	1,107,278	5,787,141	794,231	633,577	94,002	2,912,638	897,563	20,151	0
2014	10,773,017	381,978	12,384,003	1,107,157	5,759,409	774,373	636,810	91,871	2,940,593	910,370	20,052	0
2015	10,792,827	368,430	12,383,686	1,107,037	5,731,677	754,515	640,042	89,740	2,968,549	923,177	19,953	0

Table 336: Land-use matrix for 2015. In each case, the boldface number on the diagonal shows the area remaining in the same category for the column in question. The other table cells show the relevant land-use changes (including 20-year transition times)

Initial\Final	Land-use matrix for 2014: Areas [ha]										Σ additions - Σ reductions
	Forest land	Cropland	Grassland (in the strict sense)	Woody grassland	Terrestrial wetlands	Waters	Peat extraction	Settlements	Other land	Σ reductions	
Forest land	10,792,827	31,797	54,876	17,893	5,772	6,372	0	94,482	0	211,191	157,240
Cropland	115,679	12,383,686	445,655	64,416	1,116	15,384	0	548,250	0	1,190,500	-83,463
Grassland (in the strict sense)	164,354	1,009,754	5,082,131	75,069	18,035	20,365	0	244,930	0	1,532,507	-867,794
Woody grassland	25,303	10,638	27,517	546,960	582	1,360	0	14,054	0	79,454	112,934
Terrestrial wetlands	6,162	1,203	4,809	1,390	84,775	351	0	6,610	0	20,525	6,556
Waters	8,982	3,613	24,650	1,782	465	534,594	0	5,726	0	45,218	18,256
Peat extraction	0	0	0	0	0	0	19,857	0	0	0	0
Settlements	37,883	45,043	91,878	28,651	1,111	12,335	0	2,968,549	0	216,901	706,276
Other land	10,067	4,988	15,329	3,188	0	7,307	0	9,127	19,953	50,006	-50,006
Σ additions	368,430	1,107,037	664,713	192,388	27,081	63,474	0	923,177	0		
Σ Land-use category	11,161,258	13,490,722	5,746,844	739,348	111,857	598,068	19,857	3,891,726	19,953		
Total area of Germany	35,779,633										

Table 337: Annual areas for land-use changes on which inventory calculations for UNFCCC-based reporting (20-year transition period) and the Kyoto Protocol (cumulative area change) are based [hectares per year]

Land-use change [hectares per year]	1990-2000	2001-2005	2006-2008	2009-2012	2013-2015
... to forest land					
Cropland to forest land	9,715	4,843	5,648	4,274	2,949
Grassland (in the strict sense) to forest land	11,189	6,454	4,454	8,645	9,398
Woody grassland to forest land	1,874	922	1,006	1,371	941
Terrestrial wetlands to forest land	258	610	260	224	48
Wetlands to forest land	1,050	209	276	441	31
Settlements to forest land	2,467	1,805	3,035	1,327	703
Other land to forest land	1,066	506	368	276	0
... to cropland					
Forest land to cropland	3,369	1,543	784	872	466
Grassland (in the strict sense) to cropland	42,871	17,004	78,703	80,929	50,185
Woody grassland to cropland	1,552	153	199	78	401
Terrestrial wetlands to forest land	223	11	6	3	0
Waters to cropland	612	68	35	25	3
Settlements to cropland	3,517	2,350	2,813	1,008	1,078
Other land to cropland	111	847	67	0	0
... to grassland (in the strict sense)					
Forest land to grassland (in the strict sense)	2,863	3,394	2,826	2,487	1,721
Cropland to grassland (in the strict sense)	31,127	24,005	17,276	15,596	18,594
Woody grassland to grassland (in the strict sense)	3,015	1,670	743	228	317
Terrestrial wetlands to grassland (in the strict sense)	194	382	20	120	464
Waters to grassland (in the strict sense)	2,227	1,338	920	503	684
Settlements to grassland (in the strict sense)	5,258	4,330	5,026	4,819	3,194
Other land to grassland (in the strict sense)	613	1,771	668	351	0
... to woody grassland					
Forest land to woody grassland	1,008	409	1,709	778	857
Cropland to woody grassland	3,288	4,102	3,891	2,285	2,217
Grassland (in the strict sense) to woody grassland	1,114	5,145	5,620	2,688	5,387
Terrestrial wetlands to woody grassland	61	161	26	48	3
Waters to woody grassland	197	63	103	7	49
Settlements to woody grassland	1,385	2,454	1,638	612	699
Other land to woody grassland	119	319	66	200	0

Land-use change [hectares per year]	1990-2000	2001-2005	2006-2008	2009-2012	2013-2015
... to terrestrial wetlands					
Forest land to terrestrial wetlands	92	698	443	78	60
Cropland to terrestrial wetlands	127	55	10	2	56
Grassland (in the strict sense) to terrestrial wetlands	358	1,532	1,210	548	920
Woody grassland to terrestrial wetlands	72	40	2	2	3
Waters to terrestrial wetlands	60	19	2	4	16
Settlements to terrestrial wetlands	32	52	35	10	181
Other land to terrestrial wetlands	0	0	0	0	0
... to waters					
Forest land to waters	484	132	572	340	72
Cropland to waters	1,317	817	643	465	309
Grassland (in the strict sense) to waters	1,160	1,489	1,096	656	401
Woody grassland to waters	184	20	75	27	3
Terrestrial wetlands to waters	21	30	6	10	13
Settlements to waters	722	829	439	506	412
Other land to waters	99	862	468	200	99
... to settlements					
Forest land to settlements	4,723	3,245	4,981	6,450	4,632
Cropland to settlements	18,402	36,317	23,712	29,544	28,446
Grassland (in the strict sense) to settlements	8,595	12,299	16,269	13,304	12,813
Woody grassland to settlements	1,327	304	467	370	1,006
Terrestrial wetlands to settlements	96	1,111	71	68	30
Waters to settlements	668	195	68	225	103
Other land to settlements	412	1,314	167	0	0

6.3.6 Verification

The land-use categories were selected so as to be in accordance with the relevant definitions pursuant to the UNFCCC, the Kyoto Protocol and the IPCC. Germany uses a range of different definitions for important land-use categories – in particular, agricultural land (Cropland, Grassland) and Settlements. The size data for areas can vary as a result of **differences in definitions and in data-collection methods**. While such inconsistencies, on the order of over 10%, or 2 million hectares, per land-use category, have long been known, they have been retained with a view to achieving consistent time series in all data records.

The three most important data sources in Germany, for data on agricultural areas, are (cf. Table 338) as follows:

1. The main soil use survey (Bodennutzungshaupterhebung) of the Federal Statistical Office: It determines land use by surveying agricultural facilities (2014: exhaustive survey). Cropland excludes a number of permanent crops, while Grassland excludes extensive, non-commercial forms of use, such as nature-conservation and recreational uses. The Federal Statistical Office reports the cropland and grassland area data that result from the main soil use survey (Bodennutzungshaupterhebung) to Eurostat. In the inventory, the net area changes, between the cropland and grassland categories, are used for validation of land-use changes.
2. AKTIS® Basis-DLM: It derives land use from the official land-cover cadastre. Its geometries come from topographical maps with scales ranging from 1:5,000 to 1:25,000, and they are corrected and/confirmed via aerial photos. Its content (object types) is determined solely on the basis of aerial photos. Grassland includes all forms of herbaceous vegetation. Roads are depicted as lines, and thus roadside vegetation is classified as grassland, and not as infrastructure. As a result, up to 0.7 million hectares of roadside vegetation are additionally classified as grassland. The Basis-DLM is one of the inventory's central data sources. For reasons of transparency, it is used without any after-the-fact editing or reclassification.
3. The area survey (Flächenerhebung) of the Federal Statistical Office: It derives land use from the official real estate cadastre and from the AKTIS® Basis-DLM. Grassland excludes recreational areas. Because it does not always differentiate sharply between cropland and grassland, cropland and grassland data are published only as summed data for cropland + grassland. The reference date for such data is 31 December 2013. While the area survey makes use of data that are largely consistent with the ATKIS® Basis-DLM, it converts roads from lines into areas (in a post-editing step). While the area survey represents Germany completely, and consistently over time, it does not show a constant national area for the country. The area survey is consistent with the inventory.

Table 338: Cropland and Grassland, and agricultural areas, by data sources [kha]

Land-use category	Main soil use survey (Bodennutzungshaupterhebung)	Inventory	Area survey (Flächenerhebung)
Cropland	12,074	13,491	Not published
Grassland	4,651	6,534	Not published
Total	16,725	20,024	18,647

6.4 Forest land (4.A)

6.4.1 Category description (4.A)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	4.A. Forest land		CO ₂	-75,542.1	6.18%	-57,927.0	6.53%	-23.3%
-/-	4.A. Forest land		N ₂ O	231.5	0.02%	146.4	0.02%	-36.7%
-/-	4.A. Forest land		CH ₄	20.1	0.00%	19.8	0.00%	-1.3%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS/Tier 2	RS/NS	CS
CH ₄	Tier 2	RS/NS	D/CS
N ₂ O	Tier 2	RS/NS	D/CS

The categories Forest Land remaining Forest Land (4.A.1) und *Land converted to Forest Land* (4.A.2) are key sources for CO₂ emissions in terms of emissions level and trend.

Reporting in the category *Forest Land* covers CO₂ emissions / removals from mineral and organic soils, above-ground and below-ground biomass, litter, dead wood and wildfires. It also covers nitrous oxide emissions from wildfires, from drainage of organic soils and from mineralisation in mineral soils, and it covers methane emissions from wildfires and from drainage of organic soils.

In 2015, the total emissions from forests amounted to -57,750 kt CO₂ equivalents. Table 339 lists the emissions for the Forest Land category, broken down by categories, greenhouse gases and the pertinent uncertainties.

Table 339: Emissions in the Forest land category for the year 2015

		Emissions from Forest land, 2015				
Source category	Gas	Emission	2.5 % percentile [kt CO ₂ -eq.]	97.5 % percentile	2.5 % percentile	97.5 % percentile
					%	
Forest Land ^{total 101}		-57,749.6	-36,361.4	-79,139.2	37.0	37.0
Mineral soils	CO ₂ ¹⁰²	-15,617.8	-7,658.0	-23,578.8	51.0	51.0
	N ₂ O _{indirect} ¹⁰³	11.2	0.0	39.7	100.0	254.9
	N ₂ O _{direct} ¹⁰⁴	49.7	10.9	140.3	78.1	182.5
Organic soils	CO ₂ ¹⁰²	1,196.1	988.0	1,427.5	16.6	19.4
	CH ₄ ¹⁰⁵	16.9	4.3	150.6	74.6	792.6
	N ₂ O ¹⁰⁵	94.8	25.1	243.9	73.5	157.3
Biomass	CO ₂ ¹⁰²	-45,377.6	-22,289.6	-68,465.7	50.9	50.9
Litter	CO ₂ ¹⁰²	-136.5	0.0	-312.8	100.0	129.2
Dead wood	CO ₂ ¹⁰²	2,008.8	0.2	4,108.3	100.0	104.5
Wildfires	CO ₂ ¹⁰⁶	IE	-	-	-	-
	CH ₄ ¹⁰⁶	2.9	1.8	4.1	38.1	38.1
	N ₂ O ¹⁰⁶	1.9	1.2	2.7	38.1	38.1

As the time series for emissions from forests (cf. Chapter 6.4.1 and Figure 55) show, the sum of all greenhouse-gas removals in forests decreased abruptly in 2002 and then increased in 2008. The reason for the jumps is that relevant surveys in the framework of the National Forest Inventory (BWI) are carried out periodically. Additional details about this aspect are provided in Chapter 6.4.2.2.1.

In the category Forest Land, the most important factors for CO₂ removals are the categories of biomass (70.34 %), mineral soils (24.21 %) and litter (0.21 %). Sources occur via dead wood, drainage, mineralisation and wildfires. Such sources account for only a very small share – 5.24 % – of the greenhouse-gas balance for forests, however.

¹⁰¹ Sum of the emissions from CRF tables 4.A, 4.(II).A, 4.(III).A, 4.(IV).2, 4.(V).A

¹⁰² CRF table 4.A

¹⁰³ The category-specific indirect N₂O emissions are not included and shown as such in the CRF tables; they are included, however, in the sum, for all sub-categories, presented in CRF Table 4.(IV).2.

¹⁰⁴ CRF table 4.(III).A

¹⁰⁵ CRF table 4.(II).A

¹⁰⁶ CRF table 4.(V).A

Figure 54: Greenhouse-gas emissions (total of CO₂, CH₄ and N₂O) [kt CO₂-eq.] as a result of land use and land-use changes in forests, 1990 – 2015, by sub-categories

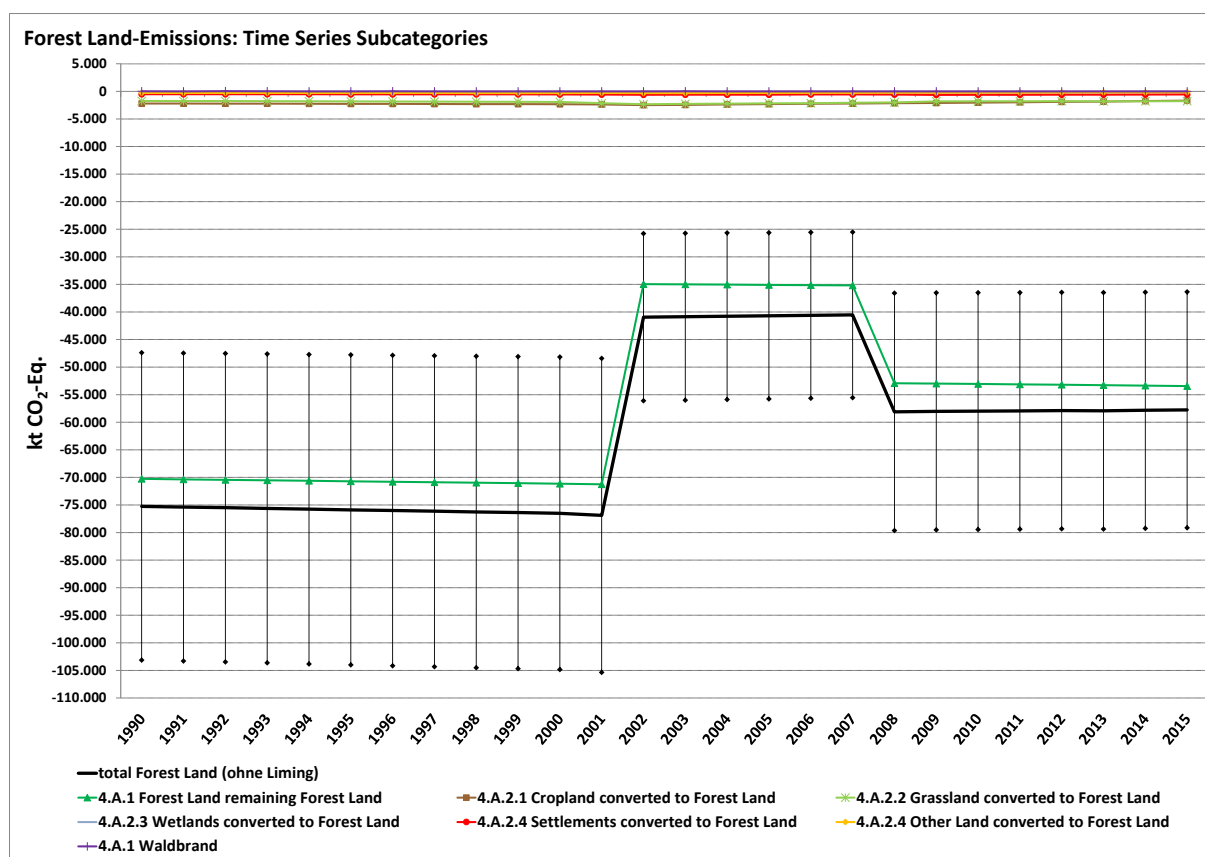
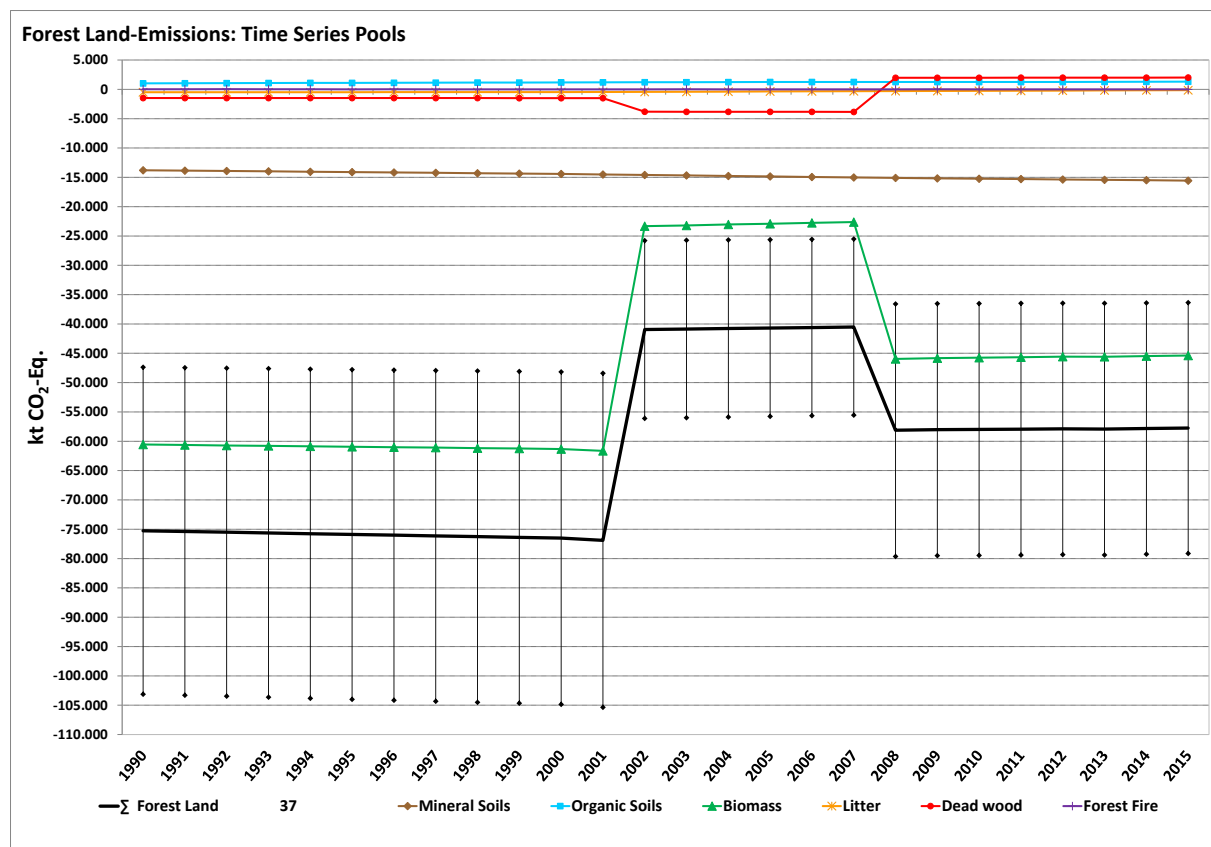


Figure 55: Greenhouse-gas emissions (total of CO₂, CH₄ and N₂O) [kt CO₂-Eq.] as a result of land use and land-use changes in forests, 1990 – 2015, by pools



In the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006 Guidelines), and in the official reporting tables, in the "Common Reporting Format" (CRF), for the greenhouse-gas inventories sent to the Climate Secretariat, the category "Forest Land" is divided into "Forest Land remaining Forest Land" (forest that remains forest during the period covered by the report) and "Land converted to Forest Land" (new forest established, via afforestation or natural succession, on areas previously used for other land-use classes). It is important to note that relevant calculations are carried out on the basis of a 20-year transition time, and with a database beginning as of the year 1970 (cf. Chapter 6.3).

6.4.1.1 Forest Land remaining Forest Land (4.A.1)

Forest Land remaining Forest Land refers to the forest area that remains forest in the report year. It also includes areas that, after a 20-year period, are shifted from the category "Land converted to Forest Land" (4.A.2) into the category "Forest Land remaining Forest Land". The category Forest Land remaining Forest Land differs from the total forest area in that it does not include Land converted to Forest Land, which is considered in the category of that name (see Chapter 6.4.1.2).

6.4.1.2 Land converted to Forest Land (4.A.2)

Forest is established through succession, afforestation and reforestation; afforested areas start to accumulate carbon as soon as they are converted. Pursuant to the 2006 IPCC Guidelines, Land converted to Forest Land remains for the duration of the transition period of 20 years in the conversion category and is subsequently transferred into the "Forest Land remaining Forest Land" category.

It must be remembered that the carbon stocks of previous land uses are deducted following the conversion. Relevant information is provided in Chapters 6.4 through 6.9.

6.4.2 Methodological issues (4.A)

6.4.2.1 Data sources

The following data sources were used for determination of forest areas; determination of land-use changes that have occurred; estimation of the relevant emission factors for soil, biomass, litter and dead wood; for calculation of carbon stocks and stock changes at various times and over various periods; and for calculation of emissions from wildfires, drainage and mineralisation:

- National Forest Inventory 1987 (Bundeswaldinventur; BWI 1987)
- National Forest Inventory 2002 (Bundeswaldinventur; BWI 2002)
- National Forest Inventory 2012 (Bundeswaldinventur; BWI 2012)
- Inventory Study 2008 (Inventurstudie; IS08)
- Datenspeicher Waldfonds (DSW)
- Forest Soil Inventory I (Bodenzustandserhebung im Wald I; BZE I)
- Forest Soil Inventory II (Bodenzustandserhebung im Wald II; BZE II)
- Maps, derived from CIR data, from the mapping of biotopes and use types carried out for 1990,
- Amtliches Official topographic-cartographic information system (Topographisch-Kartographisches Informationssystem; ATKIS®)
- CORINE Land Cover (CLC)
- Soil map for the Federal Republic of Germany 1:1,000,000 (Bodenübersichtskarte der Bundesrepublik Deutschland; BÜK 1000)
- Map of Germany's organic soils (Roskopf et al. 2015)
- Forest-fire statistics of the Federal Republic of Germany

6.4.2.1.1 National Forest Inventory, Inventory Study 2008 and Datenspeicher Waldfonds

The National Forest Inventory surveys the state of forests, and of forest production potential, on a large scale throughout Germany, using a standardised sampling procedure. The National Forest Inventory is a terrestrial sampling inventory that uses permanently marked sample points in a 4 km x 4 km basic grid whose resolution, at the request of the Länder, has been increased on a regional basis¹⁰⁷. The first National Forest Inventory (BWI 1987) covered only the territory of the Federal Republic of Germany, in its pre-1990 borders, and West Berlin. It was carried out in the period 1986 to 1989 (sample year 1987). The second National Forest Inventory (BWI 2002) was carried out in the period 2001 to 2003 (sample year 2002), as a repeat inventory in the old German Länder and as a first inventory in the new German Länder (BMVEL, 2001; BMELV, 2005). The data of the third National Forest Inventory (BWI 2012) are now available. That inventory was carried out from 2011 through 2012 (sample year 2012), as a repeat inventory, throughout the entire national territory. The BWI 2012 provides current data, as of the beginning of the Kyoto Protocol's second commitment period, on the condition of forests and the ways they are changing.

In 2008, data on the state of forests were collected on a sub-sample area of the National Forest Inventory that consisted of an 8 km x 8 km grid. In the main, the methods used for that so-called "2008 Inventory Study" (Inventurstudie 2008; IS08) are the same as those used for the National Forest Inventory (SCHWITZGEBEL et al. 2008, BMELV 2010).

¹⁰⁷ Further information: <http://www.bundeswaldinventur.de>

The Datenspeicher Waldfonds (DSWF) database contains complete-coverage forestry-management data for the territory of the former GDR through 1993. Those data were collected at periodic intervals, annually revised in connection with growth models and updated in keeping with completion and change reports of that country's forest operations (BMELF, 1994).

6.4.2.1.2 Forest Soil Inventory (Bodenzustandserhebung im Wald – BZE)

Carbon emissions from forest soils have been estimated via the stock-changes method (2006 IPCC Guidelines). To that end, data from the soil surveys BZE I and BZE II were used. The Forest Soil Inventory I (BZE I) was carried out from 1987 to 1992, while the Forest Soil Inventory II (BZE II) was carried out from 2006 to 2008. In both inventories, samples were taken of both total organic layer, referred to in the following as "litter", pursuant to the 2006 IPCC Guidelines, and of mineral soils. The data for the inventories were collected by the Länder.

In the BZE I (WOLFF & RIEK, 1996) and BZE II (WELLBROCK et al., 2006), forest soils throughout Germany were sampled within an 8 km x 8 km grid. In the sampling procedure, at each grid point, eight satellite samples were taken, within a 10 m radius around a central excavation with an exposed soil profile. For the BZE I, there were 1800 grid points; for the BZE II, there were 2000. The primary reason for the increase in the number of grid sample points, from one inventory to the next, is that for the second it became possible to access areas which had been closed for the first (for which no access permits were available; for example, various former military exercise grounds were opened up).

For the most part, corresponding grid points for the two inventories all lay, in each case, within a 30 m radius. For some 400 points, a systematic grid shift with respect to the BZE I occurred.

For the BZE I, a database is available that contains about 1,800 points for which carbon stocks in litter and mineral soils (0-30 cm) have been calculated (Wolff & Riek, 1996). For the BZE II, the German Länder (states) transmitted some 2,000 points to a common national database. Carbon-stocks data are available for about 1,800 of the 2,000 sample points available from the BZE II¹⁰⁸.

6.4.2.2 Biomass (CRF Table 4.A)

6.4.2.2.1 Forest Land remaining Forest Land

The changes in biomass carbon stocks are calculated with the stock-difference method, a Tier 2 method (Equation 2.8, 2006 IPCC Guidelines). With that method, one obtains an average country-specific implied emission factor (IEF) for the time periods between different relevant years for which data sources are available. This leads to an IEF for the period prior to 2002, expressing the average biomass change between the BWI 1987 and the BWI 2002 in the old German Länder, and between the DWSF and the BWI 2002 in the new German Länder; an IEF for the period 2002 through 2008, expressing the average biomass change between the BWI 2002 and the IS08 (2008); and an IEF for the period 2008 through 2012, expressing the average biomass change between the IS08 and the BWI 2012 for Germany as a whole. As a result, the relevant biomass changes are adjusted between the years 2001/2002 and 2007/2008, in a manner leading to the "jumps" referred to above (cf. Chapter 6.4.1). The changes between the periods are due to changes in wood use, which increased in the inventory period 2002 through 2008 and decreased in the period 2008 through 2012.

For the old German Länder, and for the period until 2002, relevant data are available from two national forest inventories (referenced to the dates 1 October 1987 and 1 October 2002). Between the BWI 1987 and the BWII 2002, carbon stocks in biomass increased by 1.26 t C ha⁻¹ a⁻¹ in the

¹⁰⁸ cf.: <https://www.thuenen.de/de/wo/arbeitsbereiche/waldmonitoring/bodenzustandserhebung/>

forests of the old German Länder. The increase in stocks is a result of low use, in comparison to growth. For the new German Länder, data from the BWI 2002 were compared with data from the Datenspeicher Waldfonds (DSWF) database, given the lack of an initial inventory comparable to the 1987 BWI. The comparison showed a net carbon-stock increase of $1.83 \text{ t C ha}^{-1} \text{ a}^{-1}$. The emission factor for Germany as a whole, for the period in question, is $1.43 \text{ t C ha}^{-1} \text{ a}^{-1}$. For the period from 2002 through 2008, data for stock-change calculations are available from the BWI 2002 and the Inventory Study 2008 (IS08) (in each case, for Germany as a whole). On the basis of that data, a carbon-stock increase of $0.44 \text{ t C ha}^{-1} \text{ a}^{-1}$ was calculated for Germany. For the period 2008 through 2012, the new data of the BWI 2012 have been used for an updated calculation of the carbon-stock change, on the basis of the IS08 and BWI 2012 data. The change amounts to $1.03 \text{ t C ha}^{-1} \text{ a}^{-1}$. That value is being updated as of 2013.

Nonetheless, the sink effect of managed forests decreased significantly in 2002. The relevant reasons include a near doubling of the annual cut. In the first inventory period (1987 – 2002), for example, an average of about 47.9 million m^3 (cubic meters of standing timber) were harvested per year in the old German Länder, while some 89.0 million m^3 were harvested in the 2002 – 2008 inventory period. Despite the increases in the annual cut, and the resulting CO_2 emissions, the sum total of such emissions is still more than offset by the relevant CO_2 removals. With the data of the BWI 2012, it has been possible to show that forests regained a major sink status as of 2008. This is due to new decreases in wood harvesting (cf. Figure 56).

Figure 56: Comparison of raw-timber production with the development of forest biomass

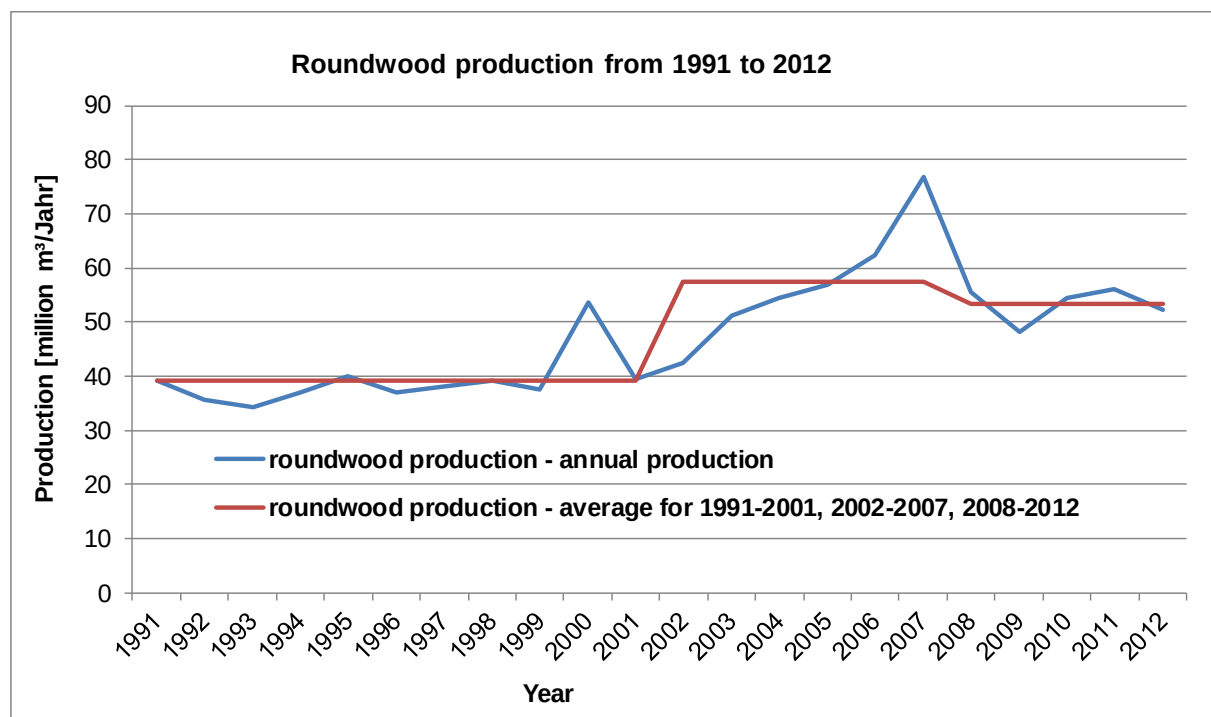
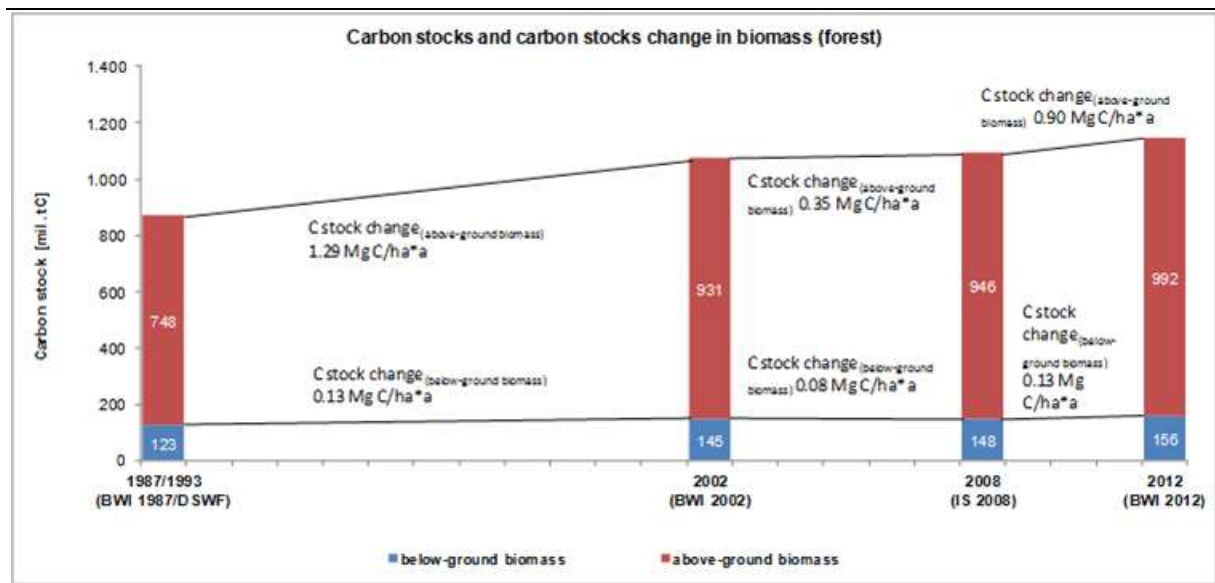


Figure 57 shows the carbon stocks for the four inventory dates. The data for 1987 and 1993 have been derived from the BWI 1987 or the DSWF; data for 2002 have been taken from the BWI 2002; data for 2008 have been derived from the IS08; and data for 2012 have been derived from the BWI 2012. These figures also highlight the increase in forest carbon stocks, even though they include only stocks on forest land remaining forest land (and not land converted to forest land).

Overall, the forests of the Federal Republic of Germany are thus a net sink for carbon.

Figure 57: Carbon stocks and carbon-stock changes in below-ground and above-ground biomass, in forest, in the years 1987/1993, 2002, 2008 and 2012



6.4.2.2.2 Land converted to Forest Land

The changes in biomass carbon stocks on Land converted to Forest Land are calculated with the Tier 2 method given by Formula 2.16 of the *2006 IPCC Guidelines*. In that approach, the stock changes are determined as the difference between the biomass stocks prior to the conversion and after the conversion (cf. also Chapter 6.1.2.3).

To obtain emission factors for Land converted to Forest Land, an individual-tree calculation was carried out on the basis of the BWI 1987, BWI 2002 and BWI 2012 inventories. For the period through 2002, only trees in the old German Länder were taken into account, since the BWI 1987 inventory was carried out only there. As of the year 2002, calculations were carried out for Germany as a whole. The carbon stocks were calculated for each area on which conversion from a given land use to forest land took place, and then all the resulting stocks were combined within the "Land converted to Forest Land" category. The stocks of earlier-use categories were deducted – and thus taken into account.

For the the new German Länder in the period 1990 through 2002, it was not possible to derive wood stocks for Land converted to Forest Land directly from comparison of two inventories. As a result, the relevant values for the old German Länder were used for that period.

The biomass stocks at the end of the vegetation period in 2002 and in 2012 represent the increase in biomass stocks throughout the entire period under consideration since 1987. That stock increase has been linearly interpolated in the periods 1990 through 2002 and 2002 through 2012. The data of the IS08 are unsuitable for calculation of biomass on land converted to forest land, since that survey did not cover land converted to forest land. For each year of the period 1990 through 2002, the carbon-stock increase is $3.40 \text{ t C ha}^{-1} \text{ a}^{-1}$; for each year of the period 2002 through 2015, the annual increase amounts to $3.64 \text{ t C ha}^{-1} \text{ a}^{-1}$. It must be remembered that afforested areas remain in this land-use category for 20 years. On the areas added each year, the carbon-stock losses from previous uses must be taken into account in the year in which conversion takes place; those losses are immediately assessed as emissions.

6.4.2.2.3 Derivation of individual-tree biomass

The above-ground biomass is estimated by means of biomass functions derived from the data of the National Forest Inventory. Further information is provided in KÄNDLER & BÖSCH (2013) and in Chapter 6.4.2.2.4. The below-ground biomass is also derived via biomass functions. The functions being used for this purpose are representative of the circumstances prevailing throughout the country (cf. Chapter 6.4.2.2.5).

Carbon stocks in the old German Länder as of 1987 were calculated on the basis of data from the BWI 1987 (some 230,000 measured trees). For the new German Länder, data on forest-management plans through 1993 are available in aggregated form, in the Datenspeicher Waldfonds database, that can be used for calculations of carbon stocks. The BWI 2002 survey, in which some 377,000 trees were measured, provides the database for the 2002 sampling year. The BWI data have been supplemented with repeat-survey data for some 83,000 trees, from the Inventory Study 2008. The data of the BWI 2012, covering some 537,000 surveyed trees, are now also available. These data sources provide such a good basis for calculation of the estimated carbon-stock changes that it was possible to use the stock-difference method (2006 IPCC Guidelines) instead of the biomass-gain-loss method (2006 IPCC Guidelines).

6.4.2.2.4 Conversion into above-ground individual-tree biomass

The some 1,600 trees covered by the study of KÄNDLER & BÖSCH (2013) included only the species spruce, pine, beech and oak. All other tree species, with the exception of soft hardwoods, were included in those four species groups. If the study had also included the soft hardwoods in the beech tree-species class, and then applied the pertinent functions and coefficients, it would have considerably overestimated the biomass of that tree-species group. For this reason, for soft hardwoods a more suitable biomass function of the same type was used that was adapted with the help of "pseudo-observations" based on the tables in GRUNDNER & SCHWAPPACH (1952).

The biomass functions based on tree-species groups are divided into three parts:

- Trees ≥ 10 cm diameter at breast height (DBH)
- Trees ≥ 1.3 m height and < 10 cm DBH, and
- Trees < 1.3 m height

Trees that are < 1.3 m in height (and for which no DBH can be measured) cannot be usefully differentiated in accordance with the five aforementioned tree-species groups. For this reason, such trees are differentiated only in terms of whether they are coniferous or broadleaf trees. In transition areas, the functions have been smoothed with the help of statistical procedures. This prevented any jumps between the functions that might otherwise have occurred.

The following section presents the functions used for deriving above-ground biomass from the National Forest Inventory data, as well as the functions' coefficients, broken down by tree-species groups.

Trees with at least 10 cm DBH

Equation 27

$$Y_{BIOM_0} = b_0 e^{b_1 \frac{BHD}{BHD+k_1}} e^{b_2 \frac{D03}{D03+k_2}} H^{b_3}$$

where Y_{BIOM_0} = Above-ground biomass in kg per individual tree,

$b_{0,1,2,3}$ and $k_{1,2}$ = Coefficients of the Marklund function,

DBH = Diameter at breast height in cm,

D03 = Diameter in cm at 30% of tree height,

H = Tree height in m.

Table 340: Coefficients of biomass function for trees ≥ 10 cm DBH

Tree species	b_0	b_1	b_2	b_3	k_1	k_2	RMSE%
Spruce	0.75285	2.84985	6.03036	0.62188	42.0	24.0	11.2
Pine	0.33778	2.84055	6.34964	0.62755	18.0	23.0	15.6
Beech	0.16787	6.25452	6.64752	0.80745	11.0	135.0	18.8
Oak	0.09428	10.26998	8.13894	0.55845	400.0	8.0	12.1
Soft hardwoods	0.27278	4.19240	5.96298	0.81031	13.7	66.8	50.0 ¹⁰⁹

Trees > 1.3 m height and < 10 cm DBH

Equation 28

$$Y_{BIOM_0} = b_0 + \left(\frac{b_s - b_0}{d_s^2} + b_3(BHD - d_s) \right) BHD^2$$

 Y_{BIOM_0} = Above-ground biomass in kg per individual tree, $b_{0,s,3}$ = Coefficients of the function,

DBH = Diameter at breast height in cm,

 d_s = Diameter-validity boundary for this function = 10 cm.Table 341: Coefficients of biomass function for trees ≥ 1.3 m height and < 10 cm DBH

Tree species	b_0	b_s	b_3
Spruce	0.41080	26.63122	0.01370
Pine	0.41080	19.99943	0.00916
Beech	0.09644	33.22328	0.01162
Oak	0.09644	28.94782	0.01501
Soft hardwoods	0.09644	16.86101	-0.00551

Trees < 1.3 m height

Equation 29

$$Y_{BIOM_0} = b_0 H_1^b$$

 Y_{BIOM_0} = Above-ground biomass in kg per individual tree, $b_{0,1}$ = Coefficients of the function,

H = Tree height in m.

In the National Forest Inventory, heights of trees shorter than 1.3 m are recorded only in terms of two basic classes: 20 – 50 cm and 50 – 130 cm, and thus the mid-range values of these classes, 35 cm and 90 cm, have been used in the function as standard values.

Table 342: Coefficients of biomass function for trees < 1.3 m height

Tree species	b_0	b_1
Spruce	0.23059	2.20101
Beech	0.04940	2.54946

No inventory data were available for the new German Länder for the year 1990. The only available data source of some relevance is the Datenspeicher Waldfonds of 1993, which surveyed the stocks and the forested areas in the new German Länder via a consistent method. For this reason, in the present submission, as in past submissions, raw-wood stocks have been converted into biomass, using the methods described in BURSCHEL et. al (1993). In a first step of the relevant process, the raw-wood volume is multiplied by the applicable root percentage; this yields the pertinent below-

¹⁰⁹ For this function, no figure for RMSE% is available. Therefore, the IPCC standard value of 50% has been used.

ground volume. Then the raw-wood volume and the below-ground volume are multiplied by a volume-expansion factor. The product of that multiplication is then the applicable total tree-wood volume. The branch volume is obtained by subtracting the raw-wood volume and the below-ground volume from the tree-wood volume. Then, the various volumes are multiplied by the bulk density, using specific-bulk-density figures pursuant to PISTORIUS et. al (2006). All relevant values are listed in the following tables.

Table 343: Root percentages and bulk densities for conversion of Datenspeicher Waldfonds data

Tree species	Root percentage (up to 20 years old)	Root percentage (> 20 years)	RMSE%	Bulk density (roundwood and roots)	Bulk density (branch wood)	RMSE%
Spruce	100	30	50	0.38	0.49	18.8
Fir	100	25	50	0.36	0.49	22.7
Douglas fir	100	25	50	0.41	0.49	20.7
Pine	100	25	50	0.43	0.49	27.2
Larch	100	25	50	0.49	0.49	18.2
Beech	100	25	50	0.56	0.54	13.7
Oak	100	25	50	0.57	0.57	19.8
Hard hardwoods	100	25	50	0.56	0.57	15.0
Soft hardwoods	100	25	50	0.46	0.54	8.7

Table 344: Volume-expansion factors for conversion of raw-wood volume + below-ground volume into the tree-wood volumes of the Datenspeicher Waldfonds data

Tree species	0 through 20 years	21 through 40 years	41 through 60 years	61 through 80 years	81 through 100 years	101 through 120 years	121 through 140 years	141 through 160 years	> 160 years	RMSE%
Spruce	4	1.65	1.51	1.45	1.45	1.45	1.46	1.47	1.48	50
Fir	4	1.52	1.44	1.44	1.38	1.41	1.41	1.42	1.41	50
Douglas fir	4	1.65	1.51	1.45	1.45	1.45	1.46	1.47	1.48	50
Pine	4	1.51	1.42	1.40	1.36	1.34	1.34	1.34	1.33	50
Larch	4	1.51	1.42	1.40	1.36	1.34	1.34	1.34	1.33	50
Beech	4	1.69	1.47	1.41	1.38	1.39	1.39	1.38	1.39	50
Oak	4	1.58	1.41	1.39	1.37	1.35	1.34	1.35	1.34	50
Hard hardwoods	4	1.69	1.47	1.41	1.38	1.39	1.39	1.38	1.39	50
Soft hardwoods	4	1.69	1.47	1.41	1.38	1.39	1.39	1.38	1.39	50

No uncertainties are known for the root percentage and for the volume-expansion factor. For this reason, the IPCC standard value of 50 % has been used.

6.4.2.2.5 Conversion into below-ground biomass

As of the 2015 Submission, biomass functions, based on reviewed articles, are being used. This addresses the need for consistency between the method used to derive above-ground biomass and that used to derive below-ground biomass, as well as the need for overall clarity and transparency. The Thünen Institut has developed a separate biomass function for derivation of below-ground biomass for pine. All biomass functions chosen are of the form Equation 30.

Equation 30

$$Y_{BIOM_u} = b_0 BHD^{b_1}$$

Y_{BIOM_u} = Below-ground biomass in kg per individual tree,

$b_{0,1}$ = Coefficients of the below-ground biomass function.

Table 345:

Tree species	b ₀	Parameter	b ₁	RMSE%	Region	Source
Spruce	0.003720	DBH [cm]	2.792465	34.6	Solling	BOLTE (2003)
Pine	0.006089	DBH [cm]	2.739073	26.3	Barnim	NEUBAUER & DEMANT (2013)
Beech	0.018256	DBH [cm]	2.321997	49.0	Solling	BOLTE (2003)
Oak	0.028000	DBH [cm]	2.440000	50.0 ¹¹⁰	Northeast France	DREXHAGE (2001) in BOLTE (2003)
Soft hardwoods (root biomass)	0.000010	DBH [mm]	2.529000	9.6	South Sweden	JOHANNSSON (2012)
Soft hardwoods (root-stump biomass) ¹¹¹	0.000116	DBH [mm]	2.290300	15.9	South Sweden	JOHANNSSON (2012)

The log functions available in the literature (cf. Figure 58) were intentionally not used. "Back transformation" of log error values, for further use in the error budget, either was unfeasible or, in cases in which the original measurements were available, yielded values as high as they were in the original scale units.

Like the Thünen Institute's own pine function (NEUBAUER & DEMANT, 2013), the function provided by DREXHAGE (2001) in BOLTE (2003), for oak, is unique in the European context. The selected functions for beech and spruce cover a considerably broader area of DBH distribution, especially for larger diameters, than do the comparable studies of WUTZLER et. al. (2008) and WIRTH et. al. (2004a). The functions thus have a considerably smaller extrapolation region, which prevents upward "drifting" of biomass values (cf. Figure 58).

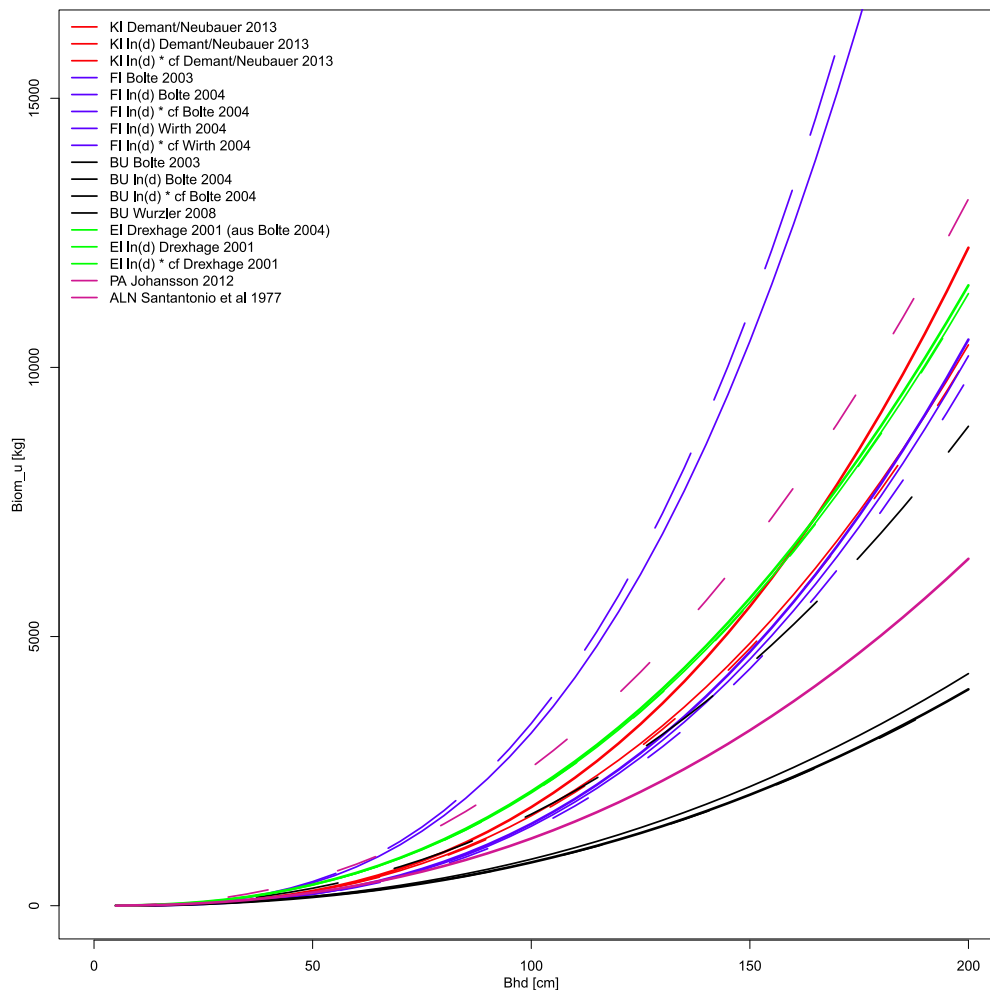
At the same time, the chosen functions for spruce and beech were derived through study of a small region, the "Solling" region. By contrast, the functions of WUTZLER et. al. (2008) and WIRTH et. al. (2004a) include data from a range of different, and geographically different, studies.

This comparison of the chosen functions for spruce, beech and soft hardwoods (in each case, the unbroken line in Figure 58) with functions from other publications shows that the chosen functions always produce conservative estimates of biomass stocks. The rates of change between two states are thus also small, by comparison to the corresponding figures produced by other functions. Since carbon accumulates in the category of below-ground biomass, throughout the entire period covered by the report, the estimates of the sequestration rate may be considered conservative.

¹¹⁰ For these function, no figure for RMSE% is available. Therefore, the IPCC default value of 50% has been used.

¹¹¹ The mean RMSE% for both functions (root-stump biomass + root biomass) is 24.2%.

Figure 58: Comparison of different functions for derivation of below-ground biomass



6.4.2.2.6 Conversion of individual-tree biomass to carbon

A value of 0.5 has been applied for conversion of biomass into carbon stocks. WIRTH et al. (2004b) report that the differences between compartments, within one and the same tree species, are larger than the differences between tree species. They obtain a range of 0.50 to 0.56 g C g⁻¹ in conifers. The relative standard error for carbon content in wood is given by BURSCHEL et al. (1993) as 1 to 2 %; WEISS et al. (2000) use 2 %. Overall, therefore, 0.5 g C g⁻¹, with a relative standard error of ± 2 %, seems appropriate as a good assumption for mean carbon content.

6.4.2.2.7 State estimator for 1987, 2002, 2008 and 2012

Some German Länder (states) use a sampling network with grids smaller than 4 x 4 km. In addition, some Länder have increased the density of their sampling networks between the inventories. For this reason, extrapolation to the level of the national territory has to take place in a stratified manner, using sampling strata with networks of homogeneous densities. This section presents the procedures for scaling up the values "raw-wood stocks", "biomass" and "carbon", in the framework of the stratified sampling plan, for given time periods. The relevant states for the years 1987, 2002, 2008 and 2012 were calculated. The up-scaling procedures for different domains (all of Germany, various regions (old/new Länder) and different LULUCF/ARD categories) are identical.

The National Forest Inventory is designed on a basis of cluster sampling. The smallest sampling unit is the cluster, with four cluster points (sample points). Along the boundaries of the inventory area, or of sampling strata, incomplete clusters, of varying sizes, will be found, i.e. the number of sample points (cluster points in forest and non-forest) within such clusters can vary between 1 and 4. For each cluster c located within a stratum l , the local density (Y) must be calculated first:

Equation 31

$$Y_{lc} = \frac{\sum_{m=1}^M I_{l,c,m} Y_{l,c,m}}{M_{l,c}}$$

where $M_{l,c}$ = number of sample points in cluster c in stratum l . The estimator of means, with respect to forest and non-forest, for stratum l is then obtained as follows:

Equation 32

$$\hat{Y}_l = \frac{\sum_{c_l=1}^{C_l} M_{l,c} Y_{lc}}{\sum_{c_l=1}^{C_l} M_l}$$

The estimator of means for a given value, throughout all sampling strata ($\hat{Y}_{st}$), is the mean of the individual stratum estimators, weighted with the area proportions for the various strata:

Equation 33

$$\hat{Y}_{st} = \sum_{l=1}^L \hat{Y}_l \frac{\lambda(U_l)}{\lambda(U)}$$

The estimator of the total is obtained by multiplying the estimator of means throughout all strata by the total area $\lambda(U)$.

Equation 34

$$\hat{Y}_{st} = \hat{Y}_{st} \lambda(U)$$

The (forest-) area-related mean estimator is defined as the quotient or ratio estimator ($\hat{R}_{st}$); it is obtained as follows:

Equation 35

$$\hat{R}_{st} = \frac{\hat{Y}_{st}}{\lambda(U_{forest})}$$

6.4.2.2.8 Estimator for stock changes, in keeping with the "stock-difference method"

For calculation of the changes between two time points (the periods 1987-2002, 2002-2008 and 2008-2012), the "continuous forest inventory" (CFI) method was used, i.e. for up-scaling only those cluster points were used that were included at both times. The change estimate is thus based on the difference between the two status estimators. At the stratum level, the total change is estimated as follows:

Equation 36

$$\hat{G}_l = \hat{Y}_l^{(t_2)} - \hat{Y}_l^{(t_1)}$$

The total change throughout all strata for a given domain is estimated in the manner used in Equation 33. The estimated total change is calculated via Equation 34. The change in the area-related mean estimator is determined via:

Equation 37

$$\hat{G}_{Rst} = \hat{R}_{st}^{(t_2)} - \hat{R}_{st}^{(t_1)}$$

6.4.2.2.9 Interpolation of time periods, to obtain annual-change estimates

The National Forest Inventory (BWI; Bundeswaldinventur) is carried out periodically. Consequently, annual rates of change – "emission factors" – have to be obtained via interpolation between two points in time. For the time periods between the inventories BWI 1987, BWI 2002, the IS 2008 and BWI 2012, linear interpolation was carried out at the level of the LULUCF and ARD classes. The emission factor EF for a LULUCF class is thus defined as the quotient of the area-related mean estimator and the number of years a within the relevant inventory interval:

Equation 38

$$EF = \frac{\hat{G}_{Rst}}{a}$$

Consequently, Equation 27 is equivalent to Equation 2.5 of the 2006 IPCC Guidelines (IPCC, 2006):

Equation 2.5, 2006 IPCC Guidelines

$$\Delta C = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$

A linear trend was also chosen in cases in which change estimates had to be extrapolated into the future, beyond an inventory period.

6.4.2.3 Dead wood (CRF Table 4.A)

6.4.2.3.1 Forest Land remaining Forest Land

The changes in dead-wood carbon stocks are calculated with the stock-difference method, a Tier 2 method (Equation 2.19, 2006 IPCC Guidelines).

The C stocks in dead wood were calculated with data of the BWI 2002 (BMELV 2005) survey, the Inventory Study 2008 and the BWI 2012. The BWI 1987 did not include any surveys of dead wood, and thus no dead-wood data for that time are available. The terrestrial survey used for the BWI 2002 included only fallen dead wood with a thicker-end diameter of at least 20 cm, standing dead wood with a diameter of at least 20 cm at breast height (DBH), and trunks with either a height of at least 50 cm or a cut-surface diameter of at least 60 cm (BMVEL 2001). In keeping with requirements for climate reporting, in the Inventory Study 2008 and the BWI 2012 the survey threshold for dead-wood objects was reduced to a diameter of at least 10 cm at the thicker end (BMELV 2010). In all three forest inventories, trees were sub-divided into three main tree-species groups: conifers, deciduous trees (except for oaks) and oaks. In addition, dead wood was classified into a total of four decomposition-level categories (BMELV 2010, BMVEL 2001).

For purposes of reporting pursuant to the 2006 IPCC Guidelines, the applicable dead-wood-stock relationship between the 10 cm and 20 cm survey limits was determined from the data collected in the Inventory Study. Under the assumption that that relationship was the same at the time of the BWI 2002, the dead-wood stocks from the 10 cm survey limit upward were estimated for the year 2002. The biomass of the dead wood stocks from the BWI 2002, the Inventory Study (2008) and the BWI 2012, for the various relevant decomposition classes, was determined with the wood density figures pursuant to FRAVER et al. (2002) for conifers, and with the wood density figures pursuant to MÜLLER-USING & BARTSCH (2009) for deciduous trees. To calculate the wood density of deciduous wood, the dead-wood objects in the deciduous (other than oak) and oak tree-species groups were combined. An overview of the biomass-expansion factors and their errors, broken down by tree-species classes and degrees of decomposition, is presented in Table 346.

Table 346: Biomass-expansion factors (BEF) and their errors (RMSE%) for the various tree-species classes and degrees of decomposition (NDH = conifers (Nadelbäume), LBH = deciduous trees (Laubbäume), EI = oak (Eiche))

Type of dead wood	Degree of decomposition	BEF	RMSE%	Source
NDH	1 Just died	0,372	17.2	FRAVER (2002)
NDH	2 Onset of decomposition	0,308	27.9	FRAVER (2002)
NDH	3 Advanced decomposition	0,141	35.5	FRAVER (2002)
NDH	4 Heavily rotted	0,123	25.2	FRAVER (2002)
LBH	1 Just died	0.58	12.1	MÜLLER-USING (2009)
LBH	2 Onset of decomposition	0.37	43.2	MÜLLER-USING (2009)
LBH	3 Advanced decomposition	0.21	33.3	MÜLLER-USING (2009)
LBH	4 Heavily rotted	0.26	65.4	MÜLLER-USING (2009)
EI	1 Just died	0.58	12.1	MÜLLER-USING (2009)
EI	2 Onset of decomposition	0.37	43.2	MÜLLER-USING (2009)
EI	3 Advanced decomposition	0.21	33.3	MÜLLER-USING (2009)
EI	4 Heavily rotted	0.26	65.4	MÜLLER-USING (2009)

The annual change of the carbon stocks in dead wood was calculated using Equation 39 (Equation 2.19, 2006 IPCC Guidelines). For the period 2002 through 2007, the change amounts to 0.0967 t C ha⁻¹ a⁻¹, and for 2008 through 2015 it amounts to -0.0519 t C ha⁻¹ a⁻¹. For all years in the period 1990 through 2001, the average change in dead-wood C stocks in the periods 2002-2007 and 2008-2012 was used, without change. It amounts to 0.0368 t C ha⁻¹ a⁻¹.

Equation 39

$$\Delta C_{FFDW} = \frac{A * (B_{t_2} - B_{t_1})}{T} CF$$

where:

ΔC_{FFDW} = Annual change in carbon stocks in dead wood, on forest land remaining forest land

A = Area of forest land remaining forest land

B_{t_1} = Dead-wood stocks at time t_1 (beginning of the period) for forest land remaining forest land

B_{t_2} = Dead-wood stocks at time t_2 (end of the period) for forest land remaining forest land

$T=(t_2-t_1)$ = Time period between the two estimates

CF = Carbon conversion factor (standard value = 0.5)

6.4.2.3.2 Land converted to Forest Land

The annual changes in carbon stocks in dead wood on land converted to forest land were calculated using Equation 2.19 of the 2006 IPCC Guidelines (IPCC, 2006). That equation is identical with the equation for calculating changes in dead-wood carbon stocks on forest land remaining forest land (cf. Equation 39). The dead-wood C stocks on land converted to forest land in 2012 (t_2) are determined via the data of the BWI 2012. Those areas that at the time of the BWI 1987 were

not forest areas count as land converted to forest land. Consequently, therefore, the dead-wood C stocks at time 1987 (t1) are assumed to be zero. The interval between the two time points is 25 years, which, for purposes of reporting under both the Convention and the Kyoto Protocol, leads to underestimation of the change in dead-wood C stocks. The method being applied is thus a conservative one. On land converted to forest land, the annual carbon-stocks change in dead wood amounts to $0.0344 \text{ t C ha}^{-1} \text{ a}^{-1}$.

Only the data of the BWI 2012 were available for determination of dead-wood C stocks on land converted to forest land. The Inventory Study 2008 did not survey land converted to forest land. With regard to dead wood, the BWI 2002 only included dead wood with a diameter of at least 20 cm at its thicker end (fallen dead wood) or with a DBH of at least 20 cm (standing dead wood). and the BWI 1987 did not survey dead wood at all.

6.4.2.4 Litter (CRF Table 4.A)

6.4.2.4.1 Forest Land remaining Forest Land

The changes in carbon stocks in litter are calculated with the stock-difference method, a Tier 2 method (Equation 2.19, 2006 IPCC Guidelines).

The calculation of carbon-stocks changes in the soil and in litter is based on data from national forest-soil inventories (BZE I and BZE II; cf. Chapter 6.4.2.1.2, Grueneberg et al. 2014). A slight decrease in carbon stocks, amounting to $-0.02 \text{ t C ha}^{-1} \text{ a}^{-1}$, occurred in the period from 1990 (BZE I) to 2006 (BZE II) (Grueneberg et al. 2014). That trend is assumed to be valid as well for the period 2007 to 2015. A detailed description of the method used to determine the carbon-stock change in litter is presented in Chapter 6.4.2.4.4.

6.4.2.4.2 Land converted to Forest Land

The carbon-stock changes were calculated with the Tier 2 method (Equation 2.23, 2006 IPCC Guidelines). To use this method, one has to derive the annual rate of carbon-stock change. That rate is calculated from the average litter stocks in forests, under equilibrium conditions, and the transition period that is required for litter stocks to develop following afforestation.

Calculations relative to the litter ground cover were carried out with the status data of the BZE I and BZE II Forest Soil Inventories. According to those calculations, the mean carbon stocks in litter, referenced to 1990 (BZE I), were 19.0 t C ha^{-1} , and, referenced to 2006 (BZE II), 18.8 t C ha^{-1} . It was found that the average carbon stocks in litter in forests also exhibited a slight trend. The average litter carbon stocks are being adjusted in keeping with that trend. For the period 1991 to 2005, the mean carbon stocks in litter are obtained via interpolation; for the period as of 2007 they are obtained via extrapolation and used as a basis for calculating afforestation areas (cf. Table 347). A description of the method used to derive carbon stocks in litter is presented in Chapter 6.4.2.4.3).

Table 347: Implied emission factors (IEF) (carbon) for litter in the land-use categories with conversion to forest land (Land converted to Forest Land)

Year	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
IEF [t C ha ⁻¹]	0.4750	0.4734	0.4719	0.4703	0.4700	0.4697	0.4694	0.4691	0.4688	0.4684	0.4681
Year	2013	2014	2015								
IEF [t C ha ⁻¹]	0.4678	0.4675	0.4672								

It was assumed that in the transition period, the resulting average carbon stocks take 40 years to form in litter. That figure is confirmed by standard values for carbon storage in litter, and by standard values for the time periods required for a new balance to form pursuant to PAUL et al.

(2009) and the 2003 Good Practice Guidance, Table 3.2.1 (IPCC, 2003). In IPCC Table 3.2.1, the warm, temperate climate zone is assumed to be moist in Germany, and an applicable mean value is obtained from the values for deciduous forests and coniferous forests. The annual carbon-stock increase in litter is obtained by dividing the mean carbon stocks for the year in question by the number of years required for those mean carbon stocks to form.

The afforestation areas were not further subdivided into the classes "natural regeneration" and "human induced" (cf. Chapter 11.4.1).

6.4.2.4.3 Derivation of carbon stocks in litter

Litter was sampled at the relevant inventory points. This was accomplished by taking mixed samples at satellite points, using sampling frames of various sizes (GRUENEGER et al., 2014). In keeping with the 2006 IPCC Guidelines, litter was considered to include the entire dead organic surface layer, including the L, Of and Oh horizons (IPCC, 2006). Organic carbon concentrations in the litter were measured via comparable methods. The following relationship is relevant: total carbon (C_{ges}) is equal to organic carbon (C_{org}) ($[C_{ges}] = [C_{org}]$). In each case, the carbon stocks in litter are calculated from the area of the sampling frame, and from the weight and organic concentration of the relevant litter. A description of the methods used for relevant sampling and analysis is presented in WELLBROCK et al. 2006 and KÖNIG et al. 2005.

All points available from the BZE I and BZE II surveys, along with information as to the forest type concerned in each case, entered into calculation of litter carbon stocks. All values that were either smaller or larger than twice the standard deviation ($x \pm 2 \sigma$) were considered to be outliers and were deleted. From the values of the remaining data points for the BZE I ($n = 1629$) and BZE II ($n = 1542$) surveys, it was possible to calculate carbon stocks separately for deciduous, coniferous and mixed forest (cf. Table 348). The mean carbon stocks given by the two inventories were calculated as a weighted mean from the carbon stocks for the three forest types concerned. The applicable weights were obtained from the forest types' area shares of the total forest area, as given by CORINE Land-Cover data for 1990 and 2006, and from the regional densities of the inventory networks. The mean carbon stocks in the samples were $19.0 \pm 0.3 \text{ t C ha}^{-1}$, for BZE I, and $18.8 \pm 0.3 \text{ t C ha}^{-1}$, for BZE II (GRUENEGER et al. 2014). These values serve as the basis for calculating CO_2 emissions from litter in connection with deforestation (cf. Chapter 11.3.1.4) and carbon sequestration in litter in connection with afforestation (cf. Chapter 6.4.2.4.2).

Table 348: Carbon stocks in litter in German forests, as determined in the BZE I and BZE II inventories, along with the pertinent standard error (Grueneberg et al. 2014)

Forest type	Carbon stocks (BZE I) [t C ha ⁻¹]	Carbon stocks (BZE II) [t C ha ⁻¹]
Deciduous forest	8.35 ± 0.37	6.78 ± 0.30
Mixed forest	17.94 ± 0.63	14.99 ± 0.70
Coniferous forest	23.75 ± 0.44	25.23 ± 0.49
Total forest	19.04 ± 0.30	18.83 ± 0.32

6.4.2.4.4 Derivation of carbon-stock changes in litter in the period from 1990 (BZE I) to 2006 (BZE II)

The sampling plots entering into calculation of carbon stocks were analysed as unpaired samples. With a two-sided t-test for unpaired samples, it was tested whether the carbon stocks (which had been logarithmised) at the two inventory times differed. Each sampling plot was assigned a weight

consisting of the area percentage for the relevant stratum and the regional network density. The average difference was $-0.02 \pm 0.02 \text{ t C ha}^{-1} \text{ a}^{-1}$ (GRUENEGER et al. 2014). The value does not deviate significantly from zero.

For Land converted to Forest Land, annually decreasing factors for litter accumulation were calculated from the carbon stocks given by BZE I / BZE II and the average difference (cf. Chapter 6.4.2.4.2 and Table 347).

6.4.2.5 Mineral soils (CRF Table 4.A)

6.4.2.5.1 Forest Land remaining Forest Land

The changes in carbon stocks in mineral soils are calculated with the Tier 2 method of the 2006 IPCC Guidelines (Equation 2.25, IPCC, 2006).

Carbon stocks, and carbon-stock changes, in mineral soils were up-scaled on the basis of the national forest soil inventories (BZE I and BZE II) (cf. Chapter 6.4.2.1.2), in accordance with GRUENEGER et al. 2014. With the available data, the changes in mineral soils were calculated, with respect to both inventories. The relevant methods are described in detail in chapters 6.4.2.5.3 and 6.4.2.5.4. The resulting extrapolation for the entire national territory yielded a mean annual increase in carbon stocks in mineral soils of $0.41 \pm 0.11 \text{ t C ha}^{-1}$. It has been assumed that that trend also continued in the period 2007 to 2014.

6.4.2.5.2 Land converted to Forest Land

For land converted to forest land, as with forest land remaining forest land, the carbon-stock change in mineral soils is calculated via the Tier 2 method (Equation 2.25, 2006 IPCC Guidelines).

For Land converted to Forest Land, the carbon-stock changes in mineral soils were calculated in keeping with the procedure in Chapter 6.1.2.1. The calculated mean emission factors (implied emission factors) for the year 2012, which are summarised in Table 306 in Chapter 6.1.2.1, are oriented to annual carbon-stock changes in mineral soils in connection with land-use changes leading to Forest Land (Land converted to Forest Land), over a change period of 20 years.

6.4.2.5.3 Derivation of carbon stocks and carbon-stock changes

The carbon stocks and their changes were derived on the basis of inventory data (cf. Chapter 6.4.2.1.2, Grueneberg et al. 2014). Mineral soil was sampled at depths of relevance for the national inventory report; at most BZE points, this involved depth ranges of 0-5 cm, 5-10 cm and 10-30 cm. In a few cases, samples were taken on a horizon basis.

As part of sampling, the fine-earth bulk density (TRD_{fb}), the coarse-fragment content (GBA) and the organic-carbon concentration (C_{org}) were determined using comparable methods (KÖNIG et al., 2005). The fine-earth bulk density was determined via volume-adapted sampling, for different depth ranges; to some extent, estimated values based on soil profiles were used (WOLFF & RIEK 1996, WELLBROCK et al. 2006). Where fine-earth bulk-density data is lacking, existing relevant values from other inventories have been used. That procedure has also been applied to obtain coarse-fragment-content values, which are needed for calculation of the TRD_{fb} and fine-earth stocks.

In carbonate-containing soils, the organic-carbon concentration (C_{org}) in fine soils was measured with respect to the inorganic-carbon concentration (C_{inorg}) ($[C_{\text{org}}] = [C_{\text{total}}] - [C_{\text{inorg}}]$). In non-carbonate-containing soils, the relationship $[C_{\text{org}}] = [C_{\text{total}}]$ applies.

The total carbon stocks per sample were calculated from the stocks for the individual depth layers. To that end, it was necessary first to translate horizon-based data into depth-layer sections. This was accomplished, in each case, by calculating the carbon stocks in a given depth layer, with stocks weighted in accordance with the thicknesses of overlapping sections and their carbon stocks.

An area-referenced approach, with strata formation, was used for calculation of carbon stocks and of their changes between the two inventory times. The basis for formation of area-relevant strata consisted of the 72 legend units used in the national soil map "Bodenübersichtskarte der Bundesrepublik Deutschland 1:1.000.000" (BÜK 1000). That source describes the dominant soil types, and parent material for soil formation, pursuant to the German soil system (AG BODEN 1994) and FAO (FAO, 1990). Since the classes concerned differed in the number of sample points they contained, the various dominant soil units were aggregated into new dominant soil groups. This increased the basic totality for each class, thereby increasing the pertinent statistical significance. The groups formed were oriented to comparable soil types, to substrate type and parent material and to texture and lime content. All in all, 16 new dominant soil groups, with their pertinent parent material, were then available for area-referenced evaluation (cf. Table 349). The inventory plots were allocated to the dominant soil groups on the basis of data, collected in the inventories, relative to the parent material and any layering of that material, to soil type, to horizon sequences and to soil texture.

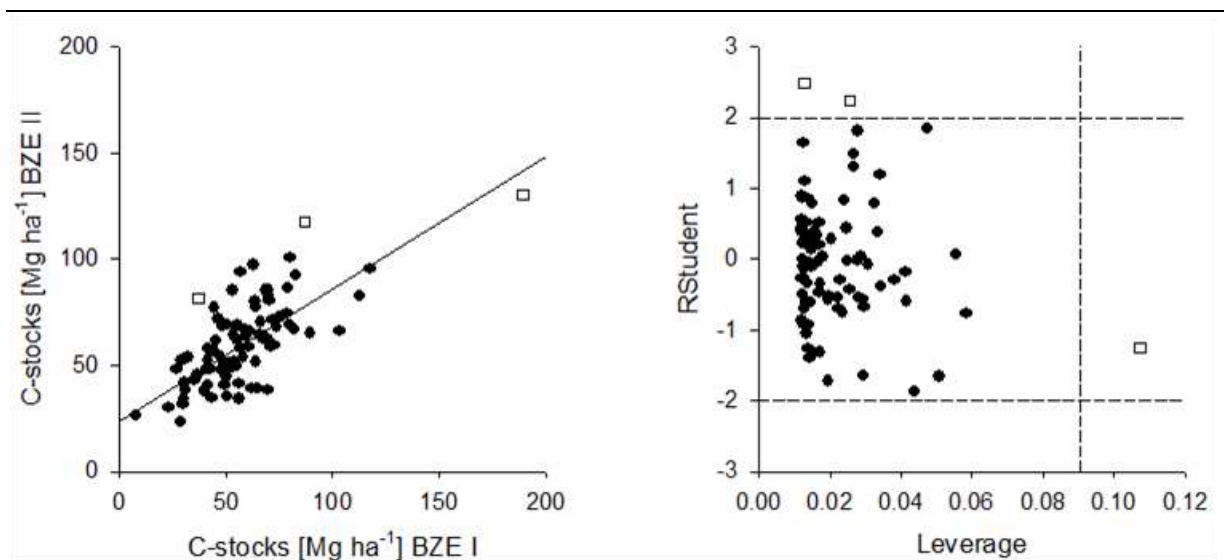
Table 349: Combined legend units on the basis of the BÜK 1000 soil map

Abb.	Dominant soil groups, by substrate type, soil texture and lime content
1	Nutrient-poor soils from dry, nutrient-poor sands
2	Various soils from sandy to loamy terrace or riverine deposits
3	Various soils from partly calcareous, loamy-clayey terrace or riverine deposits
4	Pseudo-gleyed soils from sandy to loamy sediments overlying boulder clay
5	Various soils from sandy sediments overlying boulder clay
6	Brown earths from nutrient-rich sands
7	Soils of loess areas
8	Various soils from scree overlying calcareous, marl and dolomite rock, alternating with terra fusca from silty-clayey redeposited products of limestone weathering
9	Brown earth and terra fusca from redeposited products of weathering of calcareous, marl and dolomite rock, and rendzina from limestone
10	Pelosol – brown earth / pelosol-pseudogley from weathering products of marl and clay rocks and calcareous layers
11	Brown earth from alkilene and intermediary magmatic rock
12	Brown earth from acidic magmatic and metamorphic rock
13	Brown-earth / podzolic soils from hard clayey and silty slates with fractions of greywacke, sandstone, siltstone, quartzite and phyllite
14	Podzols / brown earths from low-alkalinity quartzites, sandstones and conglomerates
15	Various soils alternating tightly with greywacke, clay slate, limestone, sandy, silty and clayey stones and loess-loam overlying various rocks
16	High-mountain soils from limestone, dolomite rock and silicate rock

For purposes of analysis, carbon-stocks data were available from a total of 1,865 points from the BZE I inventory, and from 1,813 points from the BZE II inventory (GRUENEGER et al. 2014). With the exception of the data from two German Länder (states), the data were available mainly as paired samples, i.e. samples in which it was possible to correlate each BZE I point with exactly one BZE II point. The number of points that entered into the final calculation was lower than the number suggested by the above figures, however. This was because some organic-soil areas were excluded, because a) it proved impossible to assign the relevant points to a dominant soil unit or b) because their stocks were seen to be implausible, on the basis of outlier analysis, and thus were rejected. For the analysis, the total sample, broken down by German Länder (states), was divided into a paired sample subset and an unpaired sample subset. In the paired sample subset, it proved

possible to identify outliers via residual analysis. To that end, the carbon stocks for each dominant soil unit, at the various inventory time points, were compared via plotting in a linear regression. A relevant example is presented in Figure 59 (on the left). Studentised residuals were used to eliminate outliers that seemed inconsistent with the rest of the data (cf. Figure 59 (on the right)). In addition, a "hat matrix" was generated, for identification of "leverage" points¹¹² that represent outliers within the independent variable (cf. Figure 59 (right)) (WEISBERG 2005).

Figure 59: Regression between carbon stocks (0-30cm) as shown by BZE II data and the BZE I data (left), and outliers identified via residuals analysis with studentised residuals (middle) and "high-leverage" points (right), illustrated with the example of a dominant soil group



Since some Länder have shifted the grid between the BZE I and BZE II inventories, the points for which assignment to a dominant soil group was possible are available as unpaired samples. Carbon stocks for those plots were calculated via formation of mean values for each dominant soil group. Outliers for each class were detected via double standard deviation ($\bar{x} \pm 2\sigma$) and then removed. In addition, organic soils were excluded. Then, the mean carbon stocks for each dominant soil group were correlated with the relevant annual differences. After elimination of the outliers, via outlier analysis, a total of 1577 points from the BZE I inventory, and 1539 points from the BZE II inventory, were left. Of those, a total of 1075 points were available as paired samples.

To permit area-weighted calculation of carbon-stock changes, the forest areas on the dominant soil groups were determined as percentage shares of Germany's total forested area. To that end, the CORINE Land Cover data were combined with the Soil map for the Federal Republic of Germany 1:1,000,000 (BÜK 1000), within a Geographic Information System (GIS). In each case, it proved possible to correlate a forest area with the mean carbon-stock change for a dominant soil group. That, in turn, made it possible to calculate the average annual change in organic carbon for Germany, taking account of the selected dominant soil groups' shares of the total relevant area.

6.4.2.5.4 Results of derivation of carbon stocks and carbon-stock changes

On the basis of the area-weighted approach, the carbon stocks in Germany's mineral soil, to a depth of 30 cm, amounted to $55.6 \pm 3.4 \text{ t C ha}^{-1}$ at the time of the BZE I inventory, and to $61.8 \pm 3.7 \text{ t C ha}^{-1}$ at the time of the BZE II inventories. Those figures translated into annual increases of

¹¹² Leverage is a dimensionless statistical indicator that shows how strongly a given individual value is influencing a given statistical regression model.

$0.41 \pm 0.11 \text{ t C ha}^{-1}$ (GRUENEGERG et al., 2014). A variance analysis (type III – ANOVA) showed that the differences between the two inventories were significant ($p < 0.001$). Both the rate of change and the total stocks lie within a range that other authors have already estimated for central Europe. Estimates of annual carbon sequestration in the root zone range from $0.1 \text{ t C ha}^{-1} \text{ a}^{-1}$ (NABUURS & SCHELHAAS 2002) to $0.9 \text{ t C ha}^{-1} \text{ a}^{-1}$ (SCHULZE et al. 2000). Most of the values given in the literature are based on model-based up-scaling, and they take the soil's entire root zone into account (LISKI et al. 2002; DE VRIES et al. 2006). In comparison to those studies, the present effort was able to draw on considerably more measurement plots, arrayed within a finer grid. Those data represent a more valid sample, one that supports conclusions for Germany that are more reliable and that have a complete-coverage focus.

For nearly all dominant soil groups, carbon stocks, broken down by classes, were estimated to be higher at the time of the BZE II inventory than they had been at the time of the BZE I inventory (cf. Table 350). In addition, carbon stocks were higher in soils with high clay content than they were in soils with high sand content. The reasons for this are discussed in, for example, SIX et al. (2002) and BARITZ et al. (2010). Evaluation of the time series between the BZE I and BZE II inventories shows greater annual changes in carbon stocks especially in sandy dominant soil groups of the North German lowlands. For example, the annual relevant rate of change for the dominant soil units 1, 5 and 6 was greater than $0.6 \text{ t C ha}^{-1} \text{ a}^{-1}$ (Grueneberg et al. 2014). On the other hand, PRIETZEL et al. (2006) put carbon sequestration, in the upper 30 cm, at $0.2 \text{ t C ha}^{-1} \text{ a}^{-1}$ on sandy locations and at $0.4 \text{ t C ha}^{-1} \text{ a}^{-1}$ on loamy locations. Smaller positive changes in carbon stocks, ranging between 0.1 and $0.6 \text{ t C ha}^{-1} \text{ a}^{-1}$, were found in over half of all classes formed. A marked decrease in carbon stocks, between the two inventory times, was seen in class 9.

Table 350: Carbon stocks at the time of the BZE I, and at the time of the BZE II, in the newly formed dominant soil units (Grueneberg et al. 2014)

DSU	n	Carbon stocks (BZE I) [t C ha ⁻¹]		n	Carbon stocks (BZE II) [t C ha ⁻¹]	
		MV	SE		MV	SE
1	201	52.8	1.6	187	65.5	6.8
2	56	60.5	2.6	62	65.0	4.9
3	20	67.3	3.2	25	68.1	2.4
4	105	66.4	1.8	87	64.1	4.5
5	77	33.4	1.6	75	52.8	2.2
6	34	24.6	1.6	34	43.7	1.8
7	126	55.8	1.5	109	63.0	2.2
8	110	76.3	2.4	106	79.1	0.8
9	36	77.1	4.9	43	68.3	1.0
10	55	56.7	2.1	63	60.8	0.8
11	39	51.3	3.2	39	54.6	0.9
12	187	59.5	1.7	163	62.5	2.2
13	222	54.7	1.4	233	60.1	4.1
14	245	50.5	1.2	257	55.3	3.2
15	30	51.8	2.9	30	49.0	0.9
16	34	84.4	6.2	26	104.5	0.5

(DSU = dominant soil units, n = number of soil samples, MV = mean value, SE = standard error)

6.4.2.6 Organic soils (CRF Table 4.A)

This chapter solely discusses CO₂ emissions from organic soils. Those emissions are entered in CRF Table 4.A, under "organic soils". The methods applied for N₂O and CH₄ greenhouse-gas emissions are described in Chapter 6.4.2.7.2. Those emissions are reported in CRF Table 4(II).

6.4.2.6.1 Forest Land remaining Forest Land

The areas covered by organic soils were determined via a georeferencing procedure, with overlaying of the "map of organic soils" ("Karte organischer Böden") and ATKIS® data. In the process, drained and non-drained organic soils are differentiated. For Forest Land remaining Forest Land, the organic soils area for the year 2015 is 112,420 ha, and 77 % of that area is drained. A detailed description of the method used to derive organic-soil areas is presented in Chapter 6.1.2.2.1.

The derivation of the relevant emission factor is described in Chapters 6.1.2.2.2 and 6.1.2.2.3. Table 351 summarizes the implied emission factors for organic forest soils.

Table 351: Implied emission factors (IEF) (carbon) for organic soils

Year	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
IEF [t C ha ⁻¹]	-2.1034	-2.1442	-2.1811	-2.2099	-2.2112	-2.2124	-2.2136	-2.2144	-2.2151	-2.2158	-2.2166
Year	2013	2014	2015								
IEF [t C ha ⁻¹]	-2.2222	-2.2277	-2.2331								

6.4.2.6.2 Land converted to Forest Land

In an approach similar to that used for Forest Land remaining Forest Land, a total of 77 % of all Land converted to Forest Land, on organic soils, is assumed to be drained (cf. Chapter 6.1.2.2.1). The emission factors presented in Table 351 are also used for organic soils on Land converted to Forest Land. Those annual emissions are being reported for all years since the relevant conversions. The manner in which greenhouse-gas emissions from organic soils are derived, for all land-use categories, is described in Chapter 6.1.2.2.

6.4.2.7 Other greenhouse-gas emissions from forests

6.4.2.7.1 Nitrous oxide emissions from nitrogen fertilisation (CRF Table 4(I))

No nitrogen fertilisation in forests takes place in Germany. In CRF Table 4(I), therefore, this activity has been marked "NO" (not occurring).

6.4.2.7.2 Drainage and rewetting of organic and mineral soils (CRF Table 4(II))

The derivation of greenhouse-gas emissions, from organic soils, related to drainage and rewetting is described, for all land-use categories, in Chapter 6.1.2.2. The CO₂ emissions for forests are entered in CRF Table 4.A and, in CRF Table 4(II), are marked "IE" (included elsewhere) (cf. also Chapter 6.4.2.6). The pertinent CH₄ and N₂O emissions, on the other hand, are presented in CRF Table 4(II). Table 352 summarizes the implied emission factors for organic forest soils.

No rewetting of mineral soils in forests occurs; in CRF Table 4(II), that category is marked "NO" (not occurring).

Table 352: Implied emission factors (IEF) (methane and nitrogen) for organic soils

Year	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Methane [kg CH ₄ ha ⁻¹]	4.3519	4.4363	4.5125	4.5722	4.5748	4.5774	4.5799	4.5814	4.583	4.5845	4.586	4.5976	4.6201	4.6089
IEF														
Nitrogen [kg N ₂ O-N ha ⁻¹]	1.3056	1.3309	1.3538	1.3717	1.3724	1.3732	1.374	1.3744	1.3749	1.3754	1.3758	1.3793	1.3860	1.3827

6.4.2.7.3 Direct nitrous oxide emissions related to nitrogen mineralisation and immobilisation (CRF Table 4(III))

The manner in which direct N₂O emissions from mineralisation and immobilisation of mineral soils are determined is described in Chapter 6.1.2.1.2. The pertinent N₂O emissions are listed in CRF Table 4(III).

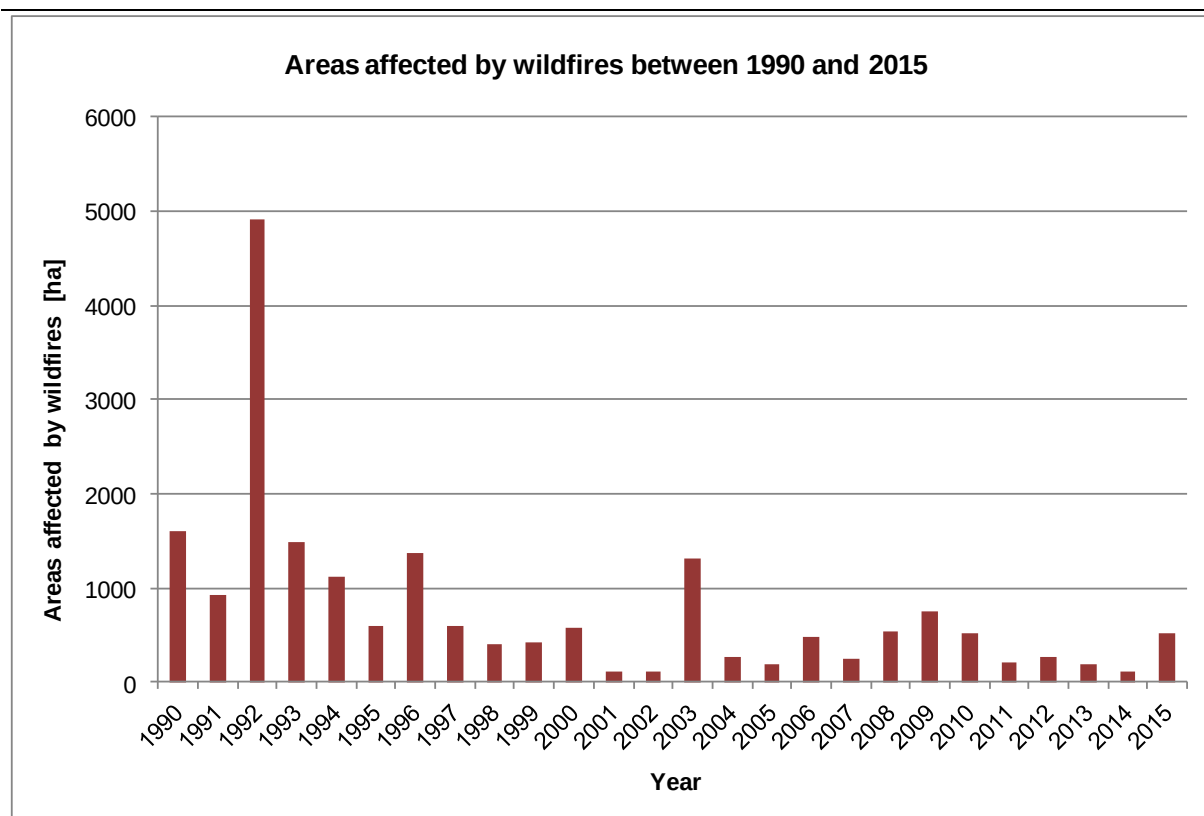
6.4.2.7.4 Indirect nitrous oxide emissions from cultivated soils (CRF Table 4(IV))

The manner in which indirect N₂O emissions related to losses of organic soil substance resulting from land-use changes and cultivation measures are determined is described, in summary form for all land-use categories, in Chapter 6.1.2.1.2. The pertinent N₂O emissions are listed in CRF Table 4(IV).

6.4.2.7.5 Wildfires (CRF Table 4(V))

While in other countries "prescribed burning" is an accepted method for clearing land or for managing ecosystems, no prescribed/controlled burning of biomass is carried out in Germany's managed forests. In CRF-Table 4 (V), therefore, NO is entered in the category "Controlled Burning". In keeping with Germany's climatic situation, and with measures taken in Germany to prevent wildfires, such fires tend to be rather seldom. This conclusion is confirmed by relevant wildfire statistics (BLE, 2016) and their data on areas affected by wildfires (cf. Figure 60). The mean forest area affected annually by wildfires, in the period 1990 – 2015, was 766 ha. In some years, unseasonably high summer temperatures have resulted in larger burn areas. This was the case, for example, in 1996 and 2003. An unusually large burn area, about 4,908 ha, was measured in 1992, which had an extremely warm summer.

Figure 60: Areas affected by wildfires between 1990 and 2015 (pursuant to BLE, 2016)



Along with CO₂, wildfires release a range of other greenhouse gases (CO, CH₄, N₂O, NO_x and NMVOC). The CO₂ emissions resulting from biomass combustion have already been taken into account as part of changes of biomass stocks (CRF Sector 4.A.1 Forest land remaining Forest Land), via the "stock-difference method". For this reason, they are listed as "IE" (included elsewhere). Emissions of other greenhouse gases were calculated with Equation 40 (Equation 2.27, 2006 IPCC Guidelines).

Equation 40

$$L_{fire} = A * B * C * D * 10^{-6}$$

where:

L_{fire} = Quantity of greenhouse gas [t] released via fire

A = Wildfire burn area [ha]

B = Mass of fuel present on the relevant site (biomass) [kgTM ha⁻¹]

C = Combustion efficiency

D = Emission factor [g(kgTM)⁻¹]

The NMVOC emissions were calculated with the pertinent equation pursuant to the 2013 EMEP/EEA Emission Inventory Guidebook.

Equation 41

$$M(C) = 0.45 * A * B * \alpha * \beta$$

where:

0.45 = Average fraction of carbon in fuel wood;

A = Area burnt [m²];

B = Average total biomass of fuel material per unit area [kg m^{-2}];

α = Fraction of average above-ground biomass, relative to the total average biomass B ;

β = Burning efficiency (fraction burnt) of the above-ground biomass.

The data on areas affected by wildfires in the period 1990 to 2015 have been taken from the wildfire statistics maintained by the Federal Agency for Agriculture and Food (BLE; Waldbrandstatistik – BLE 2016). In determination of the relevant areas, no distinction is made between Land converted to Forest Land and Forest Land remaining Forest Land. For this reason, the emissions from Land converted to Forest Land are reported within the section for "Forest Land remaining Forest Land" and listed as "IE" in the CRF tables 4(V). The data available for determination of biomass include the data for 1990 from the BWI 1987 and DSWF; the data for 2002 from the BWI 2002; the data for 2008 from the IS08; and the data for 2012 from the BWI 2012. The mean above-ground biomass for each year was derived via linear interpolation between 1990, 2002, 2008 and 2012, and via extrapolation for the years as of 2013. Pursuant to the expert assessment carried out by KÖNIG (2007), 80 % of the wildfires in Germany remain on the ground surface and 20 % rise into tree crowns. In accordance with Table 2.6 (2006 IPCC Guidelines), a combustion efficiency (mass loss via direct combustion) of 0.15 was used for fires remaining on the ground surface, and an efficiency of 0.45 was used for fires rising into tree crowns. The emission factors for CH_4 , N_2O , CO and NO_x were taken from Table 2.5 (2006 IPCC Guidelines). The emission factor for NMVOC was taken from the 2013 EMEP/EEA Emission Inventory Guidebook.

Germany suffers relatively little wildfire damage in terms of burn area, and thus the relevant CH_4 , N_2O , CO, NO_x and NMVOC gas emissions are low. Except in 1992, the CH_4 emissions lie between 25 t and 271 t, the N_2O emissions lie between 1.4 t and 15 t, the CO_2 emissions lie between 559 t and 6,165 t, the NO_x emissions lie between 16 t and 173 t and the NMVOC emissions lie between 49 t and 545 t. Those emissions ranges were exceeded in 1992 (CH_4 : 857 t, N_2O : 47.4 t, CO_2 : 19,502 t, NO_x : 547 t, NMVOC: 1,722 t), as a result of that year's unusually large burn area, which stemmed from that year's extremely warm summer. The complete time series for greenhouse gases resulting from wildfires is shown in Table 353.

Table 353: Greenhouse gases emitted via wildfires

Year	Above-ground biomass [t ha^{-1}]	Wildfire burn area [ha]	Emitted gases [t]				
			CH_4	N_2O	CO	NO_x	NMVOC
1990	171	1,606	271	15.0	6,165	173	545
1995	186	592	109	6.0	2,472	69	218
2000	201	581	115	6.4	2,621	73	232
2005	210	183	38	2.1	863	24	76
2006	210	482	100	5.5	2,280	64	201
2007	211	256	53	2.9	1,216	34	107
2008	212	539	113	6.2	2,569	72	227
2009	214	757	160	8.9	3,646	102	322
2010	216	522	111	6.2	2,538	71	224
2011	218	214	46	2.6	1,051	29	93
2012	221	269	58	3.2	1,331	37	118
2013	223	199	44	2.4	995	28	88
2014	225	120	27	1.5	606	17	54
2015	227	526	118	6.5	2,680	75	236

6.4.3 Uncertainties and time-series consistency (4.A)

Various uncertainties have to be taken into account in calculation of carbon stocks. The actual uncertainties, however, can only be approximated, with the help of pragmatic approaches.

The uncertainties described in the following chapters enter into a total-error budget for the LULUCF sector that is presented in Chapter 19.4.3.

With regard to the uncertainties in the carbon-conversion factor, we call attention to Chapter 6.4.2.2.6.

When aggregated, error estimates (U) for values ($1, \dots, i, \dots, l$) propagate themselves in two different ways. When two values are added or subtracted, the error propagation is additive (cf. Equation 42).

Equation 42

$$U = \frac{\sqrt{\sum_i (U_i x_i)^2}}{\sum_i x_i}$$

where:

U = Total uncertainty

U_i = Uncertainty for target value

x_i = Quantity of target value

On the other hand, when two values are multiplied or divided, the errors for the two values propagate themselves multiplicatively (cf. Equation 43).

Equation 43

$$U = \sqrt{\sum_i (U_i)^2}$$

6.4.3.1 Uncertainties in estimation of areas affected by land-use changes

The land-use changes are determined via a sample-based system, and thus it was possible to calculate the sampling errors for each LULUCF category (cf. Table 517 in Chapter 19.4.3). The sampling error is calculated in keeping with the formulae in Chapter 6.4.3.2. Once validation has been completed, all other error sources can be ruled out (cf. also Chapter 6.3.3). All areas have been entered significantly.

6.4.3.2 Uncertainties in estimation of emission factors of living and dead biomass

Because biomass cannot be directly measured, a number of error sources enter into the processes of deriving forest biomass and carbon stocks and of deriving changes in forest biomass and carbon stocks. The errors in the biomass functions and in the carbon-conversion factor are listed and discussed in sections 6.4.2.2.4, 6.4.2.2.5 and 6.4.2.2.6. The errors in biomass-conversion factors for dead wood, broken down by tree species and degrees of decomposition, are given in Section 6.4.2.3.

The errors related directly to tree-species groups are added to the uncertainties for the above-ground and below-ground biomass and then aggregated to yield an error figure for the total biomass. Because the biomass stocks at the first time point are subtracted from the stocks at the second time point, the uncertainty for the biomass change is obtained via addition. The error for the total biomass change is multiplied by the error for the carbon-conversion factor and by the sampling error. The sampling error is derived from the variance in the sample. The variance in the change of a ratio estimator (cf. equation 26) $v[\hat{G}_{R_{st}}]$ is defined as follows:

Equation 44:

$$v[\hat{G}_{R_{st}}] = v[\hat{R}_{st}^{(t_2)}] + v[\hat{R}_{st}^{(t_1)}] - 2 \text{cov}[\hat{R}_{st}^{(t_2)}, \hat{R}_{st}^{(t_1)}]$$

where:

$$\text{cov}\left(\hat{R}_{st}^{(2)}, \hat{R}_{st}^{(1)}\right) = \frac{1}{\hat{X}_{st}^{(2)} \hat{X}_{st}^{(1)}} \sum_{l=1}^L \left(\frac{\lambda(U_l)}{\lambda(U)} \right)^2 \frac{1}{n_{2,l}(n_{2,l}-1)}$$

$$\sum_{x \in F_1 \cap S_2} \left(\frac{M(x)}{E(M(x))} \right)^2 \left(d_c^{(2)}(x) - \hat{d}_l^{(2)} \right) \left(d_c^{(1)}(x) - \hat{d}_l^{(1)} \right)$$

where

$$d_c^{(2)}(x) = (Y_c^{(2)}(x) - \hat{R}_{st}^{(2)} X_c^{(2)}(x))$$

and

$$\hat{d}_l^{(2)} = \frac{1}{n_{2,l}} \sum_{x \in F_1 \cap S_2} (Y_c^{(2)}(x) - \hat{R}_{st}^{(2)} X_c^{(2)}(x))$$

with $d_c^{(1)}(x)$ and $\hat{d}_l^{(1)}$ having the corresponding values.

The following tables show the uncertainties for the individual error sources and for the resulting emission factor.

Table 354: Uncertainties in emission factors for living biomass on forest land remaining forest land, for various periods

FM 1987 – 2002	Error % (biomass conversion)					Error % (C)	SE %	RMSE%	
Old German Länder	Spruce	Pine	Beech	Oak	Soft hardwoods _{deciduous}	All			
Biomass _{above-ground}	7.96	11.06	13.41	8.61	35.95	6.82	2.00	2.43	7.51
Biomass _{below-ground}	24.54	18.63	34.91	35.55	17.33	13.95	2.00	2.36	14.29
Emission factor						6.21	2.00	2.40	6.95
FM 1993 – 2002	Error % (biomass conversion)					Error % (C)	SE %	RMSE%	
New German Länder	Spruce	Pine	Beech	Oak	Soft hardwoods _{deciduous}	All			
Biomass _{above-ground}	11.34	24.66	17.35	12.93	37.15	9.03	2.00	5.43	10.73
Biomass _{below-ground}	30.38	27.74	38.90	43.94	22.49	16.82	2.00	5.93	17.94
Emission factor						8.16	2.00	5.51	10.05
FM 2002 – 2008	Error % (biomass conversion)					Error % (C)	SE %	RMSE%	
Germany	Spruce	Pine	Beech	Oak	Soft hardwoods _{deciduous}	All			
Biomass _{above-ground}	7.95	11.04	13.30	8.57	35.38	14.44	2.00	28.66	32.15
Biomass _{below-ground}	24.47	18.60	34.67	35.39	17.14	19.29	2.00	16.35	25.37
Emission factor						12.21	2.00	25.95	28.75

FM 2008 – 2015	Error % (biomass conversion)					Error % (C)	SE %	RMSE%	
Germany	Spruce	Pine	Beech	Oak	Soft hardwoods deciduous	All			
Biomass _{above-ground}	7.95	11.04	13.29	8.56	35.37	5.70	2.00	11.66	13.14
Biomass _{below-ground}	24.47	18.60	34.65	35.37	17.14	12.35	2.00	10.86	16.57
Emission factor						5.22	2.00	11.29	12.60

Table 355: Uncertainties in emission factors for living biomass on afforestation areas, for various periods

AR 1987 – 2002	Error % (biomass conversion)					Error % (C)	SE %	RMSE%	
Old German Länder	Spruce	Pine	Beech	Oak	Soft hardwoods _{deciduous}	All			
Biomass _{above-ground}	11.23	15.62	18.80	12.10	50.00	12.14	2.00	7.39	14.35
Biomass _{below-ground}	34.60	26.30	49.00	50.00	24.23	19.19	2.00	8.00	20.88
Emission factor						10.59	2.00	7.41	13.08
AR 2002 – 2015	Error % (biomass conversion)					Error % (C)	SE %	RMSE%	
Germany	Spruce	Pine	Beech	Oak	Soft hardwoods _{deciduous}	All			
Biomass _{above-ground}	11.23	15.62	18.80	12.10	50.00	11.10	2.00	6.08	12.81
Biomass _{below-ground}	34.60	26.30	49.00	50.00	24.23	17.48	2.00	5.63	18.47
Emission factor						9.69	2.00	5.93	11.53

Table 356: Uncertainties in emission factors for living biomass on deforestation areas, for various periods

DF 1987 – 2002	Error % (biomass conversion)					Error % (C)	SE %	RMSE%	
Old German Länder	Spruce	Pine	Beech	Oak	Soft hardwoodsdeciduous	All			
Biomass _{above-ground}	11.23	15.62	18.80	12.10	50.00	8.29	2.00	10.00	13.15
Biomass _{below-ground}	34.60	26.30	49.00	50.00	24.23	17.38	2.00	11.05	20.70
Emission factor						7.51	2.00	10.08	12.73
DF 2002 – 2015	Error % (biomass conversion)					Error % (C)	SE %	RMSE%	
Germany	Spruce	Pine	Beech	Oak	Soft hardwoodsdeciduous	All			
Biomass _{above-ground}	11.23	15.62	18.80	12.10	50.00	8.97	2.00	7.27	11.72
Biomass _{below-ground}	34.60	26.30	49.00	50.00	24.23	16.94	2.00	7.04	18.45
Emission factor						8.04	2.00	7.17	10.95

Table 357: Uncertainties in emission factors for dead wood on forest land remaining forest land, for various periods

2002 – 2008	Error % (biomass conversion)													Error % (C)	SE %	RMSE%
Germany	N1	N2	N3	N4	L1	L2	L3	L4	EI1	EI2	EI3	EI4	all			
> 20 cm	12.30	19.82	25.12	17.87	8.87	30.62	23.95	46.25	8.92	31.54	23.71	53.23	8.36	2.00	30.80	31.98
10 to 20 cm	12.30	19.82	25.12	17.87	8.87	30.62	23.95	46.25	8.92	31.54	23.71	53.23	10.09	2.00	50.00	51.05
Emission factor																27.11
FM 2008 – 2015	Error % (biomass conversion)													Error % (C)	SE %	RMSE%
Germany	N1	N2	N3	N4	L1	L2	L3	L4	EI1	EI2	EI3	EI4	all			
> 20 cm	12.55	19.74	25.16	18.28	8.70	30.66	23.63	46.96	8.59	30.64	23.86	50.61	21.92	2.00	82.64	85.52
10 to 20 cm	12.26	19.77	25.14	17.82	8.54	30.60	23.57	46.41	8.54	30.66	23.67	47.47	13.23	2.00	30.91	33.69
Emission factor																54.52

where N = conifers (Nadelholz), L = deciduous trees (Laubholz), but not including oak, EI = oak (Eiche) and 1 – 4 = degree of decomposition

Table 358: Uncertainties in emission factors for dead wood on afforestation areas between 1990 and 2015

AR 1987 – 2015	Error % (biomass conversion)													Error % (C)	SE %	RMSE%
Germany	N1	N2	N3	N4	L1	L2	L3	L4	EI1	EI2	EI3	EI4	all			
> 20 cm	17.20	27.92	35.46	25.20	12.07	43.24	33.33	65.38	12.07	43.24	33.33	65.38	10.55	2.00	35.11	36.72
10 to 20 cm	17.20	27.92	35.46	25.20	12.07	43.24	33.33	65.38	12.07	43.24	33.33	65.38	13.05	2.00	28.37	31.30
Emission factor																24.84

where N = conifers (Nadelholz), L = deciduous trees (Laubholz), but not including oak, EI = oak (Eiche) and 1 – 4 = degree of decomposition

Table 359: Uncertainties in emission factors for dead wood on deforestation areas, for various periods

DF 2002 – 2008	Error % (biomass conversion)													Error % (C)		SE %	RMSE%
Germany	N1	N2	N3	N4	L1	L2	L3	L4	EI1	EI2	EI3	EI4	all				
> 20 cm	17.20	27.92	35.46	25.20	12.07								6.18	2.00	27.45	28.21	
10 to 20 cm	17.20	27.92	35.46	25.20	12.07								13.05	2.00	50.00	51.10	
Emission factor																24.88	
DF 2008 – 2015	Error % (biomass conversion)													Error % (C)		SE %	RMSE%
Germany	N1	N2	N3	N4	L1	L2	L3	L4	EI1	EI2	EI3	EI4	all				
> 20 cm		27.92	35.46	25.20									6.18	2.00	27.45	28.21	
10 to 20 cm	17.20	27.92	35.46	25.20	12.07	43.24	33.33	65.38					16.79	2.00	41.11	44.46	
Emission factor																24.02	

where N = conifers (Nadelholz), L = deciduous trees (Laubholz), but not including oak, EI = oak (Eiche) and 1 – 4 = degree of decomposition

6.4.3.3 Uncertainties in estimation pertaining to litter and mineral soils

6.4.3.3.1 Sampling error

In soil sampling, proper separation of litter and mineral soil can present a problem, since the transition between the two compartments cannot always be unambiguously identified. This problem becomes all the more important in light of the fact that carbon concentrations in litter differ considerably from those in mineral soil below the litter. In sampling, imprecise or improper separation of litter from mineral soil can thus have major impacts on the carbon stocks measured in a relevant horizon or depth layer.

6.4.3.3.2 Small-scale variability

Due to the high spatial variability in litter and mineral soil, and because carbon stocks maintain spatial continuity only over short distances, sampling of carbon stocks in such compartments is subject to a high degree of uncertainty. For litter in a beech forest, SCHÖNING et al. (2006) calculated stocks of 4.0 t C ha⁻¹, with a variation coefficient of 38 %. In mineral soil (0 – 36 cm), they found carbon stocks of 64.0 t C ha⁻¹, with variation coefficients between 30 % and 43 %. Similar values were recorded by LISKI (1995). He showed that different carbon stocks under a spruce site, and within a given horizon, were spatially independent as of a separation of 8 m.

6.4.3.3.3 Representativeness of points within strata

One problem in analysing samples in accordance with dominant soil units resulted from the different degrees to which classes were represented. Small classes lack statistical validity with respect to a major basic totality. Where no comparison between BZE I and BZE II data was possible, as a result of a lack of pertinent data, it was not possible to include the relevant forested dominant-soil-unit area in the calculation. In addition, it was not possible to have all dominant soil units represented, since some are found only on small areas of Germany's territory. All in all, as a result of these difficulties, 4.3 % of the forest area was not taken into account in this context.

6.4.3.3.4 Sampling error

In calculation of the sampling error with regard to stock changes in litter and mineral soil, paired and unpaired samples were differentiated, and stratification of mineral soils was taken into account. The variance of the mean stocks in stratum l, and of the unstratified total sample with n_l sample points, was calculated as follows:

Equation 45

$$v\langle\bar{Y}_l\rangle = \frac{1}{n_l(n_l - 1)} \sum_{j=1}^{n_l} (Y_{lj} - \bar{Y}_l)^2$$

For paired samples, the variance of the mean stock changes in stratum l, between times t₁ and t₂, was calculated via:

Equation 46

$$v\langle\bar{G}_l\rangle = v\langle\bar{Y}_{lt_2}\rangle + v\langle\bar{Y}_{lt_1}\rangle - 2r_{y^2y^1} \sqrt{v\langle\bar{Y}_{lt_2}\rangle} \sqrt{v\langle\bar{Y}_{lt_1}\rangle}$$

Where

$$r_{y^2y^1} = \frac{S_{y^2y^1}}{S_{y^2y^1}}$$

and

$$s_{y^2y^1} = \frac{1}{n_l(n_l - 1)} \sum_{j=1}^{n_l} (Y_{ljt_2} - \bar{Y}_{lt_2})(Y_{ljt_1} - \bar{Y}_{lt_1})$$

For unpaired samples, the variance of stock changes was calculated via:

Equation 47

$$v\langle \bar{G}_l \rangle = v\langle \bar{Y}_{lt_2} \rangle + v\langle \bar{Y}_{lt_1} \rangle$$

The total variance, throughout all strata, was estimated, taking account of the area shares w_l / w for strata, as follows:

Equation 48

$$v\langle \bar{Y} \rangle \approx \sum_{l=1}^L \left(\frac{w_l}{w} \right)^2 v[\bar{Y}_l]$$

and with

$$v\langle \bar{G} \rangle \approx \sum_{l=1}^L \left(\frac{w_l}{w} \right)^2 v[\bar{G}_l]$$

The carbon-stock changes for litter were calculated on the basis of unpaired samples, with stratification. A sampling error of $0.02 \text{ t C ha}^{-1} \text{ a}^{-1}$, or 100 %, was obtained. In calculation of carbon-stock changes in mineral soils, the overall sample was divided into a paired sample set and an unpaired sample set. In addition, stratification, in keeping with the applicable dominant soil units and the two sample sub-sets, was carried out. Overall, the sampling error for mineral soils amounted to $0.037 \text{ t C ha}^{-1} \text{ a}^{-1}$, or 9 %.

6.4.3.3.5 Quantification of methodologically related uncertainties

Another source of uncertainty, in addition to sampling variance, consists of discrepancies, in individual measurements, that originate in measuring methods and processes. A group of several samples taken independently, at one and the same location, would exhibit fluctuations in both the carbon concentration and fine-earth fraction – throughout a range determined by the precision of the measuring equipment and methods being used. This fluctuation range in measurement of carbon concentrations was quantified on the basis of the results of ring analyses (BLUM & HEINBACH 2006, 2007). In the ring analyses for the Forest Soil Inventory II (BZE II), the repeatability standard deviation for a set of carbon measurements made by various laboratories was determined as the mean within-laboratory standard deviation (DIN ISO 5725 2) of the carbon measurements within the relevant laboratories, and the reference standard deviation was determined as the standard deviation of the mean values of the measurements. The reproducibility standard deviation was calculated from those standard deviations. The reproducibility standard deviation serves as a suitable estimate of the measurement uncertainty.

The reproducibility standard deviations for mineral-soil measurements were as follows: 0.9 g kg⁻¹ for (i.e. for measurements in) lime-free soils, 2.9 g kg⁻¹ for calcareous soils and 20.2 g kg⁻¹ for organic surface layers. With regard to the Forest Soil Inventory I (BZE I), the values provided by WOLFF & RIEK (1996) were used, including coefficients of variation ranging from 5 to 20 % for carbon measurements in mineral soils and from 5 to 10 % for carbon measurements in organic surface layers. The mean values of such coefficients were used in each case. No ring-analyses results were available as a basis for calculation of the uncertainties relative to fine-earth fractions. For this reason, all those BZE points were selected for which fine-earth-fraction results were available at both relevant inventory time points. The mean deviation between such measurement pairs was calculated. The mean deviation was $193 \pm 35 \text{ t ha}^{-1}$. In keeping with the principle of conservative error estimation, it was assumed that the fine-earth fractions did not change between the two inventories, and that the mean deviation plus its spread serves as a measure of the uncertainty in measurement of fine-earth fractions. The uncertainty in the annual carbon-change rate was expanded to include the uncertainties in the relevant individual measurements (Equation 49).

Equation 49:

$$s_{total}^2 = se^2 + \left(\frac{C_1}{(t_{II} - t_I)} MA_{FBV} \right)^2 + \left(\frac{FBV_1}{(t_{II} - t_1)} s_{C_1} \right)^2 + \left(\frac{FBV_{II}}{(t_{II} - t_1)} s_{C_{II}} \right)^2$$

The uncertainties in estimation of the annual rate of change in mineral soils were as follows: for the sampling variance, 0.037 t C ha⁻¹ a⁻¹; for the laboratory analysis for C determination at the time of the BZE I, 0.058 t C ha⁻¹ a⁻¹; for such analysis at the time of the BZE II, 0.056 t C ha⁻¹ a⁻¹; and for determination of fine-earth fractions, 0.05 t C ha⁻¹ a⁻¹. These uncertainties yielded a total uncertainty of 0.11 t C ha⁻¹ a⁻¹. The total uncertainty in estimation of the annual carbon-change rate in the organic surface layer was 0.035 t C ha⁻¹ a⁻¹.

6.4.3.4 Time-series consistency

The following conditions are applied to the consistency of the time series:

- Throughout the entire time series, emissions must be calculated with the same method and the same or mutually consistent data sources.
- If any changes are made in a method, recalculations should be carried out with the new method throughout the entire time series.
- New data, such as data from repeat inventories, must be consistent with earlier data.
- If new data become available that lead to an improvement in the inventory, a recalculation should be carried out throughout the entire time series.
- If any errors are identified in estimates, they must be corrected, and the entire pertinent time series has to be recalculated.

These conditions have been systematically applied to all time series of the submission. Where "jumps" occur in time series, in certain years – for example, in the case of biomass (cf. Chapter 6.4.2.2) – then this is due to the periodicity of the available data within a consistent time series. This is because the same method, and the same data source, has been used for all years of such time series.

6.4.4 Category-specific QA / QC and verification (4.A)

The QC/QA measures carried out for the entire LULUCF sector are set forth in Chapter 6.1.3.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Quality assurance for input data (ATKIS®, BÜK, official statistics, wildfire statistics; cf. Chapter 6.4.2.1) is the responsibility of the relevant data administrators (cf. the pertinent documentation in the inventory description).

Complete error analysis was carried out for the LULUCF sector, and an attempt was made to quantify all existing sources of error. That work included error calculations, relative to the forest sector, for biomass, dead wood, litter, mineral soils, organic soils and wildfires, and to the greenhouse gases CO₂, N₂O and CH₄. In Chapter 19.4.3, a total-error budget is presented that summarises the results of error analysis.

6.4.4.1 Biomass and dead wood

The estimates of carbon stocks, and of carbon-stock changes, in the biomass and dead-wood source categories, at the various relevant times, are based on up-scaling that was carried out at the Thünen Institute for Forest Ecosystems (TI-WO), using data from the National Forest Inventories and from the 2008 Inventory Study. In the process, the stocks on a permanent, systematic sampling network, covering Germany's entire territory, are repeatedly measured. In the BWI 2012, some 420,000 trees, on a total of about 60,000 forest sampling areas, were surveyed. The stock changes are derived from the stocks. In each case, the stock change is the net change between the stocks of relevant individual inventory years. It includes the wood harvest and losses via natural disturbances such as storms and mortality. Extensive quality controls are carried out for the purpose of substantiating the results:

- quality checks during field surveys
- quality checks for the collected data sets
- plausibility checks

With regard to the quality assurance developed for the National Forest Inventory, we call attention to the literature for the National Forest Inventory (BMELV 2005)¹¹³.

In work carried out independently of the TI-WO's calculations, the carbon stocks and carbon-stocks changes for biomass were calculated with a programme developed under PostGreSQL. The results of the two sets of calculations agree.

6.4.4.2 Litter and mineral soils

In order to achieve a consistent standard of laboratory analysis in analysis of sampling carried out in the framework of the BZE surveys, ring analysis was initiated. To that end, all laboratories underwent a quality test carried out by the Gutachterausschuss Forstliche Analytik ("forestry analysis auditors' committee" (BLUM & HEINBACH 2006, 2007). To ensure the comparability of the applicable laboratory methods, only laboratories that participated successfully in the ring analysis were permitted to carry out relevant analysis. Ring analysis was also carried out at the European level, with German participation (COOLS et al. 2006).

To harmonise laboratory measurements and topographical surveys, rules for determining relevant parameters were defined, in the framework of the BZE II survey, for participating laboratories. This was done with a view to preventing any discrepancies resulting from use of different analysis equipment or methods (KÖNIG et al 2005, WELLBROCK et al. 2006). Previous ring analyses served as the basis for certifying laboratories for relevant analysis. A similar approach was taken with regard to field sampling. On the basis of various preliminary studies,

¹¹³ cf. also: <https://bundeswaldinventur.de/index.php?id=2&L=3> und <https://bwi.info/>

suitable sampling methods were defined and specified, and described in a field-sampling manual (WELLBROCK et al. 2006).

6.4.4.3 Comparison with results of neighbouring countries

A comparison with the results of other countries can yield a basic context for the way in which the circumstances prevailing in Germany must be seen in comparison with those prevailing in neighbouring countries. In the "conversions to forest land" categories in particular, the methods and procedures used for handling transition time vary widely, and thus results in this area tend not to lend themselves directly to comparison.

The comparison data for the carbon-stock changes of other countries are obtained from the national inventory reports of countries neighbouring Germany. The emission factor data have been obtained from the last available submission of the UN Climate Secretariat.

To date, due to technical problems in transmission of data to the Secretariat, data for comparison with carbon-stock changes of other countries can be downloaded solely for 2012¹¹⁴ (cf. Paragraph 11ff, Decision 13/CP.20, UNFCCC 2015).

A comparison of carbon-stock changes in living biomass (cf. Table 360) shows that, in the "conversions to forest land" categories (4.A.2.x), Germany has the highest sink performance. In the category of land conversions to forest land, the Poland, Austria and France rank in the middle of the range of sink performances, and Denmark is the only country to report lower carbon sources. In the category "Forest Land remaining Forest Land" (4.A.1), on the other hand, Germany ranks in the middle part of the range for sink performance. In this area, the Netherlands has the highest sink performance, while Austria has the smallest carbon sink.

In the area of dead organic matter (cf. Source: UNFCCC 2016a

Table 361), Germany's reported sink-performance figures, for the categories with land-use changes to forest land (4.A.2.x), lie within the upper part of the range. Denmark and the UK have the highest sink-performance levels. In the area of conversions to forest land, Switzerland is the only country with a negative balance. Belgium, the Czech Republic and France have very low levels of sink performance. In the area of forest land remaining forest land (4.A.1), Germany, along with Switzerland, France and Belgium, has reported a carbon source. Only Denmark, the UK, Austria and the Netherlands have a positive balance in this area. Denmark's reported sink performance is far and away the highest. The Netherlands and Austria report only values for the litter pool.

In the area of mineral soils (cf. Source: UNFCCC 2016a

Table 362, Germany's sink performance in the category Forest Land remaining Forest Land (4.A.1) is surpassed only by Belgium's sink performance. In this category, Austria is the only country to have registered carbon losses. In general, Germany reports carbon sources in the "conversions to forest land" (4.A.2.x) categories. Exceptions are seen in the sub-categories of conversions of agricultural land, of settlements and of other land for which sink performance can be reported. The largest carbon sinks in this area are seen in Belgium, the UK, Poland and Switzerland.

Only Germany and Switzerland report carbon fluxes, and their changes in organic soils (cf. Source: UNFCCC 2016a

Table 363), in all sub-categories. Denmark, France, the UK, the Netherlands and Poland report in from one to five sub-categories. Germany has a negative balance in all categories, while

¹¹⁴ The software that the Secretariat uses for transmission, processing and provision of CRF tables is still suffering from a number of technical problems. This has delayed the transmission of data of other Annex 1 countries.

Switzerland's organic soils show even higher losses. In the category Forest Land remaining Forest Land (4.A.1), Germany also reports the second-highest carbon losses – after Switzerland. The UK is the only country to have carbon sinks in all categories.

Table 360: Carbon-stock changes in living biomass, in various countries (Germany, for 2014 & 2015; other countries, for 2014)

Country	4.A.1 – Forest Land remaining Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2 – Land converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.1. – Cropland converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.2. – Grassland converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.3. – Wetlands converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.4. – Settlements converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.5. – Other Land converted to Forest Land [t C ha ⁻¹ a ⁻¹]
Belgium	0.94	2.55	2.18	2.39	3.16	2.95	NO
Denmark	1.64	-1.35	-1.68	-0.92	NO	NO	NO
France	0.80	1.27	1.55	1.28	1.31	1.12	0.66
UK	1.24	0.91	0.78	0.94	NO	0.85	0.90
Netherlands	1.90	1.45	1.91	1.29	1.56	1.37	1.52
Austria	0.31	1.19	1.22	1.20	1.22	1.24	1.15
Poland	0.90	1.04	1.06	0.96	NO	NO	NO
Switzerland	0.53	0.55	0.83	0.54	0.59	1.12	0.63
Czech Republic	0.79	1.88	1.85	1.85	1.90	1.90	1.90
Germany, 2014	1.03	3.28	3.47	3.10	3.59	3.42	3.64
Germany, 2015	1.03	3.18	3.48	3.09	3.58	3.41	3.64

Source: UNFCCC 2016a

Table 361: Carbon-stock changes in dead organic matter, in various countries (Germany, for 2014 & 2015; other countries, for 2014)

Country	4.A.1 – Forest Land remaining Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2 – Land converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.1. – Cropland converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.2. – Grassland converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.3. – Wetlands converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.4. – Settlements converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.5. – Other Land converted to Forest Land [t C ha ⁻¹ a ⁻¹]
Belgium	-0.01	0.00	NO	NO	NO	NO	NO
Denmark	0.53	0.35	0.03	0.01	NO	NO	NO
France	-0.03	0.06	0.52	0.24	0.51	0.35	0.38
UK ¹¹⁵	0.23	0.21	0.03	0.04	NO	0.03	0.03
Netherlands	0.02 ¹¹⁶	NO	NO	NO	NO	NO	NO
Austria	0.06 ¹¹⁷	0.06	1.35	1.27	0.80	1.25	1.24
Poland	NO	NO	NO	NO	NO	NO	NO
Switzerland	-0.14	-0.08	0.49	1.53	1.30	0.60	1.36
Czech Republic	NO	0.02	0.56	0.56	0.56	0.56	0.56
Germany, 2014	-0.06	0.50	0.50	0.50	0.50	0.50	0.50
Germany, 2015	-0.06	0.50	0.50	0.50	0.50	0.50	0.50

Source: UNFCCC 2016a

¹¹⁵ Only litter pool; for dead wood, IE is listed

¹¹⁶ Only dead wood

¹¹⁷ Litter value: Notation keys: IE, NE

Table 362: Carbon-stock changes in mineral soils, in various countries (Germany, for 2014 & 2015; other countries, for 2014)

Country	4.A.1 – Forest Land remaining Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2 – Land converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.1. – Cropland converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.2. – Grassland converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.3. – Wetlands converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.4. – Settlements converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.5. – Other Land converted to Forest Land [t C ha ⁻¹ a ⁻¹]
Belgium	0.53	0.58	2.58	1.26	0.84	3.48	NO
Denmark	NA,NO	0.01	0.10	0.12	NO	NO	NO
France	NO	0.01	1.07	-0.03	NO	1.62	NO
UK	0.23	0.31	1.72	0.93	NO	1.32	1.08
Netherlands	NO	0.00	0.40	-0.40	0.06	0.35	2.16
Austria	-0.18	-0.15	1.17	-0.76	NO	3.33	2.98
Poland	0.11	0.11	0.12	0.10	NO	NO	NO
Switzerland	0.00	0.03	0.56	0.49	1.11	1.39	4.10
Czech Republic	NO	0.00	0.51	0.01	NO	NO	NO
Germany, 2014	0.41	-0.39	0.02	-0.80	-0.05	0.10	0.21
Germany, 2015	0.41	-0.36	0.04	-0.77	-0.05	0.12	0.22

Source: UNFCCC 2016a

Table 363: Carbon-stock changes in organic soils, in various countries (Germany, for 2014 & 2015; other countries, for 2014)

Country	4.A.1 – Forest Land remaining Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2 – Land converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.1. – Cropland converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.2. – Grassland converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.3. – Wetlands converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.4. – Settlements converted to Forest Land [t C ha ⁻¹ a ⁻¹]	4.A.2.5. – Other Land converted to Forest Land [t C ha ⁻¹ a ⁻¹]
Belgium	NO	NO	NO	NO	NO	NO	NO
Denmark	-1.30	-1.30	-1.30	-1.30	NO	NO	NO
France	NO	-2.01	NO	NO	-2.01	NO	NO
UK	0.77	0.89	2.55	2.64	NO	2.78	2.68
Netherlands	NO	-0.06	-0.22	-0.23	NO	-0.32	NO
Austria	NO	NO	NO	NO	NO	NO	NO
Poland	-0.68	-0.68	-0.68	-0.68	NO	NO	NO
Switzerland	-2.60	-2.60	-2.60	-2.60	-2.60	-2.60	-2.60
Czech Republic	NO	NO	NO	NO	NO	NO	NO
Germany, 2014	-2.23	-2.23	-2.23	-2.23	-2.23	-2.23	-2.23
Germany, 2015	-2.23	-2.23	-2.23	-2.23	-2.23	-2.23	-2.23

Source: UNFCCC 2016a

6.4.5 Category-specific recalculations (4.A)

This year's submission includes category-specific recalculations for the entire 1990-2014 report period, since the emission factors for annual biomass were modified. This yielded corrected emission factors, for calculation of CO₂ emissions, for the biomass of the following land-use categories:

- Cropland
- Grassland (in the strict sense)
- Wetlands
- Settlements

This also has an impact on the land-use changes leading to forest land. In connection with recalculation of activity data and some emission factors, the pertinent uncertainties were also determined anew.

The recalculations' impacts on emissions are shown in Table 364. In the Forest Land remaining as Forest Land category, carbon-removal performance has not changed, but in the "to forest land" conversion categories, removals have increased slightly over the levels reported in the previous year's submission.

Table 364: Comparison of emissions as reported in the 2016 and 2017 submissions

Emissions [kt CO ₂ -eq]		1990	1995	2000	2005	2006	2007	2008	2009
5.A.1 Forest Land remaining Forest Land	2016	-70,268	-70,704	-71,140	-35,098	-35,144	-35,190	-52,918	-52,989
	2017	-70,268	-70,704	-71,140	-35,098	-35,144	-35,190	-52,918	-52,989
5.A.2 Land converted to Forest Land	2016	-4,997	-5,184	-5,372	-5,596	-5,465	-5,339	-5,203	-5,035
	2017	-5,000	-5,187	-5,375	-5,597	-5,467	-5,341	-5,205	-5,037
Emissions [kt CO ₂ -eq]		2010	2011	2012	2013	2014			
5.A.1 Forest Land remaining Forest Land	2016	-53,060	-53,130	-53,201	-53,284	-53,366			
	2017	-53,060	-53,130	-53,201	-53,284	-53,366			
5.A.2 Land converted to Forest Land	2016	-4,926	-4,806	-4,683	-4,640	-4,464			
	2017	-4,928	-4,808	-4,685	-4,642	-4,466			

6.4.6 Planned improvements, category-specific (4.A)

No further improvements, in addition to those previously announced, are planned. Information about the implementation status of planned improvements in the LULUCF sector is presented in Chapter 6.1.4.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

6.5 Cropland (4.B)

6.5.1 Category description (4.B)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	4.B. Cropland		CO ₂	12,436.4	1.02%	14,348.3	1.62%	15.4%
-/-	4.B. Cropland		N ₂ O	255.0	0.02%	289.0	0.03%	13.3%
-/-	4.B. Cropland		CH ₄	196.0	0.02%	247.4	0.03%	26.3%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 2	RS/NS	CS
N ₂ O	Tier 2	RS/NS	CS/D
CH ₄	Tier 2	RS/NS	CS

The category *Cropland* (4.B) is a key source of CO₂ emissions in terms of emissions level and trend.

Reporting in the *Cropland* category covers emissions / removals of CO₂ from/in mineral and organic soils, and from/in above-ground and below-ground biomass. It also includes direct and indirect nitrous oxide emissions from humus losses from mineral soils, following land-use changes leading to cropland, and it covers methane emissions from organic soils. In keeping with the IPCC Guidelines (IPCC 2006), direct and indirect nitrous oxide emissions from fertiliser application (artificial fertiliser, manure, sewage sludge, etc.), crop residues and drainage of organic soils under cultivation are reported under Agriculture (CRF 3.D). For this reason, in the Cropland chapter, those categories are marked as "IE". Burning of fields and crop residues is prohibited by law in Germany (Federal Law Gazette (BGBl) 2004) and thus is not reported (NO).

Emissions from cropland are listed, broken down by categories, in Table 365 and in the CRF Tables 4, 4.B, 4.(II).B, 4.(III).B und 4.(IV).2. The total emissions in 2015 in Germany amounted to 14,949.7 kt CO₂ equivalents. The main emissions sources are soils, especially organic soils under

cultivation (77.3 %). Mineral soils contributed 21.4% of the total emissions. Most emissions from mineral soils (99.6 % of the total for such soils) resulted from tillage of grassland (CRF 4.B.2.2.1; 4.(II).B; 4.(IV).2). The cropland sector registers very low levels of anthropogenically related net releases of CO₂ from biomass (1.04 %) and from dead organic matter (0.24 %).

The predominating greenhouse gas in the cropland sector is CO₂, accounting for 14,348.3 Gg CO₂ equivalents (96.0 %). The reported nitrous oxide emissions from decomposition of organic soil matter, as a result of land-use changes leading to cropland, are low (the total is 2.4 %, and it consists of direct emissions (289.0 kt CO₂-eq. (CRF 4.(III))) and indirect emissions (65.0 kt CO₂-Eq. (CRF 4.(IV))). A similar statement can be made for the relevant methane emissions (247.4 kt CO₂-Eq. $\pm$ 1.7 % (CRF 4.(II).B), from use of organic soils).

Table 365: CO₂, N₂O and CH₄ emissions [kt CO₂-eq.] from Germany's cropland, 2015. The table includes both the relevant sums and the upper and lower bounds of the 95 % confidence interval.

Source category	GHG	Cropland, emissions, 2015				
		[kt CO ₂ -eq.]			[%]	
		Emission	2.5 perc.	97.5 perc.	2.5 perc.	97.5 perc.
Cropland_{total} ¹¹⁸		14,949.7	11,046.1	17,098.7	26.1	14.4
Mineral soils	CO ₂ ¹¹⁹	2,851.4	2,007.3	4,238.8	29.6	48.7
	N ₂ O _{direct} ¹²⁰	289.0	28.3	895.4	90.2	209.9
	N ₂ O _{indirect} ¹²¹	65.0	0.0	255.0	100.0	292.3
Organic soil	CO ₂ ¹¹⁹	11,305.7	7,472.6	12,770.6	33.9	13.0
	N ₂ O ¹²²	IE	IE	IE	IE	IE
	CH ₄ ¹²³	247.4	124.9	677.0	49.5	173.2
Biomass	CO ₂ ¹¹⁹	155.8	132.6	179.3	14.9	15.1
Litter / dead wood	CO ₂ ¹¹⁹	35.3	30.1	40.6	14.9	14.9

Figure 61 and Figure 62 show the trends in emissions from cropland. The total emissions in 2015 were 2,005 kt CO₂ $\pm$ 15.5 % lower than in the reference year 1990.

This general trend is due primarily to increases of emissions from organic soils in the "remaining" category, as a result of increases in the relevant area (26.3 % with respect to 1990. And those increases are primarily the result of tillage of grassland (CRF 4.B.2.1.1). The decrease in the deforested area, amounting to -53 %, resulted in 73 % lower emissions from deforestation in 2015. Those emissions account for a very small fraction of the total emissions from the cropland sector, 175 kt CO₂ $\pm$ 1.2 %. Similar statements apply for land-use changes from settlements to cropland (53.8 kt CO₂ $\pm$ 0.4 %) and from wetlands to cropland (45.3 kt CO₂ $\pm$ 0.3 %); here as well, the relevant areas – and, thus, the emissions – have decreased with respect to 1990 (settlements: -64 %; Wetlands: -72 %).

The trend reversal since 2005 is due primarily to emissions resulting from land-use change from Grassland (in the strict sense) to Cropland. Since 2005, the tilled acreage on Germany's organic

¹¹⁸ Sum of the emissions from CRF tables 4.B, 4.(II).B, 4.(III).B, 4.(IV).2

¹¹⁹ CRF Table 4.B

¹²⁰ CRF Table 4.(III).B

¹²¹ The category-specific indirect N₂O emissions are not included and shown as such in the CRF tables; they are included, however, in the sum presented in CRF Table 4.(IV).2 for all sub-categories.

¹²² CRF Table 3.D.a.6

¹²³ CRF Table 4.(II).B

and mineral soils has increased by 281,673 ha $\pm$ 39 %, and that has increased emissions by 1,015.2 kt CO₂ $\pm$ 18.4 %.

The key categories that are responsible for the changes in the time series include, on the one hand, CO₂ emissions from organic and mineral soils and, on the other, a decrease in emissions from biomass and dead organic matter as a result of a decrease in deforestation.

The shapes of the time-series plots – especially the noticeable changes they show – are due primarily to the periodicity in surveying of the relevant area data (cf. Chapter 6.3.5, Table 335). Land-use changes were determined on the basis of spatially explicit data records from the years 1990, 2000, 2005, 2008, 2012 and 2014 (cf. Chapter 6.3). Land-use changes that occurred between those years were determined via linear interpolation, and thus the annual conversion areas did not change between the survey time points. The values for 2015 have been extrapolated. The main reason for the marked emissions decrease between 2000 and 2001 is a considerable decrease in deforestation.

Figure 61: Greenhouse-gas emissions from cropland (**total of CO₂, CH₄ and N₂O**) [kt CO₂-eq.] as a result of land use and land-use changes, 1990 – 2015, by sub-categories (with uncertainties shown only for the total sum)

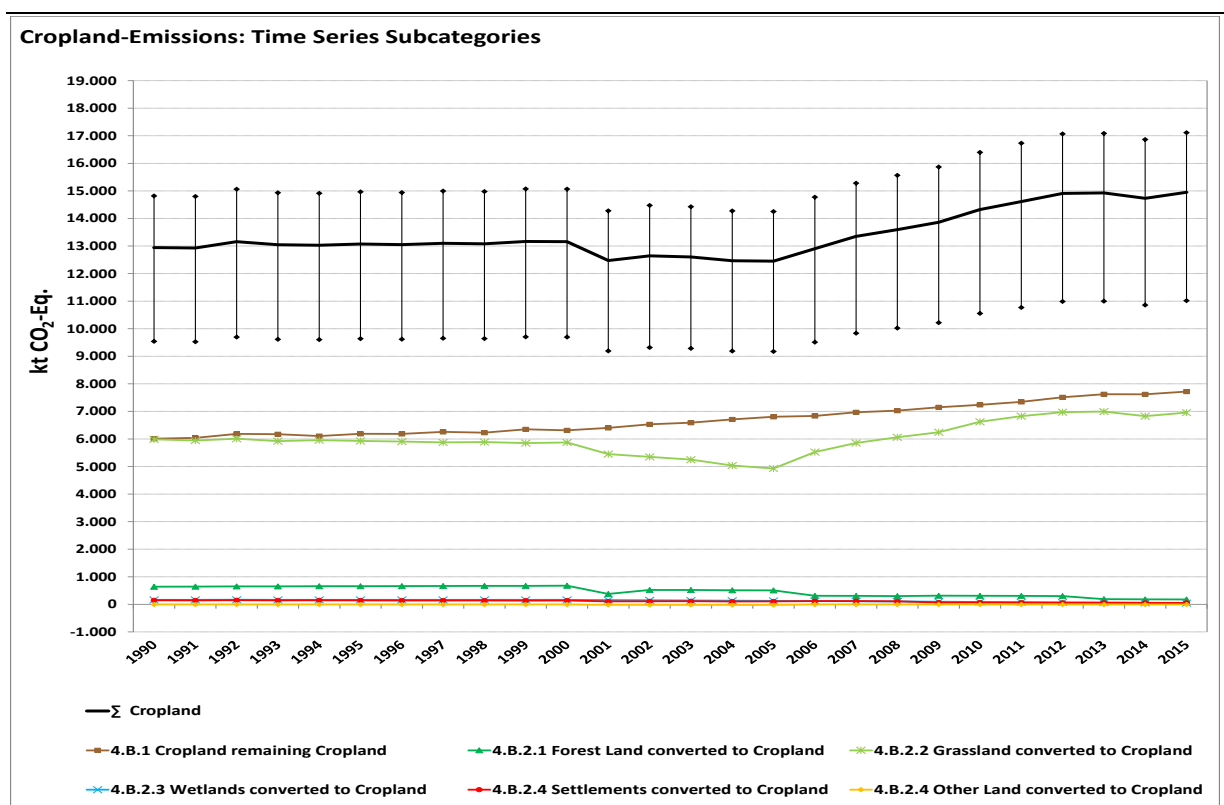
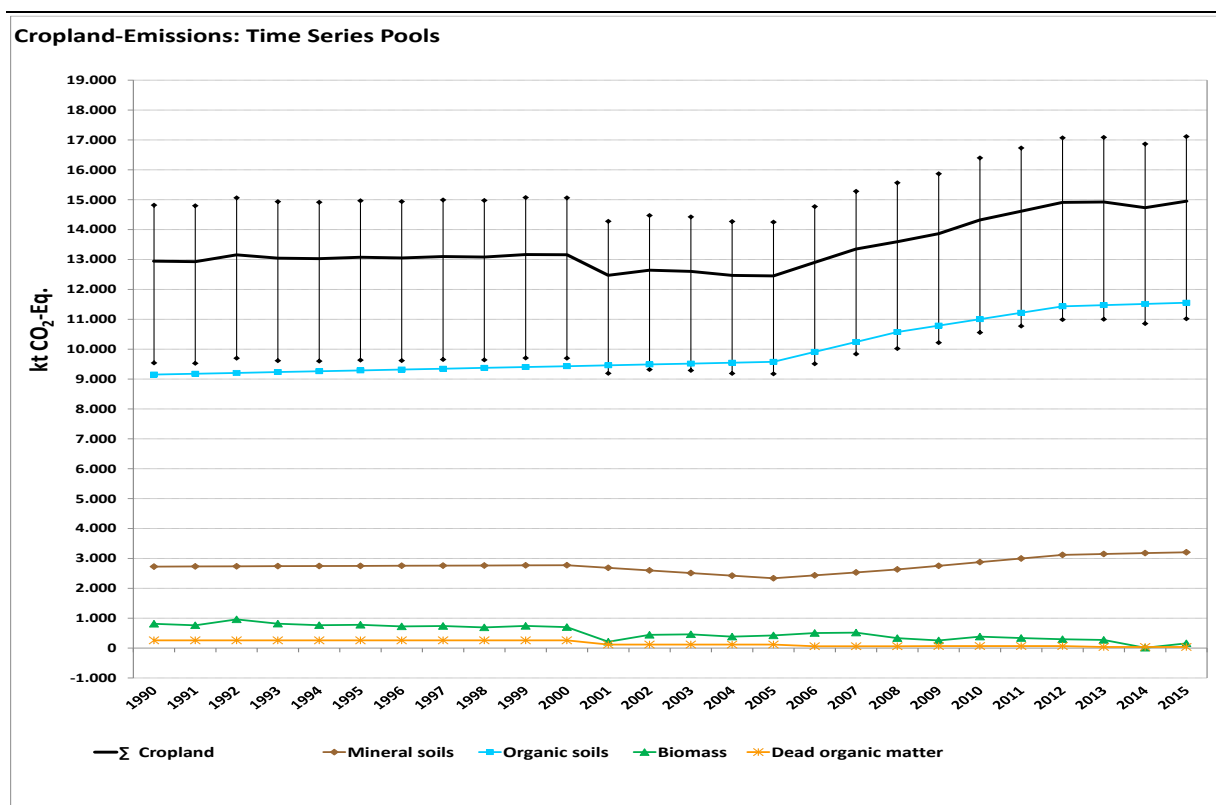


Figure 62: Greenhouse-gas emissions from cropland (total of CO₂, CH₄ and N₂O) [kt CO₂-eq.] as a result of land use and land-use changes, 1990 – 2015, by categories (with uncertainties shown only for the total sum)



6.5.2 Methodological issues (4.B)

6.5.2.1 Biomass

Carbon-stock changes in above-ground and below-ground phytomass of cropland areas are reported as part of land-use changes leading to cropland, as well as – for the first time – in the sub-category "Cropland remaining Cropland." In the Cropland category, the phytomass pool is subdivided in accordance with basic characteristics of the plants concerned:

- herbaceous plants
- perennial woody crops (orchards and vineyards, Christmas tree plantations, tree nurseries and short-rotation plantations)

The assumptions and methods used for calculation of carbon-stock changes in above-ground and below-ground biomass of plants are described in Chapter 6.1.2.3.1 and Chapter 6.1.2.3.2, while the derivations of the emission factors are described in the following chapters:

- for herbaceous plants of annual crops, in Chapter 6.1.2.3.3;
- for fruit plantations, in Chapter 6.1.2.3.4.1;
- for vineyards, in Chapter 6.1.2.3.4.2;
- for Christmas tree plantations, in Chapter 6.1.2.3.4.3;
- for tree nurseries, in Chapter 6.1.2.3.4.4;
- for short-rotation plantations, in Chapter 6.1.2.3.4.5.

6.5.2.1.1 Land-use change

As Chapter 6.1.2.3.1 explains, the existing system for listing land-use changes does not make it possible to list annual and perennial crops in a spatially explicit and complete manner. For this reason, in connection with land-use changes to/from Cropland, it is not clear whether annual or perennial cropland is the outset use or the final use. This situation is addressed by deriving an area-weighted emission factor for the entire cropland phytomass. It is obtained, via an area-weighting calculation, from the emission factors derived in Chapter 6.1.2.3.3 and Chapter 6.1.2.3.4.6, as follows:

$$EF_{crop_{phyto}} = \frac{(EF_{crop_{an}} * A_{crop_{an}} + EF_{crop_{per}} * A_{crop_{per}})}{(A_{crop_{an}} + A_{crop_{per}})}$$

EF_crop_Phyto: Area-weighted emission factor for the entire annual and perennial cropland phytomass [Mg C ha⁻¹]

EF_crop_an: Mean emission factor, weighted by crop type and area under cultivation, for herbaceous and annual cropland phytomass [Mg C ha⁻¹]

A_crop_an: Area under cultivation with herbaceous and annual biomass [ha]

EF_crop_per: Mean emission factor, weighted by crop type and area under cultivation, for perennial woody phytomass on cropland [Mg C ha⁻¹]

A_crop_per: Area under cultivation with perennial woody phytomass on cropland [ha]

The mean carbon stocks per area unit for the cropland phytomass, and the emission factors, are shown in Table 366. They serve as the basis for all calculations of CO₂ removals/emissions to/from the cropland-phytomass pool that occur as the result of land-use changes to/from cropland. The small differences with respect to the previous year's submission are due to the correction of a calculation error that had occurred in estimation of herbaceous phytomass (cf. Chapter 6.1.2.3.3).

Table 366: Mean area-weighted carbon stocks [$\text{Mg C ha}^{-1} \pm$ half of the 95 % confidence interval] of phytomass on cropland in Germany, and their percentage changes with respect to the 2016 Submission

Year	Cropland phytomass, total					
	Carbon stocks [t C ha^{-1}]			Change with respect to the 2016 Submission [%]		
	Phytomass, total	Phytomass, above-ground	Phytomass, below-ground	Phytomass, total	Phytomass, above-ground	Phytomass, below-ground
1990	5.27 ± 0.60	3.78 ± 0.51	1.49 ± 0.32	-0.34	-0.34	-0.35
1991	5.53 ± 0.63	4.08 ± 0.55	1.46 ± 0.32	-0.36	-0.36	-0.37
1992	5.11 ± 0.59	3.74 ± 0.50	1.38 ± 0.30	-0.35	-0.35	-0.36
1993	5.67 ± 0.65	4.13 ± 0.55	1.54 ± 0.33	-0.36	-0.35	-0.36
1994	5.44 ± 0.62	4.01 ± 0.54	1.43 ± 0.31	-0.35	-0.35	-0.36
1995	5.63 ± 0.65	4.17 ± 0.56	1.46 ± 0.32	-0.34	-0.33	-0.34
1996	5.77 ± 0.66	4.26 ± 0.57	1.51 ± 0.33	-0.34	-0.33	-0.34
1997	5.94 ± 0.68	4.43 ± 0.59	1.51 ± 0.33	-0.34	-0.33	-0.34
1998	5.87 ± 0.67	4.37 ± 0.59	1.50 ± 0.33	-0.35	-0.34	-0.35
1999	6.10 ± 0.70	4.54 ± 0.61	1.55 ± 0.34	-0.40	-0.40	-0.40
2000	5.97 ± 0.69	4.44 ± 0.60	1.53 ± 0.33	-0.33	-0.33	-0.33
2001	6.28 ± 0.72	4.73 ± 0.64	1.55 ± 0.34	-0.31	-0.31	-0.32
2002	5.75 ± 0.66	4.29 ± 0.58	1.46 ± 0.32	-0.32	-0.32	-0.33
2003	5.23 ± 0.60	3.92 ± 0.53	1.31 ± 0.29	-0.32	-0.32	-0.33
2004	6.55 ± 0.75	4.93 ± 0.66	1.62 ± 0.35	-0.31	-0.31	-0.32
2005	6.16 ± 0.71	4.62 ± 0.62	1.54 ± 0.33	-0.30	-0.30	-0.31
2006	5.83 ± 0.67	4.40 ± 0.59	1.43 ± 0.31	-0.29	-0.29	-0.30
2007	5.89 ± 0.68	4.39 ± 0.59	1.49 ± 0.32	-0.30	-0.30	-0.31
2008	6.37 ± 0.73	4.82 ± 0.65	1.55 ± 0.34	-0.31	-0.31	-0.32
2009	6.53 ± 0.75	4.93 ± 0.66	1.61 ± 0.35	-0.31	-0.31	-0.31
2010	6.05 ± 0.69	4.56 ± 0.61	1.49 ± 0.32	-0.30	-0.30	-0.31
2011	6.18 ± 0.71	4.60 ± 0.62	1.58 ± 0.34	-0.29	-0.29	-0.30
2012	6.49 ± 0.74	4.88 ± 0.66	1.62 ± 0.35	-0.30	-0.30	-0.30
2013	6.39 ± 0.73	4.84 ± 0.65	1.55 ± 0.34	-0.30	-0.30	-0.31
2014	7.27 ± 0.83	5.48 ± 0.74	1.79 ± 0.39	-0.30	-0.30	-0.31
2015	6.55 ± 0.75	4.98 ± 0.67	1.56 ± 0.34	/	/	/

6.5.2.1.2 The non-transition ("remaining") category:

Phytomass-pool emissions in the "remaining" cropland category are being reported for the first time. In the "remaining" categories of all other land-use categories and sub-categories, the vegetation structures involved are homogeneous, and thus dynamic equilibria can be assumed with regard to phytomass (meaning that no emissions occur) (cf. Chapter 6.1.2.3.1). The sub-category "Cropland Remaining Cropland" includes herbaceous, annual crops and perennial woody crops that do not fit that description, however. Anthropogenically related area conversions involving changes of such crops thus entail carbon-stock changes, in plant biomass, that have to be reported.

Since the existing system for listing land-use changes does not support spatially explicit and complete descriptions of area changes involving shifts between annual and perennial crops (cf. Chapter 6.1.2.3.1), the activity data needed for emissions estimation have to be obtained from official statistics (the current Fachserie 3 Reihe 3.1.2 (STATISTISCHES BUNDESAMT (Federal Statistical Office), various years)). The resulting values are shown in Table 367. The area sum proves to be relatively constant; the standard error for the sample mean is 0.9 % (half of the 95 % confidence interval). Short-rotation plantations play only a marginal role in Germany (1.7 % - 2.7

% of area under cultivation with woody crops). Statistics on such plantations have been kept only since 2010.

Table 367: Areas [ha], in Germany's croplands, under cultivation with perennial woody crops (pursuant to STATISTISCHES BUNDESAMT, various years)

Year	Woody crops on cropland Area [ha]					Σ Area _{woody crops}
	Fruit cultivation	Wine-grape cultivation	Christmas tree plantations	Tree nurseries	Short-rotation plantations	
1990	80,856	104,973	5,467	26,788		218,084
1991	80,856	104,924	7,185	26,788		219,753
1992	73,863	106,961	7,552	26,658		215,034
1993	69,723	106,917	8,136	27,226		212,002
1994	69,413	107,360	10,642	27,014		214,429
1995	68,977	106,781	10,353	27,831		213,942
1996	70,107	106,141	11,555	27,516		215,319
1997	69,598	105,390	11,954	26,808		213,750
1998	72,013	105,074	12,674	26,239		216,000
1999	69,359	104,260	12,753	25,762		212,134
2000	69,500	104,724	13,400	24,800		212,424
2001	69,200	103,605	14,100	25,700		212,605
2002	67,600	102,989	15,400	24,300		210,289
2003	69,000	102,470	14,500	23,600		209,570
2004	68,300	102,240	13,100	22,700		206,340
2005	66,200	102,037	12,900	21,700		202,837
2006	65,900	101,999	14,600	21,200		203,699
2007	65,000	102,036	14,700	20,900		202,636
2008	65,100	102,340	15,800	20,700		203,940
2009	65,300	102,276	16,900	20,200		204,676
2010	65,287	102,197	14,625	20,860	3,501	206,470
2011	65,600	102,104	15,000	20,700	5,100	208,504
2012	64,300	102,172	15,600	21,200	4,400	207,672
2013	63,400	102,427	15,800	20,700	3,600	205,927
2014	63,800	102,439	17,900	20,800	4,800	209,739
2015	64,100	102,581	20,100	19,900	5,786	212,467

From statistics on cropland areas with woody-plants cultivation, and the annual area changes that can be derived from such statistics, carbon-stock changes in the phytomass of the "remaining" category can be estimated only as a sum for all of Germany. Since the type and directions of pertinent land-use changes cannot be precisely described (cf. Chapter 6.1.2.3.1), and connections to other land-use categories cannot be proven – and thus cannot be reported – reporting in this area is based on the assumption that the annual area differences for permanent crops always represent use changes within the Cropland land-use category.

Relevant calculations are carried out in using the gain-loss method (2006 IPCC Guidelines) described in Chapter 6.1.2.3.2. In the interest of consistency in methods, the area-sum difference is multiplied by the weighted mean carbon stocks in woody phytomass (Chapter 6.1.2.3.3) or herbaceous phytomass (Chapter 6.1.2.3.4.6) and then entered into the balance with a reversed sign (i.e. plus or minus) (positive area difference: woody biomass, positive sign (gain), herbaceous biomass, negative sign (loss); and vice-versa (cf. Table 315 in Chapter 6.1.2.3.2)).

6.5.2.2 Mineral soils

6.5.2.2.1 Land-use change

The manner in which CO₂ emissions resulting from conversions leading to cropland are calculated is described in Chapter 6.1.2.1.1, while the pertinent calculations for N₂O emissions are described in Chapter 6.1.2.1.2. The emission factors for carbon are shown in Table 306 and Table 307 (Chapter 6.1.2.1.1), while the emission factor for direct nitrous oxide emissions is shown in Table 308 and the factor for indirect N₂O emissions is shown in Table 309 (Chapter 6.1.2.1.2). The manner in which the emission factors have been derived is described in Chapter 19.4.2, while the pertinent uncertainties are listed in Table 368 (Chapter 6.6.3). The results for emissions from mineral soils are presented as follows:

- CO₂ emissions in CRF tables 4.B.2.1-4.B.2.5,
- direct N₂O emissions in CRF tables 4.III.2.1-4.III.2.5,
- indirect N₂O emissions in CRF table 4.IV.2.

6.5.2.2.2 The non-transition ("remaining") category:

For areas with cropland remaining cropland, no carbon-stocks changes in mineral soils are listed; consequently, no nitrous oxide is released via mineralisation of organic soil substance. The assumption that mineral soils in continuous use as cropland, in Germany, are not a source of carbon and nitrogen emissions is supported by the following arguments:

- Results from 140 regional long-term-test sites (HÖPER & SCHÄFER, 2012; FORTMANN et al., 2012 and BAYERISCHE LANDESANSTALT FÜR LANDWIRTSCHAFT, 2007), showing the constancy of carbon stocks since the beginning of the 1990s.
- Initial studies of the carbon balance of cropland areas, carried out at 180 sites, with the help of models, as part of the country-wide Agricultural Soil Inventory (DREYSSE 2015). The models used included the "VDLUFA-Humusbilanzierung" ("VDLUFA humus balancing") model, which was developed for practical advising (KÖRSCHENS, et al. 2004; AUTORENKOLLEKTIV 2014), and the "CandyCarbonBalance" model, which is process-controlled and site-adapted (FRANKO et al., 2011). Both models clearly show that the long-used cropland soils studied are not sources for CO₂ (DREYSSE 2015).
- More-recent meta-studies (BAKER et al. 2007; LUO et al., 2010) that have shown, for soil depths > 60 cm, that the type of soil cultivation used has no influence on the total carbon stocks in mineral soils.

Along with this evidence, extensive proof of the correctness of the above theses can be listed:

1. The results of the nationwide evaluation of German long-term soil monitoring sites (MARX et al., 2016).
2. Analysis of the time series for carbon inputs via organic fertilisers and crop residues. The carbon inputs are derived from the relevant nitrogen inputs into Germany's croplands, as calculated for these source categories of the agricultural sector (CRF Table 3.D).
3. The fertilisation recommendations for implementation of the German Fertiliser Ordinance (Düngeverordnung) and the EU Nitrates Directive;

Regarding 1.) In a research project, the findings obtained on long-term soil monitoring sites of the German Länder (states) have been compiled, harmonised and synthetically evaluated on a nationwide basis (MARX et al., 2016). The key findings include:

- Evaluation of the long-term soil monitoring sites nationwide, with respect to carbon-stock changes, has confirmed the findings drawn to date at the Länder level. The shares of sites at which no statistically proven changes have occurred clearly predominate. For example, 77 % of the cultivated mineral soils show no carbon-stock changes, while 10 % show a significant increase and 13 % show a significant decrease (MARX et al., 2016).
- At 157 long-term (cropland) soil monitoring sites, data suitable for analysis, via correlation, of organic soil carbon stocks and cultivation are available. A positive significant correlation between organic soil-carbon-stocks differences and cultivation was found at only two sites, or about 1.3 % of all sites. The impacts of cultivation on carbon content are obviously marginal (MARX et al., 2016).
- MARX et al., 2016 found that the most important factors influencing organic carbon stocks in the soil are clay content, precipitation and temperature, followed by other site parameters. Factors tied to cultivation contributed insignificantly to explanation of carbon-content variance in mineral soils under cultivation. The study found that the most important factors influencing long-term changes of carbon content were outset carbon content and clay content.

The results of the nationwide evaluation of long-term soil-monitoring sites carried out by MARX et al., 2016 confirm the proposition that the net carbon-stock changes in mineral soils of cropland sites are zero on average, and that changes that occur are primarily site-related, and not tied to cultivation.

Regarding 2.) The trend for carbon inputs via organic fertilisers and crop residues supports independent estimation of the influence of cultivation on the humus balance. A positive trend implies a net C-sink, while a negative is an indication of a possible decrease of carbon stocks. The trend estimate is based on the nitrogen inputs into mineral soils, as determined for the agricultural sector (CRF Table 3.D) section of the German GHG inventory. From those inputs, the carbon inputs via organic fertilisers can be approximated, by multiplying the nitrogen inputs by a mean C/N ratio of 12 (representative for the liquid manure / solid manure mixture that predominates in organic fertilisers). A total of 66% of organic fertilisers used in Germany are applied to cropland, while 34 % are applied to grassland (Federal Statistical Office, 2010). Figure 63 shows the results.

- The carbon inputs via organic fertilisers have remained largely constant since 1990.
- The carbon inputs via crop residues have increased considerably.
- Overall, one positive trend emerges – an increase of carbon inputs into mineral soils under cropland since 1990.

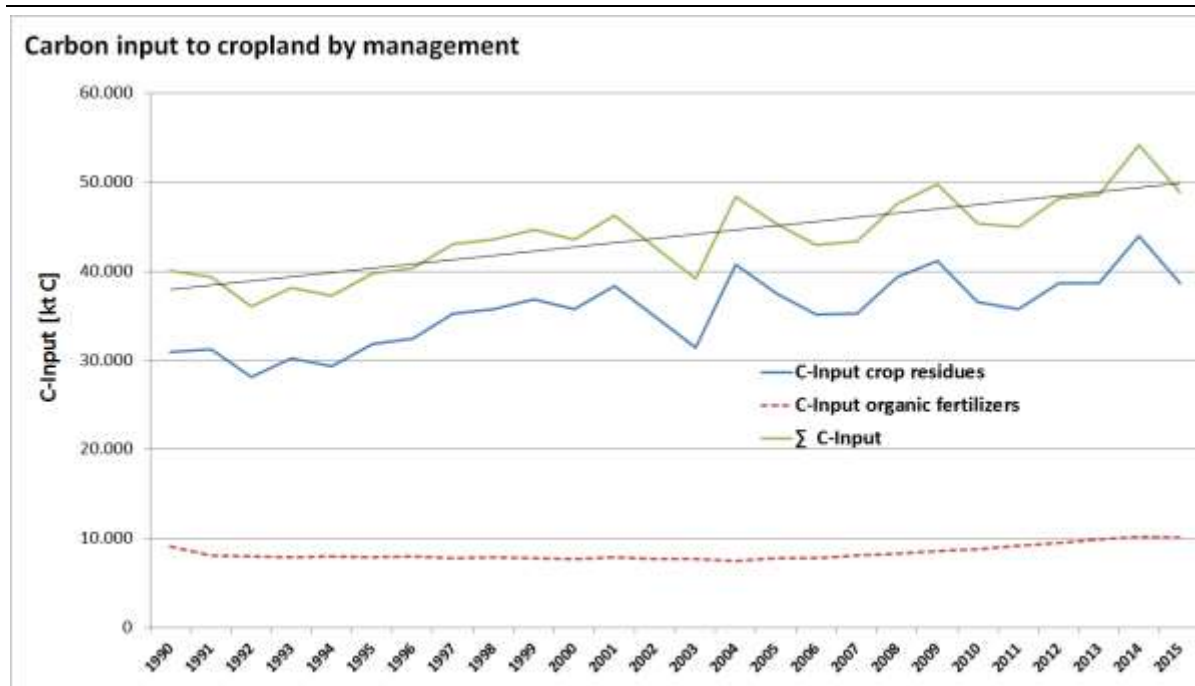


Figure 63: Carbon inputs [kt C] via organic fertilisers and crop residues, in cropland, 1990 – 2015

The results of this national analysis confirm, independently from the findings obtained via long-term soil monitoring, that mineral soils in the category "Cropland Remaining Cropland" tend to be a net carbon sink, rather than a source. The fact that crops contribute less, per carbon unit, to soils' humus balance than organic fertilisers do is further confirmation that the assessment that a zero change in stocks occurs is robust.

Regarding 3.) Yet another indication that mineral soils under permanent cropland do not lose any organic soil substance is provided by the recommendations for fertilisation of annual crops that are given, to farmers, by the agricultural authorities of the German Länder (states). The recommendations support the aims of German legislation fertilisation, the purposes of which include implementing the European Nitrates Directive. Art. 6 of the Fertiliser Ordinance (DüV; Federal Law Gazette (BGBl) 2012) establishes mandatory limits for nitrogen surpluses on cropland. Conformance with the limits is monitored by authorities. The competent authorities of the Länder provide farmers with data and tools for determination of fertilisation requirements. The Fertiliser Ordinance explicitly defines the applicable parameters (such as various site factors, cultivation conditions, cultivation methods, crops, preceding crops, residual content, use of organic fertilisers, etc.). It also calls on farmers to take the results of regional field trials into account in determining fertilisation requirements (Art 3 (2) DüV (BGBl 2012)). In keeping with this orientation, the tools developed by the various Länder for estimation of nitrogen-fertiliser requirements, and the data underlying such tools, are based on regional measurements and fertilisation trials. None of these systems address nitrogen losses from mineralisation of organic soil substance as an issue. Clearly, the only nitrogen sources involved are organic fertilisers and crop residues – mineralisation of organic soil substance does not play a role. It thus follows, as a complement to the results in 1.), that no N₂O emissions from mineralisation of organic soil substance occur in the category "Cropland Remaining Cropland."

In CRF Table 4.B.1, therefore, NA (not applicable) is entered in the column for carbon-stock changes in mineral soils in the "remaining" category; and NA is also entered for N₂O emissions in CRF Table 3.D.5.

6.5.2.3 Organic soils

The manner in which CO₂, N₂O and CH₄ emissions from organic soils, as a result of land use and land-use changes, have been calculated, and the manner in which the relevant emission factors have been derived, are described in Chapter 6.1.2.1. The manner in which the relevant areas and area uses have been determined is described in Chapter 6.3.1 ff.. The annual emissions from land-use changes are calculated in the same manner as the emissions from cropland remaining cropland. The latter emissions are listed in CRF Table 4.B.1, while emissions from land-use changes in are listed in CRF Tables 4.B.2.1 - 4.B.2.5.

N₂O emissions from cultivated organic soils are reported as part of the "Agriculture" sector, under Chapter 3.D.a.6 "Cultivation of Histosols". To prevent double-counting, in LULUCF CRF Table 4.II.B, those emissions are marked "IE".

Methane emissions from organic soils, and from drainage ditches, are included in the figures in CRF Table 4.II.B.

6.5.3 Uncertainties and time-series consistency (4.B)

The uncertainties for the emission factors and the activity data were determined in accordance with the 2006 IPCC Guidelines (IPCC 2006). Additional relevant information is provided in Chapter 19.4.3. Table 368 and 6.1.2.1 present the uncertainties in the emission factors (EF) for the cropland sector, broken down by categories and sub-categories.

Table 368 highlights the fact that distributions based on natural processes are often not symmetric and thus often have to be described with left-skewed and right-skewed (with steep sloping on the one side or other) distributions. Only the EF for biomass show standard normal distributions / distributions that are approximately normal. Furthermore, the uncertainties seen in this area are the smallest of all relevant uncertainties. With the exception of the EF for CO₂ from organic soils, which exhibits a right-skewed distribution, the other EF for soils tend to show log-normal distributions. The EF for N₂O emissions from mineral soils show the largest uncertainties. This is due primarily to use of the IPCC standard factors.

In Gaussian calculation of error propagation, uncertainties > 100 % were calculated for the lower bound of the 95 % confidence interval for the uncertainties for the factors for indirect N₂O emissions. While this calculation method conforms to the applicable rules, mathematical rigour dictates that it not be used in the present context. Pursuant to the assumptions underlying the relevant calculation method, no negative emissions can occur in connection with indirect N₂O emissions from mineral soils. For this reason, the uncertainty for the lower bound has been set to 100 %.

The large uncertainty seen in the EF for methane and nitrous oxide from organic soils is due to those factors' extremely large variability in field measurements, as well as to the fact that negative emissions are possible for methane (cf. Chapter 6.1.2.2.2).

The uncertainties for the activity data are set forth in Table 517 in Chapter 19.4.3. Those uncertainties have a normal distribution, and half of the 95 % confidence interval, in the cropland sector, falls within the range 1.0 – 90.2 %. For system-related reasons, the sampling error with the grid-point approach depends on the sample size, and thus on the relevant sub-category's share of the total area (cf. Chapter 6.3). Consequently, in the cropland sector major uncertainties are seen only for those sector sub-categories whose share of the total cropland area is < 0.1 %. Area-weighted derivation of a total uncertainty for the area data in the cropland category yields an uncertainty of 1.05 % [half of the 95% confidence interval].

Table 517 in Chapter 19.4.3 shows that, in the cropland sector, and in terms of total emissions, emissions from organic soils account for a significant share of national LULUCF emissions. Emissions from mineral soils are significant only in connection with grassland tillage.

Table 368: Uncertainties of emission factors [2.5 and 97.5 percentile, in % of location scale] used for calculation of GHG emissions from Germany's croplands in 2015, broken down by pools and sub-categories

Cropland		Emission factor	Bounds	
Land use before	Land use after		lower	upper
Mineral soils, CO ₂ -C ¹²⁴		[t C ha ⁻¹ a ⁻¹]	[%]	[%]
Forest land	Cropland	-0.025	16.9	25.0
Grassland (in the strict sense)	Cropland	-0.870	29.6	49.1
Woody grassland	Cropland	-0.658	27.9	51.1
Terr. wetlands	Cropland	-0.699	28.4	36.8
Waters	Cropland	0.000	33.0	50.5
Settlements	Cropland	0.068	27.9	49.2
Other land	Cropland	0.221	27.4	51.8
Mineral soils, N ₂ O _{direct} ¹²⁵		[kg N ₂ O ha ⁻¹ a ⁻¹]	[%]	[%]
Forest land	Cropland	0.029	72.1	201.6
Grassland (in the strict sense)	Cropland	1.078	91.0	211.9
Woody grassland	Cropland	0.845	90.4	212.4
Terr. wetlands	Cropland	0.711	90.6	209.4
Mineral soils, N ₂ O _{indirect} ¹²⁵		[kg N ₂ O ha ⁻¹ a ⁻¹]	[%]	[%]
Forest land	Cropland	0.007	100	287.8
Grassland (in the strict sense)	Cropland	0.243	100	295.2
Woody grassland	Cropland	0.190	100	295.5
Terr. wetlands	Cropland	0.160	100	293.4
Biomass ¹²⁶		[t C ha ⁻¹ a ⁻¹]	[%]	[%]
Cropland _{perennial} ¹²⁷	Cropland _{annual} ¹²⁸	-5.18	11.1	11.1
Cropland _{annual} ¹²⁸	Cropland _{perennial} ¹²⁷	5.18	11.1	11.1
Forest land	Cropland ¹²⁹	-48.11	22.2	22.2
Grassland (in the strict sense)	Cropland ¹²⁹	-0.26	16.4	16.4
Woody grassland	Cropland ¹²⁹	-36.62	47.1	48.0
Terr. wetlands	Cropland ¹²⁹	-12.38	31.9	32.5
Waters	Cropland ¹²⁹	6.55	11.5	11.5
Settlements	Cropland ¹²⁹	-5.94	31.1	31.7
Other land	Cropland ¹²⁹	6.55	11.5	11.5
Dead organic matter ¹²⁶		[t C ha ⁻¹ a ⁻¹]	[%]	[%]
Forest land	Cropland	-20.69	6.2	6.2

¹²⁴ Calculation covers a 20-year period; stock change: positive $\triangleq$ sink; negative $\triangleq$ source

¹²⁵ Calculation covers a 20-year period; emission: positive $\triangleq$ source; negative $\triangleq$ sink

¹²⁶ Calculation only for first year of land-use change, stock change: positive $\triangleq$ sink; negative $\triangleq$ source

¹²⁷ Mean for perennial crops; cf. Chapter 6.1.2.3.4.6

¹²⁸ Mean for annual crops; cf. Chapter 6.1.2.3.3

¹²⁹ Weighted mean of perennial and annual crops; cf. Chapter 6.5.2.1.2

Table 369: Uncertainties for emission factors [2.5 and 97.5 percentile, in % of location scale] for emissions from organic soils on cropland, 2015

Land use	Greenhouse gas	Emission factor	Bounds	
			lower	upper
Organic soil ¹³⁰		[t CO ₂ -eq. ha ⁻¹ a ⁻¹]	[%]	[%]
Cropland	CO ₂	29.70	45.7	17.4
Cropland	N ₂ O	5.01	85.5	286.5
Cropland	CH ₄	0.65	66.7	233.9

The calculations are spatially and chronologically consistent and complete for the entire report period, 1990 – 2013.

6.5.4 Category-specific quality assurance / control and verification (4.B)

Details regarding this year's reviews are provided in Chapter 6.1.3.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Quality assurance for input data (ATKIS®, BÜK, official statistics; cf. Chapter 6.3) is the responsibility of the relevant data administrators (cf. the pertinent documentation in the inventory description).

The emissions-calculation results as presented in the present report cannot be compared with other relevant data sources for Germany, since no such other data sources exist that meet applicable requirements, i.e. provide complete coverage, are comprehensive and are independent of the methods and data sources described in the present report.

Table 370 presents an intra-European comparison of implied emission factors (IEF) for various source categories. For this comparison, the most recent data of neighbouring countries were used. They were obtained from the countries' most recent submissions to the Secretariat of the UN Framework Convention on Climate Change. The comparison shows – especially when the large pertinent uncertainties and broad scattering of reported values are taken into account (cf. Chapter 6.5.3) – that the country-specific values for Germany exhibit no conspicuous differences from those of Germany's neighbours in terms of order of magnitude. This also applies, especially, to the IEF for emissions – being reported for the first time – from phytomass in the "remaining" category; Germany's value is extremely close to the average of all IEF listed, which are low in all countries.

¹³⁰ Annual calculation; emission: positive $\triangleq$ source; negative $\triangleq$ sink

Table 370: Comparison of implied emission factors (IEF) for various pools in the Cropland land-use category, within Europe (Germany, for 2014 & 2015; other countries, for 2014)

Country	4.B.1 – Cropland Remaining Cropland		4.B.2 – Land Converted To Cropland			
	Organic soils [t C ha ⁻¹ a ⁻¹]	Phytomass [t C ha ⁻¹ a ⁻¹]	Mineral soils [t C ha ⁻¹ a ⁻¹]	Phytomass [t C ha ⁻¹ a ⁻¹]	Dead org. matter [t C ha ⁻¹ a ⁻¹]	Nitrous oxide [kg N ₂ O-N ha ⁻¹]
Belgium	-10	-0.0005	-1.3	-0.11	-0.01	-
Denmark	-9.3	-0.038	0.02	0.34	NA,NO	-
France	NO	0	-1.18	-0.16	-0.02	-
UK	IE	0.003	-1.26	-0.03	0	-
Netherlands	-3.98	NE	-0.79	-0.22	-0.03	-
Austria	NO	-0.023	-0.98	0.03	-0.04	-
Poland	-1	0.034	-0.05	NO	NO	-
Switzerland	-9.52	0.025	-0.25	-0.08	0	-
Czech Republic	NO	-0.0001	-0.33	-0.16	0	-
Germany, 2014	-8.1	NO	-0.79	-0.02	-0.01	-
Germany, 2015	-8.1	0.001	-0.79	-0.05	-0.3	-

carbon sink; negative: Carbon source; Source: UNFCCC, 2016a

6.5.5 Category-specific recalculations (4.B)

This year's submission includes category-specific recalculations for the entire 1990–2015 report period, to take account of the fact that new / corrected data sources and methods were used to calculate phytomass in the Cropland land-use category:

1. Activity data

- Use of areas for perennial crops, in Germany, determined from official statistics in the sub-category "Cropland remaining Cropland" (cf. Chapter 6.5.2.1).

2. Emission factors

- Introduction of emission factors for phytomass of perennial and annual crops, in the sub-category "Cropland remaining Cropland" (cf. Chapter 6.5.2.1).
- The values for the emission factors for annual phytomass were slightly modified – for cropland phytomass, in connection with correction of an error; for plant biomass on grassland (in the strict sense), in connection with an improved derivation. This yielded corrected emission factors, for calculation of CO₂ emissions, for plant biomass in the following land-use categories:
 - Cropland
 - Grassland (in the strict sense)
 - Wetlands
 - Settlements

3. Methods

- Introduction of a method for calculation of carbon-stock changes in the phytomass of perennial crops, in the sub-category "Cropland Remaining Cropland" (cf. Chapter 6.5.2.1).

In connection with such recalculation of emission factors and activity data, the pertinent uncertainties were also determined anew.

Table 371 and Table 372 show the impacts of the recalculations. In the Cropland remaining Cropland category, the perennial phytomass areas have no impact on the category's total areas, since they are always parts of those total areas. Since the emissions from phytomass resulting from

land-use changes from perennial to annual crops, and vice-versa, are being reported in the "remaining" category for the first time, the differences between the two submissions' reported total emissions are equal to the 2017 Submission's absolute figures for phytomass. The differences in the time series are not directed. They range from -0.80 % to 0.79 %. The differences in the phytomass stock changes are completely responsible for these differences. In the sub-category of land-use changes leading to cropland, the total emissions in the 2017 Submission are lower, throughout the entire time series, than they were in the previous year's submission; they vary, with no trend, from -0.03 % to -0.16 %. Here as well, the corrected emission factors for phytomass are completely responsible for the differences.

Table 371: Comparison of areas [kha] and greenhouse-gas emissions [kt CO₂-eq.], as reported in 2017 and 2016, with phytomass from Cropland Remaining Cropland (4.B.1)

Areas [kha]		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total area	2017	12,588	12,529	12,470	12,381	12,382	12,383	12,384	12,384	12,384	12,385	12,385	12,384	12,384
	2016	12,588	12,529	12,470	12,381	12,382	12,383	12,384	12,384	12,384	12,385	12,385	12,384	12,384
Area, phytomass	2017	218	214	212	203	204	203	204	205	206	209	208	206	210
	2016	0	0	0	0	0	0	0	0	0	0	0	0	0
Emissions [kt CO ₂ -eq.]		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total	2017	6,009.7	6,186.8	6,314.0	6,806.1	6,836.8	6,967.0	7,027.4	7,148.4	7,238.7	7,345.5	7,513.5	7,623.0	7,618.0
	2016	6,038.5	6,178.5	6,318.5	6,752.7	6,851.1	6,949.4	7,047.8	7,160.3	7,272.7	7,385.1	7,497.5	7,588.9	7,680.2
Phytomass	2017	-28.9	8.2	-4.5	53.4	-14.3	17.5	-20.4	-11.9	-34.0	-39.6	16.0	34.1	-62.2
	2016	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 372: Comparison of greenhouse-gas emissions [kt CO₂-eq.], as reported in 2017 and 2016, with phytomass, in connection with land-use changes to Cropland (4.B.2)

Emissions [kt CO ₂ -eq.]		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total	2017	6,935.1	6,887.5	6,844.9	5,643.8	6,067.5	6,382.4	6,568.9	6,714.4	7,084.6	7,268.4	7,396.8	7,302.6	7,113.9
	2016	6,939.6	6,892.0	6,849.2	5,645.5	6,076.9	6,391.6	6,577.5	6,723.1	7,094.0	7,277.8	7,405.9	7,308.2	7,118.9
Phytomass	2017	840.3	770.5	705.6	370.3	518.1	499.8	352.7	267.8	414.5	375.0	280.2	237.8	70.2
	2016	844.9	775.0	710.0	372.1	527.5	509.0	361.3	276.6	424.0	384.4	289.3	243.4	75.2

6.5.6 Planned improvements, category-specific (4.B)

No further improvements, in addition to those previously announced, are planned. Information about the implementation status of planned improvements in the LULUCF sector is presented in Chapter 6.1.4.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

6.6 Grassland (4.C)

6.6.1 Category description (4.C)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	4.C. Grassland		CO ₂	25,543.6	2.09%	22,092.2	2.49%	-13.5%
-/-	4.C. Grassland		CH ₄	593.8	0.05%	513.5	0.06%	-13.5%
-/-	4.C. Grassland		N ₂ O	87.5	0.01%	102.8	0.01%	17.6%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 2	RS/NS	CS
N ₂ O	Tier 2	RS/NS	CS/D
CH ₄	Tier 2	RS/NS	CS

The category *Grassland* (4.C) is a key source of CO₂ emissions in terms of emissions level and trend.

In 2015, the net anthropogenic GHG emissions from grassland amounted to 22,709.7 kt CO₂ equivalents (95% confidence interval: 13,142.7 kt CO₂-eq. $\pm$ 42.1 % - 27,751.7 kt CO₂-eq. $\pm$ 22.2 %). Drainage of organic grassland soils resulted in emissions of 24,644.5 kt CO₂, 513.5 kt CO₂-eq. of methane, and 97.7 kt CO₂-eq. of nitrous oxide. Losses via decomposition of dead wood and litter from deforestation amounted to 195.5 kt CO₂. In the grassland sector, both biomass (-669.8 kt CO₂) and mineral soils (-2,077.9 kt CO₂) functioned as carbon sinks.

These emissions consist of the sum of the emissions from the sub-categories grassland (in a strict sense) and woody grassland, whose GHG emissions differ considerably, both quantitatively and qualitatively. As Table 373 and Figure 64 and Figure 65 show, grassland (in a strict sense) is a significant CO₂ source. Its absolute emissions level, 22,577.0 kt CO₂-eq., is determined primarily by emissions from organic soils (23,908.3 kt CO₂-eq. $\pm$ 105.9 %), with the fraction for CO₂ (97.9 %) greatly exceeding that of methane (2.1 %). While biomass and dead organic matter also function as small CO₂ sources (2.3 %), mineral soils under grassland (in the strict sense) are a lasting carbon sink, accounting for 7.6 % of the gross emissions for this sub-category.

Table 373: CO₂, N₂O and CH₄ emissions [kt CO₂-eq.] from Germany's grassland, 2015, broken down by sub-categories. The table includes both the relevant sums and the upper and lower bounds of the 95 % confidence interval.

Pool	GHG	Grassland (in the strict sense) Emissions, 2015				
		Emission	[kt CO ₂ -eq.] 2.5 perc.	97.5 perc.	2.5 perc.	97.5 perc.
Grassland (in the strict sense) ¹³¹		22,577.0	12,034.7	28,116.5	46.7	24.5
Mineral soils	CO ₂ ¹³²	-1,858.2	-1,445.9	-2,529.4	22.2	36.1
	N ₂ O ¹³³	0	0	0	0	0
Organic soil	CO ₂ ¹³⁴	23,412.1	11,119.5	29,722.8	52.5	27.0
	N ₂ O ¹³⁵	IE	IE	IE	IE	IE
	CH ₄ ¹³⁶	496.1	277.6	1,701.3	44.0	242.9
Biomass	CO ₂ ¹³⁴	396.5	305.1	487.9	23.0	23.1
Dead organic matter	CO ₂ ¹³⁴	130.5	104.7	156.3	19.8	19.8

Pool	GHG	Woody grassland, emissions, 2015				
		Emission	[kt CO ₂ -eq.] 2.5 perc.	97.5 perc.	2.5 perc.	97.5 perc.
Woody grassland ¹³⁷		132.6	110.4	158.5	16.8	19.5
Mineral soils	CO ₂ ¹³⁸	-219.8	-177.3	-289.0	19.3	31.5
	N ₂ O _{direct} ¹³⁹	5.1	0.2	16.2	95.7	215.6
	N ₂ O _{indirect} ¹⁴⁰	1.2	0.0	4.6	99.9	297.8
Organic soil	CO ₂ ¹³⁴	1,232.3	997.3	1,507.0	19.1	22.3
	N ₂ O ¹³⁹	97.7	14.9	274.8	84.8	181.3
	CH ₄ ¹⁴¹	17.4	2.4	176.2	86.0	913.6
Biomass	CO ₂ ¹³⁴	-1,066.3	-683.5	-1,444.8	35.9	36.4
Dead organic matter	CO ₂ ¹³⁴	65.0	47.9	82.0	26.2	26.2

In 2015, the time series for total emissions from grassland (in the strict sense) includes emissions that have decreased by 13.6 % with respect to the base year. The time series for total emissions is dominated by emissions from organic soils; in general, it reflects the area changes in such soils over time ($r = 0.996$). The highest emissions occurred in the base year. Since then, they have been decreasing, as a result of intensified transfers of organic grassland areas into other land-use categories, especially Cropland (accounting for 95.8 % of the change area, and with a trend of +48.4 % since 2005). Along with emissions from organic soils, emissions from biomass and dead organic matter also affect the trend – as a result of deforestation measures and, more recently, of decreases in such measures. Unlike such sources, mineral soils function as a sink. Over time, that sink function has exhibited a highly significant negative trend; it has decreased by 25.2 % with respect to the base year. This is due to a decrease in conversion of Forest Land, Cropland, Wetlands

¹³¹ Subtotal of emissions from CRF tables 4.C, 4.(II).C, 4.(IV).2

¹³² Subtotal of emissions from CRF table 4.C

¹³³ Sum of direct and indirect N₂O emissions; the category-specific indirect N₂O emissions are not included and shown as such in the CRF tables; they are included, however, in the sum presented in CRF Table 4.(IV).2 for all sub-categories.

¹³⁴ Subtotal, CRF table 4.C

¹³⁵ CRF Table 3.D.a.6

¹³⁶ Subtotal, CRF table 4.(II).C

¹³⁷ Subtotal of emissions from CRF tables 4.C, 4.(II).C, 4.(IV).2, and sum from 4.(III).C

¹³⁸ Subtotal of emissions from CRF table 4.C

¹³⁹ CRF table 4.(III).C

¹⁴⁰ The category-specific indirect N₂O emissions are not included and shown as such in the CRF tables; they are included, however, in the sum presented in CRF Table 4.(IV).2 for all sub-categories.

¹⁴¹ Subtotal, CRF table 4.(II).C

and Other Land to Grassland (-26.6 %). Decreases in transfers of land from Cropland, accounting for 67.0 % of that sum, are the main factor responsible for the decrease in the sink performance.

The shapes of the time-series plots – especially the noticeable changes they show – are due primarily to the changes in area data that have occurred as of the relevant explicitly defined survey dates (cf. Chapter 6.5.3, Table 335). This applies especially to the sub-category woody grassland.

Figure 64: CO₂ emissions [kt CO₂ eq.] from grassland (in the strict sense), as a result of land use and land-use changes, in Germany, 1990 – 2015, by sub-categories

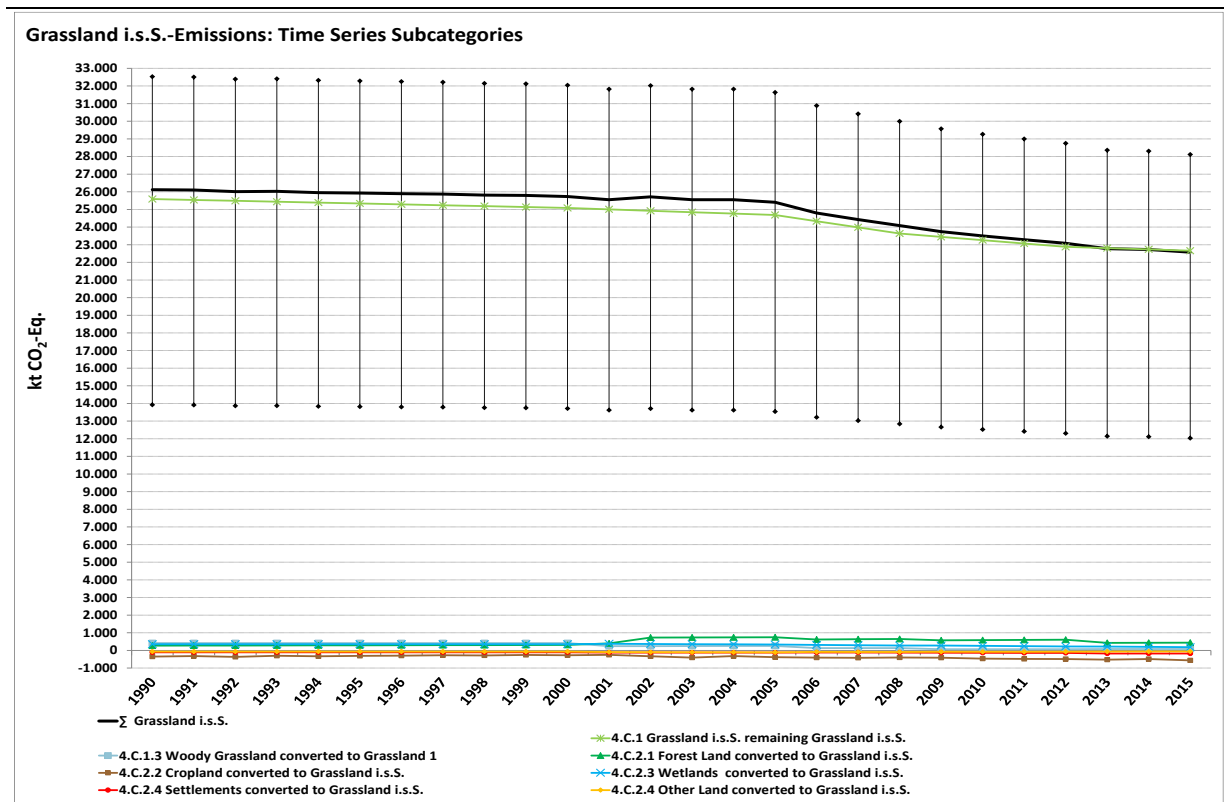
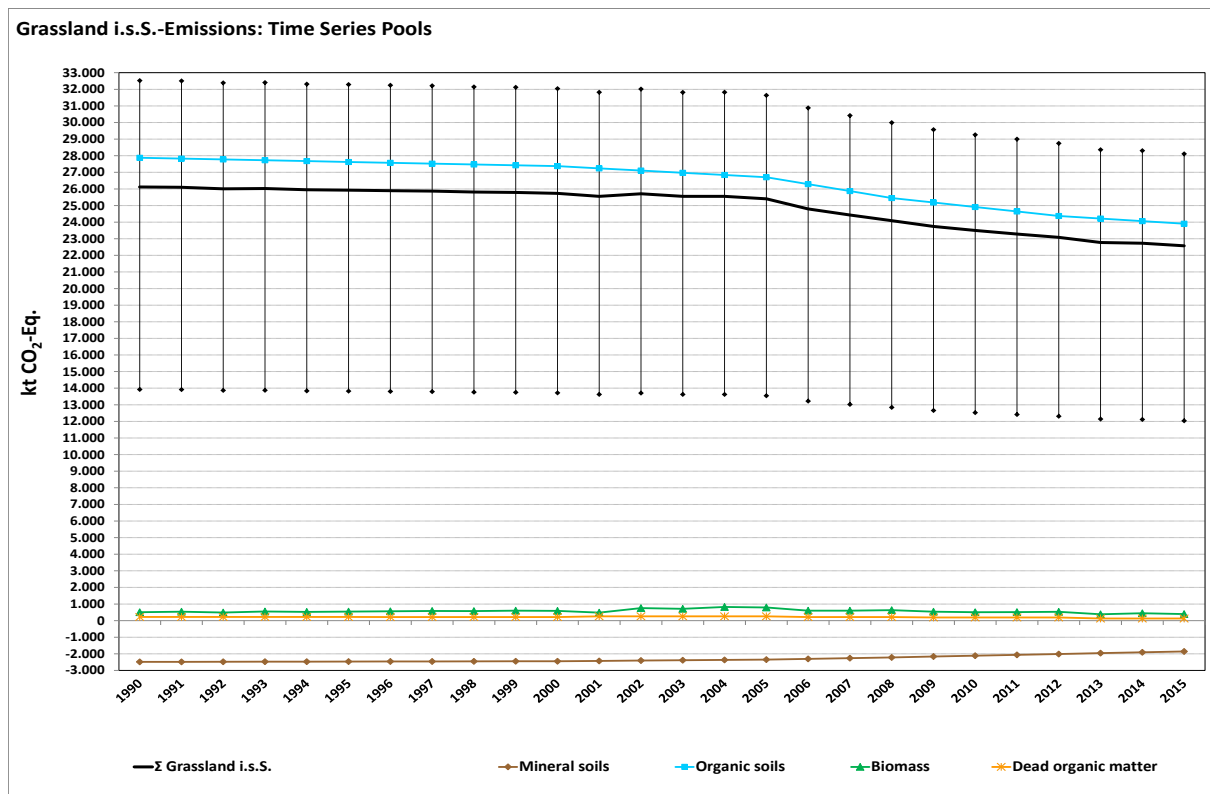


Figure 65: CO₂ emissions [kt CO₂ eq.] from grassland (in the strict sense), as a result of land use and land-use changes, in Germany, 1990 – 2015, by pools



In 2015, the sub-category woody grassland was a weak CO₂ source (132.6 kt CO₂-eq. Table 373 and Figure 64 / Figure 65). The net emissions are dominated by the source categories biomass and organic soils. The latter of these, with emissions of 1,347.4 kt CO₂-eq., are the main greenhouse-gas source (95.0 %) in the sub-category woody grassland; releases from dead organic matter (4.6 %) and nitrous oxide, via humus decomposition in mineral soils following land-use changes from grassland (in the strict sense) and from terrestrial wetlands (0.4 %) are very low. Such releases are offset by CO₂ removals in mineral soils (-213.5 kt CO₂-eq.) and in biomass (-1,066.3 kt CO₂-eq.).

The plots of the time series, as shown in Figure 66 and Figure 67, show that the source function has increased by 24.0 % with respect to the base year. The plots also show that this category is highly dynamic, because land-use changes to and from the sub-category "woody grassland" involve the significant carbon stocks found in the biomass category. The plots thus reflect the decommissioning phase that took place in the German agricultural sector around the turn of the millennium, as well as the increasing agricultural intensification that has occurred over the past few years. The shapes of the time-series plots – especially the noticeable changes they show – are due primarily to the changes in area data that have occurred as of the relevant explicitly defined survey dates. This applies especially to the sub-category woody grassland (cf. Chapter 6.3.5, Table 335).

Figure 66: CO₂ emissions [kt CO₂-eq.] from Germany's woody grasslands, as a result of land use and land-use changes, 1990 – 2015, by sub-categories

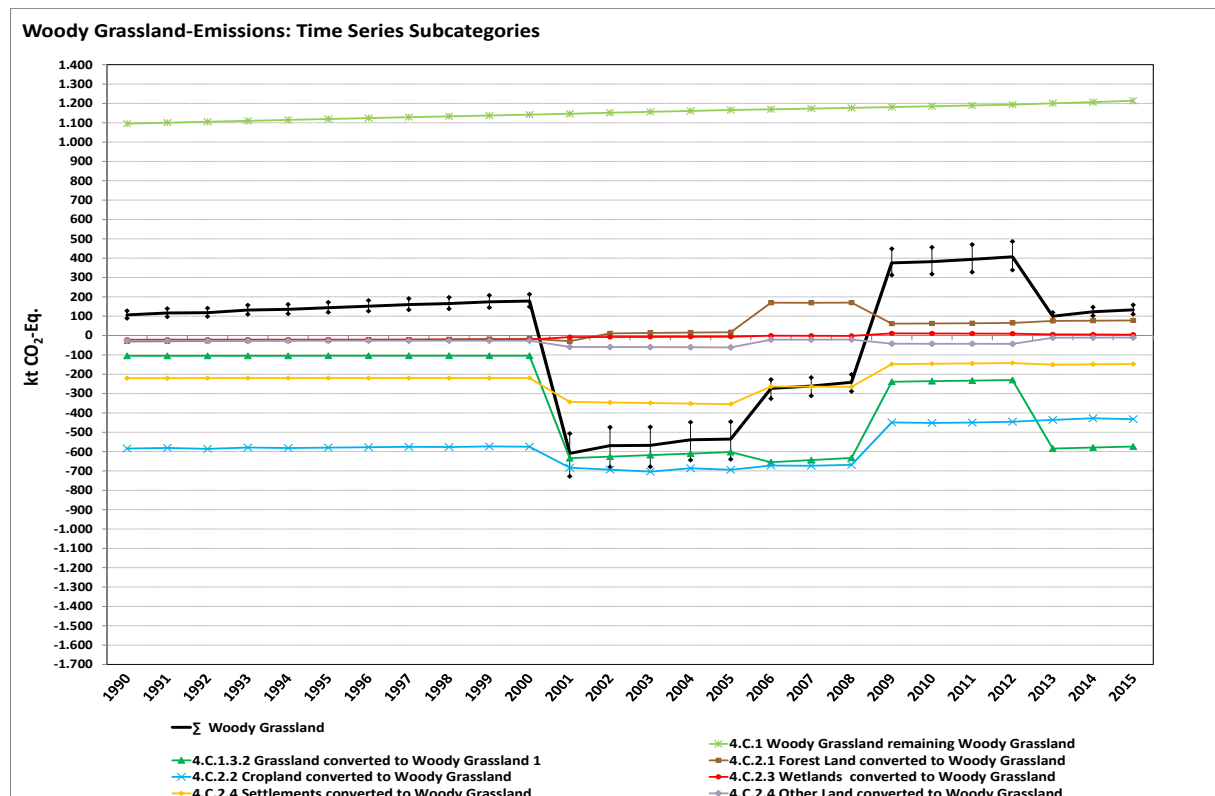
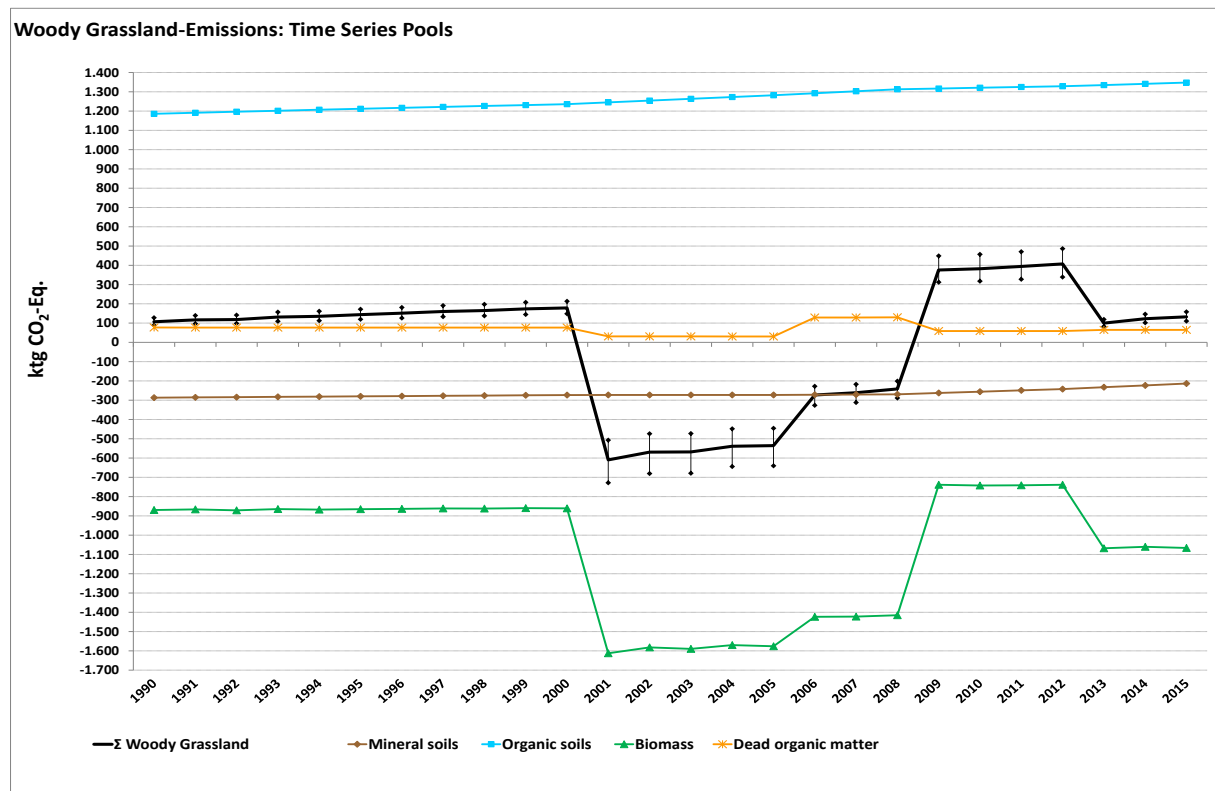


Figure 67: CO₂ emissions [kt CO₂-eq.] from Germany's woody grasslands, as a result of land use and land-use changes, 1990 – 2015, by pools



6.6.2 Methodological issues (4.C)

6.6.2.1 Data sources

- Statistisches Bundesamt, Fachserie 3, Reihe 3, Land- und Forstwirtschaft, Fischerei, Landwirtschaftliche Bodennutzung und pflanzliche Erzeugung (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries, agricultural soil use and crop cultivation; various years),
- Statistisches Bundesamt, Fachserie 3, Reihe 3.2.1, Land- und Forstwirtschaft, Fischerei, Wachstum und Ernte – Feldfrüchte (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries, growth and harvests – crops; various years),
- Statistisches Bundesamt, Fachserie 3, Reihe 3.1.2, Land- und Forstwirtschaft, Fischerei, – Bodennutzung der Betriebe (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries – soil use by sectoral operations; various years),
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 - Agriculture, Forestry and Other Land Use (IPCC 2006),
- "Ordinance on application of fertilisers, soil additives, culture substrates and plant additives according to the principles of good practice in fertilization (Ordinance on Fertilisation – Düngeverordnung (DüV))" (Ordinance on Fertilisation in the version as promulgated 27 February 2007 (Federal Law Gazette I, p. 221), last amended by Article 18 of the Act of 31 July 2009 (Federal Law Gazette I p. 2585) (Federal Law Gazette 2009),
- Interim report in the research project "Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Wäldern" ("Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth") (PÖPKEN 2011).

6.6.2.2 Biomass

For calculation of carbon-stock changes in biomass, in connection with land-use changes to and from grassland, constant (over time) carbon stocks were determined for the sub-categories "grassland (in a strict sense)" and "woody grassland". In addition, conversions from grassland (in a strict sense) to woody grassland and vice-versa are treated like land-use changes, and listed as such in the CRF tables (4.C.1).

No carbon-stock changes are given for the biomass of areas in the sub-categories grassland (i.s.s.) and woody grassland, since the carbon fluxes and the wood biomass in these categories are assumed to be in equilibrium; under the gain-loss method, therefore, $\Delta C = 0$ (Equation 2.7 in the 2006 IPCC Guidelines). The reasons for this are presented in Chapter 6.1.2.3.1. Consequently, "NA" (not applicable) has been entered in CRF table 4.C.1, under the headings "living biomass" and "dead organic matter," for the "remaining" categories of grassland (in the strict sense) and woody grassland.

The method with which CO₂ emissions from biomass, as a result of land-use changes, are calculated is presented in Chapter 6.1.2.3.2, while the method used to determine activity data is described in Chapter 6.3. The emission factors and their uncertainties are shown in Table 319 and Table 317.

6.6.2.3 Mineral soils

No change in carbon stocks in mineral soils is listed for areas remaining as cropland. The constancy of carbon stocks is substantiated by the results obtained on 42 regional long-term-trial areas (HÖPER & SCHÄFER 2012, FORTMANN et al. 2012 and BLU 2011). The pertinent long-term observations cover a period of 20 – 25 years. During that period, most of the areas studied

exhibited no changes in the carbon stocks in mineral soils. Some soils showed slight reductions, while others exhibited slight increases that nearly exactly offset the decreases, in absolute terms. In CRF Table 4.C.1, "NO" (not occurring) has thus been entered in the spaces "carbon-stock changes in mineral soils" in the final-use categories grassland (in a strict sense) and woody grassland. The manner in which CO₂ emissions resulting from conversions leading to grassland (in a strict sense) and to woody grassland are calculated is described in Chapter 6.1.2.1, while the pertinent emission factors and their uncertainties are shown in Table 374 and Table 376 in Chapter 6.6.3, and derivation of the emission factors is described in Chapter 19.4.2. The emissions in the non-transfer categories ("remaining") are listed in CRF Table 4.C.1, while the emissions resulting from land-use changes are listed in CRF Tables 4.C.2.1-4.C.2.5. The nitrous oxide emissions from mineral soils are included in the figures in CRF Tables 4(III).C and 4(IV).2.

6.6.2.4 Organic soils

In the Grassland land-use category, CO₂, CH₄ and N₂O emissions from organic soils are reported; nitrous oxide emissions are reported solely for the woody grassland sub-category, however. N₂O emissions from organic soils under grassland (in a strict sense) are reported as part of the "Agriculture" sector, in CRF Table 3.D.a.6 "Cultivation of Histosols" (cf. Chapter 6.5.2). To prevent double-counting, therefore, N₂O emissions from organic soils that result from conversions to grassland (in a strict sense) are listed in the LULUCF tables with the notation key "IE". The methods used to calculate emissions from organic soils, and to derive the relevant emission factors, are described in Chapter 6.1.2.2.

The annual emissions following land-use changes leading to Grassland (in a strict sense) are calculated with the same procedure used for emissions from organic soils in the sub-category Grassland (in a strict sense) remaining as Grassland (in the strict sense). A similar approach is taken with emissions from organic soils following land-use changes leading to Woody grassland; they are calculated in same way that emissions from Woody grassland remaining woody grassland are calculated. The emissions in the "remaining as" categories are listed in CRF Table 4.C.1, while the emissions resulting from land-use changes are listed in CRF Tables 4.C.2.1-4.C.2.5. Methane emissions from organic soils, and from drainage ditches are included in the figures in CRF Table 4.II.C, while nitrous oxide emissions from the Woody grassland sub-category are presented in 4(II).H.

6.6.3 Uncertainties and time-series consistency (4.C)

Table 374 and Table 376 show the uncertainties relative to the emission factors for the sub-categories Grassland (in a strict sense) and Woody grassland. As a rule, the relevant distribution functions show a log-normal distribution, and they are characterised by their upper and lower boundaries. The uncertainties for the mineral soils category in the two sub-categories are of about the same order of magnitude. With regard to biomass, the uncertainties for the emission factors are higher for the "woody grassland" sub-category. Those uncertainties reflect the great diversity of relevant woody grassland in Germany. With respect to the uncertainties for the emission factors for CO₂, nitrous oxide and methane from organic soils, the statements made in Chapter 6.5.3 apply.

The uncertainties shown in Table 517 in Chapter 19.4.3 for the activity data have a normal distribution, with values between 1.5 – 96.0 % for half of the 95 % confidence interval. In this case as well, the uncertainty depends on the sample size, i.e. on the area share being considered. Weighted by area, the total uncertainty for activity data in the grassland category is 1.34 %.

In terms of total emissions, Table 517 in Chapter 19.4.3 shows that emissions from organic soils under grassland contribute significantly to the emissions and total uncertainty of the LULUCF inventory.

Table 374: Emission factors [$\text{t C ha}^{-1} \text{ a}^{-1}$], with uncertainties [% of location scale], as used for calculation of 2015 GHG emissions from grassland (in the strict sense)

Grassland _{i,t.s.s.} Land use _{before} Mineral soils CO ₂ -C ¹⁴²	Land use _{after}	Emission factor [$\text{t C ha}^{-1} \text{ a}^{-1}$]	Bounds upper [%]	lower [%]
Forest land	Grassland _{i,t.s.s.}	0.85	25.6	42.7
Cropland	Grassland _{i,t.s.s.}	0.87	29.6	49.1
Woody grassland	Grassland _{i,t.s.s.}	0.21	31.5	56.9
Terr. wetlands	Grassland _{i,t.s.s.}	0.17	31.8	47.4
Waters	Grassland _{i,t.s.s.}	0.00	45.9	77.9
Settlements	Grassland _{i,t.s.s.}	0.94	32.6	57.5
Other land	Grassland _{i,t.s.s.}	1.09	32.6	59.7
Biomass ¹⁴³		[$\text{t C ha}^{-1} \text{ a}^{-1}$]	[%]	[%]
Forest land	Grassland _{i,t.s.s.}	-47.85	22.4	22.4
Cropland	Grassland _{i,t.s.s.}	-0.26	16.4	6.4
Woody grassland	Grassland _{i,t.s.s.}	-36.35	47.0	47.9
Terr. wetlands	Grassland _{i,t.s.s.}	-12.12	34.0	34.6
Waters	Grassland _{i,t.s.s.}	6.81	30.3	30.3
Settlements	Grassland _{i,t.s.s.}	-5.68	32.2	32.8
Other land	Grassland _{i,t.s.s.}	6.81	30.3	30.3
Dead organic matter ¹⁴⁴		[$\text{t C ha}^{-1} \text{ a}^{-1}$]	[%]	[%]
Forest land	Grassland _{i,t.s.s.}	-20.67	6.2	6.2

Forest land, cropland: annually variable; all other factors are constant

¹⁴² Calculation covers a 20-year period; stock change: positive $\triangleq$ sink; negative $\triangleq$ source

¹⁴³ Calculation only for first year of land-use change, stock change: positive $\triangleq$ sink; negative $\triangleq$ source

¹⁴⁴ Calculation only for first year of land-use change, stock change: positive $\triangleq$ sink; negative $\triangleq$ source

Table 375: Uncertainties for emission factors [2.5 and 97.5 percentile, in % of location scale] for emissions from organic soils, Grassland (in a strict sense), 2015

Land use	Greenhouse gas	Emission factor	Bounds	
			lower	upper
Organic soil ¹⁴⁵		[t CO ₂ -eq. ha ⁻¹ a ⁻¹]	[%]	[%]
Grassland (in the strict sense)	CO ₂	25.07	55.4	28.4
Grassland (in the strict sense)	N ₂ O	1.17	99.4	222.7
Grassland (in the strict sense)	CH ₄	0.53	46.9	258.6

Table 376: Emission factors [t C ha⁻¹ a⁻¹], with uncertainties [% of location scale], as used for calculation of GHG emissions in 2015 from woody grassland

Woody grassland Land use _{before}	Land use _{after}	Emission factor	Bounds	
Mineral soils CO ₂ -C ¹⁴⁶		[t C ha ⁻¹ a ⁻¹]	upper [%]	lower [%]
Forest land	Woody grassland	0.60	23.4	44.5
Cropland	Woody grassland	0.66	27.9	51.1
Grassland (in the strict sense)	Woody grassland	-0.21	31.5	56.9
Terr. wetlands	Woody grassland	-0.04	30.7	49.1
Waters	Woody grassland	0.00	42.9	83.3
Settlements	Woody grassland	0.73	31.2	85.0
Other land	Woody grassland	0.88	31.1	62.0
Mineral soil, N ₂ O _{direct} ¹⁴⁷		[kg N ₂ O ha ⁻¹ a ⁻¹]		
			[%]	[%]
Grassland (in the strict sense)	Woody grassland	0.263	91.6	213.9
Terr. wetlands	Woody grassland	0.042	91.3	211.9
Mineral soil, N ₂ O _{indirect} ¹⁴⁸		[kg N ₂ O ha ⁻¹ a ⁻¹]		
			[%]	[%]
Grassland (in the strict sense)		0.059	100	296.6
Terr. wetlands		0.009	100	295.2
Biomass ¹⁴⁹		[Mg C ha ⁻¹ a ⁻¹]		
			[%]	[%]
Forest land	Woody grassland	-11.50	27.7	28.1
Cropland	Woody grassland	36.61	47.1	48.0
Grassland (in the strict sense)	Woody grassland	36.35	47.0	47.9
Terr. wetlands	Woody grassland	24.23	34.0	34.6
Waters	Woody grassland	43.16	54.2	55.2
Settlements	Woody grassland	30.67	43.3	44.2
Other land	Woody grassland	43.16	54.2	55.2
Dead organic matter ¹⁵⁰		[Mg C ha ⁻¹ a ⁻¹]		
			[%]	[%]
Forest land	Woody grassland	-20.67	6.2	6.2

Forest land, cropland: annually variable; all other factors are constant

¹⁴⁵ Annual calculation; emission: positive $\triangleq$ source; negative $\triangleq$ sink

¹⁴⁶ Calculation covers a 20-year period; stock change: positive $\triangleq$ sink; negative $\triangleq$ source

¹⁴⁷ Calculation covers a 20-year period; emission: positive $\triangleq$ source; negative $\triangleq$ sink

¹⁴⁸ Calculation covers a 20-year period; emission: positive $\triangleq$ source; negative $\triangleq$ sink

¹⁴⁹ Calculation only for first year of land-use change, stock change: positive $\triangleq$ sink; negative $\triangleq$ source

¹⁵⁰ Calculation only for first year of land-use change, stock change: positive $\triangleq$ sink; negative $\triangleq$ source

Table 377: Uncertainties for emission factors [2.5 and 97.5 percentile, in % of location scale] for emissions from organic soils under woody grassland, 2015

Land use	Greenhouse gas	Emission factor	Bounds	
			lower	upper
Organic soil ¹⁵¹		[t CO ₂ -eq. ha ⁻¹ a ⁻¹]	[%]	[%]
Woody grassland	CO ₂	8.17	21.0	24.6
Woody grassland	N ₂ O	0.65	93.8	200.7
Woody grassland	CH ₄	0.12	95.2	1,011.6

For both grassland (in the strict sense) and woody grassland, the calculations are spatially and chronologically consistent and complete for the entire report period, 1990 – 2015.

6.6.4 Category-specific quality assurance / control and verification (4.C)

Details regarding this year's reviews are provided in Chapter 6.1.3.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Quality assurance for input data (ATKIS®, BÜK, official statistics) is the responsibility of the relevant data administrators (cf. the pertinent documentation in the inventory description).

The emissions-calculation results as presented in the present report cannot be compared with other relevant data sources for Germany, since no such other data sources exist that meet applicable requirements, i.e. provide complete coverage, are comprehensive and are independent of the methods and data sources described in the present report.

To provide context for the German results, the national IEF for the various pools were compared with the corresponding figures for Germany's neighbours. For the comparison, the most-recent IEF were used, i.e. the IEF sent by those countries, with their most-recent submissions, to the UNFCCC Secretariat.

As Table 378 shows, Germany's IEF for CO₂ from drainage of organic soils under grassland is comparable to those of neighbouring countries with similarly intensive bog use, such as Switzerland and the Netherlands. That value, however, is an area-weighted mixed value obtained from the factors -6.85 t C ha⁻¹ a⁻¹ for grassland (in the strict sense) and -2.23 t C ha⁻¹ a⁻¹ for woody grassland (Chapter 6.6.2.4). In the case of land-use changes leading to grassland, involving organic soils, the same emission factor applies, immediately, that applies for grassland remaining grassland.

In the category "grassland remaining grassland", the carbon-stock changes in mineral soils and in biomass, as reported for Germany, refer to changes between grassland (in a strict sense) and woody grassland. The mean emission factors are very low, since only a small area share is involved. Such changes are handled very differently from country to country, and thus the relevant mean emission factors of different countries cannot be directly compared.

In Germany, the land-use changes to grassland have produced a strong carbon sink in mineral soils; the pertinent values are comparable to those of two countries that share borders with Germany, Austria and France. All in all, the German IEF for 2015 is somewhat higher than the average of all values listed in Table 378. In addition, Germany's IEF for biomass in transition categories does not differ significantly from those of the neighbouring countries. It is comparable to the values of Belgium and the UK, it is nearly neutral (slight source) and it is somewhat higher than the mean value, which corresponds to a stronger source. The spread for the IEF for biomass

¹⁵¹ Annual calculation; emission: positive $\triangleq$ source; negative $\triangleq$ sink

is considerably larger than it is in connection with mineral soils, however. The reason for this has to do with country-specific category boundaries – and, thus, with category composition (in Germany, the figure is a mixed value reflecting grassland (in the strict sense) and woody grassland).

Table 378: Comparison of implied emission factors (IEF) for various pools in the grassland sector, within Europe (Germany, for 2014 & 2015; other countries, for 2014)

Country	4.C.1 – Grassland Remaining Grassland			4.C.2 – Land Converted To Grassland			
	Organic soils	Mineral soils	Biomass	Organic soils	Mineral soils	Biomass	Dead org. matter
	t C ha ⁻¹						
Belgium	-2.50	0.09	NO	NO	1.30	-0.03	0.00
Denmark	-6.26	NO	-0.19	-8.40	-0.02	-0.36	-0.04
France	NO	NO	0.00	-2.39	1.07	-0.12	-0.02
UK	IE, NO	0.11	0.00	-0.25	0.64	-0.01	-0.35
Netherlands	-4.62	0.00	NE	-4.20	0.68	-0.16	-0.07
Austria	-0.25	0.00	NO	NO	0.89	-0.70	-0.40
Poland	-0.25	-0.02	NO	NO	0.95	0.23	-0.16
Switzerland	-9.07	0.01	0.01	-9.00	0.53	-0.81	IE, NO
Czech Republic	NO	0.09	NO	NO	0.47	0.00	0.00
Germany, 2014	-6.19	0.00	0.03	-6.38	0.82	-0.02	-0.01
Germany, 2015	-6.19	0.002	0.03	-6.37	0.82	-0.002	-0.07

Positive: carbon sink; negative: Carbon source; Source: UNFCCC, 2016a

6.6.5 Category-specific recalculations (4.C)

This year's submission includes category-specific recalculations for the entire 1990–2015 report period, to take account of the fact that new / corrected data sources and methods were used to calculate phytomass in the Grassland land-use category: For the present submission, the emission factors for herbaceous, annual phytomass were slightly modified – for cropland phytomass, in connection with correction of an error; for plant biomass on grassland (in the strict sense), in connection with an improved derivation (cf. Chapter 6.1.2.3.3). This yielded corrected emission factors, for calculation of CO₂ emissions, for the plant biomass of the following land-use categories:

- Cropland
- Grassland (in the strict sense)
- wetlands
- Settlements

In connection with such recalculation of emission factors and activity data, the pertinent uncertainties were also determined anew.

In the Grassland land-use category, changes with respect to the previous year, as a result of recalculations, occurred only in the transition categories. A relevant comparison is shown, for the biomass pool and the total emissions, in Table 379. None of the other pools in the transition and "remaining" categories are affected by the recalculations. As a result of the recalculations, in the 2017 Submission, the total emissions for the transition categories leading to Grassland have increased, throughout the entire time series, with respect to the previous year's submission. They show a decreasing trend. On the whole, the differences are very small, and they can be attributed completely to the changes in the emission factors for biomass. The difference with respect to the 2016 Submission, and with regard to total emissions and biomass for the year 1990, amounts to 5.5 kt CO₂-eq. In relation to the total emissions, that figure represents a share of 0.02 % and, in relation to biomass, a share of 1.49 %. For the year 2014, the difference works out to 1.7 kt CO₂-eq., or 0.01 % with respect to total emissions, and 2.27 % with respect to biomass.

Table 379: Comparison of areas [kha], and of emissions [kt CO₂-eq.] from land-use changes leading to Grassland, as reported in 2017 and 2016 (4.C.2)

		Emissions [kt CO ₂ -eq.]							
		1990	1995	2000	2005	2006	2007	2008	2009
Total	2017	26,225	26,070	25,910	24,869	24,524	24,167	23,845	24,120
	2016	26,220	26,065	25,905	24,866	24,521	24,164	23,843	24,117
Biomass	2017	-364	-318	-275	-786	-824	-820	-782	-203
	2016	-369	-323	-280	-789	-827	-822	-784	-205
		2010	2011	2012	2013	2014			
Total	2017	23,879	23,679	23,491	22,874	22,853			
	2016	23,877	23,677	23,489	22,873	22,851			
Biomass	2017	-234	-226	-205	-682	-615			
	2016	-237	-228	-208	-684	-617			

6.6.6 Planned improvements, category-specific (4.C)

No further improvements, in addition to those previously announced, are planned. Information about the implementation status of planned improvements in the LULUCF sector is presented in Chapter 6.1.4.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

6.7 Wetlands (4.D)

6.7.1 Category description (4.D)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	4.D. Wetlands	0	CO ₂	4,064.0	0.33%	4,006.7	0.45%	-1.4%
-/-	4.D. Wetlands	0	CH ₄	41.8	0.00%	43.4	0.00%	3.8%
-/-	4.D. Wetlands	0	N ₂ O	21.5	0.00%	22.3	0.00%	3.6%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 2	RS/NS	CS
N ₂ O	Tier 2	RS/NS	CS/D
CH ₄	Tier 2	RS/NS	CS

The source category *Wetlands* is a key category for CO₂ emissions in terms of emissions level and trend.

In Germany, the "Wetlands" category primarily includes the country's few undrained semi-natural bogs that are largely free of anthropogenic impacts. It also includes a range of other wetlands that in the present report are combined under the headings "terrestrial wetlands", "waters and flooded land", and "peat-extraction areas" used for production of horticultural peat.

CO₂ emissions from regulated waters with widely fluctuating water levels (flooded lands) are reported pursuant to the IPCC Guidelines 2006, i.e. only as emissions from biomass that result from land-use changes. Methane emissions are thus not subject to reporting obligations. Emissions from peat extraction are reported solely in the category "Wetlands remaining Wetlands". The relevant changes in carbon stocks in above-ground and below-ground biomass, and in soils, are reported in the various transition categories. The results of the emissions calculations for the year 2015 are shown in Table 380, while the emissions trends, broken down by categories and sub-categories, are presented in Figure 68 and Figure 69.

Table 380: CO₂, N₂O and CH₄ emissions [kt CO₂-eq.] from Germany's wetlands, 2015. The table includes both the relevant sums and the upper and lower bounds of the 95 % confidence intervals.

Peat extraction, 2015						
Pool	GHG	[kt CO ₂ -eq.]		[%]		
		Emission	2.5 perc.	97.5 perc.	2.5 perc.	97.5 perc.
Peat extraction _{total}		2,197.1	1,377.9	3,016.4	37.3	37.3
Mineral soils	CO ₂	NO	NO	NO	NO	NO
	N ₂ O	NO	NO	NO	NO	NO
Organic soil	CO ₂	2,183.6	1,364.6	3,002.9	37.5	37.5
	N ₂ O	7.9	2.9	12.9	63.4	63.4
	CH ₄	5.6	1.9	10.7	65.3	92.9
Biomass	CO ₂	/	/	/	/	/
Litter / dead wood	CO ₂	/	/	/	/	/
Waters, 2015						
Pool	GHG	[kt CO ₂ -eq.]		[%]		
		Emission	2.5 perc.	97.5 perc.	2.5 perc.	97.5 perc.
Waters _{total}		57.5	42.2	72.9	26.6	26.7
Mineral soils	CO ₂	/	/	/	/	/
	N ₂ O	/	/	/	/	/
Organic soil	CO ₂	/	/	/	/	/
	N ₂ O	/	/	/	/	/
	CH ₄	/	/	/	/	/
Biomass	CO ₂	52.1	37.0	67.2	28.9	29.1
Litter / dead wood	CO ₂	5.4	2.6	8.2	51.6	51.6
Terrestrial wetlands, 2015						
Pool	GHG	[kt CO ₂ -eq.]		[%]		
		Emission	2.5 perc.	97.5 perc.	2.5 perc.	97.5 perc.
Terrestrial wetlands _{total}		1,817.9	1,003.5	2,474.9	44.8	36.1
Mineral soils	CO ₂	-0.2	-0.1	-0.4	61.9	64.4
	N ₂ O _{direct}	0.25	0.0	0.82	100	234.4
	N ₂ O _{indirect} ¹⁵²	0.06	0.0	0.23	100.0	311.7
Organic soil	CO ₂	1,801.9	942.1	2,465.3	47.7	36.8
	N ₂ O	14.2	0.0	48.6	100.0	243.0
	CH ₄	37.8	14.1	238.7	62.7	531.1
Biomass	CO ₂	-40.6	-28.5	-52.9	29.9	30.2
Litter / dead wood	CO ₂	4.6	2.1	7.0	53.5	53.5

In 2015, a total of 4,072.5 kt CO₂-eq. were released from wetlands (95 % confidence interval: 2,913.6 – 5,119.9 kt CO₂-eq.). As Table 380 shows, emissions from the Wetlands land-use category come primarily from organic soils, and in such soils the emissions break down into the two nearly equal parts of CO₂ emissions via peat extraction (53.9 %) and CO₂ emissions via drainage of terrestrial organic soils (44.5 %). Releases of methane (1.1 %) and nitrous oxide (0.5 %) are very low, in comparison to the total emissions, as are CO₂ releases from dead organic matter (0.3 %) and biomass (0.3 %). In the Waters sub-category, the latter (CO₂ releases from biomass) function as a source, while in the "Terrestrial wetlands" sub-category, they function as a sink. Mineral soils also have a sink function – a very weak one – in this sub-category.

Emissions from industrial peat extraction are divided into emissions that occur in extraction areas, during peat extraction (on-site emissions), and emissions that are released during application of peat products (off-site emissions). In 2015, the latter amounted to 2,066.4 ± 766.6 kt CO₂-eq. and thus were the main factor responsible for the magnitude of total emissions from peat extraction (94.6 %). The on-site emissions, at 130.7 kt CO₂-eq., (-9.9 % / +11.5 %), are relatively low by contrast. Their predominant component is CO₂ (89.7 %); methane (4.3 %) and nitrous oxide emissions (6.1 %) play marginal roles.

¹⁵² The category-specific indirect N₂O emissions are not included and shown as such in the CRF tables; they are included, however, in the sum presented in CRF Table 4.(IV).2 for all sub-categories.

As the time series in Figure 68 and Figure 69 show, total emissions decreased in 2015 with respect to the base year (-1.3 %), but the individual changes over time remained incremental overall. The shape of the curve is determined primarily by peat extraction – it reflects the annual peat-production quantities – while emissions from organic soils in the terrestrial soils sub-category remain at a rather constantly high level, with few changes over the period concerned (± 3 %).

Figure 68: CO₂ emissions [kt CO₂-eq.] from Germany's wetlands, as a result of land use and land-use changes, 1990 – 2015, by sub-categories

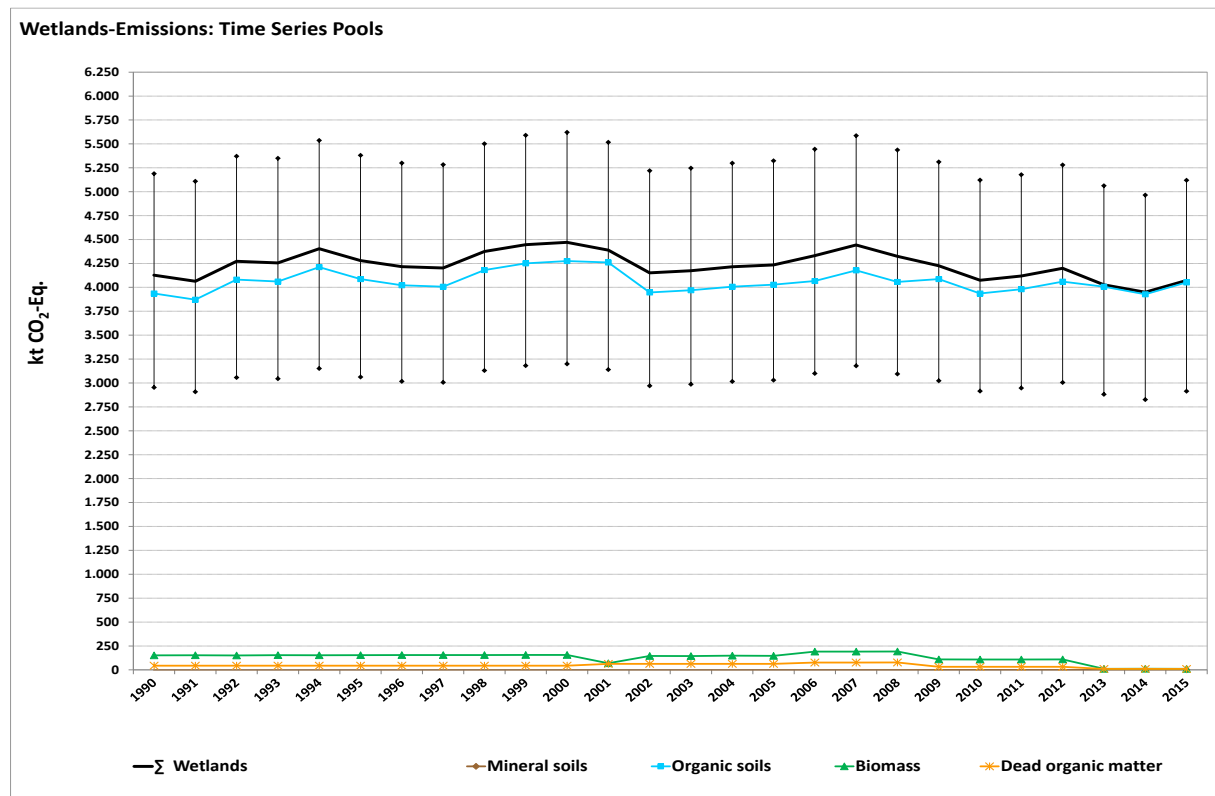
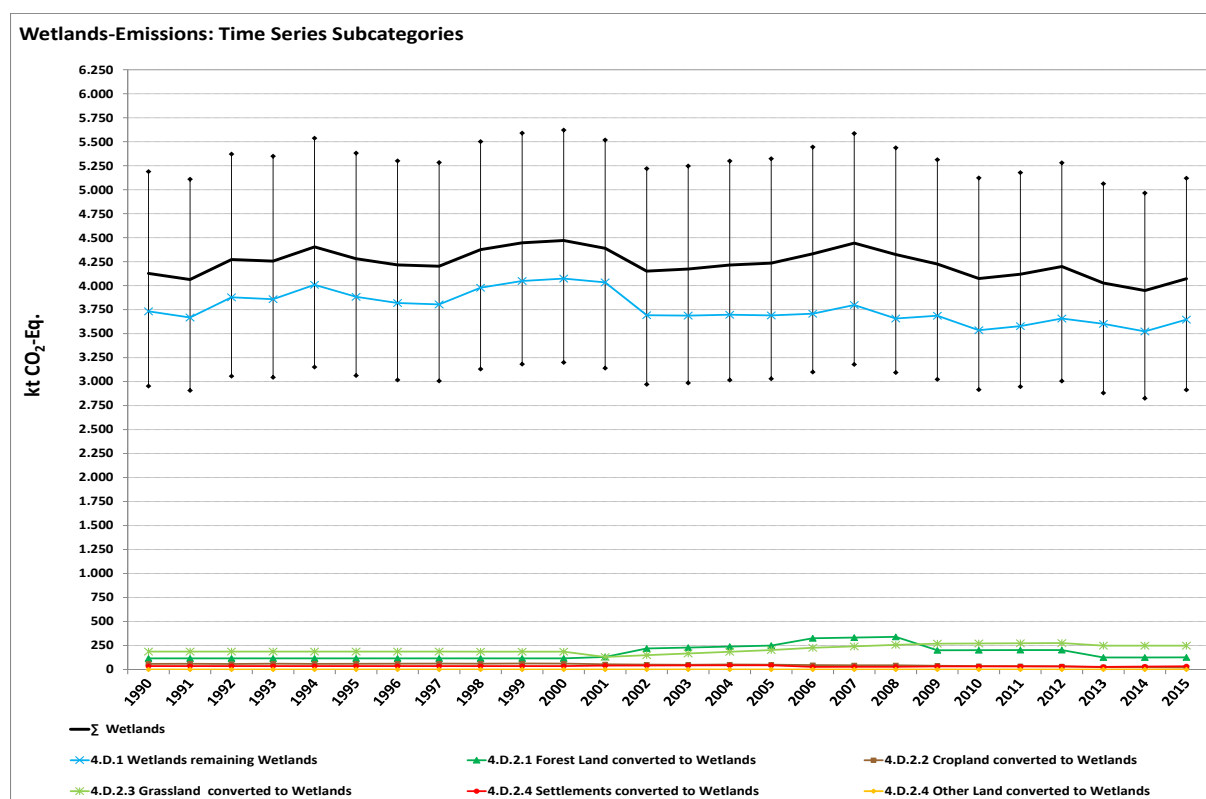


Figure 69: CO₂ emissions [kt CO₂-eq.] from Germany's wetlands, as a result of land use and land-use changes, 1990 – 2015, by pools



6.7.2 Methodological issues (4.D)

6.7.2.1 Data sources

The production-quantity data for industrial peat extraction were taken from official German statistics (FEDERAL STATISTICAL OFFICE, Fachserie 4, Reihe 3.1).

For further sources, cf. Chapters 6.3.2, 6.2 and 19.4.2.

6.7.2.2 Biomass

Water areas are free of vegetation cover, and thus the biomass carbon stocks are zero and are always reported in the CRF tables as "NO" (not occurring).

For the sub-category "Terrestrial wetlands", changes in biomass carbon stocks, as a result of land-use changes, are calculated with the procedures and methods described in Chapter 6.1.2.3.

As a rule, terrestrial wetlands are covered with trees and shrubs (throughout a spectrum ranging from scattered bushes to actual forests), mosses and grasses, with mosses and grasses predominating. Accordingly, the inventory uses the following assumption relative to the area-related distribution of carbon stocks in biomass: 1/3 trees and shrubs and 2/3 mosses/grasses.

Since no biomass surveys of such lands have been carried out in Germany, the relevant values for woody grassland and grassland (in the strict sense) are used as approximations. Therefore, the reporting methods are in keeping with those set forth in Chapter 6.6.2.2.

The carbon stocks in terrestrial wetlands can then be calculated pursuant to Equation 50. The relevant results are shown in Table 381. As a result of the changes in Grassland carbon stocks in this year (cf. Chapter 6.6.5), a change in the biomass carbon stocks in Wetlands areas, with respect

to the previous submissions, follows from Equation 50. The changes in such biomass carbon stocks are also shown in Table 381.

Equation 50:

$$C \text{ stocks}_{\text{terr. wetlands}} = C \text{ stocks}_{\text{woody grassland}} * 0.333 + C \text{ stocks}_{\text{grassland (in the strict sense)}} * 0.667$$

Table 381: Area-based carbon stocks [t ha⁻¹] for biomass in Germany's terrestrial wetlands (95% confidence interval), and the pertinent change [%] with respect to the 2016 Submission

Terr. wetlands	Carbon stocks [t C ha ⁻¹]			Change with respect to the 2016 Submission [%]		
	Biomass, total	Biomass, above-ground	Biomass, below-ground	Biomass, total	Biomass, above-ground	Biomass, below-ground
Terr. wetlands	18.93 (10.84 - 27.16)	13.42 (6.04 - 20.91)	5.51 (2.65 - 8.49)	-0.18	-0.15	-0.23

The emission factors and pertinent uncertainties are presented in Table 383 (Chapter 6.7.3).

In keeping with the statements made in Chapter 6.6.2.2, living biomass and dead organic matter are reported as "NO" (not occurring) in the relevant "remaining as" categories of CRF table 4.D.1.

6.7.2.3 Mineral soils

It was assumed that no changes in the carbon stocks of mineral soils occurred in connection with land-use changes leading to water bodies ("NO" in CRF table 4.D.1).

For the sub-category "terrestrial wetlands", changes in mineral-soil carbon stocks, as a result of land-use changes, are calculated with the procedures and methods described in Chapter 6.1.2.1.

The emission factors and pertinent uncertainties are presented in Table 383 (Chapter 6.7.3).

6.7.2.4 Organic soils

Country-specific emission factors for organic soils in the sub-category "terrestrial wetlands" were determined in a national research project. As a result, carbon-dioxide, nitrous-oxide and methane releases are also reported in this category (cf. Chapter 6.1.2.2).

6.7.2.4.1 Peat extraction

CO₂ emissions from peat extraction were calculated in conformance with the provisions of the 2006 IPCC Guidelines, using a Tier 2 method. The total emissions, comprising both on-site and off-site emissions, were calculated via the equations 7.2 - 7.5 of the 2006 IPCC Guidelines. In the sub-category peat extraction, CO₂ emissions (on-site (emissions and DOC); off-site), CH₄ emissions (emissions, and emissions from drainage ditches) and N₂O emissions (on-site) are reported. The manner in which the relevant emission factors are derived is described in Chapter 6.1.2.2. The estimates are based on the following activity data:

- Calculation of on-site emissions: The areas of the lands on which industrial peat extraction takes place were determined with the help of the Basis-DLM (cf. Chapter 6.3). Since the relevant complete data records were not added to the Basis-DLM until the year 2011, the peat-extraction area determined for 2011 has been used for calculation of on-site emissions for all relevant years. The total extraction area has been a constant 19,857 ha.
- Calculation of off-site emissions: The quantities produced annually; these are taken from official German statistics (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 3.1).

Equation 7.3 (2006 IPCC Guidelines)

$$CO_2\text{-eq.}_{\text{peat extraction}} = CO_2\text{-eq.}_{\text{on-site}} + CO_2\text{-eq.}_{\text{off-site}}$$

$$CO_2\text{-eq.}_{\text{peat extraction}}: \text{GHG emissions from peat extraction [t C-eq. a}^{-1}\text{]}$$

CO₂-eq._{on-site}: GHG emissions that occur on-site, during production [t C-eq. a⁻¹]

CO₂-eq._{off-site}: GHG emissions that occur via extracted peat that is spread for horticultural purposes [t C-eq. a⁻¹]

In Germany, only peat from raised bogs is extracted. For this reason, Equation 7.4 (2006 IPCC Guidelines) was modified in the following manner:

$$\text{CO}_2\text{-eq.}_{\text{on-site}} = A_{\text{peat, oligotrophic}} \times (\text{EF}_{\text{peat, oligotrophic\_CO}_2} + \text{EF}_{\text{peat, oligotrophic\_N}_2\text{O}} + \text{EF}_{\text{peat, oligotrophic\_CH}_4})$$

CO₂-eq._{on-site}: on-site emissions that occur on site during peat production [t CO₂-eq. a⁻¹]

A_{peat, oligotrophic}: Peat-extraction area on raised bogs [ha]

EF_{peat, oligotrophic_(CO₂, N₂O, CH₄)}: Emission factor for raised bogs on which peat extraction is taking place [t CO₂-eq. ha⁻¹ a⁻¹ (IPCC 2006 Guidelines, Table 7.4)]

Off-site emissions were calculated with Equation 7.5 (2006 IPCC Guidelines):

$$\text{CO}_2\text{-eq.}_{\text{off-site}} = \text{Vol}_{\text{peat\_dry}} \times \text{Cfraction}_{\text{vol\_peat}}$$

CO₂off-site: CO₂-eq. emissions that occur via extracted peat that is spread for horticultural purposes [t CO₂-eq. a⁻¹]

Vol_{peat_dry}: Volume of air-dried peat [m³]

C_{fraction vol_peat}: Carbon fraction with respect to the volume of air-dried peat [0.2567 t CO₂-eq. m³ (2006 IPCC Guidelines, Table 7.5)]

Table 382: Implied emission factors (IEF) [t CO₂-eq. ha⁻¹ a⁻¹] and emissions [kt CO₂-eq.] from peat extraction in Germany

Peat extraction Year	IEF	Emissions [t CO ₂ -eq.]				
	[t CO ₂ -eq. ha ⁻¹ a ⁻¹]	on-site CO ₂	on-site NO	on-site CH ₄	off-site	Σ peat extraction
1990	108.79	117.2	7.9	5.6	2,029.5	2,160.2 ± 800.7
1995	117.57	117.2	7.9	5.6	2,203.9	2,334.6 ± 869.0
2000	128.26	117.2	7.9	5.6	2,416.2	2,546.9 ± 952.3
2005	116.35	117.2	7.9	5.6	2,179.6	2,310.3 ± 859.5
2006	116.84	117.2	7.9	5.6	2,189.5	2,320.2 ± 863.4
2007	120.98	117.2	7.9	5.6	2,271.7	2,402.4 ± 895.6
2008	113.46	117.2	7.9	5.6	2,122.2	2,252.9 ± 837.0
2009	114.69	117.2	7.9	5.6	2,146.8	2,277.5 ± 846.7
2010	106.87	117.2	7.9	5.6	1,991.5	2,122.2 ± 785.8
2011	108.84	117.2	7.9	5.6	2,030.5	2,161.2 ± 801.1
2012	112.64	117.2	7.9	5.6	2,106.0	2,236.7 ± 830.7
2013	109.42	117.2	7.9	5.6	2,042.0	2,172.7 ± 805.6
2014	104.92	117.2	7.9	5.6	1,952.7	2,083.4 ± 765.6
2015	110.65	117.2	7.9	5.6	2,066.4	2,197.1 ± 810.2

6.7.3 Uncertainties and time-series consistency (4.D)

The time series for activity data provided by the Federal Statistical Office for peat extraction are consistent and available for the entire period covered by the report. Pursuant to the Federal Statistical Office, the uncertainties for these activity data are "0", since the data have been obtained via an exhaustive survey entailing an obligation to provide information. Nonetheless, an uncertainty of 20 % is assumed, in keeping with the 2006 IPCC Guidelines. That uncertainty is due primarily to the uncertainty in conversion, for peat, of volume units to mass units. The uncertainties listed in Table 383 and Table 384, ranging up to 40 % for peat extraction, are the result of an uncertainties-propagation calculation. They are due especially to the large uncertainties in the IPCC standard values used. The statements made in Chapter 6.5.3 and Chapter 6.6.3 also apply to the uncertainties for the emission factors for methane and nitrous oxide.

The activity data and area data have a normal distribution. Their uncertainties, depending on the area and sampling sizes involved, range from 2 % to -197 % (cf. Table 517 in Chapter 19.4.3). The

total uncertainty for the area data in the wetlands category is 5.1 %. Carbon sinks in wetlands contribute very little the total emissions and total uncertainty in the LULUCF sector. Only the values relating to peat extraction are large enough to be perceived (cf. Table 517 in Chapter 19.4.3).

Table 383: Emission factors and uncertainties [in % of location scale] used for calculation of GHG emissions from Germany's wetlands in 2015, broken down by pools and sub-categories

Wetlands _{terrestrial}		Emission factors	Bounds		Waters	Emission factors	Bounds	
Land use _{before}	Land use _{after}		lower	upper	Land use _{after}		upper	lower
	Mineral soils CO ₂ -C ¹⁵³	[t C ha ⁻¹ a ⁻¹]	[%]	[%]		[t C ha ⁻¹ a ⁻¹]	[%]	[%]
Forest land	Wetlands _{terrestrial}	0.64	24.0	28.5	Waters	No emissions		
Cropland	Wetlands _{terrestrial}	0.70	28.4	36.8	Waters	No emissions		
Grassland _{i.t.s.s.}	Wetlands _{terrestrial}	-0.17	31.8	47.4	Waters	No emissions		
Woody grassland	Wetlands _{terrestrial}	0.04	30.7	49.1	Waters	No emissions		
Settlements	Wetlands _{terrestrial}	0.77	31.6	47.6	Waters	No emissions		
Waters	Wetlands _{terrestrial}	0	43.9	52.5	Waters	No emissions		
Other land	Wetlands _{terrestrial}	0.92	31.5	49.8	Waters	No emissions		
Mineral soil, N ₂ O _{direct} ¹⁵⁴		[kg N ₂ O ha ⁻¹ a ⁻¹]	[%]	[%]		[kg N ₂ O ha ⁻¹ a ⁻¹]	[%]	[%]
Grassland _{i.t.s.s.}	Wetlands _{terrestrial}	0.213	91.7	211.5	Waters	No emissions		
Mineral soil, N ₂ O _{indirect} ¹⁵⁵		[kg N ₂ O ha ⁻¹ a ⁻¹]	[%]	[%]		[kg N ₂ O ha ⁻¹ a ⁻¹]	[%]	[%]
Grassland _{i.t.s.s.}	Wetlands _{terrestrial}	0.048	100.0	294.9	Waters	No emissions		
Biomass ¹⁵⁶		[t C ha ⁻¹ a ⁻¹]	[%]	[%]		[t C ha ⁻¹ a ⁻¹]	[%]	[%]
Forest land	Wetlands _{terrestrial}	-35.73	21.6	21.7	Waters	-54.66	25.0	25.0
Cropland	Wetlands _{terrestrial}	12.38	31.9	32.5	Waters	-6.55	11.5	11.5
Grassland (in the strict sense)	Wetlands _{terrestrial}	12.12	32.4	33.0	Waters	-6.81	30.3	30.3
Woody grassland	Wetlands _{terrestrial}	-24.24	34.0	34.6	Waters	-43.16	54.2	55.2
Wetlands _{terrestrial}	Wetlands _{terrestrial}	0	0	0	Waters	-18.93	42.7	43.5
Waters	Wetlands _{terrestrial}	18.93	42.7	43.5	Waters	0	0	0
Settlements	Wetlands _{terrestrial}	6.43	31.8	32.4	Waters	-12.49	47.0	47.9
Other land	Wetlands _{terrestrial}	18.93	42.7	43.5	Waters	0	0	0
Dead organic matter		[Mg C ha ⁻¹ a ⁻¹]	[%]	[%]		[Mg C ha ⁻¹ a ⁻¹]	[%]	[%]
Forest land	Wetlands _{terrestrial}	-20.67	6.2	6.2	Waters	-20.67	6.2	6.2

Positive: sink; negative: Source

¹⁵³ Calculation covers a 20-year period; stock change: positive $\triangleq$ sink; negative $\triangleq$ source¹⁵⁴ Calculation covers a 20-year period; emission: positive $\triangleq$ source; negative $\triangleq$ sink¹⁵⁵ Calculation covers a 20-year period; emission: positive $\triangleq$ source; negative $\triangleq$ sink¹⁵⁶ Calculation only for the first year following the pertinent land-use change

Table 384: Uncertainties for emission factors [2.5 and 97.5 percentile, in % of location scale] for emissions from organic soils, for wetlands and peat extraction, 2015

Land use	Greenhouse gas	Emission factor	Bounds		
			lower	upper	
Organic soil ¹⁵⁷		[t CO ₂ -eq. ha ⁻¹ a ⁻¹]	%	%	
Wetlands	terrestrial	CO ₂	18.18	59.9	46.1
Wetlands	terrestrial	N ₂ O	0.14	100.0	306.2
Wetlands	terrestrial	CH ₄	0.38	78.9	669.9
Peat extraction		CO ₂	5.90	9.7	11.2
Peat extraction		N ₂ O	0.40	46.9	258.9
Peat extraction		CH ₄	0.28	65.3	92.9

The calculations are spatially and chronologically consistent and complete for the entire report period, 1990 – 2015.

6.7.4 Source-specific QA/QC and verification (4.D)

Details regarding this year's reviews are provided in Chapter 6.1.3.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Quality assurance for input data (ATKIS®, BÜK, official statistics) is the responsibility of the relevant data administrators (cf. the pertinent documentation in the inventory description).

The emissions-calculation results as presented in the present report cannot be compared with other relevant data sources for Germany, since no such other data sources exist that meet applicable requirements, i.e. provide complete coverage, are comprehensive and are independent of the methods and data sources described in the present report.

A comparison of Germany's implied emission factors, in the wetlands category, with those of European neighbouring countries (Table 385) shows that the IEF hardly lend themselves to comparison. This is due to differences between the pertinent combinations of soil types. In the "remaining" category, for example, Germany has the largest emission factor, because Germany's wetlands category includes peat extraction and related off-site emissions. National definitions play an especially strong role in the wetlands category. Since the applicable national circumstances differ widely from country to country, the various implied emission factors span a wide range overall. The changes in the IEF, with respect to the previous year, are due primarily to differences in the prior uses for the conversion areas.

For this comparison, the most recent data of neighbouring countries were used. They were obtained from the countries' most recent submissions to the Secretariat of the UN Framework Convention on Climate Change. The last year's submissions in each case normally include the greenhouse-gas inventory of the year before last.

¹⁵⁷ Annual calculation; emission: positive $\triangleq$ source; negative $\triangleq$ sink

Table 385: Comparison of implied emission factors (IEF) for various pools in the Wetlands land-use category, within Europe (Germany, for 2014 & 2015; other countries, for 2014)

Country	4.E.1 – Wetlands Remaining Wetlands	4.E.2 – Land Converted To Wetlands		
	Organic soils	Mineral soils	Biomass	Dead org. matter
	t C ha ⁻¹			
Belgium	-2.50	0.09	NO	NO
Denmark	-6.26	NO	-0.19	-8.40
France	NO	NO	0.00	-2.39
UK	IE, NO	0.11	0.00	-0.25
Netherlands	-4.62	0.00	NE	-4.20
Austria	NO	NO	NO	NO
Poland	-0.25	-0.02	NO	NO
Switzerland	-9.07	0.01	0.01	-9.00
Czech Republic	NO	0.09	NO	NO
Germany, 2014	-6.19	0.00	0.03	-6.38
Germany, 2015	-8.77	0.001	-0.04	-4.02

Positive: carbon sink; negative: Carbon source; Source: UNFCCC, 2016a

6.7.5 Category-specific recalculations (4.D)

This year's submission includes category-specific recalculations for the entire 1990–2015 report period, to take account of the fact that new / corrected data sources and methods were used to calculate phytomass in the Wetlands land-use category: For the present submission, the emission factors for herbaceous, annual phytomass were slightly modified – for cropland phytomass, in connection with correction of an error; for plant biomass on grassland (in the strict sense), in connection with an improved derivation (cf. Chapter 6.1.2.3.3). This yielded corrected emission factors, for calculation of CO₂ emissions, for the plant biomass of the following land-use categories:

- Cropland
- Grassland (in the strict sense)
- Wetlands
- Settlements

In connection with such recalculation of emission factors and activity data, the pertinent uncertainties were also determined anew.

Table 386 and Table 387 show the impacts of the recalculations. The emissions in the Wetlands remaining Wetlands category have hardly changed at all in comparison to the previous year's submission (a max. of -0.013 ‰). The differences are due completely to the changes in the emission factors for phytomass. In the "to Wetlands" transition categories, the recalculations also led to lower emissions in the present submission, with respect to the previous year's submission. The differences in the two submissions' figures for total emissions are very small, and they decrease over time (-8.2 ‰ to -3.5 ‰). The differences are due completely to the changes in the emission factors. All other pools of the transition and "remaining" categories are not affected by the recalculations, and thus they are not included in the tables.

Table 386: Comparison of areas [kha] for Wetlands remaining Wetlands, and of pertinent emissions [kt CO₂], as reported in 2017 and 2016

		Emissions [kt CO ₂ -eq.]							
		1990	1995	2000	2005	2006	2007	2008	2009
Total	2017	3,732.316	3,883.753	4,073.188	3,689.839	3,707.828	3,798.564	3,657.461	3,686.286
	2016	3,732.312	3,883.748	4,073.183	3,689.840	3,707.828	3,798.565	3,657.461	3,686.287
Biomass	2017	-2.725	-2.725	-2.725	0.778	0.263	0.263	0.263	0.433
	2016	-2.730	-2.730	-2.730	0.780	0.264	0.264	0.264	0.434
		2010	2011	2012	2013	2014			
Total	2017	3,535.107	3,578.226	3,657.792	3,602.538	3,522.536			
	2016	3,535.108	3,578.227	3,657.792	3,602.537	3,522.535			
Biomass	2017	0.433	0.433	0.433	-0.225	-0.225			
	2016	0.434	0.434	0.434	-0.226	-0.226			

Table 387: Comparison of areas [kha] for land-use changes to Wetlands, and of pertinent emissions [kt CO₂], as reported in 2017 and 2016

		Emissions [kt CO ₂ -eq.]							
		1990	1995	2000	2005	2006	2007	2008	2009
Total	2017	395.0	396.4	397.7	544.4	623.6	644.4	666.9	539.1
	2016	395.3	396.7	398.0	544.8	623.9	644.7	667.2	539.3
Biomass	2017	154.8	156.7	158.5	146.3	190.9	191.0	192.2	108.8
	2016	155.1	157.0	158.8	146.6	191.1	191.3	192.5	109.0
		2010	2011	2012	2013	2014			
Total	2017	539.2	540.4	541.8	424.1	426.6			
	2016	539.4	540.6	542.0	424.3	426.7			
Biomass	2017	108.0	108.2	108.7	11.4	12.6			
	2016	108.2	108.4	108.9	11.6	12.8			

6.7.6 Planned improvements, category-specific (4.D)

No further improvements, in addition to those previously announced, are planned. Information about the implementation status of planned improvements in the LULUCF sector is presented in Chapter 6.1.4.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

6.8 Settlements (4.E)

6.8.1 Category description (4.E)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	4.E. Settlements		CO ₂	1,810.7	0.15%	3,302.0	0.37%	82.4%
-/-	4.E. Settlements		N ₂ O	126.5	0.01%	194.2	0.02%	53.5%
-/-	4.E. Settlements		CH ₄	24.0	0.00%	42.6	0.00%	77.2%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	Tier 2	RS/NS	CS
N ₂ O	Tier 2	RS/NS	CS/D
CH ₄	Tier 2	RS/NS	CS

The category *Settlements* is a key category for CO₂ emissions in terms of emissions level and trend.

Reporting for the land-use category "settlements" covers CO₂ emissions / removals in the categories "soil", "biomass" and "dead organic matter" on land designated for settlement and transport uses. Precise definitions and category allocations are presented in Chapter 6.2. The

results of the estimation of relevant greenhouse-gas emissions are presented in Table 388 and in Figure 70 and Figure 71.

Table 388: CO₂, N₂O and CH₄ emissions [kt CO₂-eq.] from Germany's settlements, 2015. The table includes both the relevant sums and the upper and lower bounds of the 95 % confidence interval.

Category	GHG	Emissions, settlements, 2015				
		[kt CO ₂ -eq.]			[%]	
		Emission	2.5 perc.	97.5 perc.	2.5 perc.	97.5 perc.
Settlements¹⁵⁸		3,561.4	3,049.2	4,021.3	14.4	12.9
Mineral soils	CO ₂ ¹⁵⁹	1,004.6	733.9	1,466.2	26.9	46.0
	N ₂ O _{direct} ¹⁶⁰	100.6	26.0	273.4	74.2	171.7
	N ₂ O _{indirect} ¹⁶¹	22.6	0	76.5	99.9	238.0
Organic soil	CO ₂ ¹⁵⁹	2,008.0	1,360.8	2,347.7	32.2	16.9
	N ₂ O ¹⁶²	93.6	39.7	214.0	57.5	128.7
	CH ₄ ¹⁶²	42.6	30.6	106.1	27.4	149.4
Biomass	CO ₂ ¹⁵⁹	-61.8	-51.2	-72.4	17.0	17.2
Litter / dead wood	CO ₂ ¹⁵⁹	351.1	298.3	403.9	15.0	15.0

In 2015, the CO₂ from Germany's settlement and transport areas, as a result of land use and land-use changes, amounted to 3,561.4 kt CO₂ (Table 388). The majority (60.2 %) of that quantity was caused by drainage of organic soils. Emissions from mineral soils contributed significantly to the emissions sum, with a share of 31.7 %. These emissions are caused primarily by land-use changes from Cropland(59 %), Grassland (in a strict sense) (27 %) and Forest Land (10 %) to Settlements (Figure 70).

With respect to the base year, a net emissions increase of 1,583.7 kt CO₂ $\triangleq$ 80.1 % occurred in 2015 (cf. Figure 70 and Figure 71). The trend is clearly directed, and it is being driven primarily by conversion of cropland and grassland areas for settlement purposes (in previous years, it was also driven significantly by conversion of forest land). An emissions increase (Grassland, 38 %; Forest Land, 117 %; Wetlands, 453 %), and a considerable decrease in sink function (Cropland, -18 %; Other Land, -79 %), are seen in all sub-categories. In addition, conversion of wetlands areas in particular has led to a continual increase of emissions from organic soils.

The shapes of the time-series plots – especially the noticeable changes they show – are due primarily to the changes in area data that have occurred as of the relevant explicitly defined survey dates (cf. Chapter 6.3.5).

¹⁵⁸ Sum of the emissions from CRF tables 4.E, 4.(II).H, 4.(III).E, 4.(IV).2

¹⁵⁹ CRF table 4.E

¹⁶⁰ CRF table 4.(III).E

¹⁶¹ The category-specific indirect N₂O emissions are not included and shown as such in the CRF tables; they are included, however, in the sum, for all sub-categories, presented in CRF Table 4.(IV).2.

¹⁶² CRF table 4.(II).H

Figure 70: CO₂ emissions [kt CO₂-Eq.] as a result of settlement-related land use and land-use changes, 1990 – 2015, by sub-categories

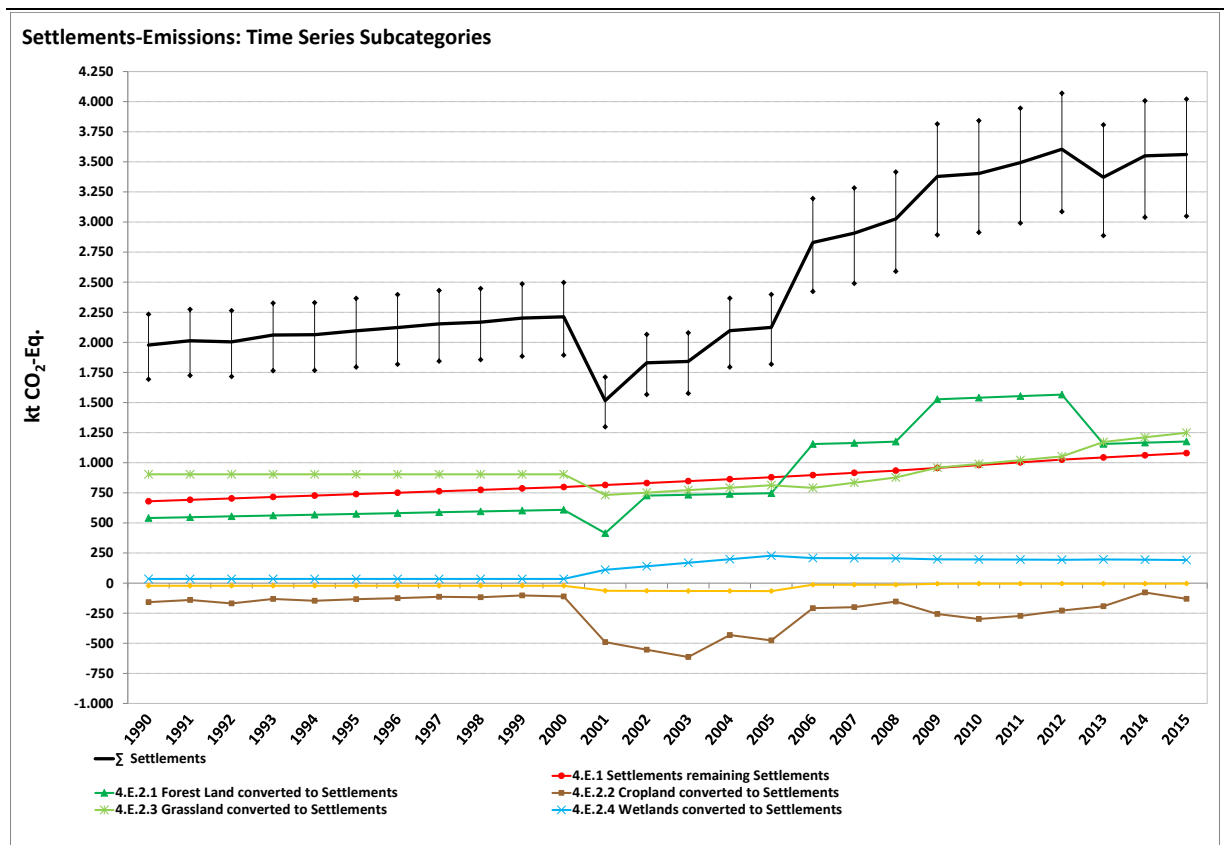
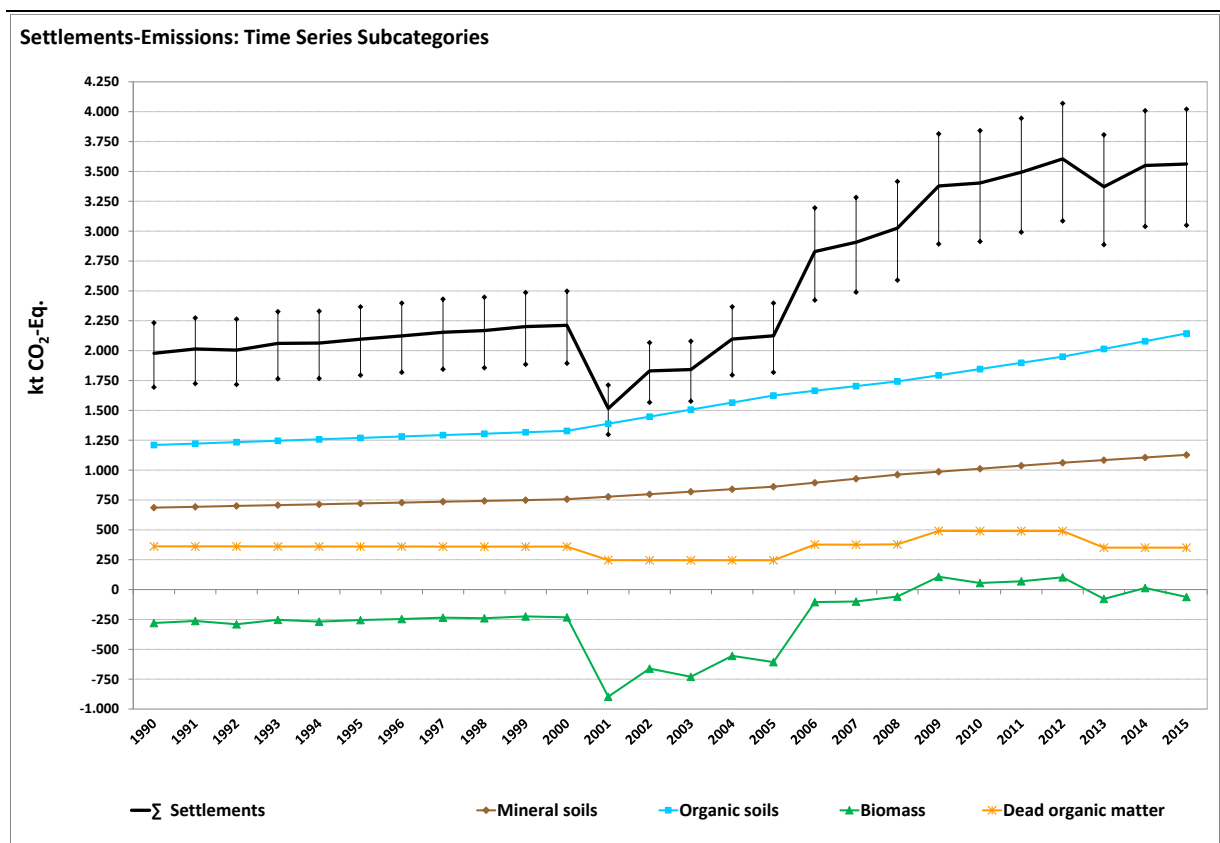


Figure 71: CO₂ emissions [kt CO₂-Eq.] from Germany's settlements, as a result of land use and land-use changes, 1990 – 2015, by pools



6.8.2 Methodological issues (4.E)

In the case of Settlements remaining Settlements, it is assumed that no carbon-stock changes occur in mineral soils (cf. Chapter 6.5.2.3) and biomass (cf. Chapter 6.6.2.2). It has also been assumed that organic soils in settlements have been drained.

All pools are reported in connection with land-use changes leading to settlements (cf. also Chapter 6.5.2).

6.8.2.1 Data sources

Further information about the data sources is provided in Chapter 6.3.2.

6.8.2.2 Biomass

Settlement and transport areas tend to have significant portions of unsealed land that is covered with vegetation. Representative-sample studies of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), an institute sited within the Federal Office for Building and Regional Planning (BBR), have shown that built-over and sealed areas account for 40 – 50 % of designated settlement and transport areas (EINIG et al. 2009). In the German inventory, areas covered with vegetation are thus assumed to account for an average of 50 % of settlement areas.

No data have been collected specifically with regard to biomass and carbon stocks on such areas within Germany's settlement and transport areas. The following assumption is used as a way of compensating for that lack: half of all areas covered with vegetation consist of woody grassland and half consist of green areas comparable to "grassland (in a strict sense)". That assumption is

approximately in keeping with the corresponding basic figures used in Switzerland. Via remote sensing, it was determined there that trees and bushes account for 47.4 % of plant cover, with trees accounting for 32.1 % and bushes accounting for 15.3 % (FOEN 2010). Since settlement and transport areas tend to have an enormous variety of trees and shrubs – including small-garden shrubs, many different types of hedges and large trees along roads and in forests – the tree/shrub biomass in this land-use category was determined on the basis of the country-specific value for woody grassland. For this reason, no carbon-stock changes in woody-plant mass are reported in the Settlements remaining Settlements category (NO in CRF table 4.E.1 for living biomass and dead organic matter). In addition, the calculation rules as described in Chapter 6.6.2.2 apply. The carbon stocks in the biomass of settlement areas can then be calculated pursuant to Equation 51. The relevant results are shown in Table 389. As a result of the changes in Grassland carbon stocks in this year (cf. Chapter 6.6.2.2), a change in the biomass carbon stocks in settlements areas, with respect to the previous submissions, follows from Equation 51. The changes in such biomass carbon stocks are also shown in Table 389.

Equation 51:

$$C \text{ stocks}_{\text{settlements}} = (C \text{ stocks}_{\text{woody grassland}} * 0.5 + C \text{ stocks}_{\text{grassland (in the strict sense)}} * 0.5) * 0.5$$

Table 389: Area-related carbon stocks [t C ha⁻¹] in biomass on settlement areas (95% confidence interval)

Settlements	Carbon stocks [t C ha ⁻¹]			Change with respect to the 2016 Submission [%]		
	Biomass, total	Biomass, above-ground	Biomass, below-ground	Biomass, total	Biomass, above-ground	Biomass, below-ground
Settlements	12.49 (6.62 - 18.47)	9.12 (3.55 - 14.77)	3.38 (1.51 - 5.32)	-0.1	-0.09	-0.14

6.8.2.3 Mineral soils

Further information about mineral soils is provided in Chapters 6.1.2.1 and 19.4.2.

6.8.2.4 Organic soils

No data have been collected specifically with regard to drainage of organic soils in settlements. In compensation for that gap, it is assumed that such soils are drained in the same manner that cultivated grassland is drained, and thus the relevant emission factor for such drainage is used (Chapter 6.6.2.4).

In cases involving land-use changes leading to settlements, the relevant value for settlements remaining settlements is used from the outset.

6.8.3 Uncertainties and time-series consistency (4.E)

The consistency of the time series is assured with regard to the activity data and emission factors.

The emission factors and uncertainties for the land-use category Settlements are listed in Table 390 and Table 391. In general, the uncertainties show a log-normal distribution, with the exception of those for CO₂ from organic soils, which have a right-skewed distribution. The statements made in Chapter 6.5.3 apply to the major uncertainties relative to direct and indirect nitrogen emissions. The uncertainties for the activity data, as shown in Table 517 in Chapter 19.4.3, and depending on the area size concerned, range from 2.5% to -91.5 % for the year 2015. The total uncertainty for the activity data in the settlements category is 2.3 %. The contribution of settlements-category emissions to the uncertainty of the inventory as a whole is low, but it is noticeable in the categories of emissions from organic soils, emissions from biomass and emissions from mineral soils.

Table 390: Uncertainties of emission factors [in % of location scale] used for calculation of GHG emissions from Germany's settlement and transport areas in 2015, broken down by pools and sub-categories

Settlements Land use before Mineral soils CO ₂ -C ¹⁶³	Area Land use after	Emission factor [t C ha ⁻¹ a ⁻¹]	upper [%]	Bounds lower [%]
Forest land	Settlements	-0.097	22.3	40.9
Cropland	Settlements	-0.07	27.9	49.2
Grassland (in the strict sense)	Settlements	-0.94	32.6	57.5
Woody grassland	Settlements	-0.73	31.2	59.7
Terr. wetlands	Settlements	-0.77	31.6	47.6
Waters	Settlements	0.00	45.1	85.0
Other land	Settlements	0.15	31.7	62.8
Mineral soil, N₂O_{direct}¹⁶⁴		[kg N₂O ha⁻¹ a⁻¹]	[%]	[%]
Forest land	Settlements	0.078	73.5	204.1
Cropland	Settlements	0.087	90.4	211.9
Grassland (in the strict sense)	Settlements	1.162	92.0	214.6
Woody grassland	Settlements	0.932	96.2	222.3
Terr. wetlands	Settlements	0.780	91.6	211.6
Mineral soil, N₂O_{indirect}¹⁶⁵		[kg N₂O ha⁻¹ a⁻¹]	[%]	[%]
Forest land	Settlements	0.018	100.0	289.7
Cropland	Settlements	0.019	100.0	295.2
Grassland (in the strict sense)	Settlements	0.261	100.0	296.7
Woody grassland	Settlements	0.210	100.0	297.1
Terr. wetlands	Settlements	0.175	100.0	294.9
Biomass¹⁶⁶		[kt C ha⁻¹ 1 a⁻¹]	[%]	[%]
Forest land	Settlements	-42.15	22.1	22.2
Cropland	Settlements	5.22	30.0	30.5
Grassland (in the strict sense)	Settlements	5.65	31.2	32.7
Woody grassland	Settlements	-30.66	43.3	44.1
Terr. wetlands	Settlements	-6.46	31.8	32.4
Waters	Settlements	12.51	47.0	47.8
Other land	Settlements	12.51	47.0	47.8
Dead organic matter¹⁶⁷		[kt C ha⁻¹ 1 a⁻¹]	[%]	[%]
Forest land	Settlements	-20.69	6.2	6.2

Table 391: Uncertainties for emission factors [2.5 and 97.5 percentile, in % of location scale] for emissions from organic soils in settlements, 2015

Land use	Greenhouse gas	Emission factor	Bounds lower [%]	upper [%]
	Organic soil¹⁶⁸	[t CO₂-eq. ha⁻¹ a⁻¹]		
Settlements	CO ₂	27.1	55.4	28.4
Settlements	N ₂ O	1.3	99.4	222.7
Settlements	CH ₄	0.6	46.9	258.6

6.8.4 Source-specific quality assurance / control and verification (4.E)

Details regarding this year's reviews are provided in Chapter 6.1.3.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Internally, data processing is checked pursuant to Thünen-Institut (2012). Quality assurance for input data (ATKIS®, BÜK, official

¹⁶³ Calculation covers a 20-year period; stock change: positive $\triangleq$ sink; negative $\triangleq$ source

¹⁶⁴ Calculation covers a 20-year period; emission: positive $\triangleq$ source; negative $\triangleq$ sink

¹⁶⁵ Calculation covers a 20-year period; emission: positive $\triangleq$ source; negative $\triangleq$ sink

¹⁶⁶ Calculation only for first year of land-use change; stock change: positive $\triangleq$ sink; negative $\triangleq$ source

¹⁶⁷ Calculation only for first year of land-use change, stock change: positive $\triangleq$ sink; negative $\triangleq$ source

¹⁶⁸ Annual calculation; emission: positive $\triangleq$ source; negative $\triangleq$ sink

statistics) is the responsibility of the relevant data administrators (cf. the pertinent documentation in the inventory description).

The emissions-calculation results as presented in the present report cannot be compared with other relevant data sources for Germany, since no such other data sources exist that meet applicable requirements, i.e. provide complete coverage, are comprehensive and are independent of the methods and data sources described in the present report.

Table 392 compares Germany's implied emission factors, for the settlements category, with those of European neighbouring countries. For this comparison, the most recent data of neighbouring countries were used. They were obtained from the countries' most recent submissions to the Secretariat of the UN Framework Convention on Climate Change.

Only Germany, Switzerland and the UK report CO₂ emissions from drained organic soils in settlement areas. The implied emission factors are referenced to the total settlement land area. Consequently, they also reflect organic soils' share of that total area. In the German inventory, other carbon-source pools are calculated only in connection with land-use changes leading to settlements. The emissions from soils are a source in this sub-category. While other neighbouring countries (such as France, the Netherlands, Poland, the UK) list considerably higher sources for mineral soils, the values reported by Austria, Switzerland, Belgium and Denmark are of the same order as Germany's value, which is sited at the lower end of the spectrum. Only Switzerland's value is directly comparable, however, since it comprises both organic and mineral soils. The current submission's IEF for biomass shows this area as a sink. Austria and the UK have corresponding sinks of a similar size. In all other countries included in the comparison, the biomass pool is a slight source. The implied emission factors for the pools of the transition categories depend strongly on the original uses involved in each case, and thus the wide range seen throughout European countries ultimately cannot be interpreted without knowledge of such uses.

Table 392: Comparison of implied emission factors (IEF) for various pools in the Settlements sector, within Europe (Germany, for 2014 & 2015; other countries, for 2014)

Country	4.E.1 – Settlements		4.E.2 – LUC to settlements		
	remaining settlements				
	Organic soils	Soils	Biomass	Dead org. matter	
		t C ha ⁻¹			
Belgium	NO	-1.26 ¹⁶⁹	-0.16	-0.01	
Denmark	NO	-0.33 ¹⁶⁹	-0.05	-0.01	
France	NO	-5.32	-0.47	-0.06	
UK	IE, NO	-8.71 ¹⁶⁹	0.02	0.00	
Netherlands	-4.5	-7.71	-0.78	-0.18	
Austria	NO	-0.67	0.30	-0.03	
Poland	NO	-4.63 ¹⁶⁹	-0.84	0.00	
Switzerland	-2.9	-0.97	-0.54	-0.08	
Czech Republic	NO	NO ¹⁷⁰	-0.44	-0.01	
Germany, 2014	-7.4	-3.11	0.00	-0.11	
Germany, 2015	-7.4	-0.59	0.02	-1.01	

Positive: carbon sink; negative: Carbon source; Source: UNFCCC 2016a

¹⁶⁹ Only mineral soils

¹⁷⁰ Notation keys for organic soils: IE, NO

6.8.5 Category-specific recalculations (4.E)

This year's submission includes category-specific recalculations for the entire 1990-2015 report period, since the emission factors for annual biomass were modified. This yielded corrected emission factors, for calculation of CO₂ emissions, for the biomass of the following land-use categories:

- Cropland
- Grassland (in the strict sense)
- wetlands
- Settlements

In connection with such recalculation of emission factors and activity data, the pertinent uncertainties were also determined anew.

The recalculations' impacts on the emissions in the Settlements land-use category are shown in Table 393, in a comparison covering the biomass pool and the total emissions in the transition categories. None of the other pools in the transition and "remaining" categories are affected by the recalculations. As a result of the recalculations, in the 2017 Submission, the total emissions for the transition categories leading to Settlements are smaller, throughout the entire time series, than they were in the previous year's submission. On the whole, the differences are very small, and they can be attributed completely to the changes in the emission factors for biomass. The difference with respect to the 2016 Submission, for the year 1990, amounts to -1.25 kt CO₂-eq. $\triangleq$ -0.06 %, for the year 2014, to -2.51 kt CO₂-eq. $\triangleq$ -0.07 %.

Table 393: Comparison of total and biomass emissions [kt CO₂] from land-use changes leading to Settlements, as reported in 2017 and 2016

		Emissions [kt CO ₂ -eq.]												
		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total	2017	1,978	2,096	2,212	2,124	2,830	2,907	3,025	3,379	3,403	3,494	3,604	3,372	3,550
	2016	1,979	2,097	2,213	2,126	2,832	2,910	3,028	3,381	3,405	3,496	3,607	3,374	3,552
Biomass	2017	-280	-255	-233	-607	-105	-100	-58	107	55	69	103	-78	13
	2016	-279	-254	-231	-605	-103	-97	-55	110	57	71	105	-76	16

6.8.6 Planned improvements, category-specific (4.E)

No further improvements, in addition to those previously announced, are planned. Information about the implementation status of planned improvements in the LULUCF sector is presented in Chapter 6.1.4.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

6.9 Other land (4.F)

6.9.1 Category description (4.F)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	4.F. Other land		CO ₂	0.0	0.00%	0.0	0.00%	---

Since, by definition, the areas in the category "Other Land" consist of areas that are not cultivated, the sizes of such areas are included solely for the purpose of completing the area matrix. Emissions within the meaning of the IPCC Guidelines cannot occur on such areas. Therefore, no such

emissions are reported. For this reason, "NO" is entered in all relevant spaces in CRF table 4.F, with the exception of the space for the area of the non-transfer category.

6.9.2 Methodological issues (4.F)

In emissions calculation, Other Land areas are taken into account solely as a "before" category in connection with land-use changes leading to other categories. No conversions back to "Other Land" take place, since, by definition, land that has been used once can no longer be returned to an "unused land" land-use category.

The carbon stocks in the categories biomass, dead wood and dead organic matter of Other Land are "zero."

The carbon stocks in mineral soils of Other Land are listed in Chapters 6.1.2 and 19.4.2.

Organic soils in Other Land are not drained.

6.9.3 Uncertainties and time-series consistency (4.F)

The uncertainties for the emission factors and the activity data were determined in accordance with the 2006 IPCC Guidelines (IPCC 2006). Additional relevant information is provided in Chapter 19.4.3.

The time series is complete and consistent.

6.9.4 Source-specific quality assurance / control and verification (4.F)

Details regarding this year's reviews are provided in Chapter 6.1.3.

6.9.5 Category-specific recalculations (4.F)

Not applicable, since no greenhouse-gas sources and sinks are reported in this category.

6.9.6 Planned improvements, category-specific (4.F)

Not applicable, since no greenhouse-gas sources and sinks are reported in this category.

6.10 Harvested wood products (4.G)

6.10.1 Category description (4.G)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	4.G. Harvested wood products	0	CO ₂	-1,330.4	0.11%	-2,123.5	0.24%	59.6%

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	CS/Tier 2	IS/NS	D

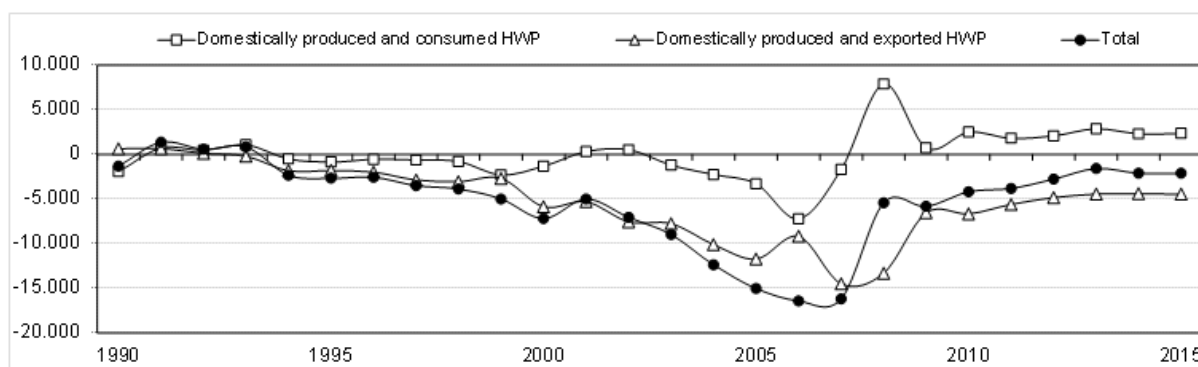
The category *Harvested wood products* is not a key category.

As in the previous years, the contribution of HWP in the land-use sector in Germany, in terms of greenhouse emissions by sources and removals by sinks, was estimated with the WoodCarbonMonitor model, via a calculation approach based on production data for wood products. The estimate covers all wood products that are produced in Germany, that consist of wood that originates from trees harvested in Germany and that are used for their material (not energy) value.

For reasons of consistency, the calculation conforms to the methods prescribed in Chapter 2.8 of the 2013 IPCC KP Supplement (IPCC 2014) since, pursuant to Footnote 12 in Table sheet 4.G s1 of the Common Reporting Format in Annex II of Decision 24/CP.19 Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention¹⁷¹ (UNFCCC 2014), the approach chosen (approach B; in the present case, based on production data) may refer either to the 2006 IPCC Guidelines (IPCC 2006) or to any other IPCC methodological guidance reflecting this approach. The system boundaries described in the rules of the 2013 IPCC KP Supplement (IPCC 2014), for estimation of the contribution of HWP, are consistent with the system boundaries of the approach referred to in Table 12.1 of the 2006 IPCC Guidelines (IPCC 2006) as "variable 2A" (production-oriented approach for wood products for material use).

In the interest of transparency, pursuant to reporting table 4.G s1, wood products for material use are divided into products that, following their production, are used in Germany, and products that are exported following their production. The carbon stored in wood in landfills is not taken into account.

Figure 72: Net CO₂ emissions and removals in HWP (in kt CO₂)

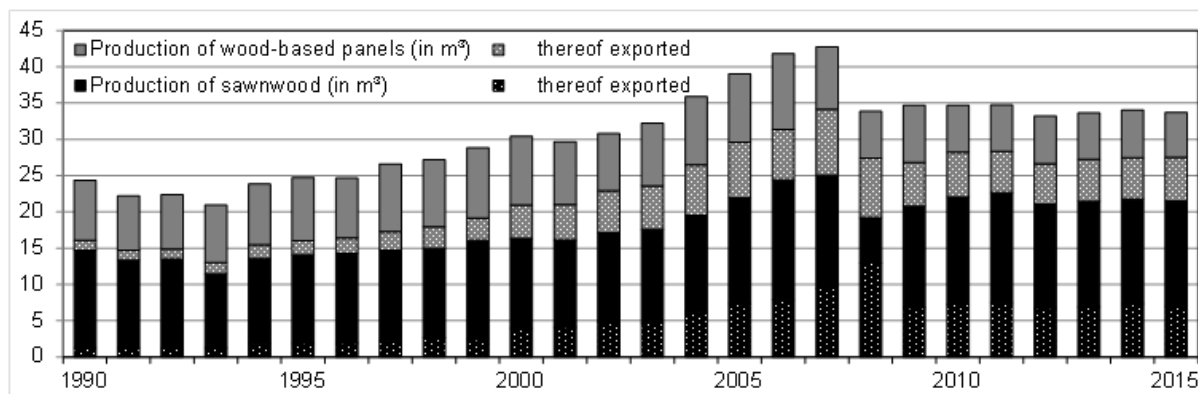


6.10.2 Methodological issues (4.G)

6.10.2.1 Activity data

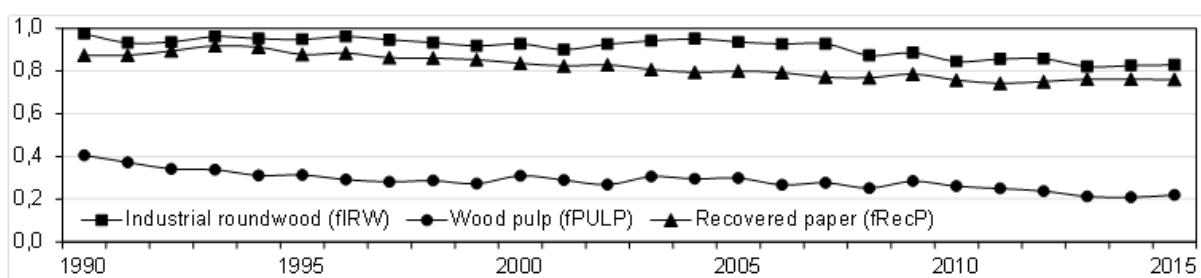
Figure 73 shows the development of production quantities in the semi-finished-product categories sawnwood, and wood materials, broken down by the wood quantities remaining in Germany (production, less exports) and the quantities exported (exports), since 1990. The figure is based on data of the Food and Agriculture Organization of the United Nations (FAO) (FAO 2016). These time series are in keeping with the data proposed in the 2006 IPCC Guidelines for estimation of the contribution of HWP using a Tier 1 calculation method (Chapter 12.2.1, IPCC 2006: 12.9).

¹⁷¹ Footnote 12 of CRF table sheet 4.G s1

Figure 73: Sawn wood and wood-based panels produced in Germany [Mm³] (FAO 2016)

In line with the IPCC Guidelines, and in a first step, the feedstock fraction in HWP from domestically harvested wood was calculated, and a domestic feedstock factor $f_{DP}(i)$ was determined. For the semi-finished-product categories sawnwood and wood materials, this factor is based on the FAO data on the feedstock category *industrial roundwood*. For calculation of the domestically harvested fraction in the product category paper and paperboard, the use of recovered paper in paper production was taken into account, in addition to the *wood pulp* feedstock category as proposed in the IPCC 2013 KP Supplement (IPCC 2014), since the recovered-paper fraction in produced paper and paperboard in Germany has been growing continually in recent years and now exceeds 70 %. As in the previous report year, the fraction p of recovered paper used in paper products was determined via the consumption (as determined via calculation) of wood pulp and recovered paper in Germany (cf. Chapter 6.10.5).

Along with the relevant factors for industrial roundwood (f_{IRW}) and wood pulp (f_{PULP}), which were calculated pursuant to equations 2.8.1 and 2.8.2 of the 2013 IPCC KP Supplement (IPCC 2014: 2.115), a factor for recovered paper (f_{RecP}) was also determined, using the same approach as for those factors, and with the help of FAO data (Figure 74). That factor was taken into account in calculation of the product fractions originating in the domestic harvest, via equation 2.8.4 of the 2013 IPCC KP Supplement (IPCC 2014: 2.118), for the HWP category "paper and paperboard", with $f_{DP}(i) = \{(f_{IRW}(i) \cdot (1-p) \cdot f_{PULP}(i)) + p \cdot f_{RecP}(i)\}$.

Figure 74: Development of the domestic feedstock factor $f_{DP}(i)$ for the raw-material categories considered (FAO 2016)

In a second step (Chapter 2.8.1.2, IPCC 2014), the carbon contained in the relevant products was allocated to the respective land-use classes from which the raw material originates. For Germany, the wood harvest can be broken down into wood harvested on forest land remaining forest land (category 5.A.1, Chapter 6.2.1), and wood harvested as a result of land-use changes from forest land to other categories (Table 394). In keeping with IPCC requirements, HWP from deforestation are taken into account on the basis of instantaneous emissions (cf. Chapter 2.8.3, IPCC 2014). Consequently, the annual wood-harvest fractions from managed forest areas can be calculated on

the basis of the inventory information available for Germany and of Equation 2.8.3 (IPCC 2014: 2.116) $f_{FM}(i)$.

Table 394: Annual wood-harvest fraction from forest land remaining forest land

Time period	$f_{FM}(i)$
1990 – 2002	0.98989
2003 – 2007	0.99202
2008 – 2012	0.98881

6.10.2.2 Emission factors

The carbon outflows from the carbon stock are calculated with the default values listed in Table 2.8.2 of the IPCC 2013 KP Supplement (IPCC 2014). Those values are based on the standard values given in Table 3a.1.3 of the 2003 IPCC GPG (IPCC 2003).

6.10.2.3 Calculation method used

To calculate the contribution of HWP used, as material, to the delayed release of CO₂ emissions, on the basis of carbon-pool changes, Germany uses the exponential decay function described in the IPCC Guidelines, in combination with the product categories described in Table 2.8.1 of the 2013 IPCC KP Supplement. That approach is in keeping with the standard method described in the 2006 IPCC Guidelines (Equation 12.1, IPCC 2006: 12.11), as well as with the standard method described under "Tier 2" in the 2013 IPCC KP Supplement (Equation 2.8.5). For the carbon conversion calculation, factors listed in Table 2.8.1 (IPCC 2014) are used. For the "wood materials" product categories, the detailed factors are used; for the "paper and paperboard" category, the aggregated factor is used. The carbon quantities in the product categories "non-coniferous and coniferous sawnwood" are calculated by means of the factors described in RÜTER 2011 (cf. also UNFCCC 2011), in order to take account of the wood types typically used in Germany for the production of sawnwood. For sawn softwood, the factor amounts to 0.225 Mg C/m³, while for hardwood lumber it is 0.335 Mg C/m³.

Time series, of adequate quality, for HWP and the relevant feedstock categories are available only for the period since German reunification in 1990. For that reason, and in order to reduce the uncertainties associated with the activity data, the initial value of the carbon stocks in HWP is calculated on the basis of Equation 2.8.6 (IPCC 2014), with $C(t_0) = 1990$.

6.10.3 Uncertainties and time-series consistency (4.G)

The time series for HWP activity data from the FAO database are consistent and are available for the entire period covered by the report. Pursuant to the information provided in the relevant chapter of the IPCC KP Supplement (IPCC 2014), the uncertainties for these time series amount to -25/+5 % (cf. also Chapter 11.3.1.5.3).

6.10.4 Source-specific quality assurance / control and verification (4.G)

Details regarding this year's reviews are provided in Chapter 6.1.3.

6.10.5 Category-specific recalculations (4.G)

In the current report year, the values for several product categories were corrected, with respect to the FAOSTAT 2015 statistical data that were used last year (cf. FAO, 2016). Production statistics' figures for the current report year (i.e. 2015, in the present case) are always provisional, and the corresponding final figures do not become available until the following year. For Germany this year, corrections extending further back, to the period as of 2006, were also made in the FAO

database. These changes have to do with export data for the HWP product category "sawn lumber" and the product group "wood pulp." The later data set is used, in keeping with the methods prescribed via Equation 2.8.2 (IPCC, 2014), for calculation of the carbon fractions in domestically produced paper (cf. Chapter 6.10.2). The relevant changes are shown in Table 395.

Table 395: Comparison of changes in production-data sets used in the FAOSTAT 2016 statistics (FAO 2016)

[m³]	Product (item number)	2006	2007	2011
2015	Wood pulp (1875)	-	-	1,078,000
	Sawn softwood (1632)	7,972,625	931.8000	-
2016	Wood pulp (1875)	-	-	1,077,000
	Sawn softwood (1632)	7,042,327	8,432,139	-

The resulting changes in the determined net emissions time series, with respect to the previous year, are shown in Table 396.

Table 396: Comparison of changes, in the 2016 Submission and the 2017 Submission, with regard to net CO₂ emissions for HWP

	Net emissions [kt CO ₂]	2006	2007	2008	2009	2010	2011	2012	2013	2014
2016	From exported wood materials	-	-	-	-	-	-	-	-	-1686
	From domestically used wood materials	-	-	-	-	-	-	-	-	2384
	From exported paper and paperboard	-	-	-	-	-	-133	-171	-92	-283
	From domestically used paper and paperboard	-	-	-	-	-	234	91	370	205
	From exported sawn lumber	-5332	-6499	-7645	-3090	-3156	-3258	-2735	-2602	-2857
	From domestically used sawn lumber	-2141	-1319	5330	-524	-480	-940	-334	-52	-63
2017	From exported wood materials	-	-	-	-	-	-	-	-	-1687
	From domestically used wood materials	-	-	-	-	-	-	-	-	2370
	From exported paper and paperboard	-	-	-	-	-	-142	-175	-118	202
	From domestically used paper and paperboard	-	-	-	-	-	228	89	353	-147
	From exported sawn lumber	-4633	-5847	-7672	-3116	-3181	-3283	-2760	-2626	-2945
	From domestically used sawn lumber	-2839	-1971	5356	-498	-454	-915	-310	-28	76

6.10.6 Planned improvements, category-specific (4.G)

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

6.11 Other areas (4.H)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	4.H. Other	0	N ₂ O	108.5	0.01%	100.0	0.01%	-7.8%

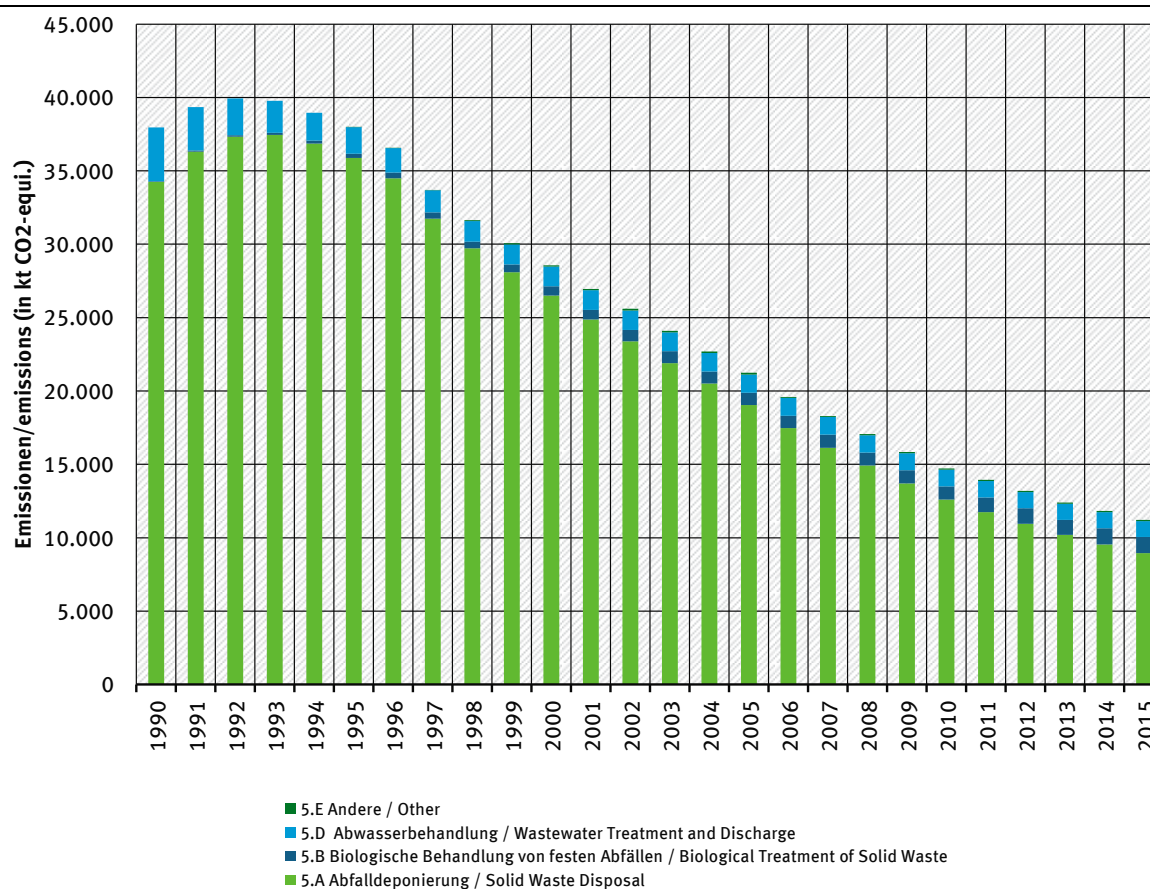
Gas	Method used	Source for the activity data	Emission factors used
-	-	-	-

For technical reasons, CH₄ and N₂O emissions from the category *Settlements*, and N₂O emissions from the category *Grassland*, cannot be entered in the relevant table, CRF Table 4 (II), in the CRF Reporter database. As a result, these emissions are reported for the time being in 4 H.

7 Waste and Waste Water (CRF Sector 5)

7.1 Overview (CRF Sector 5)

Figure 75: Overview of greenhouse-gas emissions in CRF Sector 5



7.2 Solid waste disposal on land (5.A)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
L/T	5.A. Solid Waste Disposal on Land	Managed Waste Disposal on Land	CH ₄	34,250.0	2.80%	8,950.0	1.01%	-73.9%

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	Tier 2	NS	CS

The category *Solid waste disposal on land* is a key category of CH₄ emissions in terms of emissions level and trend.

Only managed disposal in landfills (5.A.1) is relevant for purposes of German emissions reporting under CRF 5.A. "Wild" or illegal dumping of solid waste (CRF 5.A.2) is prohibited by law in Germany.

Emissions from composting and from mechanical biological waste treatment (MBT) have been reported since 2004, in keeping with the growing importance of such other methods for treating biodegradable waste fractions. Since the 2015 report, emissions from waste digestion are also reported. With the conversion of the CRF tables as of the 2013 report year, these emissions are reported either under category 5.B Biological waste treatment or category CRF 5.E Other – MBT.

In the Central System of Emissions (CSE), the categories assigned to category 5.A Solid waste disposal on land include landfilled residential waste, biologically degradable waste from industry and sewage sludge.

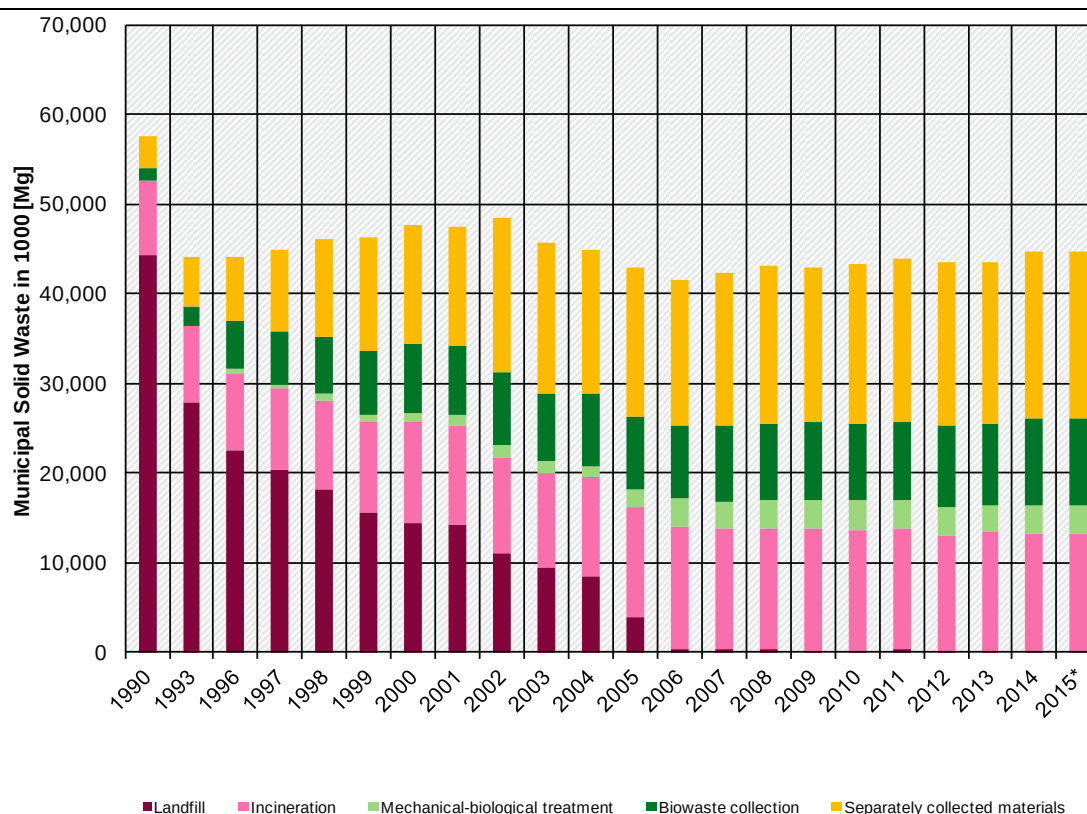
7.2.1 Managed disposal in landfills – landfilling of municipal waste (5.A.1)

7.2.1.1 Category description (5.A.1)

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 organisational 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 settlement waste has been expanded, and mechanical biological treatment of residual waste has been introduced. As a result of such measures, amounts of landfilled settlement waste decreased very sharply from 1990 to 2006, and they have been stabilising at a low level since 2006 (cf. Figure 76). As the figure shows, over half of settlement waste produced in Germany today is collected separately and gleaned for recyclable materials (separate collection of recyclable materials and biodegradable waste). Official statistical data (*STATISTISCHES BUNDESAMT* (Federal Statistical Office) Fachserie 19, Reihe 1 Abfallentsorgung 2014 ("Waste management, 2014") of 18 August 2016) are available for the period until 2014. The activity data for a given year (such as 2015) are obtained, initially, by carrying the relevant data from the previous year (such as 2014) forward, in unchanged form. In the following year (2014), when the actual activity data for the given year (2013) become 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, since those emissions are determined predominantly by the waste that has been landfilled in the past.

In 2004, about 330 landfills for settlement waste were in operation in the Federal Republic of Germany. By that year, strict legal regulations were already in place that require such landfills to have equipment for collecting and treating landfill gas. Those regulations have extensively reduced methane emissions from such facilities. 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*), over half of all landfills were closed. As a result, only about 150 landfills for settlement waste are now still in operation. Pursuant to regulations in force since June 2005, landfilling of biodegradable waste is no longer permitted. Consequently, since June 2005 it has no longer been possible to landfill waste with the potential for significant methane formation. For conformance with pertinent requirements, settlement waste and other biodegradable waste must be pre-treated via thermal or mechanical biological processes. In waste landfilled after 2006, just a few waste components, with very small methane-formation potential (such as residues from treatment in MBT facilities; small wood fractions in construction rubble) have contributed to landfill-gas formation. As landfill-gas formation in older landfills drops off, methane emissions from landfills will again decrease extensively and will then, in the long term, stabilise at a very low level.

Figure 76: Changes in pathways for management of settlement waste, 1990 to 2015, with intermediate years



By reducing landfill methane emissions from 1.4 million Mg CH₄ in 1990 to 0.4 million Mg in 2014, Germany's waste-management sector has made an important contribution to climate protection. The lower methane emissions from category 5.A.1 amount to a decrease of 24 million tonnes of CO₂ equivalents per year and, thus, to a 2.2 % reduction of Germany's entire greenhouse-gas emissions. Experience gained by Germany's waste-management sector shows that reductions of landfilled quantities of biodegradable waste can provide significantly higher contributions to climate protection than can collection and treatment of landfill gas.

7.2.1.2 Methodological issues (5.A.1)

The method that the 2006 IPCC Guidelines for National Greenhouse Gas Inventories present for calculation of CH₄ emissions from landfills is based on the "first order decay" method (FOD method). The tier-classification scheme is oriented to use of high-quality national data. The method used in Germany lies between Tier 2 and Tier 3. The Tier 3 method requires national / country-specific key parameters for DOC, DOC_F and half-lives (k values). Germany uses country-specific DOC values, but it uses default values for DOC_F and k values.

The following section describes the FOD method, and the relevant parameters used, for determining methane formation in landfills. The FOD method uses the following equations:¹⁷²

¹⁷² A detailed description of the FOD method and its parameters is presented in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, in the Greenhouse Gas Inventory Reference Manual, known as the "IPCC Guidelines" (IPCC 1996b), and in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, known as the "Good Practice Guidance" (IPCC 2000).

Equation 52: (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Equation 3.6)

$$CH_4 \text{ produced in year } t \left(\frac{Gg}{year} \right) = DDOCm \text{ decomp}_t \times F \times 16/12$$

where:

$CH_4 \text{ produced in year } t$	= Quantity of CH_4 produced by relevant biologically degradable waste.
$DDOCm \text{ decomp}_t$	= Mass of the biodegradable DOC that decomposes in year T
F	= Percentage share of CH_4 with respect to landfill gas
$16/12$	= Factor for conversion of C to CH_4
t	= Inventory year

The following also holds:

Equation 53: (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Equation 3.2)

$$DDOC_m = W \times DOC \times DOC_f \times MCF$$

where:

$DDOC_m$	= Mass of biodegradable and landfilled DOC, (Gg)
W	= Mass of landfilled waste, Gg
DOC	= Fraction of biodegradable organic carbon in the year in which landfilling takes place (Gg C/Gg waste)
DOC_f	= Fraction of DOC that is biodegradable
MCF	= Methane-correction factor for year x

Since 1972, only orderly landfilling has been permissible by law in western Germany. In 1989/90, in connection with German reunification, the relevant standards were extended to the new German Länder. The inventory calculations take account of all waste landfilled since 1950, regardless of whether the landfills in which the waste is now located have been decommissioned or are still in operation.

The emissions contributions from waste landfilled between 1950 and 1972 are calculated with an MFC of 0.6. For the period 1973-1989, an MFC of 0.6 is used for the new German Länder, while an MFC of 1 is used for the old German Länder. For purposes of emission calculation in the inventory, an MFC is determined for that period that is weighted in accordance with the applicable waste quantities for Germany as a whole. The emissions from waste landfilled since 1990 are calculated with an MFC of 1.

Germany uses the IPCC Waste Model, which was developed on the basis of Equations 3.4 and 3.5 of the 2006 IPCC Guidelines. Under this approach, the total quantity of biodegradable DOC in landfills is calculated for each year, in order to calculate the quantity of DOC that is broken down, in each year, into CH_4 and CO_2 :

Equation 54: (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Equation 3.4)

$$DDOCma_t = DDOCmd_t + (DDOCma_{t-1} * e^{-k})$$

where:

t	= Inventory year

$DDOCm_a_t = DDOCm$ accumulated in the landfill at the end of year t (Gg)

$DDOCm_{a_{t-1}} = DDOCm$ accumulated in the landfill at the end of year $t-1$ (Gg)

$DDOCm_{d_t} = DDOCm$ added to the landfill in year t (Gg)

k = Constant methane-production rate (1/year)

Equation 55: (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Equation 3.5)

$$DDOCm_{decomp_t} = DDOCm_{a_{t-1}} \times (1 - e^{-k})$$

where:

t = Inventory year

$DDOCm_{decomp_t}$ = DDOCm that decomposes in the landfill in year t (Gg)

A multi-phase model was applied. In addition, the calculation was carried out with different half-lives for the different waste fractions involved, and the results so obtained were summed.

To obtain the final CH₄-emissions result, methane that is collected and then flared, or then used for energy recovery, is deducted, and a correction factor is applied that accounts for methane oxidation in landfill covering layers, as shown by Equation :

Equation 56: (2006 IPCC Guidelines, Equation 3.1):

$$CH_4 \text{ emitted in year } t \text{ (Gg/year)} = (CH_4 \text{ produced in year } t - R(t)) \cdot (1 - OX)$$

Where

$R(t)$ = CH₄ collection in year t

OX = Oxidation factor (fraction)

With the IPCC Waste Model, users may define a time period during which landfilled waste has not yet begun producing gas, i.e. a period of delay until gas formation begins. The 2006 IPCC Guidelines recommend 6 months as a standard value for this delay period. As a result of discussions with national waste experts, and on the basis of measurements of CH₄ formation following landfilling, a delay-period value of 3 months has been chosen. This change has only a slight effect on emission calculations.

For purposes of calculation, the relevant quantities of settlement waste (MSW_T), and the fraction of settlement waste that is landfilled (MSW_F), must be determined. For the FOD method, settlement-waste-production quantities have to be determined throughout the past few decades. Pursuant to the 2006 IPCC Guidelines, estimates should be made of the different waste-type fractions contained in landfilled settlement waste, since the further emissions-calculation procedure is based on the fact that different waste types have different DOC values.

7.2.1.2.1 Quantities of landfilled waste

The FOD model calculates emissions from landfilled settlement waste, landfilled industrial waste and landfilled sewage sludge.

Pertinent quantities of landfilled settlement waste (household and commercial waste) are taken from relevant statistics of the Federal Statistical Office, which are based on annual surveys of waste types, origins and final destinations, as well as on surveys taken of waste-storage facilities, every two years, that focus on specific equipment of the facilities. The surveys of landfilled quantities of settlement waste in the old German Länder commenced in 1975, on the basis of the Environmental Statistics Act of 1974. Waste quantities for the period from 1950 to 1975 were extrapolated on the basis of population data.

For the new German Länder, data on landfilled quantities of settlement waste, differentiated by Länder, are available for the years 1990 and 1993. For the 1980s in the former GDR, LALE (2000) has presented data that provide information about per-capita landfilled quantities of waste, waste composition, landfill types and types of waste storage involved. The per-capita quantities of landfilled waste in the former GDR, at 190 kg/person, were considerably lower than the corresponding quantities in the old German Länder (330 kg / person and year). The reason for this was that larger percentages of waste were recycled in the former GDR. In 1990, the year of German reunification, landfilled quantities of waste increased sharply in the new German Länder, to the extent that the relevant per-capita quantities even outstripped the corresponding quantities in the old German Länder. The reasons for this were that the former GDR's recycling systems collapsed in that year and that a flood of new products suddenly became available, leading to high levels of replacement purchases and to sharply increasing quantities of packaging waste. Since 1990, per-capita waste quantities in both parts of Germany have slowly been moving into alignment.

The inventory calculations include landfilled sewage-sludge quantities of the old and new German Länder (states), and of the former Federal Republic of Germany and the former GDR, for the entire period 1950 through 2015. No statistical data are available relative to landfilling in the new German Länder / the former GDR. The applicable waste compositions (including those of sewage sludge fractions) have been estimated on the basis of findings of a research project that in the 1990s studied waste inventories of GDR landfills.

In the former GDR, all non-recycled waste quantities were landfilled.

Since 1996, the Federal Statistical Office has published differentiated data on waste-landfilling by industry. The relevant inventory takes account of the landfilled waste quantities from industrial sectors as follows:

- Waste from agriculture, horticulture, forestry, fisheries and food processing
- Waste from wood processing
- Waste from production of pulp, paper and carton
- Waste from the textile industry
- Packaging waste, absorbent and filtration materials, wiping cloths and protective clothing
- Wood fractions in construction and demolition waste (data since 1975)

The quantities of industrial waste landfilled between 1975 and 1996 were derived on the basis of total quantities of landfilled waste. While the total quantities include industrial waste, the total-waste figures are not broken down to show industrial waste separately. Extrapolations between waste production and production data of relevant sectors, for the 1996-2002 period, produced no satisfactory statistical relationships. While production figures increased, waste-production figures decreased – considerably, in part – as a result of changes in production processes. Due to the lack of statistical relationships, the figures for landfilled waste quantities were kept constant for the period between 1950 and 1975. Changes in assumptions relative to industrial waste in the 1950-1970 period have only a very marginal effect on emissions in the base year.

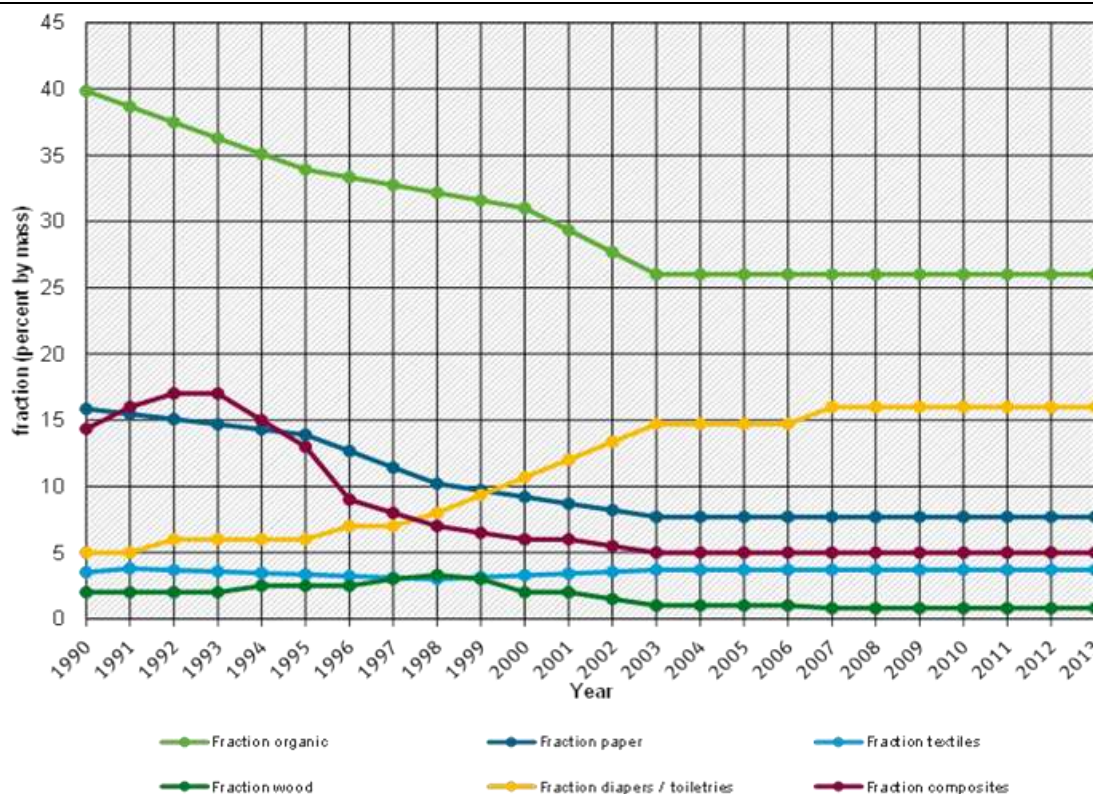
For the entire period from 1950 through 2015, and for all relevant types of waste, including sewage sludges, complete and seamless data are available that are based on the best-available sources for the sub-periods concerned.

7.2.1.2.2 Waste composition

For the inventory calculations, landfilled waste has to be divided into the landfill-waste fractions organic waste, garden and park waste, paper, wood, diapers and textiles, composite materials,

sewage sludge and MBT output. To some extent, waste statistics include separate listings for these categories. On the other hand, such statistics also include landfilled quantities of mixed settlement waste that, for calculation purposes, have to be subdivided into the aforementioned fractions. To this end, numerous studies of the components of mixed settlement waste were evaluated, with a view to determining the historical development of waste fractions (organic waste, garden and park waste, paper, wood, diapers and textiles, composite materials). In the years 1980 and 1985, mixed-waste compositions were determined for the entire territory of the former Federal Republic of Germany (Federal Environment Agency (UBA) 1983, 1986). For the subsequent period, a large number of individual studies exists – studies carried out by individual cities, administrative districts and Länder. Some of these had already been evaluated and combined within overarching studies. The pertinent figures were used to obtain time series for waste composition for the period between 1980 and 2013 (cf. Figure 77). Such evaluation of existing studies was carried out for household waste, household-like commercial waste and bulky waste, categories that are listed separately in national statistics. As to waste composition in the new German Länder, the figures provided by LALE (2000) for the 1980s in the former GDR were adopted (composition of household waste: 28 % vegetable waste, 14 % paper/cardboard, 2.3 % wood, rubber, composites, 3 % textiles; household waste accounted for only 16 % of total landfilled waste quantities, however). Quantities of settlement waste landfilled in the former GDR contain smaller fractions of biodegradable materials and large inorganic fractions (primarily ash from household combustion systems). Food waste was collected and used as feed; feeds tended to be scarce during certain periods of time. Paper was collected; it was also a scarce resource. Wood and paper were often burned in ovens for purposes of heating and cooking. The "SERO" recycling system efficiently collected the country's relatively small fractions of plastic packaging. Deposit systems were operated for glass, and glass was also collected. All in all, the former GDR's economy was subject to scarcities of resources, and this led to efficient waste recycling. Ash from household combustion systems accounted for large fractions of landfilled quantities of household waste. In 2014, existing evaluations of waste-composition studies were reviewed, and more-recent studies of residual-waste composition in the period 2006 through 2013 were identified (6 studies) and evaluated. These more-recent studies confirmed existing assumptions regarding the composition of mixed-waste fractions, and thus the relevant data were carried forward without change. After 2005, landfilling of mixed settlement waste decreased dramatically, as a result of changes in applicable laws (from 5.8 million tonnes in 2004 to 2,000 tonnes in 2013). The need for precise determination of residual-waste fractions for the period as of 2005 has diminished correspondingly, and thus the Federal Government, and the country's Länder, administrative districts and municipalities, have commissioned fewer numbers of studies of waste composition since then.

Figure 77: Trends in household-waste composition between 1990 and 2013



The waste quantities stored in landfills are recorded by the Federal Statistical Office, in terms of separate fractions based on waste codes. For purposes of emission calculation, all waste types that can contribute to landfill-gas formation are taken into account, and each waste type is separately assessed in terms of its waste composition. Table 397 shows the waste types of relevance for landfill-gas formation (wood fractions of construction and demolition waste have been taken into account). The collected quantities of landfill gas are based on official statistical data.

Since 1 June 2005 only waste with a total carbon content < 3 %, and mechanically and biologically treated settlement waste, may be landfilled in Germany. Since that time, landfilled waste quantities have decreased very sharply and now make only very small contributions to gas formation. Table 397 outlines the development of quantities of landfilled biodegradable waste. Biodegradable waste fractions have decreased further with respect to 2009. No data are yet available for 2015. Therefore, it has been assumed that waste quantities and waste composition have remained unchanged with respect to 2014.

Table 397: Quantities of biodegradable waste landfilled between 2002 and 2014, broken down by waste fractions

Waste fraction	Units	2002	2003	2004	2005	2006	2007	2008	2009
Organic	1000 t	2.513	2.064	1.831	813	28	13	12	5
Garden and park waste	1000 t	43	43	49	26	19	25	23	1
Paper	1000 t	1.191	1.095	974	426	10	5	6	6
Diapers and textiles	1000 t	1.856	1.720	1.276	519	30	13	13	5
Wood	1000 t	860	709	529	238	10	11	5	1
Composite materials	1000 t	481	398	349	155	5	2	2	1
Sewage sludge	1000 t	369	308	624	634	130	129	133	31
Output from MBT facilities	1000 t	1.226	1.108	990	1.170	1.177	1.266	1.253	1.113

Waste fraction	Units	2010	2011	2012	2013	2014	
Organic	1000 t	6	5	0	0	0	0
Garden and park waste	1000 t	0	0	0	0	1	1
Paper	1000 t	7	6	2	4	1	1
Diapers and textiles	1000 t	5	5	2	2	2	2
Wood	1000 t	0	0	3	3	0	0
Composite materials	1000 t	1	1	0	0	0	0
Sewage sludge	1000 t TM	27	34	67	25	73	73
Output from MBT facilities	1000 t	991	934	764	692	703	703

During the 2010 inventory review, the review team requested that CH₄ emissions from landfilled MBT residues also be included in calculation of emissions from landfilling. While that fraction has now been included, there is no unambiguous method for that waste category, nor are there suitable national parameters for it. Furthermore, no results have yet been obtained with regard to the behaviour of landfilled waste from MBT facilities (i.e. behaviour in real landfills). Only laboratory data have been obtained to date, and thus the results in this area are subject to very high levels of uncertainty. The mechanical biological (waste) treatment (MBT) process is described in Chapter 7.5.2.

In 2011/12, the residual-gas emissions from landfill storage of mechanically and biologically treated waste were quantified in an expert opinion (IFAS, 2012). The opinion confirms that emissions calculations to data have been correct in applying low emissions contributions from landfilling of MBT waste.

In keeping with the recommendations provided in the inventory review 2010 (paragraph 146, FCCC/ARR/2010/DEU), additional information is provided in this regard as of the 2011 report. Table 398 shows the per-capita waste quantities landfilled, per day, between 1990 and 2013. Those values do not represent the per-capita waste-production rate that is to be reported, as additional information, in the CRF tables. That figure comprises total waste consumption, taking all waste-management pathways into account. It will be calculated for the next report.

In Germany, landfilling of settlement waste has decreased very sharply since 2005, and that trend is also reflected in the per-capita rate of landfilled household waste.

Table 398: Per-capita quantities of landfilled household waste

	Units	1990	1995	2000	2001	2002	2003	2004
Per-capita quantities of landfilled waste	kg/capita/day	1.612	0.851	0.546	0.507	0.440	0.387	0.334
	Units	2005	2006	2007	2008	2009	2010	2011
Per-capita quantities of landfilled waste	kg/capita/day	0.178	0.050	0.053	0.043	0.040	0.040	0.040
	Units	2012	2013	2014	2015			
Per-capita quantities of landfilled waste	kg/capita/day	0.031	0.028	0.029	0.029			

Table 399: Per-capita quantities of settlement waste

	Units	1995	2000	2001	2002	2003	2004	2005
Production of settlement waste per capita	kg/capita/day	1.707	1.802	1.802	1.752	1.647	1.608	1.547
	Units	2006	2007	2008	2009	2010	2011	2012
Production of settlement waste per capita	kg/capita/day	1.545	1.596	1.616	1.623	1.650	1.713	1.693
	Units	2013	2014	2015				
Production of settlement waste per capita	kg/capita/day	1.693	1.702	1.702				

7.2.1.2.3 MCF (methane-correction factor)

Until 1972, when the first Waste Act was introduced, waste was usually stored in uncontrolled landfills; such landfills were closed after 1972. After 1972, waste was stored in managed landfills. In keeping with this history, a default MCF value of 0.6 was used for "unclassified landfills" ("nicht zugeordnete Deponien"), while an MCF of 1 was used after 1972.

Data are available from a 1989 survey of the territory of the former GDR that covered 120 managed landfills, some 1,000 controlled storage sites and some 10,000 uncontrolled dump sites (MNUW, 1990). Of the some 13,000 waste-storage sites, a total of 11,000 were for household waste and 2,000 were for industrial waste; most of the latter were plant-owned facilities (BMU, 1990: p. 28). Consequently, an MCF of 0.6 (default value for unclassified landfills) was assumed for the territory of the former GDR for the period 1950 to 1990. Upon German reunification, the Federal Republic of Germany's waste laws were extended to the territory of the new German Länder, and transitional regulations were introduced to ensure that facilities – including both decommissioned facilities and still-operational facilities in which waste was (or is) produced or disposed of – were accounted for and that suitable clean-up measures were initiated (BMU, 1990: p. 46). Uncontrolled landfills were closed in 1990, facilities permitted to remain open were secured, cleaned up and modernised/expanded in keeping with the standards of Federal German waste law, and sites for new facilities were sought. As of 1990, the Federal Statistical Office has collected statistics on both parts of Germany. For purposes of calculation for the period after 1990, an MCF of 1 is used for all of Germany's territory.

7.2.1.2.4 DOC

Both national data and IPCC default factors are used for DOC, the proportion of degradable organic carbon in waste. Table 400 below provides an overview of the DOC values used.

With regard to dry matter, the 2006 IPCC Guidelines give a default DOC of 50%, which is computationally equivalent to a dry-matter content of about 10%. From the 1980s until 2005, virtually all of the sewage sludge that was landfilled was mechanically dewatered sludge with a dry-matter content of about 30%. A weighted mean DOC of 15% has been derived on the basis of the dry-matter content of the total quantity of municipal and industrial sewage sludge landfilled over time. Since 1 June 2005, only waste with a total carbon content < 3 % may be landfilled in

Germany. This also applies to sewage sludge. Computations use a DOC of 3% for the period as of 2006, because sewage sludge may be landfilled only if it has undergone proper pretreatment or if the relevant industrial wastewater has been proven to have suitably low carbon-content levels.

In the 2015 inventory, an error was corrected in the calculations for sewage sludge, and that correction led to considerably lower emissions quantities for earlier years in the time series in comparison to the corresponding figures in previous inventories.

Table 400: DOC values used

Fraction	DOC	Source
Organic	18%	Various national studies show DOC levels that are higher than the IPCC default value
Garden and park waste	20%	National value
Paper and cardboard	40%	IPCC default
Wood and straw	43%	The national value is somewhat higher than the IPCC default
Textiles	24%	National value
Diapers	24%	National value
Composite materials	10%	National value
Sewage sludge	15%	Determined computationally from the IPCC default for sewage sludge, oriented to dry matter; after 2006, a DOC of 3% is used
Waste from MBT facilities	2.3%	National value (10 % of the average DOC of landfilled fractions from the current year)

7.2.1.2.5 DOC_F

DOC_F , the DOC fraction that can be converted into landfill gas, is put at 50 % for settlement waste, on the basis of a national study (RETTENBERGER et al, 1997: p. 277). That value is in keeping with the IPCC default of 0.5.

7.2.1.2.6 F = Fraction of CH_4 in landfill gas

A value of 50%, the mean value in the IPCC default-value range, is assumed for F . That value has been confirmed by a national research project (UBA, 1993).

In recent years, the methane concentrations in collected landfill gas (Table 398) have been decreasing. Presumably, this decrease in methane concentrations is to oxidation effects in the gas-collection systems, effects that intensify as gas formation decreases.

Table 401: Fraction of CH_4 in landfill gas

	2004	2006	2008	2010	2012
Fraction of CH_4 in landfill gas	49%	50%	49%	48%	48%

Source: FEDERAL STATISTICAL OFFICE, Fachserie 19, Reihe 1, 2012, Table 1.5

7.2.1.2.7 Half-life

The calculation model is a multi-phase model that takes account of the different half-lives of different waste fractions. Table 402 shows the half-lives and the methane-formation rate used for the pertinent waste fractions. In conformance with the recommendations provided in the 2010 inventory review (paragraph 146, FCCC/ARR/2010/DEU), additional information has been provided for reporting as of 2011. The constant methane-production rate that appears in the FOD method corresponds to the time required for biodegradable organic carbon in waste to decompose to the point at which it has lost half of its original mass. It thus can be derived from the half-lives of the various relevant fractions, in keeping with Equation 57.

Equation 57: (2006 IPCC Guidelines)

$$k = \ln 2 / t_{1/2}$$

Table 402: Half-lives and constant methane-formation rates of waste fractions

Type of waste	Half-life (years)		CH ₄ formation rate (k value)	
	IPCC default value*	National value	IPCC default value*	National value
Food waste	4	4	0.173	0.173
Garden/park waste	7	7	0.099	0.099
Paper / cardboard	12	12	0.058	0.058
Wood	23	23	0.030	0.030
Textiles / diapers	12	12	0.058	0.058
Composite materials	--	12	---	0.058
Sewage sludge	4	4	0.173	0.173
Waste from MBT facilities	--	12	--	0.058

* Wet temperate

7.2.1.2.8 Landfill-gas use

The "TA Siedlungsabfall" of 1993¹⁷³ made gas collection one of the prerequisites for licensing of landfills for settlement waste. The amended version of the Environmental Statistics Act (UStatG) of 2005 mandates that in future the Federal Statistical Office, in its surveys, is to take account of, and publish, levels of landfill-gas collection. For the years 2004, 2006 and 2008, and with regard to landfill-gas collection and use, Fachserie 19 of 12 July 2012 includes only data for landfills in operation and closure phases. Collection of gas-collection data for all landfills, i.e. including landfills in the aftercare phase, began for the first time for the year 2010 and has been reported to date for the years 2010 and 2012.

As a result of the above-described data gaps, in reporting in recent years (up to and including the 2012 NIR), total quantities of collected landfill gas have been determined by combining data from the energy sector and from Fachserie 19. The data obtained for all landfills as a whole, for the years 2010 and 2012, show that the quantities of gas collected at landfills in the aftercare phase have been considerably overestimated. For this reason, a recalculation had to be carried out to correct the amounts of gas collected at landfills in recent years and, thus, to correct the relevant methane emissions. The quantities of methane listed in Table 17 include both the landfill-gas quantities used for energy generation and those flared off.

Since the greenhouse-gas emissions from the category landfill-gas flares in 5.A account for less than 0.05 % of the total inventory (not including LULUCF), and since they would not exceed 500 kt CO₂ equivalents (significance thresholds pursuant to FCCC/SBSTA/2013/L.29/Add.1), and since annual recording cannot be assured (in keeping with FCCC/SBSTA/2013/L.29/Add.1, para 37), we opt not to report on this area (IPCC Guideline, 2006). A one-time quantitative estimation of the emissions from landfill-gas flares that are thus not being included in the inventory yielded a figure of about 0.6 t CO₂ equivalent. In addition, a compilation of all sources listed as "not estimated" is presented in Annex 5 (Annex Chapter 21) of the present report.

¹⁷³ Technical instructions on recycling, treatment and other management of settlement waste (Third general administrative provision on the Waste Act (Abfallgesetz)) of 14 May 1993

Table 403: Methane collection in landfills

Year	Methane formation, in kt	NIR 2012		NIR 2015			
		Collected quantity of methane, in kt	Collection rate in %	Methane formation, in kt	Waste-addition and closure phases	Aftercare phase	Collection rate in %
1990	2,169	126	5.8	1,614			5.8
1991	2,228	136	6.1	1,715			6.1
1992	2,246	146	6.5	1,772			6.5
1993	2,223	156	7.0	1,787			7.0
1994	2,167	166	7.7	1,770			7.7
1995	2,095	176	8.4	1,738			8.4
1996	2,008	190	9.5	1,690			9.5
1997	1,906	260	13.6	1,629			13.6
1998	1,801	280	15.5	1,559			15.5
1999	1,703	349	20.5	1,490			16.6
2000	1,611	352	21.8	1,423			17.6
2001	1,520	356	23.4	1,353			18.7
2002	1,441	360	25.0	1,288			19.7
2003	1,355	363	26.8	1,222			20.8
2004	1,280	425	33.2	1,158	236	11	21.8
2005	1,202	447	37.2	1,094			23.0
2006	1,120	460	41.1	1,018	231	11	24.3
2007	1,026	445	43.4	937			24.1
2008	943	374	39.7	865	190	11	23.8
2009	874	358	41.0	800			24.4
2010	816	347	42.5	741	171	11	24.4
2011				689			24.2
2012				641	140	14	24.0
2013				598			24.2
2014				559	121	13	24.0
2015				523			24.0

Italics: Data of the Federal Statistical Office (Fachserie 19, Reihe1, 2014, of 18 August 2016)

For the recalculation, it was necessary to close data gaps via extrapolation and qualified estimates, since official statistical data are available only for certain single years.

For the years through 1998, proportional gas-collection rates (i.e. expressed as percentages) from earlier estimates continue to be used (cf. the 2012 NIR for the relevant sources and data derivation), and the collected quantities of methane have been calculated from the methane formation and the pertinent collection rate (expressed as a percentage).

For the years 1999 through 2003, the proportional collection rates (expressed as percentages) have been interpolated from the values for 1998 (old method) and 2004. The collected quantities of methane were calculated from the total methane formation and the relevant proportional collection rate (expressed as a percentage).

For the years 2004, 2006 and 2008, Federal Statistical Office data are available only for landfills in waste-addition and closure phases. The total quantities of methane collected at all landfills were determined by adding a) the methane quantities determined for 2010, for landfills in the aftercare phase, and b) the pertinent annual figures for 2004, 2006 and 2008.

For the years 2010 and 2014, the Federal Statistical Office has complete data on landfill-gas collection at all landfills. For the years 2005, 2007, 2009, 2011, 2013 and 2015, no data on collected quantities of landfill gas are available, since the Federal Statistical Office collects such data only every other year. For those years, the proportional (percentage) rates of landfill-gas collection were thus obtained via interpolation between the relevant previous and subsequent years, and the collected quantities of gas were then calculated from the gas formation and the applicable proportional (percentage) collection rate. For 2015, with this approach, the proportional (percentage) collection rate for 2014 was used.

7.2.1.2.9 Oxidation factor

As to the factor determining the proportion of CH₄ that is oxidised in landfill covering layers, the IPCC default value of 0.1 was adopted for the entire time series. While in the early 1990s the former GDR probably had a higher percentage of uncontrolled landfills than did the old German Länder, a research project has found that the former GDR's landfills have a low CH₄-formation potential, and thus use of the factor 0.1 is also justified for that period (BMBF, 1997).

7.2.1.3 Uncertainties and time-series consistency (5.A.1)

The method's uncertainties were estimated for the first time for the 2006 NIR.

Over the long, 30-year period covered by the activity data, inconsistencies in the time series are unavoidable, since the pertinent waste categories and survey methods changed several times as a result of improvements in legislation and waste statistics. In Germany, special problems arise especially via German reunification and the resulting merging of two different economic and statistical systems. For this reason, considerable effort has to be invested in reviewing data consistency and allocations to the reported categories, in the interest of making time series as consistent as possible.

7.2.1.4 Category-specific quality assurance / control and verification (5.A.1)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The selected parameters were compared with relevant data for other countries.

In entry of data, the correctness of entries was checked via sum values – various waste categories were recorded solely for the purpose of checking correctness of data entry.

The national calculation model used to date was reviewed via the IPCC's FOD model – i.e. by entering the same pertinent parameters and data into that FOD model. The same result was obtained.

7.2.1.5 Category-specific recalculations (5.A.1)

During the preparation of the 2016 NIR, official statistical data for stored waste quantities were available only through the year 2013. For this reason, the waste quantities for 2014 were assumed to be constant with respect to the year 2013. In Fachserie 19 of 27 July 2015, the waste data for 2014 were published. A recalculation for 2014 was then carried out on the basis of those data.

In earlier versions of the NIR, a national value of 49 %, based on official statistical data, was used for the share of CH₄ in landfill gas (F). In the review processes for the NIR, that approach was criticised, and use of the IPCC default value of 50 % was recommended. The lower methane content in the national figure could be due to reduction effects at landfills or in landfill-gas collection systems – this cannot be ruled out. For this reason, a recalculation with a methane content of 50 % was carried out.

In the Excel tool for calculation of methane emissions, transfer errors (methane concentration in landfill gas; the DOC for mechanically-biologically treated waste) were corrected. These corrections have only slight impacts on the overall result.

7.2.1.6 Planned improvements, category-specific (5.A.1)

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

7.3 Biowaste treatment (5.B)

In category 5.B, emissions from composting systems (5.B.1) and from digestion of biowaste in biogas plants (5.B.2) are reported. Both facility types in category 5.B treat separately collected biowaste and produce compost or digestates that are used in the agricultural or horticultural sectors. This is the difference with regard to the mechanical-biological treatment covered in category 5.E. Those facilities handle mixed settlement waste (residual waste). The residues from those facilities are either landfilled or incinerated.

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	5.B. Biological treatment of solid waste	0	CH ₄	25.3	0.00%	776.6	0.09%	2964.6%
-/-	5.B. Biological treatment of solid waste	0	N ₂ O	16.0	0.00%	326.3	0.04%	1943.8%

The category *Biowaste treatment* is not a key category.

7.3.1 Biowaste treatment – composting systems (5.B.1)

7.3.1.1 Category description (5.B.1)

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	Tier 2	NS	CS
N ₂ O	Tier 2	NS	CS

In Germany, annually increasing fractions of biodegradable waste are being separately collected and treated. Composts and digestates produced from such separately collected kitchen and garden waste are used for agricultural and horticultural purposes. The 2006 inventory report included a first report on CH₄ and N₂O emissions from treatment of biowaste in composting systems, along with a complete time series for those emissions. In the 2015 NIR, reporting in this area was brought into line with the 2006 IPCC Guidelines.

The area of composting includes centralised composting of separately collected biowaste as well as the composting that residents carry out in their own gardens (home composting). For this area, no reliable data are available to us on the relevant quantities involved and the emissions produced. For this reason, we do not report on these emissions.

7.3.1.2 Methodological issues (5.B.1)

Nitrous oxide emissions from composting of kitchen and garden waste systems are reported in keeping with the 2006 IPCC Guidelines. On the other hand, we use our own national emission factors, obtained via a research project. In the relevant research project, emission factors for methane emissions were also determined. This has eliminated any need to offset methane quantities formed against methane quantities used. The methane and nitrous oxide emissions are calculated in accordance with the following formula:

$$E = M * EF$$

E = emissions in kg

M = mass of biowaste in Gg (1000 t)

EF = g/t (kg/Gg)

Activity data

Since 1980, the Federal Statistical Office has regularly collected and published data on waste quantities managed in composting facilities (Abfallentsorgung 2014 ("waste management 2014"), STBA, Fachserie 19, Reihe 1 of 18 August 2016, Table 7). To this end, it carries out exhaustive surveys of waste treatment facilities.

The activity data for the current report year have to be estimated, since official waste statistics are published with a one-year time lag. For purposes of estimation, the waste-quantity figure from the previous year is used, unchanged. In each case, such estimates are replaced in the following year with the relevant figures from survey statistics. Recalculations for the year prior to the past year thus have to be carried out on an annual basis.

Table 404: Waste quantities added to biowaste composting facilities

[in 1000 t]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Composting	724	1,515	1,956	2,397	3,783	5,168	6,554	7,214	7,320	7,964
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Composting	9,030	8,562	9,459	9,200	8,981	8,886	8,754	9,115	8,895	8,728
	2010	2011	2012	2013	2014	2015				
Composting	8,609	8,793	8,886	8,977	8,684	8,684				

Emission factors

Emission factors for composting of biowaste were determined in the framework of a research project (Cuhls et al. 2015). In that project, emissions measurements, covering methane, nitrous oxide and ammonia, were carried out at 19 composting facilities. From the results of those measurements, and from findings obtained via study of the literature, emission factors were extrapolated for the complete group of such facilities in Germany.

The following emission factors were obtained for composting of biowaste:

EF-CH₄ = 1,400 g CH₄/Mg biowaste

EF-N₂O = 74 g N₂O/Mg biowaste

These national emission factors were used for the inventory calculations.

7.3.1.3 Uncertainties and time-series consistency (5.B.1)

Activity data

The uncertainties for the composted waste quantities are considered very small (2 %), since the relevant data were obtained via an exhaustive survey, the reporting quality is good and operators have an interest in high-quality reporting.

Emission factors

The uncertainties for the emission factors are high. They depend on the type of facility/plant in question, on waste composition and on the effectiveness of the biofilters used. The pertinent figures from the literature and from other countries vary so widely that uncertainties of +400 % to -69 % for CH₄, and of at least +177 % to -46 % for N₂O, are assumed. The uncertainties were determined in the framework of the aforementioned research project (Cuhls et al. 2015).

7.3.1.4 Category-specific quality assurance / control and verification (5.B.1)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

7.3.1.5 Category-specific recalculations (5.B.1)

The activity data for the current report year have to be estimated, since official waste statistics are published with a one-year time lag. Recalculations for the year prior to the past year thus have to be carried out on an annual basis.

7.3.1.6 Planned improvements, category-specific (5.B.1)

No further improvements are planned at present. Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

7.3.2 Biowaste treatment – digesters (5.B.2)**7.3.2.1 Category description (5.B.2)**

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	CS	NS	CS
N ₂ O	CS	NS	CS

In Germany, annually increasing fractions of biodegradable waste are being separately collected and treated. The emissions reported under 5.B.2 come from biowaste digestion facilities that ferment primarily separately collected biowaste from households, food waste from cafeterias and restaurants and biowaste from food production and processing. They do not include emissions from digestion of sewage sludge.

Such digestion processes are operated specifically for the purpose of generating biogas – and, thus, for producing a fuel (unlike composting). For this reason, most of the so-generated biogas is used for energy generation, and only a small fraction is flared off. These gas quantities are statistically recorded directly at the pertinent installations and are listed in waste statistics (Abfallentsorgung 2014 ("waste management 2014"), STBA, Fachserie 19, Reihe 1 of 18 August 2016, Table 1.5). They do not have to be calculated. The emission factors listed below are used solely for calculation of the quantities of methane that are emitted via operation of digesters. The Central System of Emissions (CSE) has separate time series for methane used for energy generation, methane that is flared and methane that is emitted. Methane emissions from combustion of biogas for energy generation are reported in the energy sector.

Composts and digestates produced from such separately collected kitchen and garden waste are used for agricultural and horticultural purposes. The 2006 inventory report included a first report on CH₄ and N₂O emissions from treatment of biowaste in composting facilities, along with a complete time series for those emissions. Biowaste digestion in biogas plants has been growing in importance, and statistical surveys of such digestion have been carried out since 1998. As of the 2015 NIR, therefore, and in keeping with the 2006 IPCC Guidelines, the inventory now also reports on biowaste digestion in biogas plants.

7.3.2.2 Methodological issues (5.B.2)

Nitrous oxide emissions from digestion of kitchen and garden waste are reported in keeping with the 2006 IPCC Guidelines. On the other hand, we use our own national emission factors, obtained via a research project. In the relevant research project, emission factors for methane emissions

were also determined. This has eliminated any need to offset methane quantities formed against methane quantities used. The methane and nitrous oxide emissions are calculated in accordance with the following formula:

$$E = M * EF$$

E = emissions in kg

M = mass of biowaste in Gg (1000 t)

EF = g/t (kg/Gg)

The quantities of gas from biowaste digestion that are used for energy generation, and the gas quantities that are flared off, are also reported; since 2004, these data have been directly recorded in waste statistics at two-year intervals.

Activity data

Since 1998, the Federal Statistical Office has regularly collected and published data on waste quantities managed in biowaste digestion plants (Abfallentsorgung 2014 ("waste management 2014"), STBA, Fachserie 19, Reihe 1 of 18 August 2016, Table 7). To this end, it carries out exhaustive surveys of waste treatment facilities. The activity data for the current report year have to be estimated, since official waste statistics are published with a one-year time lag. For purposes of estimation, the waste-quantity figure from the previous year is used, unchanged. In each case, such estimates are replaced in the following year with the relevant figures from survey statistics. Recalculations for the year prior to the past year thus have to be carried out on an annual basis.

Table 405: Waste quantities added to biowaste digestion plants

[in 1000 t]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Digestion	0	0	0	0	0	0	0	0	411	821
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Digestion	1,254	1,812	2,783	3,088	3,410	3,526	3,628	4,119	4,149	4,470
	2010	2011	2012	2013	2014	2015				
Digestion	4,398	5,370	6,094	5,681	6,752	6,752				

Emission factors

Emission factors for digestion of biowaste were determined in the framework of a research project (Cuhls et al. 2015). In that project, emissions measurements, covering methane, nitrous oxide and ammonia, were carried out at 16 digesters. From the results of those measurements, and from findings obtained via study of the literature, emission factors were extrapolated for the complete group of such facilities in Germany.

The following emission factors were obtained for digestion of biowaste:

$$EF-CH_4 = 2,800 \text{ g } CH_4/\text{Mg biowaste}$$

$$EF-N_2O = 67 \text{ g } N_2O/\text{Mg biowaste}$$

These national emission factors were used for the inventory calculations.

7.3.2.3 Uncertainties and time-series consistency (5.B.2)

Activity data

The uncertainties for the waste quantities treated in digesters are considered very small (2 %), since the relevant data were obtained via an exhaustive survey, the reporting quality is good and operators have an interest in high-quality reporting. This also applies to the statistical data

collected on the gas quantities from biowaste digestion facilities that are used and on those that are flared off.

Emission factors

The uncertainties for the emission factors are high. They depend on the type of facility/plant in question, on waste composition and on the effectiveness of the biofilters used. The pertinent figures from the literature and from other countries vary so widely that uncertainties of +179 % to -77 % for CH₄, and of at least +320 % to -37 % for N₂O, are assumed. The uncertainties were determined in the framework of the aforementioned research project (Cuhls et al. 2015).

7.3.2.4 Category-specific quality assurance / control and verification (5.B.2)

General and category-specific quality control and quality assurance have been carried out, in conformance with the requirements of the QSE manual and its associated applicable documents, by the relevant involved experts and the Single National Entity.

7.3.2.5 Category-specific recalculations (5.B.2)

Recalculations have to be carried out annually for the year prior to the previous year, since the activity data of the Federal Statistical Office appear with a one-year time lag and thus the current report-year data have to be estimated. In each case, such estimates are replaced in the following year with the relevant figures from survey statistics.

7.3.2.6 Planned improvements, category-specific (5.B.2)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

7.4 Waste incineration (5.C)

All waste incineration in Germany is carried out with energy recovery; for this reason, and in order to avoid double counting, the resulting emissions are reported in the energy section (CRF 1.A.1.a, Chapter 3.2.6). Because energy is recovered from waste incineration, no emissions from waste incineration occur under 6.C (NO). Only emissions of NO_x, SO₂ and NMVOC from crematoria are reported here. Those emissions are calculated in keeping with the EF default values in the "EMEP/EEA air pollutant emission inventory guidebook 2013". In the CRF Reporter, use of the units "kt" is fixed. Since this setting cannot be adjusted, in the CRF tables "NA" is entered for the activity data (number of cremations).

7.5 Wastewater treatment (5.D)

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/T	5.B Wastewater Handling	Domestic Wastewater	CH ₄	2,696.2	0.22%	583.8	0.07%	-78.3%
-/-	5.B Wastewater Handling	Domestic Wastewater	N ₂ O	926.7	0.08%	427.4	0.05%	-53.9%
-/-	5.D.2 Wastewater Handling	Commercial Wastewater	N ₂ O	31.6	0.00%	25.1	0.00%	-20.5%
-/-	5.D.2 Wastewater Handling	Commercial Wastewater	CH ₄	9.3	0.00%	43.1	0.00%	365.7%

The category *Wastewater handling – municipal wastewater treatment* is a key category for CO₄ emissions in terms of trend. Because relevant emissions have been falling very sharply since 1990,

and thus an extremely low emissions level has been attained, the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this category that are required for key categories.

7.5.1 Municipal wastewater treatment (5.D.1)

7.5.1.1 Methane emissions from municipal wastewater treatment (5.D.1 wastewater treatment)

7.5.1.1.1 Category description (5.D.1)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	NA	NA	NA
CH ₄	D/CS	NS	D/CS
N ₂ O	D/CS	NS	D/CS

The category *Wastewater handling – municipal wastewater treatment* is a key category for CO₄ emissions in terms of trend.

A total of 99.5% of the wastewater produced in Germany is treated in wastewater treatment plants. In such treatment, methane is produced, although most wastewater treatment is aerobic. All process steps contribute to the emissions, although sludge digestion and stacking of digested sludge account for the largest shares. Sludge thickening, grit-chamber processes and denitrification account for considerably smaller shares. On the other hand, it is likely that these shares have changed throughout the period covered by the report.

The remaining 0.5 % of the total wastewater quantity (STBA 2015a) consists of human sewage of inhabitants not connected to sewage networks or small wastewater-treatment facilities. Wastewater from such inhabitants is collected, for later transport to wastewater treatment plants, in cesspools or septic tanks with no drainage. In cesspools and septic tanks, uncontrolled processes (partly aerobic, partly anaerobic) can occur that lead to methane formation. Since 1990, the organic loads discharged into cesspools and septic tanks have been drastically reduced, however, because the percentages of inhabitants connected to wastewater treatment facilities have continually increased. As a result, this sector's CH₄ emissions show a sharply decreasing trend.

In addition, the open sludge digestion that was carried out, for purposes of sludge stabilisation, in the new German Länder until the early 1990s was gradually reduced and then completely discontinued as of 1994 (cf. Chapter 7.5.1.2.1).

Planned improvements

In connection with calculation of emissions from wastewater treatment, only N₂O emissions from activated sludge pools and from effluent are reported. Other possible treatment steps that can be emissions-relevant – such as sludge treatment – are not reported, since the 2006 IPCC Guidelines do not cover them and since no pertinent data are available to date.

With regard to fugitive emissions of methane and other gases from wastewater treatment plants, no representative measurements are available for Germany as a whole. For this reason, a research project was launched last year with the aim of identifying possible fugitive emissions via relevant sections of facilities. To that end, measurements of the gases CH₄, N₂O and NH₃ (indirect GHG; since to a small degree it converts to N₂O in the atmosphere) are to be carried out at representative wastewater treatment facilities. The project is not expected to produce results before the end of 2018. As soon as those findings are available, the current estimates of methane emissions from this source can be replaced with figures that are considerably more precise.

7.5.1.1.2 Methodological issues (5.D.1 wastewater treatment)

Equation 6.1 presented by the IPCC (2006 IPCC Guidelines, Vol. 5, Chapter 6.2.2.) for calculation of CH₄ emissions from municipal wastewater cannot be applied to the situation in Germany. Of the population fractions (U_i) referred to in Table 6.5 of the IPCC Guidelines (*ibid.*), just one, extremely small source group (mentioned above) – a group that, in terms of CH₄, is not related to wastewater treatment plants and their CH₄-recovery systems – contributes significantly to the reported CH₄ emissions. In addition, primary and secondary sludges are used to generate CH₄ in digestion towers. The resulting methane is collected, and the total quantity of CH₄ produced in the process far exceeds to the CH₄ emissions calculated in the present context. As a consequence, the pertinent value resulting from the IPCC equation would be negative. Furthermore, only after such treatment, i.e. after it has been fully digested, is the relevant sewage sludge incinerated or used for agricultural or landscaping purposes. For this reason, the term "sludge removed" as used within the meaning of the Guidelines is not appropriate, since the sewage sludge no longer has any BOD₅ (cf. also Chapter 7.5.1.2.1). Furthermore, the statistics available in Germany on numbers of persons connected to cesspools and septic tanks are much more precise than the values for U_i and $T_{i,j}$ (degree of utilisation of treatment system) that can be derived with Table 6.5 of the Guidelines. All in all, the 2006 Guidelines method is too limited for the situation that actually prevails in Germany. For the reasons described, the 1996 IPCC method is used, instead of the 2006 IPCC equation, but in a way that takes the requirements of the 2006 IPCC Guidelines into account.

The calculation of methane emissions from wastewater treatment plants is based on a limited number of measurements (Becker et al). That source gives an emission factor of 0.28kg methane per year and inhabitant. Since virtually all of Germany's inhabitants are connected to one of the some 6,000 wastewater treatment plants in the country, the country's population is used as the activity data. The trend applied for the period 1990 through 2015 is based on a technical article (Schmelz et al 2013). That source's specific remarks with regard to the catchment area of the "Emscher system" (North Rhine – Westphalia) have been generalised and, via an expert assessment, translated into a representative trend. The source assumes that emissions will be halved in the period 1990 through 2020. Organic loads from cesspools and septic tanks are calculated pursuant to the IPCC method, in which the number of persons connected to cesspools or septic tanks (P) is multiplied by the average organic load per person. The average organic load is assumed to be 60 g BOD₅ per inhabitant (Gujer, 2006). While that is the specific value for Germany, it is also used throughout Europe as a statistical average (Amtsblatt_der_Europäischen_Gemeinschaft, 1991); ((91/271/EWG, 1991)). The IPCC default value for Germany (2006 IPCC Guidelines, Vol. 5, Chapter 6, Table 6.4), at 62 g, is of the same order of magnitude.

Methane emissions from cesspools and septic tanks are determined in keeping with the IPCC method. The IPCC default value for methane formation potential (0.6 kg CH₄ / kg BOD₅) has been used.

Pursuant to IPCC 2006 (*ibid.*, Chapter 6.1, page 6.7), the methane correction factor (MCF) depends on temperature. No significant methane production occurs at temperatures below 15°C.

In light of the long-term mean soil temperature in Germany (DWD, 2013) at a depth of 1 m, the average soil temperature in summer months ranges between 15 and 18°C. Methane thus can form during summer months, since the relevant cesspools and septic tanks are situated at depths averaging between about 0.5 m and 2.5m. In keeping with (Gibbs & Woodbury, 1993), the MCF for this period (about 3.5 months) is conservatively estimated to be 0.35. Throughout the rest of the year, the temperatures are below – significantly, in part – the IPCC's 15°C boundary. They drop to

about 3.8 °C. In keeping with (GIBBS & WOODBURY, 1993), the MCF for this period (about 8.5 months) is estimated to be 0.1. Furthermore, since the cesspools and septic tanks are regularly emptied, for transport of their wastewater to treatment plants, and thus no sedimentation or sludge concentration occurs, the values used are assumed to be realistic or even conservative. The described conditions and temperature distribution in the soil yield a mathematically averaged MCF for Germany of 0.173.

The MCF is determined as follows:

$$MCF = (0.35 * 3.5 \text{ months} + 0.1 * 8.5 \text{ months}) / 12 \text{ months}$$

(Gibbs and Woodbury 1993) use an estimate of 0.35 for temperatures > 15° C and an estimate of 0.1 for temperatures < 15° C

The emissions are calculated as follows:

$$CH_4 = BOD_{5Y} \times B_o \times MCF$$

$$BOD_{5Y} = P_{\text{cesspool, septic tank}} \times BOD_5 \times 365 \times 0.001$$

Where

$$MCF = \text{Methane correction factor, 0.173}$$

$$B_o = \text{Default value for max. } CH_4 \text{ formation capacity, } 0.6 \text{ kg } CH_4 / \text{kg } BOD_5$$

$$P_{\text{cesspool, septic tank}} = \text{Number of persons connected to cesspools or septic tanks}$$

$$BOD_{5Y} = BOD_5 \text{ in g / year}$$

$$BOD_5 = 60 \text{ g / day} \times \text{persons}$$

Calculation pursuant to higher-Tier methods, as required for key categories, is not feasible, since the substance flows for cesspools and septic tanks are not separately recorded.

7.5.1.1.3 Uncertainties and time-series consistency (5.D.1 wastewater treatment)

The MCF value has been adjusted in keeping with the climatic conditions prevailing in Germany (long-term average soil temperature in Germany). The uncertainty for the value is ± 20 % (expert estimate).

In addition, the following uncertainties are also used (all are expert estimates):

Emission factor for methane from wastewater treatment plants	=	± 25 %
Inhabitants with cesspools or septic tanks	=	± 3 %
BOD ₅	=	± 30 %
B _o	=	± 30 %

The activity data for organic loads in cesspools and septic tanks are based on figures of the Federal Statistical Office (StBA 2015a). Every three years, the Federal Statistical Office conducts a survey – without determining the relevant uncertainties – of the numbers of inhabitants who are not connected to the public sewer system and whose wastewater is disposed of via cesspools and septic tanks. Data for interim years are linearly interpolated or extrapolated. No other data sources are available. The results of such surveys may be considered very precise, since the surveys are exhaustive.

Until 1995, data for the old and new Federal Länder were determined separately; since then, a single value for all of Germany has been determined in each case. This does not affect time-series consistency, however.

7.5.1.1.4 Category-specific quality assurance/ control and verification (5.D.1 Wastewater treatment)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

As noted above (Chapter 7.5.1.1.1), 0.5 % of the population in Germany are not connected to the sewage network and thus collect their wastewater in cesspools or septic tanks. That value accords quite well with the values proposed by IPCC (2006 IPCC Guidelines, Vol. 5, Chapter 6.2.2.3; Table 6.5), for Germany, for the relevant fraction of the rural population and the associated degree of utilisation of septic systems. With the IPCC values, one obtains the result that about 1.2% of the population collects wastewater via septic systems. The two values are of the same order of magnitude and, additionally, lie quite close together.

7.5.1.1.5 Source-specific recalculations (5.D.1 Wastewater treatment)

The data for 2014/2015 have been extrapolated, while those for 2011 and 2012 have been interpolated, since the Federal Statistical Office (STBA 2015a) publishes its data on cesspools and septic tanks at 3-year intervals.

The MCF (0.173) was adjusted in keeping with climatic conditions prevailing in Germany (mean soil temperature at a depth of 1m). This led to a reduction of the methane emissions.

The data on digester-gas collection and sewage-sludge utilisation are reported annually. Enquiries to several wastewater treatment facilities with digester-gas collection revealed that the gas losses at such facilities amount to 5 %. This confirms the figures of the Federal Statistical Office. The installations have no permanent leakages. Accident prevention regulations are in place for sections of installations that handle digester gas, and such regulations call for gas-tightness checks to be carried out at certain intervals (DGUV 1997). These leakages significantly increase the methane emissions at wastewater treatment plants with digester-gas collection. The quantities of digester gas that are produced, i.e. including leakages, are saved upon further utilisation of the pertinent sewage sludge. In addition, the indirect emissions tied to required energy generation and heat production are reduced by the share of digester gas – obtained from biogenic raw materials, i.e. the sewage sludge – that is used for these generation/production purposes.

7.5.1.1.6 Planned improvements, category-specific (5.D.1 Wastewater treatment)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

7.5.1.2 Methane emissions from municipal sludge treatment (5.D.1 Sludge treatment)

7.5.1.2.1 Category description (5.D.1 Sludge treatment)

As a general rule, the treatment of municipal sewage sludge comprises two treatment stages:

- Water removal via mechanical processes (chamber-filter press, cyclone);²evaporation in sludge-drying lagoons or sludge-drying beds
- Stabilisation: Aerobic stabilisation (open pool with oxygen input);²or anaerobic stabilisation in digestion tower;

- (Formerly: open sludge digestion)

With reference to population figures, mechanical *dehydration* + treatment in a digestion tower (with dehydration before or after the digestion-tower treatment) currently represents the main treatment method (some treatment is also carried out in small, rural sewage treatment plants). Moreover, sewage sludge is generally stabilised prior to subsequent use.

The purpose of sludge stabilisation is to prevent uncontrolled sludge digestion. In facilities for fewer than 10,000 inhabitants, such stabilisation is usually carried out aerobically, with energy consumption, while in facilities for more than 30,000 inhabitants it normally is carried out anaerobically, with production of methane gas. In 2015, digester gas was collected in a total of 1,252 wastewater treatment facilities. The amount of digester gas produced depends especially on the composition of the sewage sludge, the temperature and the reaction conditions. Gas so produced is usually recovered for energy generation in combined heat/power generating systems (CHP). It is reported under 1.A.1. Where facilities are unable to use the methane gas cost-effectively in this manner, or when technical disruptions or overloads of attached CHPs occur, the methane gas may be flared off. Further losses occur, for example, in connection with maintenance work involving emptying of gas pipelines and with gas leakages. The amended version of the Energy Statistics Act (EnStatG) does not require further specification of losses. This releases insignificant amounts of methane emissions into the environment ($\leq 5\%$) (StBA, 2016a, 2016b) (StBA 2016 c). The figures were confirmed via a study of losses in wastewater treatment facilities. Annual gas-tightness checks are required in such installations.

Until the early 1990s, in eastern Germany sludge was stabilised via open digestion, a process that produced methane emissions. Open sludge digestion is no longer practiced, however. It was phased out gradually, and was then completely discontinued in 1994.

Emissions from open sludge digestion continue to be the reason, however, why NO is reported for this point in the CRF, instead of IE (for the energy-related use under 1.A.1 – see above), since this technique, with its related emissions, was used through 1993. Today, it is no longer used in Germany – this is the reason for the "NO".

The secondary sludge (excess sludge) occurring in wastewater treatment, and the pertinent primary sludge, are anaerobically treated, together, in digestion towers (completely digested; see above) and thus anaerobically stabilised. That process produces digested sludge. That sludge, in turn, undergoes further treatment in wastewater treatment facilities and leaves such facilities as sewage sludge. Use of this process ensures that the sewage sludge is completely free of readily biodegradable substances.

The sewage sludge and the treated wastewater are the final products of wastewater treatment.

In Germany, sewage sludge remaining after biological wastewater treatment is managed in the following ways (where applicable, after dehydration and stabilisation):

- Thermal disposal: no methane emissions occur. Thermal disposal requires energy inputs and thus is allocated to CRF 1.
- Recycling for substance recovery: the most important procedures for recycling sewage sludge for substance recovery include recycling in agriculture, pursuant to the Ordinance on Sewage Sludge (Klärschlammverordnung), and use in landscaping and other measures. Emissions from recycling for substance recovery are not reported under wastewater and sludge treatment.

Table 406: Use of sewage sludge

Sewage sludge	t dry matter			
	2011	2012	2013	2014
Total quantity (t TM)	1,950,126	1,846,441	1,787,871	1,809,166
<i>Thermal disposal</i>	<i>1,067,431</i>	<i>1,008,830</i>	<i>1,034,771</i>	<i>1,084,108</i>
- Mono-incineration			230,581	431,286
- Co-incineration			250,326	400,115
- Unknown			553,864	252,707
<i>Landfill</i>		0	0	0
Recycling for substance recovery	882,695	837,611	748,868	722,416
- Agriculture	567,187	544,065	484,464	470,882
- Landscaping-related measures	254,402	235,439	203,712	216,148
- Composting		0	0	
- Other	61,106	58,107	60,692	35,386
Other direct disposal			4,232	2,642

Source: (StBA 2016 d, e)

The activity data for sewage-sludge utilisation are based on data of the Federal Statistical Office. (StBA 2016d). The relevant report appears every 3 years. The figures for interim years are taken from the publication "Wasserwirtschaft Öffentliche Abwasserentsorgung Klärschlammentsorgung aus der biologischen Abwasserbehandlung" ("Water resources sector, public wastewater management, management of sewage sludge from biological wastewater treatment") Federal Statistical Office, appears annually, StBa 2016e). No data are available for the period prior to 1998 and for the years 1999-2000, 2002-2003 and 2005. No interpolation is possible, because a statistical conversion for the period as of 2007 makes it impossible to form a 100% sum(Wiechmann et al., 2013). No figures for the current inventory year are available at present. For 2013, the Federal Statistical Office reported for the first time, under "substance recovery" ("Stofflicher Verwertung") "other direct disposal."¹⁷⁴

The activity data for sewage-sludge utilisation, for the years prior to 2011, are available in the 2015 NIR.

7.5.1.2.2 Methodological issues (5.D.1 Sludge treatment)

7.5.1.2.2.1 Digester gas

As described above, the digester gas that is produced by the digestion process is collected and used for energy generation. The methane content in digester gas is nearly 65 % (Schön et al., 1993). For 2015, the Federal Statistical Office (StBa 2016f) found that the average methane content in sewage gas was 63.15 %. The relevant quantity of methane per raw-gas volume (StBa 2016f) is determined as follows:

$$M_{\text{methane}} = V_{\text{raw gas}} \times 0.65 \times \sigma \times 0.000001$$

Where

M_{methane} = Mass of methane produced via digestion (kt)

$V_{\text{raw gas}}$ = Volume of digester gas produced (m³)

0.65 = Factor for conversion of digester gas to contained methane

σ = Density of methane (0.717 kg/m³) (v. Vogel & Synowietz, 1974)

¹⁷⁴ This includes provision to drying facilities in cases in which further disposal steps are not known. This was listed for the first time in 2013.

7.5.1.2.2 Flaring (losses)

In gas collection, flaring is used as a safety response in cases of technical difficulties, accidents and other incidents, etc.. Consequently, gas collection can entail flaring losses. All of the gas flares used with relevant gas-collection systems are emergency/shutdown flares; i.e. they also come into play when systems (such as combined heat-and-power (CHP) generating systems) have to be shut down for maintenance purposes. Such gas flares are designed to be able, in emergencies, to burn all of the gas being collected. Gas flares are equipped with automatic ignition systems that assure reliable burning of collected gas during disruptions of normal system operation.

7.5.1.2.3 Open sludge digestion

An emission factor of 210 kg CH₄/t TS is used for open sludge digestion in the new German Länder, in keeping with the results of the study (Schön et al., 1993).¹⁷⁵ The activity rates for the years 1990 to 1992 were communicated personally to the Federal Environment Agency by the then Chief Inspector of the former GDR's water-processing plants.

In keeping with the fact that open sludge digestion is prohibited in the Federal Republic of Germany, use of that treatment method was gradually reduced in the new German Länder until 1994 and then was completely discontinued as of 1994.

The above-described data for the years 1990-1994 were most recently provided, in tabular form, in the 2015 NIR.

7.5.1.2.3 Uncertainties and time-series consistency (5.D.1 Sludge treatment)**7.5.1.2.3.1 Digester gas**

The uncertainties in determination and calculation of the applicable quantities of methane are assessed as follows (expert assessment):

Volume of digester gas produced = ± 5 %

The uncertainties originate in the measurement inaccuracies of the measuring devices used

Methane content in digester gas = ± 15 %

Varies in keeping with the composition of the wastewater – and, thus, of the composition of the sludge

Density = ± 30 %

The literature gives a range of different densities for methane (depending on temperature, etc.)

The figure for the quantity of digester gas produced is based on data of the Federal Statistical Office. The time series are thus internally consistent. The relevant surveys are carried out annually. The results of the surveys are considered accurate.

7.5.1.2.3.2 Open sludge digestion

Since the uncertainties connected with open sludge digestion have not yet been estimated, the default values (conservative factors) given in UNFCCC Decision 20/CMP.1 (p. 39ff) are used. The activity rates between 1990 and 1992 are based on a personal communication; those for 1993 are

¹⁷⁵ The emission factor was determined via the difference between methane emissions from psychrophilic sludge stabilisation in the new German Länder and the total amount of sewage sludge produced.

based on estimates of the Federal Environment Agency. As a result, a high degree of time-series consistency is not assured.

7.5.1.2.4 Category-specific quality assurance / control and verification (5.D.1 Sludge treatment)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

No comparable emissions data for Germany, or data on methane collection from wastewater-treatment plants, are known.

7.5.1.2.5 Source-specific recalculations (5.D.1 Sludge treatment)

No recalculations are required.

7.5.1.2.6 Category-specific planned improvements (5.D.1 Sludge treatment)

At present, improvements seem neither necessary nor possible, since no further activity data can be obtained.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

7.5.1.3 Nitrous oxide emissions from municipal wastewater (5.D.1 Nitrous oxide emissions from municipal wastewater)

7.5.1.3.1 Category description (5.D.1 Nitrous oxide emissions from municipal wastewater)

Municipal wastewater contains numerous nitrogen compounds. In bacterial decomposition processes, part of the available organic nitrogen is converted back into biomass. So that they can eliminate virtually all of the nitrogen remaining in wastewater, nearly all of the municipal wastewater-treatment plants in Germany are operated with an additional nitrification and denitrification stage that complements the plants' biological wastewater treatment. In nitrification, the nitrogen compounds in the wastewater are converted into nitrate, under aerobic conditions. In denitrification, the nitrogen bound in the nitrate is converted into molecular nitrogen and nitrogen oxides. Under unfavourable conditions (cf. also Chapter 7.5.2.2.1), nitrous oxide (N_2O) can occur as a by-product / intermediate product in both processes, although denitrification is the predominate source in this regard (2006 IPCC Guidelines, Vol. 5, Chapter 6.1, page 6.8) (direct emissions). The N-elimination efficiency of biological wastewater treatment plants in Germany, for the years 2006-2014, is about 81.4 %, (18. - 27. Leistungsvergleich Kommuner Kläranlagen (18th - 27th comparison of the performance of municipal wastewater treatment plants) (DWA 2007-2015)). Pursuant to (UBA 2016), the efficiency is very similar – 81.2 %. The nitrogen that remains in wastewater, following the conclusion of wastewater treatment, enters into water bodies, where microbial decomposition processes take place that can form nitrous oxide (inter alia) that can then be emitted (indirect emissions).

The total emissions of nitrous oxide that are produced via municipal wastewater are determined as a combination of direct nitrous oxide emissions (N_2O_{Plants}) and indirect nitrous oxide emissions ($N_2O_{Effluent}$). The total emissions are obtained as follows:

$$N_2O_{Total} = N_2O_{Plants} + N_2O_{Effluent}$$

The following chapters consider the direct and indirect sources of nitrous oxide emissions.

The emissions show a strongly decreasing trend, as a result of extensive additions of denitrification systems to wastewater treatment facilities in the period 1990 through about 2001. This has been due to implementation of the Waste Water Ordinance (Abwasserverordnung)(91/271/EWG, 1991). In the early 1990s, that ordinance made nutrient removal part of the state of the art for wastewater-treatment plants. Nutrient removal technology has since reached high technological standards, and a slightly decreasing emissions trend became established in about 2005.

7.5.1.3.2 Methodological issues (5.D.1 Nitrous oxide emissions from municipal wastewater)

Direct emissions

Pursuant to the 2006 IPCC Guidelines, only countries with modern, centralised wastewater treatment facilities are required to report direct emissions. According to the IPCC, "modern" facilities in this context are facilities with nitrification and denitrification phases. As noted above, nitrous oxide emissions occur primarily in connection with denitrification (2006 IPCC Guidelines, Vol. 5, Chapter 6.1). For this reason, in the following the fraction of German wastewater treatment plants with denitrification equipment ($T_{\text{Plant deni}}$) – and not the fraction of plants with nitrification equipment – is used for the calculations. 97 % of wastewater treatment plants are equipped with nitrification, while 96 % have denitrification and 97 % have a biological stage (StBA, 2015b). This year, we are basing the calculation of nitrous oxide emissions on central wastewater treatment plants that are equipped with denitrification. The differences in equipment standards are minimal (about 1-2 %).

Pursuant to the 2006 IPCC Guidelines, the nitrous oxide emissions of centralized wastewater treatment plants with denitrification are calculated as follows:

$$N_2O_{\text{Plants}} = P \cdot T_{\text{Plant deni}} \cdot F_{\text{Ind-comm}} \cdot EF_{\text{Plant}}$$

Where

N_2O_{Plants} = Total annual N_2O emission of plants, in kg N_2O /year)

P = Population

$T_{\text{PLANT DENI}}$ = Degree of utilisation of modern centralised wastewater-treatment plants with denitrification, %/100 (i.e. with respect to the entire wastewater load in Germany)

$F_{\text{Ind-comm}}$ = Fraction of protein of industrial / commercial origin that is managed via wastewater; default = 1.25

EF_{Plant} = Emission factor; 3.2 g N_2O /person x year

While the emission factor for nitrous oxide and the fraction of industrially and commercially discharged protein ($F_{\text{Ind-comm}}$) are IPCC default values, the population figure (P) and the degree of utilisation of modern, centralised wastewater-treatment plants with denitrification ($T_{\text{Plant deni}}$) are country-specific values.

Indirect emissions

In keeping with the method proposed by the 2006 IPCC Guidelines, first the total annual quantity of nitrogen in wastewater effluent is determined. For countries with modern, centralised wastewater treatment plants, and taking N_{WWT} into account, this is to be determined as follows:

$$N_{\text{Effluent}} = (P \times \text{Protein} \times F_{\text{NPR}} \times F_{\text{Non-con}} \times F_{\text{Ind-comm}}) - N_{\text{Sludge}} - N_{\text{WWT}}$$

(2006 IPCC Guidelines, Vol. 5, Chapter 6.3.1.3., Equation: 6.8)

Where

N_{Effluent} = Total annual quantity of nitrogen in wastewater effluent, in kg N/year

P	=	Population
Protein	=	Per-capital protein consumption, in kg/person/year
F _{NPR}	=	Nitrogen fraction in protein; default = 0.16 kg N / kg protein
F _{NON-CON}	=	Fraction of non-consumed protein in wastewater; default = 1.1
F _{IND-COM}	=	Fraction of protein of industrial / commercial origin that is managed via wastewater; default = 1.25
N _{SLUDGE}	=	Nitrogen removed with sludge; default = 0 in kg N / year
N _{WWT}	=	Nitrogen fraction in the nitrous oxide occurring in connection with wastewater treatment
	=	N ₂ O _{PLANTS} x 28/44 in kg N/year
28/44	=	Factor for conversion N ₂ O to N ₂

According to experts, this formula is erroneous, however, and ineffective by itself, since it does not take account of the N-removal performance of wastewater treatment plants' denitrification phases. For the years 2006-2014, data on the average N content of the wastewater flowing into (N_{influent}) and out of (N_{effluent}) German wastewater treatment plants are available (DWA, 2007-2015). From those data, biological wastewater-treatment plants in Germany were determined to have an average N-removal efficiency of 81.4 % in the years mentioned. To obtain realistic results, one must thus adapt the above equation. In the interest of data comparability, T_{Plant deni} was determined, via selection of wastewater treatment plants with denitrification. The factors to be taken into account include a) the removal efficiency of wastewater treatment plants with denitrification¹⁷⁶ and b) the N load of all plants without biological wastewater treatment. The factor N_{WWT} does not suffice for this purpose, since it includes only the nitrogen fraction in the nitrous oxide that is produced (direct emissions); it does not include the N fraction in the molecular nitrogen produced via denitrification. The factor N_{WWT} is thus removed from the equation. In addition, the factor N_{SLUDGE} is also removed, since N_{SLUDGE} value used by Germany is equal to 0, and since nitrogen removal from the sludge is already taken into account via F_{ELIMINATION}:

$$N_{\text{EFFLUENT}} = (P \times \text{Protein} \times F_{\text{NPR}} \times F_{\text{NON-CON}} \times F_{\text{IND-COM}})$$

That formula applies for plants without nitrogen removal.

For calculation of the N load (N_{Effluent with}) in the effluent of plants with nitrogen removal, a removal factor F_{Removal} is introduced. The formula is thus as follows:

$$N_{\text{EFFLUENT with}} = (P \times \text{Protein} \times F_{\text{NPR}} \times F_{\text{NON-CON}} \times F_{\text{IND-COM}}) \times (1 - F_{\text{ELIMINATION}}) \times T_{\text{PLANT Deni}}$$

Where

F_{ELIMINATION} = Factor for nitrogen-elimination performance in wastewater treatment facilities = N_{effluent} / N_{influent} 81.4 / 100 (DWA 2007-20015)

T_{PLANT Deni} = Degree of utilisation of modern centralised wastewater-treatment plants with denitrification, %/100 (i.e. with respect to the entire wastewater load in Germany)

N_{EFFLUENT with} = N load in the effluent of wastewater treatment plants

N_{EFFLUENT without} = N load in the effluent of wastewater treatment plants

The N load (N_{Effluent without}) in the effluent of wastewater treatment plants without biological wastewater treatment is calculated as follows:

¹⁷⁶ Only installations with denitrification are considered, since nitrous oxide formation is more likely in such installations.

In its surveys, DWA does not break the data down in accordance with individual treatment stages.

$$N_{\text{EFFLUENT without}} = (P \times \text{Protein} \times F_{\text{NPR}} \times F_{\text{NON-CON}} \times F_{\text{IND-COM}}) \times (1 - T_{\text{PLANT Deni.}})$$

Then, the nitrogen loads in the effluent of wastewater treatment plants with denitrification and in the effluent of wastewater treatment plants without biological wastewater treatment are added, to yield the total N load in the effluent of all wastewater treatment plants:

$$\begin{aligned} N_{\text{Effluent}} &= N_{\text{Effluent with}} + N_{\text{Effluent without}} \\ &= (P \times \text{Protein} \times F_{\text{NPR}} \times F_{\text{NON-CON}} \times F_{\text{IND-COM}}) \times (1 - F_{\text{ELIMINATION}}) \times T_{\text{PLANT Deni.}} + \\ &\quad (P \times \text{Protein} \times F_{\text{NPR}} \times F_{\text{NON-CON}} \times F_{\text{IND-COM}}) \times (1 - T_{\text{PLANT Deni.}}) \end{aligned}$$

The result obtained with the above-described procedure has been verified via comparison with alternative data (DWA, 2007-2014, 2007-2015; UBA, 2014), and it thus seems to be correct (cf. Chapter 7.5.1.3.6).

The IPCC default values are used for the emission factor for nitrous oxide, the nitrogen fraction in protein, the fraction for non-consumed protein ($F_{\text{Non-con}}$) and for industrially and commercially discharged protein ($F_{\text{Ind-comm}}$). Country-specific values are used for the average per-capita protein intake and the population size (number of persons). The value for non-consumed protein ($F_{\text{NON-CON}}$) is so low, because waste disposal via wastewater (garbage disposal units) is not widespread in Germany. 177.

As of this year, we are using only the data in the FAOSTAT database (FAO, 2015) for determination of the average protein intake per person and day throughout the entire period covered by the report. The FAOSTAT data differ only marginally from the data in the Statistical Yearbook.

The nitrous oxide emissions are determined as follows, in keeping with the IPCC method:

$$N_2O_{\text{Emissions}} = N_{\text{Effluent}} \times EF_{\text{Effluent}} \times 44/28$$

Where

$N_2O_{\text{Emissions}}$ = N_2O emissions, in kg N_2O /year

N_{Effluent} = Nitrogen discharged into the aquatic environment, in kg N/year

EF_{Effluent} = Emission factor for N_2O emissions released into wastewater, in kg N_2O -N/kg N (default = 0.005)

44/28 = Factor for conversion of N_2O -N to N_2O

Due to the great many plants concerned, calculation with higher-Tier methods is not feasible. What is more, the Federal Statistical Office does not list the substance flows of wastewater-treatment plants separately.

7.5.1.3.3 Uncertainties and time-series consistency (5.D.1 Nitrous oxide emissions from municipal wastewater)

The following uncertainties are used (all are expert estimates):

¹⁷⁷ While Germany does not prohibit garbage disposal units at the national level, some municipalities' wastewater ordinances prohibit addition of waste, including ground or shredded waste, to wastewater.
<https://de.wikipedia.org/wiki/K%C3%BCchenabfallzerkleinerer> 28 July 2016

P (population)	=	± 5 %
T _{Plant deni} (wastewater treatment plants with denitrification)	=	± 5 %
F _{Ind-comm}	=	± 25 %
Protein	=	± 15 %

The activity data are based on data of the Federal Statistical Office. The population of Germany is determined on an annual basis, while the quantity of wastewater treated in wastewater-treatment facilities with denitrification is determined every three years (without determination of pertinent uncertainties). The results of the latter surveys may be considered very precise, since the surveys are exhaustive. The figures for the years prior to 1998 have been extrapolated. They are plausible, since inclusion of nitrogen removal processes in wastewater treatment began to be expanded in Germany as of the beginning of the 1990s. The figures for the years after 2013 have been carried forward from earlier years. All other lacking data have been linearly interpolated.

The uncertainties for the EF_{Plant} have been taken from Table 6.11 (2006 IPCC Guidelines, Vol. 5, Chapter 6.3.3); they are - 37.5 % and + 150 %. Experts consider those values plausible.

The uncertainty for the average N-removal efficiency of German wastewater-treatment plants is estimated at ± 5 %.

The activity data for 1990 – 2011 have been taken from the FAOSTAT database. As described in Chapter 7.5.1.3.2, lacking values were obtained via extrapolation or calculation of the pertinent arithmetic mean.

Calculations were based on the average daily protein requirements listed by the FAO database, to ensure that the time series is consistent and to prevent any need for extrapolation of individual values. An uncertainty of ± 20 % (expert estimate) is assumed.

The average nitrogen fraction in protein (F_{NPR}) is 16 % ± 1%. In obtaining this value, it was assumed that Bovine serum albumin is the standard protein. In light solely of the aforementioned standard deviation (± 1%), the uncertainty would be about ± 6 % (with respect to the 16% fraction). It is estimated to total ± 7 %, however, since the relevant wastewater contains a broader spectrum of protein (expert estimate).

In addition, the following uncertainties have also been used (all are expert estimates):

$$F_{NON-CON} = \pm 30 \%$$

$$F_{IND-COM} = \pm 25 \%$$

The uncertainties for EF_{Effluent} have been taken from Table 6.11 (2006 IPCC Guidelines, Vol. 5, Chapter 6.3.3).

7.5.1.3.4 Category-specific quality assurance / control and verification (5.D.1 Nitrous oxide from municipal wastewater)

General and category specific quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The formula adapted via *F_{ELIMINATION}*, for determination of the N effluent into water bodies, was verified with the average values, as published in the comparison of the performance of municipal wastewater treatment plants (Leistungsvergleich Kommunalen Kläranlagen), for N discharges into water bodies (DWA, 2007-2015). At present, relevant results are available only for the years 2006-2014. The calculation and the survey were carried out independently of each other. Table 8 presents the results of calculations of N_{Effluent} (indirect emissions) using the IPCC 2006 method,

the modified IPCC method (with the nitrogen-removal factor $F_{\text{Elimination}}$), the approach described in the Federal Government's report to the EU pursuant to 91/271/EEC (UBA 2016) and the results using the measurements obtained by the German Association for Water, Wastewater and Waste (DWA). It also presents a consideration of the DWA data in conjunction with use of the activity data of the Federal Statistical Office.

Table 407: Comparison of the results for N_{EFFLUENT} (indirect emissions) obtained with the 2006 IPCC Guidelines, with the modified IPCC 2006 method, DWA measurements and (UBA, 2014); (kt N/year)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
With the IPCC 2006 method										
N_{EFFLUENT}	654.2	653.4	671.4	669.8	676	664.2	665.8	667.8	671.4	680.3
With the modified IPCC 2006 method										
N_{EFFLUENT}	137.4	135.4	138.4	137.4	137.9	135.5	135.9	136.3	137	142.5
Effluent content determined on the basis of DWA data										
$N_{\text{EFFLUENT}}[1]$	71.5	86.1	86.5	82.7	87	77.9	79.1	81.7	72.8	72.3
$N_{\text{EFFLUENT}}[2]$	80.8	90.6	95.4	95.1	92.9	90.9	89.9	89.9	88	95.7
On the basis of (UBA 2016)										
N_{EFFLUENT}			87.3		82.6		83.1		75.1	

The modified method yields significantly lower values for the N load in the effluent (N_{Effluent}) than does the IPCC method. The alternatively calculated results are confirmed in that they are of the same order of magnitude as the values measured by the DWA. In addition, the average N concentrations in the effluent, as determined by the DWA, were combined with the Federal Statistical Office's data on annual wastewater quantities, and the results showed good agreement. The data agree very well with those in the Federal Government's report to the EU pursuant to 91/271/EEC (UBA 2015). The rather considerable discrepancy seen with the adapted IPCC method can be ascribed to the IPCC default emission factor used. In light of this verification, it must be considered too high. Nonetheless, in spite of its probable overestimation of the real N load in the effluent, and of the related possible N_2O emissions, it lies within the range allowed by the uncertainties.

Alternative data sources for the average protein intake per person and day include:

- The 1991 food table for practical applications (Senser & Scherz, 1991) gives an average protein intake of 94 g/inhabitant and day.
- The nutrition report of the German Nutrition Association (Deutsche Gesellschaft für Ernährung) (DGE, 2008)¹⁷⁸ used estimated food-consumption data for 2005/2006 to estimate average daily protein intake. From that data, an average value of about 79 g protein / person and day¹⁷⁹ was derived.

As of this year, the FAOSTAT database is being used for determination of (FAO, 2015) N_2O emissions in wastewater, since it contains a consistent time series. It is internationally comparable, and it is regularly updated. In addition, the FAO has declared that the previous FAO publications will be replaced. The Federal Environment Agency has no information to the effect that the country-specific values in the food table and in the 2008 nutrition report are more precise or enjoy greater national acceptance. In addition, many countries use the FAO database; as a result, the emissions-determination process used by Germany is internationally comparable. A European comparison shows that the daily protein intake assumed for Germany lies within the middle of the overall range. The FAO data do not take account of the protein fractions that are

¹⁷⁸ The nutrition report is published every four years.

¹⁷⁹ This value was obtained with the help of the rough estimate that each population group in Germany consists of 50 % men (90.8 g/day) and 50% women (66.7 g/day).

disposed of upon use (FNON – CON) and that are disposed of instead of being eaten. The WWF (WWF, 2015) assumes consumption waste of up to 16 % for meat, eggs and milk.

The protein-consumption data used by the FAO are derived on the basis of production data (supplied by the Federal Statistical Office) and trade data (EUROSTAT) (FAO 2016). The relevant work considers and studies five different, successive losses along the value chain, including harvest, post-harvest, process, distribution and consumption losses (WWF, 2015).

7.5.1.3.5 Category-specific recalculations (5.D.1 Nitrous oxide from municipal wastewater)

Changes with respect to the previous year have been made to take account of updated figures for the share of wastewater treatment plants with denitrification stages, and to take account of use of FAO statistical data on protein consumption. While the adjustment of Tplant-biol has only very minor impacts at the end of the time series (2011-2015), calculations with the new FAO data yield extensive differences throughout the entire period from 1990 through 2015. It emerges that the base-year emissions are somewhat lower than they were in the last report, while the figures for more-current years are slightly higher. As a result, the trend is less pronounced than had previously been assumed.

7.5.1.3.6 Planned improvements, category-specific (5.D.1 Nitrous oxide from municipal wastewater)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

7.5.2 Industrial wastewater treatment (5.D.2)

7.5.2.1.1 Category description (5.D.2)

Gas	Method used	Source for the activity data	Emission factors used
CO ₂	NA	NA	NA
CH ₄	CS	NS	CS
N ₂ O	CS	NS	CS

The emissions from industrial wastewater treatment are a key category only as a result of their aggregation with municipal wastewater treatment (5.D.1).

The CH₄ emissions reported here relate only, pursuant to IPCC 2006, to that wastewater fraction that is treated in industrial wastewater treatment facilities. The industrial wastewater fraction that is sent to municipal facilities is included under 5.D.1 (municipal wastewater treatment), via an added share of 25 percent.

The foundations for calculation of CH₄ emissions from industrial wastewater treatment are described in detail in the underlying research report (AUSTERMANN-HAUN 2014).

In Germany, the biological stage of industrial wastewater treatment is partly aerobic and partly anaerobic. In aerobic treatment of industrial wastewater, as in aerobic treatment of municipal wastewater, no methane emissions occur. On the other hand, digester gas, consisting largely of CO₂ and CH₄, occurs when organic substances in wastewater are broken down anaerobically.

In Germany today, industrial wastewater is treated anaerobically in many sectors. Such treatment is especially prevalent in the food industry. Data on the relevant plant equipment and systems used in this area are not systematically collected in Germany. On the other hand, an evaluation of (Austermann-Haun & Witte) (2014) shows that 184 anaerobically operating facilities are

currently in service in Germany, at a total of 136 plants. The plants involved cover a total of 26 industrial sectors, throughout a spectrum that includes such diverse areas as vegetable processing, sugar production, paper production and production of cleansers. The largest COD loads that are treated anaerobically occur in pulp and paper production, sugar production and the breweries sector.

The systems used for anaerobic industrial wastewater treatment especially include sludge-bed reactors (upflow anaerobic sludge blanket (UASB) and expanded granular sludge bed (EGSB) reactors). Anaerobic activated sludge processes are also used. All relevant facilities are equipped with gas flares with automatic ignition, as required by law. Only one plant, a relatively small sugar plant, treats its wastewater in anaerobic ponds.

Almost all of the resulting digester gas is collected and combusted either to provide process heat (where it replaces town gas) or to generate electricity. Use for energy recovery is reported under CRF 1.A.1. The sewage-gas-quantity data published by the Federal Statistical Office include both the digester gas that occurs in this category and the digester gas produced by municipal installations.

The only CH₄ emissions that are relevant for Germany, therefore, are those that occur via unintended releases. Such unintended releases can include:

- CH₄ in the liquid-phase effluent of methane reactors (the relevant quantities are temperature-dependent),
- Losses from gas-storage systems,
- Losses via sludge removed from systems for storage of anaerobically granulated sludge,
- Gas that forms in non-aerated pond systems,
- Gas that forms in acidification reactors,
- Gas that forms in wastewater ponds of the sugar industry,
- Losses via leaks/malfunctions/flaring losses.

All of the gas flares used with relevant gas-collection systems are emergency/shutdown flares; i.e. they also come into play when systems (such as combined heat-and-power (CHP) generating systems) have to be shut down for maintenance purposes. Such gas flares are designed to be able, in emergencies, to burn all of the gas being collected. The gas quantities routed through gas flares are not recorded. The flares are used as emergency flares, meaning that the quantities of combusted gas in this area of application are near zero. Gas flares are equipped with automatic ignition systems that assure reliable burning of collected gas during disruptions of normal system operation. During the start-up and shut-down phases of digesters, the methane that is produced may be burned via gas flares, if methane concentrations are too low for other use. In seasonally operating plants, this occurs at the beginning and end of the operational season. The methane emissions from gas flares are assessed by experts as "zero".

According to experts (AUSTERMANN-HAUN 2014), in the area of anaerobic industrial wastewater treatment, two malfunctions involving gas losses have occurred in Germany in recent decades as a release of leakage from methane reactors' gas-containment vessels. As a result of the odour emissions that accompany them, such leaks are quickly discovered, located and eliminated. In 1992, odour emissions at a wastewater treatment plant led to the discovery of a leak in a methane reactor's glass-fibre reinforced plastic (GRP) roof. A second case of leakage occurred in 2013, in the steel roof of a methane reactor. As a result of the small number of such malfunctions (2 in a total of 30 years of operation of a pool of methane reactors that now numbers 184), the methane emissions from malfunctions involving leakage are classified as negligible.

Other types of malfunctions – for example, malfunctions that inhibit the methane bacteria – do not result in any methane emissions.

7.5.2.1.2 Methodological issues (5.D.2)

The calculation method selected is in keeping with Tier 2.

Annual COD loads were calculated for 20 of the 26 relevant industrial sectors, using the formula below (2006 IPCC Guidelines, Vol. 5, Chapter 6.2.3.3, Equation 6.6). To that end, the applicable production quantities for 2013, and the applicable specific wastewater production as given in federal statistics (FEDERAL STATISTICAL OFFICE (STATISTISCHES BUNDESAMT), Fachserie 4 Reihe 3.1), were determined for each industrial sector and then combined with the relevant specific COD concentrations in the raw wastewater given in the research report. For 6 industrial sectors, it was not possible to calculate the annual COD load, because the literature provided no data on the sectors' specific wastewater production.

$$TOW_i = P_i \cdot W_i \cdot COD_i$$

including

TOW_i	= Total organically degradable material in the wastewater of industrial sector i (annual COD load), in kg COD / year
i	= Industrial sector
P_i	= Total annual production in industrial sector i, in t / year
W_i	= Specific wastewater production in industrial sector i, in m ³ /t _{product}
COD_i	= Chemical oxygen demand (degradable organic components in industrial wastewater), in kg COD/m ³

Since it is good practice to calculate with country-specific data, and since country-specific data are available for Germany, we use our own method for calculation of total methane emissions, rather than the IPCC method (2006 IPCC Guidelines, Vol. 5, Chapter 6.2.3.1, Equation 6.4). The total methane emissions from industrial wastewater treatment are calculated with the following formula:

$$CH_4 \text{ Emissions} = \sum_i [(TOW_i \cdot \omega_{ANR,i} \cdot \omega_{CSB,i} \cdot EF_{CH_4, \text{gelöst},i}) + E_{CH_4,GS,i} + E_{CH_4,PS,i} + E_{CH_4,AT,i}]$$

where:

$CH_4 \text{ Emissions}$	= CH ₄ emissions in the inventory year, in kg CH ₄ / year
TOW_i	= Total organically degradable material in the wastewater of industrial sector i (annual COD load), in kg COD / year
i	= Industrial sector
$\omega_{ANR,i}$	= Percentage share of anaerobic treatment, for industrial sector i
$\omega_{CSB,i}$	= Degree of COD degradation in anaerobic treatment, for industrial sector i
$EF_{CH_4, \text{gelöst},i}$	= Emission factor for CH ₄ dissolved in water, in industrial sector i, in kg CH ₄ / kg COD _{removed}
$E_{CH_4,GS,i}$	= CH ₄ emissions from gas-storage systems in industrial sector i, in kg CH ₄ / year
$E_{CH_4,PS,i}$	= CH ₄ emissions from systems for storage of anaerobically granulated sludge in industrial sector i, in kg CH ₄ / year
$E_{CH_4,AT,i}$	= CH ₄ emissions from wastewater ponds in industrial sector i, in kg CH ₄ / year

It is not usefully feasible to compare the results with results obtained with the method described in IPCC 2006, since only the approach chosen is feasible in light of the technical realities (cf. "Category description") and the prevailing data situation.

The specific emission factors $EF_{CH_4, gelöst, i}$ for methane dissolved in the water phase have been calculated on the basis of Henry's law, and they are listed in the research report.

The emissions from gas-storage systems are based on the permissible rates of leakage from such storage systems. On this basis, the CH₄ emissions per gas-storage system have been calculated as 20 m³ CH₄ / year.

The emissions from systems for storage of anaerobically granulated sludge have been set at 0 kg CH_{4b} / year, since the emissions from this area are considered to be negligible (expert assessment). Similarly, the CH₄ emissions from malfunctions have been set at 0 kg CH₄ / year.

The methane emissions from acidification reactors are negligible, as a result of such reactors' unfavourable conditions for methane formation, and have been set at 0 kg CH₄ / year.

The emission factor for emissions from wastewater ponds has been determined in keeping with Formula 6.5 and Table 6.8 in (2006 IPCC Guidelines, Vol. 5, Chapter 6). For Bo, the IPCC default value has been used; for the MCF, 0.2 has been used, for a pond depth of no more than 2 metres.

The time series for the period as of 1990 was obtained on the basis of trends in anaerobic industrial wastewater treatment – especially with regard to capacities for treatment of COD loads. The entire time series for period from 1990 to 2013 has been published in the 2015 NIR. Until the next updating of the database, the data as of 2014 will be carried forward with growth of 2 percent per year, under the assumption that moderate additions of anaerobically operating facilities will take place (expert assessment). All in all, with the formula given above, methane emissions of **1.72 Gg CH₄ / year** from industrial wastewater treatment have been calculated **for the year 2015**. The following table provides an overview of the time series. The percent values given show the changes in comparison to the base year 2013. The table also shows the annual COD loads upon which the calculation is based. The calculations produce an implied emission factor of 1.86 kg CH₄/t COD.

Table 408: Time series for CH₄ emissions from industrial wastewater treatment

Year	Anaerobically treated annual COD loads [t/a]	Percentage with respect to the CH ₄ emissions of 2013	CH ₄ emissions [kg CH ₄ / year]
1990	198,477	22 %	370,087
1995	332,950	37 %	620,829
2000	493,357	56 %	919,931
2005	744,371	84 %	1,387,979
2010	854,374	96 %	1,593,094
2011	881,360	99 %	1,643,412
2012	886,829	100 %	1,653,610
2013	888,757	100 %	1,657,206
2014	906,532	102 %	1,690,350
2015	924,307	104 %	1,723,494

The TOW for the individually considered sub-sectors is documented in AUSTERMANN-HAUN 2014. For the chemical industry, the food industry, and the paper and pulp industry, the total TOW was determined on the basis of an average COD concentration and the absolute wastewater quantity (Table 409). On the other hand, the total TOW is not important with regard to the calculation of CH₄ emissions since, as described above, those emission were calculated using a country-specific method. It was not possible to determine average COD quantities for other sectors. In addition to the sectors previously included, the 2006 IPCC Guidelines also provide default values for "Organic Chemicals," "Plastic & Resins" and "Soap & Detergents." Under the heading "Chemische Erzeugnisse" ("chemical products"), wastewater statistics combine products with WZ 2008 Code 20. This group include organic chemistry (WZ 2008 Code 20.14), plastics and

resins (Code 20.1) and soap and cleansers (Code 20.4). Code 22 lists end products – plastic and rubber products. In this regard, it differs from Code 20.4, in which precursors are reported. The default value reported in IPCC 2006 (2006 IPCC Guidelines, Vol. 5, Chapter 6) refers to precursors. The reporting to date thus already includes the required additional product categories. IPCC 2006 notes that the default values have to be used with care, since they are industry-specific, process-specific and country-specific.

Table 409: Calculation of the TOW for 2015, direct discharges

Industrial sector	Average COD [kg/m ³]	Wastewater quantity (2015) [m ³]	TOW (2015) [t COD/year]
Chemical industry	3 ¹⁾	266,000,000	797,000
Food industry	3 ²⁾	64,000,000	193,000
Paper and pulp industry	2 ²⁾	204,000,000	407,000

1) Expert assessment, based on 2006 IPCC Guidelines, Vol. 5, Chapter 6, Table 6.9

2) Expert assessment

7.5.2.1.3 Uncertainties and time-series consistency (5.D.2)

Experts put the uncertainty for the total methane emissions at $\pm 50\%$. The reasons for this include a lack of data for some industrial sectors, differences between methane reactors' operational pressures, differences between the membranes used in gas-storage systems and the fact that it is not known how many gas-storage systems are in service.

7.5.2.1.4 Category-specific quality assurance / control and verification (5.D.2)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The data cannot be cross-checked against ETS data, since the described installations are not subject to emissions trading requirements. To this end, countries with relevant parameters (climate, installed equipment) that are similar to those in Germany were selected.

In Austria, methane emissions from industrial wastewater treatment are considered negligible, since the resulting methane is collected and either used for energy generation or burned in flares.

In the Netherlands, methane emissions are reported on the basis of the IPCC default values, in conjunction with country-specific data on TOW and with other specific adjustments. No current information about the COD quantities treated in industrial wastewater treatment plants is available. Here as well, therefore, data availability is the limiting factor. The data cannot be compared directly.

In Denmark, no distinction is made between industrial and municipal installations. The method is in keeping with the IPCC Guidelines.

Further verification is not feasible, since no additional specific data on this category are available for Germany.

7.5.2.1.5 Source-specific recalculations (5.D.2)

Recalculations were carried out to take account of more-recent statistical data for TOW, for the years 2011-2014.

Table 410: Results of recalculations for TOW from industrial wastewater treatment. Chemical industry

Year	TOW [Gg]	TOW [Gg], previous report	Difference from previous reporting
2011	434	448	+3%
2012	421	448	+6%
2013	407	448	+10%
2014	407	448	+10%

Table 411: Results of recalculations for TOW from industrial wastewater treatment. Paper and cardboard

Year	TOW [Gg]	TOW [Gg], previous report	Difference from previous reporting
2011	830	846	-2%
2012	813	846	-4%
2013	797	846	-6%
2014	797	846	-6%

Table 412: Results of recalculations for TOW from industrial wastewater treatment. Food industry

Year	TOW [Gg]	TOW [Gg], previous report	Difference from previous reporting
2011	188	186	-1%
2012	191	186	-2%
2013	193	186	-4%
2014	193	186	-4%

7.5.2.1.6 Planned improvements (category-specific) (5.D.2)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

7.5.2.2 Nitrous oxide emissions from industrial wastewater treatment (5.D.2)

7.5.2.2.1 Category description (5.D.2 N₂O, industrial)

Nitrous oxide emissions can occur as a by-product of biological wastewater treatment with added nitrogen elimination. They occur mainly in connection with denitrification, although they are presumed to occur also in connection with nitrification. (Cf. IPPC 2006, Vol. 5, Chapter 6.1, page 6.8.) Presumably, in such treatment, reduction from N₂O to N₂ is hindered by various influencing factors, such as free oxygen, high concentrations of nitrite, ammonium and/or sulphides, and such hindrance leads to the formation of N₂O (UBA 2011b page 2-12 ff).

The majority of industrial wastewater is treated in municipal wastewater-treatment plants. Consequently, that majority is covered in 5.D.1 (as an added share of 25 percent). For this reason, only industrial direct discharges are considered under 5.D.2.

7.5.2.2.2 Methodological issues (5.D.2 N₂O, industrial)

The 2006 IPCC Guidelines do not mandate, or provide regulations for, calculation of N₂O emissions from industrial sectors (Vol. 5, Chapter 6.3.4). Neither a relevant decision tree nor any higher-Tier calculation methods are available. The calculation methods presented in the following are thus seen in the context of the decision tree and the Tier classification for CH₄ (industrial). The approach used here is thus in keeping with a Tier 2 calculation method.

For determination of nitrous oxide emissions from industrial wastewater treatment, a research project collected data on product-specific wastewater production, on nitrogen concentrations and on COD (chemical oxygen demand) for all industrial areas and then, on the basis of annual

production figures, determined annual nitrogen loads. The underlying data on nitrogen loads have been obtained from information sheets of the DWA (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V.). They reflect the current, recognised state of scientific research. The relevant procedure is set forth in detail in UBA 2011b. A COD:N ratio < 40 served as the threshold criterion for assuming that the wastewater of a given sector had a nitrogen surplus that would be able to cause nitrous oxide emissions in subsequent biological wastewater treatment. A possibility that nitrous oxide could be emitted in biological wastewater treatment can be assumed only if the wastewater contains so much nitrogen that, after conversion into biomass, a residual amount of nitrogen remains that has to be removed via biological nitrogen elimination. The value used has been verified by the document ATV-DVKK-Arbeitsblatt A 131 which, as a simplification, considers the nitrogen load to amount to 2 to 2.5 % of the COD concentration (2.5 % is equivalent to a COD:N ratio of 40:1). The data compilation made it possible to identify the 6 industrial sectors that are most important in this regard. Together, those sectors account for some 75 % of the nitrogen load from industrial wastewater treatment (UBA 2011b). These include:

- Slaughterhouse and meat-processing operations,
- Milk processing,
- Processing of animal by-products,
- Beer production,
- Sugar production,
- Wheat starch production.

Data for the textile industry (7.5 % of the total nitrogen load) and for potato processing (2.6 % of the total nitrogen load) have not been included, since the wastewater from those areas has a COD:N ratio greater than 40 and thus, according to the findings of the research report, does not lead to formation of nitrous oxide. Production of potato starch is not considered relevant with regard to formation of nitrous oxide – that area accounts for less than 0.4 % of the total nitrogen load in wastewater. The remaining some 20 % of the total nitrogen load are spread over many individual sectors with unclear data situations (especially the ratio COD:N). Most of these sectors discharge their nitrogen loads into municipal wastewater-treatment plants, as indirect dischargers; this is covered by the emissions reporting under 5.D.1.

The annual nitrogen load that is discharged into raw wastewater is determined on the basis of the mean product-specific nitrogen loads for the 6 aforementioned industrial sectors, as well as of the pertinent annual production figures. In the process, it is assumed that, as a result of organisational and technical measures, such discharges were gradually reduced to the level seen in 2010, and that the nitrogen quantity discharged into wastewater in 1990 was 30 % higher than that level (expert estimate). For the years 1990 through 2000, annual nitrogen-load reductions of 2 percentage points are assumed, while one-percent reductions are assumed for the period 2000 through 2010 (expert estimate). As of 2010, the nitrogen load per cubic metre of wastewater is assumed to be constant (expert estimate).

The activity-data calculation was carried out as follows:

$$AD = \sum_B [NF_B \times PZ_B \times 10^{-6}]$$

Where

AD	= Total activity data [t N ₂ / year] = average N load in the inflow = N ₂
NF _B	= Average specific N load for the relevant sector [g N per unit]
PZ _B	= Production figures for the year 2010, for the relevant sector [number of units / year]
10 ⁻⁶	= Factor for conversion of g into t

The N₂O emission factor was determined, in the aforementioned research project, by analysing various data from the literature. From those data, a weighted mean value was formed. As a result, it was found that 1 % of the nitrogen load in a wastewater treatment plant is emitted as N₂O-N. In IPCC 2006, Vol. 5, Chapter 6.3.1.2, page 6.25, the default emission factor is given as 0.005 (0.0005 - 0.25) kg N₂O-N/kg N. The selected emission factor is thus larger, by a factor of two, than the default value. It still falls within the given range, however.

$$\text{N}_2\text{O} = \text{EF} \times \text{AD} \times 44/28$$

Where

N₂O = N₂O emissions in t N₂O / year

EF = Emission factor of 0.01 t N₂O-N / t N

44/28 = Stoichiometric factor for conversion of N₂O-N to N₂O

In addition, the shares of direct dischargers in the various individual sectors were determined and taken into account in the calculation.

The nitrous-oxide-formation rate in the sectors considered differs significantly from the corresponding formation rate in municipal wastewater-treatment plants; the rate for industrial wastewater-treatment plants is higher, by a factor of 100, than that for municipal plants. This is due to the above-described COD:N ratio and to the resulting better conditions, in industrial plants, for N₂O formation.

7.5.2.2.3 Uncertainties and time-series consistency (5.D.2 N₂O, industrial)

The uncertainties in the production figures originate in the relevant Federal statistics, and other statistics, all of which are based on exhaustive surveys. The uncertainties for the data are thus likely to be very low.

In the aforementioned research project, the N₂O emission factor was determined (by expert estimate) to have a very high uncertainty of - 99.9 % / + 300 %.

The mean specific nitrogen loads in the various relevant sectors have the uncertainties shown in (Table 413). The uncertainties were determined via expert estimates. In a conservative estimate, the uncertainty for the total nitrogen load (activity data) is assumed to be -50 % / +50 % (expert estimate)

Table 413: Uncertainties for the mean specific nitrogen loads for the 4 industrial sectors that are most important in this regard

Mean spec. N load of the industrial sector	Uncertainty, upper bound	Uncertainty, lower bound
Slaughtering of swine	40	40
Slaughtering of sheep	50	50
Slaughtering of goats	50	50
Slaughtering of cattle	40	40
Slaughtering of horses	50	50
Slaughtering of poultry	40	40
Meat processing	40	40
Processing of animal by-products	20	20
Milk processing	15	15
Beer production	30	30
Sugar production	30	30
Wheat-starch production	30	30

7.5.2.2.4 Category-specific quality assurance / control and verification (5.D.2, N₂O industrial)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

The data cannot be cross-checked against ETS data, since the described installations are not subject to emissions trading requirements. The described activity data have been obtained from the public statistics of the Federal Statistical Office, with the exception of the data for processing of animal by-products; those data have been taken from the report of the "Servicegesellschaft tierische Nebenprodukte". No further activity data of relevance for plausibility checking are available at present.

For purposes of plausibility checking, an attempt was made to consult comparable data from the inventory reports of other countries. To this end, countries with relevant parameters (climate, installed equipment) that are similar to those in Germany were selected.

In Austria, N₂O emissions from industrial wastewater treatment are considered only in the framework of co-treatment in municipal wastewater treatment facilities. It is assumed that N₂O emissions from industrial wastewater treatment amount to 30 % of the emissions from municipal wastewater treatment. In German emissions reporting, reporting on municipal wastewater treatment includes an added 25 % for co-treated industrial wastewater. On the other hand, specific emissions from industrial wastewater-treatment installations are additionally determined for the above-described sectors. While it is not possible to compare the two methods precisely, the difference between the two methods may be assumed to be small.

In the Netherlands, N₂O emissions from industrial wastewater treatment are classified as irrelevant in comparison to N₂O emissions from municipal wastewater treatment, and they are not reported. For this reason, no comparison was possible.

In Denmark, industrial wastewater treatment is not considered separately.

[UBA 2011b] lists a study, in the pertinent literature, on nitrous oxide emissions from wastewater treatment. The emission factors used in the present context have been derived from that study.

Further verification is not feasible, since no additional specific data on this category are available for Germany.

The approach used differs from the IPCC default approach. IPCC gives a value range of 0.0005 – 0.25 kg N₂O-N/kg –N (Default 0,005 kg N₂O-N/kg –N). In reporting, an emission factor of 0.01 kg N₂O-N/kg –N has been used.

7.5.2.2.5 Category-specific recalculations (5.D.2 N₂O, industrial)

Recalculations for the years 2013 and 2014 were carried out to take account of minor statistical corrections. Examples of the results of the recalculation are shown in Table 414.

Because the changes are so small, they are not presented here.

Table 414: Results of recalculations for N₂O from industrial wastewater treatment.

Year	N ₂ O emissions [kt]	N ₂ O emissions [kt], previous reporting	Difference from previous reporting
2013	0.084	0.084	+0%
2014	0.093	0.093	+0%

7.5.2.2.6 Planned improvements, category-specific (5.D.2 N₂O, industrial)

No improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

7.6 Other sectors (5.E)

At present, only emissions from mechanical-biological waste treatment are reported in category 5.E.

KC	Category	Activity	EM of	1990 (kt CO ₂ -e.)	(fraction)	2015 (kt CO ₂ -e.)	(fraction)	Trend 1990-2015
-/-	5.E. Other	Other	CH ₄	0.0	0.00%	4.3	0.00%	---
-/-	5.E. Other	Other	N ₂ O	0.0	0.00%	74.0	0.01%	---

The category 5.E – Other is not a key category.

7.6.1 Other areas – mechanical biological waste treatment (MBT) (5.E Other MBT)

7.6.1.1 Category description (5.E Other MBT)

Gas	Method used	Source for the activity data	Emission factors used
CH ₄	CS	NS	CS
N ₂ O	CS	NS	CS

As of 1 June 2005, direct landfilling of organic and biodegradable waste is no longer permitted in Germany. Miscellaneous settlement waste, and other waste of similar composition, may thus be landfilled only following pre-treatment. In addition to thermal waste-treatment processes (waste incineration), mechanical biological processes are increasingly being used for this purpose.

In Germany, a distinction is made between a) biological treatment of separately collected biowaste and b) biological treatment of residual waste. The purpose of biowaste treatment is to produce compost or digestates that can be used as fertiliser. The purpose of biological treatment of residual waste is to pre-treat organic waste so that it can be landfilled or used for energy generation. The emissions-control requirements pertaining to treatment of residual waste are stricter than those pertaining to biowaste treatment. For this reason, the emission factors for MBT are considerably lower than those for composting and digestion of biowaste. The relevant waste streams are separately recorded in federal statistics.

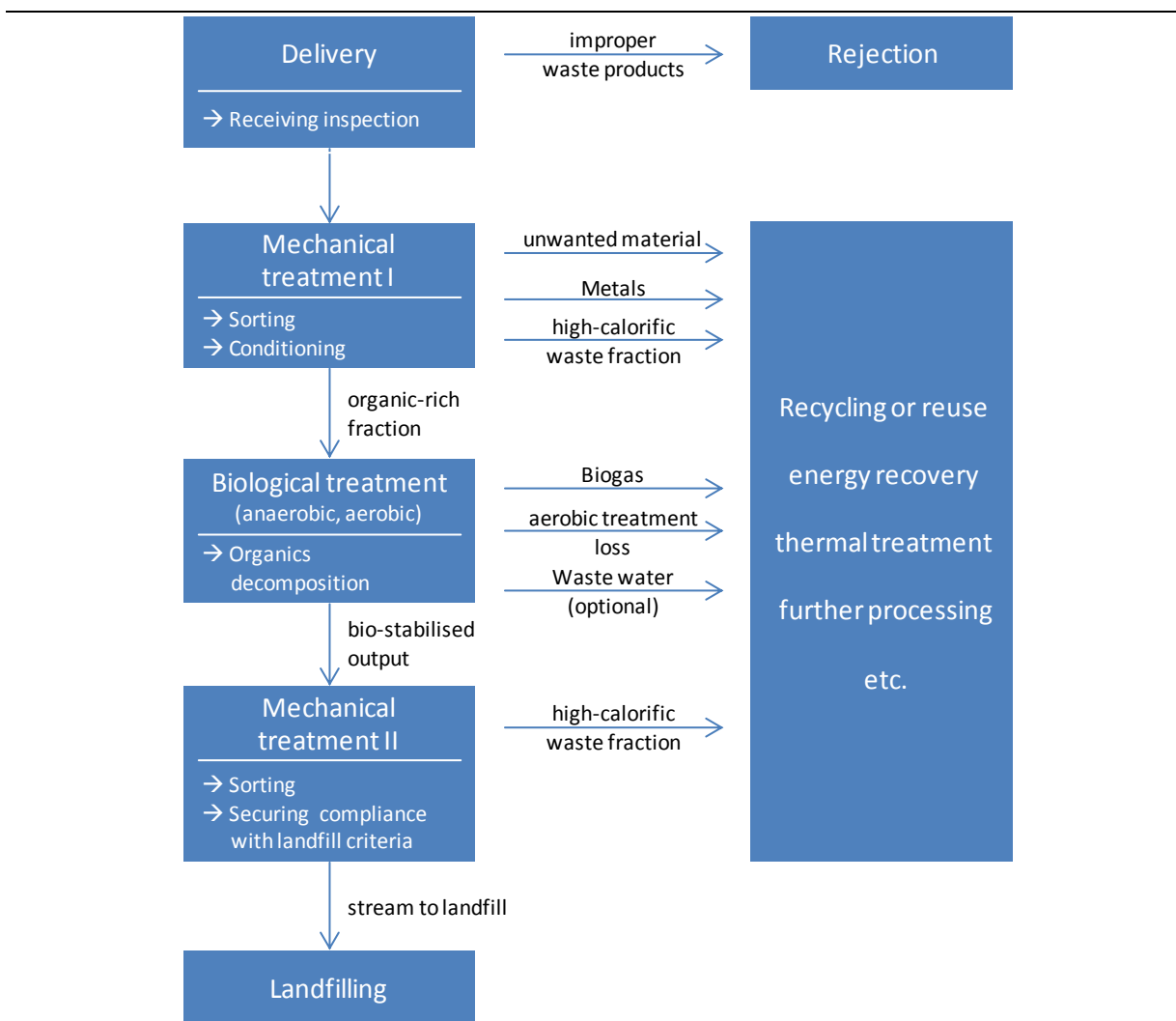
For MBT installations, the 30th Ordinance on the Execution of the Federal Immission Control Act (30. Verordnung zum Bundesimmissionsschutzgesetz – BImSchV) limits emissions loads for organic substances to 55 g per tonne of treated waste and, for N₂O, to 100 g per tonne of treated waste. These emissions limits have been used as emission factors. A number of reviews have found that all German installations reliably meet the emissions limits, and that many installations even remain considerably below them. The emissions limits and the emission factors are oriented to wet substance; waste quantities are recorded in those terms when delivered to the installations.

Since the 1990s, mechanical biological processes have been used extensively in Germany for managing miscellaneous waste. Initially, relevant plants had relatively simple designs and were not fitted for waste-gas collection and treatment. As processes have improved, however, closed systems, with "biofilters" for waste-gas scrubbing, have gradually become the norm. While the waste-gas-scrubbing processes used by such plants have significantly reduced the plants' odour emissions, they have not reduced greenhouse-gas emissions.

In 2005, when all landfilling of untreated waste was terminated, capacities for mechanical biological waste treatment were considerably expanded. Pursuant to the 30th Ordinance on the Execution of the Federal Immission Control Act (30th BImSchV), as of 1 March 2001, new plants for mechanical biological waste treatment must fulfil strict technical requirements and conform to demanding standards for maximum permitted emissions. The transitional provisions for old plants call for such plants to be retrofitted by no later than 1 March 2006.

Nearly all recently constructed new facilities were commissioned in 2005. Via expansions and operational upgrades, nearly all old facilities were brought into conformance with the 30th BImSchV by 2005. The transitional situation prevailing in 2005 can hardly be described with existing calculation models, since the relevant waste quantities cannot be correlated with the various relevant facility technologies. For the sake of simplicity, emissions through the year 2005 are calculated with the higher emission factors applying to the older-facility systems. For 2006, emissions are being calculated using the lower emission factors for the new facilities.

Currently, about 4.5 million Mg of waste are treated annually in mechanical biological waste treatment plants. This produces about 0.5 million Mg of treatment residues that have to be landfilled. In addition, about 2.5 million Mg of waste fractions with high calorific values are separated out and then used as substitute fuels in industrial combustion systems. The metals contained in the waste are separated out and used as secondary raw materials. The remainder of 1.5 million Mg consists of mass losses, in the treatment process, occurring via biodegradation of organic fractions and evaporation or drainage (wastewater) of the water in the waste.

Figure 78: Substance-flow scheme for mechanical biological waste treatment (MBT)¹⁸⁰

7.6.1.2 Methodological aspects (5.E Other MBT)

Since 1995, the Federal Statistical Office has regularly collected and published data on waste quantities managed in MBT systems. For the period 2007 through 2010, recent reports have used data from the research project "Facilities for mechanical and biological treatment of residual waste" ("Anlagen zur mechanisch-biologischen Restabfallbehandlung") (UBA, 2007). In connection with those earlier reports, there was doubt as to whether the data of the *Federal Statistical Office* cover all types of facilities that, in terms of their emissions behaviour, must be grouped with MBT facilities. As a conservative approach therefore, emissions calculation was carried out using the higher waste quantities determined by the research project. Via a number of discussions with the Federal Statistical Office, those doubts have since been eliminated. For the years 2007 through 2010, the 2014 NIR included a recalculation carried out with data of the Federal Statistical Office (STBA, Fachserie 19, Reihe 1 of 12 July 2012). For further reporting, the current data of the Federal Statistical Office are used.

¹⁸⁰ Source: VDI 3475 Blatt 3, Emissionsminderung - Anlagen zur mechanisch-biologischen Behandlung von Siedlungsabfällen, 2006-12 (amended)

Activity data

Since 1995, the Federal Statistical Office has regularly collected and published data on waste quantities managed in MBT systems.

Emission factors

In the 1990s, emissions from mechanical biological waste treatment were studied in a major collaborative research project supported by the Federal Ministry of Education and Research (BMBF). In a project carried out in 2003, the Institute for Energy and Environmental Research (IFEU) used the collaborative research project's findings to develop emission factors. In doing so, it differentiated between mechanical biological waste-treatment processes that were open (with no waste-gas collection and treatment) and processes that were closed (with waste-gas collection and treatment in biofilters). For methane, the emission factors for both types of processes were considered to be the same, since that substance is hardly broken down at all in biofilters. The N_2O emission factor for closed systems was considered to be higher than that for open systems, since N_2O also forms in biofilters, via oxidation of ammoniacal nitrogen.

Since June 2005, as a result of new legal provisions (30th BImSchV), all mechanical biological waste-treatment facilities are closed facilities, which have the more effective waste-gas-scrubbing processes. As of 2006, therefore, the emissions standards of the 30th BImSchV are used as the emission factors.

For open mechanical biological waste-treatment facilities, the following emission factors resulted:

$$\text{EF-}\text{N}_2\text{O} = 190 \text{ g N}_2\text{O/Mg waste}$$

$$\text{EF-CH}_4 = 150 \text{ g CH}_4/\text{Mg waste}$$

For closed mechanical biological waste-treatment facilities with biofilters, the same study obtained the following emission factors:

$$\text{EF-}\text{N}_2\text{O} = 375 \text{ g N}_2\text{O/Mg waste}$$

$$\text{EF-CH}_4 = 150 \text{ g CH}_4/\text{Mg waste}$$

For the period as of 2006, for inventory reports through the 2015 inventory report, the emissions-load limits set forth by the 30th BImSchV have been used as the applicable emission factors:

$$\text{EF-}\text{N}_2\text{O} = 100 \text{ g N}_2\text{O/Mg waste}$$

$$\text{EF-CH}_4 = 55 \text{ g CH}_4/\text{Mg waste}$$

Since in 2005 most MBT systems were equipped with waste-gas-treatment systems for minimising N_2O emissions, the emission factor for 2005 was estimated to be 169 g.

In 2013, in the framework of data collection for revision of the Best Available Techniques Reference Document "Waste Treatment", the Federal Environment Agency, in cooperation with the Arbeitsgemeinschaft stoffstromspezifische Abfallbehandlung ((ASA); Working group for substance-stream-specific waste treatment (association of MBT operators), collected emissions data on MBT. The emissions data for the parameters methane and N_2O proved to be considerably below the maximum permitted levels (Table 415).

Table 415: Emissions of MBT

Emissions parameter (exhaust gas)	Framework conditions (normal conditions)	Emissions range 16 installations	Maximum permitted levels 30. BImSchV
Total carbon (C _{ges.})	Half-hour averages	min. Median	0 – 1.53 1.2 – 11.6
	Concentration in mg/m ³ Continuous measurement	max.	1.5 – 38.7
	Daily averages	min.	0 – 2.68
	Concentration in mg/ m ³ Continuous measurement	Median max.	1.3 – 15.9 4.58 – 23.9
	Monthly averages	min.	2.3 – 21.8
	Load in g C _{total} /Mg waste Calculated from half-hour averages	Median max.	8.36 – 30.7 10.6 – 44.0
Nitrous oxide (N ₂ O)	Monthly averages	min.	0.01 – 33.3
	Load in g N ₂ O/Mg waste Calculated from half-hour averages	Median max.	1.54 – 59.0 6.23 – 108

The emissions data reported in the survey are representative for existing German installations and take all MBT types used in Germany into account. For the data survey, each installation reported its emissions ranges in terms of the highest and lowest measurements for the relevant parameters. Table 415 lists the installations with the lowest and highest emissions, along with the installation that fell into the middle of the emission range in each case (the median).

In the 2016 inventory, on the basis of this survey, the emission factors for years as of 2006 have been brought into line with the actual installation emissions. In the process, the maximum emissions loads of the median installations were taken as the emission factors.

$$EF\text{-}N_2O = 59.0 \text{ g } N_2O/\text{Mg waste}$$

$EF\text{-}CH_4 = 40.9 \text{ g } CH_4/\text{Mg waste}$ (30.7 g C_{total} correspond to 40.9 g CH₄). These national emission factors are used here for the first time, in the 2016 inventory, for purposes of inventory calculations. Recalculations were made for the period as of 2006.

7.6.1.3 Uncertainties and time-series consistency (5.E Other MBT)

The uncertainties for the mechanically-biologically treated waste quantities are considered to be very small (2 %) theoretically, since the relevant data were obtained via a complete-coverage survey, the reporting quality is good and operators have an interest in quality reporting. The uncertainties for the emission factors are high for the period before 2005. They depend on the type of facility/plant in question, on the type of process used at the relevant time and on the effectiveness of the biofilters used. The pertinent figures from the literature vary widely.

7.6.1.4 Category-specific quality assurance / control and verification (5.E Other MBT)

General quality control and a quality assurance have been carried out by source-category experts and the Single National Entity, according to the QSE-Handbook.

7.6.1.5 Category-specific recalculations (5.E Other MBT)

As the NIR 2016 was being prepared, statistical data on landfilled waste quantities were available only up to 2014. The quantities of waste treated were thus considered to have remained constant in 2013 and 2014. Therefore, the emissions of the year 2013 were recalculated with the current data published in Fachserie 19 Reihe 1 of 18 August 2016.

7.6.1.6 Planned improvements, category-specific (5.E Other MBT)

No further improvements are planned at present.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

8 Other (CRF Sector 6)

In keeping with recommendations made by the UNFCCC Expert Team in the 2016 In Country Review, no greenhouse gases are reported in CRF Category 6. Because certain relevant categories of the CRF Reporter do not support data entry, the non-greenhouse gases NO_x, CO and NH₃ are subsumed under CRF 6. The actual allocation involved is shown in the following table:

Table 416: Actual allocation of the non-greenhouse gases listed under CRF 6

Gas	Quantity in kt	Actual allocation
CO	0.15	1.B
NO _x	0.04	1.B
NH ₃	723.95	3

9 Indirect CO₂ & NO_x

Germany does not report any emissions for indirect NO_x, and for indirect CO₂ it reports only NMVOC emissions from solvent use. These NMVOC emissions are determined for information purposes. For details on how they are converted into indirect CO₂, we refer to the sections on non-energy-related products from fuels and solvents in Chapter 4.5.3, *Other, solvents – NMVOC*.

10 Recalculations and improvements

10.1 Explanation and justification of the recalculations

10.1.1 Greenhouse-gas inventory

10.1.1.1 General procedure

There are a number of other reasons, in addition to the need for corrections, why recalculations and improvements can be necessary:

- Additional data become available that make it possible to close gaps in the inventory.
- A data source has changed.
- A method used for a source category has been adapted to provisions of the *Good Practice Guidance*.
- A source category has become a key category, thus necessitating a change of methods.
- New country-specific calculation procedures need to be used.
- Recommendations and results provided by reviews have been implemented.

In good practice, when methods change, the entire relevant time series should be consistently recalculated with the same method, to ensure that the same method is used each year and old values can be suitably replaced. Where the same method cannot be used for all relevant years, one of the following four recalculation procedures (pursuant to the *IPCC Good Practice Guidance, 2000: Chapter 7*) should be used:

- *Overlap* – For this method, the data for calculation pursuant to the old and new methods should be jointly available for at least one year.
- *Surrogate method* – For this method, the EF and/or AD used to date should be highly similar to the newly available data.
- *Interpolation* – The data previously used for recalculation cover only a few years of the time series, and the lacking data are interpolated.
- *Trend extrapolation* – The data for the new method are not available for the beginning and/or end of the time series.

The QSE manual contains a guide to the above-outlined recalculation procedures. It also presents relevant examples.

10.1.1.2 Recalculations in the 2017 inventory, by source categories

This year's recalculations were necessitated by a range of methodological adjustments, some of which led to significant changes in the affected source categories, as well as by further improvements in details.

The inventories contain improvements in the following areas (unless otherwise indicated, in each case the changes refer to the entire pertinent time series):

Energy

For report year 2014, the most significant recalculations that result, with the appearance of the now *-final* 2014 Energy Balance, for emissions from combustion of natural gas (+3 million t CO₂) and hard coal (+2 million t). For these fuels, of which considerable shares are imported, retroactive statistical corrections are virtually unavoidable. The figures for lignite, on the other hand, show only slight changes. As a rule, correct data are normally available earlier for this fuel, which is obtained (extracted) solely domestically.

For petroleum, recalculations result throughout, with respect to the previous submission; they show a CO₂-emissions reduction of about 2.5 million t. They are due to a retroactive reduction of the net calorific value for diesel fuel, from 42,960 kJ/kg (through 2013) to 42,649 kJ/kg (as of 2014).

(and beyond, in some cases)

- Correction of the waste model (1.A)
- Revision of the EF(CO₂) for black liquor, refinery gas, natural gas & LP gas and hard-coal products (1.A, 1.D.1.b)
- Updating of the TREMOD MM (1.A.2.g vii, 1.A.4.a ii, b ii, c ii)
- Revision of EF(CH₄) pursuant to TREMOD (5.62) (1.A.3.c)
- Revision of statistics that previously were provisional; 2013 & 2014 (1.B)
- The density of crude oil has now been taken into account (1.B.2.a.iii)
- Inclusion of fugitive emissions from inland-waterway tankers (1.B.2.a.iii)
- Changes in the degree of usage and the efficiency of vapour recovery systems used at service stations; as of 2002 and 2011 (1.B.2.a.v)
- Carbon dioxide in natural gas now taken into account (1.B.2.b.iii-vi)
- Application of the split factor (1.B.2.b.iii)

Industrial processes & product use

- Correction of the activity data for the glass industry and for soda-ash inputs in the glass industry, for 2014 (2.A.3, 2.A.4.b)
- Correction of figures for carbon dioxide from carbon black production; as of 2005 (2.B.8)
- Reduction of NMVOC and indirect CO₂ from solvent use; as of 2005 (2.D.3)
- New information relative to the printing industry and to de-icing agents (2.D.3)
- Correction of HFC and PFC for commercial and industrial refrigeration, refrigerated vehicles, automobiles, room air-conditioners, chillers and heat pumps; as of 2003 (2.F.1)
- Correction of domestic consumption of HFC and PFC for foam production; 2014 (2.F.2)

Agriculture

- Updating of initial and final weights for dairy cows, heifers and male beef cattle (3.A, 3.B, 3.D)
- Updating of initial and final weights, weight-gain rates and the "piglets per sow" index for swine (3.A, 3.B, 3.D)
- Updating of the input value "total gross meat quantity obtained at slaughter" for broilers; as of 2013 (3.A, 3.B, 3.D)
- Updating of the activity data for manure digestion (3.B, 3.D)
- Updating of the N quantities in connection with application of manure and manure digestates, on the basis of updated input data (animal yield, relative shares of digestate types, use of gas-tight storage of digestates) (3.D)
- Updating of activity data for digestion of energy crops (fresh matter, and use of gas-tight storage of digestates) (3.D, 3.J, 3.s2).
- Updating of sewage-sludge quantities (3.D)
- Updating of the N quantities excreted on pasture, on the basis of updated animal yield data (3.D)
- Updating of crop residues for leeks; as of 2012 (3.D)
- Organic soils: Reduction of the N₂O emission factor for drained grassland (3.D)

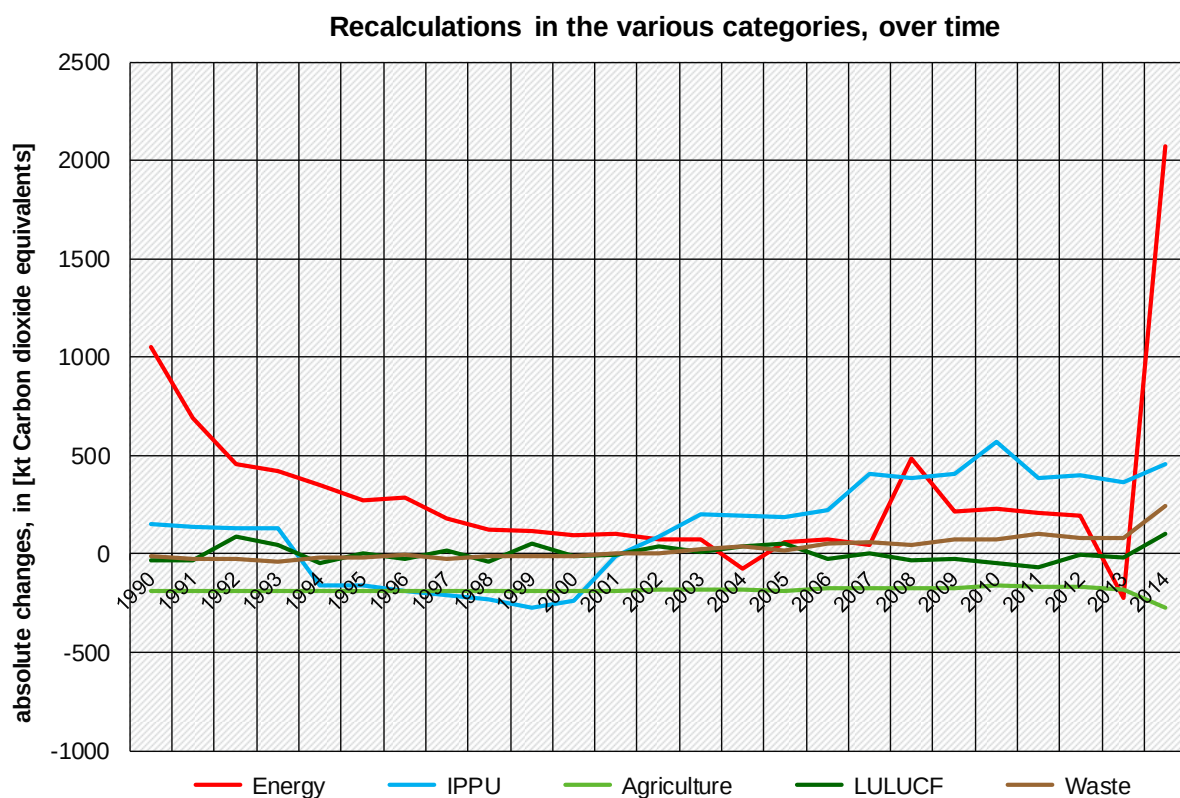
Land use, land-use changes and forestry:

- Use of new activity data, and derivation of specific EF (4.B.1; 4(KP-I)B.2)
- Figures on use of areas for perennial crops taken from official statistics (4.B)
- Introduction of EF for phytomass of perennial and annual crops (4.B)
- Correction of the EF for annual phytomass (4.B – 4.E)
- Introduction of a method for calculation of carbon-stock changes in the phytomass of perennial crops (4.B)
- Updating of the FAO database for data on HWP exports; product category *sawn lumber*, product group *wood pulp*; as of 2006 (4.G)

Waste and wastewater:

- Inclusion of leakages (5.D.1)
- Updating of the fraction of the population share with cesspools and septic tanks (5.D.1)
- Updating of the fraction of wastewater treatment plants with biological treatment stage (5.D.1)
- New statistical data for TOW; 2011-2014 (5.D.2)

Figure 79: Change in total emissions, throughout all categories, with respect to the 2016 Submission

**10.1.1.3 Recalculations in the 2017 inventory, by gases**

Recalculations were carried out in the following source categories (cf. also the specifications in 10.1.1.2):

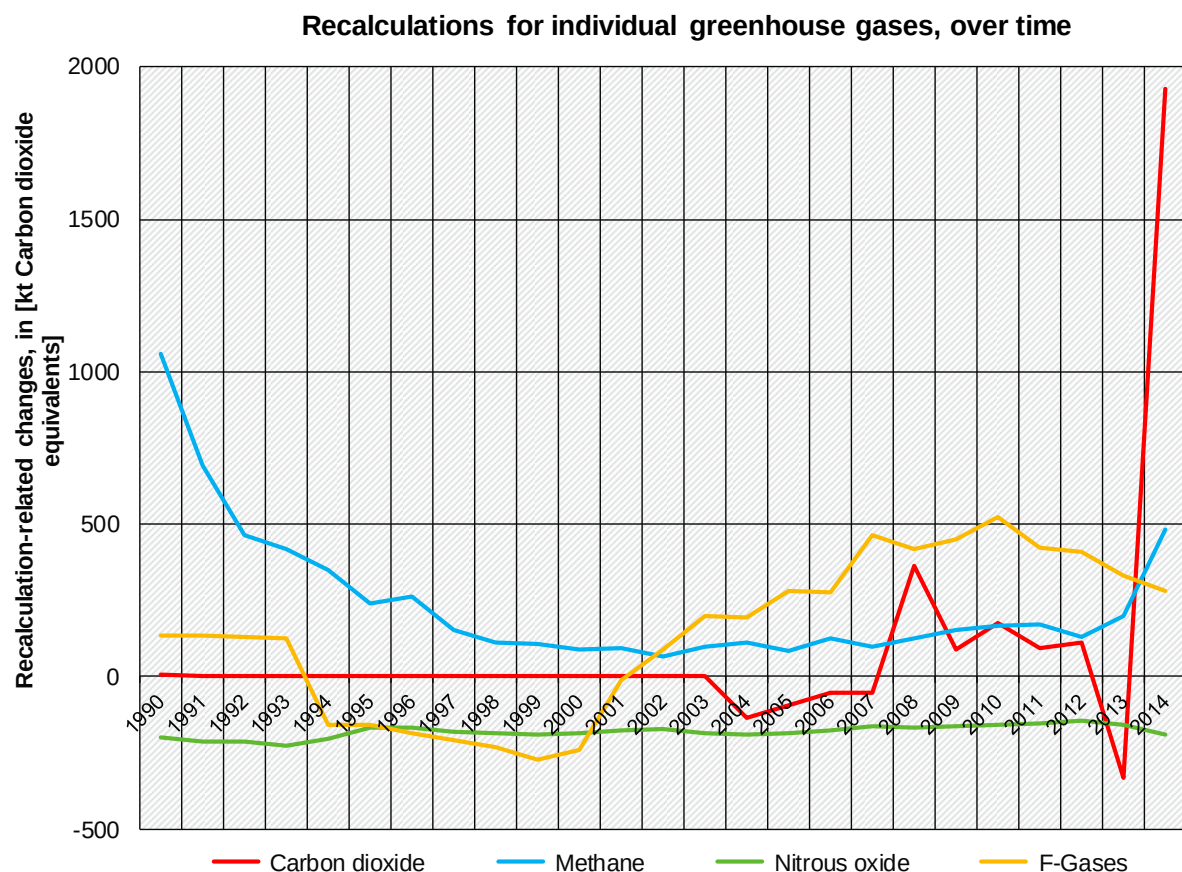
Table 417: Overview of the main CRF categories affected by recalculations

CRF	CO ₂	CH ₄	N ₂ O	HFCs	PFCs	SF ₆	NF ₃
1 – Energy	x	x	x				
2 – IPPU	x	x	x	x	x		
3 – Agriculture	x	x	x				
4 – LULUCF	x						
5 – Waste & wastewater		x	x				

Table 418: Relative changes resulting from recalculations, with respect to last year's report

	Base year	2013
Total (CO₂ equiv.)		0.28 %
CO₂	1990:	0.00 %
CH₄		0.89 %
N₂O		-0.31 %
F gases	1995:	1.93 %
HFCs		-1.93 %
PFCs		0.08 %
SF₆		0.00 %
NF₃		0.00 %

Figure 80: Recalculation of total emissions of individual greenhouse gases, throughout all source categories, with respect to the 2016 Submission



10.1.1.4 Recalculations carried out to implement results of the review process

The following recalculations were carried out, with respect to the 2016 Resubmission, in keeping with information and recommendations provided by the Review Teams:

Recalculations that were already carried out in the Resubmission are described separately in Chapter 10.5.

10.1.2 KP-LULUCF inventory

10.1.2.1 General procedure

The methods used for recalculations under the Kyoto Protocol are the same as those used under the Convention. Detailed information on the general procedure is provided in Chapter 10.1.1.1.

10.1.2.2 Recalculations in the 2017 inventory, by categories

In the sub-category *Cropland remaining Cropland*, the figures from official statistics for areas with perennial crops have entered into the activity data.

In the *Cropland* category, biomass, emission factors for the phytomass of perennial and annual crops have been introduced. The values for the emission factors for annual phytomass were slightly modified – for cropland phytomass, in connection with correction of an error; for plant biomass on grassland (in the strict sense), in connection with an improved derivation. This led to revision of the carbon dioxide emission factors for plant biomass in the land-use categories *Cropland*, *Grassland i.t.s.s.*, *Wetlands* and *Settlements*.

Calculation of carbon-stock changes in the phytomass of perennial crops, in the sub-category *Cropland remaining Cropland*, was included (cf. Chapter 6.5.2.1).

For *Harvested Wood Products (HWP)*, the export data used last year, pursuant to FAOSTAT 2015, were corrected for all years as of 2006, to take account of revision of the product category *sawn lumber* and the product group *wood pulp* (cf. Chapter 6.10.5).

10.1.2.3 Recalculations in the 2017 inventory, by gases

The described changes only affect the reported CO₂ emissions.

10.1.2.4 Recalculations carried out to implement results of the review process

In keeping with a suggestion emerging from the 2016 In Country Review, a method for calculating carbon-stock changes in the phytomass of perennial crops was introduced. Along with this change, emission factors for the phytomass of perennial and annual crops are being listed, and activity data for the areas with perennial crops have been derived.

10.2 Impact on emissions levels

10.2.1 Greenhouse-gas inventory

The changes with respect to the 2016 Resubmission, at +0.08 % for 1990 and +0.28 % for 2014, tend to be small.

Table 421 and Table 422 show the changes in emissions as reported for 1990 and for 2014, for the various CRF sectors.

The inventory has been improved with regard to completeness and accuracy.

Table 419: Recalculations-related absolute and percentage changes in total national emissions (not including LULUCF), with respect to last year's report

	2016	2017	Change with respect to 2016	
1990	1,249,913	1,250,915	1,002	0.08%
1991	1,203,219	1,203,834	615	0.05%
1992	1,152,900	1,153,282	382	0.03%
1993	1,143,675	1,143,993	318	0.03%
1994	1,124,258	1,124,246	-12	0.00%
1995	1,120,944	1,120,856	-88	-0.01%
1996	1,138,768	1,138,677	-91	-0.01%
1997	1,104,244	1,104,005	-239	-0.02%
1998	1,078,643	1,078,341	-303	-0.03%
1999	1,045,420	1,045,067	-352	-0.03%
2000	1,043,294	1,042,958	-337	-0.03%
2001	1,058,070	1,057,978	-92	-0.01%
2002	1,036,942	1,036,925	-18	0.00%
2003	1,033,728	1,033,843	115	0.01%
2004	1,017,294	1,017,276	-18	0.00%
2005	991,849	991,933	84	0.01%
2006	999,044	999,220	176	0.02%
2007	971,998	972,344	346	0.04%
2008	973,942	974,682	739	0.08%
2009	906,423	906,949	526	0.06%
2010	941,039	941,750	712	0.08%
2011	921,830	922,363	534	0.06%
2012	926,338	926,850	511	0.06%
2013	945,151	945,186	35	0.00%
2014	901,764	904,262	2,498	0.28%

"2016": pursuant to the 2016 Resubmission; "2017": pursuant to the 2017 Submission

Source: own calculations

Table 420: Recalculations-related percentage changes, with respect to last year's report, in inventory data reported for informational purposes

	1990	2014
Emissions reported as memo items:	4.33%	1.18%
From international transports	0.00%	0.00%
<i>of which: international civil air transport</i>	0.00%	0.00%
<i>of which: international maritime navigation</i>	0.00%	0.00%
From multilateral military missions	NE	NE
CO ₂ from combustion of biomass	-0.90%	1.11%

Source: own calculations

10.2.1.1 Impacts on 1990 emissions levels

Total emissions (not including LULUCF) for 1990 were upwardly corrected, by a total of about 0.08 %, or 1,002 kt CO₂ equivalents (cf. Table 421).

The most important inventory-affecting correction, at minus 1,052 kt, or 0.10 %, occurred in the energy sector.

In the sectors *Industrial processes and Product Use (IPPU)* and *Agriculture*, similarly small relative changes were made. At +150 and -188 kt CO₂ equivalents, the absolute changes offset each other closely.

A minus of 11 kt CO₂ equivalents translates into nearly unchanged (-0.03 %) emissions from the *Waste and wastewater* sector.

In the *LULUCF* sector (*Land Use, Land Use Changes and Forestry*), the only change for 1990 was a very slight increase in the CO₂ sink performance, amounting to 32 kt. Methane and nitrous oxide emissions remained unchanged.

More-detailed pertinent information, in addition to that provided in the following table, is available in CRF tables 8(a)s1 through 8(a)s4.

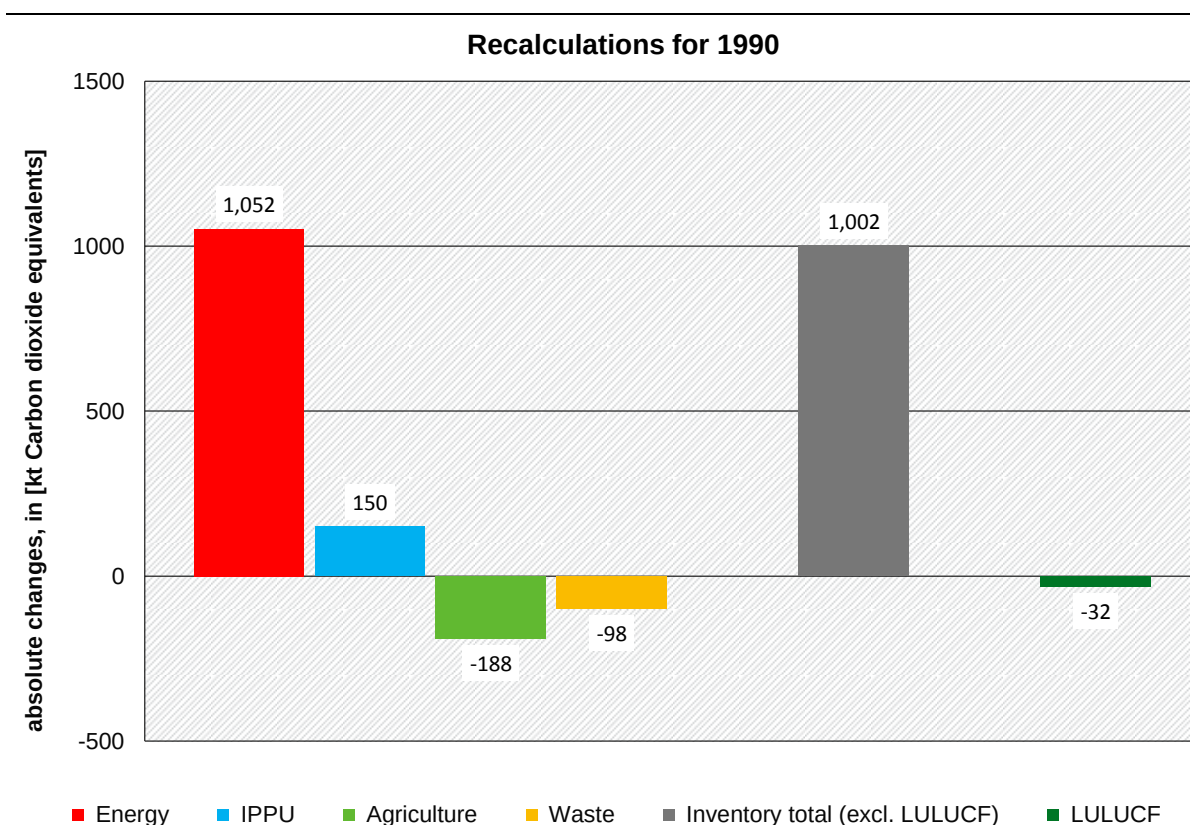
Table 421: Recalculation of CRF-specific total emissions, for all greenhouse gases in 1990

	2016	2017	Change with respect to 2016	
Total national emissions (without LULUCF)	1,249,913	1,250,915	1,002	0.08%
1. Energy	1,035,684	1,036,736	1,052	0.10%
2. IPPU	96,493	96,643	150	0.16%
3. Agriculture	79,770	79,582	-188	-0.24%
4. Land-use changes and forestry	-31,279	-31,312	-32	-0.10%
CO ₂ (net emissions / removals)	-32,985	-33,018	-32	-0.10%
N ₂ O + CH ₄ (emissions)	1,706	1,706	0	0.00%
5. Waste & wastewater	37,966	37,955	-11	-0.03%

"2016": pursuant to the 2016 Resubmission; "2017": pursuant to the 2017 Submission

Source: own calculations

Figure 81: Impacts of recalculations on CRF sectors and on the total inventory for 1990



10.2.1.2 Impacts on emissions levels of categories in 2014

The total emissions reported for the year 2014, without LULUCF, increased, by comparison to the 2016 Resubmission, by 2,498 kt CO₂ equivalents, or 0.28 % (cf. Table 422).

The key inventory-relevant correction produces a plus of 2,071 kt, or 0.27 %, in the energy sector, and it is needed to take account of the the final statistical data that have replaced the provisional data in the 2016 Submission and 2016 Resubmission.

Quite-similar absolute changes occurred in most of the other sectors, largely as a result of the availability of updated statistical data.

The second-largest absolute change, at +457 kt CO₂ equivalents (+0.57 %), has occurred in the sector *Industrial processes and product use (IPPU)*, while the third-largest absolute change (-272 kt, or -0.41 %) has occurred in the *Agriculture* sector.

The largest relative change, amounting to an increase of 243 kt CO₂ equivalents, or +2,10 %, has occurred in the sector *Waste and wastewater*.

In the *LULUCF* sector (*Land Use, Land Use Changes and Forestry*), the only change for 2014 was an increase in the CO₂ sink performance, amounting to 99 kt. The methane and nitrous oxide emissions for both that year and 1990 remained unchanged, however.

More-detailed pertinent information, in addition to that provided in the following table, is available in CRF tables 8(a)s1 through 8(a)s4.

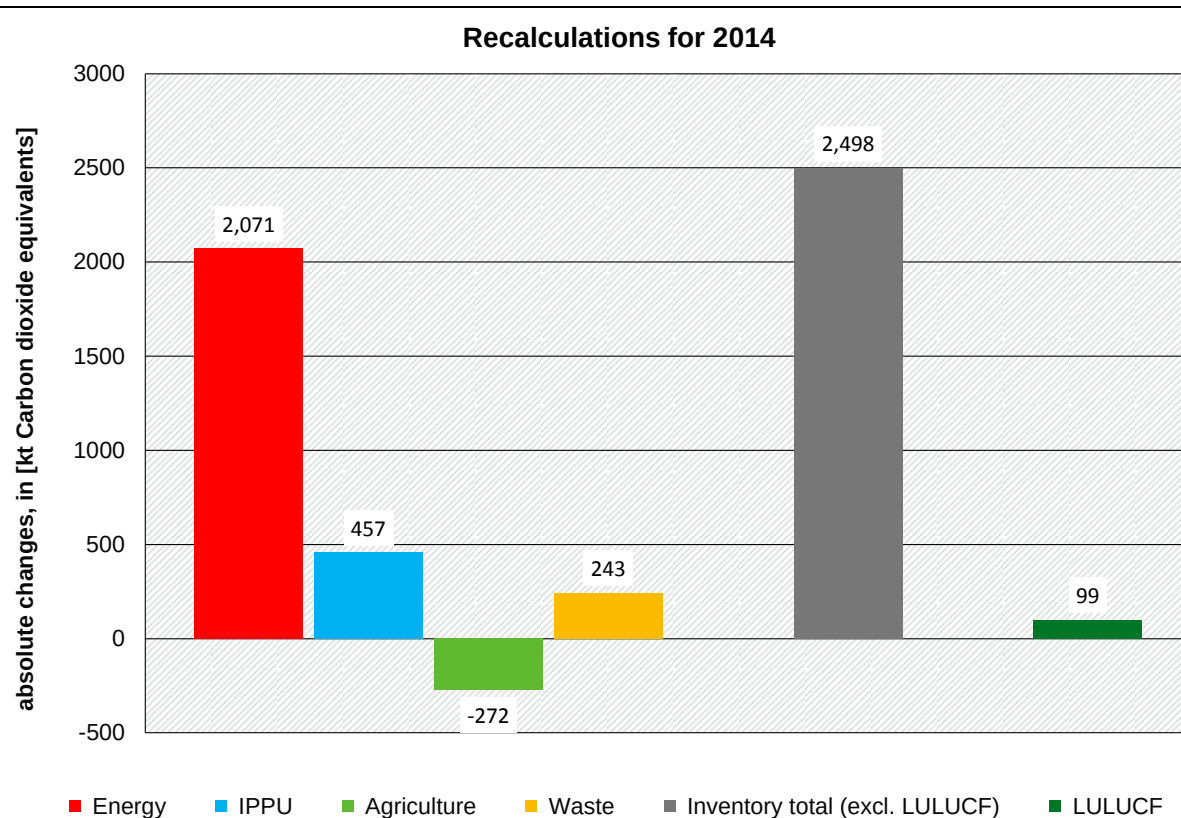
Table 422: Recalculation of CRF-specific total GHG emissions for 2014, in kt CO₂ equivalents

	2016	2017	Change with respect to 2016	
Total national emissions (not including CO₂ from LULUCF)	901,764	904,262	2,498	0.28%
1. Energy	762,338	764,409	2,071	0.27%
2. IPPU	60,989	61,446	457	0.75%
3. Agriculture	66,863	66,591	-272	-0.41%
4. Land-use changes and forestry	-14,977	-14,877	99	0.66%
CO ₂ (net emissions / removals)	-16,689	-16,589	99	0.60%
N ₂ O + CH ₄ (emissions)	1,712	1,712	0	0.00%
5. Waste	11,573	11,816	243	2.10%

"2016": pursuant to the 2016 Resubmission; "2017": pursuant to the 2017 Submission

Source: own calculations

Figure 82: Impacts of recalculations on CRF sectors and on the total inventory for 2014



10.2.2 KP-LULUCF inventory

10.2.2.1 Impacts on emissions levels of categories in 1990

The total sink for 1990 has increased by 0.08 % with respect to the 2016 Submission. This increase is due primarily to a change of methods in differentiation of perennial and annual crops and to changes in the emission factors for biomass. The relative changes, for all categories, are less than 1 % (cf. Table 423).

Table 423: Recalculation of total emissions for 1990, throughout all greenhouse gases, in kt CO₂ equivalents

Land-use category	2016	2017	Change with respect to 2016	
Afforestation (KP 3.3)	585	582	-3	-0.51 %
Deforestation (KP 3.3)	1,763	1,768	5	0.28 %
Forest management (KP 3.4)	-74,806	-74,806	0	0.00 %
Cropland management (KP 3.4)	12,702	12,669	-3	-0.26 %
Grassland management (KP 3.4)	25,766	25,772	6	0.02 %
Total	-33,989	-34,015	26	0.08 %

"2016": pursuant to the 2016 Resubmission; "2017": pursuant to the 2017 Submission

Source: own calculations

10.2.2.2 Impacts on emissions levels of categories in 2014

The total sink performance for the year 2014 has decreased by 0.75 % with respect to the 2016 Submission. This is also due to changes in the Cropland sector. The largest relative change (one that has little influence on the total emissions, however) is seen in the category *Deforestation* (+3.36 %).

Table 424: Recalculation of total KP-LULUCF emissions, for all gases in 2013

Land-use category	2016	2017	Change with respect to 2016	
Afforestation (KP 3.3)	-6,449	-6,451	2	0.03 %
Deforestation (KP 3.3)	1,997	2,064	67	3.36 %
Forest management (KP 3.4)	-55,070	-54,900	-170	-0.31 %
Cropland management (KP 3.4)	14,520	14,453	-67	-0.46 %
Grassland management (KP 3.4)	22,314	22,317	3	0.01 %
Total	-22,689	-22,518	-171	-0.75 %

"2016": pursuant to the 2016 Resubmission; "2017": pursuant to the 2017 Submission

Source: own calculations

10.3 Impacts on emissions trends and on time-series consistency

10.3.1 Greenhouse-gas inventory

The time-series consistency has improved as a result of the recalculations.

As a result, the trend for total national emissions (not including LULUCF) shows a reduction of nearly 28 % with respect to the current base year. This reduction is virtually unchanged from the corresponding figure in the 2016 Submission.

Following a recent considerable increase, the 2015 figures for pure CO₂ emissions are now only 0.3 % below the corresponding values for the previous year. A similar statement can be made for methane, which shows a decrease of 0.7 %. By contrast, nitrous oxide emissions increased by 1.3 %.

The trends for HFC, PFC and SF₆ and NF₃ emissions have continued to diverge: With respect to 2014, HFC emissions are up by 1.5 %, while PFC emissions are up by a full 8.1 %. The emitted quantities of SF₆ increased by 4.9 %, while NF₃ emissions decreased considerably, by -41.4 %.

10.3.2 KP LULUCF inventory

The consistency of the time series is maintained, in spite of the recalculations that have been carried out. The emission calculation has been significantly improved, thanks especially to an improved method for differentiating perennial and annual crops.

10.4 Inventory improvements

10.4.1 Greenhouse-gas inventory

The following table summarises the improvements made in greenhouse-emissions reporting on the basis of the ERT's references and remarks in past reviews under the UN Framework Convention on Climate Change and the Kyoto Protocol. The table lists only aspects that were not already successfully addressed during the Review.

Table 425: Compilation of the Review recommendations successfully addressed as of the current report

CRF	Review Findings	Improvement	Report [year]	Source	Reference	Resolved in NIR-Chapter
1.	Germany included in its NIR a time-series comparison of aggregate CO ₂ emissions with other independent national and international data sets (NIR tables 23 and 24 and figures 22 and 23). While the comparisons confirm the consistent emission trends and annual emission levels in all calculation approaches, the ERT noted that a fuel-level comparison between the data sets would provide useful information on the discrepancies between the reference and sectoral approaches. The ERT commends Germany for its efforts to reconcile the differences between the approaches and encourages the Party to include qualitative and quantitative information on any significant differences, at the level of primary fuel consumption, in the CRF documentation box and in the NIR of its next annual submission.	Issue has been resolved	2012	ARR	\$ 40	-
1.	To further increase the transparency of the inventory, the ERT also reiterates the encouragement in the previous review report to include in the NIR details of primary fuel types for the entire time series.	ERT conclusion E2 - ICR 2016: Resolved. Germany is making progress in applying national energy balance and EU ETS data, which are the most important components to improve the quality of Germany's energy inventory	2013	ARR	\$ 22	-
1.	The ERT is of the view that the GHG inventory compiler should have access to any data that allow the Party to improve the quality of its GHG emissions inventory, including for QA and quality control (QC) purposes. The ERT also considers that the new reporting requirements for the energy sector, the ongoing and planned quality inventory improvements and the thoroughness of the reviews will also place additional demands on the inventory compiler.	ERT conclusion E5 - ICR 2016: Resolved. Germany provided additional information on the use of EU ETS plant-specific data during the review, indicating that sufficient access to relevant data is provided to the inventory compiler	2014	ARR	\$ 24	-
1.A.	ERT found that the Party's reporting on the energy sector could be improved in relation to the comparability of its emission estimates and emission factors (EFs) with those of other Parties included in Annex I to the Convention (Annex I Parties). The ERT notes there has been no change regarding the recommendation made in the 2013 annual review report that Germany assess the possibility of preparing emission data at the level of disaggregation in the CRF tables. ⁵ During the review, the Party explained that it does not believe that the inventory quality would improve by providing the relevant breakdown of industrial activities in the CRF tables. Germany provided a detailed line of reasoning on why it believes that comparability with other Annex I Parties would not improve by reporting emission estimates for manufacturing industries and construction according to the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I (...). This is mainly a result of the reporting of autoproduction (e.g. combined heat and power plants, which are part of industrial installations), the size of the plants (e.g. thresholds), ownership issues, as well as feedback between industrial installations and the main electricity producers (e.g. industrial plants selling electricity back to the main activity producers). The ERT (...) still notes that emissions from autoproducers are to be assigned to the category where they were generated. The ERT also notes that the comparability of emission estimates and EFs, at the required level of disaggregation provided in the CRF tables, is one of the quality criteria provided in the UNFCCC reporting guidelines. In addition, as Germany already reports the required breakdown to the Statistical Office of the European Union (Eurostat) under the European Union (EU) Regulation No 147/2013 on energy statistics, it should be possible for Germany to report the emissions using the required CRF breakdown.	ERT conclusion ICR 2016: Resolved. Germany is making progress in applying national energy balance and EU ETS data which are the most important components to improve the quality of Germany's energy inventory.	2014	ARR	\$ 21	-

CRF	Review Findings	Improvement	Report [year]	Source	Reference	Resolved in NIR-Chapter
4.A. (b)	Emissions from land converted to forest land have increased by 19 per cent over the period 1990–2012, from –5,878.56 Gg CO ₂ eq in 1990 to –4,776.83 Gg CO ₂ eq in 2012. While the IEF for the carbon stock changes in living biomass was relatively constant over this period, the area of land converted to forest land decreased from 606.20 kha in 1990 to 400.18 kha in 2012. This decline occurred because the rate of land conversion to forest land decreased during that period. As a result, land is moving from the category land converted to forest land to the category forest land remaining forest land at a higher rate than it is being replaced with new land converted to forest land.	Issue has been resolved	2014	ARR	\$ 50	-

All measures are aimed at achieving complete consistency with the UNFCCC report guidelines and the IPCC Guidelines and at preventing any adjustments under the Kyoto Protocol.

The following table summarises the information, as provided in the various source-category chapters of the inventory reports (since 2011), relative to planned improvements. That information is supplemented with details on the resulting needs for action, the planned deadlines for completing the measures and the current processing status in each case.

Table 426: Compilation of a) the planned improvements completed as of the present report and of b) the planned improvements that are mentioned in NIR category chapters and are still pending

CRF	Planned improvement	Data quality objective	Deadline	STATUS	Comment	Resolved in NIR-Chapter	Year of Reporting	Reference NIR-Chapter
1.A.4.a.i.	With regard to reporting on stationary combustion systems, review is currently being carried out to determine whether the applicable percentage for wood use can be determined via other scientific studies.	After finalization of a survey project of wood firing facilities new EFs are to be integrated into the inventory and be completely documented.	[2017]	done	Issue has been resolved	-	2015	3.2.11.6
1.A.4.c.i.	In addition, plans call for redetermining, and adjusting as necessary, the energy-input fraction listed in Energy Balance line 67 for Combustion systems in the agricultural sector and in nurseries (garden centers) (1.A.4.ci), with regard to the Commercial and Institutional sector.	The energy-input fraction listed in Energy Balance line 67 for Combustion systems in the agricultural sector and in nurseries (garden centers) (1.A.4.ci) needs to be redetermined, and adjusted as necessary.	[2017]	done	Issue has been resolved	-	2016	-
1.D.1.b.	In 2013 or later, use will begin of LNG bunkered in Germany. Such use will duly be taken into account in future reports.	LNG bunkered in Germany shall be included into the inventory.	[2015]	closed	No LNG in use yet.	-	2013	3.2.2.3.6
2.B.2	In 2015, a new plant that produces nitric acid was identified. The Single National Entity is in the process of bringing that plant into the cooperation agreement.	In 2015, a new plant that produces nitric acid was identified. That plant needs to be included in the cooperation agreement.	[2017]	closed	The Plant in question is a Plant for the production of Caprolactam and is reported under the EU ETS out of consistency reasons. Emissionen are below 1 t N ₂ O - therefore extremely low. Data are gathered continuously, therefore no need for an cooperation agreement.	-	2016	4.3.2.6
2.B.4.a.	Plans call for the production quantities of ε-caprolactam as of 2009 to be determined via other sources, and for the N ₂ O reductions of other producers to be determined.	Results of the survey related to verification of produced caprolactam and of N ₂ O-mitigation efforts have to be implemented in the national inventory and reporting and be completely documented.	[2016]	overdue			2015	4.3.4.6
2.B.8	Plans call for improving the database.	The database needs to be improved.	[2017]	overdue			2016	4.3.8.1.6
2.C.6.	Specific data for determination of emission factors will be collected in the next rounds of reporting.	Revision of EF as well as complete documentation of results..	[2016]	overdue			2015	4.4.6.6
2.D.3.(a)	Currently, the currentness of the data collected for 2.D.3.h (printing industry / printing applications) is being reviewed.	The results of the review of the currentness of the data collected for 2.D.3.h (printing industry / printing applications) need to be documented in the NIR and the IB. The inventory is to be adjusted if necessary.	[2017]	done	Currentness of data-gathering has been reviewed. Results are given in the NIR.	-	2016	4.5.3.6

CRF	Planned improvement	Data quality objective	Deadline	STATUS	Comment	Resolved in NIR-Chapter	Year of Reporting	Reference NIR-Chapter
2.D.3.(b)	Relevant findings currently available from a research project are to be used for specific evaluation of emission factors.	The emission factors need to be evaluated on the basis of the existing project report.	[2012]	overdue			2011	4.2.6.6
3.A.	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	[2020]	to do			2011	6.2.6
3.A.	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	[2020]	to do			2012	6.2.6
3.B.	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	[2020]	to do			2011	6.3.2.6
3.B.	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	[2020]	to do			2012	6.3.2.6
3.D	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	[2020]	to do			2011	6.5.6
3.D	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	[2020]	to do			2012	6.5.6
4.	The results of the Agricultural Soil Inventory are being used for step-by-step validation of the current emission factors.	The currently used EF are to be verified with the results of the Agricultural Soil Inventory	[2019]	to do			2014	19.5.2.3
4. LULUCF (Total area)	Development of new, country-specific emission factors for mineral soils, via a major inventory (Agricultural Soil Inventory).	Integration of new EF for mineral soils into the inventory and complete documentation of background data, results and assumptions.	[2021]	to do			2015	6.1.5

CRF	Planned improvement	Data quality objective	Deadline	STATUS	Comment	Resolved in NIR-Chapter	Year of Reporting	Reference NIR-Chapter
4. LULUCF (Total area)	Derivation of country-specific emission factors, and development of models for determination of the impacts of cultivation on cropland and grassland areas, using data from the Agricultural Soil Inventory, data from long-term soil monitoring and mathematical models.	Integration of new EF for mineral soils into the inventory and complete documentation of background data, results and assumptions.	[2019]	to do			2015	6.1.5
4. LULUCF (Total area)	The following inventory-improvement measures are planned: Derivation of country-specific emission factors, and development of models for identification of annually varying wood harvests and of wood growth.	Derivation of country-specific emission factors, and development of models for identification of annually varying wood harvests and of wood growth, and integration of the results within the inventory.	[2018]	to do			2016	6.1.4
4.A.	<i>Litter and mineral soils</i> Evaluation of the data relative to changes in organic carbon in the upper 30 cm of mineral soil shows that sandy soils in particular, soils whose distribution is concentrated in northern Germany, have accumulated carbon since the BZE I survey. A study is already underway, with regard to the BZE, to determine the reasons for the carbon increase. A comparison with a regional soil inventory carried out on long-term study areas (KONOPATZKY 2009) indicates that changes have taken place primarily in recent years. On the other hand, a study carried out in the framework of the BZE has concluded that significant changes of carbon stocks in mineral soil take at least 10 years to become apparent in surveys (MELLERT et al. 2007). It is thus necessary to determine the relevant rate of change via a follow-on inventory. The time for that inventory will be determined after evaluation of the BZE II survey has been completed.	Once the Forest Soil Inventory II (BZE II) has been evaluated, a follow-on inventory needs to be initiated to determine changes in organic carbon in the top 30cm of mineral soils (cf. the relevant individual objective).	[2017]	overdue			2011	7.2.8.2
4.A.	Evaluation of the data relative to changes in organic carbon in the upper 30 cm of mineral soil shows that sandy soils in particular, soils whose distribution is concentrated in northern Germany, have accumulated carbon since the BZE I survey. A study is already underway, with regard to the BZE, to determine the reasons for the carbon increase. A comparison with a regional soil inventory carried out on long-term study areas (KONOPATZKY 2009) indicates that the changes have taken place primarily in recent years. On the other hand, a study carried out in the framework of the BZE has concluded that significant changes of carbon stocks in mineral soil take at least 10 years to become apparent in surveys (MELLERT et al. 2007). It is thus necessary to determine the relevant rate of change via a follow-on inventory. The time at which that inventory is to be carried out will not be decided until after the BZE II inventory has been evaluated.	Once the Forest Soil Inventory II (BZE II) has been evaluated, a follow-on inventory needs to be initiated to determine changes in organic carbon in the top 30cm of mineral soils.	[2017]	overdue			2012	7.2.8.2

CRF	Planned improvement	Data quality objective	Deadline	STATUS	Comment	Resolved in NIR-Chapter	Year of Reporting	Reference NIR-Chapter
4.B, 4.C	Improvement of the area data for organic soils under cultivation: ongoing research project.	The area data for organic soils on cropland need to be improved.	[2016]	done	Improvement of the area data for organic soils under cultivation has taken place and is reported in the NIR 215.		2012	7.3.8
4.B, 4.C	Mineral soils: Agricultural soil inventory: generation of national measurements of C stocks, for cropland and grassland.	On the basis of the Agricultural Soil Inventory, data on C stocks in mineral soils need to be derived for cropland and grassland, and the inventory has to be improved accordingly.	[2020]	to do			2012	7.3.8
5.A.1.	In an international comparison, collection rates of landfill gas, at about 20 %, seem very low. They also seem low in that nearly all German landfills have gas-collection facilities and that the technical characteristics of German landfills would seem to provide a comparatively good basis for high collection rates. This apparent contradiction will need to be cleared up for future reports.	The causes for the high differences between statistical data and estimated amount of landfill gas shall be determined.	[2018]	to do			2013	8.2.1.6
5.D.1.	In the area of wastewater treatment, only CH ₄ emissions from open cesspools and N ₂ O emissions from aeration tanks and from effluent are currently being reported. Other possible treatment steps that could be emissions-relevant – such as sludge treatment – are not reported, since the 2006 IPCC Guidelines do not cover them and since no pertinent data are available to date. Recently, however, initial national spot surveys have been carried out that suggest that various treatment steps that are currently not being considered might produce additional CH ₄ and N ₂ O emissions. For this reason, a research project was launched this year with the aim of identifying possible fugitive emissions via relevant sections of facilities. To that end, measurements of the gases CH ₄ , N ₂ O and NH ₃ (indirect GHG; since to a small degree it converts to N ₂ O in the atmosphere) are to be carried out at representative wastewater treatment facilities.	The inventory needs to be adjusted in keeping with the results of the R&D project on "fugitive emissions."	[2019]	to do			2016	7.5.1.1.1

10.4.2 KP & LULUCF

The LULUCF-sector improvements described for the Convention inventory, in Chapter 6.1.3, are also to be applied to the KP-LULUCF inventory.

10.4.3 Implementing Regulation Article 9: Reporting on implementation of recommendations and adjustments

Table 427: Implementing Regulation Article 9: Reporting on implementation of recommendations and adjustments

Member State:	Germany			
Reporting year:	UNFCCC Annual Review Report 2014 -- Implementation of ARR 2015 and 2016 was not possible due to not being finalised!			
CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
1.	greater focus on explaining the recalculations that led to the largest changes --> energy balance and particularly natural gas consumption	§ 18	Issue has been resolved. There are quantitative and qualitative analyses of recalculations available in the sector specific chapters of 1.A.	1.A
1.	Continue improving the inventory of the energy sector in future annual submissions, not only by implementing the recommendations made in the 2014 annual review report but also as a result of Germany's own quality improvements	§ 20	Issue has been resolved. . This takes place every year on an ongoing basis.	-
1.A.	ERT found that the Party's reporting on the energy sector could be improved in relation to the comparability of its emission estimates and emission factors (EFs) with those of other Parties included in Annex I to the Convention (Annex I Parties). The ERT notes there has been no change regarding the recommendation made in the 2013 annual review report that Germany assess the possibility of preparing emission data at the level of disaggregation in the CRF tables. During the review, the Party explained that it does not believe that the inventory quality would improve by providing the relevant breakdown of industrial activities in the CRF tables. Germany provided a detailed line of reasoning on why it believes that comparability with other Annex I Parties would not improve by reporting emission estimates for manufacturing industries and construction according to the "Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I (...). This is mainly a result of the reporting of autoproduction (e.g. combined heat and power plants, which are part of industrial installations), the size of the plants (e.g. thresholds), ownership issues, as well as feedback between industrial installations and the main electricity producers (e.g. industrial plants selling electricity back to the main activity producers). The ERT (...) still notes that emissions from autoproducers are to be assigned to the category where they were generated . The ERT also notes that the comparability of emission estimates and EFs, at the required level of disaggregation provided in the CRF tables, is one of the quality criteria provided in the UNFCCC reporting guidelines. In addition, as Germany already reports the required breakdown to the Statistical Office of the European Union (Eurostat) under the European Union (EU) Regulation No 147/2013 on energy statistics, it should be possible for Germany to report the emissions using the required CRF breakdown.	§ 21	ERT conclusion ICR 2016: Resolved. Germany is making progress in applying national energy balance and EU ETS data which are the most important components to improve the quality of Germany's energy inventory.	-
1.A.	The Party explained that the German inventory compiler has no access to plant-specific EU ETS data, or to plant-specific statistical data. The responsibility for the QA of data collected under the EU ETS lies strictly with the national emissions trading authority. The inventory compiler has initiated activities to perform the verification of aggregated data collected under the EU ETS with those used for the compilation of the inventory. The ERT notes that this is a very big task given the number of installations, legal restrictions and different responsibilities within the Quality System for Emissions Inventories. During the review, Germany also indicated that it	§ 23	Germany is continuing to work on that issue.	

Member State:	Germany			
Reporting year:	UNFCCC Annual Review Report 2014 -- Implementation of ARR 2015 and 2016 was not possible due to not being finalised!			
CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
1.	has already started a discussion between the Federal Statistical Office, the single national entity (the coordinating agency for the national system) and EU ETS authorities to extend the cooperation regarding the QA of the EU ETS data and energy statistics.			
	The ERT is of the view that the GHG inventory compiler should have access to any data that allow the Party to improve the quality of its GHG emissions inventory, including for QA and quality control (QC) purposes. The ERT also considers that the new reporting requirements for the energy sector, the ongoing and planned quality inventory improvements and the thoroughness of the reviews will also place additional demands on the inventory compiler.	§ 24	ERT conclusion E5 - ICR 2016: Resolved. Germany provided additional information on the use of EU ETS plant-specific data during the review, indicating that sufficient access to relevant data is provided to the inventory compiler	-
	The ERT notes that some of the uncertainties reported in the NIR are relatively large. For example, the uncertainty of the AD related to CO2 emissions from road transportation is around 9 per cent and the uncertainties for the residential and commercial categories are around 8 per cent. The ERT notes that these are very large emission sources and well-established statistical flows in the energy balance. During the review, the Party explained that the uncertainty of 8 per cent for the residential and commercial categories takes into account the uncertainty of the net calorific value (NCV) and the AD. The ERT notes that accurate and reliable AD are prerequisites for the calculation of good-quality emission estimates for the energy sector.	§ 25	Issue has been explained.	1.7.1.2
	With regard to QA/QC procedures, the NIR states that “Due to a lack of relevant specialized staff, it has not yet been possible to have source category experts carry out quality control and quality assurance for the area of CO2 emission factors”. The ERT asked the Party to clarify whether this statement refers to category-specific (tier 2) QC procedures during the inventory preparation process and/or to QA activities performed by personnel not directly involved in the inventory preparation process. The Party responded that all CO2 EFs and NCVs are thoroughly checked by an experienced expert, including comparisons with IPCC default values, the EFs of other countries and EFs based on EU ETS data. The Party also explained that there are regular discussions with the Federal Statistical Office and the industry about NCVs and the composition of special gases. The ERT found that no experts outside the inventory team are involved in the performance of regular QA/QC procedures and considers that QA checks would further enhance the quality of the Party's GHG inventory. The ERT encourages Germany to establish a process for external QA of its annual submissions.	§ 26	The conclusion that there is no external QA is wrong. Please see NIR, (role concept and process organisation). If in some cases an expert or the belonging superior is missing (e.g. illness) and cannot be replaced in short-term there is always a back-up within the national entity responsible for qc and qa. More over there is a basic expert peer review mechanism established on a routinely and yearly basis.	1.3.3.1.3+4
1.A.	The energy statistics reported by Germany to Eurostat under the EU regulation on energy statistics show that, in 2012, gas consumption by households was 2.4 per cent higher according to the Eurostat data than in the data reported to the UNFCCC (905,134 TJ compared with 883,630 TJ). The difference in consumption of liquid fuels was 3.6 per cent: higher in the Eurostat data (545,477 TJ) than in the data reported in the CRF tables (525,833 TJ). Finally, the difference in consumption of liquid fuels in the commercial sector was even greater (36.9 per cent): 308,317 according to the Eurostat data compared with 194,647 reported in the CRF tables. During the review, the Party informed the ERT that data pertaining to the Joint Annual Questionnaires, which are submitted to both Eurostat and the International Energy Agency, have to be reported by the end of November when the final energy data are not yet available in Germany. The ERT notes that these differences partly reflect the reporting of ‘preliminary’ energy statistics to Eurostat by 30 November, which are more up to date, compared with the ‘preliminary’ energy statistics that are made available to the inventory compiler in August.	§ 28	Germany is continuing to work on that issue.	

Member State:	Germany			
Reporting year:	UNFCCC Annual Review Report 2014 -- Implementation of ARR 2015 and 2016 was not possible due to not being finalised!			
CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
1.D.1.b.	Germany cannot distinguish the amount of bunker fuel that is used for international transport on inland waterways (such as on the Rhine river) from that used for domestic navigation because of a lack of statistical data. The ERT notes that the approach followed by Germany leads to an overestimation of emissions from navigation as all fuel and emissions are considered domestic and reported under navigation. During the review, Germany explained that no statistics are available to report this breakdown. The IPCC good practice guidance also requires that estimates are accurate in the sense that they do not systematically overestimate or underestimate true emissions or removals.	§ 29	Issue has been resolved.	NIR 2015 3.2.10.4
1.A., 1.B	Inconsistencies in the Party's reporting of non-energy use of fuels among CRF tables 1.A(b), 1.A(c) and 1.A(d), including in the use of the notation keys (e.g. "NA" (not applicable) instead of "NO" (not occurring)). For example, the sum of total carbon stored reported in CRF table 1.A(b) (67,777.26 Gg CO ₂) is not equal to the sum of CO ₂ not emitted reported in CRF table 1.A(d) (68,429.68 Gg CO ₂). Also, the difference between the apparent consumption and the apparent consumption excluding non-energy use and feedstocks reported in CRF table 1.A(c) (1,109,155 TJ) is not equal to the sum of all fuel quantities reported in CRF table 1.A(d) (1,116,767 TJ). In addition to these findings regarding the consistency of the reported information, the ERT considers that the reporting of non-energy use of fuels and feedstocks could be improved in relation to transparency. For example, the relevant information in the last three columns of CRF table 1.A(d) (i.e. subtracted from energy sector, associated CO ₂ emissions and allocated under) has not been reported. The ERT considers that ensuring access to this information by the inventory compiler is important for improving the transparency of the reporting of the energy and industrial processes sectors.	§ 30	Given the fundamental revision and harmonisation of the named CRF tables after submission 2014, going along with changes in the data compilation work flow, the inventory compiler regards this issue as solved until a contrary assessments of a future ERT.	-
1.A.1-2	Germany reported a consumption of solid fuels equivalent to 191,340 TJ in 2012 for iron and steel. For the same year, the data reported to Eurostat show a consumption of 363,690 TJ. The Party explained that this difference is a result of the different reporting structure in the GHG inventory compared with the national energy statistics. The ERT notes that the AD used to estimate emissions from iron and steel in Germany include coke breeze, hard coal use of sinter plants, blast furnace gas and basic oxygen furnace gas, as well as coke oven gas used in power plants and in boilers of the different steel-making processes. Also, an important part of the emissions from solid fuels is reported under iron and steel production in the industrial processes sector. During the review, the ERT asked Germany to provide the carbon balance for the iron and steel category. The Party responded that the current reporting structure, as well as the carbon balance, is the result of the in-country review conducted in 2010. The carbon balance shows that the output is indeed higher than the input, with a very high statistical difference. The Party explained that there was an intensive discussion with the Iron and Steel Association and the Federal Statistical Office to determine the exact reason for this inconsistency. The reason for the imbalance is an overestimation of the blast furnace gas volume as a result of high measurement uncertainties. The ERT notes that Germany is planning to revise its calculation method and increase the consistency with the EU ETS data in its 2015 annual submission.	§ 31	Issue has been resolved. In chapter 1.A.2.a and 2.C.1 a comprehensive explanation of the reporting structure is available. A couple of graphs help to illustrate this subject. The carbon balance cannot be reported due to confidential data. Information on the carbon balance can be supplied to the review experts upon request.	1.A.2.a and 2.C.1 a
2.A.2.	Germany uses lime production data to estimate CO ₂ emissions for the entire time series. The estimated emissions and collected production-quantity data were compared with findings from the EU ETS and with national statistical data. Responding to recommendations made in previous review reports, Germany reported on the analysis of the differences between the CO ₂ emissions reported in the NIR and those from the EU ETS. Germany has reported in the NIR that these comparisons have revealed a need for further review of the EU ETS methodology.	§ 35	It's checked, but it is not possible to provide EU ETS methodology over three trading periods.	NIR 2015 4.2.2
2.B.3.	In Germany, emissions from adipic acid production were estimated based on IPCC default EFs and the amount of adipic acid produced until the mid-1990s. In recent years, the emissions were estimated using confidential AD. The NIR reports that there are three facilities producing adipic acid and these facilities have installed abatement technologies for which no description has been provided.	§ 36	Issue has been resolved	4.3.3

Member State:	Germany			
Reporting year:	UNFCCC Annual Review Report 2014 -- Implementation of ARR 2015 and 2016 was not possible due to not being finalised!			
CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
2.C.1.	In iron and steel production, the ERT noted that the trend in the CO ₂ implied emission factor (IEF) decreased by 22.7 per cent between 2004 (0.48 t/t) and 2012 (0.37 t/t). Also, several large inter-annual changes were identified (...). During the review, Germany explained that the inter-annual fluctuations are caused by the reallocation of fuel provided from the blast furnace from the category iron and steel in the energy sector to the category iron and steel production in the industrial processes sector, and by changes in production. The Party also explained that because the allocation methods are different, the aggregation of steel, pig iron and sinter production for the determination of the IEF could lead to incorrect conclusions.	§ 37	Issue has been resolved.	NIR-Kapitel 3.2.9.1.1 und 4.4.1.2
2.B.9.	Germany has reported hydrofluorocarbon-23 (HFC-23) emissions as "NA" under by-product emissions in CRF table 2(II).E, while other HFCs are reported as "C" (confidential) and "NO" under fugitive emissions. There is no information in the NIR that shows that direct production of HFC-23 occurs in Germany. In response to questions raised by the ERT during the review, Germany agreed that it has used the incorrect notation keys.	§ 38	Issue has been resolved. Notation key was changed into NO	-
3.	HB (recommendation) passt nicht zum Issue (dieses enthält keine Empfehlung, daher hier nicht wiedergegeben)	§ 40	Issue has been resolved. In NIR 2016, chapter 5.1.3.2.1 it is clearly described for which animal categories (and how often) the German Federal Statistical Office is carrying out surveys. In years without agricultural-structure surveys there is no information about animal numbers of sheep, goats, horses and poultry. In line with the IPCC guidelines, these animal numbers are estimated by inter-/extrapolation.	NIR 2016, chapter 5.1.3.2.1
3.	The NIR includes a separate section describing the different data sources, database and statistics used for the estimation of the AD (mainly animal numbers). The ERT noted that in several animal categories (i.e. poultry, goats and horses) the AD were not available for the latest reporting year (i.e. 2012) and, therefore, the same values as for 2011 were used to estimate the emissions. The ERT also noted several discrepancies with the international statistics published in the database of the Statistics Division of the Food and Agriculture Organization of the United Nations (FAOSTAT). During the review, Germany provided an additional document regarding the comparison of data published in FAOSTAT with the national background data on goats, horses, sheep, pigs and poultry, and information that justifies the differences (e.g. meat production in Germany).	§ 41	Issue has been resolved.	NIR 2016, chapter 5.1.3.2.4
3.B.	In response to a recommendation made in the previous review report, Germany has made improvements in the reporting of emissions from biogas plants and in providing information on the share of slurry digested, disaggregated by cattle and swine. The ERT commends Germany for these improvements and considers the explanation provided transparent.	§ 44	As stated in the review findings, the German methodology is explained transparently. The NIR is not the place to conduct an additional literature review, so this point is rejected.	-
3.B.	Germany uses an N ₂ O IEF for solid storage and dry lot (0.0091 kg N ₂ O-N/kg N) which is lower than the IPCC default value (0.02 kg N ₂ O-N/kg N). In response to questions raised by the ERT during the review, Germany provided additional information about the methodology used to estimate a country-specific EF for solid manure ("N ₂ O emissions from solid manure storage. Calculation of a national emission factor").	§ 45	Derivation and justification of the country specific EF for solid manure is given in VANDRE et. al. (2013) and has been made available to the ERT. Due to	-

Member State:	Germany			
Reporting year:	UNFCCC Annual Review Report 2014 -- Implementation of ARR 2015 and 2016 was not possible due to not being finalised!			
CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
4.A.(a)	During the period 1990–2012, emissions from forest land remaining forest land increased by 16,379.09 Gg CO ₂ eq/year from –63,332.15 Gg CO ₂ eq in 1990 to –47,074.09 Gg CO ₂ eq in 2012. The carbon stock change method used by Germany integrates the gains and losses of carbon stocks over the time period between inventory years. The increase in emissions over the period 1990–2012 was the result of a generally high rate of harvesting in the period 2000–2012, which is broadly reflected in the inventory results obtained from the national forest inventory (NFI) in 2012. The forest inventory method underestimates the amount of roundwood production by up to 35 per cent based on the national statistics. In response to a question raised by the ERT during the review, Germany explained that wood harvested is considered implicitly by the inventory method. The ERT sought information that would aid the transparency of reporting of emissions on forest land, specifically in relation to harvesting activity. In response to a draft version of this report, Germany stated that “German logging statistics is flawed. It is not based on measurements, but partly on expert judgments with a very high uncertainty and has been considered inappropriate for inventory purposes by the national logging and timber trade experts”.	\$ 49	the change to IPCC 2006 this EF now is higher than the IPCC default EF (German EF: 0.013; IPCC default: 0.005). Issue has been closed due to incorrect assumptions by the reviewer. The wood harvest statistics have been deleted from the NIR. falsche Annahme und Forderung vom Reviewer - Textpassagen zur Holzeinschlagsstatistik wurden aus dem NIR entfernt	-
4.A.(b)	Emissions from land converted to forest land have increased by 19 per cent over the period 1990–2012, from –5,878.56 Gg CO ₂ eq in 1990 to –4,776.83 Gg CO ₂ eq in 2012. While the IEF for the carbon stock changes in living biomass was relatively constant over this period, the area of land converted to forest land decreased from 606.20 kha in 1990 to 400.18 kha in 2012. This decline occurred because the rate of land conversion to forest land decreased during that period. As a result, land is moving from the category land converted to forest land to the category forest land remaining forest land at a higher rate than it is being replaced with new land converted to forest land.	\$ 50	Issue has been resolved	-
5.A.1.	Germany has reported the fraction of municipal solid waste (MSW) disposed using the notation key “NE” (not estimated) in the CRF tables. The ERT considers that this is not in accordance with the UNFCCC reporting guidelines. In response to a question raised by the ERT during the review, the Party explained that as a result of regulations in force since June 2005, the landfilling of biodegradable waste is no longer permitted in Germany. The outcome of this is that municipal waste and other biodegradable waste must be pre-treated via thermal or mechanical biological processes and the fraction of MSW disposed has been zero since that time.	\$ 53	Tere is no additional information box in the CRF tables anymore.	-
5.D.2.	During the review, the ERT noted that there were errors in the formula described in the NIR and the AD presented were not consistent across the annual submission. In response to questions raised by the ERT during the review, Germany explained that the AD have been completely updated to reflect 2012 values and were used in the correct formula, but the values were not correctly described in the NIR.	\$ 54	Issue has been resolved. AD have been revised.	7.5.2.1.5
5.B.1.	The ERT noted that the EF for waste composting is high compared with other reporting Parties. This issue was raised by the ERT during the review and the Party explained that research projects relating to this issue are currently under way and that improved data will be reported as they become available.	\$ 56	Issue has been resolved.	NIR-Kapitel 7.3.1.2
KP-LULUCF	During the first commitment period, Germany reported average annual net emissions of 2,283.19 Gg CO ₂ eq/year. The deforestation area and emission estimates were subject to a significant recalculation in the 2014 annual submission. The average annual recalculation over the first commitment period was 515 per cent for deforestation area and 1,691.9 per cent for emissions.	\$ 61	Issue has been closed due to not being relevant for improvement. nicht relevant für Verbesserungen	-

Member State:	Germany			
Reporting year:	UNFCCC Annual Review Report 2014 -- Implementation of ARR 2015 and 2016 was not possible due to not being finalised!			
CRF category / issue	Review recommendation	Review report / paragraph	MS response / status of implementation	Chapter/section in the NIR
KP-LULUCF	These recalculations were primarily undertaken following the availability of the results from the third NFI, which provided a basis for more accurate estimates of deforested area and on-site biomass on deforested land. Germany reported in CRF table 5(KP-I)A2.1 the total area of deforestation as otherwise subject to elected activities under Article 3, paragraph 4, of the Kyoto Protocol. The ERT noted that the Party misinterpreted the purpose of the table. All forests in Germany, except those classified under afforestation or reforestation, were included within the forest management activity. By 2012, net removals on forest management land were estimated to amount to 46,692.65 Gg CO ₂ eq from 10.76 million ha of forest land. The forest management removal estimates were subject to a significant recalculation in the 2014 annual submission. The average annual recalculation of forest management removals over the first commitment period was 68.5 per cent. This recalculation increased net removals from forest management land by an average of 18,978.24 Gg CO ₂ eq/year throughout the first commitment period. This recalculation was primarily undertaken following the availability of the results of the third NFI, which provided a basis for more accurate estimates of on-site biomass. In response to a draft version of this report, Germany explained that “before the new data of the NFI 2012 became available, the removals on forest management land were estimated up to submission 2013 by applying the same removal rate as between 2002 and 2008 (extrapolation method), when harvest rates were very high. The logging statistics – with all their flaws and uncertainties – had suggested for years that harvest rates have declined since then, which is supported by lower timber prices”. The ERT agrees with Germany that declines in logging activity may help to explain the increase in removals on forest management land during the first commitment period	§ 62	Issue has been resolved.	-
KP-LULUCF	Germany’s description of the minimization of adverse impacts in accordance with Article 3, paragraph 14, of the Kyoto Protocol since the previous annual submission is the same as the reporting in the 2013 NIR. The ERT noted that Germany did not provide information on changes in its reporting of the minimization of adverse impacts in accordance with Article 3, paragraph 14, of the Kyoto Protocol in its annual submission. Although noting that changes have not been reported, the ERT concluded that the information provided continues to be complete and transparent.	§ 63	Issue has been closed due to incorrect assumptions by the reviewer. The wood harvest statistics have been deleted from the NIR. falsche Annahme und Forderung vom Reviewer - Textpassagen zur Holzeinschlagsstatistik wurden aus dem NIR entfernt	-
KP		§ 75	Germany is continuing to work on that issue.	

10.5 Recalculations as a result of the 2016 In-Country Review

In September 2016, the 2015 and 2016 greenhouse-gas inventories were reviewed in the framework of an in-country review. As a result, a number of corrections were made to the inventory. These corrections led to a number of recalculations, including both relatively minor recalculations and some major ones. Ultimately, they also led to the resubmission of 07 November 2016.

In the following section, all of the recalculations made in the framework of the 2016 Resubmission are described, along with the pertinent impacts on the 2016 greenhouse-gas inventory.

The data provided with the resubmission serve as the basis for all of the recalculations described in the context of the individual source categories and in Chapters 10.1 through 10.3.

10.5.1 Impacts, on the entire 2016 inventory, of the recalculations made as a result of the in-country review

For all years, the recalculations led to increases in the total national GHG emissions. For 1990, the increase amounted to 3,727 kt CO₂ equivalents (+0.3 %), while for 2014 it was 1,562 kt CO₂ equivalents. (+0.17 %).

The largest corrections occurred in the CRFs 3 – *Agriculture* and 5 – *Waste & wastewater*. In each of the CRF sub-categories 3.D – *Agricultural soils*, 3.G – *Soil liming*, 5.A – *Solid waste disposal on land* and 5.D – *Wastewater treatment*, the annual emissions levels increased by several hundred kilotonnes of carbon dioxide equivalents.

A correction – a relatively small one – also was made in CRF 3.A – *Enteric fermentation*, and emissions were reallocated from CRF 6 to CRF 2.C – *Metal production*.

As a result, Germany's base-year emissions were corrected, as described below, to 1,253,599,336 tonnes of CO₂ equivalents.

Table 428: Recalculation of base-year emissions, in kt CO₂ equivalents

	not including LULUCF	not including LULUCF, but including indirect CO ₂
indirect CO ₂ (1990)	0	0
CO ₂ (1990)	1,052,238,234	1,052,238,234
CH ₄ (1990)	119,234,770	119,234,770
N ₂ O (1990)	65,188,852	65,188,852
HFCs (1995)	2,606,074	2,606,074
PFCs (1995)	2,085,721	2,085,721
unspecified mix of HFCs & PFCs	5,773,247	5,773,247
SF ₆ (1995)	6,467,150	6,467,150
NF ₃ (1995)	5,290	5,290
base year – not including contributions under Article 3(7bis)	1,253,599,336	1,253,599,336
deforestation cf. Article 3 (7bis)	NA	NA
base year – including contributions under Article 3(7bis)	1,253,599,336	1,253,599,336

Table 429: Overview of corrections made, and of their impacts on reported total national emissions, in kt CO₂ equivalents

	1990	1995	2000	2005	2010	2011	2012	2013	2014
Total national GHG emissions (not including LULUCF) – <i>pursuant to the 2016 Submission of 15 June 2016</i>	1,246,101	1,118,523	1,041,064	989,916	939,372	920,151	924,701	943,520	900,202
Revised categories									
CRF 2 – industrial processes	26.54	16.78	18.62	19.34	15.69	15.23	12.92	13.19	14.02
2.C – Metal production	26.54	16.78	18.62	19.34	15.69	15.23	12.92	13.19	14.02
CRF 3 – Agriculture	2,071.73	771.34	780.86	711.56	705.78	769.10	741.97	775.10	793.40
3.A – Enteric fermentation	12.27	11.39	9.98	9.56	8.35	7.36	7.31	6.98	7.04
3.D – Agricultural soils	780.23	658.99	690.15	655.51	657.84	718.03	693.15	721.08	742.15
3.G – Soil liming	1,279.23	100.96	80.73	46.49	39.59	43.71	41.51	47.04	44.21
CRF 5 – Waste & wastewater	1,655.45	1,649.99	1,449.75	1,221.33	960.85	909.15	894.98	856.07	768.39
5.A – Solid waste disposal on land	725.00	775.00	650.00	500.00	325.00	300.00	300.00	275.00	200.00
5.D – Wastewater treatment	930.45	874.99	799.75	721.33	635.85	609.15	594.98	581.07	568.39
CRF 6 – Other sources / sinks	-26.54	-16.78	-18.62	-19.34	-15.69	-15.23	-12.92	-13.19	-14.02
Total national GHG emissions (not including LULUCF) – <i>pursuant to the 2016 Resubmission of 07 November 2016</i>	1,249,829	1,120,944	1,043,294	991,849	941,039	921,830	926,338	945,151	901,764
Effect of the recalculations – in kt	+3,727.18	+2,421.33	+2,230.61	+1,932.90	+1,666.63	+1,678.26	+1,636.96	+1,631.17	+1,561.78
Effect of the recalculations – in %	+0.3	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2

All of the recalculations made in the *Saturday Letter*, as a result of comments made by the *Expert Review Team*, are described in detail in Chapter 10.5.2 with regard to a) their specific content and b) their impacts on the inventory for the relevant source category in each case and on the inventory as a whole.

Table 430: Impacts of the recalculations on national greenhouse-gas emissions, in kt CO₂ equivalents

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2016 Submission	1,246,186	1,118,523	1,041,064	989,916	997,152	970,186	972,146	904,689	939,372	920,151	924,701	943,520	900,202
2016 Resubmission	1,249,913	1,120,944	1,043,294	991,849	999,044	971,998	973,942	906,423	941,039	921,830	926,338	945,151	901,764
absolute change	3,727	2,421	2,231	1,933	1,892	1,812	1,796	1,735	1,667	1,678	1,637	1,631	1,562
relative change	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%

Table 431: Impacts of the recalculations on national carbon dioxide emissions, in kt

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2016 Submission	1,050,959	938,047	899,204	865,912	877,378	850,750	853,194	788,377	832,220	812,440	816,990	835,746	792,859
2016 Resubmission	1,052,238	938,148	899,285	865,959	877,422	850,796	853,230	788,422	832,259	812,483	817,031	835,793	792,903
absolute change	1,279	101	81	46	45	46	36	45	40	44	42	47	44
relative change	0.122%	0.011%	0.009%	0.005%	0.005%	0.005%	0.004%	0.006%	0.005%	0.005%	0.005%	0.006%	0.006%

Table 432: Impacts of the recalculations on national methane emissions, in kt CO₂ equivalents

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2016 Submission	117,567	103,061	86,188	67,162	63,257	61,054	60,128	57,937	57,123	56,050	56,745	56,112	54,752
2016 Resubmission	119,235	104,722	87,648	68,393	64,446	62,176	61,207	58,948	58,092	56,966	57,647	56,975	55,528
absolute change	1,668	1,661	1,460	1,231	1,189	1,122	1,079	1,011	969	917	902	863	775
relative change	1.4%	1.6%	1.7%	1.8%	1.9%	1.8%	1.8%	1.8%	1.7%	1.6%	1.6%	1.5%	1.4%

Table 433: Impacts of the recalculations on national nitrous oxide emissions, in kt CO₂ equivalents

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2016 Submission	64,409	60,477	42,584	42,987	42,692	44,614	45,088	44,291	36,295	37,629	36,804	37,364	38,038
2016 Resubmission	65,189	61,136	43,274	43,642	43,351	45,258	45,769	44,970	36,953	38,347	37,497	38,085	38,780
absolute change	780	659	690	656	659	644	681	678	658	718	693	721	742
relative change	1.2%	1.1%	1.6%	1.5%	1.5%	1.4%	1.5%	1.5%	1.8%	1.9%	1.9%	1.9%	2.0%

10.5.2 ERT recommendations included in the Saturday Letter, and the resulting recalculations

The following section describes the corrections recommended by the *Expert Review Team (ERT)* that were included in the *Saturday Letter*, along with the pertinent solutions that have been proposed by the inventory preparers (and, to date, not yet assessed by the ERT).

10.5.2.1 N₂O from caprolactam production

(As described under CRF 2.B.4. – Caprolactam, glyoxal and glyoxylic acid production)

To date, no N₂O emissions from flaring of gaseous waste substances have been reported for the two active facilities in Germany that produce caprolactam. "Not applicable" (NA) has been listed for this emissions category, because no pertinent emissions occur.

In the framework of the review, the ERT was informed that both facilities are equipped with a redundant system for thermal post-treatment of waste gas, and that the systems are able to thermally decompose nitrous oxide.

The ERT noted in this regard that the 2006 IPCC Guidelines give the efficiency of such systems as 99 %, and that no proof has yet been provided for the complete decomposition assumed in the reporting. The ERT thus found that the figures reported for N₂O emissions may be underestimations.

To rule out the possibility of such underestimation, the ERT requested Germany to either a) provide proof to the effect that the waste gases are indeed being completely decomposed as assumed, and that the relevant systems have been operating continuously without any malfunctions, or b) calculate the pertinent N₂O emissions on the basis of the methods proposed in the Guidelines.

For one of the two producers, the nitrous oxide emissions from caprolactam production are assigned, in the inventory, to nitric acid production (2.B.2). This is being done to assure consistency with emissions trading data. For this reason, the relevant contributions are listed as *included elsewhere* (IE). For the other producer's system, the ERT's recommendation has been implemented – the expected N₂O emissions have been calculated with the help of the 2006 IPCC Guidelines. In the CRF table, the emissions from that system are listed as *not estimated* (NE), under 2.B.4.a. For further details, cf. Chapter **Fehler! Verweisquelle konnte nicht gefunden werden..**

10.5.2.2 CH₄ from enteric fermentation in sheep

(As reported under CRF 3.A.2 – Enteric fermentation)

The ERT indicated that the implied emission factor (IEF) being reported for methane from enteric fermentation in sheep was too low (6.21 instead of 8 kg CH₄ per sheep and year). That factor results from use of the IPCC default for sheep (8 kg) and a 60 % lower value (3.2 kg) for lambs. The ratio of the EF used for adult sheep to that used for lambs has been derived from a study whose results have not yet been described in the NIR. As a possible alternative to the inadequately justified country-specific approach, the inventory preparers proposed use of a revised EF for lambs – revised in keeping with the IPCC Guidelines – of 3.57 kg CH₄ per lamb and year.

To address the possible emissions underestimation found in the reported methane emissions, the ERT proposed the following alternative approaches:

5. Submission of valid reasons for the use of an EF of 3.2 kg CH₄ per lamb and year, or
6. Submission of a new time series calculated on the basis of the corrected EF (3.57 kg).

As a result, it was decided to use the corrected EF, which leads to an IEF of 6.36 kg CH₄ per sheep and year, or to methane emissions that are higher by an average of about 2.4 %, or 7 to 13 kt:

Table 434: Correction of the GHG emissions reported under 3.A.2, in kt CO₂ equivalents

	1990	1995	2000	2005	2010	2014
2016 Submission	506.0	461.5	428.9	413.9	348.8	294.0
2016 Resubmission	518.2	472.9	438.9	423.4	357.1	301.0
absolute change	12.3	11.4	10.0	9.6	8.4	7.0
relative change	2.43%	2.47%	2.33%	2.31%	2.39%	2.39%

10.5.2.3 Indirect N₂O emissions from managed agricultural soils

(As reported under *CRF 3.(II).D.B – Indirect N₂O emissions from managed soils*)

The country-specific approach, described in the NIR, for calculation of these indirect nitrous oxide emissions, was judged by the ERT as being non-conformal with the Guidelines.

As a result, the emissions were recalculated in keeping with the provisions of the 2006 IPCC Guidelines:

Table 435: Correction of the GHG emissions reported under 3.(II).D.B, in kt CO₂ equivalents

	1990	1995	2000	2005	2010	2014
2016 Submission	3,477.6	3,022.6	3,259.8	3,058.0	2,938.4	3,275.0
2016 Resubmission	4,257.8	3,681.6	3,949.9	3,713.5	3,596.2	4,017.2
absolute change	780.2	659.0	690.2	655.5	657.8	742.2
relative change	22.44%	21.80%	21.17%	21.44%	22.39%	22.66%

10.5.2.4 CO₂ from liming of agricultural soils

(As reported under *CRF 3.(II).G – Liming*)

Due to a lack of differentiated input data, in the German inventory *CO₂ from use of dolomite* is reported as part of *CO₂ from use of limestone*. The ERT noted that in this grouping the EF for pure limestone (0.12 t C / t of material used) is used, instead of a weighted implied emission factor, while the corresponding EF for dolomite inputs (0.13 t C / t) is not used.

As a result of the recalculations, the relevant emissions increased by between 2.0 and 7.7 %, or 36 to 108 kt CO₂ equivalents:

Table 436: Correction of the GHG emissions reported under 3.(II).G, in kt CO₂ equivalents

	1990	1995	2000	2005	2010	2014
2016 Submission	1,424.8	1,643.9	2,144.2	1,680.9	1,698.0	2,198.0
2016 Resubmission	2,704.0	1,744.9	2,224.9	1,727.4	1,737.6	2,242.2
absolute change	1,279.2	101.0	80.7	46.5	39.6	44.2
relative change	89.78%	6.14%	3.76%	2.77%	2.33%	2.01%

10.5.2.5 CH₄ from managed landfills

(As reported under *CRF 5.A.1 – Managed waste disposal sites*)

The German inventory makes use of measurements of the methane content of landfill gas. The ERT found that the inventory's resulting average methane-content figure, 49 %, is not conformal with the Guidelines, and it recommended a recalculation using the pertinent value given by the IPCC (50 %).

This recommendation has been acted on, and a suitably recalculated time series has been presented:

Table 437: Correction of the GHG emissions reported under 5.A.1, in kt CO₂ equivalents

	1990	1995	2000	2005	2010	2014
2016 Submission	33,525	35,100	25,850	18,525	12,200	9,200
2016 Resubmission	34,250	35,875	26,500	19,025	12,525	9,400
absolute change	725.0	775.0	650.0	500.0	325.0	200.0
relative change	2.16%	2.21%	2.51%	2.70%	2.66%	2.17%

10.5.2.6 CH₄ from domestic wastewater

(As reported under CRF 5.D.1 – Domestic wastewater)

To date, the German inventory has used a methane conversion factor (MCF) of 0, which implies that all treatment of domestic wastewater takes place aerobically, and that all methane from anaerobic sewage sludge digestion is collected and used for energy recovery. This approach was to be reviewed, and revised as necessary, via a literature study conducted in preparation for a measurement programme.

After reviewing two pertinent studies, the ERT saw a need for changes with regard to calculation of methane releases from wastewater treatment and via leakages from containers used for sewage sludge digestion.

Although the studies noted that further measurements would be needed to confirm the results they present, those studies were used as a basis for a recalculation. That recalculation shows a methane release of 0.28 kg per capita and year for 2014. An expert assessment taking account of the development and spread of applicable technology has suggested that methane releases would drop by half in the period 1990 through 2020, however.

Use of that assumption, which the ERT has not yet conclusively assessed, leads to a figures of 37.2 kt CH₄ for 1990 and 22.7 kt for 2014:

Table 438: Correction of the GHG emissions reported under 5.D.1, in kt CO₂ equivalents

	1990	1995	2000	2005	2010	2014
2016 Submission	NE	NE	NE	NE	NE	NE
2016 Resubmission	930.5	875.0	799.8	721.3	635.8	568.4
absolute change	930.5	875.0	799.8	721.3	635.8	568.4

10.5.2.7 N₂O from iron and steel production, as reported under CRF 6 – Other

While the NIR 2016 indicates that no emissions are to be reported in *CRF 6 – Other*, the CRF tables in the 2016 Submission include N₂O emissions from CRF 2.C.1 that, due to functionality limitations of the *CRF Reporter* software, were not reported at the appropriate location. In the interest of the inventory's completeness, those emissions were then reported under CRF 6.

Since CRF 6 is not taken into account in the framework of the Kyoto Protocol (only the source categories listed in the annex to the Protocol are included), the ERT found that this approach could lead to underestimation of the total national emissions in the context of further data processing. Furthermore, so the ERT, such possible underestimation could be ruled out only by reallocating the emissions into CRFs 1 through 5.

Specifically, the ERT proposed that they be shifted to CRF 2.C.7 – *Other* or 2.H.3 – *Other*. In keeping with this proposal, the nitrous oxide emissions were shifted to 2.C.7.

Table 439: Reallocation of the GHG emissions most recently reported under CRF 6, in kt CO₂ equivalents

	1990	1995	2000	2005	2010	2011	2012	2013	2014
CRF 2.A	26.54	16.78	18.62	19.34	15.69	15.23	12.92	13.19	14.02
CRF 6	-26.54	-16.78	-18.62	-19.34	-15.69	-15.23	-12.92	-13.19	-14.02

11 Supplementary information required under Article 7, Paragraph 1 of the Kyoto Protocol

11.1 General information

11.1.1 The definition of forest, and any other criteria

The National Forest Inventory is the main data source used, in the forest sector, for determination of activity data and emission factors. Its forest definition, which serves as a basis for the report, is presented in Chapter 6.2.1.

In keeping with Germany's initial report under the Kyoto Protocol (UNFCCC 2007), Germany has defined the following specific parameters for its national forest definition:

Table 440: Definition of "forest" in Germany

Parameter	Range	Selected value
Minimum area of land (minimum area of land)	0.05 – 1.00 ha	0.1 ha
Tree crown cover or equivalent stocking level (tree crown cover or equivalent stocking level)	10 – 30 %	10 %
Potential tree height at maturity (potential tree height at maturity)	2 – 5 m	5 m

Within the range defined by the Marrakesh Accords (c.f. the above range), these parameters are the ones that come closest to the definition used in the National Forest Inventory. As comparative studies have shown, the differences between different activity-data calculations carried out in accordance with the aforementioned parameters are negligible (Tomter et al. 2010).

Pursuant to the Kyoto Protocol (UNFCCC 1998), areas are to be assigned to the activities "afforestation" and "deforestation" if they have been afforested / deforested since 1990. Such areas remain in those assigned categories until the end of the commitment period. As a result, the areas of said categories increase constantly. In the context of greenhouse-gas reporting, short-rotation plantations are not included as forest (cf. Chapter 6.3.2.1), and are reported under cropland.

In general, reforestation requirements apply in Germany (cf. Art. 11 (1) p. 2 Federal Forest Act (BWaldG)), meaning that clear-cut forest areas and thinned forest stands have to be reforested or replenished. Areas that have been afforested since 1990, but temporarily have no forest cover as a result of natural disasters, continue to fall within the definition of forest and must be reforested. No deforestation as a result of natural disasters takes place in Germany.

11.1.2 Elected activities under Article 3 Paragraph 4 of the Kyoto Protocol

In the second commitment period, Germany has to credit *Forest Management (FM)* activities pursuant to Article 3 (4) of the Kyoto Protocol. In addition, Germany is reporting emissions from harvested wood products. Germany has not selected the option *natural disturbances*.

Germany has selected the following voluntary activities under Article 3.4 of the Kyoto Protocol:

- Cropland management (CM)
- Grazing land management (GM).

Germany has opted for accounting at the end of the second commitment period.

11.1.3 Description of how the definitions of each activity under Article 3.3, and each elected activity under Article 3.4, have been implemented and applied consistently over time

11.1.3.1 Afforestation, reforestation and deforestation (ARD)

The definitions used by Germany for afforestation, reforestation and deforestation are in accordance with the Marrakesh Accords (MA). Pursuant to the MA, afforestation is defined as "the direct human-induced conversion of land that has not been forested for a period of at 50 years to forested land through planting, seeding and / or the human-induced promotion of natural seed sources"¹⁸¹. Reforestation differs from afforestation solely with regard to the time since the area was last forested and, pursuant to the IPCC, occurs on land that has not been forest since 31 December 1989¹⁸². Since the reporting period for Germany begins with base year 1990, and since adequate data for differentiation of land-use forms are available only for the period as of 1970, afforestation and reforestation are considered together in the present context (and hereafter are both referred to as afforestation). Afforestation means the establishment of trees on abandoned land, if the relevant rejuvenation suffices for producing forest in accordance with the national forest definition. In general, the time of afforestation is the time at which the first activity in the relevant regeneration process was carried out. In the case of spontaneous regeneration of trees, the time of afforestation is considered to be the time at which the national criteria for the forest definition have been met, i.e. when the natural forest cover has reached an average age of five years, and a crown cover of at least 50 % (cf. Chapter 6.2.1).

The afforestation category corresponds to the following categories in reporting under the UN Framework Convention on Climate Change:

Table 441: Afforestation in KP and UNFCCC categories

Category for KP reporting	Category pursuant to UNFCCC
Afforestation under Art. 3.3 KP	4.A.2.1 Cropland converted to forest land

¹⁸¹ "Afforestation is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources." (IPCC KP Supplements (2014))

¹⁸² Original: "Reforestation" is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, Reforestation activities will be limited to Reforestation occurring on those lands that did not contain forest on 31 December 1989. (IPCC KP Supplements (2014))

4.A.2.2. Grassland converted to forest land	4.A.2.2.1 Grassland (in a strict sense – i.t.s.s.) converted to forest land
	4.A.2.2.2 Woody grassland converted to forest land
4.A.2.3. Wetlands converted to forest land	4.A.2.3.1 Wetlands (terrestrial) converted to forest land
	4.A.2.3.2 Waters converted to forest land
4.A.2.4. Settlements converted to forest land	
4.A.2.5. Other land converted to forest land	

The IPCC defines deforestation as "the direct human-induced conversion of forested land to non-forested land"¹⁸³. In accordance with the provisions of the IPCC, harvest that is followed by regeneration is not considered deforestation, since harvest is a forest-management activity pursuant to Art. 3.4. This definition also does not include "forest cover loss resulting from natural disturbances, such as wildfires, insect epidemics or wind storms", since "in most cases these areas will regenerate naturally or with human assistance". Such areas also fall within the category of managed land pursuant to Art. 3.4 or, if the areas are afforested land, within the category of afforested land pursuant to Art. 3.3.

Where, since 1990, human activities have however taken place on such areas temporarily without forest cover – activities such as road construction, settlement construction or other forms of land use (management of grassland or wetlands) – with the result that forest regeneration is prevented, then, so the IPCC, the areas must be considered deforested.

The deforestation category corresponds to the following categories in reporting under the UN Framework Convention on Climate Change:

Table 442: Deforestation in KP and UNFCCC categories

Category in KP reporting	Category pursuant to UNFCCC
	4.B.2.1. Forest land converted to cropland
	4.C.2.1. Forest land converted to grassland
	4.C.2.1.1 Forest land converted to grassland (i.t.s.s.)
	4.C.2.1.2 Forest land converted to woody grassland
Deforestation under Art. 3.3 KP	4.D.2.1.1 Forest land converted to wetlands (terrestrial)
	4.D.2.1.2 Forest land converted to waters
	4.E.2.1. Forest land converted to settlements
	4.F.2.1. Forest land converted to other land (NO)

NO: not occurring

¹⁸³ Original: "Deforestation" is the direct human-induced conversion of forested land to non-forested land (IPCC KP Supplements (2014))

11.1.3.2 Forest management (FM)

In Germany, all forest areas that have been forest since 1990 are considered managed within the meaning of the Marrakesh Accords¹⁸⁴ and are reported under *forest management*¹⁸⁵ pursuant to Art. 3.4 KP. A detailed pertinent description is presented in Chapter 11.5.1.

Table 443: Forest management in KP and UNFCCC categories

Category in KP reporting	Category pursuant to UNFCCC
Forest management pursuant to Art. 3.4 KP	4.A.1 Forest land remaining forest land

Since every land-use change to forest is considered afforestation, every land-use change from forest land to a different land-use category is considered deforestation, and all forest areas not afforested are subject to forest management, there is no possibility that the manner in which the relevant definitions are applied could change over time.

The emissions contribution from harvested wood products in Germany, in terms of greenhouse emissions from sources and removals in sinks, in the land-use sector, was estimated with the help of the WoodCarbonMonitor model, via a calculation approach based on wood-product production data. The estimate covers all wood products that are produced in Germany, that consist of wood that originates from trees harvested in Germany and that are used for their material (not energy) value.

11.1.3.3 Cropland management (CM)

Cropland management (CM) is agricultural use of land for cultivation of field crops (such as grain, pulses, root crops) and berries (such as strawberries); of garden land for cultivation of vegetables, fruit and flowers and for culturing of crops; and of special crop areas, for cultivation of certain plants (such as hops, wine grapes, fruit in orchards). Cropland management includes annual crops and permanent crops such as wine grapes, fruit trees, Christmas trees and short-rotation plantations. Permanent crops do not fall within the German definition of forest.

The definition of cropland management is in keeping with the definition of areas under cropland as used for reporting under the UN Framework Convention on Climate Change (cf. Chapter 6.2 and Table 329).

The afforestation category corresponds to the following categories in reporting under the UN Framework Convention on Climate Change:

¹⁸⁴ Paragraph 1 lit. f of Annex A of Decision 16/CMP.1

¹⁸⁵ Original: "'Forest management' is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner." (IPCC KP Supplements (2014))

Table 444: Afforestation in KP and UNFCCC categories

Category in KP reporting	Category pursuant to UNFCCC
Cropland management pursuant to Art. 3.4 KP	4.B.1 Cropland remaining cropland
	4.B.2.2.1 Grassland (in the strict sense) converted to cropland
	4.B.2.2.2 Woody grassland converted to cropland
	4.B.2.3.1 Wetlands (terrestrial) converted to cropland
	4.B.2.3.2 Waters converted to cropland
	4.B.2.4 Settlements converted to cropland
	4.B.2.5 Other areas converted to cropland
	4.C.2.2.2 Cropland converted to woods ¹⁾
	4.D.2.2.3 Cropland converted to terrestrial wetlands ³⁾
	4.D.2.2.2 Cropland converted to wetlands ⁴⁾
	4.E.2.2 Cropland converted to settlements ⁵⁾
	4.F.2.2 Cropland converted to other areas (NO) ⁶⁾

Numbers: 1), 2), 3), 4), 5) emissions and removals are listed as zero (IPCC KP Supplement (2014) Chap. 2.9.2).

Footnote 6) NO: Not occurring

All areas under cropland management are subject to periodic cultivation measures, and thus the pertinent emissions and removals are anthropogenic.

11.1.3.4 Grazing land management (GM)

Grazing land management (GM) is the use of grassland in the strict sense as meadows, pastures, mountain pastures, rough pastures, heath land, natural grassland, recreational areas or swamps/marshes.

The definition of grazing land management is in keeping with the definition of areas under grassland (in the strict sense) as used for reporting under the UN Framework Convention on Climate Change (cf. Chapter 6.2 and Table 329).

The grazing land management category corresponds to the following categories in reporting under the UN Framework Convention on Climate Change:

Table 445: Grazing land management in KP and UNFCCC categories

Category in KP reporting	Category pursuant to UNFCCC
Grazing land management pursuant to Art. 3.4 KP	4.C.1.1 Grassland (in the strict sense) remaining as Grassland (i.t.s.s.)
	4.C.2.2.1 Cropland converted to grassland (i.t.s.s.)
	4.C.1.3 Woody grassland converted to grassland (i.t.s.s.)
	4.C.2.3.1 Wetlands converted to grassland (i.t.s.s.)
	4.C.2.3.3.1 Terrestrial wetlands converted to grassland (i.t.s.s.)
	4.C.2.3.2.1 Waters converted to grassland (i.t.s.s.)
	4.C.2.4.1 Settlements converted to grassland (i.t.s.s.)
	4.C.2.5.1 Other areas converted to grassland (i.t.s.s.)
	4.C.1.4 Grassland (i.t.s.s.) converted to woody grassland ¹⁾
	4.D.2.3.1.3 Grassland (i.t.s.s.) converted to terrestrial wetlands ³⁾
	4.D.2.3.1.2 Grassland (i.t.s.s.) converted to waters ⁴⁾
	4.E.2.3.1 Grassland (i.t.s.s.) converted to settlements ⁵⁾
	4.F.2.3.1 Grassland (i.t.s.s.) converted to other areas ⁶⁾

Numbers 1), 2), 3), 4), 5) emissions and removals are listed as zero (IPCC KP Supplement (2014) Chap. 2.9.2).

Footnote 6) NO: Not occurring

All areas under grazing land management are subject to periodic cultivation measures, and thus the pertinent emissions and removals are anthropogenic.

11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, how they have been consistently applied in determining how land was classified

Germany has defined the hierarchy of activities relative to Art. 3.4 of the Kyoto Protocol pursuant to the provisions of the 2013 IPCC KP Supplement (IPCC 2014). The activity *forest management* is binding, and thus has priority over the voluntary activities *cropland management* and *grazing land management*. In the first commitment period, Germany selected *forest management* voluntarily. The hierarchy makes it possible to carry out consistent reporting for the first and second commitment periods.

Pursuant to the provisions of the 2013 IPCC KP Supplement (IPCC 2014), forest management (FM) can take place only on lands that meet the definition of forest. The forest areas reported under FM are the forest areas reported, pursuant to the Convention, under *forest land remaining forest land*, except for areas assigned either to the categories of conversion leading to forest land (Convention) or to the category of afforestation (Kyoto Protocol). The total forest area under the Convention and the total forest area under the Kyoto Protocol are the same. All German forest lands are considered managed within the meaning of the provisions of the Marrakesh Accords. The definition of forest management is broadly interpreted (cf. for a detailed discussion Chapter 11.5.1).

Within the group of voluntary activities, allocations to *cropland management* have priority over allocations to *grazing land management*. Agricultural grass within the context of crop rotations is allocated to cropland management. By contrast, permanent land-use changes from cropland to grassland (in the strict sense), and vice-versa, are reported as activity changes from cropland management to grazing land management, and vice-versa. As a result, the land classifications for cropland management and grazing land management are in keeping with the inventory's classifications of cropland and grassland (in the strict sense) under the UNFCCC.

11.2 Land-oriented information

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

The method used to derive activity data (areas) is described in Chapter 6.3. It corresponds to Approach 3 pursuant to the 2006 IPCC Guidelines (IPCC 2006). The reference area is Germany; it comprises 35,779.63 kha. The areas in the "forest" land-use form, and their additions and removals, are derived primarily from the point data of the National Forest Inventories (BMELV 2005). For the new German Länder in 1990, the BWI data are supplemented with CIR data. A detailed description of land-use-classification procedures is provided in Chapter 6.2, while a description of the procedures for derivation of the land-use matrix (LUM) is provided in Chapter 6.3.

Thanks to the use of a consistent method for derivation of the LUM, the same spatial assessment unit is used for deforestation areas as is used for afforestation areas.

11.2.2 Method used to develop the land-transition matrix

The method used to define forest areas, and to derive areas for the "change" classes, is described in detail in Chapter 6.3. Table 446 provides an overview of land-use changes leading to forest land (afforestation/reforestation), of land-use changes leading away from forest land (deforestation), and of managed areas (forest management). Conversion areas remain in the conversion category until the end of the 2nd commitment period of the Kyoto Protocol, 2020; for this reason, the annual areas accumulate. In Table 446, the column for the accumulated areas lists those areas as they are reported. An adjacent column shows the corresponding annual areas.

Table 446: Accumulated and annual areas in the categories afforestation, deforestation and forest management

Year	Afforestation/ Reforestation (KP 3.3) [kha]		Deforestation (KP 3.3) [kha]		Forest Management (KP 3.4) [kha]	
	Accumulated areas	Annual areas	Accumulated areas	Annual areas	Accumulated areas	Annual areas
1990	27,619	27,619	12,539	12,539	10,901,001	10,901,001
1995	165,712	27,619	75,235	12,539	10,838,306	10,976,399
2000	303,806	27,619	137,931	12,539	10,775,610	11,051,797
2005	380,558	15,350	185,033	9,420	10,728,508	11,093,715
2006	395,605	15,048	196,348	11,315	10,717,193	11,097,751
2007	410,653	15,048	207,662	11,315	10,705,878	11,101,483
2008	425,701	15,048	218,977	11,315	10,694,563	11,105,216
2009	442,258	16,557	229,983	11,005	10,683,558	11,109,258
2010	458,815	16,557	240,988	11,005	10,672,552	11,114,810
2011	475,372	16,557	251,994	11,005	10,661,547	11,120,362
2012	491,930	16,557	262,999	11,005	10,650,541	11,125,914
2013	506,001	14,071	270,808	7,809	10,642,732	11,134,662
2014	520,072	14,071	278,617	7,809	10,634,924	11,140,924
2015	534,142	14,071	286,425	7,809	10,627,115	11,147,187

The method used to define cropland and grassland areas, and to derive areas for the "change" classes, is described in detail in Chapter 6.3. In Table 447, the areas under Cropland Management

and Grassland Management are summarised for the base year 1990 and for the years 2013 through 2015. In the base years, the land-use changes in the period 1970 through 1990 are included, except those consisting of land-use changes leading to forest land. For purposes of methodological consistency with KP Art. 3.3, those changes have been recorded cumulatively, since 1990, as afforestation. The areas are divided into the categories

- Cropland remaining Cropland and Grassland remaining Grassland (in the strict sense)
- Land-use changes leading to Cropland or to Grassland (in the strict sense) (except for Forest Land)
- Land-use changes from Cropland, and from Grassland (in the strict sense), to land-use categories that are not included in other activities under KP Art. 3.3. or 3.4.

In the case of land-use changes from Cropland, and from Grassland (in the strict sense), to land-use categories that are not included in other activities under KP Art. 3.3. or 3.4, the following procedure is used: in keeping with the IPCC 2013 KP Supplements (IPCC 2014), Chap. 2.9.2, that area is reported that has been converted from Cropland or Grassland (in the strict sense) to other use categories. Pursuant to the IPCC 2013 KP Supplements (IPCC 2014), Chapter 2.9.2, the emissions from those areas are accounted as zero.

Table 447: Overview of areas under Cropland Management and Grazing-Land Management in the base year 1990 and in the years 2013 through 2015

Sub-categories	Cropland Management (CM)				Grazing Land Management (GM)			
	Area, 1990 [ha]	Area, 2013 [ha]	Area, 2014 [ha]	Area, 2015 [ha]	Area, 1990 [ha]	Area, 2013 [ha]	Area, 2014 [ha]	Area, 2015 [ha]
...land remaining	12,587,710	12,384,320	12,384,003	12,383,686	5,808,654	5,149,747	5,115,939	5,082,131
...land Total for								
LUC to	1,041,719	1,056,200	1,055,614	1,055,027	903,073	636,746	614,702	592,659
...land Total for								
LUC from	462,690	1,145,473	1,176,501	1,207,529	224,550	600,043	619,565	639,087
...land								
Total	14,092,119	14,585,993	14,616,117	14,646,242	6,936,277	6,386,536	6,350,206	6,313,877

11.2.3 Maps and/or databases to identify the geographical locations, and the pertinent system of identification codes for the geographical locations

The following data sources were used in determination of activity data:

- National Forest Inventory 1987 (Bundeswaldinventur; BWI 1987)
- National Forest Inventory 2002 (Bundeswaldinventur; BWI 2002)
- National Forest Inventory 2012 (Bundeswaldinventur; BWI 2012)
- Inventory Study 2008 (Inventurstudie; IS08)
- Maps, derived from CIR data, from the mapping of biotopes and use types carried out for 1990,
- Official topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem; ATKIS®)
- CORINE Land Cover (CLC)
- Soil map for the Federal Republic of Germany 1:1,000,000 (Bodenübersichtskarte der Bundesrepublik Deutschland; BÜK 1000; BGR 1997)
- Map of Germany's organic soils (ROSSKOPF et al., 2015)
- Forest-fire statistics of the Federal Republic of Germany

Detailed descriptions of the data sources are presented in Chapters 6.4.2.1 and 6.3.2.1.

All afforestation and deforestation are accounted for under Article 3.3 and are not listed under forest management, cropland management and grazing land management pursuant to Article 3.4. The changes in areas between the measures pursuant to Article 3.3 and to Article 3.4 are listed in KP table NIR 2. The method for deriving areas uses a sample-based system that records the area for each land-use category and the land-use changes to and from the various land-use categories (cf. Chapter 6.3). The sampling network used is based on the grid for the BWI 2012. Each sample point is proportionally assigned to the land-use categories forest management, afforestation and deforestation, cropland management and grazing land management. In the categories afforestation and deforestation, no changes of pertinent sample-point proportions into other land-use categories can take place. Each proportion of a sample point corresponds to an area. Such an area's geographic position is determined in terms of the pertinent sample-point coordinates. This identification system ensures that differentiation between a) afforested and deforested areas under KP Article 3.3 and b) forest management, cropland management and grazing land management areas under KP Article 3.4 is unambiguous.

11.3 Activity-specific information

11.3.1 Methods for determination of carbon-stock changes, greenhouse-gas emissions and reduction estimates

11.3.1.1 Description of methodologies and the underlying assumptions used

11.3.1.1.1 Summary

Most of the descriptions of methods are presented in Chapter 6, which discusses the issue of reporting for the UN Framework Convention on Climate Change.

Forest management and afforestation

As described in Chapter 11.1.3, the activities forest management and afforestation in the Kyoto Protocol are equivalent to the UNFCCC categories 4.A.1 Forest Land remaining Forest Land and 4.A.2 Land converted to Forest Land, respectively. For this reason, in the following chapters methodological information relative to these categories is usually provided via referencing to Chapter 6; additional methodological descriptions are provided largely only for the area of deforestation.

Deforestation

For the period 1987 to 2002 in the old German Länder, and for the period 2002 to 2012 in all German Länder, up-scaling was carried out for this category on the basis of individual-tree data from the National Forest Inventories and from the Inventory Study (samples, Tier 2). In addition, the biomass carbon stocks for deforested areas were estimated (cf. Chapter 11.3.1.1.2). The carbon stocks of the old German Länder, in this category for the period from 1987 to 2002, were applied to the "forest land converted to other land" areas in the new German Länder, since the Datenspeicher Waldfonds forest database does not provide any information in this regard. As of the year 2013, the results for the period 2002 through 2012 are carried forward. All in all, carbon stocks of $-54.66 \text{ t C ha}^{-1}$ were lost from biomass (not including the biomass of the converted land) via deforestation in 2015. As a simplification, it was assumed that carbon stocks are emitted into the atmosphere in the year in which the land is converted.

The implied emission factors derived from biomass losses, and from the areas calculated for each relevant year since 1987, decreased continuously, for purposes of reporting under the Kyoto Protocol, from 1990 to 2015. This is due solely to the fact that the relevant areas remain in the

deforestation category (activity) as of 1990, with the result that the total area increases in each report year. Table 448 illustrates this effect with the example of decreasing above-ground biomass in connection with deforestation. Along with decreasing biomass, increasing biomass in the new land-use category has to be taken into account. Such increasing biomass is offset against the relevant decreasing biomass.

Table 448: Annual and accumulated deforested areas, and annual and implied emission factors for decreasing above-ground forest biomass; positive: carbon sink; negative: carbon emissions

		1990	2000	2010	2014	2015
Deforested area [ha]	Annually	12,539	12,539	11,005	7,809	7,809
	Accumulated	12,539	137,931	240,988	278,617	286,425
Emission factor [t C ha⁻¹]	Annually	-24.53	-24.53	-46.48	-46.48	-46.48
	Accumulated	-24.53	-2.23	-2.12	-1.30	-1.27

In addition to losses of biomass in connection with conversion of forest land, other types of losses must be considered as well, including losses in the areas of dead wood, litter, mineral soils and organic soils. In the case of biomass, dead wood and litter, it is assumed that the pertinent losses take the form of emissions in the year of conversion. Emissions from organic soils take place each year on the entire deforested area. For mineral soils, a transition time of 20 years is assumed. An overview of the carbon losses from deforestation, and from deforestation areas, for the year 2015 is provided in Table 449.

Table 449: Deforested areas and deforestation-related carbon-stock losses from biomass (including the biomass of the converted land), dead wood, litter and mineral and organic soils, for the year 2015; positive: carbon sink; negative: carbon emissions

Pool	Carbon-stock loss [GgC]
Biomass	-316.026
Dead wood	-15.505
Litter	-145.925
Mineral soils	34.879
Organic soils	-120.108
Total	-562.684
Deforested area [ha]	
Annual	7,809
Accumulated	286,425

Cropland management

- Methodologically, the activity cropland management corresponds to the UNFCCC categories 4.B.1 and 4.B.2, with the exception of 4.B.2.1 Forest land converted to cropland. In keeping with the IPCC 2013 KP Supplements (IPCC 2014), Chap. 2.9.2, emissions and removals on areas converted from cropland to non-credited land-use categories are credited as zero. The relevant calculation methods are as follows:
- Changes in carbon stocks in above-ground and below-ground biomass: Chapter 6.5.2.1,
- Carbon-stocks change in mineral soils: Chapter 6.5.2.2,
- CO₂, CH₄ and N₂O emissions from drained organic soils: Chapter 6.5.2.3,
- Direct and indirect N₂O emissions from humus losses connected to land-use changes: Chapter 6.1.2.1.2

The carbon pools dead wood and litter occur only on forest land; they do not occur in cropland management (NO), since land-use changes from forest land to cropland are accounted under

deforestation. N₂O emissions from organic soils under cropland are reported not under the cropland management activity pursuant to Art. 3.4, but as part of the agricultural sector.

Table 450 provides an overview for 2015 of carbon-stock changes, and of greenhouse-gas emissions, in connection with cropland management.

Table 450: Carbon-stock and greenhouse-gas emissions as a result of cropland management, for the year 2015

Sub-categories	C-stock changes in biomass, 2015 ¹⁸⁶ [kt C]	C-stock changes in mineral soils, 2015 ⁷⁹ [kt C]	CO ₂ from organic soils, 2015 ⁷⁹ [kt C]	CH ₄ from organic soils, 2015 ¹⁸⁷ [kt CH ₄]	Direct and indirect N ₂ O from decomposition of organic material in mineral soils, 2015 ⁸⁰ [kt N ₂ O]	Total, 2015 ^{80/188} [kt CO ₂ -eq.]
Cropland remaining cropland	14.13	NO	-2,074.11	6.66	NO	7,719.70
Total for LUC to cropland	-34.21	-762.42	-979.16	3.14	1.16	6,936.53
Total for LUC from cropland	NO	NO	NO	NO	NO	NO
Total	-20.8	-762.42	-3,053.27	9.80	1.16	14,656.22

The emissions from cropland management in 2015 are dominated by CO₂ from organic soils. Carbon losses from mineral soils, as a result of conversions of grassland (in the strict sense) to cropland, are also significant.

In 2015, the net emissions from cropland management were lower than they were in the base year 1990 (cf. Table 466), with the result that a net emissions reduction of 1,987.58 kt CO₂-eq. can be credited in 2015. The majority of this results from an increase of cropland areas on organic soils. It also originates in mineral soils, however – especially in connection with grassland tillage. These effects offset, far and away, the decrease in the (still-positive) emissions from the sub-categories settlements and wetlands to cropland since 1990.

Greenhouse-gas emissions and removals from land-use changes from cropland to activities that are not accounted (terrestrial wetlands, waters, settlements) are reported, pursuant to the IPCC 2013 KP Supplements (IPCC 2014), Chap. 2.9.2, as zero. Consequently, no pertinent emissions have been reported.

Grazing land management:

Methodologically, the activity grazing land management corresponds to the sub-categories of grassland (in the strict sense) (4.C.1.1 and land-use changes to grassland (in the strict sense), except for changes from forest land to grassland (in the strict sense)). In keeping with the IPCC 2013 KP Supplements (IPCC 2014), Chap. 2.10.2, emissions and removals on areas converted from grassland (in the strict sense) to non-accounted land-use categories are accounted as zero. The relevant calculation methods are as follows:

- Changes in carbon stocks in above-ground and below-ground biomass: Chapter 6.6.2.2,
- Carbon-stocks change in mineral soils: Chapter 6.6.2.3,
- CO₂, CH₄ and N₂O emissions from drained organic soils: Chapter 6.6.2.4,
- Direct and indirect N₂O emissions from humus losses connected to land-use changes: Chapter 6.1.2.1.2

¹⁸⁶ Stock change, positive: carbon sink; negative: carbon source

¹⁸⁷ GHG emissions, positive: GHG source; negative: GHG sink

¹⁸⁸ Not including N₂O emissions from organic soils; they are reported as part of the agricultural sector

The carbon pools dead wood and litter occur only on forest land; they do not occur in grazing land management (NO), since land-use changes from forest land to grassland (in the strict sense) are accounted under deforestation.

Table 451 provides an overview for 2015 of carbon-stock changes, and of greenhouse-gas emissions, in connection with grazing land management. N₂O emissions from organic soils under cropland are reported not under the grazing land management activity pursuant to Art. 3.4, but as part of the agricultural sector.

Table 451: Carbon-stock and greenhouse-gas emissions as a result of grazing land management, for the year 2015

Sub-categories	C-stock changes in biomass, 2014 ¹⁸⁹	C-stock changes in mineral soils, 2014 ⁸²	CO ₂ from organic soils, 2014 ⁸²	CH ₄ from organic soils, 2014 ¹⁹⁰	Direct and indirect N ₂ O from decomposition of organic material in mineral soils, 2014 ⁸³	Total, 2014 ^{83/191}
	[kt C]	[kt C]	[kt C]	[kt CH ₄]	[kt N ₂ O]	[kt CO ₂ -eq.]
Grassland (in the strict sense) remaining as Grassland (i.t.s.s.)	0	0	-6,071.44	18.87	0	22,733.70
Total for LUC to grassland (in the strict sense)	-38.43	467.88	-308.45	0.96	0	-419.69
Total for LUC from grassland (in the strict sense)	0	0	0	0	0	0
Total	-38.43	467.88	-6,379.89	19.83	0	22,314.01

Almost all of the emissions from grazing land management in 2015 come from drained organic soils. Those emissions are slightly offset by the carbon sink resulting in mineral soils following land-use changes.

In 2015, the net emissions from grazing land management were lower than they were in the base year 1990 (cf. Table 467), with the result that a net emissions reduction of -3,612.48 kt CO equivalents can be credited in 2015. Most of that reduction is due to decreases of the grassland areas on organic soils. The relevant emissions reduction since 1990 (- 14 %) offsets, far and away, the reduction of the sink function for mineral soils (-30 %), during the period covered by the report, due to the absolute size difference involved.

Greenhouse-gas emissions and removals from areas with land-use changes to activities that are not accounted (terrestrial wetlands, waters, settlements) are reported, pursuant to the IPCC 2013 KP Supplements (IPCC 2014), Chap. 2.10.2, as zero. Consequently, no pertinent emissions have been reported.

11.3.1.1.2 Biomass

Forest management and afforestation:

Information on methods used for calculating carbon stocks, and carbon-stock changes, in above-ground and below-ground biomass is presented in the following chapters:

- Forest Land remaining Forest Land, cf. Chapter 6.4.2.2.1.
- Land converted to Forest Land cf. Chapter 6.4.2.2.2.

Additional methodological descriptions are presented in the following chapters:

¹⁸⁹ Stock change, positive: carbon sink; negative: carbon source

¹⁹⁰ Emissions, positive: GHG source; negative: GHG sink

¹⁹¹ Not including N₂O emissions from organic soils; they are reported as part of the agricultural sector

- Derivation of individual-tree biomass, cf. Chapter 6.4.2.2.3.
- Conversion to above-ground individual-tree biomass, cf. Chapter 6.4.2.2.4.
- Conversion to below-ground biomass, cf. Chapter 6.4.2.2.5.
- Conversion of individual-tree biomass to carbon, cf. Chapter 6.4.2.2.6
- Procedures for scaling up to relevant states in 1987, 2002 and 2008, cf. Chapter 6.4.2.2.7.
- With regard to up-scaling procedures for stock changes, using the "stock-difference method," cf. Chapter 6.4.2.2.8.
- Interpolation of time periods, to obtain annual-change estimates, cf. Chapter 6.4.2.2.9.

Deforestation:

With regard to deforested areas, an individual-tree calculation was carried out on the basis of the BWI (NFI) 1987, BWI 2002 and BWI 2012 inventories. The data of the 2008 Inventory Study were not taken into account, due to the small size of that survey's sample of trees on deforestation areas. For the period between the BWI 1987 and BWI 2002 inventories, only trees in the old German Länder were considered, since the BWI 1987 inventory was carried out only there. The wood-stocks data for the old German Länder were applied to the new German Länder. The emission factor for the decreasing above-ground and below-ground biomass for the period 1990 through 2001 is $-28.93 \text{ t C ha}^{-1} \text{ a}^{-1}$. For the period as of 2002, an individual-tree calculation, spanning the BWI 2002 and BWI 2012 inventories, was carried out for Germany as a whole. The emission factor for the decreasing above-ground and below-ground biomass for the period 2002 through 2015 is $-54.66 \text{ t C ha}^{-1} \text{ a}^{-1}$. The carbon stocks released upon deforestation are counted, completely, as emissions in the same year. The stocks in the following use classes are listed for the relevant conversion year, on a one-time basis, under "gains" in the CRF table. They are thus taken into account.

Cropland management:

Information on methods used for calculating carbon stocks, and carbon-stock changes, in above-ground and below-ground biomass is presented in Chapter 6.5.2.1, divided into the following categories:

- Permanent crops (perennial crops) – cf. Chapter 6.1.2.3.
- For annual crops that are taken into account in connection with land-use changes, cf. Chapter 6.1.2.3.3. The biomass stocks are calculated from annual cultivation and yield statistics, in a manner consistent with the method used in Chapter 5 (agriculture) to calculate N inputs from crop residues.
- For aggregation of the biomass figures, cf. Chapter 6.5.2.1.

Grazing land management:

Information on methods used for calculating carbon stocks, and carbon-stock changes, in above-ground and below-ground biomass is presented in Chapter 6.6.2.2.

11.3.1.1.3 Dead wood

Forest management and afforestation:

Information on methods used for calculating carbon stocks and carbon-stock changes in dead wood is presented in the following chapters:

- Forest Land remaining Forest Land, cf. Chapter 6.4.2.3.1.
- Land converted to Forest Land cf. Chapter 6.4.2.3.2.

Deforestation:

The C stocks in dead wood were calculated with data of the BWI 2002 survey, the 2008 Inventory Study (IS08) and the BWI 2012. In the BWI 2002, terrestrial sampling was limited to dead wood with a diameter > 20 cm at its thicker end, for fallen dead wood, or with a DBH > 20 cm, for standing dead wood (BMVEL 2001). For other sampling, the boundary used conformed to the provisions for climate reporting, i.e. was > 10 cm.

For the dead-wood diameter class > 20 cm, the change in dead-wood C stocks was calculated with the data of the BWI 2002 and 2012, for the period 2002 through 2012. For the diameter class 10 cm through 20 cm, the change was calculated for the period 2008 through 2012, with the data of the IS08 and the BWI 2012. For the same diameter class in the period 2002 through 2008, the ratio of the two diameter classes' changes in dead-wood C stocks for the period 2008 through 2012 was used as a basis. The mean value for the change in dead-wood C stocks in the period 2002 through 2012 was used as the change in such stocks for the period 1990 through 2002. Table 452 presents the changes in dead-wood C stocks for the different relevant periods and diameter classes. For the period as of the year 2013, the emission factor for the period 2008 through 2012 has been extrapolated. In each case of deforestation, the carbon stocks in dead wood, for the relevant year, were taken into account immediately as carbon emissions.

Table 452: Emission factors (EF) for dead wood for the periods 1990-2001, 2002-2007 and 2008-2012

t C ha ⁻¹ a ⁻¹	1990 - 2001	2002 - 2007	2008 - 2012
EF dead wood, total	-1.884	-1.817	-1.986
EF dead wood, diameter class > 20cm	-1.298	-1.298	-1.298
EF dead wood, diameter class 10 through 20cm	-0.586	-0.519	-0.687

Cropland management and grazing land management:

Dead wood does not occur in connection with cropland management and grazing land management. Dead wood and tree cuttings are removed from areas with permanent crops. Such measures have already been taken into account in the biomass calculation.

11.3.1.1.4 Litter**Forest management and afforestation:**

Information on methods used for calculating carbon stocks and carbon-stock changes in litter is presented in the following chapters:

- Forest Land remaining Forest Land, cf. Chapter 6.4.2.4.1.
- Land converted to Forest Land cf. Chapter 6.4.2.4.2.

Additional methodological descriptions are presented in the following chapters:

- Derivation of litter carbon stocks in 1990 (BZE I) and 2006 (BZE II), cf. Chapter 6.4.2.4.3.
- Derivation of carbon-stock changes in litter in the period from 1990 (BZE I) to 2006 (BZE II), cf. Chapter 6.4.2.4.4.

Deforestation:

Calculations relative to the litter ground cover were carried out with the status data of the BZE I and BZE II forest soil inventories. According to the relevant calculations, the average carbon stocks in litter amounted to 19.05 t C ha⁻¹ in 1990 (BZE I) and to 18.83 t C ha⁻¹ in 2006 (BZE II). For the years 1991 through 2005, the stocks were derived by interpolating the status data for the years 1990 and 2006. For the period as of 2007, the stocks were obtained via extrapolation. In each case

of deforestation, the carbon stocks in litter, for the relevant year, were taken into account immediately as carbon emissions.

Cropland management and grazing land management:

Litter does not occur in connection with cropland management and grazing land management, and it is included in the relevant biomass pool.

11.3.1.1.5 Mineral soils

Forest management:

- Information on methods used for calculating carbon stocks and carbon-stock changes in mineral soils of the "Forest Land remaining Forest Land" area is provided in Chapter 6.4.2.5.1.

Additional methodological descriptions are presented in the following chapters:

- Derivation of carbon stocks and carbon-stock changes, cf. Chapter 6.4.2.5.3.
- Results of derivation of carbon stocks and carbon-stock changes, cf. Chapter 6.4.2.5.4.

Afforestation and deforestation:

For each land-use-change category, the carbon-stock changes in mineral soils are calculated as the difference between the carbon stocks of the final land-use category and the carbon stocks of the original land-use category. Pursuant to the IPCC Guidelines (IPCC 1996b, 2003, 2006), the total changes are linearly distributed over a period of 20 years (cf. Chapter 6.1.2.1). For afforested and deforested areas, the carbon-stock changes in mineral soils were calculated in keeping with the procedures in Table 453 and Chapter 19.4.2. For each relevant year, the forest-soil carbon stocks were calculated via linear interpolation of the results of the forest-soil surveys.

Table 453: Implied emission factors (IEF) [$\text{t C ha}^{-1} \text{ a}^{-1}$] for mineral soils in the source categories afforestation and deforestation (negative = emission, positive = removal)

[$\text{t C ha}^{-1} \text{ a}^{-1}$]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
KP 3.3														
Afforestation/ Reforestation	-0.608	-0.558	-0.509	-0.478	-0.466	-0.455	-0.443	-0.440	-0.399	-0.361	-0.326	-0.297	-0.270	-0.245
KP 3.3														
Deforestation	0.454	0.405	0.356	0.343	0.334	0.326	0.317	0.304	0.266	0.232	0.202	0.176	0.153	0.131

Cropland management:

The mineral soils category is subdivided by land use, soil type / soil-parent-rock groups and climate region (cf. Chapter 19.4.2.2). Information on methods used for calculating carbon stocks and carbon-stock changes in mineral soils is presented in Chapter 6.5.2.2 and Chapter 6.1.2.1.1.

For areas remaining as cropland, national measurements show no change in carbon stocks in mineral soils. The constancy of carbon stocks since the early 1990s is evidenced by the results obtained on 140 regional long-term-trial areas (HÖPER und SCHÄFER 2012; FORTMANN et al. 2012 and BAYERISCHE LANDESANSTALT FÜR LANDWIRTSCHAFT 2007). The observations agree with the data derived from agricultural statistics, for the period since 1990, on manure production and on carbon inputs into soils from crop residues and catch crops, and those data are consistent with the relevant data, presented in Chapter 5 (agricultural sector) on nitrogen inputs into agricultural soils. While carbon inputs from manure have been decreasing since 1990, those decreases are more than offset by increases in crop residues that have been resulting from increasing harvests, from changes in crop selections and from increases in catch-crop cultivation. What is more, initial evaluations of the results of the national soil inventory clearly support the

assumption that Germany's mineral cropland soils are not a carbon source. The carbon balance of cropland areas was studied at 180 sites by the country-wide Agricultural Soil Inventory, with the help of models (DREYSSE 2015). The models used included the "VDLUFA-Humusbilanzierung" ("VDLUFA humus balancing") model, which was developed for practical advising (KÖRSCHENS, et al. 2004, and AUTORENKOLLEKTIV 2014), and the "CandyCarbonBalance" model, which is process-controlled and site-adapted (FRANKO, et al. 2011). In sum, the calculations carried out with both models yielded positive humus balances (Table 454), and they show that cropland soils studied – which have been used for many years – are not sources for greenhouse gases (DREYSSE 2015).

Table 454: Statistical results of the model studies relative to the humus balance of 180 cropland sites in northern Germany (DREYSSE 2015)

Model	Unit	n = 180						
		Mean	Standard error	Min	25 %	Median	75 %	Max
VDLUFA	[H-eq ha ⁻¹ a ⁻¹]	205.83	21.81	-426.00	72.00	195.00	319.5	2,641
CCB	[kg SOM-C ha ⁻¹ a ⁻¹]	75.82	41.72	-1,857.6	-181.21	188.35	456.71	1,261.96
ΔC_{org}	[% 10 a ⁻¹]	0.0192	0.0096	-0.406	-0.0454	0.0374	0.0979	0.298

H-eq = Humus equivalents

Grazing land management:

The mineral soils category is subdivided by land use, soil type / soil-parent-rock groups and climate region (cf. Chapter 19.4.2.2). Information on methods used for calculating carbon stocks and carbon-stock changes in mineral soils is provided in Chapter 6.6.2.3.

For areas remaining as grassland (in the strict sense), national measurements show no change in carbon stocks in mineral soils. The constancy of carbon stocks is substantiated by the results obtained on 42 long-term-trial areas in Germany (HÖPER und SCHÄFER 2012, FORTMANN et al. 2012 and BLU 2011). The pertinent long-term observations cover a period of 20 – 25 years. During that period, most of the areas studied exhibited no changes in the carbon stocks in mineral soils. Some soils showed slight reductions, while others exhibited slight increases that nearly exactly offset the decreases, both in terms of numbers and in absolute terms. There are no indications that any major changes in management of permanent grassland have occurred since 1990 that could affect carbon stocks in mineral soils.

11.3.1.1.6 Organic soils

Forest management and afforestation:

Information on methods used for calculating carbon stocks and carbon-stock changes in organic soils is presented in the following chapters:

- Forest Land remaining Forest Land, cf. Chapter 6.4.2.6.1.
- Land converted to Forest Land cf. Chapter 6.4.2.6.2.

Deforestation:

For land converted to forest land, the carbon-stock changes in organic soils were calculated in keeping with the procedures in Table 455 and Chapter 6.1.2.2. The area-weighted emission factor for deforestation in 2015 is -5.857 t C ha⁻¹. It is important to remember that these calculations do not yield the carbon-stock difference between forest land and the subsequent use; they yield the emissions for the new use, in keeping with drainage intensity. Organic soils under forest already emit -2.233 t C ha⁻¹ a⁻¹.

Table 455: Emission factors for organic soils of deforestation categories of the year 2015 (negative = loss; positive = sink)

Land-use change	Emission factor [t C ha ⁻¹ a ⁻¹]
Forest land converted to cropland	-8.100
Forest land converted to grassland	-6.834
Forest Land converted to woody gl.	-2.233
Forest land converted to wetlands	-4.964
Forest land converted to water	0.000
Forest land converted to settlements	-7.400
Forest land converted to other land	0.000

Cropland management and grazing land management:

Emission factors for organic soils were derived from spatially explicit data. This was done by differentiating the frequency distribution for depths to water table by uses, and by applying regressions between depths to water table and CO₂ emissions. For land-use changes, the emission factor for the new land-use category applies right away. Additional information is presented in the following chapters:

- Derivation of emission factors, cf. Chapter 6.1.2.2.
- Methods for cropland, cf. Chapter 6.5.2.3
- Methods for grassland (in the strict sense), cf. Chapter 6.6.2.4

11.3.1.1.7 Harvested wood products

In the first commitment period of the Kyoto Protocol, and in accordance with the IPCC 2003 GPG (IPCC 2003), the contribution from carbon storage in wood products was taken into account as an immediate emission and thus was neither reported nor credited (cf. Chapter 2.8.2, IPCC 2014).

As described in detail in Chapter 6.10, for the present reporting year, the emissions contribution made by harvested wood products in Germany, in terms of sources and removals into sinks for greenhouse gases, was determined (as in past years) with the *WoodCarbonMonitor* model, in keeping with the specifications of the IPCC KP Supplement (IPCC 2014).

First, the availability of activity data, i.e. data on the production of and foreign trade in harvested wood products, was reviewed (cf. Chapter 2.8.1.1, IPCC 2014), and the product fractions originating from domestic harvest were calculated. Then, in a second step (cf. Chapter 2.8.1.2, IPCC 2014), the carbon contained in those products was allocated, using the procedure described in Chapter 6.10.2.1, to the forest activities listed in the Kyoto Protocol under Article 3, paragraphs 3 and 4. For Germany, the wood harvest can be fully assigned to the two activities *forest management* and *deforestation*. In keeping with the provisions of the IPCC 2013 KP Supplement (IPCC 2014), harvested wood products from deforestation are taken into account on the basis of instantaneous oxidation. As a result, the annual wood-harvest fractions from the activity forest management $f_{FM}(i)$ can be calculated from the inventory information available for Germany and from Equation 2.8.3 (IPCC 2014).

Germany has no wood that comes from deforestation areas but not from the actual deforestation events involved (cf. the CRF table). For this reason, "NO" was entered at this point in the CRF table. Wood from the activities afforestation and reforestation, on the other hand, is included in the forest management data, and thus is marked "IE" in the table.

Further information, and details on the emission factors used and on the calculation carried out for Germany, in keeping with the provisions of the IPCC 2013 KP Supplement (IPCC 2014), are provided in Chapters 6.10.2.2 and 6.10.2.3. In keeping with these provisions, wood used for energy

purposes, and wood in landfills, are taken into account on an immediate-emission basis (cf. Chapter 2.8.2, IPCC 2014).

11.3.1.1.8 Other greenhouse-gas emissions

Information relative to calculations of other greenhouse-gas emissions is presented in the following chapters:

Forests:

- Nitrous oxide emissions from nitrogen fertilisers (CRF Table 4(KP-II)1); cf. Chapter 6.4.2.7.1
- Drainage and rewetting of organic and mineral soils (CRF Table 4(KP-II)2); cf. Chapter 6.4.2.7.2
- Direct nitrous oxide emissions from nitrogen mineralization and immobilization (CRF Table 4(KP-II)3); cf. Chapter 6.4.2.7.3
- Indirect nitrous oxide emissions from cultivated soils (CRF Table 4(KP-II)3); cf. Chapter 6.4.2.7.4
- Forest fires (CRF Table 4(KP-II)4); cf. Chapter 6.4.2.7.5

Cropland management and grazing land management:

- Drainage and rewetting of organic and mineral soils (CRF Table 4(KP-II)2); cf. Chapters 6.1.2.2, 6.5.2.3, 6.6.2.4
- Direct nitrous oxide emissions from nitrogen mineralization and immobilization (CRF Table 4(KP-II)3); cf. Chapter 6.1.2.1.2
- Indirect nitrous oxide emissions from cultivated soils (CRF Table 4(KP-II)3); cf. Chapter 6.1.2.1.2

For purposes of Kyoto reporting, the direct and indirect nitrous oxide emissions are combined, and the pertinent joint emission factor is reported in CRF Table 4(KP-II)3. N₂O emissions from organic soils under cropland management and grazing land management are reported in the agricultural sector, in the sub-category cultivation of histosols.

11.3.1.2 Justification when omitting any carbon pool or of greenhouse-gas emissions / removals from activities under Article 3.3 and elected activities under Article 3.4

No fertilisation of forest areas, with mineral fertilisers, takes place in Germany. For this reason, fertilisation with mineral fertilisers is listed as NO (not occurring) in CRF table 4(KP-II)1.

Dead wood and litter do not occur in connection with cropland management and grassland management (NO; not occurring).

11.3.1.3 Information on whether or not indirect and natural greenhouse gases and removals have been factored out

No indirect or natural greenhouse-gas emissions or sinks were taken into account.

11.3.1.4 Changes in data and methods since the previous submission (recalculations)

This year's submission includes category-specific recalculations for the entire 1990–2015 report period, to take account of the fact that new / corrected data sources and methods were used to calculate phytomass in the Cropland land-use category:

- With regard to official statistics regarding Germany's use of areas for perennial crops in the sub-category "Cropland remaining Cropland" (cf. Chapter 6.5.2.1)

- Introduction of emission factors for phytomass of perennial and annual crops in the sub-category "Cropland remaining Cropland" (cf. Chapter 6.5.2.1).
- The values of the emission factors for annual phytomass were modified slightly. This yielded corrected CO₂ emission factors for plant biomass.
- Introduction of a method for calculation of carbon-stock changes in the phytomass of perennial crops, in the sub-category "Cropland Remaining Cropland" (cf. Chapter 6.5.2.1).

In connection with the recalculation, the pertinent uncertainties were also determined anew.

The recalculations' impacts on emissions are shown in Table 456 and Figure 83.

Table 456: Comparison of the changes in emissions as reported in the 2016 and 2017 submissions

Emissions [kt CO ₂ -eq]		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
KP 3.3 Afforestation/Reforestation	2016	585	-996	-2,632	-4,258	-4,459	-4,666	-4,866	-5,035	-5,323	-5,600	-5,874	-6,228	-6,449
	2017	582	-999	-2,635	-4,260	-4,461	-4,668	-4,867	-5,037	-5,325	-5,602	-5,876	-6,230	-6,451
KP 3.3 Deforestation	2016	1,763	1,733	1,725	2,235	2,539	2,555	2,577	2,624	2,660	2,693	2,726	1,969	1,997
	2017	1,768	1,757	1,769	2,267	2,580	2,597	2,622	2,712	2,751	2,788	2,824	2,036	2,064
KP 3.4 Forest Management	2016	-74,806	-75,756	-79,856	-50,433	-51,786	-51,539	-58,471	-58,579	-57,002	-56,577	-55,633	-54,371	-55,070
	2017	-74,806	-75,756	-79,856	-50,433	-51,786	-51,539	-58,471	-58,579	-57,002	-56,593	-55,639	-54,415	-54,900
KP 3.4 Cropland Management	2016	12,702	12,681	12,664	11,968	12,675	13,075	13,346	13,568	14,036	14,319	14,547	14,629	14,520
	2017	12,669	12,684	12,655	12,019	12,651	13,083	13,317	13,548	13,993	14,270	14,553	14,658	14,453
KP 3.4 Grazing Land Management	2016	25,766	25,574	25,379	24,635	24,161	23,782	23,430	23,165	22,911	22,692	22,484	22,362	22,314
	2017	25,772	25,580	25,385	24,639	24,164	23,785	23,433	23,168	22,914	22,695	22,486	22,365	22,317

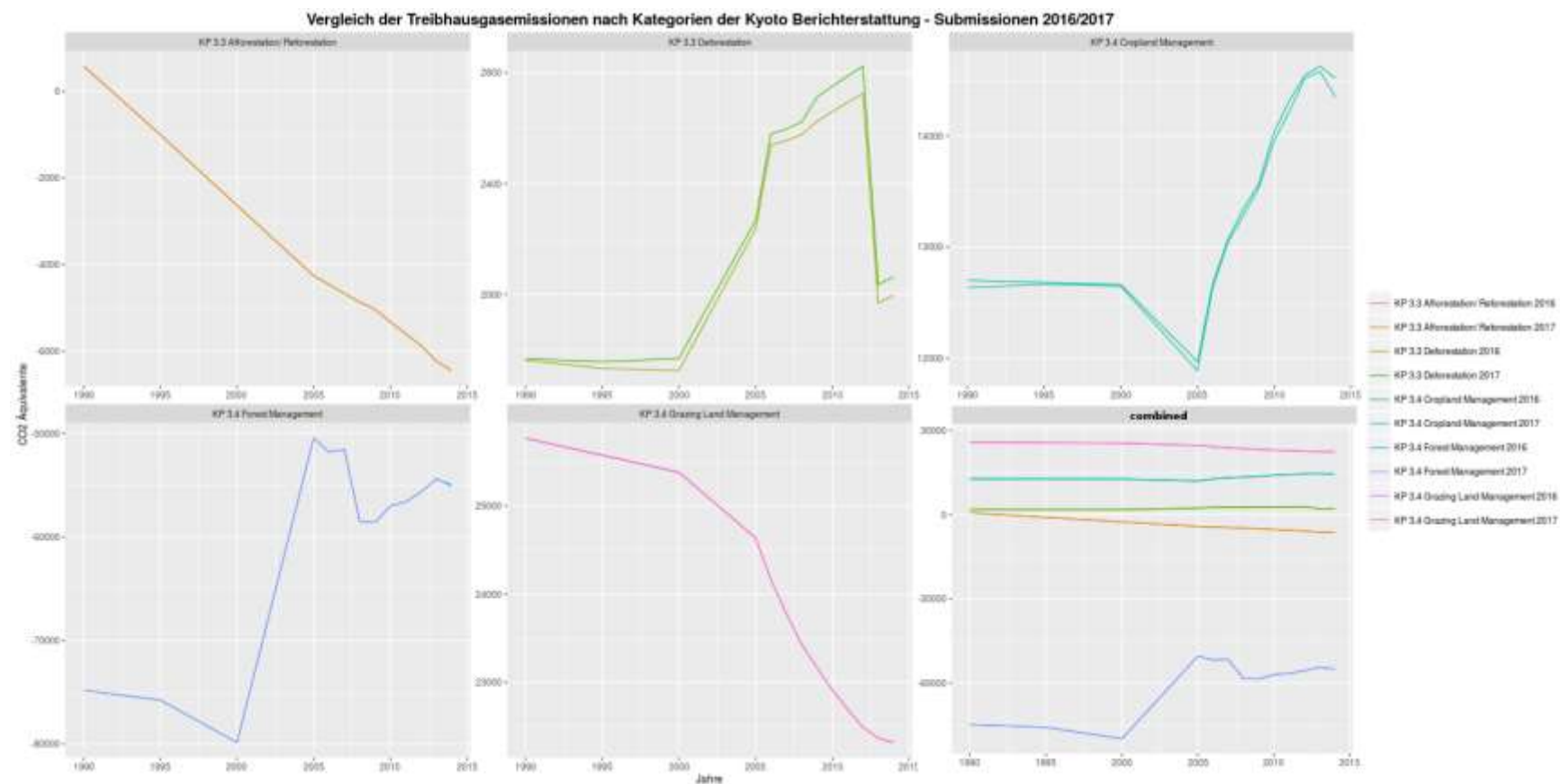


Figure 83: Comparison of greenhouse-gas emissions, after recalculations for the 2017 Submission (sum of CO₂, CH₄ and N₂O) [kt CO₂ equivalents], and in Kyoto reporting categories

11.3.1.5 Estimation of uncertainties

The uncertainties for activities pursuant to Article 3.3 Afforestation/Deforestation and 3.4 Forest Management, Cropland Management and Grazing Land Management of the Kyoto Protocol (KP) were determined in keeping with the provisions of the 2006 IPCC Guidelines (IPCC 2006). The uncertainty statistics given for a normal distribution include the 95 % confidence interval, $\pm$ half of the 95 % confidence interval and $1.96 \times$ the standard error, in % of the mean. For asymmetric distributions – in the present context, usually consisting of data sets with a logarithmic normal distribution – the relevant deviations are described as upper and lower bounds, expressed as % values of the pertinent position scale. The propagation of uncertainties was calculated via a conservative approach in which the distance between the extreme value of the sloping axis section and the position scale is defined as half of the 95 % confidence interval.

Table 457 shows the results of uncertainties calculation for all categories and sub-categories of the KP 3.3/3.4 inventory (except for harvested wood products, cf. Chapter 11.3.1.5.3). The total uncertainty is ± 24.61 %.

Further information relative to uncertainties is provided as follows: for estimation of land-use-change areas, in Chapter 6.4.3.1; for above-ground and below-ground biomass and dead wood, in Chapter 11.3.1.5.1; for litter and mineral soils, in Chapter 11.3.1.5.2; and summarised for the LULUCF sector overall, in Chapter 19.4.3.



Table 457: Uncertainties for greenhouse-gas reporting for Kyoto Protocol activities in Articles 3.3 and 3.4

Category	Pool	Gas	Base year emissions [CO ₂ -eq.] kt a ⁻¹	Year 2015 emissions [CO ₂ -eq.] kt a ⁻¹	Combined uncertainty, maximum value %	Contribution to Variance by Category in Year 2015 %
KP 3.3 Afforestation/Reforestation	Mineral soils	CO ₂	57.14	438.42	37.37	0.02
KP 3.3 Afforestation/Reforestation	Organic soils	CO ₂	15.36	373.40	86.57	0.08
KP 3.3 Afforestation/Reforestation	Organic soils	CH ₄	0.22	5.27	879.53	0.00
KP 3.3 Afforestation/Reforestation	Organic soils	N ₂ O	1.22	29.60	176.46	0.00
KP 3.3 Afforestation/Reforestation	Above-ground biomass	CO ₂	323.67	-5,612.54	43.05	4.72
KP 3.3 Afforestation/Reforestation	Below-ground biomass	CO ₂	226.81	-1,029.19	43.51	0.16
KP 3.3 Afforestation/Reforestation	Litter	CO ₂	-48.10	-915.00	6.18	0.00
KP 3.3 Afforestation/Reforestation	Dead wood	CO ₂	-3.48	-67.33	48.98	0.00
KP 3.3 Afforestation/Reforestation	SOM	N ₂ O	9.32	88.80	161.90	0.02
KP 3.3 Deforestation	Mineral soils	CO ₂	-19.77	-127.89	40.20	0.00
KP 3.3 Deforestation	Organic soils	CO ₂	15.82	440.40	41.95	0.03
KP 3.3 Deforestation	Organic soils	CH ₄	0.34	9.17	385.37	0.00
KP 3.3 Deforestation	Organic soils	N ₂ O	0.37	15.48	90.31	0.00
KP 3.3 Deforestation	Above-ground biomass	CO ₂	758.38	1,037.89	27.05	0.06
KP 3.3 Deforestation	Below-ground biomass	CO ₂	52.73	120.87	27.55	0.00
KP 3.3 Deforestation	Litter	CO ₂	873.56	535.06	8.79	0.00
KP 3.3 Deforestation	Dead wood	CO ₂	86.64	56.85	57.35	0.00
KP 3.3 Deforestation	SOM	N ₂ O	0.00	6.86	175.32	0.00
KP 3.4 Forest Management	Mineral soils	CO ₂	-16,206.97	-15,825.05	52.60	56.01
KP 3.4 Forest Management	Organic soils	CO ₂	927.89	822.66	24.66	0.03
KP 3.4 Forest Management	Organic soils	CH ₄	13.09	11.60	1,011.57	0.01
KP 3.4 Forest Management	Organic soils	N ₂ O	73.55	65.21	200.69	0.01
KP 3.4 Forest Management	Above-ground biomass	CO ₂	-52,340.82	-35,127.24	63.03	396.24
KP 3.4 Forest Management	Below-ground biomass	CO ₂	-4,981.66	-5,192.49	49.74	5.39
KP 3.4 Forest Management	Litter	CO ₂	499.63	487.08	294.00	1.66
KP 3.4 Forest Management	Dead wood	CO ₂	-1,471.56	2,023.69	106.88	3.78
KP 3.4 Forest Management	Forest fires	CH ₄	6.77	2.91	38.08	0.00
KP 3.4 Forest Management	Forest fires	N ₂ O	4.46	1.92	38.08	0.00
KP 3.4 Forest Management	SOM	N ₂ O	0.00	0.00	0.00	0.00
KP 3.4 to Cropland Management	Mineral soils	CO ₂	2,676.32	2,795.54	49.25	1.53
KP 3.4 to Cropland Management	Organic soils	CO ₂	3,035.28	3,590.26	44.87	2.10
KP 3.4 to Cropland Management	Organic soils	CH ₄	66.43	78.57	233.40	0.03
KP 3.4 to Cropland Management	Above-ground biomass	CO ₂	231.38	-164.52	38.68	0.00
KP 3.4 to Cropland Management	Below-ground biomass	CO ₂	316.66	289.95	34.57	0.01

Category	Pool	Gas	Base year emissions [CO ₂ -eq.] kt a ⁻¹	Year 2015 emissions [CO ₂ -eq.] kt a ⁻¹	Combined uncertainty, maximum value %	Contribution to Variance by Category in Year 2015 %
KP 3.4 Cropland Management	Mineral soils	CO ₂	0.00	0.00	50.52	0.00
KP 3.4 Cropland Management	Organic soils	CO ₂	5,909.20	7,605.07	45.66	9.75
KP 3.4 Cropland Management	Organic soils	CH ₄	129.33	166.44	233.93	0.12
KP 3.4 Cropland Management	Above-ground biomass	CO ₂	-15.53	-27.36	11.43	0.00
KP 3.4 Cropland Management	Below-ground biomass	CO ₂	-13.33	-24.46	24.07	0.00
KP 3.4 total Cropland Management	SOM	N ₂ O	332.91	346.72	181.22	0.32
KP 3.4 to Grazing Land Management	Mineral soils	CO ₂	-2,375.99	-1,663.77	42.28	0.40
KP 3.4 to Grazing Land Management	Organic soils	CO ₂	2,237.67	1,045.99	46.91	0.19
KP 3.4 to Grazing Land Management	Organic soils	CH ₄	47.42	22.17	219.04	0.00
KP 3.4 to Grazing Land Management	Above-ground biomass	CO ₂	389.86	185.08	34.87	0.00
KP 3.4 to Grazing Land Management	Below-ground biomass	CO ₂	-116.51	-90.63	28.35	0.00
KP 3.4 Grazing Land Management	Mineral soils	CO ₂	0.00	0.00	77.89	0.00
KP 3.4 Grazing Land Management	Organic soils	CO ₂	25,058.33	22,190.24	55.36	121.98
KP 3.4 Grazing Land Management	Organic soils	CH ₄	531.03	470.25	258.59	1.20
KP 3.4 Grazing Land Management	Above-ground biomass	CO ₂	0.00	0.00	36.24	0.00
KP 3.4 Grazing Land Management	Below-ground biomass	CO ₂	0.00	0.00	50.86	0.00
KP 3.4 total Grazing Land Management	SOM	N ₂ O	0.00	0.00	0.00	0.00
Uncertainty total ARD / FM / CM / GM [%]:					24.61	

11.3.1.5.1 Estimation of uncertainties of emission factors for biomass and dead wood, for KP Art. 3.3 and KP Art. 3.4 Forest management

Table 458 shows the uncertainties that result for the calculation of carbon-stock changes in living biomass, as carried out in keeping with the information provided in Chapter 6.4.3.2. The following should be noted in this regard:

- It was not possible to derive emission factors for KP Afforestation/Reforestation and KP Deforestation for the new German Länder for the period 1993 – 2002, since the Datenspeicher Wald forest database does not contain the data necessary for such derivation. Consequently, the emission factors for the old German Länder have been used for that period.
- In the 2008 Inventory Study, no afforestation areas were surveyed, and those survey data for deforested points lack reliability. For this reason, the emission factors and applicable errors for the period 2002 through 2012 have also been derived from the data of the BWI 2002 and BWI 2012.

Table 458: Total error for estimation of C-stock changes in biomass for the inventory periods of the National Forest Inventory, 1987–2002, 2002–2008 and 2008–2012 (RMSE% – root mean square error percent)

RMSE%	1987-2002 Old German Länder	1993-2002 New German Länder	2002-2008 Germany as a whole	2008-2012 Germany as a whole
Afforestation (KP 3.3)	13.08	-	11.53	11.53
Deforestation (KP 3.3)	12.73	-	10.95	10.95
Forest Management (KP 3.4)	6.95	10.05	28.75	12.60

Table 459 shows the uncertainties that result, on the basis of the information provided in Chapter 6.4.3.2, for the calculation of C-stock changes in dead wood. The following should be noted in this regard:

- For deforestation, the applicable error for the period 1987–2002 is derived from the mean error for the period 2002–2012.
- For areas under forest management, the applicable dead-wood error for the period 1987–2002 is calculated from the mean error for the period 2002–2012.

Table 459: Total error for estimation of C-stock changes in dead wood for the inventory periods of the National Forest Inventory, 1987–2002, 2002–2008 and 2008–2012 (RMSE% - root mean square error percent)

RMSE%	1987-2002	2002-2008	2008-2012
Afforestation (KP 3.3)	24.84	24.84	24.84
Deforestation (KP 3.3)	28.96	24.88	44.46
Forest Management (KP 3.4)	46.67	27.11	54.52

The total-error calculation for purposes of reporting under the Kyoto Protocol is presented in Table 457 in Chapter 11.3.1.5.

11.3.1.5.2 Estimation of uncertainties of emission factors for mineral soils and litter, for KP Art. 3.3 and KP Art. 3.4 Forest management

The following uncertainties result for the emission factors for mineral soils and litter, as carried out in keeping with the information provided in Chapter 6.4.3.3 (cf. Table 460):

Table 460: Error budget for the emission factors for mineral soils and litter; se = standard deviation of the mean value; C 90, C 06 = laboratory error in carbon-stocks determination, BZE I and BZE II; FE = error in determination of the fine-earth fraction

LULUCF category	Pool	Emission factor					Uncertainty [%]
		se [%]	C 90 [%]	C 06 [%]	FE [%]	Error total [%]	
KP Forest Management	Litter	105.9	111.2	73.4		168.9	337.8
KP Forest Management	Mineral soil	9.0	14.1	13.6	12.2	26.7	53.4

11.3.1.5.3 Estimation of uncertainties for harvested wood products

Pursuant to information in the IPCC 2013 KP Supplement (IPCC 2014) Guidelines, the uncertainties for the activity data for harvested wood products amount to -25/+5%. For the emission factors, the standard values listed in Table 2.8.2 of the IPCC 2013 KP Supplement (IPCC 2014) Guidelines are used. Those values include no uncertainties. Due to the lack of uncertainties, no error calculation can be carried out for harvested wood products.

11.3.1.6 Information on other methodological issues

In this chapter, the individual-pools results in the present submission are compared with those of other countries. As described in Chapter 6.4.4.3, the comparison of Germany with other countries is carried out only to provide a general classification, since the various countries differ in their choice of methods of approaches, and especially with regard to their definitions of "forest" and to their choices of activities under Article 3.4. All countries that can be usefully compared to Germany report forest management as a mandatory category pursuant to Article 3.4. Since to date only Germany, Denmark and the UK have committed to reporting in the reporting-option categories Cropland management and Grazing land management, no comparison with other countries, for these two voluntary activities, has been carried out.

The comparison data for the carbon-stock changes of other countries are obtained from the national inventory reports of countries neighbouring Germany and the UK. The emission factor data have been obtained from the last submission to the UN Climate Secretariat, and the are in keeping with the 2014 inventory year.

A by-country comparison of afforestation-related carbon-stock changes in living above-ground biomass (Table 461) shows that Germany has the second-largest carbon sink. Only the Netherlands report a larger carbon sink. For the pool of living below-ground biomass, Germany has the highest carbon storage from afforestation. Its carbon storage in this category is slightly higher than that of France, followed by the Netherlands. All countries report carbon losses in the deforestation category. Germany can report the smallest carbon losses in the area of below-ground biomass in deforestation areas, however. With regard to the pool of above-ground living biomass in deforestation areas, only Austria has a smaller carbon source than Germany does. The largest carbon losses via deforestation, in both above-ground and below-ground biomass, are reported by Denmark, Switzerland and the Netherlands. In the forest management category, Germany's carbon sinks in the area of above-ground and below-ground biomass rank in the middle segment of the group ranking. The highest carbon-storage results in this category are found in the Netherlands (above-ground) and Denmark (below-ground), while the lowest results are found in Austria (above-ground and below-ground).

In the dead wood pool (Table 443), Germany and France report the same – very low – carbon-storage results for the activity afforestation. Poland, the Netherlands and Belgium report no values in this pool. In the area of deforestation activities, Germany reports small carbon losses. Still lower losses are found only in Poland, while Austria reports neither a source nor a sink. The Netherlands report the highest carbon losses in this category, while the UK reports "not occurring." In the area

of forest management, Germany reports the highest relative – although still small in absolute terms – carbon emissions. Denmark and Austria report low carbon storage via forest management, while Poland and the Czech Republic report "not occurring."

In the litter pool (Table 443), Germany's carbon storage in the area of afforestation ranks third. The highest value – and, thus, the highest carbon storage – is seen on the part of Austria, followed by the Czech Republic. In the deforestation category, Germany's carbon losses rank in the middle of the range for the group, and they are comparable to those of Austria, while France reports the lowest losses. The highest losses via deforestation are found in Denmark, while Belgium is even able to show a small level of storage in this category. Forest management produces a small carbon source for Germany, while Switzerland reports a relatively large source. Storage in this category is reported by Denmark and the UK, while France and Poland report neither losses nor storage, and the Netherlands, the Czech Republic and Poland do not report in this category. Germany and the Netherlands report carbon losses, in the mineral soils poolSource: UNFCCC 2016a

, from afforestation. The largest carbon sinks in this area are in Belgium, the UK and Austria, while the other countries in the comparison have only medium-sized or small sinks. In the deforestation category, Germany and Denmark have low carbon storage. The smallest carbon losses are found in the Czech Republic, while the largest C losses, far and away, are seen in Poland, followed by Belgium. In forest management, Belgium reports the highest level of carbon storage, followed by Germany. Austria reports a carbon source in this category, while Denmark, the Netherlands and the Czech Republic do not report at all ("NO").

In the organic soils pool, the only countries to report, apart from Germany, are Switzerland (all activities), Denmark, the Netherlands (both only Article 3.3 activities), Poland and the UK (both only A/R and forest management activities). Germany has registered carbon losses in all three categories. Only Switzerland reports higher losses in all three activities. Denmark reports higher losses in deforestation activities. For organic soils in all reported activities, France indicates that the relevant emissions are being reported in other categories and source categories ("IE"). For land under afforestation activities, only the UK reports a certain level of carbon storage. All comparable countries also show deforestation-related carbon losses in organic soils. In the area of forest management, the emission-source ranking is as follows: Switzerland, Germany, Denmark and Poland. While the UK again reports carbon storage, Belgium, the Netherlands, Austria and the Czech Republic report "not occurring" (NO).

Table 461: Carbon-stock changes in living biomass (Germany, for 2014 & 2015; other countries, for 2014)

Country [t C ha ⁻¹]	Afforestation		Deforestation		Forest management	
	Above-ground	Below-ground	Above-ground	Below-ground	Above-ground	Below-ground
Belgium	1.75	0.35	-1.12	-0.22	0.79	0.03
Denmark	0.26	0.05	-5.67	-1.24	1.18	0.26
France	1.10	0.47	-1.48	-0.35	0.59	0.21
UK	1.41	IE	-1.59	IE, NO	1.15	IE
Netherlands	2.91	0.41	-3.69	-0.54	1.33	0.24
Austria	0.96	0.26	-0.69	-0.17	0.26	0.03
Poland	0.82	0.22	-1.91	-0.38	0.71	0.19
Switzerland	0.97	0.40	-2.92	-0.90	0.42	0.10
Czech Republic	1.73	0.35	-2.70	-0.54	0.60	0.12
Germany, 2014	2.86	0.52	-1.01	-0.12	0.90	0.13
Germany, 2015	2.87	0.53	-0.99	-0.12	0.90 ¹⁹²	0.134

Source: UNFCCC 2016a

Table 462: Carbon-stock changes in litter (Germany, for 2014 & 2015; other countries, for 2014)

Country [t C ha ⁻¹]	Afforestation		Deforestation		Forest management	
	Dead wood	Litter	Dead wood	Litter	Dead wood	Litter
Belgium	NO	NO	-0.11	0.01	-0.01	0.00
Denmark	0.00	0.15	-0.17	-1.90	0.13	0.39
France	0.03	0.17	-0.05	-0.17	-0.03	0.00
UK	IE	0.09	IE, NO	-0.25	IE	0.24
Netherlands	NO	NO	-0.24	-1.47	0.00	NO
Austria	0.02	0.89	0.00	-0.54	0.06	IE, NE
Poland	NO	NO	-0.01	0.00	NO	NO
Switzerland	0.00	-0.08	-0.23	-1.01	0.00	-0.14
Czech Republic	0.01	0.50	-0.07	-0.37	NO	NO
Germany, 2014	0.03	0.47	-0.06	-0.52	-0.05	-0.01
Germany, 2015	0.03	0.47	-0.05	-0.51	-0.05	-0.01

Source: UNFCCC 2016a

Table 463: Carbon-stock changes in dead wood (Germany, for 2014 & 2015; other countries, for 2014)

Country [t C ha ⁻¹]	Afforestation		Deforestation		Forest management	
	Mineral soil	Organic soil	Mineral soil	Organic soil	Mineral soil	Organic soil
Belgium	1.42	NO	-1.60	NO	0.53	NO
Denmark	0.09	-1.30	0.10	-6.03	NO	-1.30
France	0.18	IE	-0.63	IE	0.00	IE
UK	1.00	2.28	-1.59	IE, NO	0.20	0.68
Netherlands	-0.07	-0.23	0.00	-2.52	NO	NO
Austria	0.53	NO	-0.57	NO	-0.18	NO
Poland	0.06	-0.68	-1.76	NO	0.11	-0.68
Switzerland	0.44	-2.60	-0.99	-6.05	0.00	-2.73
Czech Republic	0.12	NO	-0.04	NO	NO	NO
Germany, 2014	-0.27	-2.23	0.15	-4.94	0.41	-2.23
Germany, 2015	-0.24	-2.23	0.13	-5.86	0.41	-2.23

Source: UNFCCC 2016a

¹⁹² Biomass losses are indicated with the notation key 'IE'

11.3.1.7 The year of the onset of an activity, if after 2013

Table 464 shows the area sizes for KP 3.3 activities that began after 2013. The activity Forest Management (KP.3.4) is included only for those areas that have been forest since 1990. As the table indicates, there are no areas on which forest management began after 2013.

Table 464: Relevant area sizes for activities that began after 2013.

KP 3.3 Activity	Year of onset	
	2014	2015
Afforestation/Reforestation [ha]	14,071	14,071
Deforestation [ha]	7,809	7,809

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2020 and are directly human-induced

As described in Chapter 6.3, the procedure for determining land-use changes from and to forest land identifies area changes as of 1970, while the methods used for purposes of reporting under the Kyoto Protocol take account only of changes since 1990. As of the 2014 Submission, submissions take account of the results of the third National Forest Inventory, for which the reference year is 2012. Those results provide the database for the initial year of the second commitment period. All included activities in this context fall within the period 1 January 1990 to 31 December 2020.

While each land-use change from and to forest land is recorded primarily via the National Forest Inventory (Bundeswaldinventur; BWI), such changes are also recorded in additional data sets. The relevant sampling points form a grid that covers all of Germany. Via repeated surveying of the sample points, all changes can be mapped on a large scale. If a point is mapped as forest that was mapped as non-forest in the previous inventory, it represents a specific area of afforestation. The BWI differentiates between afforestation via planting / sowing and afforestation via natural rejuvenation. However, an area afforested via natural rejuvenation is classified as *afforested* only when the relevant stand has an average age of five years and crown cover of at least 50 % (cf. Chapter 6.2.1).

Agricultural land can change from (managed) cropland to unmanaged land and, via spontaneous establishment of trees (natural rejuvenation), into forest land. Pursuant to the IPCC 2013 KP Supplements (IPCC 2014), this type of afforestation may be accounted only if it is "directly human-induced". "It is good practice to provide documentation that all afforestation and reforestation activities included (...) are directly human-induced. Relevant documentation includes forest management records or other documentation that demonstrates that a decision had been taken to replant or to allow forest regeneration by other means."¹⁹³ German law requires a "permit from the competent authority under the law of the Länder" (Art. 10 (1) Federal Forest Act (BWaldG)) for each afforestation. Pursuant to Para. 2, no permit is required only in those cases in which, for the area to be afforested, "afforestation has been mandated in a legally binding way, on the basis of other public legal provisions, or the requirements of regional planning and Land (state) planning are not affected". Germany is a densely populated, intensively managed country in which all areas nation-wide are subject to land-use plans. In addition, Germany has different planning levels, ranging from large-scale planning (e.g. regional planning) to specific small-scale planning

¹⁹³ Vgl. IPCC 2014, Section 2.5.2

(e.g. landscape plans, operational plans for forest management). Preparation of, and compliance with, plans is monitored by the relevant competent authorities in each case, including authorities of the Federal Government, of the Länder and of individual municipalities. Thus it may be assumed that all afforested areas fulfill the "directly human-induced" requirement, since the act of permission, as well as the act of mandating in a legally binding manner and the preparation and establishment of regional and landscape plans all presuppose active decisions by humans.

11.4.2 Information about a Scheme for differentiation between a) harvest or forest disturbance that is followed by reforestation, and b) deforestation

Pursuant to Art. 11 (1) Federal Forests Act (BWaldG), "forests (...) (should) be properly and sustainably managed, in the framework of their defined purposes. Länder laws are to be enacted that set forth obligations for all forest owners whereby clear-cut or degraded forest areas

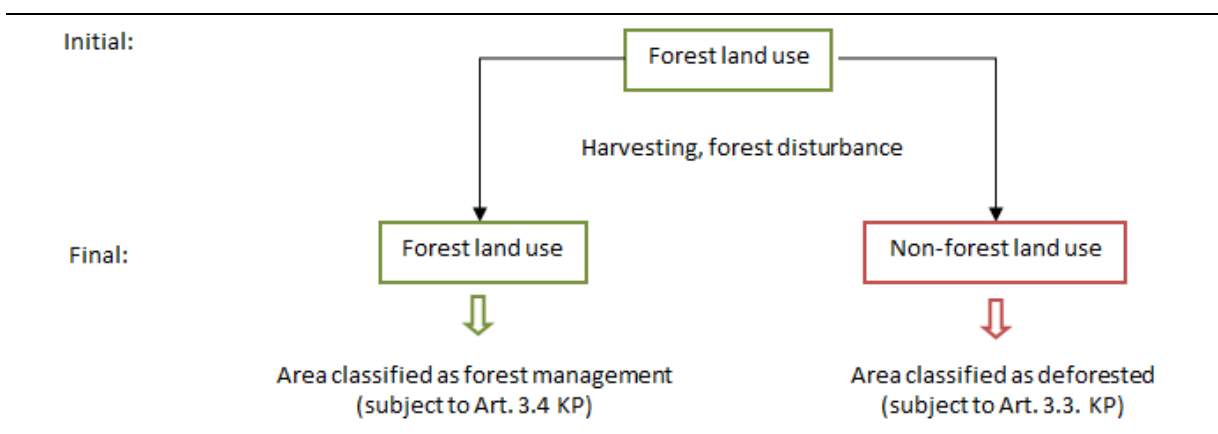
7. are to be reforested, or

8. replenished, in cases in which natural regrowth remains incomplete,

within a reasonable period of time, unless conversion to another type of use has been approved or is otherwise permitted."

In general, reforestation is called for on all forest areas that are to remain in use as forest land. That is a legal requirement, and it is the customary practice in the German forestry sector. Forest land that is temporarily unstocked thus continues to fall within the scope of required reporting on forest management pursuant to Art. 3.4 KP. The situation is different in cases in which forest land becomes unstocked and planning calls for subsequent use of the land to fall within the category "non-forest land". Such land is to be considered deforested land, with the relevant deforestation directly human-induced, regardless of whether the deforestation was caused by harvesting or by natural disturbances.

Figure 84: Scheme for differentiation between a) harvest or forest disturbance that is followed by reforestation, and b) deforestation



11.4.3 Information about the size and geographic location of forest areas that have lost forest cover but which are not yet classified as deforested

Forest management routinely generates small unstocked areas (bare areas) in forests. Pursuant to the data of the BWI 2012, such areas total about 41,742 ha and account for 0.36 % of the total forest area. As explained above in Chapter 11.4.2, such areas continue to fall within the national forest definition and continue to figure in calculations relative to carbon stocks and their changes.

11.4.4 Information about natural disturbances under Article 3.3

As explained in Chapter 11.1.2, Germany has not selected the natural disturbances option. Natural disturbances that occur are not considered separately; instead, they enter into the change calculations for the relevant pools.

11.4.5 Information about harvested wood products under Article 3.3

As described in detail in Chapter 6.10, the emissions contribution made by harvested wood products in Germany, in terms of sources and removals into sinks for greenhouse gases, was determined with the WoodCarbonMonitor model, in keeping with the specifications of the IPCC KP Supplement (IPCC 2014).

For Germany, the wood harvest can be fully assigned to the two activities forest management and deforestation. Wood products from deforestation (Article 3.3) are taken into account, pursuant to the provisions of the IPCC KP Supplements (IPCC 2014), on the basis of instantaneous oxidation.

11.5 Article 3.4

11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

11.5.1.1 Forest management

Since an integrated procedure is used for surveying forest lands, land-use changes and the carbon-stock changes caused by relevant activities, the statements made in Chapter 11.4.1 apply mutatis mutandis for the activity "forest management".

Pursuant to Art. 1 No. 1 Federal Forest Act (BWaldG), "forests are to be preserved, to be enlarged as necessary and to be properly and sustainably managed, in light of their economic value (utility function) and of their importance with regard to the environment, especially the long-term vitality of natural systems and cycles, and with regard to climate, water cycles, air quality, soil fertility, landscape beauty, agrarian structures and infrastructure and the population's needs for rest and recreation (protection and recreation functions)".

Forests are thus assigned three key basic functions, namely utility, conservation and recreation functions, in light of which they are to be preserved and properly and sustainably managed. In addition, Art. 11 (1) p. 1 BWaldG sets forth that "forests (...) (should) be properly and sustainably managed, in the framework of their defined purposes." While that formulation does not mean that forests "must" be managed, and thus it does not establish a general obligation, it is important to note that it does not use "may" phrasing, which would rule out any obligation. The wording chosen thus clearly reveals a basic orientation – namely, that forests should be managed. An obligation to manage forest lands thus applies to all of Germany.¹⁹⁴

In the interest of protecting forests' three basic functions, forests, pursuant to Art. 1 No. 1 in conjunction with Art. 11 (1) p.1 BWaldG, should be protected and properly and sustainably managed. The aim of proper forest management as set forth by the Marrakesh Accords (MA) thus agrees with the requirements set forth by the Federal Forest Act (BWaldG). In both cases, management is oriented to the aim of ensuring that the forest can continue to fulfill its functions in perpetuity.

¹⁹⁴ Häusler and Scherer-Lorenzen (2002) speak of an obligation, for all forest owners, "to carry out sustainable, proper management"; the citation appears in: Nachhaltige Forstwirtschaft in Deutschland im Spiegel des ganzheitlichen Ansatzes der Biodiversitätskonvention. BfN – Skripten 62, p. 5 and 15.

The Marrakesh Accords define forest management as "a system of practices". That indicates that management involves actions / measures. A forest area that is left untouched, and for which no measures are taken, is thus not a managed forest area. For a forest area to qualify as "unmanaged", however, no human activities may take place in it, i.e. no active human interventions may be permitted in it (equivalent to MCPFE conservation category 1.1). Forest areas meeting those criteria are "practically non-existent" in Germany (BMELV, 2009). In 2007, forest conservation areas in which permitted human interventions are restricted to a minimum, i.e. fully protected areas (MCPFE conservation category 1.2), accounted for 1.1% of Germany's total forest area, and were tending to be enlarged (BMELV, 2009). The primary focus with regard to such forest areas is on biotope and species conservation (for example, protected forests, natural forest reserves, core zones of national parks and biosphere reserves). Certain types of interventions are expressly permitted, however (for example, measures to control wildfires, hoofed game, diseases or insect calamities¹⁹⁵). For protected forests, as for all protected areas, concepts are to be prepared that set forth / define / describe the object/focus of protection, the protection purpose, the necessary requirements and prohibitions for achieving the protection purpose and the necessary relevant care, management, development and restoration measures¹⁹⁶ (for example, in ordinances or guidelines on protected areas; cf. for example, Art. 23 (2) State Forest Act (LWaldG) of Mecklenburg – West Pomerania). In addition, some 23% of Germany's forest area consists of protected areas whose conservation purpose is actively assured via management measures (MCPFE conservation category 1.3); 56 % consist of forests whose primary purpose is to conserve landscapes and specific natural elements (MCPFE conservation category 2); and 34 % have the primary purpose of providing protective functions (MCPFE conservation category 3). In MCPFE conservation categories 1.3 through 3, management is to be aligned with the relevant conservation purpose. Such categories thus fulfill the criteria for forest management. Human activities for protecting conservation areas are also certainly allowed in MCPFE category 1.2. Pursuant to the 2006 IPCC Guidelines (IPCC 2006), such areas thus fulfill forest-management criteria in accordance with Art. 3.4 KP: "For example forested national parks (...) where these parks are managed to fulfil relevant ecological (including biodiversity) and social functions, and are subject to forest management activities such as fire suppression, a country may choose to include these forested national parks as lands subject to forest management."¹⁹⁷ It should be noted that the aforementioned area shares in the different forest-conservation categories cannot simply be summed, since they overlap to some extent; in some cases, the same forest area will have been repeatedly included (BMELV, 2009).

Much of Germany's forest land is subject to planning. According to estimates of the BMEL, forest-management plans (economic plans, operational plans or reports) are in place for about ¾ of the country's forested area (BMELV, 2009). In addition to such operational plans, in many cases forest landscape plans (forest framework plans) are also prepared for forests, in the framework of landscape planning¹⁹⁸. The aim of forest framework planning is to "safeguard the forest functions necessary for the development of ecological and economic conditions pursuant to Art. 1 No. 1 (BWaldG)". That accords precisely with the aim prescribed by the IPCC Good Practice Guidance (2003) with respect to forest management. To that end, measures may be, or must be, prescribed

¹⁹⁵ In addition, environmentally compatible measures to develop forests for recreational purposes and for nature-compatible research are permitted.

¹⁹⁶ Cf. for example, Art. 22 (1) Federal Nature Conservation Act (BnatSchG).

¹⁹⁷ IPCC KP Supplements (2014) Chapter 2.7.2 and IPCC 2006 Guidelines, Chapter 2, Volume 4

¹⁹⁸ Until 2005, the Federal Forest Act (BWaldG) required the preparation of forest framework plans. Because the Länder differ widely in their planning structures, those provisions were eliminated, however. Cf. BMELV (2009) Waldbericht der Bundesregierung (Forest Report of the Federal Government), p. 28.

(cf. for example, Art. 6 (3) No. 4 p. 2 BWaldG old version; Art. 6 (1) No. 2 Bavarian Forest Act (BayWaldG); Art. 9 (4) State Forest Act (LWaldG) of Mecklenburg – West Pomerania; Art. 6 p. 2 Forest and Landscape Act of the State of Lower Saxony (NWaldLG); Art. 7 (1) State Forest Act for the State of North Rhine – Westphalia (LFoG NRW); Art. 6 (2) Forest Act of the State of Saxony-Anhalt (WaldG Sachsen-Anhalt)¹⁹⁹). In some cases, requirements explicitly call for such planning to serve as a guideline for management, inter alia (cf. Art. 8 (3) LFoG NRW).

All in all, it must thus be considered confirmed that all forests in Germany are managed in accordance with forest-management criteria as set forth by the Marrakesh Accords and by the IPCC 3013 KP Supplements (IPCC 2014).

A compilation of excerpts from state forest acts, relative to requirements for forest management and for forest framework planning, is provided by STEUK (2010). A pertinent summary is presented in Table 465.

Table 465: Overview of obligations relative to forest management, preparation of plans and use of forest framework plans, as set forth by the forest acts of the Länder

State (Land)	Forest-management obligations			Obligations to prepare plans (economic plans, operational plans, operational reports or other specialised forest-management plans)			Obligations to prepare forest framework plans
	State forest	Municipal forest	Private forest	State forest	Municipal forest	Private forest	
Baden-Württemberg	X	X	X	X	X	(X)	(X)
Bavaria	X	X	X	X	[X]		(X)
Berlin	X	X	X				X
Brandenburg							X
Bremen	X	X	X				
Hamburg	X	X	X				X
Hesse	X	X	X	X	X	[X]	
Mecklenburg – West Pomerania	X	X	X				X
Lower Saxony	X	X	X	[X]	[X]		X
North Rhine – Westphalia	X	X	X		X		X
Rhineland-Palatinate	X	X	X	[X]	[X]	[X]	X
Saarland	X	X	X	X	X	(X)	X
Saxony	X	X	X	X	X		(X)
Saxony-Anhalt	X	X	X	X	X		X
Schleswig-Holstein				[X]	[X]		
Thuringia	X	X	X	X	X	[X]	X

Legend:

- X Binding requirement (includes "should" requirements)
- [X] Requirement is binding only under certain conditions (for example, conditions pertaining to minimum size)
- (X) Optional guideline / not binding (a "can" requirement)

¹⁹⁹ For definition of measures in operational plans, cf. Art. 5 (6) p. 3 State Forest Act (LWaldG) of Schleswig-Holstein.

11.5.2 Cropland management and grazing land management

All areas under cropland management and grazing land management are subject to periodic cultivation measures (carried out once or several times per year), and thus the pertinent emissions and removals are anthropogenic.

11.5.3 Information relative to cropland management and grazing land management for the base year

11.5.3.1 Cropland management

The emissions from cropland management in 1990 are dominated by CO₂ from organic soils. Carbon losses from mineral soils, as a result of conversions to Cropland, are also significant (Table 466). The emission pattern is very similar to that seen in 2015 (Table 450).

Table 466: Carbon-stock and greenhouse-gas emissions as a result of cropland management, in the base year 1990

Sub-categories	C-stock changes in biomass, 1990 ²⁰⁰	C-stock changes in mineral soils, 1990 ⁹³	CO ₂ from organic soils, 1990 ⁹³	CH ₄ from organic soils, 1990 ²⁰¹	Direct and indirect N ₂ O from decomposition of organic material in mineral soils, 1990 ⁹⁴	Total, 1990 ^{94/202}
	[kt C]	[kt C]	[kt C]	[kt CH ₄]	[kt N ₂ O]	[kt CO ₂ -eq.]
Cropland remaining cropland	7.87	NO	-1,611.60	5.17	NO	6,009.66
Total for LUC to cropland	-149.47	-729.91	-827.80	2.66	1.12	6,658.98
Total for LUC from cropland	NO	NO	NO	NO	NO	NO
Total	-141.60	-729.91	-2,439.40	7.83	1.12	12,668.64

Emissions and removals from land-use changes from cropland to other land-use categories are taken into account under Art. 3.3 (afforestation), Art. 3.4 (grazing land management) or, in keeping with the IPCC 2013 KP Supplements (IPCC 2014), Chapter 2.9.2, are accounted as zero. N₂O emissions from organic soils under cropland are reported in the agricultural sector, in the sub-category cultivation of histosols.

11.5.3.2 Grazing land management

The emissions from grazing land management in 1990 are dominated by CO₂ from organic soils. The carbon sink in mineral soils, in the land-use changes category, only slightly offsets the emissions (Table 467). The emission pattern is very similar to that seen in 2015 (Table 451).

²⁰⁰ Stock change, positive: C sink; negative: C source

²⁰¹ GHG emissions, positive: GHG source; negative: GHG source

²⁰² Not including N₂O emissions from organic soils; they are reported as part of the agricultural sector

Table 467: Carbon-stock and greenhouse-gas emissions as a result of grazing land management, in the base year 1990

Sub-categories	C-stock changes in biomass, 1990 ²⁰³	C-stock changes in mineral soils, 1990 ⁹⁶	CO ₂ from organic soils, 1990 ⁹⁶	CH ₄ from organic soils, 1990 ²⁰⁴	Direct and indirect N ₂ O from decomposition of organic material in mineral soils, 1990 ⁹⁷	Total, 1990 ^{97/205}
	[kt C]	[kt C]	[kt C]	[kt CH ₄]	[kt N ₂ O]	[kt CO ₂ -eq.]
Grassland (in the strict sense) remaining as Grassland (i.t.s.s.)	NO	NO	-6,834.09	21.24	NO	25,589.36
Total for LUC to grassland (in the strict sense)	-74.55	648.00	-610.27	1.90	NO	182.46
Total for LUC from grassland (in the strict sense)	NO	NO	NO	NO	NO	NO
Total	-74.55	648.00	-7,444.36	23.14	NO	25,771.82

Emissions and removals from land-use changes from grassland (in the strict sense) to other land-use categories are taken into account under Art. 3.3 (afforestation), Art. 3.4 (grazing land management) or, in keeping with the IPCC 2013 KP Supplements (IPCC 2014), Chapter 2.10.2, are accounted as zero. N₂O emissions from organic soils under grassland (in the strict sense) are reported in the agricultural sector, in the sub-category cultivation of histosols.

11.5.4 Information relating to Forest Management

11.5.4.1.1 Definition of forest management

As explained above in Chapter 11.5.1, the law requires German forests to be managed properly and sustainably. National provisions on forest management are set forth in the Federal Forest Act (BWaldG). In addition, the Länder have their own Land (state) forest acts in place that further detail the provisions of the Federal Forest Act. A comparison of Germany's national provisions with the relevant international definition shows broad agreement.

International definition pursuant to the Marrakesh Accords²⁰⁶:

"'Forest management' is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner."

Translation: "'Forest management' is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner".

National definitions pursuant to state forest acts (Landeswaldgesetze - LWaldG):

Pursuant to Art. 1 No. 1 Federal Forest Act (BWaldG), the purpose of the Act is, in particular, "to conserve forest for the sake of its economic value (utility function) and for the sake of its (...) (conservation and recreation function), to increase it, if necessary, and to assure its proper management for the long term". Pursuant to Art. 11 (1) p. 1 BWaldG, forests are to be "managed properly and sustainably, in the framework of their defined purposes." In keeping with the Federal Government's restricted legislative competence in this regard, the Federal Government simply

²⁰³ Stock change, positive: C sink; negative: C source

²⁰⁴ GHG emissions, positive: GHG source; negative: GHG sink

²⁰⁵ Not including N₂O emissions from organic soils; they are reported as part of the agricultural sector

²⁰⁶ Paragraph 1 lit. f of Annex A of Decision 16/CMP.1

provides a framework that the Länder implement and detail with regard to specific applications (cf. Art. 5 and Art. 11 (1) p. 2 BWaldG). As a result, the Länder define what is to be understood by "proper and sustainable forest management". A compilation of relevant sections of Länder forest acts is provided by STEUK (2010).

The forest-management requirements pursuant to Länder forest acts are comparable to those set forth by international forest legislation. The requirement that forests are to be managed sustainably, with a view to fulfilling ecological (including biological diversity), economic and social functions²⁰⁷, is found in all Länder forest acts. In Germany, ecological, economic and social functions are often referred to as "conservation, utility and recreation" functions²⁰⁸ (cf. Table 468). Where the ecological, economic and social functions that are to be served by management are not referred to explicitly as such in Länder laws, the laws add the phrase "within the framework of its [their] defined purposes"²⁰⁹. Forests are thus to be managed sustainably, within the framework of their defined purposes. This orientation is found in Art. 1 BWaldG (purpose of the act), which appears verbatim in every Land forest act. In addition, Art. 1 No. 1 BWaldG sets forth that forests are to be protected especially "in light of their economic value (utility function) and their (...) (conservation and recreation functions)". The aim of protecting economic, ecological and social functions is thus found in all such laws. Furthermore, both the Federal Forest Act and the forest acts of the Länder warrant the sustainability of forest management.

Table 468: Comparison of forest functions pursuant to the Federal Forest Act and the IPCC

Forest functions pursuant to BWaldG	Forest functions pursuant to MA
Utility function	Economic functions
Conservation function	Ecological functions
Recreation function	Social functions

11.5.4.2 Conversion of Natural Forest to Planted Forest

Within the meaning of the Kyoto Protocol, the majority of German forests are defined as part of the Planted Forest (cf. Annex 4A.1, Chapter 4, Volume 4, 2006 IPCC Guidelines). Within this meaning, this definition includes all managed forests, plantations and planted stocks. With its broadest sense of the definition, a management plan can be in place even when a protection concept is in place. Consequently, Germany has no forest areas for which no management concept is in place. Germany has no primary forest – or no such areas of relevance – within this sense (KRISMANN & HENNENBERG (2012)).

For the aforementioned reasons, Germany has no conversion of Natural Forest to Planted Forest.

11.5.4.3 Forest Management Reference Levels (FMRL)

Pursuant to resolution 2/CMP.6 (Cancun Agreements), for the second commitment period of the Kyoto Protocol, anthropogenic greenhouse-gas emissions from sources and sinks that result from forest management under Article 3.4 are to be accounted against the Forest Management Reference Levels (FMRL). In each case, the FMRL contains a value that projects the average annual net emissions from forest management, in the second commitment period, from historic data and political decisions.

²⁰⁷ Cf. Art. 4 No. 1 BayWaldG; Art. 1a LFoG NRW; a similar meaning also is seen in Art. 6 (1) LWaldG RLP; and a similar meaning is seen in Art. 18 (1) in conjunction with Art. 19 (1) p. 2 ThürWaldG.

²⁰⁸ Cf. Art. 1 No. 1 BWaldG; Art. 13 LWaldG BW; Art. 11 (2) No. 1 LWaldG B; Art. 4 (2) LWaldG Bbg; Art. 5 (1) BremWaldG, Art. 6 (1) HeFoG; Art. 6 (1) No. 1 LWaldG MV; Art. 11 (1) NWaldLG; Art. 5 (1) LWaldG SH.

²⁰⁹ Cf. Art. 6 (1) LWaldG Ha; Art. 11 (1) LWaldG SL; Art. 17 SächsWaldG; Art. 4 (1) WaldG LSA; Art. 18 (1) ThürWaldG.

For Germany, an FMRL of -22,418 Mt CO₂-eq per year has been reported. The documents submitted in 2011 relative to the FMRL, and the pertinent review report, are provided on the UNFCCC website <http://unfccc.int/bodies/awg-kp/items/5896.php>. Those documents include a description of the methods used to obtain the FMRL.

11.5.4.4 Technical correction of the FMRL

The IPCC 2013 KP Supplements require a technical correction of the FMRL if methodological changes result in calculation of the time series, if new historical data become available or if pools are included in current reporting that could not be taken into account in the original FMRL calculation. The reference level developed to date does not contain all categories and other emissions that are reported relative to KP 3.4, pursuant to the current rules for GHG reporting, and thus are part of the pertinent accounting (cf. Figure 85). For this reason, Germany has to carry out a technical correction of the FMRL. Due to a lack of predictive models – models that are currently being developed, however – Germany cannot carry out this technical correction in the current 2016 Submission. It will provide it in subsequent submissions, however.

Pool/GHG source	Relevant changes	Need of technical correction
Forest living biomass	- NFI cycle 2012 ➤ New parameters for tree growth functions ➤ New biomass functions	<i>New model run, adaptation to GHGI methodology and values, causing also new HWP calculations</i>
Soils	- Forest soil inventory (country specific emission factors) • Future: use of soil model	<i>Adaptation to GHGI methodology and values</i>
Litter		
Deadwood	NFI cycle 2012 (full sample, adapted threshold)	
Others	Minor changes	<i>Small adjustments possible</i>

Figure 85: Improvements and changes in the greenhouse-gas inventory, since 2011, that necessitate a technical correction of the Forest Management Reference Level

11.5.4.5 Information about natural disturbances under Article 3.4

As explained in Chapter 11.1.2, Germany has not selected the natural disturbances option. Natural disturbances that occur are not considered separately; instead, they enter into the change calculations for the relevant pools.

11.5.4.6 Information about harvested wood products under Article 3.4

As described in detail in Chapter 6.10, the emissions contribution made by harvested wood products in Germany, in terms of sources and removals into sinks for greenhouse gases, was determined with the WoodCarbonMonitor model, in keeping with the specifications of the IPCC KP Supplement (IPCC 2014).

First, the availability of activity data, i.e. data on the production of and foreign trade in harvested wood products, was reviewed (cf. Chapter 2.8.1.1, IPCC 2014), and the product fractions originating from domestic harvest were calculated. Then, in a second step (cf. Chapter 2.8.1.2, IPCC 2014), the carbon contained in those products was allocated, using the procedure described in Chapter 6.10.2.1, to the forest activities listed in the Kyoto Protocol under Article 3, paragraphs 3 and 4. For Germany, the wood harvest can be fully assigned to the two activities forest management and deforestation. In keeping with the provisions of the IPCC KP Supplements (IPCC 2014), harvested wood products from deforestation are taken into account on the basis of

instantaneous oxidation. As a result, the annual wood-harvest fractions from the activity forest management fFM(i) can be calculated from the inventory information available for Germany and from Equation 2.8.3 (IPCC 2014).

Further information, and details on the emission factors used and on the calculation carried out for Germany, in keeping with the provisions of the IPCC KP Supplement (IPCC 2014), are provided in Chapters 6.10.2.2 and 6.10.2.3.

11.6 Other information

11.6.1 Key-category analysis for Article 3.3 activities and any elected activities under Article 3.4

In connection with analysis for the UNFCCC inventory, key-category analysis was also carried out for activities pursuant to Article 3.3 and for selected activities pursuant to 3.4. The results are presented in tabular form in Chapter 1.5.2 of this report. The procedures, bases and methods used are described in detail in Chapter 17.1.4.

11.7 Information relative to Article 6 (JI & CDM projects / management of ERU)

Pursuant to Section 5 (1) Sentence 1 of the Project Mechanisms Act (Projekt-Mechanismen-Gesetz; ProMechG, http://www.gesetze-im-internet.de/promechg/_5.html), no projects in the area of LULUCF may be approved that are to take place in Germany.

The impermissibility results from Section 5 in conjunction with the concept of emissions reduction pursuant to Art. 2 No. 5 ProMechG, which states that "emission reduction" "means the reduction of emissions from sources; this shall not include the increased removal of greenhouse gases by sinks in the areas of land use, changes in land use and forestry." Furthermore, JI projects are hindered in that use of JI in Germany ended at the end of 2012; cf. Section 5 (3) ProMechG.

12 Information relative to accounting for Kyoto units

12.1 Background information

Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** and 14 include information on the German emission trading registry. The accounting on Kyoto units and the public availability of information is described in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** Any significant changes in the national registry are reported in chapter 14.

12.2 Summary of information reported in the SEF tables

According to decision 15/CMP.1, annex, part 1, section E each Party must include information on its aggregate holdings and transactions of Kyoto units in its annual report. The information has to be reported in the Standard Electronic Format (SEF), which is an agreed format, embodied in a special report, for reporting on Kyoto units.

The SEF for 2016 was generated on 2 March 2017 with the Union registry in version 8.0.8 r. 12510, provided by the EU commission on 01.03.2017 and the SEF application version 3.6.1, provided by the secretariat on 1.12.2015. The German SEF for 2016 contains the information required in paragraph 11 of the annex to decision 15/CMP.1 and adhere to the guidelines of the SEF. The SEF has been submitted to the UNFCCC Secretariat electronically.

12.3 Discrepancies and Notifications

15/CMP.1 annex I.E paragraph 12 List of discrepant transactions	No discrepant transactions occurred in 2016.
15/CMP.1 annex I.E paragraph 13 and 14 List of CDM notifications	No CDM notifications occurred in 2016.
15/CMP.1 annex I.E paragraph 15 List of non-replacements	No non-replacements occurred in 2016.
15/CMP.1 annex I.E paragraph 16 List of invalid units	No invalid units exist as at 31 December 2016.
15/CMP.1 annex I.E paragraph 17 Actions and changes to address discrepancies	No actions were taken or changes made to address discrepancies for the period under review.

12.4 Publicly accessible information

13/CMP.1 annex II paragraph 45 Account information	The requested information is publicly available for all accounts. The data of all accounts can be viewed online at: https://ets-registry.webgate.ec.europa.eu/euregistry/DE/public/reports/publicReports.xhtml Representative name and contact information is classified as confidential due to Article 107 Registry Regulation No. 389/2013.														
13/CMP.1 annex II paragraph 46 Joint implementation project information	The complete documentation of the JI projects is presented in the German JI project database which is accessible at the following URL. The database also contains already registered but not yet approved JI projects. https://jicdm.dehst.de/promechg/pages/project1.aspx In 2016, no ERU were converted from AAU or and no ERU converted from RMU were issued.														
13/CMP.1 annex II paragraph 47 Unit holding and transaction information	The information requested in (a), (d), (f) and (l) is classified as confidential due to Article 107 Registry Regulation No. 389/2013 as well as national data protection law and therefore not publicly available. Transactions of units within the most recent five year period are also classified as confidential, therefore the transactions provided are only those completed more than five years in the past. The information requested in (b), (c), (e), (g), (h), (i), (j) and (k) is publicly available at https://ets-registry.webgate.ec.europa.eu/euregistry/DE/public/reports/publicReports.xhtml .														
13/CMP.1 annex II paragraph 48 Authorized legal entities information	The following legal entities are authorized by the Member State to hold Kyoto units: <table border="1"> <thead> <tr> <th></th><th>Legal entities authorised by Germany to hold units</th></tr> </thead> <tbody> <tr> <td>AAU</td><td>Federal Government only</td></tr> <tr> <td>ERU</td><td>Each account holder</td></tr> <tr> <td>CER</td><td>Each account holder</td></tr> <tr> <td>RMU</td><td>Federal Government only</td></tr> <tr> <td>tCER</td><td>Federal Government only</td></tr> <tr> <td>ICER</td><td>Federal Government only</td></tr> </tbody> </table>		Legal entities authorised by Germany to hold units	AAU	Federal Government only	ERU	Each account holder	CER	Each account holder	RMU	Federal Government only	tCER	Federal Government only	ICER	Federal Government only
	Legal entities authorised by Germany to hold units														
AAU	Federal Government only														
ERU	Each account holder														
CER	Each account holder														
RMU	Federal Government only														
tCER	Federal Government only														
ICER	Federal Government only														

12.5 Calculation of the Commitment Period Reserve

Germany's Commitment Period Reserve (CPR) is calculated as 90 percent of Germany's assigned amount (3,592,699,888 tonnes CO₂ equivalent) calculated pursuant to Article 3 paragraphs 7 and

8 of the Kyoto Protocol. The initial CPR of the current commitment period did not change and is still 3,233,429,899 tonnes CO₂ equivalent (or AAU).

In accordance to Article 4 paragraph 4 Registry Regulation No. 389/2013 the Union registry has to prepare for keeping the CPR. If a transfer proposal would result in an infringement of the CPR, the registry should reject it internally.

The German registry did not violate the CPR during the reported year.

13 Information on changes in the national system

In the period covered by the report, work focused further institutional consolidation of the National System, in keeping with the requirements imposed by the 2nd commitment period of the Kyoto Protocol, via the Revised UNFCCC Reporting Guidelines, and via the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. In particular, in the area of the newly selected activities pursuant to Article 3.4 of the Kyoto Protocol, the revised concept for preparing emissions and carbon inventories for source categories 3 and 4, and the quality assurance concept for KP-LULUCF (cf. Chapter 1.2.1.4), have been implemented in inventory preparation. In addition, the existing institutionalisation was continually reviewed, in terms of its continuing availability for the 2nd commitment period. No other changes were made in 2016 in the institutionalisation of the National System.

14 Information on changes in the National registries

The following changes to the national registry of Germany have occurred in 2016.

15/CMP.1 annex II.E paragraph 32.(a) Change of name or contact	No change in the name or contact information of the registry administrator occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(b) Change regarding cooperation arrangement	No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(c) Change to database structure or the capacity of national registry	New tables were added to the CSEUR database for the implementation of the CP2 SEF functionality. Versions of the CSEUR released after 6.7.3 (the production version at the time of the last Chapter 14 submission) introduced other minor changes in the structure of the database. These changes were limited and only affected EU ETS functionality. No change was required to the database and application backup plan or to the disaster recovery plan. The database model, including the new tables, is provided in Annex A. No change to the capacity of the national registry occurred during the reported period.
15/CMP.1 annex II.E paragraph 32.(d) Change regarding conformance to technical standards	Changes introduced since version 6.7.3 of the national registry are listed in Annex B. Each release of the registry is subject to both regression testing and tests related to new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to the relevant major release of the version to Production (see Annex B). Annex H testing was completed in January 2017 and the test report is submitted as Annex H. No other change in the registry's conformance to the technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32.(e) Change to discrepancies procedures	No change of discrepancies procedures occurred during the reported period.

15/CMP.1 annex II.E paragraph 32.(f) Change regarding security	The mandatory use of hard tokens for authentication and signature was introduced for registry administrators.
15/CMP.1 annex II.E paragraph 32.(g) Change to list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(h) Change of Internet address	No change of the registry internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(i) Change regarding data integrity measures	No change of data integrity measures occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32.(j) Change regarding test results	Changes introduced since version 6.7.3 of the national registry are listed in Annex B. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission; the report is attached as Annex B. Annex H testing was carried out in January 2017 and the test report is submitted as Annex H.
1/CMP.8 paragraph 23 PPSR account	The opening of the PPSR account is linked to the entry into force of the Doha amendment (Article 73f introduced by the Delegated Regulation 2015/1844). Since only 74 countries have ratified out of the 144 needed in total, it currently prevents the carry-over of AAUs and thus the creation of PPSR accounts in the Union Registry.

15 Information regarding minimisation of negative impacts pursuant to Article 3 (14)

Most of the measures that would be carried out in Germany would not be expected to have direct effects on developing countries. In the case of other measures, the expected effects are largely considered to be positive. Such effects, for example, would include establishment of technical and administrative structures for climate protection.

Almost all of the possible indirect effects are also considered to be positive. Such effects would include beneficial impacts on energy supplies and prices in co-operating countries. Detailed descriptions of the individual measures were provided in the 2016 NIR. The areas covered by the measures include promotion of use of biofuels, reduction of subsidies for hard coal, policies and measures at the EU level – especially EU emissions trading – and support for developing countries in energy-supply diversification. No current changes have been made with respect to these reported measures.

16 Other information

This chapter is currently not required.

17 Annex 1: Key categories within the German greenhouse-gas inventory

Pursuant to the *2006 IPCC Guidelines*, the parties to the UN Framework Convention on Climate Change and to the Kyoto Protocol are required to calculate and publish emissions data annually.

These emissions inventories must be readily comprehensible (transparency); must be calculated in a consistent manner in the time series since 1990 (consistency); must be evaluated uniformly at international level via application of the prescribed calculation methods (comparability); must contain all the relevant emission sources and sinks in the reporting country (completeness); must be evaluated with error specification; and must undergo ongoing internal and external quality management (accuracy).

To facilitate concentrating the many and detailed activities and resources required for this purpose on the inventory's principal categories, the IPCC has introduced the term "key category." Key categories are categories which are highlighted in the national inventory system because their emissions have a significant influence on total emissions of direct greenhouse gases, either in terms of absolute emissions, or as a contribution to the emissions trend over time, or in both ways.

Chapter 4 of the 2006 IPCC Guidelines describes the methods to be applied for identifying key categories. These methods include inventory analysis for one year (Approach 1, Level Assessment), time-series analysis of inventory data (Approach 1, Trend Assessment), detailed analysis of inventory data with error evaluation (Approach 2, Trend Assessment with consideration of uncertainties) and assessment of qualitative criteria (pursuant to Chapter 4.3.3 2006 IPCC GL: Vol. 4, Ch. 1).

Approach 1 analyses must always be carried out using two procedures. In a first procedure, only emissions from sources are evaluated, and storage in sinks is not considered. In a second procedure, emissions storage in sinks is then included (without any consideration of whether it is positive or negative). As would be expected, the two results differ. Pursuant to the 2006 IPCC GL, both results must be taken into account in identification of key categories.

For identified key categories, the Parties are then required to use highly detailed calculation methods (Tier 2 or higher; the relevant methods are also specified in the 2006 IPCC GL). Should direct use of such methods prove impossible, for whatever reason (e.g. data are not available for the required input variables, etc.), Parties are required to prove that the methods applied nationally achieve at least a comparable degree of accuracy in the calculation result. Such proof, as well as the key-category analysis performed overall, must be outlined in the national inventory report to be prepared annually.

17.1 Description of the method for identifying key categories

The results of key-category analysis via the two Approach 1 procedures (Level and Trend), the Approach 2 procedure and assessment in terms of qualitative criteria are outlined below. In this context, we call attention to the description of the underlying methods in the *2006 IPCC GL*. Annual emissions inventories were divided, with regard to their CO₂-equivalent emissions, into a total of 151 individual activities.

17.1.1 Approach 1 procedures

Level analysis has the purpose of identifying those source categories responsible for 95 % of total national emissions (as CO₂-equivalent emissions), in the Kyoto Protocol's base year and in the

current year; those sources are then defined as key categories (2). Calculations were performed using formula 4.1 from the 2006 IPCC Guidelines (Vol. 1).

With the category structuring used for such analysis, Approach 1 level analysis identified a total of 35 key categories for the current report (cf. Table 6, Chapter 1.5).

Trend analysis identifies as key categories (2) those categories which have made an especially significant contribution to changes in total GHG emissions in the most recent year, in terms of the development of their contribution since the base year. In this respect, it is irrelevant whether such changes have led to a reduction or an increase in total emissions. Calculations were performed using formula 4.2 from the 2006 IPCC Guidelines (Vol. 1).

Tier 1 Trend analysis, using category structuring as described, identified a total of 39 key categories (cf. Table 6, Chapter 1.5).

17.1.2 Approach 2 procedure

Key-category analysis using the Approach 2 procedure is based on the results of current uncertainties determination in accordance with Approach 1. In the present case, the results have provided extensive confirmation of the results of the Approach 1 key-category analyses. Six additional categories also have to be considered, however (cf. Table 8, Chapter 1.5.1).

17.1.3 Assessment with qualitative criteria

Germany assesses key categories with help of qualitative criteria. Chapter 4.3.3 of the 2006 IPCC Guidelines (Vol. 1) provides recommendations relative to the criteria to be applied. The criteria allow assessment on the basis of use of emissions-reduction equipment, of expected disproportionate emissions increases, of a high level of uncertainty or of unexpectedly lower or higher emissions in a given category. The criteria may be used as a basis for defining additional categories as key categories.

In the category adipic acid production (2.B.3), a redundant waste-gas-treatment system was installed. In light of that installation, the category has been classified as a key category, on the basis of qualitative criteria. 2.B.3 is already a key category, however, in terms of Approach 1 Level and Trend assessment. SF₆ emissions from soundproof windows are reported in 2.G.2. Even though such a trend cannot yet be recognized, it is clear that SF₆ emissions must be expected to increase sharply in coming years as disposal of old windows increases. For that reason – i.e. on the basis of qualitative criteria – the category has already been identified as a key category. That classification leads to no change, however, since 2.G is already a key category, according to Approach 1 Level and Trend, for SF₆. Qualitative assessment on the basis of large uncertainties is not required, since Germany carries out Approach 2 key-category analysis for the entire inventory every three years. No unexpectedly low or high emissions have been seen in the inventory.

Use of qualitative criteria has not identified any additional key categories in Germany.

Germany uses all recommended procedures for identifying and evaluating categories. The IPCC Guidelines mandate that 95% of emissions from sources / removals in sinks be classified in key categories. The key categories that Germany has identified comprise emission-causing activities that account for about 98 % of the total inventory. This high percentage results from Germany's practice of identifying key categories by combining the results of all analysis procedures and evaluations.

17.1.4 Key-category analysis for Kyoto reporting

The following CRF Table NIR.3 summarises information relative to key-category analysis for Kyoto reporting.

Table 469: KP CRF Table NIR.3: Summary Overview for Key Categories for Land Use, Land-Use Change and Forestry Activities under the Kyoto Protocol

Key Categories of Emissions and Removals	Gas	Criteria used for Key Category Identification			Comments ⁽³⁾
		Associated category in UNFCCC inventory ⁽¹⁾ is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory ^{(1), (4)} (including LULUCF)	Other ⁽²⁾	
Specify key categories according to the national level of disaggregation used ⁽¹⁾					
Afforestation and Reforestation	CO ₂	Conversion to forest land	Yes	High expected growth.	The value is very close to the value in the smallest category considered key in the UNFCCC inventory. The value has increased about tenfold since 1990.
Forest Management	CO ₂	Forest Land remaining Forest Land	Yes	None	No Comment
Cropland management	CO ₂	Cropland remaining Cropland Land converted to Cropland	Yes	None	No comment
Deforestation	CO ₂	Land converted to Cropland	Yes	None	No comment
Grazing Land Management (GM)	CO ₂	Grassland remaining grassland	Yes	None	No comment

⁽¹⁾ See section 5.4 of the IPCC good practice guidance for LULUCF.

⁽²⁾ This should include qualitative consideration as per section 5.4.3 of the IPCC good practice guidance for LULUCF or any other criteria.

⁽³⁾ Describe the criteria identifying the category as key.

⁽⁴⁾ If the emissions or removals of the category exceed the emissions of the smallest category identified as key in the UNFCCC inventory (including LULUCF), Parties should indicate YES. If not, Parties should indicate NO.

18 Annex 2: Detailed discussion of the methodology and data for calculating CO₂ Emissions from combustion of fuels

18.1 The Energy Balance for the Federal Republic of Germany

In the Federal Republic of Germany, energy statistics are published by numerous agencies, and these statistics can differ in terms of their presentation, scope and aggregation. The Energy Balances of the Federal Republic of Germany, which are prepared under commission to the German Federal Ministry for Economic Affairs and Energy (BMWi), are the central data foundation for determining/preparing energy-related emissions, scenarios and forecasts of the impacts of energy-policy and environmental-policy measures. On an annual basis, the associations in the German energy sector, working in co-operation with economic research institutes, and in the framework of the Working Group on Energy Balances (AGEB), combine the relevant data to form a complete picture. They then make the data available to the public in the form of Energy Balances.

The complete Energy Balances for the years since 1990 are available in the Internet at:

http://www.ag-energiebilanzen.de/index.php?article_id=7&clang=0

The AGEB's website presents a foreword for the Energy Balances, in German and English, that describes the structure of the Energy Balance.

The members of the Working Group on Energy Balances (AGEB) include (as of: September 2015):

- Bundesverband der deutschen Energie- und Wasserwirtschaft e.V. (BDEW) (Association of the German Energy and Water Industry), Berlin
- Deutscher Braunkohlen-Industrie-Verein e.V. (DEBRIV) (Federal German association of lignite-producing companies and their affiliated organisations), Cologne,
- Deutsches Institut für Wirtschaftsforschung (DIW) (German Institute for Economic Research), Berlin,
- EEFA GmbH, Münster
- Energiewirtschaftliches Institut an der Universität Köln (EWI) (Institute of Energy Economics at the University of Cologne), Cologne,
- Gesamtverband Steinkohle (GVSt) association of the German hard-coal-mining industry, Herne,
- Mineralölwirtschaftsverband (MWV) (Association of the German Petroleum Industry), Berlin,
- Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI) (Rhine-Westphalian Institute for Economic Research), Essen.
- Verein der Kohlenimporteure e.V. (German Coal Importer Association), Hamburg
- Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW), Stuttgart

The work of the Working Group on Energy Balances (AGEB) is also supported by the Energieeffizienzverband für Wärme, Kälte und KWK e.V. (AGFW; Association for energy efficiency in heating, cooling and CHP systems) and the Association of Industrial Energy and Power Producers (VIK). Since the 1994 balance year, overall responsibility for preparation of Energy Balances has lain with the German Institute of Economic Research (DIW; Berlin); since 2002, the DIW has carried out relevant work in co-operation with EEFA (Energy Environment Forecast Analysis GmbH) and with Mr. Rossbach (formerly with the Association of the German Petroleum Industry (MWV), who serves as a consultant for the section on petroleum. Overall, with due regard for the available data, the Energy Balances provide a comprehensive picture of energy production and use quantities/structures in the German economy.

Official statistics are the most important source. The surveys of the Federal Statistical Office that were used are listed in Table 470. The final Energy Balance continues to include data of the following associations: German Association of Energy and Water Industries (BDEW), German Atomic Forum (DATF), Gesamtverband Steinkohle association of the German hard-coal-mining industry (GVSt), DEBRIV Federal German association of lignite-producing companies and their affiliated organisations and Association of the German Petroleum Industry (MWV). In addition, for the period until 2011 figures on wood consumption in the residential sector were obtained from GfK-Rheinbraun data that are reported via DEBRIV, in February/March of the relevant subsequent year + 1. For wood consumption by private households as of the year 2012, data from an RWI survey (Erhebungsstudie) was used as a basis, while for wood consumption in the Commercial and Institutional sector figures of the Johann Heinrich von Thünen Institute (Federal Research Institute for Rural Areas, Forestry and Fisheries) are being used for the period as of 2013.

In addition, figures of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat)) are used for the final Energy Balance. Provisional data on renewable energy sources are discussed with AGEE-Stat and the BDEW. They enter into the estimated Balance and, thus, into the evaluation tables.

In a number of categories, furthermore, experts personally provide relevant data – in categories, for example, such as non-energy-related consumption by the chemical industry.

18.2 Structure of the Energy Balances

The Energy Balances, which are structured in matrix form, provide an overview of the interconnections within the energy sector. As a result, they not only provide information about consumption of energy resources in the various source categories, they also show the relevant flows of such resources, from production to use in the various production, transformation and consumption areas. The **production balance** shows:

- Domestic production
- Imports
- Removals from stocks
- Exports
- Maritime bunkering
- 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 (PROGNOS, 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.

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, as well as what other resources they are transformed into. The transformation production shows the results of such transformation. Energy transformation can involve either

substance modification – such as transformation of crude oil (transformation input) into petroleum products (transformation production) – or physical transformation – such as combustion of hard coal (transformation input) – in power stations, for production of electrical energy (transformation production). 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 broken down by facility type; a total of 12 different types of facilities are considered.

Non-energy-related consumption, as a component of the consumption balance, is shown as a total, without allocation to facility types or branches of industry. It describes which energy resources are used as raw materials (e.g. in the chemicals industry, transformation of energy resources into plastics).

Finally, the consumption balance indicates the final consumption sectors in which energy is transformed into the useful energy ultimately needed (such as power, light, room and process heating) (**final energy consumption**). This includes industry, sub-divided into 14 sectors, transport, households and commercial use, trade, services and other consumers (including agriculture).

The energy flow in the Energy Balances is depicted for 30 energy resources. 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, firedamp, excluding landfill gas and the aforementioned gases),
- Renewable energies (including renewable waste and, as of 2013, sewage sludge),
- Other energy sources (non-renewable waste, waste heat),
- Electrical power and other energy resources.

Energy Balances have been drawn up for the years 1990 to 1994, both separately for the old and new Länder and for Germany as a whole. Since 1995, only one Energy Balance for Germany as a whole (in its territorial boundaries of 3 October 1990) is prepared. In a satellite balance, renewable energies are further broken down as of 1996 (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 resources are listed in *natural units*, including tonnes (t) for solid and liquid fuels, cubic metres (m³) 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 suitable for addition, all values are converted into joules (J) using calorific value tables and conversion factors. Unlike gas statistics, the Energy Balance lists even gases in terms of calorific value.

To date, Energy Balances through 2014 have been published. To meet the need for currentness in emissions reporting, the Working Group on Energy Balances (AGEB) provides the Federal Environment Agency with a complete provisional Energy Balance, for purposes of inventory preparation.

18.3 Methodological issues: Energy-related activity rates

Essentially, the inventories for air pollutants and greenhouse gases prepared by the Federal 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 biomass fuels, and for natural gas and light heating oil, EB line 14, depending on the fuel in question, also has to be 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 3.2.8.2.
- Natural gas inputs in compressors, for the years 1995-2002, can be read 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 Chapter 3.2.10.5.2 (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 3.2.6.2 (category 1.A.1.a) and in Chapter 3.2.9.7.2 (category 1.A.2.g Other (stationary)).
- Firewood use in the categories commercial and institutional is not listed in the Energy Balance through 2012 and has to be added. A description of category 1.A.4 is provided in Chapter 3.2.11.2.

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 of the related blast-furnace gas for energy 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.

18.4 Uncertainties, time-series consistency and quality assurance in the Energy Balance

As a result of increasing energy-market liberalisation, and in conjunction with the formation of a European single market, the condition of the statistical energy database has worsened in recent years of change (ZIESING et al, 2003). While the Act on Energy Statistics (which entered into force in 2003) improved the relevant basic data foundations, relatively speaking, the dynamic development of the energy sector has again created a need for amendment of that Act.

The data structures of the Energy Balance are adjusted on an ongoing basis, in order to enhance data availability to the best possible extent.

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 – 2006²¹⁰
- Remarks regarding changes in the Energy Balances 2003 through 2007²¹¹

²¹⁰ [http://www.ag-energiebilanzen.de/#revision der eb 2003 bis 2006](http://www.ag-energiebilanzen.de/#revision%20der%20eb%202003%20bis%202006)

²¹¹ [http://www.ag-energiebilanzen.de/#aktualisierungen der energiebilanzen 2003 bis](http://www.ag-energiebilanzen.de/#aktualisierungen%20der%20energiebilanzen%202003%20bis%202007)

- Revision of the Energy Balances 2003 through 2009²¹²
- Methodological changes in the 2012 Energy Balance²¹³

18.4.1 Quality report of the Working Group on Energy Balances (AGEB) regarding preparation of Energy Balances for the Federal Republic of Germany

In 2012, the Working Group on Energy Balances (AGEB) began submitting annual joint quality reports, to the Federal Environment Agency (UBA), that document its quality-assurance measures in preparation of Energy Balances.

The following section presents the content of the current reports, in their original wording (marked with a different typeface).

18.4.1.1.1 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) and the EEFA research institute also work on such Energy Balances, as sub-contractors to the AGEB. 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 2014 Energy Balance.

18.4.1.1.2 Work-sharing in preparation of Energy Balances

The DIW Berlin is responsible for preparing Energy Balances for the following energy areas:

- Natural gas, petroleum gas
- Renewable energies (hydro, wind and photovoltaics; biomass and renewable waste; other renewable energy sources),
- Non-renewable waste, waste heat,
- Electricity (through 2012),
- Nuclear energy and
- District heat (through 2012).

Also in the framework of its Energy Balance work, the DIW Berlin coordinates the quarterly estimates of primary energy consumption for the Federal Republic of Germany, and it prepares estimates for the energy area "Other".

In addition, DIW Berlin awards a service contract to Mr. Ulrich Rossbach, who prepares the petroleum section of the Energy Balances.

- Crude oil, and
- Petroleum products (gasoline; naphtha; jet fuels; diesel fuel; light heating oil; heavy heating oil; petroleum coke; LP gas; refinery gas; other petroleum products)

²¹² [http://www.ag-energiebilanzen.de/#revision der energiebilanzen 2003 bis 2009 05](http://www.ag-energiebilanzen.de/#revision%20der%20energiebilanzen%202003%20bis%202009%2005)

²¹³ [http://www.ag-energiebilanzen.de/#methodische aenderungen der eb 2012](http://www.ag-energiebilanzen.de/#methodische%20aenderungen%20der%20eb%202012)

The tasks of the EEFA research institute include preparing complete Energy Balances for the following fuels:

- Hard coal, hard-coal coke, hard-coal briquettes and other hard-coal products,
- Lignite (raw), lignite briquettes, other lignite products and hard lignite, and
- Coking-plant gas and city gas, blast furnace gas and basic oxygen furnace gas, and mine gas.
- Electricity (through 2013),
- District heat (through 2013).

In the framework of its work on the Energy Balances, the EEFA institute also coordinates deliveries and reporting of energy-statistics data in the context of European and international obligations (IEA/EUROSTAT Annual Joint Questionnaires).

Since Energy Balance year 2009, estimate balances have been prepared in the framework of work for the evaluation tables. They incorporate data from Statistik-Nr. 066 (Erhebung über die Elektrizitäts- und Wärmeerzeugung der Stromerzeugungsanlagen der allgemeinen Versorgung; Survey of electricity and heat generation of public-sector electricity generation systems) of the Federal Statistical Office (StBA), association data of the German Association of Energy and Water Industries (BDEW) and data of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat)). The estimates are coordinated especially with the BDEW and the AGEE-Stat. Data from Official Mineral Oil Statistics (AMS of the Federal Office of Economics and Export Control (BAFA)) are also used.

At that early stage in Energy-Balance preparation, important official data sources, such as surveys relative to energy consumption of industrial sectors, are normally not yet available. The pertinent data gaps are closed with the help of estimates. It is thus clear that an estimated Energy Balance cannot fulfill the strict requirements pertaining to data quality that the final Energy Balance meets, a work published with a time lag of about one year.

18.4.1.1.3 Quality of the data sources used

The following *data of the Federal Statistical Office (StBA)* are used in the preparation of the Energy Balances for the Federal Republic of Germany:

- Survey (No. 060) of energy use of mining, quarrying and manufacturing companies,
- Survey (No. 061E) in coal imports,
- Survey (No. 062) of geothermal energy,
- Survey (No. 064) of heat generation, demand, use and supply,
- Survey (No. 066) of electricity and heat generation of public-supply electricity generation systems,
- Survey (No. 067) of electricity generation systems in the mining and manufacturing sectors,
- Survey (No. 070) of network operators relative to electricity feed-in,
- Survey (No. 073) of production, use and supply of sewage gas,
- Survey (No. 075) of production, demand, use and supply of LP gas,
- Survey (No. 082 P) of supply, import and export of natural gas and petroleum gas, and of revenue of producers,
- Survey (No. 082) of production, supply, import and export of gas, and of revenue of gas utilities and gas sellers.
- Energiesteuerstatistik (energy taxation statistics), Fachserie 14, Reihe 9.3),
- Data on the coal industry (Statistik der Kohlenwirtschaft coal-sector-statistics association, supported by the Gesamtverband Steinkohle association of the German hard-coal-mining industry (GVSt) and by the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations).

The data of the Federal Statistical Office (StBA) are subject to official quality requirements. The quality reports of the Federal Statistical Office are available in the Internet, at its Web site:

<https://www.destatis.de/DE/Publikationen/Qualitaetsberichte/Energie/EnergieWasserversorgung.html>.

In addition, data from the *Official Mineral Oil Statistics (AMS)* of the Federal Office of Economics and Export Control (BAFA) are used. The Official Mineral Oil Statistics for Germany (AMS), which are published monthly and annually, imply that the entire system for petroleum production and consumption in Germany is a closed system that is free of internal contradictions. The statistical basis for the AMS is the "Integrated Mineral Oil Report" (IM), which all major oil companies are provided to submit. The Federal Office of Economics and Export Control (BAFA) regularly reviews the figures provided by oil companies. In addition, BAFA also surveys and monitors traders / importers, a group defined via the "survey group" process. The Official Mineral Oil Statistics include – apart from a few exceptions – no information on sectoral oil consumption in Germany. Such data are obtained from other official and other sources and – if necessary – modified. The net calorific values for petroleum products and crude-oil inputs are reviewed on an annual basis, and reset as necessary. This process is carried out in light of technical progress and market trends. The aim of the process is to make conversion of tonne data into terajoule units as precise as possible.

In addition to the available official data, the following *association data* are also used:

- Data on gross electricity generation in the Federal Republic of Germany (BDEW)
- Data on electricity generation in nuclear power stations (Deutsches Atomforum e.V.)
- Figures on petroleum production and consumption Angaben (Association of the German Petroleum Industry (MWV); MWV member companies; surveys of consumers),
- Data on petroleum and natural gas production (annual report of the Wirtschaftsverband Erdöl- und Erdgasgewinnung (W.E.G.) German oil and gas industry association)
- Data on LP gas (German Liquid Petroleum Gas Association (DVFG)),
- Data on the coal industry (Statistik der Kohlenwirtschaft coal-sector-statistics association, supported by the Gesamtverband Steinkohle association of the German hard-coal-mining industry (GVSt) and by the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations).

The *Statistik der Kohlenwirtschaft* coal statistics play a special role among the association statistics. The data used for the Energy Balance include the following:

For hard coal:

- Statistics on domestic sales, broken down by types of hard coal and consumer groups, and
- Statistics on production, use in transformation sectors and changes in stocks (form 4a).

For lignite:

- 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 (cf. in the Internet: <http://www.kohlenstatistik.de/files/50jahre.pdf>). 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; its refers instead explicitly to the functioning system of coal statistics.

The following *additional sources* are also used:

- Various studies on fuel consumption of machines in the "non-road" sector (Institute for Energy and Environmental Research – ifeu-Institut GmbH, Heidelberg)
- Figures on renewable energies (Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat))).

With regard to wood consumption in the Residential sector for the year 2014, results from the survey by RWI/forsa are being carried forward. Since 2013, wood consumption in the Commercial and Institutional sector has been determined on the basis of data of the Johann Heinrich von Thünen Institute (Federal Research Institute for Rural Areas, Forestry and Fisheries).

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 well-documented in the sources used for preparation of Energy Balances. This ensures that methods are always properly adjusted.

18.4.1.1.4 Transparency of methods and procedures

The Act on Energy Statistics (Energiestatistikgesetz – (EnStatG) entered into force on 1 January 2003. That act consolidates official energy statistics, from different legal frameworks, and adapts them to users' current 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 exactly defined, mathematically, and it is explained in the forewords to the Energy Balances.

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 framework assumptions, such as the reference efficiencies of non-CHP generation as provided in the documentation for the Energy Balances, are clearly 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.

18.4.1.1.5 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, and
- 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 annual Energy Balance is prepared independently by several experts, in a process that includes cross-checking of work.
- 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).
- The Energy Balances are cross-checked against the data provided to IEA/Eurostat.
- In addition, the AGEB member associations carry out supporting checks.
- With regard to renewable energies, the Working Group on Renewable Energy Statistics (AGEE-Stat) carries out its own consultations and "four-eyes" checks.
- Furthermore, at early stages data and results are exchanged and discussed with responsible experts of the Federal Environment Agency (UBA).
- Statistical questions pertaining to the Energy Balance are also discussed by the "Working Group on methods" ("Arbeitskreis Methodik" – AKM) within the Federal Ministry for Economic Affairs and Energy (BMWi).

Only when the completed Energy Balance has successfully passed through all controlling bodies is it published on the AGEB's Web site 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.

18.4.1.1.6 Documentation and archiving

DIW Berlin and the EEFA research institute keep careful, detailed 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 Energy Balance staff and by the Federal Ministry for Economic Affairs and Energy (BMWi) and the Federal Environment Agency. 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 pertinent electronic data are backed up automatically by the DIW – both automatically, on dedicated server space, and manually, at regular intervals. For electronic archiving, the EEFA institute uses portable media (CD-ROMs, DVD), external drives and network-based server systems. Data back-ups are carried out both automatically and manually (at regular intervals).

18.4.1.1.7 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"), DIW Berlin and the EEFA research institute rely on experienced staff with solid backgrounds in the areas of statistics, economics and the energy sector.

18.4.1.1.8 Explanations regarding the currentness and availability of data for preparation of Energy Balances

Official statistics

The final annual data from the monthly survey 066 (electricity generation for the public supply) for 2014 became available in April 2015 and were corrected in July 2015. Other annual surveys became available as follows: 064 (heat generation), November 2015; 067 (electricity generation systems of industry) became available in its final version, following correction, in November 2015; 070 (electricity feed-in), October 2015; and 073 (sewage gas), July 2015. Nos. 082/082P became available in November 2014. The results of surveys 066 (electricity generation systems for the public supply) and 067 (electricity generation systems for industry) have to be converted via the "Finnish" method. Calculations, checking and processes of consultation with the German Association of Energy and Water Industries (BDEW), Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), Energy Environment Forecast and Analysis (EEFA) institute, and Association of the German Petroleum Industry (MWV) take at least three weeks.

The results of survey 060 (energy use by industry), which account for a significant part of the Energy Balances, became available in November 2015. That significantly shortened the amount of time available for preparation of the Energy Balance. Calculations for individual sectors, plausibility checks, checking requests submitted to the Federal Statistical Office (which has to forward the requests to the Länder) and consultations with participating associations take at least three weeks. The results of survey 062 (geothermal energy) became available in October 2015.

As a result of such time constraints, an estimated Balance is prepared in July (in a process first carried out for the 2009 report) that incorporates the available official data from survey 066. The remaining data are first estimated and agreed on in cooperation with the AGEb member associations.

Association statistics

Data from associations (see above), which become available early, enter into the final Energy Balance.

Because quarterly estimates of primary energy consumption in Germany are carried out, provisional data in the relevant areas also become available quickly. The BDEW provides important provisional data, dated as of 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" ("Energiemarkt Deutschland – Zahlen und Fakten zur Gas-, Strom- und Fernwärmeversorgung"). In addition, the estimated Balance incorporates BDEW data on gross electricity generation, data of Gesamtverband Steinkohle (GVSt; Association of the German hard-coal mining industry), of the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations, of the Association of the German Petroleum Industry (MWV) and of the Deutsche Atomforum nuclear-energy association.

Other data

For the final Energy Balance, data of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat)), are also used; those data regularly become available with a "last revised" date in August.

The 2013 figures on electricity generation from biomass, and on biomass-fuel inputs in decentralised CHP systems, are based on information of the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW). In this connection, a method is used that was developed by ZSW and EEFA in the framework of reporting to IEA and Eurostat. With regard to wood consumption in the Residential and Commercial / Institutional sectors, figures of RWI/forsa and of the Thünen Institute were carried forward.

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.

Table 470: Federal Statistical Office surveys used in preparation of Energy Balances for the Federal Republic of Germany

Survey	No.	Survey period	Currentness, pursuant to quality report	Type of data	Group surveyed	Units surveyed
Survey of energy use by the mining, quarrying and manufacturing sectors	060	Annually	End of the following year (available as of the end of October / beginning of November)	Electricity generation, deliveries and consumption Fuels / energy sources, orders and consumption, by energy source / fuels Fuels / energy sources, deliveries and stocks, by energy source / fuels Average net calorific value	Sections B "Mining and quarrying" and C "Manufacturing"	Producing companies (currently, at least 40,000) with at least 20 employees Exception: Plants of Manufacturing sector companies with 10 or more persons active in the relevant economic sectors
Survey on coal imports	061E	Monthly; annually	end of April of the following year	Coal imports	Companies that import lignite, lignite products, hard coal, hard-coal coke and hard-coal briquettes.	Exhaustive survey (but does not include units located abroad)
Survey on geothermal energy	062	Annually	About 9 weeks after the end of the reporting period	Net heat generation and output by type of system, and by domestic customer groups being supplied with heat.		The survey covers a maximum of 100 operators of systems for use of geothermal energy
Survey of heat generation, demand, use and supply,	064	Annually	End of the following year (available usually at the end of September)	District heating: Net heat generation, demand, deliveries and network losses. No information on energy sources / fuels is provided Heating plants: Fuel inputs and heat production, by energy sources / fuels	Operators of heating plants with outputs of at least 1 MWth, and operators of district heating networks (only large networks that have grown "historically"). No "island networks" for district heating are surveyed	Max. of 1,000 operators of heating plants, including absorption systems for refrigeration, and with outputs of at least 2 MWth.
Survey of electricity and heat generation of electricity generation systems serving the public grid	066K	Monthly; annually	6 weeks after the end of the reporting period; end of June of the following year (available in May)	Number, net-electricity and net-heat production, by plant type, Electricity and heat production, by energy sources / fuels Fuel inputs for electricity and/or heat production, by energy sources / fuels (separate survey of CHP systems)	Companies and plants in the electricity sector (public grid)	Max. of 1,000 operators of plants with outputs of at least 1 MWel.
Survey of electricity generation systems of manufacturing, mining and quarrying companies	067	Annually	9 weeks after the end of the reporting period (available usually at the end of September)	Number and bottleneck capacity, by plant type Net-electricity and net-heat production (separate survey of CHP systems) Fuel inputs for electricity and/or heat production, by energy sources / fuels (separate survey of CHP systems) Own consumption of electricity and heat	Sections B "Mining and quarrying" and C "Manufacturing"	Operators (currently, about 500) of systems serving their own requirements. Surveys cover systems for generating electricity, including systems for co-generation of electricity and heat (CHP) with outputs of at least 1 MWel
Survey of network operators relative to electricity feed-in	070	Annually	12 weeks after the end of the reporting period (available usually at the end of September)	Electricity feed-in, by Länder and energy sources / fuels Power statistics, separately for Länder and energy sources / fuels	Operators of electricity grids for the public supply	Exhaustive survey
Survey of production, use and supply of sewage gas	073	Annually	8 weeks after the end of the reporting period (available at the end of June / beginning of July)	Anaerobic sewage-gas collection Fuel inputs in power stations Fuel inputs for heating only or motors (drive units) only Electricity feed-in Own consumption	Operators of wastewater-treatment plants	Max. of 6,000 operators of wastewater-treatment plants (currently, about 1,300 operators)
Survey on provision of liquefied petroleum gas	075	Annually	8 weeks after the end of the reporting period (available at the end of June / beginning of July)	Provision of liquefied petroleum gas, by domestic customer groups and German Länder (states); and exports	Companies that provide liquefied petroleum gas to end users and resellers	A maximum of 130 companies that provide liquefied petroleum gas to end users or resellers

Survey	No.	Survey period	Currentness, pursuant to quality report	Type of data	Group surveyed	Units surveyed
Survey of production, supply, import and export of gas, and of revenue of gas utilities and gas sellers	082	Annually	National results become available 12 months after the end of the period covered by the report	Extraction and production of gas, demand for gas, and value of relevant imports Deliveries and exports of gas, and relevant revenue Gas production, by gas types Gas deliveries, and revenue, by Länder	Gas-sector companies	Exhaustive survey
Survey of supply, import and export of natural gas and petroleum gas, and of revenue of producers	082P	Annually	National results become available 12 months after the end of the period covered by the report	Imports and exports; sales by domestic customer groups	Natural gas producers	Exhaustive survey

Link to the nomenclature for classification of industrial sectors (Nomenklatur der Wirtschaftszweige; WZ 2008):

<https://www.destatis.de/DE/Methoden/Klassifikationen/Klassifikationen.html>

Link to the quality reports on energy statistics, and a questionnaire: <https://www.destatis.de/DE/Publikationen/Qualitaetsberichte/Energie/EnergieWasserversorgung.html>

18.5 Energy-Data Action Plan for inventory improvement

Also in 2012, the Federal Environment Agency, working in cooperation with the Federal Ministry for Economic Affairs and Energy (BMWi), the Working Group on Energy Balances (AGEB) and the Federal Statistical Office, prepared an "Energy-Data Action Plan for inventory improvement" that outlined actions to be taken to address the criticism that emerged from the inventory review. This action plan fulfills the action-plan requirement set forth in Paragraph 39 of the 2011 review report (FCCC/ARR/2011/DEU).

Table 471: Energy-Data Action Plan for inventory improvement

No.	Issue	Responsibility	Responsibility for execution	Reference (paragraph)	Quotation from 2011 review report (FCCC/ARR/2011/DEU)	Instrument for implementation / publication	Activity for improvement	Result planned / achieved	Time frame	Remark
1	Energy-Data Action Plan for inventory improvement	Federal Ministry for Economic Affairs and Energy (BMWi) / UBA / AGEB / Federal Statistical Office	UBA	39	<i>address review relevant issues in an action plan in the 2011 submission. [...] The ERT reiterates the recommendation of the previous review report that Germany prepare a plan for the remaining abovementioned issues, and to report on it and on any progress achieved in its next annual submission</i>	Action plan; NIR	The pertinent action plan is being prepared, for the first time, for the 2013 inventory report	A coordinated Energy-Data Action Plan for inventory improvement is available for the 2012 inventory review process and will be updated annually	Ongoing	
2.1	Deadline compliance of the final Energy Balance	BMWi/AGEB/Federal Statistical Office/Statistical offices of the Länder	BMWi	39	<i>timeliness of reporting [...]</i>	Process analysis, energy data; NIR	For the 2013 inventory report, a process analysis is presented. Inter alia, it covers reporting channels (these are described more precisely than in the past), the efforts made to shorten such channels and the relevant success achieved.	Process analysis, describing applicable reporting channels more precisely than in the past, and describing efforts made to shorten such channels and the relevant success achieved, enables review experts to determine that Germany has made use of all available possibilities for optimisation; the status of relevant work is documented in the NIR 2013.	Completed	

No.	Issue	Responsibility	Responsibility for execution	Reference (paragraph)	Quotation from 2011 review report (FCCC/ARR/2011/DEU)	Instrument for implementation / publication	Activity for improvement	Result planned / achieved	Time frame	Remark
2.2	Deadline compliance of the final Energy Balance	BMWi/AGEB/Federal Statistical Office/Statistical offices of the Länder	BMWi/AGEB (not for official data)/Federal Statistical Office and statistical offices of the Länder (for official data);	137	<i>In the course of the review, the ERT formulated a number of recommendations relating to the transparency of background and methodological information (e.g. in the energy[...] sectors), justification and documentation of recalculations (e.g. in the energy[...] sectors)[...] The key sectoral recommendations are that Germany: [...] (b) Improve the timeliness of reporting of the NEB (energy);</i>	Process analysis, energy data; NIR	Organisational improvements in the statistical offices of the Länder. In rapporteurs' meetings with the Länder, the Federal Statistical Office discusses possibilities and ways of improving the cooperation.	In future, official statistics are to be transmitted at an earlier time than has been the case to date.		
3.1	Discrepancies between provisional and final EB	BMWi/AGEB/Federal Statistical Office/Statistical offices of the Länder	AGEB; UBA	39	<i>significant differences between the preliminary and final NEB</i>	QC report; NIR	Energy data consistency analysis (EDKA)	Identification and clarification of discrepancies, along with differentiation and addressing of a) Informational deficits b) Documentation requirements c) Data problems d) Methodological changes	Ongoing	
3.2	Discrepancies between provisional and final EB	AGEB	AGEB	39	<i>significant differences between the preliminary and final NEB</i>	QC	The AGEB is working to reduce estimation errors.	AGEB reports on plausibility checks The AGEB reviews new procedures and methods for preparing the estimated Energy Balance. Specific proposals in this regard have been made (cf. the report of the EEFA research institute regarding approaches in estimation and modelling for the preparation of provisional Energy Balances.	Ongoing	

No.	Issue	Responsibility	Responsibility for execution	Reference (paragraph)	Quotation from 2011 review report (FCCC/ARR/2011/DEU)	Instrument for implementation / publication	Activity for improvement	Result planned / achieved	Time frame	Remark
3.3	Discrepancies between provisional and final EB	AGEB, UBA	UBA	39	<i>significant differences between the preliminary and final NEB</i>	Inventory description	In the framework of work on the inventory and the 2015 National Inventory Report (NIR), discrepancies are described, and the results are presented in a "differences discussion".	The status of this work is documented in the 2015 inventory description: Documentation, revision of data for earlier years, reduction of estimation errors	Ongoing since 2012	
4	Complex National System	Federal Ministry of Economics and Technology (BMWi) / UBA / AGEB	UBA	39	<i>The previous review report noted several issues related to Germany's NEB (such as [...] the complexity of the NEB compiling process that may contribute to the problems with regard to timeliness and quality.</i>	NaSE	Exchange regarding the results of the inventory review and derivation of requirements for action;	Energy-data workshop on 16 Nov. 2010 Energy-data workshop on 5 August 2011 Energy-data workshop on 27 April 2012 Energy-data workshop on 7 August 2012 2013 Energy-data workshop on 7 May 2013 2014 Energy-data workshop on 5 June 2014 2016 Energy-data workshop on 3 May 2016		
5	Quality assurance	EEFA / German Institute for Economic Research (DIW) / Federal Statistical Office / AGEB / UBA	AGEB / UBA	39	<i>lack of QA/QC procedures in place for some data sources used to compile the NEB</i>	NIR	Joint AGEB quality report in the new Annex 2 of the NIR 2012 and in subsequent inventory reports	the NEB is subject to QA/QC procedures in accordance with the national system	Ongoing since 2012	
6.1	Discrepancies between EB and IEA data	BMWi, AGEB, persons responsible for questionnaires	BMWi	39	<i>low comparability with the IEA data</i>		To be jointly defined in the framework of the action plan	Introduction of a transition procedure for assuring compatibility between the Energy Balance and surveys in the areas of electricity and heat (cf. in this regard	Completed or ongoing	

No.	Issue	Responsibility	Responsibility for execution	Reference (paragraph)	Quotation from 2011 review report (FCCC/ARR/2011/DEU)	Instrument for implementation / publication	Activity for improvement	Result planned / achieved	Time frame	Remark
								the report of the EEFA research institute to the AGEB and the Federal Ministry for Economic Affairs and Energy (BMWi). The transition has been successfully carried out as part of comprehensive revision of the questionnaires. Efforts to minimize discrepancies are being continued in other areas of the surveys and the Energy Balance. AGEB reports on plausibility checks Revision of the questionnaire for 2003-2011.	Completed Spring 2014	
								Planned revision of the NEB		
6.2	Discrepancies between EB and IEA data	BMWi, AGEB, persons responsible for questionnaires	BMWi	45	<i>The ERT also noted differences between the inventory data and the corresponding IEA data (e.g. for solid fuels exports, the data show differences of over 60 per cent in some recent years [...]) Germany has provided some explanations for the divergences and informed the ERT that it is continuing to investigate these differences. The ERT considers that the differences cause no underestimation of emissions, but reiterates the recommendation of the previous review report that</i>		To be jointly defined in the framework of the action plan	See 6.1		

No.	Issue	Responsibility	Responsibility for execution	Reference (paragraph)	Quotation from 2011 review report (FCCC/ARR/2011/DEU)	Instrument for implementation / publication	Activity for improvement	Result planned / achieved	Time frame	Remark
					<i>Germany explain the reasons for these differences between its inventory data and the corresponding IEA data in its next annual submission.</i>					
7.1	Improvement of the balance sheet for gases	BMWi / Federal Statistical Office / DIW / UBA / and others	Federal Statistical Office	39	<i>significant amount of flaring/losses of natural gas in the NEB that were not transparently accounted for</i>	NIR, EB	Meeting involving all participating energy experts; review and adjustment of the data source	The significant amount of flaring/losses of natural gas are taken into account	Apr 12	Completed
7.2	Improvement of the balance sheet for gases	BMWi / Federal Statistical Office / DIW / UBA / and others	Federal Statistical Office	39	<i>significant amount of flaring/losses of natural gas in the NEB that were not transparently accounted for</i>	NIR, EB	Updating of the gas balance sheets in the positions relative to flaring losses, and in positions relative to production, foreign trade, changes in stocks, non-energy-related consumption and energy-related consumption, in the Energy Balances for 2005 and for subsequent years	The significant amount of flaring/losses of natural gas are taken into account with regard to the time series Revision of the NEB	Completed	

18.6 Uncertainties in the activity data for stationary combustion systems

See NIR 2007, Chapter 13.6.

18.7 CO₂ emissions

The CO₂ emission factors have been completely revised for the 2015 report. For the first time, such work was able to draw extensively on data from emissions trading. Emissions trading data were available on relevant calorific values, emission factors, fuel quantities and data quality. The data were subjected to thorough quality control. For example, only factors on level 3 or 4 (measurement) entered into the calculations. In addition, emission factors were replaced if it was clear that they had simply been taken from lists. In emissions trading, some substance flows are not unambiguously named, and this can lead to erroneous material allocations in solid fuels categories. With regard to coal, it was possible to identify such misallocations, via the pertinent net calorific values, and then carry out the necessary resorting. Lignite and hard coal can be clearly differentiated via net calorific values. Annually weighted average values were calculated from the quality-checked data. To make it possible to determine whether the resulting factors are representative, the underlying fuel quantities were compared with the corresponding quantities in the Energy Balance. In addition, every effort was made to achieve extensive consistency between net calorific values and emission factors.

Other data sources, in addition to the data from emissions trading, were evaluated as well. Furthermore, archive data were reviewed and measurements of our own were carried out. The recalculations through 1990 were carried out with widely differing procedures, chosen in each case in accordance with the specific subject area. This was done with a view to assuring time-series consistency and to obtaining the most realistic solutions possible. The task of finding well-documented archive data for the year 1990 presented a special challenge, since the documents from that period are available only in paper form and are housed at various different institutions. What is more, data are seldom kept for a period of longer than 20 years.

Since no reliable and representative data are available on the carbon content remaining in ash, an oxidation factor of 1 has been assumed. That figure is also the default value in the 2006 IPCC Guidelines.

18.7.1 Hard coal

For hard coal, an inter-sectoral emission factor has been calculated. In the present case, this ensures that the total emissions are determined as precisely as possible. One exception in this case consists of the coking coal for the iron and steel industry, which differs considerably from steam coal. Another exception consists of the anthracite coal used in the residential sector and in other small combustion plants; that coal has considerably higher calorific values and carbon-content levels.

For the other types of hard coal, emissions trading data from the years 2005 – 2014 were evaluated. For each type, there are substance flows that can be correlated with specific areas of origin. This makes it possible to determine origin-specific CO₂ emission factors and calorific values. Apart from the coal for which origin-specific data are available, there are quantities of mixed coal, and of coal of uncertain origin, to consider. CO₂ emission factors and calorific values were determined for all individual coal fractions (Germany, South Africa, Australia, Indonesia, Columbia, Norway, Poland, Czech Republic, Russia, the U.S. and Venezuela). In addition, weighted averages were calculated for the other hard-coal types for which specific values cannot be

obtained. Two different methods for recalculating the emission factors for hard coal were reviewed. On the one hand, a weighted average for each year was calculated with the help of the data on the various individual areas of origin and the import-flow figures from hard-coal statistics. On the other, a weighted average was formed from all of the emission factors reported and checked in the emissions trading framework. The following figure shows the results of this comparison:

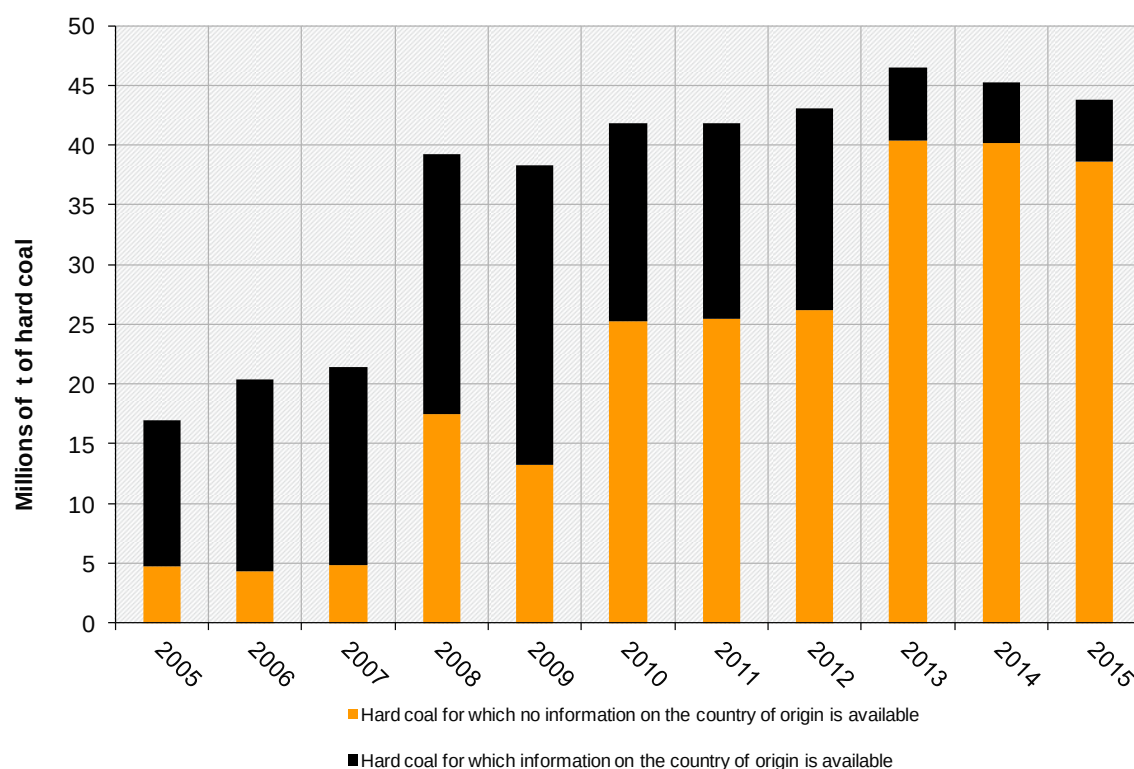
Table 472: Comparison of CO₂ emission factors for hard coal

[t CO ₂ /TJ]	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Calculation via imports	93.874	93.976	93.865	93.924	93.993	94.003	94.181	93.652	93.276	93.888
Weighted EF from all ETS data	93.606	93.940	93.792	94.317	94.121	94.032	94.228	93.675	93.363	93.560
Difference	0.29%	0.04%	0.08%	-0.42%	-0.14%	-0.03%	-0.05%	-0.02%	-0.09%	0.35%

Since the differences are very small in most years, as of the year 2006 the weighted emission factors for all hard coal reported in the emissions trading framework (apart from that in the iron and steel sector) can be used – regardless of the area of origin involved. For the recalculation through 1990, the origin-specific emission factors calculated from emissions trading data are combined with the relevant import flows. This produces a consistent time series.

The following figure shows the evaluable hard-coal quantities for which emission factors and calorific values were available that were measured in the emissions trading framework.

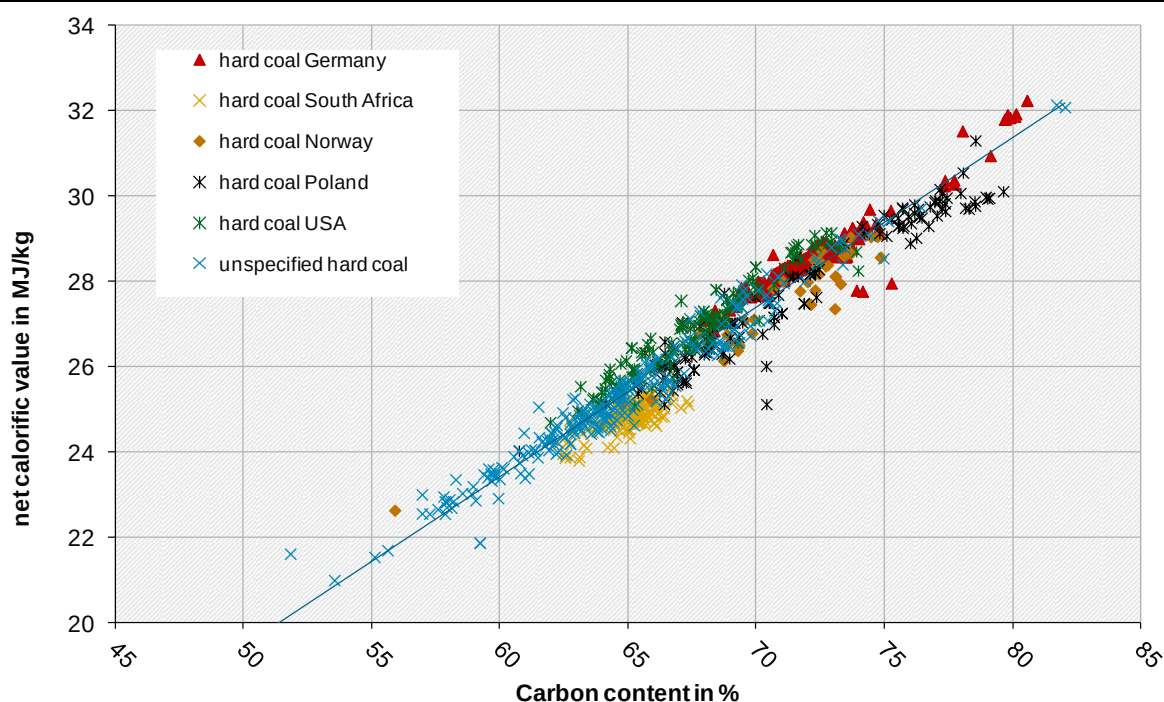
Figure 86: Hard-coal quantities for the emission factors and calorific values measured in the emissions trading framework are available



It emerges that the quality of the values increases – especially so as of the year 2008 – due to changes in regulations. Furthermore, the quantity of hard coal that can be clearly allocated to a specific mining area decreases noticeably. For this reason, the most sensible approach, from a technical standpoint, is to form a weighted average for all hard coal, regardless of area of origin. This is the only way to ensure that the emission factors are representative.

All in all, very thorough quality checks were conducted, and numerous evaluations were carried out. As the following figure illustrates, it is possible to develop fairly clear origin profiles, and there is a clear relationship between carbon content and net calorific value.

Figure 87: Relationship between carbon content and calorific values, for various qualities of hard coal



Most types of hard coal have a carbon content (with respect to the original substance) of between 60 and 75 %. The average, depending on the year concerned, lies between 65 and 66 %. The hard coal in the lower range, with a carbon content as low as 56 %, and a net calorific value of no more than 22 MJ/kg, can be referred to as "high-ballast coal". The hard coal in the upper range, as of a net calorific value of about 30 MJ/kg, is of coking-coal quality. The highest carbon-content levels are found in anthracite.

The figure does not include values for the **coking coal** used in Germany. Coking coal was evaluated separately, due to its special characteristics. In addition, no evaluable net calorific values are reported, with regard to coal in the emissions trading framework, for the iron and steel industry. As a result, only weight-based emission factors have been determined for that area. Consequently, the coal quantities in that area have also been recorded in terms of tonnes. Since the available statistics give virtually no pertinent calorific-value figures, it seems useful to calculate with natural units. With the help of intensive discussions with the responsible experts of the German Emissions Trading Authority (DEHSt), it proved possible to determine representative emission factors for the hard coal used in the iron and steel industry. From the same data set, combined emission factors were developed for **hard-coal coke, hard-coal tar and benzene**, which in the Energy Balance are listed under "other hard-coal products".

With regard to **hard-coal coke**, an average, energy-based CO₂ emission factor was calculated, for all other industrial sectors, from the emissions trading data for the years 2005 – 2013.

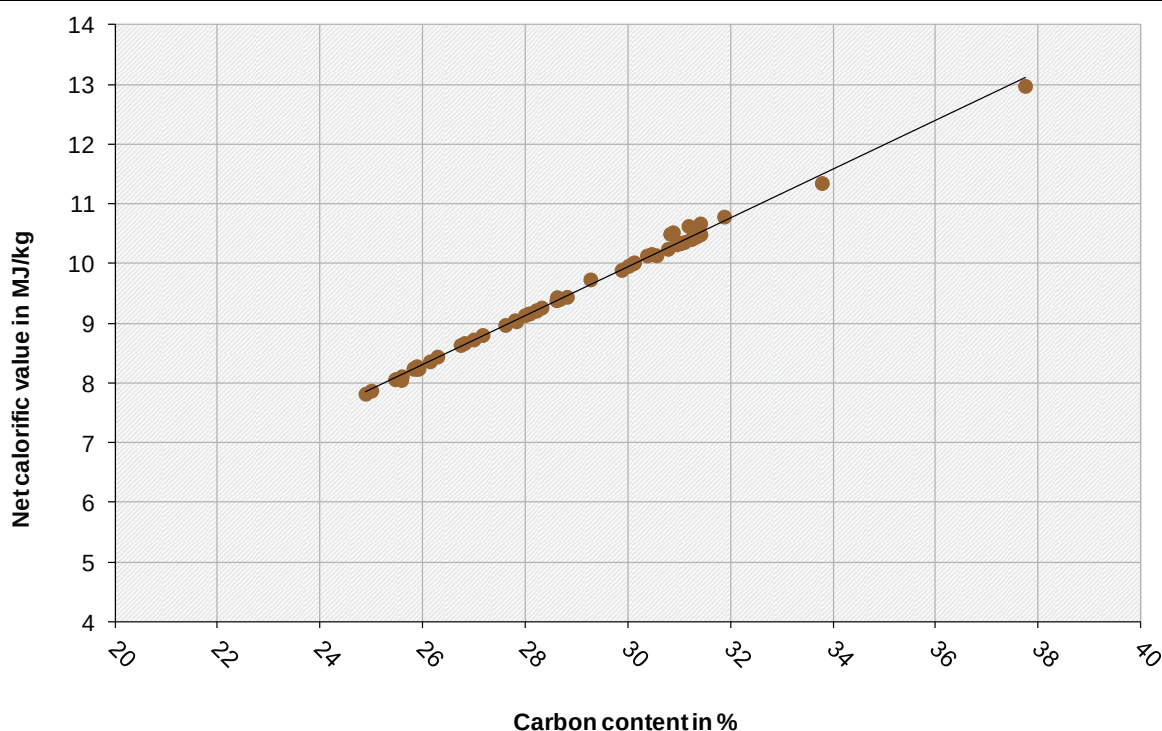
Since emissions trading statistics do not cover the **hard-coal briquettes** used in small combustion plants, we carried out our own analyses for that area, in the framework of a project. The resulting

values have been entered back through the year 1990, since no representative values are available for the base year.

18.7.2 Lignite

The raw lignite used for electricity generation for the public grid can be allocated, via lignite statistics, to specific coalfields. For the period as of the year 2005, the CO₂ emission factors are determined from emissions trading data. The carbon content figures (with respect to the original substance) are also available in mining-district-specific form. The following figure provides an illustrative example:

Figure 88: Relationship between carbon content and net calorific values, illustrated with the example of crude-lignite quality



The variances in sulphur content are larger in lignite than they are in hard coal. Since sulphur content has a noticeable effect on net calorific value and, thus, on the relationship between carbon content and net calorific value, lignite has to be evaluated mining-district-specifically. As Figure 88 shows, there is a clear correlation between net calorific value and carbon content. Consequently, for each relevant year the carbon content, and the energy-related CO₂ emission factor, can be calculated, via a resulting formula, from the net calorific value as known for that year. This makes it possible to recalculate the figures back through 1990 – and thus to form a consistent time series. Some uncertainties do remain, however, since it is likely that a number of small mines were in operation in 1990 that produced coal with other sulphur-content levels. That supposition can no longer be checked, however. Hardly any carbon analyses were carried out in 1990, because carbon content was not an issue at that time. Only a few individual analyses were carried out, and their results are not necessarily representative. For example, only net-calorific-value data are available for lignite from the state of Hesse (Hessische Braunkohle), which was mined until 2003. For recalculation purposes, a mid-level sulphur content was assumed, a level between those found in the Mitteldeutsch ("central German") and Rhenish coalfields. That coal is of little relevance in

terms of quantity, however. Between 1991 and 1992, the applicable emission factor changed sharply, because two power stations in that district went offline during that period, and they had been fired for some time with low-quality coal.

For raw-lignite inputs in district heating stations, a weighted emission factor is calculated from lignite inputs for the public electricity supply. For industry and the residential, institutional and commercial (small consumers) sectors, a weighted emission factor was calculated, from sales statistics of the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations, that reflects the distribution of the relevant coalfields.

The emission factors for **lignite briquettes** were determined on the basis of emissions trading data for the period as of 2005. From those data, mining-district-specific averages, for each specific year, were formed. Then a weighted average was calculated from those averages, with the help of DEBRIV sales statistics. The emissions trading data cannot be used directly, since they do not completely reflect and cover the areas being reported on. The residential, institutional and commercial sectors do not take part in emissions trading. To ensure that the fuel-quality figures are the same, the ETS-based data evaluations were compared with our own analyses for briquettes in the residential sector. The two data sets show good agreement. While lignite briquettes are a standardized product, for which certain quality requirements apply, mining-district-specific differences still occur, in the form of carbon-content and sulphur-content variances in the raw lignite used. The recalculation back to 1990 proved to be considerably more complicated than the calculation for raw lignite. From the ETS data for the period 2005 – 2013, it was possible to calculate an average CO₂ emission factor only for Rhenish lignite briquettes. That factor can also be used for the years 1990 – 2004. In the new German Länder, a great many briquette factories were closed in the early 1990s. This considerably changed fuel quality levels in that region. No briquettes are now produced from central German (Mitteldeutsch) lignite. Consequently, no current relevant measurements are available. For this reason, we had to rely on archive data in this area. Data from analyses carried out by Mohry in 1986, and data from the 1986 "Jahresbericht der Kohleindustrie der DDR" ("annual report on the coal industry of the GDR") were available. It emerged that the carbon content previously assumed for central German (Mitteldeutsch) briquettes was too high, by a considerable amount. In calculation of the average values, care was taken to ensure that the resulting emission factors agreed with the net calorific values published by DEBRIV. As a result, it was possible to calculate an annual CO₂ emission factor for each coalfield. From those factors, it was then possible, with the help of DEBRIV sales statistics, to calculate weighted annual CO₂ emission factors.

Data on **lignite dust and fluidised-bed coal** are easier to obtain, since emissions trading data are available from all relevant coalfields. For the recalculations through 1990, average values from the years 2005, and 2008 – 2013, were used, depending on data quality. In an approach similar to that used for raw lignite and briquettes, a weighted CO₂ emission factor was calculated for lignite dust and fluidised-bed coal with the help of DEBRIV sales statistics. As of the year 2005, the CO₂ emission factors from emissions trading are entered directly into the calculation. Then, via the customary procedure, weighted factors are calculated with the help of mining-district-specific sales statistics.

Lignite coke is currently being produced in only one coalfield. In general, hearth furnace coke is used primarily for its properties as a material. Since fuel quality in this category fluctuates very little, an average was formed from the ETS data for the period 2008 – 2013 and then used for recalculations back through 1990. For the new German Länder, only one data source was available. That source consists of analyses carried out by the Ingenieurschule für Bergbau und Energetik "Ernst Thälmann" (the "Ernst Thälmann" school of engineering, specialising in mining and energy

technology), located in Senftenberg. It seems plausible, however, that the coke studied in those analyses, in comparison to Rhenish coke, had a considerably lower carbon content and considerably higher ash and sulphur content. Consequently, the emission factor calculated for the new German Länder is lower.

The emission factor determined for 2014, from emissions trading data, at 109.317 t CO₂/TJ, is very close to the average value calculated for 2005 – 2013, 109.578 t CO₂/TJ.

The data set from the Ingenieursschule für Bergbau und Energetik "Ernst Thälmann" in Senftenberg also included analyses for **air-dried peat**. The net calorific value given agrees with the corresponding value used in the Energy Balance. The values for the **lignite tar oil** used in refineries in the new German Länder come from the same data source.

No data were available for the **lignite tar** used in the new German Länder. As an alternative, analysis data from the research report Vertrag Nr. (contract no.) 7220-EB/106 (DEBRIV 1980) were used. Lignite tar has not been used since 1991.

The ETS data can be used to generate CO₂ emission factors for **meta-lignite** for the period as of 2008. At present, only very small quantities of meta-lignite are used in Germany. To make it possible to calculate the applicable emission factors for the period back through 1990, the relevant carbon / net calorific value relationship was determined from the available ETS data. It was then possible, with the help of the net calorific values known from the DEBRIV lignite statistics, to produce a consistent time series.

18.7.3 Petroleum

Crude oil and **naphtha** are not used in combustion systems in Germany. For this reason, the emissions trading data do not include any carbon-content figures for these raw materials. In addition, no analysis values are available from other sources. For this reason, the default values from the 2006 Guidelines have been used. The relevant factors have been used only for the Reference Approach and for the transformation balance for refineries. Default values have also been used for **avgas** and **lubricants**.

For calculation of the CO₂ emission factors for **gasoline**, research report 502-1 of the German Society for Petroleum and Coal Science and Technology (DGMK), "Zusammensetzung von Ottokraftstoffen aus deutschen Raffinerien" ("composition of gasolines produced by German refineries") (DGMK 2002) was comprehensively evaluated. That study studied the components of the fuels involved in great detail. As a result, data are available on the average concentrations of 113 individual substances, and of 16 substance groups, in the categories regular gasoline, super (premium) and super plus (premium plus), for all German refineries. Via the carbon-content levels in the substances listed, and the pertinent concentrations, it was possible to calculate weighted carbon-content levels for each of the 3 grades of gasoline involved. This was because it was possible to calculate weight-based emission factors from carbon content. The following table presents the average values and fluctuation ranges for the CO₂ factors:

Table 473: Composition of, and emission factors for, gasoline

		average CO ₂ EF	Minimum	Maximum	Units
Regular gasoline		3.183	3.160	3.206	t CO₂/ t
Super (premium)		3.185	3.152	3.211	t CO₂/ t
Super plus (premium plus)		3.141	3.102	3.176	t CO₂/ t
With the following composition:					
Regular gasoline	Kerosenes	45.30	52.06	41.64	%
	Aromatic compounds	37.14	28.68	48.12	%
	Oxygen compounds	0.30	0.32	0.19	%
Super (premium)	Kerosenes	40.23	23.32	32.22	%
	Aromatic compounds	43.44	47.99	46.30	%
	Oxygen compounds	2.54	11.52	0.01	%
Super plus (premium plus)	Kerosenes	33.95	41.60	33.29	%
	Aromatic compounds	44.33	34.43	49.19	%
	Oxygen compounds	10.49	13.44	6.80	%

The naphthenes and olefins in the gasolines, while worthy of mention as additional components, have virtually no influence on CO₂ factors. In the case of regular gasoline, levels of aromatic compounds are the main factor that affects the size of CO₂ emission factors. On average, aromatic compounds tend to have higher carbon-content levels than kerosenes do. The levels of aromatic compounds found in a gasoline depend primarily on whether the refinery that produces the gasoline also produces basic chemical compounds. Where refineries do produce such compounds, efforts are made to make the highest possible fractions of aromatic compounds available for chemical production processes. The levels of aromatic compounds found in premium-grade gasolines fluctuate only very slightly. The CO₂ factors for such gasolines are determined primarily by the gasolines' content of oxygen compounds (MTBE). In the case of super plus (premium plus) grades, the levels of aromatic compounds and of oxygen compounds both play a role.

A weighted CO₂ emission factor has been calculated from the figures on annual sales of regular gasoline (Normalbenzin), premium (Super) and premium plus (Super Plus) (Official Mineral Oil Statistics). No figures for the new German Länder are available for the year 1990. For this reason, the breakdown by individual fuel qualities for the year 1991 has been applied to 1990. In the interest of consistency, an energy-related CO₂ emission factor has been calculated from the calculated weight-based emission factor and the lower net calorific value listed in the Energy Balance. So-calculated emission factors hardly fluctuate at all over the years concerned. The only year in which the emission factor changed more significantly was 2011, when the factor was unusually low. When the "E10" fuel was introduced (with a 10% biofuel fraction in premium grade fuel), greater quantities of Super Plus (premium plus) were sold.

The basis for calculation of the emission factor for **diesel fuel** is research report (Forschungsbericht) 583 of the German Society for Petroleum and Coal Science and Technology (DGMK): "Zusammensetzung von Dieselmotorkraftstoffen aus Deutschen Raffinerien 1999-2002" ("Composition of diesel fuels from German refineries, 1999-2002"). For that study, winter and summer samples from 13 refineries were studied. From the analysis results, an average value for the fuel quality in summer and an average value for the fuel quality in winter were calculated. In Germany, the availability of "winter diesel" is regulated by law. The law requires petrol stations to offer winter diesel from 15 November to 28 February. In addition, a transition phase has to be taken into account, and thus a usage period of about 4 months can be expected for winter diesel. Consequently, diesel-powered vehicles operate with summer diesel for 8 months. Via this distribution, a weighted emission factor was calculated from the analysis results relative to summer and winter diesel.

The CO₂ emission factors for **light fuel oil, petroleum coke, heavy fuel oil and other petroleum products** have been calculated from emissions trading data. The relevant average values for the years 2005 – 2013 have been applied to the years back through 1990. It is difficult to draw a precise line between heavy fuel oil and other petroleum products. In keeping with Mineral Oil Statistics (Mineralölstatistik), "other petroleum products" have been defined as residual substances from refineries, and the pertinent emission factor has been calculated accordingly.

For **refinery gas**, a weight-based CO₂ emission factor has been calculated from the ETS data. Since the annual fluctuations for such gas are small, the same factor, formed from the average values for the years 2005 – 2013, has been used for all years. While the lower net calorific values given in the context of emissions trading show only slight annual fluctuations, the calorific values used in the Energy Balance vary significantly, in some cases, and show discrepancies with the ETS data. The refinery-gas quantities reported in the Energy Balance come from the Mineral Oil Statistics. Those values agree well with the ETS data. In the interest of consistency, the lower net calorific values used in the Energy Balance were chosen for inventory preparation. The pertinent emission factor has been adjusted accordingly.

For determination of the CO₂ emission factors for **LP gas**, first the applicable carbon content levels for butane and propane were calculated via molar masses. The pertinent fractions for the two components are published in the annual report of the German Liquid Petroleum Gas Association (Deutscher Verband Flüssiggas e.V.). The data through 1990 have also been provided by that association. Via the applicable fractions for the two components, a weighted emission factor years was calculated, and then that factor was divided by the lower net calorific value used in the Energy Balance. The LP gas emission factors published in the NIR apply only to energy-related consumption. The data for material-related use differ, since the relevant mixtures contain more butane than propane on average. Gas for energy-related use tends to contain more propane than butane.

18.7.4 Gases

Some gaseous fuels are allocated to the solid fuels category, in keeping with a) the IPCC fuel definitions and b) the Guidelines' emphasis on the fact that they originate in solid fuels or are produced from such fuels. This approach is taken for coke oven gas, town gas, blast furnace gas and basic oxygen furnace gas. The other relevant produced gases are allocated to the liquid fuels category, since those gases are produced primarily by the chemical industry, in non-energy-related consumption of naphtha and other petroleum products. These allocations play a necessary role in enabling the Reference Approach to achieve useful results.

For determination of CO₂ emission factors for **coke oven gas, blast furnace gas, basic oxygen furnace gas and petroleum gas**, emissions trading data are used. For the recalculations back through 1990, average values were calculated from the ETS data for the period 2005 – 2013 and then used for the years 1990 – 2004. In energy statistics, blast furnace gas and basic oxygen furnace gas are reported only as a gas mixture. For this reason, a weighted emission factor for such mixtures has been calculated from the individually determined emission factors for the two gases and from produced quantities of blast furnace gas and basic oxygen furnace gas. In all likelihood, the mixing ratios of such mixtures vary throughout the different specific areas in which the mixtures are used. Emissions trading data only partially cover combustion of blast furnace gas and basic oxygen furnace gas, but the calculation method used here ensures that the total emissions of such gases are still calculated correctly.

Until 1996, town gas was still used in Germany. In the Energy Balance, it is combined with coke oven gas. The applicable fractions of **coke oven gas and town gas** cannot be determined on the usage side (the situation is similar to that for combustion of blast furnace gas and basic oxygen furnace gas). For this reason, here as well a weighted emission factor is calculated – in this case from the produced quantities of coke oven gas and town gas. The values for **town gas** have been obtained from the firms of GASAG and DBI Gas- und Umwelttechnik GmbH Leipzig. Detailed analyses are available for the years 1989 through 1991. The different gases have been mixed so as to yield mixtures with fairly constant town-gas quality. DBI Gas- und Umwelttechnik GmbH Leipzig has also provided information regarding the mixing ratios in which the gas fractions are combined to produce summer-quality and winter-quality grades. The emission factors have been weighted accordingly. The figures for **fuel gas**, which is used exclusively in the new German Länder, have been obtained from a data set provided by the Ingenieurschule für Bergbau und Energetik "Ernst Thälmann" (the "Ernst Thälmann" school of engineering, specialising in mining and energy technology), located in Senftenberg. The term "fuel gas" has not been clearly defined. Since that gas has been used primarily in mine-mouth power plants, it may be assumed to be lignite-based. Such gases can vary widely in composition, however. Consequently, the applicable emission factors can also vary widely. They lie within the range 118.6 – 131 t CO₂/TJ. To ensure that the base-year emissions are not overestimated, a conservative approach is applied, and the lowest emission factor is used. The 1989 annual report for the energy sector (Energiewirtschaftlicher Jahresbericht 1989) gives a net calorific value of 5.3 MJ/Nm³ for "other gas", a figure that points to a higher emission factor. Since coke oven gas, town gas and fuel gas are reported in combined form in the Energy Balance, the net calorific values for those individual gases can no longer be determined.

Other produced gases are used primarily in the chemical industry. The category to which that term refers includes both a) gases with high calorific values and with large hydrogen fractions and b) flare gases with low calorific values and with large nitrogen fractions. The pertinent emission factor has been calculated from emissions trading data for the chemical industry. In the process, an average value for the years 2008 – 2013 was formed. Although the calorific-value figures given in energy statistics differ considerably from those used in emissions trading, the applicable cubic-metre quantities listed in the two contexts show good agreement. Consequently, an emission factor based on those natural units (cubic metres) was calculated for this category. In the interest of consistency, the net calorific value used in energy statistics is used for calculations for inventory preparation.

For **mine gas**, a methane content figure was calculated with the help of the methane-utilization data provided by the Gesamtverband Steinkohle (GVSt) hard-coal-mining association and the total methane quantities listed (in cubic metres) in the Energy Balance. A CO₂ emission factor was then calculated via the corresponding gas composition. Statistical differences result in some years, and thus calculations are carried out with the lowest methane-content figure, in the interest of applying a conservative approach.

Since the **natural gas** quantities recorded in the emissions trading context are not representative, and since default emission factors are often used in this category, the firm of DBI Gas- und Umwelttechnik GmbH Leipzig carried out its own analyses in the framework of the project "Messungen der Erdgasqualität an verschiedenen Stellen im Netz zur Ableitung bzw. Verifizierung von durchschnittlichen Emissionsfaktoren und Heizwerte von Erdgas" (2014; measurements of natural gas quality at various locations within the network, for purposes of derivation and verification of average emission factors and net calorific values for natural gas). In that effort, measurements were carried out at 32 locations throughout Germany. The measurement points

were selected so as to ensure that all important imported gases and the country's own in-country production were taken into account. In addition, a mixture distributed in Germany was analysed. Alternative measuring sites were found for selected border handover points at which measures proved unfeasible. Within the relevant gas-quality ranges, the CO₂ emission factors fluctuate only very slightly. And the values fluctuate very little overall. In an approach similar to that used for other fuels, no sector-specific emission factors were determined for natural gas. As it is, the data do not allow determination of such factors. It thus seemed advisable, and more feasible, to determine weighted emission factors at the national level. They were calculated on the basis of the measurements carried out, of import flows and of the country's own production.

18.7.5 Waste and special fuels

For **waste**, a carbon content pursuant to VDI 3460 is assumed. Energy statistics serve as the data source for the calorific values. The data for **special fuels** were obtained from the project "Einsatz von Sekundärbrennstoffen" ("use of secondary fuels"; UBA 2005b, FKZ 204 42 203/02). These data still need to be reviewed, with the help of emissions trading data, and corrected as necessary. In general, it is difficult to compare data on fuels with relevant biomass fractions with ETS data, since the emission factors for such fuels do not always take account of the biomass fractions. What is more, the terms used in the ETS context are not always unambiguous. And since the net calorific values of special fuels vary considerably more strongly than those of conventional fuels do, net calorific values cannot be used for unambiguous identification of special fuels. All of these factors considerably complicate such comparisons. While for conventional fuels inter-sectoral emission factors are determined in most cases, for special fuels the factors have to be calculated sector-specifically.

For a few special fuels, emissions trading data have already been evaluated. This applies to **waste oil** and **waste plastics**. The relevant values are used in the carbon balance for the iron and steel industry. The emission factor for **waste tyres** has been calculated from ETS data from the year 2010.

18.7.6 Biomass fuels

The emission factors for the biomass fuels that are used as **substitute fuels** in industry have also been obtained via the project "Einsatz von Sekundärbrennstoffen" ("use of secondary fuels"; UBA 2005b, FKZ 204 42 203/02). The CO₂ emission factors for **wood** have been obtained from the research report "Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung" ("Efficient provision of current emissions data for purposes of air quality control"; STRUSCHKA 2008).

With regard to **black liquor** from wood pulp production, emission factors for spent sulphate liquor and for spent sulphite liquor were calculated on the basis of operator information relative to liquor composition. A weighted mean is formed annually by applying those two values to the produced quantities of sulphite and sulphate wood pulp.

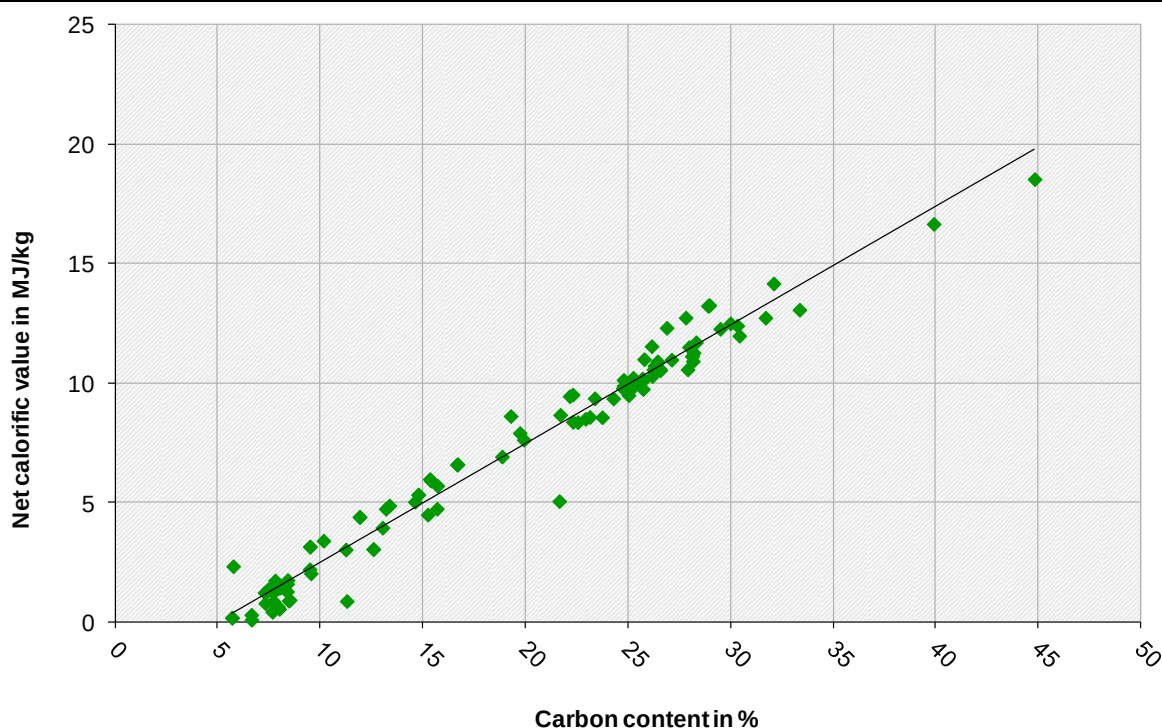
The process for calculation of the CO₂ emission factors for **biogas**, **landfill gas** and **sewage gas** began with evaluation of relevant net calorific values from energy statistics. Averages of those calorific values were then calculated for each category from the values for the years 2009 – 2011. Then, corresponding methane quantities were determined from each such average calorific value. Apart from methane, these gases consist mainly of carbon dioxide and a small nitrogen fraction. As a result, the net calorific value is determined via the methane content. The biogases also contain

other hydrocarbons, in fractions totalling about 1 %. A CO₂ emission factor was then calculated via this known gas composition.

The emission factor for **bioethanol** was calculated on the basis of the number of carbon atoms, and of the molar mass, of ethanol. The relevant net calorific value is published by the Bundesverband der Deutschen Bioethanolwirtschaft German bioethanol industry association. For **biodiesel**, we did not carry out any analyses of our own. For this reason, the default emission factor given in the 2006 IPCC Guidelines has been used.

For determination of the CO₂ emission factors for **sewage sludge, waste wood and animal meal**, data from emissions trading were evaluated. For animal meal and waste wood, a median was formed from data on carbon content and net calorific value available for the period 2005 through 2014. For sewage sludge, data from municipal waste-management companies were also included in the evaluation. Since sewage sludges are used both in their original condition and in a dry condition, the spectrum of net calorific values ranges from < 1 MJ/kg to 18 MJ/kg. Consequently, the standard deviation for the CO₂ emission factors is so high that it would not be useful to form an average or median. Since the carbon content correlates very well with the net calorific value, a suitable formula can be derived from the graphic representation (cf. the following figure).

Figure 89: Relationship between carbon content and calorific values, for various qualities of hard coal



As a result, the pertinent carbon content and emission factors can be calculated with the help of the net calorific values, as given in energy statistics, for co-incineration and for mono-incineration.

18.7.7 List of carbon dioxide emission factors derived for energy & industrial processes

The following tables provide an overview of the carbon dioxide emission factors used in the inventory.

Table 474: CO₂ emission factors derived for emissions reporting for the period as of 1990; energy

Fuel-based emission factors	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Coal															
Hard coal															
Raw hard coal (power stations, industry)	t CO ₂ /TJ	93.1	93.1	93.5	93.9	93.9	93.8	94.3	94.1	94.0	94.2	93.7	93.4	93.6	93.5
Hard-coal briquettes	t CO ₂ /TJ	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9	95.9
Hard-coal coke (not including that for the iron & steel industry)	t CO ₂ /TJ	108.1	108.1	108.1	108.1	108.1	108.1	108.1	108.1	108.1	108.1	108.1	108.1	108.1	108.1
Hard-coal coke for the iron & steel industry	t CO ₂ / t	3.29	3.26	3.23	3.19	3.18	3.16	3.17	3.17	3.18	3.17	3.17	3.20	3.19	3.17
Anthracite (heat market for households, commerce, trade, services)	t CO ₂ /TJ	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6
Ballast hard coal, <i>old German Länder</i>	t CO ₂ /TJ	95.2													
Coking coal, Germany	t CO ₂ / t	2.96	2.93	2.90	2.87	2.86	2.86	2.85	2.85	2.86	2.85	2.86	2.85	2.89	2.90
Hard coal for the iron & steel industry	t CO ₂ / t	2.92	2.92	2.92	2.95	2.99	2.96	2.91	2.86	2.89	2.89	2.91	2.96	2.97	2.90
Other hard-coal products	t CO ₂ / t	3.30	3.30	3.30	3.30	3.30	3.30	3.27	3.29	3.29	3.30	3.30	3.32	3.32	3.32
Hard-coal tar	t CO ₂ / t	3.27	3.27	3.27	3.28	3.28	3.28	3.24	3.26	3.27	3.27	3.28	3.31	3.31	3.30
Benzene	t CO ₂ / t	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38	3.38
Lignite															
Raw lignite															
Public district heating stations, <i>Germany</i>	t CO ₂ /TJ		111.7	110.8	111.1	111.2	111.3	111.5	111.4	110.7	110.7	111.0	110.7	110.9	111.0
<i>Old German Länder</i>	t CO ₂ /TJ	113.8													
<i>New German Länder</i>	t CO ₂ /TJ	110.0													
Industry, residential, institutional and commercial (small consumers), <i>Germany</i>	t CO ₂ /TJ		106.0	109.8	108.2	107.3	107.4	106.5	106.1	106.3	106.0	105.0	105.1	103.8	104.0
<i>Old German Länder</i>	t CO ₂ /TJ	114.7													
<i>New German Länder</i>	t CO ₂ /TJ	107.7													
Public power stations; coalfield:															
Rheinland	t CO ₂ /TJ	114.8	113.9	113.1	113.2	113.5	113.5	113.8	113.6	113.3	113.3	113.2	113.0	113.1	113.1
Helmstedt	t CO ₂ /TJ	98.7	98.7	98.7	98.7	98.7	98.7	95.2	97.3	96.7	101.7	97.9	103.3	101.1	99.5
Hesse	t CO ₂ /TJ	112.2	103.2	103.5	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Lausitz	t CO ₂ /TJ	111.2	111.3	111.5	111.2	111.3	111.3	112.2	112.0	110.6	109.9	111.0	110.3	111.2	110.9
Mitteldeutschland	t CO ₂ /TJ	105.7	103.9	102.9	104.0	103.9	103.5	103.4	103.3	103.4	103.4	102.8	102.9	102.8	102.9
Lignite briquettes, Germany	t CO ₂ /TJ		98.3	99.0	99.3	99.0	99.6	99.8	99.4	99.0	99.3	99.3	99.1	99.6	99.4
<i>Old German Länder</i>	t CO ₂ /TJ	99.5													
<i>New German Länder</i>	t CO ₂ /TJ	96.6													
Lignite tar, <i>New German Länder</i>	t CO ₂ /TJ	82.9													
Lignite tar oil, <i>New German Länder</i>		78.6													
Lignite dust and fluidised bed coal, Germany	t CO ₂ /TJ		97.6	98.1	98.1	98.1	97.9	98.0	97.8	98.0	98.1	98.0	98.0	98.1	98.0
<i>Old German Länder</i>	t CO ₂ /TJ	98.3													
<i>New German Länder</i>	t CO ₂ /TJ	96.1													

Fuel-based emission factors	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Lignite coke, Germany	t CO ₂ /TJ		109.6	109.6	109.6	109.6	109.6	109.6	109.6	109.6	109.6	109.6	109.6	109.6	109.6
Old German Länder	t CO ₂ /TJ	109.6													
New German Länder	t CO ₂ /TJ	100.2													
Peat, old German Länder, Germany		101.8	101.8	101.8	101.8	101.8	NO	NO	NO	NO	NO	NO	NO	NO	NO
Meta-lignite ("hard lignite")	t CO ₂ /TJ	96.4	96.4	96.5	NO	96.6	95.7	96.7	95.5	94.9	94.8	94.9	94.2	95.6	94.5
Petroleum															
Crude oil ⁴⁾	t CO ₂ /TJ	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
Gasoline	t CO ₂ /TJ	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.0	73.1	73.1	73.1
Naphtha, Germany⁴⁾	t CO ₂ /TJ		73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
Old German Länder ⁴⁾	t CO ₂ /TJ	73.3													
New German Länder ⁴⁾	t CO ₂ /TJ	73.3													
Kerosene⁴⁾	t CO ₂ /TJ	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
Avgas⁴⁾	t CO ₂ /TJ	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
Diesel fuel, Germany	t CO ₂ /TJ		74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Old German Länder	t CO ₂ /TJ	74.0													
New German Länder	t CO ₂ /TJ	74.0													
Light heating oil, Germany	t CO ₂ /TJ		74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Old German Länder	t CO ₂ /TJ	74.0													
New German Länder	t CO ₂ /TJ	74.0													
Heavy fuel oil	t CO ₂ /TJ	79.8	79.8	79.8	79.6	79.7	79.8	80.1	79.0	79.7	79.9	80.1	80.0	81.3	80.9
Petroleum	t CO ₂ /TJ	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Petroleum coke (not including coke burn-off in catalyst regeneration)	t CO ₂ /TJ	94.8	94.8	94.8	94.8	94.8	94.8	95.0	94.2	94.6	95.4	94.7	95.1	95.7	97.6
LP gas, Germany (energy-related consumption)	t CO ₂ /TJ		65.3	64.4	65.3	65.4	66.6	65.2	65.3	65.3	65.4	65.4	65.4	65.5	65.4
Old German Länder	t CO ₂ /TJ	65.6													
New German Länder	t CO ₂ /TJ	65.6													
Refinery gas, Germany	t CO ₂ /TJ		56.9	56.7	57.0	57.1	57.6	57.9	62.2	65.4	61.3	62.3	61.3	62.0	62.0
Old German Länder	t CO ₂ /TJ	54.6													
New German Länder	t CO ₂ /TJ	54.6													
Other petroleum products, Germany	t CO ₂ /TJ		82.1	82.1	82.1	82.1	82.1	82.1	82.5	82.5	82.8	82.9	82.6	82.7	82.3
Old German Länder	t CO ₂ /TJ	82.1													
New German Länder	t CO ₂ /TJ	82.1													
Lubricants⁴⁾	t CO ₂ /TJ	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
Gases															
Coke oven gas, Deutschland	t CO ₂ /TJ		41.0	41.0	40.7	41.1	40.6	40.9	41.1	40.3	41.6	41.2	41.8	41.2	41.3
Old German Länder	t CO ₂ /TJ	41.0													
New German Länder	t CO ₂ /TJ	43.6													
Coking-plant and city gas, Germany	t CO ₂ /TJ		42.6												
Old German Länder	t CO ₂ /TJ	43.2													
New German Länder	t CO ₂ /TJ	58.3													

Fuel-based emission factors	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Blast furnace gas and basic oxygen furnace gas, Germany	t CO ₂ /TJ		257.1	258.7	252.9	256.6	249.4	257.5	265.9	259.7	264.7	263.5	259.5	256.8	261.3
Old German Länder	t CO ₂ /TJ	264.6													
New German Länder	t CO ₂ /TJ	264.6													
Fuel gas, New German Länder	t CO ₂ /TJ	118.4													
Other produced gases, Germany	t CO ₂ /1000 m ³	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77	1.77
Natural gases															
Natural gas, Germany	t CO ₂ /TJ		55.8	55.8	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9
Old German Länder	t CO ₂ /TJ	55.7													
New German Länder	t CO ₂ /TJ	55.5													
Petroleum gas	t CO ₂ /TJ	61.9	61.9	61.9	61.9	61.9	61.9	61.9	61.9	61.9	61.9	61.9	61.9	61.9	61.9
Pit gas	t CO ₂ /TJ	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1
Waste															
Household waste / municipal waste	t CO ₂ /TJ	109.6	96.9	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5
Industrial waste, Germany	t CO ₂ /TJ		71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Old German Länder ²⁾	t CO ₂ /TJ	73.9													
New German Länder ²⁾	t CO ₂ /TJ	74.9													
Special waste, Germany	t CO ₂ /TJ		83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0
Special fuels¹⁾															
Used oil	t CO ₂ / t	75.7	75.7	75.7	75.7	75.7	75.7	74.6	76.8	75.9	75.9	77.3	75.6	75.5	75.3
Waste plastics	t CO ₂ / t	80.9	80.9	80.9	80.9	80.9	80.9	80.9	80.9	80.9	80.9	80.9	80.9	80.9	80.9
Waste tyres	t CO ₂ /TJ	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4
Bleaching clay	t CO ₂ /TJ	NO	78.2	78.2	78.2	78.2	78.2	78.2	78.2	78.2	78.2	78.2	78.2	78.2	78.2
Sewage sludge (2 MJ/kg)	t CO ₂ /TJ	NO	NO	NO	168.9	168.9	168.9	168.9	168.9	168.9	168.9	168.9	168.9	168.9	168.9
Sewage sludge (4 MJ/kg)	t CO ₂ /TJ	NO	NO	NO	120.4	120.4	120.4	120.4	120.4	120.4	120.4	120.4	120.4	120.4	120.4
Sewage sludge (6 MJ/kg)	t CO ₂ /TJ	NO	NO	NO	104.2	104.2	104.2	104.2	104.2	104.2	104.2	104.2	104.2	104.2	104.2
Sewage sludge (8 MJ/kg)	t CO ₂ /TJ	NO	NO	NO	96.1	96.1	96.1	96.1	96.1	96.1	96.1	96.1	96.1	96.1	96.1
Sewage sludge (10 MJ/kg)	t CO ₂ /TJ	NO	NO	NO	91.3	91.3	91.3	91.3	91.3	91.3	91.3	91.3	91.3	91.3	91.3
Solvents (waste)	t CO ₂ /TJ	74.2	74.2	74.2	74.2	74.2	74.2	74.2	74.2	74.2	74.2	74.2	74.2	74.2	74.2
Biomass fuels³⁾															
Spent liquors from pulp production	t CO ₂ /TJ	121.1	121.1	110.3	104.8	99.2	98.6	98.1	97.6	98.3	98.0	98.2	97.9	97.5	97.8
Fibre/de-inking residues	t CO ₂ /TJ	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9
Firewood, untreated	t CO ₂ /TJ	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1
Waste wood, wood scraps (industry)	t CO ₂ /TJ	107.8	107.8	107.8	107.8	107.8	107.8	107.8	107.8	107.8	107.8	107.8	107.8	107.8	107.8
Waste wood, wood scraps (commercial/institutional)	t CO ₂ /TJ	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4
Bark	t CO ₂ /TJ	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6
Animal meals and fats	t CO ₂ /TJ	85.8	85.8	85.8	85.8	85.8	85.8	85.8	85.8	85.8	85.8	85.8	85.8	85.8	85.8
Biogas	t CO ₂ /TJ	90.6	90.6	90.6	90.6	90.6	90.6	90.6	90.6	90.6	90.6	90.6	90.6	90.6	90.6
Landfill gas	t CO ₂ /TJ	111.4	111.4	111.4	111.4	111.4	111.4	111.4	111.4	111.4	111.4	111.4	111.4	111.4	111.4
Sewage gas	t CO ₂ /TJ	104.9	104.9	104.9	104.9	104.9	104.9	104.9	104.9	104.9	104.9	104.9	104.9	104.9	104.9
Bioethanol	t CO ₂ /TJ	NO	NO	NO	71.6	71.6	71.6	71.6	71.6	71.6	71.6	71.6	71.6	71.6	71.6
Biodiesel ⁴⁾	t CO ₂ /TJ	NO	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8

Fuel-based emission factors	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Other factors, units [kg/t]															
Flue-gas desulphurisation	kg/t	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0

- 1) Designations of fuels as defined for the inventory data can diverge from other standards, and they are listed as such, and given EF as such, only in the inventory.
- 2) Annual changes in EF as a result of varying fractions for combustion systems and plants' own systems. 1990 through 1994 – for each year, separately for old German Länder / new German Länder
- 3) Listed for selected fuels; calculated CO₂ emissions are reported only as memo items, and do not enter into the total inventory quantities; biomass fractions from special fuels (see above) are not listed separately, because their CO₂ EF are not differentiated.
- 4) Default values

Remark: The information and FAQ provided by the German Emissions Trading Authority (DEHSt) must be taken into account in any use of substance data from the NIR in the context of the ETS.

Table 475: Emission factors for CO₂ as of 1990, as derived for emissions reporting: industrial processes

Units [kg CO ₂ / t (raw material or product)]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
2.A.1 Production of cement clinkers	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
2.A.2 Production of burnt lime	746.00	746.00	746.00	746.00	746.00	746.00	746.00	746.00	746.00	746.00	746.00	746.00	746.00	746.00
2.A.2 Production of dolomite lime	867.00	867.00	867.00	867.00	867.00	867.00	867.00	867.00	867.00	867.00	867.00	867.00	867.00	867.00
2.A.3 Production of container glass	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00
2.A.3 Production of flat glass	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00
2.A.3 Production of household and table glassware	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
2.A.3 Production of special glass	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00
2.A.3 Production of glass fibres	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00
2.A.3 Production of rock wool	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00
2.A.3 Production of glass (all glass types, including cullet inputs)	118.94	115.64	112.76	115.53	115.60	110.02	109.78	109.91	115.70	113.75	116.30	118.54	119.58	123.76
2.A.4.a Production of masonry bricks	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10
2.A.4.a Production of roof tiles	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60
2.A.4.b Use of soda ash	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00
2.B.1 Production of ammonia	2,405.10	2,410.30	2,340.45	2,372.79	2,310.39	2,363.87	2,383.54	2,492.09	2,377.53	2,350.73	2,421.49	2,353.47	2,019.64	1,876.24
2.B.5 Production of calcium carbide	C	C	C	C	C	C	C	C	C	C	C	C	C	C
2.B.7 Production of soda ash	C	C	C	C	C	C	C	C	C	C	C	C	C	C
2.B.8 Petrochemicals	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00
2.B.8.f Production of carbon black	1,960	1,960	1,960	1,960	1,960	1,960	1,960	1,960	1,960	1,960	1,960	1,960	1,960	1,960
2.C.1 Production of electrical steel	8.50	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374
2.C.1 Production of oxygen steel; limestone input	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00
2.C.2 Ferroalloys production	1500.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00
2.C.3 Production of primary aluminium	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00
2.C.5 Production of refined lead (D)		371.00	220.00	220.00	220.00	220.00	220.00	220.00	220.00	220.00	220.00	220.00	220.00	220.00
2.C.5 Production of refined lead (old German Länder)	434.00													
2.C.5 Production of refined lead (new German Länder)	200.00													
2.C.6 Zinc production: primary and resmelted zinc	1720.00	1720.00	1720.00	1720.00	1720.00	1720.00	1720.00	1720.00	1720.00	1720.00	1720.00	1720.00	1720.00	1720.00

C Confidential data

ABL/NBL/D = reference: old German Länder / new German Länder / Germany as a whole

Remark: The information and FAQ provided by the German Emissions Trading Authority (DEHSt) must be taken into account in any use of substance data from the NIR in the context of the ETS.

18.8 Analysis of CO₂ emissions from non-energy-related use of fuels

The great majority of the coal, oil and gas that Germany uses is used for energy-related purposes. The remainder of the coal, oil and gas is used as feedstock for production processes. This consumption enters into the balance as "non-energy use" (NEU).

In the German Energy Balance, this consumption is listed separately, in line 43. The chemical industry is the leading user of fossil fuels for non-energy-related purposes. It uses fossil fuels in steam crackers, in reforming processes, in synthetic-gas production and in the production of graphite electrodes. For cracking and reforming, the most important downstream products are ethylene, propylene, 1,3-butadiene, benzene, toluene and xylenes; for production of synthetic gases, the most important such products are ammonia and methanol. Bitumen, lubricants and paraffin waxes are produced in refineries. Bitumen is used in a range of applications, including road surfaces and bitumen sheeting for roofs. Lubricants are used in road vehicles and machines (inter alia). Without suitable adjustments, the consumption figures listed in Energy Balance line 43 cannot be compared with the CO₂ and NMVOC emissions from use of fossil fuels, in non-energy-related uses, that are reported in the inventory under industrial processes. The reason is that for the industrial processes, only emissions from production or use of products are taken into account, while line 43 takes account of entire feedstocks, thereby including both product-specific emissions and the carbon quantities stored in products. The latter account for far and away the largest share of the feedstocks. Another important difference is that calculation of emissions from product use takes account of imported and exported quantities. In the interest of complete accounting, the carbon quantities stored in the relevant fossil fuel products were taken into account in Table 477 (see below). The correlation between material-related applications and products and the various relevant fuels is oriented to Table 1.3 from Volume 3 of the 2006 IPCC GL, and is based on information provided by relevant associations, producers and experts. In some cases, we had to make our own estimates of the applicable correlation with individual fuels.

The produced quantities of the products listed in the table have been obtained from data reported by the Federal Statistical Office and by the Federal Office of Economics and Export Control (BAFA) and have been converted into CO₂ equivalents. For petrochemical products, the conversion was made on the basis of a) specific carbon content pursuant to Table 3.10 in Volume 3 of the 2006 IPCC-GL and b) the molar mass of CO₂. The pertinent CO₂ equivalent emissions were split among the three feedstocks used in Germany (naphtha, LP gas and other petroleum products), in keeping with (internal) data provided by associations.

In the case of carbon black, the product is assumed to consist of pure carbon. That carbon was also converted into CO₂ equivalents.

The production quantities for bitumen, lubricants and paraffin waxes were obtained from the Official Mineral Oil Statistics, and they are based on gross refinery production. The production quantities have been converted into CO₂ equivalents with the help of the following IPCC standard values (Table 1.2 and Table 1.4 from Vol. 2 of the 2006 IPCC GL).

Table 476: IPCC standard values for EF & lower net calorific value

	EF t CO ₂ /TJ	Lower net calorific value TJ/kt
Bitumen	80.6	40.2
Paraffin wax	73.3	40.2
Lubricating oil	73.3	40.2

For the year 2014, the sum of the carbon from the pertinent emissions and of the carbon stored in products amounts to 106 % of the non-energy-related consumption given in line 43 of the Energy Balance. Consequently, the relevant material-related use can clearly be shown to include the quantities listed in the Energy Balance as non-energy-related consumption. No gaps in determination of non-energy-related CO₂ emissions are apparent in the inventory.

Table 477: Verification of the completeness of reported CO₂ from non-energy-related use of fossil fuels

Year	2014	Units	Coal			Petroleum					Gas	
			Hard coal + hard-coal coke	Lignite + lignite products	Total, solid fuels	Raw benzene (naphtha)	Petrol coke	LP gas	Other petroleum products	Total, liquid fuels	Natural gas	Total, gas
A: Listed NEU quantity (Energy Balance line 43)		TJ	3,110	13,004	16,114.4	488 619	8,707	50,432	299,883	847,640.7	116,305	116,305.0
B: Carbon content		kg C/GJ	29.2	30.2		20.0	26.0	17.8	22.4		15.3	
C: Total input as feedstock / non-energy use		kt C	90.8	397.0	487.8	9,767.5	225.9	899.7	6,714.4	17,607.5	1,779.5	1,779.5
D: Total input as feedstock / non-energy use		kt CO ₂	333.0	1,455.6	1,788.6	35,814.1	828.5	3,298.9	24,619.4	64,560.9	6,524.7	6,524.7
E: Implied oxidised carbon fraction		%	142%			104%	88%	114%	115%	108%	102%	102%

Year	2014	Units	Coal Hard coal + hard- coal coke	Lignite + lignite products	Total, solid fuels	Petroleum Raw benzene (naphtha)	Petrol coke	LP gas	Other petroleum products	Total, liquid fuels	Gas Natural gas	Total, gas
	AD [kt]	EM [kt CO ₂]	Activity data + emissions (C in Gg CO ₂)			Activity data + emissions (C in Gg CO ₂)						
F: Total reported fossil IPPU CO ₂		7,790	474			37,181	730	3,765	28,321	69,997	6,636	6,636
2 Industrial processes		7,790	474			37,181	730	3,765	8,759	50,436	6,636	6,636
2B: Chemical industry		6,591				37,181	4	3,765	8,759	49,710	6,636	6,636
2B1: Ammonia production	2,899	5,856							586	586	5,270	5,270
2B5: Carbide production	C	4					4			4		
2B6: Titanium dioxide production		NE										
2B8: Petrochemical industry (1)											1,366	1,366
Methanol	993											
Ethylene	5,070					12,571		1,273	2,069	15,913		
Propylene	3,986					9,888		1,001	1,627	12,517		
Butene and 1,3-Butadiene	2,300					5,917		599	974	7,490		
Benzene	2,150					5,746		582	946	7,273		
Toluene	636					1,683		170	277	2,130		
Xylene	524					1,375		139	226	1,741		
Carbon black	372	731							2,055	2,055		
2C: Metal industry		1,199	474				725			725		
2C1: Iron and steel production (2)		IE										
2C2: Production of ferroalloys	55	6	6									
2C3: Primary aluminium production	531	725					725			725		
2C5: Lead production (2)	C	IE										
2C6: Zinc production (2)	C	IE										
2D: Non-energy-related products from fuels and solvents (1)									19,562	19,562		
Lubricants	2746								8,095	8,095		
Waxes, paraffins, vaseline, etc.	137								404	404		
Bitumen	3,410								11,063	11,063		
Solvents and other product use (3)	IE	IE				IE						

- (1) To ensure that a complete carbon balance is obtained, a departure is made here from the report format used for the categories in the inventory. For this reason, the production quantities listed here cannot be compared with the inventory figures in 2.B.8 and 2.D. The emissions given in the table refer to complete transformation of products into CO₂ – instead of, as in the inventory categories – to emission in production or use.
- (2) For reasons of confidentiality, these data are reported in aggregated form.
- (3) Since over 90% of solvents from basic chemicals are produced in steam crackers, it is assumed that carbon emitted from NMVOCs comes from products of such crackers.

19 Annex 3: Other detailed methodological descriptions for individual source or sink categories, including KP-LULUCF activities

19.1 Other detailed methodological descriptions for the source category "Energy" (1)

19.1.1 Revision of the activity rates for stationary combustion systems of the new German Länder for the year 1990 and for subsequent years (1.A.1 and 1.A.2)

Problems with the GDR's official statistics in 1990, the year of German reunification, along with the creation of a standardised system of official statistics for all of Germany, had a noticeable effect on the quality of figures, as reported in past inventories, for activity rates of stationary combustion systems of the new German Länder for the year 1990 (and for subsequent years). For this reason, these figures have been revised. This work was carried out by the Institute for Energy and Environment (Institut für Energetik und Umwelt gGmbH; IE gGmbH). In work package 1 of the research project "Base year and update" ("Basisjahr und Aktualisierung"; UBA, 2005c: FKZ 20541115), "the activity rates for stationary combustion systems of the new German Länder, in their role as a basis for emissions inventories and the report relative to determination of allocated quantities, were explicitly reviewed for any gaps, completed and corrected as necessary and substantiated". For a detailed description of the procedure used for revising the activity rates for stationary combustion systems, please see the 2010 NIR.

19.1.2 Energy industry (1.A.1)

19.1.2.1 *Methodological aspects of determination of emission factors (Chapter 3.2.6.2)*

This section of the Annex describes the main steps carried out in the research projects RENTZ et al (2002) and RENTZ et al (2002) und FICHTNER et al (2011) for determination of emission factors. (This description does not apply to the CO₂ emission factors whose determination is described in Annex 2 (Chapter 18.7).)

Determination of emission factors requires detailed analysis of all operational facilities with regard to technologies used and design-specific emission behaviour. Three overarching categories are formed: large combustion systems, combustion systems within the scope of application of the Technical Instructions on Air Quality Control (TA Luft) and gas turbines. Existing plants are classified in terms of emissions-relevant characteristics, and the pertinent emission factors are determined. These so-called "technology-specific" factors can then be aggregated in an adequate manner. This database also provides the basis for estimating future emissions (changes in the overall make-up of the entire group of facilities, in terms of percentage shares for various facility types). This procedure thus consists of the following steps:

9. Characterisation of the technology-specific emissions behaviour of combustion systems. In a first step, the combustion and emissions-reduction technologies used in Germany are briefly described, and the relevant emissions-determining factors are explained. On the basis of this characterisation, emission factors are derived for the various different relevant technologies, differentiated by size class and fuel type. The chosen classification is also oriented to applicable provisions under immissions-control law, an orientation that permits derived emission factors to be compared with limits applicable now or in the future.
10. Analysis of the relevant category structure
Emissions calculations must be carried out using emission factors that have the same

references as the pertinent energy-input data. The latter (data) are broken down by categories that are derived from the national energy balance – cf. Chapter 3.2 – and are not based on the combustion technologies used. The project has defined and analysed the following categories: Public electricity and heat production (CRF 1.A.1a), Industrial power stations (CRF 1.A.1c for mining-sector power stations; otherwise CRF 1.A.2), District-heating stations (CRF 1.A.1a), Refinery power stations (CRF 1.A.1b), Industrial combustion systems (CRF 1.A.1c and 1.A.2) and Residential and Institutional and commercial (small consumers) (CRF 1.A.4 and 1.A.5).

In the analysis, the various technologies' contributions to total energy use must be determined. The most important data sources for this include the power-station database of the DFIU (now the KIT), relevant statistics, communications of industry associations (VGB, VDEW, VIK), operator information and technical publications. Furthermore, excerpts of emissions declarations from the years 1996 and 2004, as provided by some Länder authorities, were also evaluated in the present context.

11. Aggregation of emission factors

On the basis of the percentage contributions for the various technologies – which were determined separately for the old and new Länder – the technology-specific emission factors are aggregated to form category-specific factors. Finally, factors for Germany as a whole are formed. The category-specific factors are sub-divided in accordance with the categories "large combustion systems", "TA Luft combustion systems" and "gas turbines", as well as by fuel type. The aggregated emission factors are formed first for the reference year 1995 (RENTZ et al, 2002) and for the reference year 2004 (FICHTNER et al, 2011).

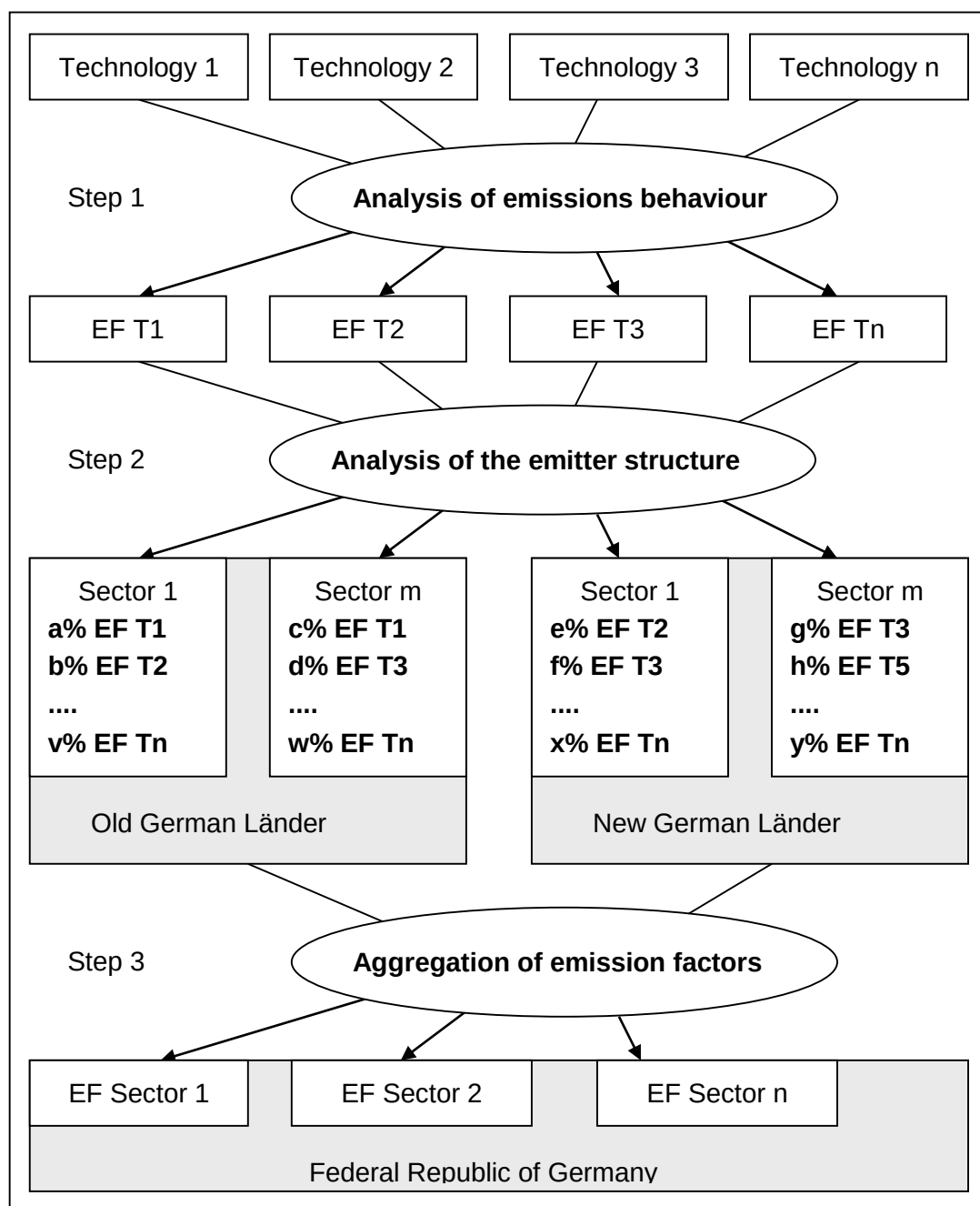
12. Projections for the years 2000 and 2010 (RENTZ et al, 2002) and for the years 2010 and 2020 (FICHTNER et al, 2011)

Technology-specific emission factors are defined for the purpose of describing ongoing technical progress. These are derived from characterisation of modern technologies. An increasing contribution of low-emissions technologies to total relevant activity, thus, can be represented by suitably changing the percentage shares for the technologies under consideration. The framework for such carrying forward consists of the relevant applicable provisions under immissions-control law. For the reference year 2010, it is assumed that requirements from the amended Technical Instructions on Air Quality Control (TA Luft) from 2002 and the EU Large Combustion Plants Directive of 2001 have been implemented; for the reference year 2020, we assume that the requirements of Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions have been implemented.

The above-described methods, beginning with characterisation of the emissions behaviour of relevant combustion technologies and gradually leading to aggregated factors at various regional and category-specific levels, make it possible to represent the required factors transparently.

The chosen methods for deriving emission factors for a given reference year are shown in Figure 90 below.

Figure 90: Methods for calculating emission factors



The origins and the quality of the data involved are discussed in detail in the relevant project reports (RENTZ et al, 2002; and FICHTNER et al, 2011). A large part of the data has been taken from the emissions declarations of the German Länder (states) Baden-Württemberg, Brandenburg, North Rhine – Westphalia and Thuringia for 1996, and from the emissions declarations of all Länder (except for Berlin) for the year 2004. The annual pollutant-load data included in those data are based, depending on the pollutant in question, on measurements from continuous monitoring, on individual measurements or on calculations based on physical laws, mass balances or emission factors. In the following, the emissions declarations of the state of Baden-Württemberg are used to show, by way of illustration, what data-determination methods tend to be used for the various types of combustion systems and substances in question. Such analysis makes it possible to classify the quality of the underlying data with regard to the derived

technology-specific emission factors. At the same time, the description illustrates the data-evaluation procedure. Where a sufficient amount of data for a source category is available, the relevant value range is characterised via the median and the percentile is characterised at 25 % and 75 %²¹⁴. This produces a robust estimate that, unlike characterisation via the mean value, is not distorted by extreme values. In general, percentiles at 5 % and 95 % are also listed, to describe the distribution of values. Similar percentile evaluations were also carried out for the emissions declarations of the other Federal Länder.

In the following, a distinction is made between measured data (either continuous measurements or individual measurements) and data based on calculations or emission factors. In evaluation, therefore, individual data items are first classified as either "measurements" (M) or "assumptions" (A). This general overview, in turn, is divided into the categories of large combustion systems, TA Luft combustion systems and gas turbines. These are then further subdivided, with regard to declaration obligations, into facilities subject to abbreviated (K) or complete (V) declarations. For each of the three groups of systems, evaluation and derivation of emission factors is carried out, using the sample data from Baden-Württemberg and with classification by "measurements" and "assumptions".

Table 478 provides an overview of the facility types considered, grouped on the basis of their numbers under the 4th Ordinance Implementing the Federal Immission Control Act (BImSchV) and of the type of declaration concerned.

²¹⁴ For the entire value range of a variable *X*, the sum-frequency distribution can be used to estimate what percentage of all units considered will have a maximal value of *x*. That value is referred to as a *quantile* or, when percentage values are being considered, as a *percentile*. The best-known percentile, the one that separates the lower half of all values from the upper half, is the 50th percentile, the so-called *median*. The 25th and 75th percentiles cut off the upper and lower quarters of the distribution. They are thus also referred to as upper and lower *quartiles* or as the first and third *quartile* (with the median being a sort of second quartile).

Table 478: Facility types pursuant to Annex of 4th BImSchV (4th Ordinance on Execution of the Federal Immission Control Act)

Large combustion systems (Großfeuerungsanlagen)			Type of declaration required
Index			
1 01 1	Power stations	≥ 50 MW for solid, liquid and gaseous fuels	V
1 02A 1	Combustion systems	≥ 50 MW for solid and liquid fuels	V
1 02B 1	Combustion systems	≥ 50 MW for gaseous fuels	V
TA Luft installations			Type of declaration required
Index			
1 02A 2	Combustion systems heating oil EL)	1 - < 50 MW, solid and liquid fuels (except for	V
1 02B 2	Combustion systems	5 - < 50 MW heating oil EL	K
1 02C 2	Combustion systems	10 - < 50 MW for natural gas	K
	Combustion systems installations	10 - < 50 MW, except for natural gas	V
1 03 1	Combustion systems	> 1 MW, other fuels	V
Gas turbine systems			Type of declaration required
Index			
1 05 1	Gas turbines	≥ 50 MW for natural gas	K
	Gas turbines	≥ 50 MW, except for natural gas installations	V
1 05 2	Gas turbines	< 50 MW for natural gas	K
	Gas turbines	< 50 MW, except for natural gas installations	V

In the analyses, emissions data are differentiated by combustion technologies. Table 479 provides an overview of this technology classification based on types. Categories 110 to 118 apply mainly to solid fuels, while 120 to 125 apply to liquid fuels and 130 to 132 apply to gaseous fuels.

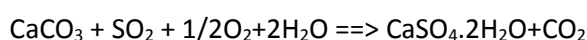
Table 479: Classification of sources by type of combustion system

Technology	
Type	Meaning
110	Combustion systems for solid fuels / waste
111	Filled-shaft combustion systems
112	Combustion with throw feed
113	Combustion systems with pneumatic feed
114	Under-thrust combustion
115	Combustion with mechanically moved grids
116	Dust incineration with dry-ash ventilation
117	Dust incineration with wet-ash ventilation
118	Fluidised-bed combustion
120	Combustion systems for liquid fuels / waste
121	With evaporative burner
122	With pressure-atomising burner
123	With steam-atomising burner
124	With rotation-atomising burner
125	With air-atomising burner
130	Combustion systems for gaseous fuels / waste
131	With atmospheric gas burner
132	With gas-blower burner
141	Multiple-substance combustion systems
142	Mixed combustion
815	Gas turbines

19.1.2.2 CO₂ emissions from flue-gas desulphurisation (CRF 1.A.1, Limestone balance)

In the framework of the research project "limestone balance" ("Kalksteinbilanz"; UBA 2006, FKZ 20541217/02), data for CO₂ emissions from flue-gas desulphurisation were determined for the category Electricity and heat production in public power stations (cf. 3.2.6.2). Flue-gas desulphurisation systems have the task of converting sulphur dioxide in combustion gases, via chemical and physical processes, into substances that are less harmful. Limestone is commonly used as a reagent in flue-gas desulphurisation. Desulphurisation systems are tailored to the applicable requirements under immissions-control law and to the economic value of the resulting residual substances (plaster). The predominant process used in electricity generating plants is limestone scrubbing. Some 87 % of all power stations in Germany, in terms of installed output, use this process (RENTZ et al. 2002b).

Desulphurisation with CaCO₃ consists of several sub-reactions. For stoichiometric calculation of limestone inputs in the limestone-scrubbing process, the relevant chemical gross-reaction equation for the process is used (STRAUSS 1998):



This equation can be used to derive the limestone/plaster molar mass ratio. Such derivation shows that 581.39 kilograms of limestone are used per produced tonne of plaster. Plaster-production figures thus can be used to obtain the theoretically maximal limestone inputs for flue-gas desulphurisation in hard-coal-fired and lignite-fired power stations. The plaster-production figures do not indicate whether limestone or lime has been used, however. This problem was resolved with the help of statistics of the German Lime Association (BV Kalk) relative to sales of burnt and unburnt lime for the air-quality-control sector. Using the above reaction equation, the pertinent process-related CO₂ emissions can be determined from the mass relationship between CaCO₃ and CO₂. The results of the calculation are shown in the following table. They take account of figures for plaster production in all years between 1990 and 2011. To calculate plaster production for the years 2012 through 2015, we have used the 2011 plaster-production figure as a provisional input figure for the calculation.

Table 480: CO₂ emissions from flue-gas desulphurisation in public power stations

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CRF 1.A.1	Figures in kt									
CO ₂ from flue-gas desulphurisation in public power stations	618	652	629	662	616	683	867	878	1,005	966
Year	2001	2001	2002	2003	2004	2005	2006	2007	2008	2009
CRF 1.A.1	Figures in kt									
CO ₂ from flue-gas desulphurisation in public power stations	1,135	1,069	1,094	1,156	1,162	1,142	1,076	1,017	985	995
Year	2010	2011	2012	2013	2014	2015				
CRF 1.A.1	Figures in kt									
CO ₂ from flue-gas desulphurisation in public power stations	1,003	1,028	1,019	979	973	981				

Source: Calculation on the basis of the "limestone balance" project (UBA 2006, FKZ 20541217/02); updated in 2008 (cf. NIR 2009)

In the inventory, these CO₂ emissions were assigned to emissions from use of solid fuels, because such use is the reason for operation of the flue-gas desulphurisation systems and for the systems'

CO₂ emissions. Pursuant to expert estimates of the group carrying out the pertinent research, the uncertainty for limestone use and, thus, the uncertainty for related CO₂ emissions, is +/- 10 %.

19.1.3 Transport (1.A.3)

19.1.3.1 Transport – Civil aviation (1.A.3.a)

19.1.3.1.1 Derivation of additional emission factors (1.A.3.a)

Due to scheduling reasons, it was not possible to update the underlying model in time for the 2017 Submission and for report year 2015. For this reason, the year-specific emission factors for the report 2014 were carried forward, unchanged, for the year 2015.

Kerosene

Emissions of *sulphur dioxide* depend directly on the sulphur content of the jet kerosene being used. That, in turn, is subject to regional and chronological fluctuations. (IPCC, 2006b) gives an EF of 1 kg SO₂/t kerosene, which is based on a sulphur content of 0.05 % by weight. According to current information of the Fachausschuss für Mineralöl- und Brennstoff-Normung²¹⁵ (FAM; technical committee for petroleum and fuels standardisation), jet kerosene in Germany typically has a total sulphur content of about 0.01 % by weight, i.e. one-fifth of the content given by the IPCC. The 2009 inventory report uses a sulphur-content figure of 0.021 % by weight for jet kerosene, on the basis of measurements from the year 1998 (DÖPELHEUER, 2002). It seems plausible that the emission factor would decrease over time as a result of improved procedures and reduced maximum permitted levels. Consequently, a linear reduction is included here between the framework years 1990 (1.08 g SO₂ / kg kerosene), 1998 (0.4 g) and 2009 (0.2 g). In addition, it is assumed that all of the sulphur in the fuel is converted into sulphur dioxide. Because the emission factor depends directly and solely on the sulphur content of the jet kerosene, this emission factor is used for both flight phases.

NO_x and *CO* emissions are calculated with the help of emission factors based on TREMOD-AV calculations. Those results, in turn, are based on aircraft-type-specific and operational-state-specific emission factors taken largely from the EMEP/EEA database. Adjusted emission factors have to be used in some cases, when specific aircraft types cannot be directly allocated to the proper categories, even with the help of data on technically similar aircraft types. Those emission factors were determined via emissions functions, in the context of regression calculations, that calculate the emission factor for each engine type as a function of take-off weight. The basis for those functions consisted of the emission factors for existing aircraft types pursuant to (IFEU & ÖKOINSTITUT, 2010).

In each case, the *NM_{VOC}* emission factors are obtained from the difference between the emission factor for hydrocarbons and that for methane.

Avgas

In (IPCC, 2006: Vol. 2, p. 3-64), the emission factors for *nitrous oxide* are explicitly defined as equal to the relevant values given for jet-kerosene use. That assumption has been adopted here – along with the forecasts for jet-kerosene use in cruise phases of national air transports.

As to fuel properties, there are no fundamental differences between avgas and automobile gasoline²¹⁶. Consequently, values for specific SO₂ emissions from automobile gasoline may be used

²¹⁵ Personal e-mail communication with Dr. Feuerhelm, FAM Hamburg, 9 June 2009

²¹⁶ E-mail communication with Mr Winkler of the Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry, 8 June 2009

for avgas. Pursuant to the Fachausschuss für Mineralöl- und Brennstoff-Normung (FAM; technical committee for petroleum and fuels standardisation), the maximum permitted level for total sulphur content in gasoline-station fuel is 10 mg/kg, or 0.001 % by weight, which is one-tenth of the figure given for jet kerosene. As a result, the 2008 emission factor for SO₂ from jet kerosene, reduced by 90 %, is used in the present context.

In each case, the *NM VOC* emission factors are obtained from the difference between the emission factor for hydrocarbons and that for methane.

The other emission factors are not available as special values for average small aircraft. For this reason, they are assumed to be the same as the relevant jet-kerosene emission factors (national, cruise).

Table 481: Emission factors for avgas, 2015

	EF		Remarks regarding the source or calculation
	[g/kg]	[kg/TJ]	
CO ₂	3,048.00	70,000	Tier 1 default EF pursuant to (IPCC, 2006: Table 3.6.4)
CH ₄	0.36	8.21	same as EF kerosene, LTO/national
N ₂ O	0.10	2.33	same as EF kerosene, Cruise/national
SO ₂	0.02	0.51	equivalent to 1/10 of EF for kerosene, cruise/national
NO _x	11.76	270.15	same as EF kerosene, Cruise/national
NM VOC	7.98	183.36	Tier 3 EF from EF(HC) minus EF(CH ₄)
CO	660.69	15,173	Tier 3 EF, calculated in TREMOD-AV

Source: ÖKO-INSTITUT (2015)

Table 482: Overview of emission factors for kerosene

in g/kg	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1.A.3.a – Overarching																		
CO₂									3,150									
SO₂	1.08	0.66	0.36	0.35	0.33	0.31	0.29	0.27	0.25	0.24	0.22	0.20	0.20	0.20	0.20	0.20	0.20	0.20
National, LTO cycle																		
CH₄									0.35									
N₂O									0.12									
NO_x	11.73	11.47	12.04	12.03	11.75	11.46	11.39	11.20	11.12	11.19	11.62	12.07	12.24	12.17	12.26	12.41	12.42	12.42
NM VOC	2.03	1.18	0.90	0.80	0.83	0.80	0.83	0.87	0.83	0.90	0.86	0.74	0.67	0.72	0.73	0.76	0.782	0.782
CO	12.26	12.27	11.69	11.56	11.82	12.08	12.02	12.15	12.01	11.75	11.41	10.64	10.39	10.60	10.52	10.036	9.921	9.921
National, cruise																		
CH₄									0.00									
N₂O									0.10									
NO_x	16.03	15.95	16.32	16.21	16.15	15.95	15.68	15.56	15.50	15.88	16.60	17.00	17.22	17.20	17.47	18.07	18.14	18.14
NM VOC	0.48	0.52	0.53	0.51	0.54	0.53	0.56	0.47	0.41	0.39	0.39	0.38	0.38	0.37	0.37	0.40	0.40	0.40
CO	4.21	4.40	4.29	4.01	3.98	3.91	3.87	3.75	3.70	3.47	3.43	3.55	3.64	3.68	3.55	3.16	3.204	3.204
National, cruise																		
CH₄									0.13									
N₂O									0.09									
NO_x	12.45	12.20	12.20	12.29	12.33	12.43	12.50	12.55	12.59	12.72	12.80	13.08	13.34	13.33	13.48	13.70	13.80	13.80
NM VOC	3.14	3.09	2.00	1.87	1.98	1.89	1.61	1.44	1.38	1.29	1.28	1.14	1.00	1.03	0.98	0.88	0.82	0.82
CO	11.82	10.93	10.96	10.80	10.68	10.56	10.44	10.29	10.27	10.08	10.09	10.02	9.85	9.86	9.77	9.50	9.35	9.35
International, cruise																		
CH₄									0.00									
N₂O									0.10									
NO_x	15.47	14.86	14.46	14.50	14.53	14.62	14.66	14.75	14.79	14.93	15.01	15.22	15.57	15.65	16.01	16.287	16.48	16.48
NM VOC	0.35	0.25	0.20	0.19	0.18	0.19	0.18	0.17	0.17	0.17	0.17	0.17	0.16	0.16	0.15	0.15	0.15	0.15
CO	2.12	1.86	1.68	1.63	1.58	1.55	1.47	1.45	1.45	1.43	1.40	1.40	1.39	1.37	1.35	1.33	1.31	1.31

Source: ÖKO-INSTITUT (2015)

19.1.3.1.2 Detailed overview of the uncertainties underlying the pertinent activity data and emission factors (1.A.3.a)

Table 483: Overview of the applicable partial uncertainties for activity rates and emission factors

Individual components		Partial uncertainties		AR (kerosene & avgas)		SF (LTO / cruise)		AR (kerosene) LTO and cruise		EM (H ₂ O) LTO and cruise		EM (CH ₄) LTO and cruise		EM (N ₂ O) LTO and cruise		EM (SO ₂) LTO and cruise		EM (H ₂ O) LTO and cruise		Remaining EM LTO + cruise		Source / reason for assumptions
		[%]		Total	n / i	n	i	n	i	n	i	n	i	n	i	n	i	n	i	n	i	
AD of AGEB and BAFA		-5	5	x	x																	Öko-Institut / DIW 2007 Here, the higher uncertainties of the Energy Balance are used. The uncertainties for the BAFA data are +3, -1% (conservatively estimated, using the approach for the uncertainties of mineral-oil statistics, which are based on BAFA data.)
Split factor SF n <> i		-10	10		x																	Calculated
AR (kerosene)	n & i	-11	11					x	x													Calculated
Data of the Federal Statistical Office relative to aircraft movements	n	-0.1	0.1			x																Aviation statistics are based on the Transport statistics act (Verkehrsstatistikgesetz - VerkStatG). The data specified by Arts. 12, 13 VerkStatG are recorded. Pursuant to that act, all civil aviation craft, including aircraft, helicopters, airships, motorised gliders, sailplanes and manned balloons, are to be included in relevant surveys, as long as airports/airfields in Germany are involved.
	i	-0.1	0.1				x															
Real-distance addition	n & i	-3	3			x	x															The data of the Federal Statistical Office are oriented to great-circle distances. A detour factor for cruise flight has been used, as a means of estimating the distances actually flown (cf. IFEU and Öko-Institut 2010).
Allocation of consumption values for kerosene to aircraft types	n	-5	5			x																Aircraft types pursuant to the Federal Statistical Office are assigned emission factors from the EMEP-EEA database. There are four different quality levels for such assignment: a) direct, b) via similar types, c) via regression functions depending on take-off weight, and d) lump-sum EF.
	i	-5	5				x															
SF (LTO / cruise)	n	-6	6					x														Calculated
	i	-6	6						x													Calculated
AD (kerosene) LTO and cruise	n	-13	13							x		x		x		x		x		x		Calculated
	i	-13	13								x		x		x		x		x		x	Calculated
Emission factors (EF)	CO ₂	5	5							x	x											2006 IPCC GL (Vol. 2, Chapter 3.6 – Civil aviation, p. 3.69), low uncertainty, since the EF depends solely on the C content of the fuel.
	CH ₄	-57	100									x	x									2006 IPCC GL (Vol. 2, Chapter 3.6 - Civil aviation, p. 3.69), dependent on technology, which yields a high uncertainty in standardisation with a Tier 1 approach
	N ₂ O	-70	150											x	x							The emission factor depends only on fuel characteristics (sulphur content).
	SO ₂	-10	10													x	x					The emission factor depends only on fuel characteristics. Low values, ranging from -4.9 to 1.6, given in (EUROCONTROL, 2004, p.49).
	H ₂ O	-5	5															x	x			Assumption – for NO _x , HC and CO, a mean EF is calculated via TREMOD, on the basis of the EF for individual aircraft types
Remaining EF	n & i	-10	10																	x		
Total uncertainty, above				+5	+11	+6	+6	+13	+13	+14	+14	+58	+58	+71	+71	+16	+16	+14	+14	+16	+16	
Total uncertainty, below				-5	-11	+6	-6	-13	-13	-14	-14	-101	-101	-150	-150	-16	-16	-14	-14	-16	-16	

n = national share; i = international share

Source: ÖKO-INSTITUT (2009)



19.1.3.2 Derivation of activity rates for road transport (1.A.3.b)

19.1.3.2.1 Harmonisation with the Energy Balance

The basis for CSE data collection for the road-transport sector consists of energy consumption data provided by the Working Group on Energy Balances (AGEB). For each year, the sum of the activity rates for the various individual structural elements must correspond to the Energy Balance data, in TJ. The relevant basic Energy Balance data are shown in Table 484 below.

Table 484: Energy inputs in road transports, 1990-2015

	Gasoline	Diesel	Biofuels	Natural gas & LP gas	Petroleum	Lubricants a
Energy inputs pursuant to Energy Balances 1990-2015 (last revision: 10/2016), in TJ						
1990	1,330,479	735,920	0	138	0	2,416.41
1991	1,332,285	785,174	0	137	0	1,387.13
1992	1,344,129	853,502	0	229	0	1,283.70
1993	1,350,617	907,787	0	184	473	885.23
1994	1,276,637	932,060	0	184	559	364.85
1995	1,299,982	964,013	1,504	138	610	335.05
1996	1,299,879	964,580	2,046	115	638	294.50
1997	1,297,487	979,586	3,652	106	357	232.72
1998	1,300,463	1,022,794	4,081	106	637	200.96
1999	1,300,602	1,097,036	5,370	100	637	123.02
2000	1,237,055	1,108,105	12,276	94	414	89.36
2001	1,199,318	1,097,416	16,740	98	471	85.69
2002	1,166,381	1,105,842	20,460	607	472	81.56
2003	1,108,989	1,078,352	29,948	694	0	82.93
2004	1,072,720	1,110,931	39,950	1,887	0	88.27
2005	992,377	1,078,620	78,641	5,484	0	88.18
2006	930,834	1,082,042	143,583	9,051	0	91.49
2007	892,982	1,073,987	155,297	14,787	0	87.26
2008	854,002	1,102,623	125,721	22,796	0	89.54
2009	829,227	1,114,939	113,066	32,285	0	91.04
2010	791,416	1,168,063	119,463	30,591	0	87.60
2011	787,803	1,197,252	115,102	32,384	0	90.40
2012	742,000	1,223,718	118,565	32,401	0	87.89
2013	741,150	1,283,637	107,274	30,466	0	88.32
2014	744,661	1,296,828	111,397	28,936	0	90.12
2015	712,855	1,338,988	103,937	27,284	0	87.17

Sources: Evaluation tables of the Energy Balances, "Mineralöl-Zahlen" ("Petroleum Data") of the Association of the German Petroleum Industry (MWV) (2016) and "Amtliche Mineralöldata" ("Official Mineral Oil Statistics").

^a as components of 1:50 two-stroke fuel mixtures

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 IFEU, 2002). 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 mean energy consumption figures in the time series are plausible. For this reason, the TREMOD results for the energy 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 energy consumption in tonnes, the results first have to be converted into TJ. For this purpose the net calorific values provided by the Working Group on Energy Balances (AGEB) are used (cf. Table 485).

Table 485: Net calorific values for gasoline and diesel fuel

Validity period	Gasoline	Diesel fuel
1990-1992	43.543 MJ/kg	42.704 MJ/kg
since 1993	43.543 MJ/kg	42.960 MJ/kg

Source: Working Group on Energy Balances (AGEB)

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 gasoline consumption for all vehicle categories and from gasoline 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 ≤ 3.5 t (light duty vehicles (LNF), and of motor homes and motorcycles (MZR)), into line with the Energy Balance.
- The difference between the corrected diesel-fuel consumption of automobiles and of other vehicles ≤ 3.5 t and the Energy Balance is then allocated to heavy duty vehicles and buses.
- The correction factor for heavy duty vehicles and buses 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.

The following table summarises the correction factors used.

Table 486: Correction factors for harmonisation with the Energy Balance

	Area of application	Gasoline (including bioethanol)	Diesel fuel (including biodiesel)	
		<i>Automobiles, light duty vehicles, motorcycles</i>	<i>Automobiles, light duty vehicles</i>	<i>Heavy duty vehicles, buses</i>
1990	ABL	1.035	1.035	1.126
1990	NBL	1.051	1.051	1.390
1991	ABL	1.032	1.032	1.084
1991	NBL	1.050	1.050	0.983
1992	ABL	1.035	1.035	1.166
1992	NBL	0.990	0.990	1.169
1993	ABL	1.039	1.039	1.277
1993	NBL	0.970	0.970	1.126
1994	ABL	0.981	0.981	1.181
1994	NBL	0.981	0.981	1.181
1995	D	0.993	0.993	1.205
1996	D	0.994	0.994	1.183
1997	D	0.991	0.991	1.186
1998	D	0.984	0.984	1.247
1999	D	0.987	0.987	1.305

	Area of application	Gasoline (including bioethanol)	Diesel fuel (including biodiesel)	
		<i>Automobiles, light duty vehicles, motorcycles</i>	<i>Automobiles, light duty vehicles</i>	<i>Heavy duty vehicles, buses</i>
2000	D	0.957	0.957	1.334
2001	D	0.944	0.944	1.236
2002	D	0.939	0.939	1.193
2003	D	0.926	0.926	1.134
2004	D	0.933	0.933	1.080
2005	D	0.923	0.923	1.074
2006	D	0.919	0.919	1.090
2007	D	0.916	0.916	1.032
2008	D	0.918	0.918	1.021
2009	D	0.912	0.912	1.056
2010	D	0.901	0.901	1.088
2011	D	0.912	0.912	1.054
2012	D	0.891	0.891	1.127
2013	D	0.914	0.914	1.143
2014	D	0.934	0.934	1.076
2015	D	0.908	0.908	1.110

Remark: 1994 correction factors for old German Länder (ABL) and new German Länder (NBL) as for Germany (D) as a whole

19.1.3.2.2 Allocation of biofuels, petroleum, natural gas and LP gas to the structural elements

The Energy Balance includes data on biomass and other fuels, broken down by individual vehicle categories. Those data are allocated as follows:

- The figures for biodiesel and bioethanol are divided in accordance with the various vehicle categories' shares of consumption of the corresponding fossil fuels.
- Petroleum is allocated to buses (on roads outside urban areas) in keeping with the buses' percentage shares of consumption of conventional diesel fuel.

19.1.3.2.3 Activity rate for evaporation

The activity rate for evaporation emissions is set as total gasoline consumption, on *municipal roads* (= city); the corresponding figure for mopeds is the *total consumption*. The values corrected to the Energy Balance are used.

19.1.3.3 Derivation of emission factors

19.1.3.3.1 Emission factors from TREMOD

In the Central System of Emissions (CSE), implied emission factors, in [kg/TJ] or [kg/t], generated from more-specific TREMOD data, are given for the categories *engine type* and *evaporation*. For gasoline and diesel fuel, those values can be derived directly from TREMOD. To that end, emissions in [t] and energy consumption in [TJ] (converted from the results "energy consumption in t", using the net calorific values pursuant to Table 485) are derived from the TREMOD results and allocated to the relevant structural elements. The implied emission factors (IEF) result as the quotient of specific emissions in [t] divided by the specific energy consumption in [TJ].

$$IEF [kg \text{ pro TJ}]_{inventory} = EM [kg]_{specific, TREMOD} \div AR [TJ]_{specif. consumption, TREMOD}$$

A similar procedure is used for the implied emission factors for evaporation:

$$IEF [kg \text{ pro t}]_{inventory} = EM [kg]_{specific, TREMOD} \div AR [t]_{specif. consumption, TREMOD}$$

In general, TREMOD data that have not been corrected in accordance with the Energy Balance are used for this derivation. Use of the so-corrected figures for emissions and energy consumption would lead to the same results, however, since the correction factor cancels out when the IEF is calculated.

$$EM_{corr.} \div AR_{corr.} = EM_{TREMOD} \div AR_{TREMOD}$$

19.1.3.3.2 Emission factors for biodiesel, bioethanol, petroleum, natural gas and LP gas

In all cases, the emission factors for biodiesel and petroleum are set to the same values as those for conventional diesel fuel. The emission factors for bioethanol are set to the same values as those for conventional gasoline.

Exceptions:

- The EF (CO₂) used for biodiesel is 70.8 t/TJ, a default value pursuant to the 2006 IPCC GL (Vol. 2, Chapter 2 - Stationary Combustion, p. 2.20, Tab. 2.4).
- The EF (SO₂) 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.

Now, the emission factors for LP gas and natural gas, like those for diesel fuel and gasoline, are being taken from the "Handbook for emission factors of road transports 3.2" ("Handbuch für Emissionsfaktoren des Straßenverkehrs 3.1").

19.1.3.4 Derivation of data for western and eastern Germany, 1994

TREMOD distinguishes between old and new German Länder only until 1993. Since the CSE also requires such differentiation for 1994, a relevant breakdown must be made using simplifying assumptions. The framework conditions include:

- The sum total of activity rates for engine-type categories (Antrieb) must correspond to the relevant Energy Balance values (in each case, for old and new German Länder).
- In the overall result, emissions resulting from linking activity data with emission factors must correspond to the TREMOD results for Germany.

With these framework conditions, a relevant breakdown is possible only under the following assumptions:

- The EF (CSE) for the old and new German Länder are set to the relevant values for all of Germany (TREMOD) in 1994.
- The individual CSE vehicle layers' percentage shares of the activity rates are considered to be the same in each case in the old and new German Länder, and they are the same as the relevant values for all of Germany in 1994.

With these assumptions, the aforementioned conditions are fulfilled. A third framework condition is not fulfilled: the plausibility of emissions results in the time series, in each case, for the old/new German Länder.

19.1.4 CO₂ emissions from co-combustion of lubricants, in various vehicle categories and other mobile sources

The German greenhouse-gas inventory covers CO₂ emissions from co-combustion of lubricants for all mobile sources. In keeping with emissions reporting requirements, emissions from two-stroke

gasoline engines are allocated directly to the pertinent emission sources, since in those cases lubricants are seen as part of the relevant fuels (fuel mixtures for two-stroke engines). On the other hand, all co-combustion emissions not caused by two-stroke engines are reported under CRF 2.D.1 (product use).

19.1.4.1 CO₂ emissions from lubricant co-combustion in two-stroke gasoline engines

For the entire time series as of 1990, it is assumed, as a simplification, that the two-stroke fuel mixture used in Germany consists of 49 parts gasoline and one part lubricants (mixture of 1:50). Since the 1980s, this mixing ratio has been the standard for most vehicles with two-stroke engines. No reliable usage data are available on motors that use mixtures of 1:100 (newer mobile devices such as chainsaws, lawnmowers, etc.).

Mopeds and small motorcycles are now virtually the only types of *vehicles with two-stroke engines* that are found on German roads. Until the end of the 1990s, the automobile and utility vehicle fleet included a fraction of vehicles with two-stroke engines produced in the former GDR.

TREMODO contains pertinent separate sets of consumption data for automobiles and light utility vehicles (through 1999) and for mopeds and motorcycles.

TREMODO MM contains current figures on use of *mobile devices with two-stroke engines* for both the Residential (1.A.4.b ii) and Forestry (1.A.4.c ii) sectors.

The figures on gasoline consumption in road transports and by mobile sources in the Commercial and Institutional, and Residential, sectors agree with the corresponding figures in the Energy Balance. To obtain a complete picture of the fuel consumption that must be assigned to two-stroke engines, the relevant quantities of additionally used (i.e. in fuel) lubricants have been calculated – in accordance with the mixing ratio of 1:50. On the basis of an r_V 2 % fraction by volume, the fraction r_E applying to the pertinent energy quantity in [TJ] has to be determined, via the relationship of the two components' average densities (ρ) and net calorific values (H_i):

$$r_{E\%} = r_{V\%} \times \frac{\rho_{\text{lubricant}}}{\rho_{\text{fuel}}} \times \frac{H_{i,\text{lubricant}}}{H_{i,\text{fuel}}}$$

$$r_{E\%} = 2\% \times \frac{0.875 \frac{\text{kg}}{\text{l}}}{0.750 \frac{\text{kg}}{\text{l}}} \times \frac{40.000 \frac{\text{kJ}}{\text{kg}}}{43.543 \frac{\text{kJ}}{\text{kg}}} = 2.1435\%$$

The lubricant quantities in [TJ] that are co-combusted as part of two-stroke fuel mixtures are then calculated from the annual energy inputs in [TJ] that are assigned to two-stroke engines and the pertinent fraction r_E . The CO₂ emissions from lubricant co-combustion in two-stroke engines in road transports can thus be listed separately.

In the category of mobile machines and devices, no separate lubricant quantities in [TJ] are calculated. Instead, in a simplification the energy inputs applying to these two-stroke engines are upwardly corrected by 2.1435 %. The CO₂ emissions from lubricant co-combustion in two-stroke engines in mobile machines and devices are thus included in the total emissions of the relevant sectors.

Emission factors

To make it possible to show CO₂ emissions from combusted two-stroke fuel mixtures in the inventory, weighted implied emission factors were formed for the entire time series. These consist of a 49/50ths fraction based on the year-specific EF(CO₂) for gasoline ((or the Tier 1 EF for bioethanol) and a 1/50th fraction based on the default value 73,300 kg CO₂/TJ for lubricants

pursuant to 2006 IPCC GL (Vol. 2, Chapter 2 – *Stationary Combustion*, p. 2.20, Tab. 2.4). These IEF, which include 2 % by vol. for lubricants, are thus slightly higher than the values used for the relevant pure fuels (gasoline, bioethanol).

Table 487: Derivation of the EF(CO₂) for two-stroke fuel mixtures, in kg/TJ

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Gasoline	73,069	73,075	73,094	73,103	73,119	73,025	73,088	73,091	73,091	73,105
Bioethanol					71,607					
Lubricants ^a					73,300					
Two-stroke fuel, fossil	73,074	73,079	73,098	73,107	73,123	73,030	73,093	73,095	73,095	73,109
Two-stroke fuel, biogenic					71,641					

Source: own calculations

^a Default emission factor pursuant to 2006 IPCC GL (Volume 2, Chapter 2 – *Stationary Combustion*, p. 2.20, Tab. 2.4)

The CO₂ emissions resulting from lubricant co-combustion in two-stroke gasoline engines are thus already included in the emissions reported for the relevant sectors (1.A.3.b – Road transportation, 1.A.4.b ii – Residential, 1.A.4 c ii (ii) – Forestry) and are not listed separately in the CRF tables. Table 488 thus provides solely an overview of these CO₂ emissions:

Table 488: CO₂ from lubricants co-combusted in two-stroke gasoline engines, in kt

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1.A.3.b	176.58	24.49	6.53	6.45	6.41	6.60	6.42	6.46	6.59	6.37
1.A.4.b ii	2.28	1.76	1.17	1.10	1.40	1.65	1.55	1.41	1.48	1.39
1.A.4.c ii	4.52	4.39	4.86	4.47	2.37	2.06	0.60	0.59	0.63	0.60
Total	183.38	30.64	12.57	12.02	10.17	10.31	8.58	8.45	8.69	8.37

Source: Own calculations, based on (IEU, 2016a & b)

Carbon dioxide from lubricant co-combustion in four-stroke gasoline engines, and in other engines in vehicles and in mobile machinery and equipment, on the other hand, is reported separately under CRF 2.D.1, as emissions from product use. (cf. the following Chapter)

19.1.4.2 CO₂ emissions from lubricant co-combustion in four-stroke engines and in other engines in vehicles and mobile sources

The data on the total lubricant quantities used in connection with lubricant co-combustion in four-stroke gasoline engines and in other engines in vehicles and mobile sources are very spotty. As a result, the co-combusted quantities are calculated largely on the basis of figures provided by the *Verband Schmierstoff-Industrie e. V.* (VSI; the association of the German lubricant industry) on the relevant fuel quantities.

Pursuant to (VSI, 2014) the following co-combustion fractions, with respect to the relevant fuel quantities used, are achieved in the various usage areas:

Table 489: Overview of the specific co-combustion fractions used

Sector	Fuel	Fraction	Source / remark
1.A.2.g vii	OK	0.00 %	Assumption, based on (VSI, 2014)
	DK	0.10 %	
1.A.3.a, 1.D.1.a, 1.A.5.b ii	Ke & FB	0.01 %	Avgas: like kerosene
1.A.3.b	All	-	Calculation via TREMOD
1.A.3.c	DK	0.05 %	
1.A.3.d, 1.D.1.b, 1.A.4.c iii, 1.A.5.b iii	DK & HOS	0.15 %	Heavy fuel oil: like diesel fuel
1.A.4.a ii	DK	0.10 %	Like 1.A.3.b
	LPG	0.10 %	Like 1.A.3.b
1.A.4.b ii	OK	0.00 %	Assumption, based on (VSI, 2014)
1.A.4.c ii (i)	OK	0.00 %	Assumption, based on (VSI, 2014)
	DK	0.10 %	Like 1.A.3.b
1.A.4.c ii (ii)	DK	0.10 %	Like 1.A.3.b
1.A.5.b i	OK	0.00 %	Assumption, based on (VSI, 2014)
	DK	0.15 %	Like 1.A.3.d; takes account of heavy armored vehicles
	HOS	0.15 %	Like diesel fuel

OK: gasolines (including bioethanol), only four-stroke engines; DK: diesel fuel (including biodiesel), Ke: kerosene; FB: avgas; HOS: heavy fuel oil; LPG: LP gas

The quantities of co-combusted lubricants are calculated on the basis of the energy quantities used in some sectors in non- two-stroke engines, and the co-combustion fractions pursuant to VSI. Those lubricant quantities are then used, with the help of the unified emission factor of 73,300 kg CO₂ / TJ, to calculate the sector-specific carbon dioxide emissions from lubricant co-combustion that are shown in the following table.

Table 490: Carbon dioxide from co-combusted lubricants, in kt (cf. CRF 2.D.1)

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
1.A.2.g vii	3.57	3.58	3.39	2.77	2.95	3.14	2.85	2.94	3.10	3.27
1.A.3.a	0.24	0.24	0.28	0.25	0.26	0.26	0.24	0.22	0.22	0.22
1.A.3.b	86.21	103.61	113.54	117.27	120.43	122.62	122.65	123.64	126.02	128.62
1.A.3.c	1.41	1.14	0.93	0.68	0.57	0.58	0.53	0.53	0.48	0.46
1.A.3.d	5.31	4.17	2.99	2.86	2.53	2.60	2.61	2.62	2.78	2.68
1.A.4.a ii	0.77	0.72	0.78	0.80	0.88	0.87	0.88	0.89	0.91	0.93
1.A.4.b ii	<i>Here, only use of two-stroke engines</i>									
1.A.4.c ii	4.39	3.66	3.65	3.47	3.81	3.78	3.72	3.85	4.00	4.23
1.A.4.c iii	0.08	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05
1.A.5.b i	1.65	0.88	0.15	0.38	0.12	0.07	0.11	0.08	0.08	0.07
1.A.5.b ii	0.28	0.12	0.07	0.02	0.02	0.03	0.01	0.02	0.02	0.03
1.A.5.b iii	0.11	0.07	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.03
NATIONAL	104.04	118.26	125.90	128.59	131.66	134.04	133.68	134.87	137.71	140.58
1.D.1.a	1.20	1.48	1.91	2.27	2.40	2.28	2.48	2.53	2.43	2.43
1.D.1.b	8.93	7.61	8.21	9.91	11.39	11.22	10.31	9.21	9.09	9.77

Source: own calculations

19.1.5 CO₂ emissions from use of AdBlue® in road transports and off-road vehicles

Since 2005, increasing numbers of vehicles have been in service in Germany that are equipped with SCR catalytic converters. These catalytic converters control NO_x emissions with the help of a

liquid-reductant agent, an aqueous urea solution.²¹⁷ When the urea solution is chemically converted, carbon dioxide is released. In Germany, virtually the only the product used for this purpose is AdBlue® (VDA, 2014).

In 2013, to address a lack of current, comprehensive statistics or market studies on sales of AdBlue® or on the CO₂ emissions caused by AdBlue®, the ifeu Institute in Heidelberg conducted a relevant survey (IFEU, 2013). In the framework of that survey, the AdBlue® quantities used were modelled, and the resulting CO₂ emissions calculated, on the basis of fuel consumption data for vehicles equipped with SCR catalytic converters.

Table 491: Modelled quantities of AdBlue® used (figures in [kt])

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Automobiles	0.0	0.0	0.0	0.1	0.7	2.2	4.9	9.0	17.4	33.4	57.8
Light duty vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
Heavy duty vehicles: trucks	4.7	24.1	75.5	147.9	183.6	230.5	271.8	310.4	347.8	390.0	436.8
Heavy duty vehicles: buses	0.1	0.5	2.1	4.6	7.2	8.6	9.6	14.6	16.0	18.8	21.7
Other motor vehicles	0.0	0.1	0.6	1.5	2.5	3.3	3.5	4.9	6.0	6.9	7.9
1.A.3.b	4.8	24.7	78.2	154.0	194.0	244.5	289.8	339.0	387.2	449.1	525.2
Construction vehicles, etc.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	8.9
Total	4.8	24.7	78.2	154.0	194.0	244.5	289.8	339.0	387.2	451.2	534.0

Source: (IFEU, 2013)

The resulting CO₂ emissions are calculated with the following formula pursuant to 2006 IPCC GL (Vol. 2, Chapter 3.2 – Road Transportation, p. 3.12, formula 3.2.2):

$$EM_{CO_2} = AR_{AdBlue®} \times \frac{12}{60} \times \frac{32,5}{100} \times \frac{44}{12}$$

The following table presents the so-determined CO₂ emissions, for the period 2005 through 2013, from use of AdBlue® in vehicles equipped with SCR catalytic converters.

Table 492: CO₂ emissions resulting from use of AdBlue®, in kt

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Automobiles	0.0	0.0	0.0	0.0	0.2	0.5	1.2	2.2	4.1	8.0	13.8
Light duty vehicles	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Heavy duty vehicles: trucks	1.1	5.7	18.0	35.2	43.8	54.9	64.8	74.0	82.9	93.0	104.1
Heavy duty vehicles: buses	0.0	0.1	0.5	1.1	1.7	2.0	2.3	3.5	3.8	4.5	5.2
Other motor vehicles	0.0	0.0	0.1	0.4	0.6	0.8	0.8	1.2	1.4	1.6	1.9
1.A.3.b	1.1	5.9	18.6	36.7	46.2	58.3	69.1	80.8	92.3	107.0	125.2
Construction vehicles, etc.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.1
Total	1.1	5.9	18.6	36.7	46.2	58.3	69.1	80.8	92.3	107.5	127.3

Source: (IFEU, 2013)

In the German GHG inventory, these emissions are reported, pursuant to footnote (6) to CRF Table 2(I).A-Hs2, under 2.D.3 – *Non-energy products from fuels – Other*.

²¹⁷ Mean urea concentration pursuant to DIN 70070: 32.5 %

19.2 Other detailed methodological descriptions for the category "industrial processes" (2)

19.2.1

19.3 Other detailed methodological descriptions for the category "Agriculture" (3)

19.3.1 Calculation of the emissions for additional animal categories

Under "Other Livestock", the CRF tables pursuant to IPCC (2006a) list the following additional animal categories that the former CRF tables did not include:

- Deer,
- Rabbits,
- Reindeer,
- Ostriches,
- Fur-bearing animals.

No reindeer are kept in Germany. In the following chapters, the greenhouse-gas emissions from the other four categories are calculated, by way of example, and using Tier 1 methods, for one year. Table 493 summarises the results of these calculations. These data serve as the basis for concluding that the relevant emissions are insignificant and thus do not have to be reported in the NIR.

Table 493: Total GHG emissions of deer, rabbits, ostriches and fur-bearing animals

	CH ₄ [kt a ⁻¹]	N ₂ O [kt a ⁻¹]	CO _{2eq} [kt a ⁻¹]
Total	5.635	0.1119	174.20
Deer	5.348	0.0829	158.42
Rabbits	0.194	0.0143	9.09
Ostriches	0.043	0.0024	1.81
Fur-bearing animals (mink)	0.050	0.0122	4.88

19.3.1.1 Animal-place figures

In Germany, no official counts are taken of populations of deer, rabbits, ostriches and fur-bearing animals. Table 494 presents estimates of the Federal Statistical Office concerning the average animal populations (Federal Statistical Office, Section G 105, C. Schreiner, personal communication, 2012). These figures are interpreted as continuously occupied animal places (AAP) (cf. Chapter 5.1.3.2). The FAO also provides figures for rabbits, but those figures are far lower than the figures estimated by the Federal Statistical Office. For this reason, the approach used here may be considered a conservative one.

Table 494: Average annual animal populations, pursuant to estimates of the Federal Statistical Office

	Population	Source
Deer	264,500	Landesverbände für landwirtschaftliche Wildtierhaltung (state associations for agricultural husbandry of wild animals); survey conducted in the period 2008/2009
Rabbits	440,000	Bundesverband deutscher Kaninchenfleisch- und -wollerzeuger e.V. (national association of German producers of rabbit meat and rabbit fur)
Ostriches	7,632	Tierseuchenkasse (animal diseases fund; 2012)
Fur-bearing animals (mink)	63,500	Länderabfrage zur Haltung von Pelztieren (State survey on husbandry of fur-bearing animals; last revision March 2012)

19.3.1.2 CH₄ emissions from enteric fermentation

No CH₄ emissions from enteric fermentation are calculated for ostriches, since IPCC (2006a) does not specify any methods for such calculation. The emissions for the categories deer, rabbits and fur-bearing animals are calculated by multiplying the relevant numbers of animals by the pertinent emission factors.

For deer, the CH₄ default emission factor in IPCC (2006a)-10.28, Table 10.10, is used (20 kg pl⁻¹ a⁻¹).

IPCC (2006a) does not provide an emission factor for rabbits. Pursuant to footnote 1 for Table 10.10 on p. 10.28 in IPCC (2006a), the emission factor can be approximated by selecting an emission factor for an animal with a similar digestive system and then scaling that emissions factor using the ratio of the weights of the animals raised to the 0.75 power. For such estimation, the horse was chosen as the comparison animal, since it is neither a ruminant (cattle, sheep, goats) nor an omnivore (swine). According to IPCC (2006a)-10.28, Table 10.10, a horse weight of 550 kg per animal should be used for the calculation. The specified weight for rabbits is 3.0 kg (final live weight of a fattening rabbit, pursuant to LfL Bayern (Bavarian state office for agriculture)²¹⁸). From the CH₄ emission factor for horses (18 kg pl⁻¹ a⁻¹, IPCC (2006a)-10.28, Table 10.10), one then obtains a CH₄ emission factor of 0.36 kg pl⁻¹ a⁻¹ for rabbits.

For fur-bearing animals, we have adopted the CH₄ emission factor used by other countries (Estonia, Finland, Iceland, Norway; the 2014 NIR in each case), 0.1 kg pl⁻¹ a⁻¹.

Table 495 shows, by way of example, the annual emissions from enteric fermentation calculated for deer, rabbits and fur-bearing animals.

Table 495: CH₄ emissions from enteric fermentation for deer, rabbits and fur-bearing animals

	EF [kg pl ⁻¹ a ⁻¹]	CH ₄ [kt a ⁻¹]	CO _{2eq} [kt a ⁻¹]
Total		5.45	136.37
Deer	20.00	5.29	132.25
Rabbits	0.36	0.16	3.96
Fur-bearing animals (mink)	0.10	0.0064	0.16

19.3.1.3 CH₄ emissions from manure management

The default emission factors specified in IPCC (2006a)-10.83, Table 10A-9, have been used. The resulting emissions are shown in Table 496.

²¹⁸ <http://www.lfl.bayern.de/itt/tierhaltung/37339/>

Table 496: CH₄ emissions from manure management for deer, rabbits, ostriches and fur-bearing animals

	EF [kg pl ⁻¹ a ⁻¹]	CH ₄ [kt a ⁻¹]	CO _{2eq} [kt a ⁻¹]
Total		0.180	4.50
Deer	0.22	0.058	1.45
Rabbits	0.08	0.035	0.88
Ostriches	5.67	0.043	1.08
Fur-bearing animals (mink)	0.68	0.043	1.08

19.3.1.4 N₂O emissions from manure management

To calculate N₂O emissions from manure management, one must know the relevant N excretions. It is also useful to know how the relevant animal population is divided among the applicable housing systems. The latter factor is not known for deer, rabbits, ostriches and fur-bearing animals in Germany. As a simplification, therefore, year-round free-range management is assumed for deer, while year-round housing in solid-manure-based stable systems is assumed for rabbits, fur-bearing animals and ostriches. With regard to the N excretions, cf. Chapter 19.3.1.4.1. The resulting N₂O emissions are listed in Chapter 19.3.1.4.2.

19.3.1.4.1 N excretions

Neither IPCC (2006a) nor EMEP (2013) specifies a default value for the N excretions of deer. The following table shows the N-excretion values used by those countries that report on deer emissions (2012 NIR). The German calculations have been carried out with the value used by Denmark (16 kg pl⁻¹ a⁻¹), since it can be assumed that the average N excretions of deer in Denmark do not differ significantly from those of deer in Germany. The resulting value is only slightly higher than the mean value of all data in Table 497 (15.1 kg pl⁻¹ a⁻¹).

Table 497: Deer: N excretions N_{excr} reported by other countries in the 2012 NIR

Deer	N_{excr} [kg pl ⁻¹ a ⁻¹]	Remarks
Denmark	16	
UK	13	
Austria	13.1	The value for sheep has been used
Norway	12	
Russia	8.48	
New Zealand	28.23	

For rabbits, IPCC (2006a), in Table 10.19 on p. 10.59, specifies a default N-excretion value of 8.1 kg pl⁻¹ a⁻¹ N. That value seems unrealistic, since it is of the same order of magnitude as the total weight gain per animal place and year. Assuming about four rounds of fattening per year (n_{round} , derived from a 87-day duration of fattening pursuant to LfL Bayern²¹⁹ (Bavarian state office for agriculture) and a final live weight of about 3 kg animal⁻¹ (cf. also LfL Bayern), the latter works out to about 12 kg pl⁻¹ a⁻¹. For this reason, the N excretions of rabbits are estimated on the basis of the relevant N balance for the animals; cf. Equation 58:

Equation 58: Calculation of the N excretions of rabbits (N balance)

$$N_{\text{excr, rabbit}} = n_{\text{round}} \cdot \Delta w_{\text{round}} \cdot (x_{\text{N}} \cdot x_{\text{XP, feed}} \cdot x_{\text{feed}} - x_{\text{N, ret}})$$

including

$N_{\text{excr, rabbit}}$	N excretions (in kg place ⁻¹ a ⁻¹)
n_{round}	Number of fattening rounds per year (in rounds a ⁻¹)
Δw_{round}	Weight gain per fattening round (in kg round ⁻¹ place ⁻¹)

²¹⁹ <http://www.lfl.bayern.de/itt/tierhaltung/37339/>

x_N	N content of raw protein (1 / 6.25 kg kg ⁻¹)
$x_{XP, feed}$	Raw protein content of feed (fresh matter) (in kg kg ⁻¹)
x_{feed}	Feed input (fresh matter) per kg of weight gain (in kg kg ⁻¹)
$x_{N, ret}$	Specific N retention (kg kg ⁻¹)

In a conservative approach, and as a simplifying approximation, Δw_{round} is considered to be equal to the end weight after fattening (see above). The raw protein content of the feed, $x_{XP, feed}$, pursuant to ²²⁰, is about 0.17 kg kg⁻¹. The feed input x_{feed} is about 3.5 kg kg⁻¹ (LfL Bayern). Pursuant to DLG (2005), p.12, $x_{N, ret} = 0.03$ kg kg⁻¹. Equation 58 then yields an N-excretion value of 0.8 kg pl⁻¹ a⁻¹.

For ostriches, neither IPCC (2006a) nor EMEP (2013) specify default values for N excretions. The values listed in Table 11 have been taken from the CRF tables (2012 NIR) of those countries that report on ostriches.

Table 498: Ostriches: N excretions N_{excr} reported by other countries in the 2012 NIR

Ostriches	N_{excr} [kg pl ⁻¹ a ⁻¹]	Remarks
Denmark	15.6	
Norway	12	
Luxembourg	12	
Australia	7	N excretions of ostriches and emus

As with deer, the German calculations have been carried out using the Danish value (15.6 kg pl⁻¹ a⁻¹ N).

For mink, IPCC (2006a)-10.59, in Table 10.19, specifies a default N-excretion value of 4.59 kg pl⁻¹ a⁻¹ N.

19.3.1.4.2 Direct N₂O emissions from manure management

The direct N₂O emissions from manure management for rabbits and fur-bearing animals have been calculated by multiplying the number of animal places by the annual N excretions per place, the national German N₂O-N emission factor for solid manure (0.013 kg kg⁻¹, VANDRÉ et al., 2013) and the molar ratio of N₂O to N (44/28). The emissions for ostriches have been calculated in a similar manner, with the exception that the relevant IPCC default value of 0.001 kg kg⁻¹ (IPCC (2006a)-10.63, Table 10.21) has been used as the emission factor. No N₂O emissions occur in the area of manure management for deer, since free-range management may be considered equivalent to "grazing" in this regard. The resulting emissions are reported together with the direct N₂O emissions from soils; cf. Chapter 19.3.1.6.

Table 499: Direct N₂O emissions from manure management for deer, rabbits, ostriches and fur-bearing animals

	N_{excr} [kg pl ⁻¹ a ⁻¹]	N ₂ O [kt a ⁻¹]	CO _{2eq} [kt a ⁻¹]
Total		0.013	3.97
Deer	16	0.000	0.00
Rabbits	0.8	0.007	2.14
Ostriches	15.6	0.0002	0.06
Fur-bearing animals (mink)	4.59	0.006	1.77

19.3.1.5 Indirect N₂O emissions from manure management

Indirect N₂O emissions from leaching / surface runoff are not calculated, as is the case for other animals (cf. Chapter 5.3.1). The following section describes the calculation of indirect N₂O

²²⁰ http://www.meissner-widder-kaninchen.de/F_WERT_TAB1.html

emissions from deposition of reactive nitrogen from NH_3 and NO emissions from housing and storage. Due to a lack of relevant data, nitrogen inputs from bedding material cannot be taken into account.

First, the NH_3 and NO emissions from housing and storage are determined. The procedure for calculating the NO emissions is similar to that for calculating direct N_2O emissions from housing and storage (cf. Chapter 19.3.1.4.2). As was the case for the other animals (cf. Chapter 5.3.4.2.2), the emission factor is set to ten percent of the N_2O emission factor: $0.0013 \text{ kg kg}^{-1}$ for rabbits and fur-bearing animals, and $0.0001 \text{ kg kg}^{-1}$ for ostriches.

The NH_3 emissions from housing are calculated by multiplying the excreted quantity of TAN (total ammoniacal nitrogen) by the relevant emission factor. The TAN quantity is obtained as the product of N excretions and the excretions' relative TAN content. The NH_3 emissions from storage are proportional to the TAN quantity that remains following deduction of N losses due to NH_3 emissions from the stable. The pertinent proportionality factor is the emission factor for storage. No data on TAN content and emission factors are available for rabbits and ostriches. For this reason, the relevant default values for horses and geese in EMEP (2013)-3B-27 have been used. The data ultimately used are listed in Table 500, with the emission factors given in $\text{kg NH}_3\text{-N}$ per kg of TAN. For deer, the calculation is not required, since deer are assumed to remain outdoors year-round.

Table 500: Input data for calculation of NH_3 emissions (emission factors [EF] in $\text{kg NH}_3\text{-N}$ per kg TAN)

	TAN content [%]	EF stable [kg kg^{-1}]	EF storage [kg kg^{-1}]	Remarks
Rabbits	60	0.22	0.35	Default for horses; EMEP (2013)-3B-27
Ostriches	70	0.57	0.16	Default for geese; EMEP (2013)-3B-27
Fur-bearing animals (mink)	60	0.27	0.09	Default; EMEP (2013)-3B-27

The resulting deposition of reactive nitrogen (N_{reac}), and the then-resulting indirect N_2O emissions, are given in Table 501. Pursuant to IPCC (2006a)-11.24, Table 11.3, emission factor $\text{EF}_4 = 0.01 \text{ kg N}_2\text{O-N}$ per $\text{kg N}_{\text{reac}}$ has been used.

Table 501: Indirect N_2O emissions from deposition of reactive nitrogen from NH_3 and NO emissions from housing and storage

	N_{reac} [kt a^{-1}]	N_2O [kt a^{-1}]	$\text{CO}_{2\text{eq}}$ [kt a^{-1}]
Total	0.2169	0.00341	1.02
Rabbits	0.1046	0.00164	0.49
Ostriches	0.0533	0.00084	0.25
Fur-bearing animals (mink)	0.0591	0.00093	0.28

19.3.1.6 Direct N_2O emissions from agricultural soils

Application of manure of rabbits, ostriches and fur-bearing animals, and free-range husbandry of deer, leads to direct N_2O emissions from agricultural soils.

The emissions from manure application are calculated by multiplying the N quantity that remains, following N losses (as NH_3 , N_2O , NO and N_2) from housing and storage, by the IPCC default emission factor EF_1 ($0.01 \text{ kg N}_2\text{O-N}$ per kg N , IPCC (2006a)-11.11, Table 11.1) and the molar ratio 44/28.

The N_2O emissions caused by deer are obtained by multiplying the number of animals by the TAN excretions, the $\text{N}_2\text{O-N}$ emission factor for grazing and the molar ratio 44/28. The applicable TAN quantity is obtained as the product of N excretions and the excretions' relative TAN content. Since

the latter factor is unknown, the relevant value for sheep pursuant to EMEP (2013)-3B-27 (50 %) is used. The emission factor used is the $EF_{3PRP,SO}$ given in IPCC (2006a)-11.11, Table 11.1 for sheep and other animals (0.01 kg N_2O -N per kg N excretions).

Table 502 shows the pertinent emissions, along with the N quantities used to obtain them, via multiplication by the relevant emission factors and the molar ratio 44/28.

Table 502: Direct N_2O emissions from soils as a result of free-range husbandry of deer and of application of manure of rabbits, ostriches and fur-bearing animals.

	N [kt a ⁻¹]	N ₂ O [kt a ⁻¹]	CO _{2eq} [kt a ⁻¹]
Total	4.744	0.0745	22.21
Deer	4.232	0.0665	19.82
Rabbits	0.229	0.0036	1.07
Ostriches	0.065	0.0010	0.31
Fur-bearing animals (mink)	0.217	0.0034	1.02

19.3.1.7 Indirect N_2O emissions from agricultural soils

To calculate the indirect emissions from deposition of reactive nitrogen, one must know the NH_3 -N emissions from free-range husbandry of deer and from manure application, along with the relevant NO -N emissions. Table 504 shows the parameters that are used, with the pertinent emission factors given in kg NH_3 -N per kg TAN.

Table 503: Parameters for calculation of indirect N_2O emissions from deposition of reactive nitrogen as a result of free-range husbandry and of application (emission factors [EF] in kg N_2O -N per kg of reactive nitrogen)

	EF _{NH₃-N} Free-range	EF _{NH₃-N} application	Remarks
Deer	0.09		Default for sheep; EMEP (2013)-3B-27
Rabbits		0.90	Default for horses; EMEP (2013)-3B-27
Ostriches		0.45	Default for geese; EMEP (2013)-3B-27
Fur-bearing animals (mink)		0.90	Default; EMEP (2013)-3B-27

The NO -N emissions from free-range husbandry of deer are calculated with the default emission factor, 0.007 kg kg⁻¹ N (EMEP (2007)-B1020-12). The NO -N emissions from application, like the N_2O -N emissions from application, are calculated with the emission factor 0.012 kg NO -N per kg N (EMEP (2013)-3D-11; that sources gives the EF as 0.026 kg NO per kg N).

Table 504: Indirect N_2O emissions from deposition of reactive nitrogen (N_{reac}) from NH_3 and NO emissions from free-range husbandry of deer and from manure application

	N _{reac} [kt a ⁻¹]	N ₂ O [kt a ⁻¹]	CO _{2eq} [kt a ⁻¹]
Total	0.424	0.0067	1.99
Deer	0.220	0.0035	1.03
Rabbits	0.090	0.0014	0.42
Ostriches	0.014	0.0002	0.07
Fur-bearing animals (mink)	0.100	0.0016	0.47

The indirect emissions from leaching / surface runoff are calculated by multiplying the N quantity available in the soil (N_{soil}) by $FRAC_{\text{Leach}}$ (0.3 kg kg⁻¹ pursuant to IPCC (2006a)-11.24, Table 11.3) and the emission factor $EF_5 = 0.0075$ (IPCC (2006a)-11.24, Table 11.3). The N quantity available in the soil is calculated via the same procedure used for the other animals; cf. Chapter 5.1.5.1.4.

Table 505: Indirect N₂O emissions from the soil as a result of leaching / surface runoff

	N _{soil} [kt a ⁻¹]	N ₂ O [kt a ⁻¹]	CO _{2eq} [kt a ⁻¹]
Total	3.395	0.0139	4.15
Deer	3.673	0.0130	3.87
Rabbits	0.118	0.0004	0.12
Ostriches	0.045	0.0002	0.05
Fur-bearing animals (mink)	0.098	0.0003	0.10

19.3.2 Distributions of housing, storage and application procedures, and of grazing data (CRF 3.B, 3.D)

Table 506 through Table 509 show the applicable distributions, aggregated at the national level (and rounded to whole-number percentages), of housing, storage and application procedures. They also include data on grazing. Buffalo, and mules and asses, are not listed separately in the following tables, because buffalo data are reported together with cattle data, and data for mules and asses are reported together with data for horses (cf. Chapter 5.1.3.2.2).

The relevant emissions were calculated not with the data shown in Table 506 through Table 509, but with the data underlying those data. Those underlying data have state-level (German Länder) resolution. The tables also include information relative to emission factors (including that for NH₃). For further details, cf. RÖSEMANN et al. (2017).

Table 506: Frequency distributions of animal housing procedures (in %), and pertinent litter quantities and NH₃ emission factors

livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	bedding material (straw) kg place d ⁻¹	NH ₃ -N EF for housing, kg NH ₃ -N per kg TAN in excreta
dairy cows	tied systems, straw based	31	31	31	31	15	15	15	15	13	13	13	12	12	12	11	11	10	10	10	9	9	9	9	9	9	9	5.0	0.066
	tied systems, slurry based	37	37	37	37	36	36	36	36	34	34	33	31	30	28	27	25	24	23	21	20	18	18	18	18	18	18		0.066
	loose housing, straw based	2	2	2	2	3	3	3	3	3	3	4	4	5	5	6	6	7	7	8	8	9	9	9	9	9	9	5.0	0.197
	loose housing, slurry based	29	29	29	29	46	46	46	46	49	49	50	52	53	55	56	57	59	60	61	63	64	64	64	64	64	64		0.197
	loose housing, deep bedding	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.0	0.197
	time spent on pastures (in % of year)	18	18	18	18	14	14	14	14	13	13	13	13	12	12	12	11	11	11	11	11	10	11	11	11	11	11		
male beef cattle	tied systems, straw based	4	4	4	4	2	2	2	2	2	2	2	3	3	4	4	5	5	6	6	6	7	7	7	7	7	7	2.0	0.066
	tied systems, slurry based	7	7	7	7	4	4	4	4	4	4	4	5	5	6	7	7	8	8	9	10	10	10	10	10	10	10		0.066
	loose housing, slurry based	83	83	83	83	89	89	89	89	91	91	87	84	81	78	74	71	68	65	61	58	55	55	55	55	55	55		0.197
	loose housing, sloped floor	5	5	5	5	4	4	4	4	3	3	6	8	10	12	15	17	19	21	24	26	28	28	28	28	28	28	2.5	0.213
	time spent on pastures (in % of year)	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	4	4	3	3	3	3	3		

livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	bedding material (straw) kg place d ⁻¹	NH ₃ -N EF for housing, kg NH ₃ -N per kg TAN in excreta
heifers	tied systems, straw based	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	10	10	10	10	10	10	10	10	10	10	2.0	0.066
	tied systems, slurry based	15	15	15	15	17	17	17	17	17	17	16	16	15	14	14	13	12	12	11	10	10	10	10	10	10	10		0.066
	loose housing, slurry based	48	48	48	48	49	49	49	49	49	49	49	49	48	48	47	47	47	46	46	45	45	45	45	45	45	45		0.197
	loose housing, straw based	29	29	29	29	25	25	25	25	25	25	26	27	28	29	30	31	32	32	33	34	35	35	35	35	35	35	3.0	0.197
	time spent on pastures (in % of year)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	21	21	21		
calves	tied systems, straw based	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0.066
	loose housing, deep bedding	50	50	50	50	50	50	50	50	50	50	50	50	50	100	100	100	100	100	100	100	100	100	100	100	100	100	2.5	0.197
	time spent on pastures (in % of year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
suckler cows	tied systems, straw based	6	6	6	6	6	6	6	6	6	6	7	8	9	10	11	12	13	14	15	16	17	17	17	17	17	17	5.0	0.066
	tied systems, slurry based	3	3	3	3	3	3	3	3	2	2	2	3	3	3	3	4	4	4	5	5	5	5	5	5	5	5		0.066
	loose housing, slurry based	9	9	9	9	8	8	8	8	6	6	7	8	9	9	10	11	12	12	13	14	14	14	14	14	14	14		0.197
	loose housing, deep bedding	82	82	82	82	83	83	83	83	86	86	84	82	80	78	76	74	71	69	67	65	63	63	63	63	63	63	8.0	0.197
	time spent on pastures (in % of year)	41	40	42	42	42	42	43	43	44	44	44	44	45	44	45	45	45	46	46	47	47	47	47	47	47	47		

Table 1. Estimated annual NH ₃ -N excretion from livestock housed in different housing systems in the Netherlands, 1990-2015																													bedding material	NH ₃ -N EF for housing,
livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	(straw) kg place d ⁻¹	kg NH ₃ -N per kg TAN in excreta	
mature males > 2 years	tied systems, straw based	16	16	16	16	15	15	15	15	14	14	14	14	15	15	15	15	15	15	15	15	15	15	15	15	15	15	5.0	0.066	
	tied systems, slurry based	10	10	10	10	9	9	9	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		0.066	
	loose housing, slurry based	38	38	38	38	35	35	35	35	36	36	36	36	35	35	35	34	34	34	34	34	33	33	33	33	33	33		0.197	
	loose housing, straw based	37	37	37	37	41	41	41	41	41	41	41	42	42	42	43	43	43	44	44	44	44	44	44	44	44	44	5.0	0.197	
	time spent on pastures (in % of year)	35	33	33	34	33	33	33	32	33	33	32	32	32	32	32	33	33	33	34	34	34	34	34	34	34	34	34		
fattening pigs	fully slatted floor, slurry	49	49	49	49	57	57	57	57	62	62	63	64	64	65	66	67	68	69	70	71	72	72	72	72	72	72		0.3	
	partly slatted floor, slurry	40	40	40	40	34	34	34	34	31	31	31	30	29	28	27	26	26	25	24	23	22	22	22	22	22	22		0.3	
	plane floor with bedding	8	8	8	8	6	6	6	6	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	0.3	0.4	
	deep bedding	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1.0	0.4	
	time spent on pastures (in % of year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
weaners	fully slatted floor, slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.3	
	partly slatted floor, slurry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.3	
	plane floor with bedding	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	0.4	
	deep bedding	45	45	45	45	57	57	57	57	62	62	63	64	64	65	66	67	68	68	69	70	71	71	71	71	71	71	71	0.2	0.4
	time spent on pastures (in % of year)	41	41	41	41	33	33	33	33	28	28	28	27	27	26	26	25	25	24	24	23	23	23	23	23	23	23	23		
sows	straw based	10	10	10	10	7	7	7	7	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	0.5	0.34	
	Slurry based	4	4	4	4	3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2		0.34	
	time spent on pastures (in % of year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

EUROPEAN COMMISSION																												bedding material	NH ₃ -N EF for housing, kg NH ₃ -N per kg TAN in excreta	
livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	(straw) kg place d ⁻¹		
boars	straw based	32	32	32	32	23	23	23	23	21	21	21	20	20	19	19	18	18	17	16	16	15	15	15	15	15	15	0.5	0.34	
	slurry based	68	68	68	68	77	77	77	77	79	79	79	80	80	81	81	82	82	83	84	84	85	85	85	85	85	85		0.34	
	time spent on pastures (in % of year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
laying hens	cages; ≥2010: small group housing systems	95	95	95	95	95	94	92	90	89	88	87	85	84	81	77	73	70	68	62	38	18	14	13	11	11	11		*)	
	floor management, aviary	4	4	4	4	4	5	5	7	7	7	7	7	7	9	12	14	15	17	22	45	63	64	64	64	64	64	0.5	*)	
	free range, organic farming	1	1	1	1	1	2	2	4	4	5	7	8	9	10	11	13	14	15	16	18	19	22	23	24	26	26	0.5	*)	
broilers	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	1.4	0.09
pullets	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.75	0.09
ducks	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	22	0.16
geese	floor management and free range	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		0.57. per kg TAN (UAN) in excreta	

livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	bedding material (straw) kg place d ⁻¹	NH ₃ -N EF for housing, kg NH ₃ -N per kg TAN in excreta
turkeys, female	floor manageme nt	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	10.3	0.22
turkeys, male	floor manageme nt	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	10.3	0.22
horses	straw based system time spent on pastures (in % of year)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	8.0 / 5.0	0.22
		21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21		
sheep without lambs	straw based system time spent on pastures (in % of year)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	101	0.4	0.22
		55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55		
lambs	straw based system time spent on pastures (in % of year)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	101	0.16	0.22
		57	57	58	58	57	57	58	57	57	57	57	57	57	57	57	57	57	57	57	57	55	55	55	55	55	55		
goats	straw based system time spent on pastures (in % of year)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	101	0.4	0.22
		34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34		

^{*)} cf. Table 509: Laying hens, housing-specific partial NH₃ emission factors

Table 507: Frequency distributions of storage systems (in %); quantities of digested energy crops; and pertinent emission factors

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	NH ₃ -N EF for storage, kg NH ₃ -N per kg TAN in storage system (leachate / urine)	NH ₃ -N EF for storage, kg NH ₃ -N per kg TAN in storage system (leachate / urine)	N ₂ O EF for storage, kg N ₂ O-N per kg N in storage system (leachate / urine)	N ₂ O EF for storage, kg N ₂ O-N per kg N in storage system (leachate / urine)	CH ₄ MCF for storage, % of Bo < 10 °C	maximum CH ₄ producing capacity (Bo) m ³ CH ₄ per kg VS
cattle, untreated slurry	open tank (% of total untreated slurry)	1	1	1	1	1	1	1	1	1	1	1	2	2	2	3	3	4	4	5	5	6	6	6	6	6	6	0.150		0.000		17.0	0.23
	solid cover (% of total untreated slurry)	22	22	22	22	22	22	22	22	22	22	23	23	24	25	25	26	27	27	28	29	29	29	29	29	29	29	0.015		0.005		17.0	0.23
	natural crust (% of total untreated slurry)	36	36	36	36	40	40	40	40	40	40	39	38	36	35	34	33	31	30	29	28	27	27	27	27	27	27	0.045		0.005		10.0	0.23
	plastic film (% of total untreated slurry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.023		0.000		17.0	0.23
	artificial crust (chaff) (% of total untreated slurry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.030		0.000		17.0	0.23
	storage below animal confinements > 1 month (% of total untreated slurry)	41	41	41	41	36	36	36	36	36	36	36	37	37	37	37	37	38	38	38	38	38	38	38	38	38	38	0.045		0.002		17.0	0.23

																												NH ₃ -N EF for storage,	NH ₃ -N EF for storage,	N ₂ O EF for storage	N ₂ O EF for storage	CH ₄ MCF for storage	maximu m CH ₄ producin g capacity (Bo)
livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	kg NH ₃ -N per kg TAN in storage system	kg NH ₃ -N per kg TAN in storage system (leachate / urine)	kg N ₂ O-N per kg N in storage system	kg N ₂ O-N per kg N in storage system (leachate / urine)	% of Bo	m ³ CH ₄ per kg VS
cattle, digestion of slurry	% of total cattle slurry	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	4	6	9	11	14	17	21	23	26	27	27						
cattle, digestion of solid manure	% of total solid manure of cattle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	2	3	4	4	4	5	5						
cattle, storage of digestate s	gas tight storage (% of slurry)	0	1	2	3	4	5	5	6	7	8	9	10	11	12	14	15	20	25	30	35	41	46	57	60	62	62	0.000 *)		0.000 *)		2.7 *)	0.23
cattle, storage of digestate s	open tank (% of slurry)	100	99	98	97	96	95	95	94	93	92	91	90	89	88	86	85	80	75	70	65	59	54	43	40	38	38	0.045 *)		0.005 *)		3.1 *)	0.23
cattle, storage of digestate s	gas tight storage (% of solid manure)	0	1	2	3	4	5	5	6	7	8	9	10	11	12	14	15	20	25	30	35	41	46	57	60	62	62	0.000 *)		0.000 *)		1.2 *)	0.23
cattle, storage of digestate s	open tank (% of solid manure)	100	99	98	97	96	95	95	94	93	92	91	90	89	88	86	85	80	75	70	65	59	54	43	40	38	38	0.045 *)		0.005 *)		1.6 *)	0.23
dairy cows, solid manure	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600	0.013	0.013	0.005	2.0	0.23
male beef cattle, solid manure	heap (% of total solid manure)	42	42	42	42	39	39	39	39	38	38	30	27	25	23	22	22	21	21	20	20	20	20	20	20	20	20	0.600	0.013	0.013	0.005	2.0	0.23
	sloped floor (% of total solid manure)	58	58	58	58	61	61	61	61	62	62	70	73	75	77	78	78	79	79	80	80	80	80	80	80	80	80	0.600		0.010	0.005	17.0	0.23
heifers, solid manure	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600	0.013	0.013	0.005	2.0	0.23

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	NH ₃ -N EF for storage,	NH ₃ -N EF for storage,	N ₂ O EF for storage	N ₂ O EF for storage	CH ₄ MCF for storage	maximum CH ₄ producing capacity (Bo)
																												kg NH ₃ -N per kg TAN in storage system	kg NH ₃ -N per kg TAN in storage system (leachate / urine)	kg N ₂ O-N per kg N in storage system	kg N ₂ O-N per kg N in storage system (leachate / urine)	% of Bo	m ³ CH ₄ per kg VS
calves, solid manure	heap (% of total solid manure)	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0.600	0.013	0.013	0.005	2.0	0.23
	deep bedding (% of total solid manure)	50	50	50	50	50	50	50	50	50	50	50	50	50	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600		0.010		17.0	0.23
suckler cows, solid manure	heap (% of total solid manure)	7	7	7	7	7	7	7	7	6	6	7	9	10	11	13	14	15	17	18	20	21	21	21	21	21	21	0.600	0.013	0.013	0.005	2.0	0.23
	deep bedding (% of total solid manure)	93	93	93	93	93	93	93	93	94	94	93	91	90	89	87	86	85	83	82	80	79	79	79	79	79	79	0.600		0.010		17.0	0.23
mature males, solid	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600	0.013	0.013	0.005	2.0	0.23

																											NH ₃ -N EF for storage,	NH ₃ -N EF for storage,	N ₂ O EF for storage	N ₂ O EF for storage	CH ₄ MCF for storage	maximu m CH ₄ producin g capacity (Bo)	
livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	kg NH ₃ -N per kg TAN in storage system	kg NH ₃ -N per kg TAN in storage system (leachate / urine)	kg N ₂ O-N per kg N in storage system	kg N ₂ O-N per kg N in storage system (leachate / urine)	% of Bo	m ³ CH ₄ per kg VS
pigs, untreated slurry	open tank (% of total untreated slurry)	47	47	47	47	27	27	27	27	27	27	25	23	22	20	19	17	15	14	12	10	9	9	9	9	9	9	0.150		0.000		25.0	0.30
	solid cover (% of total untreated slurry)	18	18	18	18	22	22	22	22	22	22	23	23	23	24	24	25	25	25	26	26	26	26	26	26	26	26	0.015		0.005		25.0	0.30
	natural crust (% of total untreated slurry)	3	3	3	3	13	13	13	13	13	13	14	16	17	19	20	22	23	25	26	28	29	29	29	29	29	29	0.105		0.005		15.0	0.30
	plastic film (% of total untreated slurry)	0	0	0	0	6	6	6	6	6	6	6	5	4	4	3	3	2	2	1	1	0	0	0	0	0	0	0.023		0.000		25.0	0.30
	artificial crust (chaff) (% of total untreated slurry)	0	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	3	3	3	4	4	4	4	4	4	4	0.030		0.000		25.0	0.30
	storage below animal confinem ents > 1 month (% of total untreated slurry)	32	32	32	32	31	31	31	31	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	0.105		0.002		25.0
pigs, digested slurry	% of total pig slurry	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	3	4	5	6	8	10	12	13	15	15	16						
pigs, storage of digestate	gas tight storage (% of digestate s)	0	1	2	3	4	5	5	6	7	8	9	10	11	12	14	15	20	25	30	35	41	46	57	60	62	62	0.000 ^{*)}		0.000 ^{*)}		3.5 ^{*)}	0.30
pigs, storage of	open tank (% of of	100	99	98	97	96	95	95	94	93	92	91	90	89	88	86	85	80	75	70	65	59	54	43	40	38	38	0.045 ^{*)}		0.005 ^{*)}		3.9 ^{*)}	0.30

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	NH ₃ -N EF for storage, kg NH ₃ -N per kg TAN in storage system	NH ₃ -N EF for storage, kg NH ₃ -N per kg TAN in storage system (leachate / urine)	N ₂ O EF for storage, kg N ₂ O-N in storage system	N ₂ O EF for storage, kg N ₂ O-N in storage system (leachate / urine)	CH ₄ MCF for storage, % of Bo < 10 °C	maximum CH ₄ producing capacity (Bo) m ³ CH ₄ per kg VS
fattening pigs / weaners, solid manure	heap (% of total solid manure)	75	75	75	75	70	70	70	70	69	69	69	70	70	71	71	71	72	72	73	73	74	74	74	74	74	74	0.600	0.030	0.013	0.005	3.0	0.30
	deep bedding (% of total solid manure)	25	25	25	25	30	30	30	30	31	31	31	30	30	29	29	29	28	28	27	27	26	26	26	26	26	26	0.600		0.010		25.0	0.30
sows / boars, solid manure	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600	0.030	0.013	0.005	3.0	0.30
laying hens	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.140		0.001		1.5	0.39
broilers	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.170		0.001		1.5	0.36
pullets	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.170		0.001		1.5	0.39
ducks	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.240		0.001		1.5	0.36
geese	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.160		0.001		1.5	0.36
turkeys, female	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.240		0.001		1.5	0.36
turkeys, male	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.240		0.001		1.5	0.36

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	NH ₃ -N EF for storage, kg NH ₃ -N per kg TAN in storage system	NH ₃ -N EF for storage, kg NH ₃ -N per kg TAN in storage system (leachate / urine)	N ₂ O EF for storage, kg N ₂ O-N per kg N in storage system	N ₂ O EF for storage, kg N ₂ O-N per kg N in storage system (leachate / urine)	CH ₄ MCF for storage, % of Bo < 10 °C	maximum CH ₄ producing capacity (Bo) m ³ CH ₄ per kg VS
poultry, digested solid manure		0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	3	4	5	6	8	10	11	11	13	13	13						
poultry, storage of digestates	gas tight storage (% of digestates)	0	1	2	3	4	5	5	6	7	8	9	10	11	12	14	15	20	25	30	35	41	46	57	60	62	62	0.000 ^{*)}		0.000 ^{*)}		1.1 ^{*)}	see animal - specific values (above)
poultry, storage of digestates	open tank (% of digestates)	100	99	98	97	96	95	95	94	93	92	91	90	89	88	86	85	80	75	70	65	59	54	43	40	38	38	0.045 ^{*)}		0.005 ^{*)}		1.6 ^{*)}	
horses	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.350		0.013		2.0	0.30
sheep	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.280		0.013		2.0	0.19
goats	heap (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.280		0.013		2.0	0.18
digestion of energy crops	amount of energy crops digested (1000 kt fresh matter)	0,01	0,02	0,03	0,04	0,05	0,12	0,20	0,25	0,56	0,64	1,0	1,5	2,1	2,5	3,2	8,7	12,2	16,7	19,5	25,0	31,4	39,2	42,9	51,8	54,3	54,6						
	gas tight storage (% of digestates)	0	1	2	3	4	5	6	7	8	8	9	10	11	13	14	16	21	26	32	37	42	48	59	63	67	67	0.000 ^{*)}		0.000 ^{*)}		1.0 ^{*)}	0.36
	open tank (% of digestates)	100	99	98	97	96	95	94	93	92	92	91	90	89	87	86	84	79	74	68	63	58	52	41	37	33	33	0.045 ^{*)}		0.005 ^{*)}		1.4 ^{*)}	0.36

*) digestion of slurry, solid manure, poultry manure and energy plants: EFs and MCFs are overall values for the system "pre-storage (if existent) + digester + storage of digestates"

Table 508: Frequency distributions of application procedures (in %), and pertinent emission factors

livestock category	application type	NH ₃ -N EF for application, kg NH ₃ -N per kg TAN applied																											
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015		
cattle, untreated slurry	broadcast, without incorporation	10	10	10	10	2	2	2	2	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0.50		
	broadcast, incorporation < 1 h	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	0.10		
	broadcast, incorporation < 4h	0	0	0	0	2	2	2	2	2	2	3	3	4	5	6	7	7	8	9	10	11	11	18	18	18	18	0.26	
	broadcast, incorporation < 6h	5	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.35	
	broadcast, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	3	4	4	5	5	6	6	0	0	0	0	0.40	
	broadcast, incorporation < 12h	0	0	0	0	20	20	20	20	22	22	20	18	16	14	12	11	9	7	5	3	1	1	0	0	0	0	0	0.43
	broadcast, incorporation < 24h	32	32	32	32	9	9	9	9	9	9	8	8	7	6	5	4	3	3	2	1	0	0	0	0	0	0	0.46	
	broadcast, incorporation < 48h	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50	
	broadcast, vegetation	0	0	0	0	0	0	0	0	0	0	1	3	4	6	7	9	10	12	13	15	16	16	16	16	16	16	0.50	
	broadcast, grassland	44	44	44	44	42	42	42	42	41	41	41	41	42	42	42	42	43	43	43	43	44	44	44	44	44	44	0.60	
	trailing hose, without incorporation	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.46
	trailing hose, incorporation < 1 h	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	0.04
	trailing hose, incorporation < 4h	0	0	0	0	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	0.15	
	trailing hose, incorporation < 6h	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.20
	trailing hose, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0.24
	trailing hose, incorporation < 12h	0	0	0	0	9	9	9	9	9	9	8	7	7	6	5	4	3	3	2	1	0	0	0	0	0	0	0	0.30
	trailing hose, incorporation < 24h	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0.39
	trailing hose, incorporation < 48h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.46
	trailing hose, vegetation	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	3	3	3	4	4	4	4	4	4	4	4	0.35
	trailing hose, short vegetation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50
	trailing hose, grassland	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	0.54
	trailing shoe	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	0.36
	injection (open slot)	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0.24
	grubber and injection	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	3	0.05
cattle, solid manure	broadcast, without incorporation	13	13	13	13	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0.90	
	broadcast, incorporation < 1 h	6	6	6	6	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	0.09	
	broadcast, incorporation < 4h	0	0	0	0	9	9	9	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.45	
	broadcast, incorporation < 12h	10	10	10	10	28	28	28	28	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	0.81	
	broadcast, incorporation < 24h	46	46	46	46	24	24	24	24	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	0.90	
	broadcast, incorporation < 48h	7	7	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.90
broadcast, vegetation/grassland	20	20	20	20	25	25	25	25	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	0.90		

livestock category	application type	NH ₃ -N EF for application, kg NH ₃ -N per kg TAN applied																											
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015		
pigs, untreated slurry	broadcast, without incorporation	7	7	7	7	4	4	4	4	4	4	4	3	3	3	2	2	1	1	1	0	0	0	0	0	0	0	0.25	
	broadcast, incorporation < 1 h	4	4	4	4	8	8	8	8	8	8	8	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	0.04	
	broadcast, incorporation < 4h	0	0	0	0	1	1	1	1	1	1	2	2	3	4	5	5	6	7	8	9	9	9	15	15	15	15	0.09	
	broadcast, incorporation < 6h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.11	
	broadcast, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	3	4	4	4	5	5	0	0	0	0	0.13	
	broadcast, incorporation < 12h	0	0	0	0	29	29	29	29	28	28	25	23	21	18	16	13	11	8	6	4	1	1	0	0	0	0	0	0.16
	broadcast, incorporation < 24h	50	50	50	50	4	4	4	4	4	4	3	3	3	2	2	2	1	1	1	0	0	0	0	0	0	0	0.21	
	broadcast, incorporation < 48h	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	
	broadcast, vegetation	30	30	30	30	22	22	22	22	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	0.25
	broadcast, grassland	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	3	3	3	3	3	3	3	3	3	3	0.30
	trailing hose, without incorporation	0	0	0	0	2	2	2	2	2	2	2	2	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0.18
	trailing hose, incorporation < 1 h	0	0	0	0	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	0.02
	trailing hose, incorporation < 4h	0	0	0	0	1	1	1	1	1	1	2	2	3	3	3	4	4	5	5	6	6	6	10	10	10	10	10	0.06
	trailing hose, incorporation < 6h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08
	trailing hose, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	0	0	0	0	0	0.09
	trailing hose, incorporation < 12h	0	0	0	0	10	10	10	10	10	10	9	8	7	7	6	5	4	3	2	2	1	1	0	0	0	0	0	0.11
	trailing hose, incorporation < 24h	4	4	4	4	2	2	2	2	2	2	2	2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0.14
	trailing hose, incorporation < 48h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17
	trailing hose, vegetation	0	0	0	0	0	0	0	0	0	0	3	5	8	11	13	16	19	21	24	27	29	29	29	29	29	29	29	0.13
	trailing hose, short vegetation	1	1	1	1	8	8	8	8	9	9	8	7	6	6	5	4	3	2	2	1	0	0	0	0	0	0	0	0.25
	trailing hose, grassland	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.21
	trailing shoe	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	0.12
	injection (open slot)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0.06
	grubber and injection	0	0	0	0	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	0.02
pigs, solid manure	broadcast, without incorporation	36	36	36	36	29	29	29	29	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	0.90	
	broadcast, incorporation < 1 h	4	4	4	4	16	16	16	16	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	0.09	
	broadcast, incorporation < 4h	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0.45	
	broadcast, incorporation < 12h	0	0	0	0	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	0.81	
	broadcast, incorporation < 24h	53	53	53	53	33	33	33	33	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	0.90	
	broadcast, incorporation < 48h	8	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.90
broadcast, vegetation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.90	

livestock category	application type	NH ₃ -N EF for application, kg NH ₃ -N per kg TAN applied																										
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
cattle and pigs, leachate	broadcast, without incorporation	50	50	50	50	50	50	50	50	50	50	45	41	36	32	27	23	18	14	9	5	0	0	0	0	0	0	0.20
	broadcast, incorporation < 1 h	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3	3	3	3	0.02
	broadcast, incorporation < 4h	0	0	0	0	0	0	0	0	0	0	1	1	2	3	4	4	5	6	7	7	8	8	19	19	19	19	0.07
	broadcast, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	1	1	2	3	4	4	5	6	6	7	8	8	0	0	0	0	0.12
	broadcast, incorporation < 12h	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	0	0	0	0	0.14
	broadcast, vegetation	0	0	0	0	0	0	0	0	0	0	1	3	4	6	7	8	10	11	13	14	15	15	15	15	15	15	0.20
	broadcast, grassland	50	50	50	50	50	50	50	50	50	50	50	49	49	49	49	48	48	48	48	47	47	47	47	47	47	47	0.20
	trailing hose, without incorporation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.18
	trailing hose, incorporation < 1 h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0.01
	trailing hose, incorporation < 4h	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	2	2	4	4	4	4	0.05
	trailing hose, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0.09
	trailing hose, incorporation < 12h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0.12
	trailing hose, vegetation	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	4	4	4	4	4	4	0.10
	trailing hose, grassland	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	3	3	3	3	3	3	3	0.14
	trailing shoe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0.08
injection (open slot)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0.04	
grubber and injection	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	3	3	3	3	3	3	3	3	3	0.01	
laying hens, solid manure	broadcast, without incorporation	8	8	8	8	5	5	5	5	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.90
	broadcast, incorporation < 1 h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
	broadcast, incorporation < 4h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.18
	broadcast, incorporation < 12h	0	0	0	0	11	11	11	11	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	0.40
	broadcast, incorporation < 24h	92	92	92	92	84	84	84	84	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	0.45
poultry, except laying hens, solid manure	broadcast, incorporation < 24 h	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.45
all other animals, solid manure *)	broadcast, without incorporation	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.90
digested manure (cattle, pigs,	broadcast, without incorporation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50

livestock category	application type	NH ₃ -N EF for application,																											
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	kg NH ₃ -N per kg TAN applied	
poultry) and digested energy plants	broadcast, incorporation < 1 h	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0.10	
	broadcast, incorporation < 4h	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	16	16	16	16	0.26	
	broadcast, incorporation < 8h	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0	0	0	0	0.40	
	broadcast, incorporation < 12h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0.43	
	broadcast, vegetation	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	0.50	
	broadcast, grassland	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	0.60	
	trailing hose, without incorporation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.46	
	trailing hose, incorporation < 1 h	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0.04	
	trailing hose, incorporation < 4h	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	13	13	13	0.15	
	trailing hose, incorporation < 8h	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0	0.24
	trailing hose, incorporation < 12h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0.30	
	trailing hose, vegetation	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	0.35	
	trailing hose, grassland	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0.54	
	trailing shoe	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0.36	
	injection (open slot)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0.24	
	grubber and injection	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	0.04	

*) horses, sheep, goats

Table 509: Laying hens, housing-specific partial NH₃ emission factors

[in kg NH ₃ -N per excreted kg N]	≤ 2000	2001 - 2009	≥2010
cage housing;		0.164	0.066
as of 2010: small-group housing			
floor management, aviary	0.351	linear interpolation	0.351
intensive outdoor management, free-range management, organic production		0.099	

19.4 Other detailed methodological descriptions for the source/sink category "Land-use change and forestry" (4)

19.4.1 Land-use matrix

19.4.1.1 Justification of the decision in favour of a sample-based system

Germany has a range of spatial data available for annual determination of land-use changes. Each of the different data sets involved has specific advantages and disadvantages, in terms of such aspects as:

- Periodic vs. annual surveys
- Regional surveys vs. national, complete surveys
- Surveys with complete area coverage vs. incomplete surveys with gaps (with incompleteness system-based)
- Focus on surveying (actual) states vs. focus on surveying changes
- Detection of only a single land-use category Forest land

Owing to the aforementioned differences between data sets, the following questions arise in connection with any further use of data:

- Do the data take adequate account of all types of land use?
- In their definitions of land-use and land-use-change classes, do the different data records agree among themselves – and with national or international definitions?
- Are the data updated?
- Do their underlying survey methods continue to improve?
- Are any new sources of information available, etc.?

In many cases, development and establishment of GIS-based map systems that are both substantially comprehensive and spatially explicit and complete did not begin until the 1990s. Gradually, the available database was built, and its quality was successively improved. As a result, information about land uses in 1990 – or in periods before or after that year – is not available for every area and every sample point. For that reason, a flexible system has been developed that draws information from the greatest possible number of data sources, for the following purposes:

- Obtaining comprehensive and complete land-use-change information,
- Taking account of the qualitative differences between the different data sources,
- Taking account of the spatial and qualitative development of the data,
- Verifying changes shown via comparison of different data sources,
- Ensuring that the definitions of land-use categories in the time series are consistent, and
- Allowing additional (own) research.

In light of the data available in Germany, only a sample-based system can achieve these purposes, since such a system

- can verify data sources,
- can quantify different error sources,
- considers changes on a point-wise basis, rather than on an area-wise basis. For these reasons, a sample-based system
 - is more robust in handling minor degrees of imprecision, in area-boundary delimitation, that result from differences between different data sources, and
 - does not need to provide 100% accuracy in georeferencing (FULLER 2003).

- can verify the plausibility of land-use changes, and
- can integrate data sources that are available only in sample form, meaning that the database can be expanded.

The National Forest Inventory (Bundeswaldinventur – BWI) is such a sample-based system. In place since 1987, it periodically, and very precisely, surveys land-use changes from and to forest land. The BWI network is now being used systematically for determination of all land-use changes. In addition to providing consistency in area calculations, the system achieves full consistency between reporting under the UN Framework Convention on Climate Change and reporting within the framework of Article 3.3/3.4 of the Kyoto Protocol. In May 2011, Germany's decision in favour of a sample-based system was approved by a national workshop for experts. Subsequently, it was presented and discussed in the context of an international workshop for experts. The international experts who took part in that event found the system to be well-suited for current and future use.

19.4.1.2 Justification of the decision in favour of the BWI grid

Some of the 31 LULUCF classes (main land-use classes with no changes to "Other Land") account for very small total areas in Germany. For that reason, a simulation was carried out to determine whether such areas can be surveyed precisely enough with the current nation-wide basic 4 km x 4 km grid, and with the current Länder-specific higher-resolution 2 km x 2 km grid areas, or whether the resolution of the BWI network needs to be further increased. To that end, a systematic, simple sampling network with 100 m x 100 m grid cells was generated. From that network, up to 25 sub-networks were derived for each of the following grid cell sizes: 200 m x 200 m, 500 m x 500 m, 1,000 m x 1,000 m and 2,000 m x 2,000 m. From a statistical perspective, it is desirable for each of the 31 LULUCF classes to be covered if at all possible. At the same time, no requirement has been imposed to the effect that estimates of the area shares of even the smallest LULUCF classes have to differ significantly from zero. The test results indicate that a 1 km x 1 km network has the optimal resolution. If one ignores the manner in which the 243,454 BWI cluster points used nationwide are arranged into clusters and higher-resolution areas, then each cluster point represents an area of 1.4 km² which, in a quadratic arrangement, about corresponds to a network density of 1,183 m x 1,183 m. From a statistical perspective, the decision in favour of the current BWI 2012 network thus represents a good compromise. The number of sample points actually used is near to the number that would be achieved with a systematic 1 km x 1 km network. Since the correlation between the cluster points is smaller than 1, the probability increases that a single cluster will cover several land-use-change classes, and this also applies to clusters covering land-use-change classes with very small area shares. At the same time, the number of extremely small sampling elements is smaller with a cluster sample than it is with a simple sample, if the same number of sample points is used in each case. The sampling error thus has been conservatively estimated.

In light of reporting requirements, the BWI 2012 network can be considered optimal, since:

- an internally consistent land-use matrix can be prepared only with the BWI network,
- including a matrix that is consistent with the BWI forest-area estimates,
- and is consistent with the BWI carbon- stock-change estimates.

The approach thus fulfills the stringent quality criteria required especially in the KP-reporting context.

19.4.2 Determination of emission factors for mineral soils

The following data sources provide the basis for determination of the mean carbon stocks in mineral soils, weighted by climate region, and considered from a complete-coverage perspective, as a function of land use:

- Soil-overview map (Bodenübersichtskarte; BÜK), scaled to 1:1,000,000 (BÜK 1000; BGR 1995, 1997, Düwel et al. 2007)
- Estimator profiles from the BÜK 1000 n 2.3; FISBo BGR (BGR 2011)
- "Gehalte an organischer Substanz in Oberböden Deutschlands – Bericht über länderübergreifende Auswertung von Punktinformationen im FISBo BGR" ("Concentrations of organic matter in Germany's topsoils – report on Länder-overarching evaluation of point data in the FISBo BGR") (DÜWEL et al. 2007)
- Results of the Forest Soil Inventory II (BZE II; WELLBROCK et al. 2016)
- Data records of the Basic Digital Landscape Model (Basis-Digitalen Landschaftsmodell; B-DLM) of the ATKIS® official topographic-cartographic information system, for the years 2000, 2005, 2010 (AdV 2000; 2005; 2010)
- IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 – Agriculture, Forestry and Other Land Use (IPCC 2006)

The emission factors for the various land-use categories were determined with the help of a fallback system. This means that

- where specifically collected soil data are available for a given land-use category (BZE II data; data from the BGR study (DÜWEL et al. 2007)), those data have been used, either by themselves or in combination with data from the BÜK 1000, for determination of the soil carbon stocks in the relevant categories;
- where such data are not available, determination has been based on estimates from the BÜK 1000.

In keeping with the different data situations for the various land-use categories, the area-weighted, use-specific and soil-specific carbon stocks were determined separately for the various categories.

19.4.2.1 Forest Land

The mean value, as determined in Forest Soil Inventory II (BZE II), for carbon stocks in mineral soils, to a soil depth of 30 cm, was assigned to areas that the National Forest Inventory has declared to be "forest land", within the meaning of the definition of the Federal Forest Act and of Germany's choice of IPCC definition of "Forest Land".

The BZE II, a systematic sampling survey, was carried out for the purpose of collecting basic information about the condition of forest soils and the changes taking place in them. Its aims included collecting data on key soil characteristics. To that end, the various Länder intensively studied the soil and site characteristics at a total of some 2,000 points distributed throughout a complete-coverage 8 x 8 km grid. The effort was carried out in accordance with standardised work instructions that had been developed and defined via a cooperative effort of the Federal Government and the Länder (cf. Chapters 6.4.2.1.2 and 6.4.2.5).

Upon being completed, the work made it possible to base LULUCF inventory calculations, as of the 2013 Submission, on the final results of the Forest Soil Inventory II (BZE II) relative to soil carbon stocks and their rate of change. That survey found the mean carbon stocks for mineral soils, to a depth of 30 cm, to be $61.8 \pm 3.7 \text{ t ha}^{-1}$ for the year 2006. The mean annual rate of change

determined for the period between the two soil inventories amounts to $0.41 \pm 0.22 \text{ t ha}^{-1} \text{ a}^{-1}$ (cf. Chapter 6.4.2.1.2). To determine the carbon stocks of forest mineral soils for the various years covered by the report, the mean rate of change was added to / deducted from the average mineral-soil carbon stocks for all of Germany's forest soils determined for the year 2006. This yielded the following time series for the reporting period beginning in 1990 (Table 510):

Table 510: Mean carbon stocks [to 30 cm soil depth, in $\text{tC ha}^{-1} \pm 1.96 \cdot \text{standard error}$] in Germany's mineral forest soils, 1990 – 2015

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
C _{stocks_forest soil}	55.24 ± 6.44	57.29 ± 6.68	59.34 ± 6.92	61.39 ± 7.16	61.80 ± 7.25	62.21 ± 7.26	62.62 ± 7.30	63.03 ± 7.35	63.44 ± 7.40	63.85 ± 7.45	64.26 ± 7.49
	2013	2014	2015								
C _{stocks_forest soil}	64.67 ± 7.54	65.08 ± 7.59	65.49 ± 7.64								

In each case, the value shown for a year serves as the basis for all relevant calculations in the framework of inventory preparation.

19.4.2.2 The land-use categories Cropland, Grassland, Wetlands, Settlements and Other Land

19.4.2.2.1 General information relative to 4.B – 4.F

The BÜK 1000 soil overview map divides Germany's soils into 71 different characteristic soil categories / legend units. Those units, known as "dominant soil associations" (DSA), comprise dominant and secondary soil types. They are characterised on the basis of dominant soil types that are representative for the areas in question and that have been assigned selected soil profiles. Along with descriptive parameters, the profile descriptions include information about key soil characteristics, such as humus and nitrogen content and physical soil parameters (DÜWEL et al. 2007). For example, the data set on which the present calculations are based includes derived specific measurements for carbon (C_t), inorganic carbon (C_i), nitrogen (N_t), rock content and raw density_{dry}, as well as ranges for those values, in the form of class information pursuant to KA 4 (AG BODEN 1994).

The mean carbon stocks of a dominant soil association can be calculated from these data by multiplying the carbon content by soil mass and correcting for skeleton and carbonate content. For determination of the mean carbon stocks in mineral soils of the categories cropland, grassland, wetlands, settlements and other land, the BÜK 1000 was merged with the Basis-DLM (Chapter 6.3.2.1). The use-specific area data and soil-characteristics data of the BÜK 1000 (bulk density, skeleton content) were combined with the organic-carbon data produced by the BGR study "Gehalte organischer Substanz in Oberböden Deutschlands: Länderübergreifende Auswertung von Punktinformationen im FISBo BGR" ("Concentrations of organic matter in Germany's topsoils – report on Länder-overarching evaluation of point data in the FISBo BGR") (DÜWEL et al. 2007).

DÜWEL et al. 2007 list typical concentrations of organic matter (C_{org}) and humus in Germany's topsoils, for a total of 15 groups of soil parent material and 4 climate zones. Those listings are based on complete-coverage evaluation of data for ca. 14,000 profiles, broken down by use (cropland, grassland and forest) and by climate region.

In addition, that study assigns the 71 legend units of the BÜK, on the basis of their pedo-lithological characteristics, to those 15 groups of soil parent material (DÜWEL et al. 2007), with the result that those groups serve as links to the legend-unit information of the BÜK 1000.

19.4.2.2.2 Cropland

Cropland with annual crops

For cropland with annual crops, the BGR study asserts that its values are valid to a soil depth of 30 cm. As a result, it was possible to apply the carbon-content data from the BGR study to all dominant soil associations of the BÜK 1000.

Table 511: Area [ha], mean area-based carbon stocks [tC ha⁻¹] and pertinent uncertainties (upper and lower bounds in %) for croplands in Germany with annual crops

Mineral soils	Carbon stocks [t C ha ⁻¹]	Bounds	
		upper [%]	lower [%]
Cropland _{annual}	59.77	50.07	32.67

Cropland with perennial crops

With regard to croplands with perennial crops (such as fruit trees, grapevines), it was assumed that such areas are not plowed and are covered to a degree of 75 % with grass. For that reason, calculations of mean carbon stocks for such areas were based on the profile characteristics for grassland. The relevant approach is described in Chapter 19.4.2.2.3. Table 512 shows the values obtained for such areas.

Table 512: Area [ha], mean area-based carbon stocks [tC ha⁻¹] and pertinent uncertainties (upper and lower bounds in %) for croplands in Germany with perennial crops

Mineral soils	Carbon stocks [t C ha ⁻¹]	Bounds	
		upper [%]	lower [%]
Cropland with perennial crops	72.64	68.18	46.40

Carbon stocks for Cropland

The mean carbon stocks for mineral soils in cropland are obtained as follows:

$$C_{Min\ cropland} = \frac{(C_{cropl. annual} * A_{cropl. annual} + C_{cropl. perennial} * A_{cropl. perennial})}{A_{cropl. annual} + A_{cropl. perennial}}$$

$C_{min\_cropland}$: Mean area-related carbon stocks for all of Germany's mineral cropland soils [t C ha⁻¹]

$C_{cropland\_annual}$: Mean area-related carbon stocks for all of Germany's mineral cropland soils with annual crops [t C ha⁻¹]

$C_{cropland\_perennial}$: Mean area-related carbon stocks for all of Germany's mineral cropland soils with perennial crops [t C ha⁻¹]

$A_{cropland\_annual}$: Area of mineral-soil lands in Germany under cropland with annual crops [ha]

$A_{cropland\_perennial}$: Area of mineral-soil lands in Germany under cropland with perennial crops [ha]

Table 513 shows the mean carbon stocks, for mineral soils under cropland, that have been used as a basis for all pertinent calculations within the inventory.

Table 513: Mean area-based carbon stocks [t C ha⁻¹] and pertinent uncertainties (upper and lower bounds in %) for croplands in Germany

Mineral soils	Carbon stocks [t C ha ⁻¹]	Bounds		Distribution function
		upper [%]	lower [%]	
Cropland	60.03	50.50	32.99	Log-normal

19.4.2.2.3 Grassland

The land-use category "Grassland" comprises the sub-categories "Grassland in the strict sense" and "Woody Grassland" (cf. Chapter 6.2.3). Calculations for both sub-categories are carried out on the basis of the same data. The differences between the carbon stocks of these sub-categories thus result only from differences in spatial distribution of land uses and, thus, differences in percentage shares of soil-parent-material groups and climate zones.

For grassland areas, the BGR study asserts that its values are valid to a depth of 10 cm (DÜWEL et al. 2007). The soil carbon stocks were correlated with the characteristics of the mineral-soil profiles of the BÜK 1000 via relationships with soil-parent-material groups, as follows: The soil-carbon-stocks data of the BGR study (DÜWEL et al. 2007) were assigned to the uppermost horizon, in keeping with the thickness as listed (maximum thickness of 10 cm). For that horizon, the bulk density and the skeleton content were taken from the BÜK 1000, as were the data for all characteristics and thicknesses of deeper horizons and depth layers, to a depth of 30 cm. The relevant results are shown in Table 514.

Table 514: Mean area-based carbon stocks [t C ha^{-1}] and pertinent uncertainties (upper and lower bounds in %) for grasslands in Germany

Mineral soils	Carbon stocks [t C ha^{-1}]	Bounds		Distribution function
		upper [%]	lower [%]	
Grassland in the strict sense	77.43	77.87	45.93	Log-normal
Woody grassland	73.18	83.27	42.94	Log-normal

19.4.2.2.4 Terrestrial Wetlands, Settlements and Other Land

The mean carbon stocks of mineral soils in terrestrial wetlands (the "Wetlands" category is subdivided into terrestrial wetlands and waters) were determined via a procedure similar to that used for grassland. Consequently, the procedure is described in Chapter 19.4.2.2.3. Differences in carbon stocks, between grassland and terrestrial wetlands, result solely from differences in spatial distribution of category areas.

The database on which the BÜK 1000 (Soil map for the Federal Republic of Germany 1:1,000,000) is based lists no dominant profiles for soils on settlement areas and other land; it lists such profiles only for forest, cropland and grassland locations. Dominant profiles are not available for all dominant soil associations for those latter three uses, however. For this reason, the profiles for grassland locations were used as substitute dominant profiles for soils in settlement and other-land locations (due to grassland soils' relative similarity to soils in gardens and parks). For those dominant soil associations for which no dominant grassland profiles, with key pedological data, were available, the horizons seen in forest-soil profiles were used, since settlement soils – and, especially, soils in "other land" areas – are often disturbed and, lack the deeply developed A horizons in their topsoils that agriculturally cultivated grasslands or croplands have. For a total of 42 of the 71 dominant soil profiles, this approach leads to changes in – and, in most cases, reductions of – carbon stocks in comparison with grassland. In addition, the spatial distribution of settlement areas and other land in the soil landscape has a clear influence on the mean carbon stocks of mineral soils – on mineral soils' stocks with respect to grassland soils, and on these categories' (4.E and 4.F) mineral-soil stocks with respect to each other.

The mean carbon-stocks values are listed in Table 515.

Table 515: Mean area-based carbon stocks [t C ha^{-1}], and pertinent uncertainties (upper and lower bounds in %), in mineral soils under terrestrial wetlands, settlements and other land

Mineral soils	Carbon stocks [t C ha^{-1}]	Bounds		Distribution function
		upper [%]	lower [%]	
Terrestrial wetlands	74.00	52.48	43.85	Log-normal
Settlements	58.67	84.97	45.11	Log-normal
Other land	55.60	92.86	44.56	Log-normal

The emission factors derived from these mean carbon stocks, which are weighted by climate region, land use and areas, are listed in Table 306 and Table 307 in Chapter 6.1.2.1. The emission factors are listed with statistical indexes, for description of uncertainties, in Table 383 and Table 390 in Chapter 6.7.3 and 6.8.3, respectively.

The value for the carbon stocks of soils under settlements (58.67 t/ha) is credited completely in connection with land-use changes, i.e. it is offset against the mineral soils stocks of the old / new land use, without any proportional deduction for soil sealing (pursuant to the methods described in Chapter 6.1.2.1). The method of determining the carbon stocks for settlement soils is thus in conformance with the 2006 IPCC Guidelines. The resulting values fulfill the requirements pertaining to Tier 2 method, since

- they are derived on a country-specific basis
- they take account of soil sealing
- they are conservative

Reasons:

1. The carbon stocks for settlement soils were derived from the only complete-coverage soil map available for Germany (BÜK 1000 (BGR 1997)), which was used in conjunction with the map of Germany's soil parent material (BAG 5000 (BGR 2008)). The resulting value is thus the best value – area-weighted by soil type, parent material and climate zone – that can currently be determined for carbon in Germany's city soils. It may be used as an index for all settlement and transport areas, including sealed ground areas. German law mandates special protection for topsoil (Section 202 German Building Code (BauBG) (BauBG (2004))), and, in connection with construction measures, topsoil is to be stored, preserved and protected in unmixed form. Furthermore, in cases involving sealing, it must be laid down laterally, must not be contaminated and must not be mixed (German soil protection act (BBodSchG) (1998); Closed Cycle Management Act (KrWG) (2012); and 16 pertinent state construction codes). For example, topsoil sections of sealed areas are normally applied to unsealed (neighbouring) areas, to ensure that the overall area balance with regard to carbon remains the same.
2. EDELMANN (2013)) studied the carbon stocks in terrestrial and semiterrestrial soils, comprising a total of 146 representative profiles, in the Berlin metropolitan area, in order to obtain sums of organic carbon stocks as a function of area use. To this end, he divided the metropolitan area into "built-up areas" and "green and open areas." Table 516 shows the results of this study, with respect to a soil depth of 30 cm. As Table 516 shows, the soil carbon stocks in the built-up areas, taking account of sealed areas, amounted to a mean of 60.3 t C ha^{-1} to 30 cm soil depth⁻¹, and to a mean of 67.2 t C ha^{-1} to 30 cm soil depth⁻¹ for green and open areas, with the result that the mean for the entire Berlin area is 62.6 t C ha^{-1} to 30 cm soil depth⁻¹. These values are all smaller than the corresponding values in the soil map, even though the calculation took sealed areas into account. Furthermore:

Considering Berlin's location in the center of a major soil landscape with predominantly oligotrophic sandy soils, and with low levels of precipitation, it can be concluded that the soil carbon stocks determined for the settled Berlin area very likely lie above the nationwide average for Germany. In addition, it may be concluded that the value derived from the soil map, 58.67 t C ha⁻¹ to 30 cm soil depth⁻¹, is conservative.

Table 516: Areas [ha], area shares [%] and soil carbon stocks [t C ha⁻¹ to 30 cm soil depth⁻¹] in Berlin city soils, differentiated by area use (modified in accordance with EDELMANN (2013))

Type of land use	Area	Area share		C _{org} stocks
	Use-specific	City area		
	[ha]	%		[Mg ha ⁻¹]
Built-up areas				
Residential use	13,766.5	24.4	16.2	89.4
Mixed use	751.1	1.3	0.9	48.6
Core-area use	85.5	0.2	0.1	48.7
Commercial and industrial use	2,171.5	3.8	2.5	45.7
Common and special use, use for sports	5,292.7	9.4	6.2	114.1
Supply and disposal facilities	353.4	0.6	0.4	48.7
Weekend homes and allotment-like use, allotments (garden plots)	3,246.4	5.7	3.8	89.4
Traffic areas	1,624.3	2.9	1.9	23.4
Sealed soils	29,190.0	51.7	34.3	37.1
Σ	56,481.3	100.0	66.3	60.3
Green and open areas				
Forest land	15,614.3	54.4	18.3	60.0
Grassland	1,130.6	3.9	1.3	66.1
Cropland	2,277.0	7.9	2.7	47.7
Parks and green areas	4,272.5	14.9	5.0	102.0
City squares / promenades	62.7	0.2	0.1	64.2
Cemeteries	1,021.7	3.6	1.2	82.3
Fallow land free of vegetation	175.0	0.6	0.2	30.5
Fallow land with meadow-like vegetation	1,563.1	5.5	1.8	73.1
Fallow land with mixture of meadows, shrubbery and trees	2,299.6	8.0	2.7	58.4
Tree nurseries / horticultural land	262.9	0.9	0.3	111.7
Σ	28,679.3	100.0	33.7	67.2
City area				
Σ	85,160.6		100.0	62.6

19.4.2.2.5 Uncertainties

Since individual profiles do not support conclusions relative to the heterogeneity of soil parameters within the legend units (DÜWEL et al. 2007), relevant extreme constellations of class values were constructed for purposes of estimating the potential ranges of carbon and nitrogen stocks in dominant soil associations (DSA) – and, thus, for purposes of determining the relevant uncertainties:

DSA carbon stocks_{maximum}: C_{org} content_{maximum}, bulk density_{maximum}, skeleton content_{minimum}

DSA carbon stocks_{minimum}: C_{org} content_{minimum}, bulk density_{minimum}, skeleton content_{maximum}

The values for bulk density, skeleton content and carbon stocks in horizons for which no corresponding values were available from the topsoil study of the BGR (DÜWEL et al. 2007) were derived, with the help of KA 4, in accordance with pertinent class information from the dominant-profile descriptions in the BÜK 1000 (BGR 1997).

The so-determined minimum and maximum carbon stocks form the relevant upper and lower boundaries and, in combination with the location scale, show the steep-left distribution that is typical for such data.

The carbon-stocks data from the BGR study (DÜWEL et al. 2007) are backed by descriptive statistics. The values for the 25th and 75th percentiles, i.e. the upper and lower threshold values for the carbon stocks, were derived from those statistics.

19.4.2.3 Planned improvements

The values listed in the above chapters are the best data now available in complete-coverage form. Major inventories for determination of the carbon and nitrogen stocks in mineral soils have been carried out, and are being carried out, in Germany, with a view to improving such data:

- The Forest Soil Inventory II (BZE II Wald), for all forest soils – the results of which have been used as of the 2013 Submission;
- The Agricultural Soil Inventory (Bodenzustandserhebung Landwirtschaft), for cropland and grassland soils (cf. Chapter 6.5.6)

Those two major inventories cover about 84 % of Germany's total surface area, or about 88 % of its mineral-soil area. The results of the Agricultural Soil Inventory are being used for step-by-step validation of the current emission factors. Complete implementation of the results, as a basis for reporting on mineral soils, is not expected prior to 2019.

Chapter 10.4, Inventory Improvements (Table 426), presents an overview of the improvements that previous reports have listed in this chapter. Improvements that have been completed are listed in Table 425 in the same chapter.

19.4.3 Uncertainties

Uncertainties in the LULUCF section of the German greenhouse-gas inventory are determined in accordance with the 2006 IPCC Guidelines and the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000). The uncertainty statistics commonly given for a normal distribution include the 95 % confidence interval, $\pm$ half of the 95 % confidence interval or $1.96 \times$ the standard error, in % of the mean. In the case of non-symmetric distributions – such as the log-normal distributions widely encountered in the present case – the uncertainties are expressed as percentages of the position scale, and as upper and lower bounds. As a rule, they are determined via the quantiles ($p = 0.025$ and $p = 0.975$). In keeping with the aforementioned guidelines, the propagation of uncertainties was calculated via a conservative estimation in which the distance between the extreme value of the sloping axis section and the position scale is defined as half of the 95 % confidence interval. Due to a lack of uncertainties figures for the relevant emission factors, it was not possible to calculate uncertainties for harvested wood products (cf. also Chapter 11.3.1.5.3). Table 517 shows the results of the uncertainties calculations for all pools and sub-categories, with the exception of harvested wood products.

The overall uncertainty of the LULUCF section of the German GHG inventory thus amounts to 23.26 % with respect to the level of emissions. The largest contributions to the total uncertainty are made by CO₂ emissions (99.71 %), especially such emissions from the biomass pool (68.00 %), followed by the categories organic soils (21.39 %), mineral soils (9.44 %) and dead organic matter (0.89 %). Methane (0.22 %) and nitrous oxide emissions (0.07 %) have only a marginal effect on the total uncertainty – in fact, the effect is hardly noticeable.

With respect to the land-use categories, the largest uncertainties occur in the sub-category Forest Land remaining Forest Land. In this area, the biomass pool, as a result of the 56 % uncertainty of its emission factor, and of the large absolute size of its sink, (-40,948.45 kt CO₂-), constitutes the largest contribution to the total uncertainty of the LULUCF inventory. In this land-use category,

mineral soils (9.09 %) and dead organic matter (0.88 %) rank next in this regard. Their contributions are determined primarily by the size of the relevant emission factors (litter: 294 %; dead wood: 107 %). Outside of the forest sector, CO₂ emissions from organic soils, in the "remaining" categories of Grassland (in the strict sense) (19.24 %) and of Cropland (1.54 %), contribute especially to the total uncertainty of the LULUCF inventory, due to the absolute level of the CO₂ emissions (22,190.22 and 7,605.07 kt CO₂-eq.) and to the uncertainties of the relevant emission factors (55 % and 46 %). All other sub-categories and pools play only a marginal role in this regard; in sum, they contribute only about 1.32 % to the total uncertainty.

Table 517: Uncertainty Calculation for the German GHG Emissions from Sector 4.B - 4.F (LULUCF)

A		B	C	D	E	F	G	H ²²¹	
Source category	Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015	
			[kt CO ₂ equivalent]	[kt CO ₂ equivalent]					[%]
4.A.1	Forest Land remaining Forest Land	Mineral soils	CO2	-15,474.96	-16,056.21	1.23	52.59	52.60	49.2135
4.A.1	Forest Land remaining Forest Land	Organic soils	CO2	636.12	920.48	1.72	24.60	24.66	0.0356
4.(II).A	Forest Land remaining Forest Land	Organic soils	CH4	8.97	12.98	1.72	1,011.57	1,011.57	0.0119
4.(II).A	Forest Land remaining Forest Land	Organic soils	N2O	50.43	72.97	1.72	200.69	200.69	0.0148
4.A.1	Forest Land remaining Forest Land	Biomass	CO2	-54,563.08	-40,948.45	1.21	56.35	56.37	367.5818
4.A.1	Forest Land remaining Forest Land	Litter	CO2	475.58	494.67	1.21	294.00	294.00	1.4594
4.A.1	Forest Land remaining Forest Land	Dead wood	CO2	-1,400.72	2,055.25	1.21	106.87	106.88	3.3290
4.(IV).2	Forest Land remaining Forest Land	SOM indirect	N2O	0.00	0.00	1.23	291.54	291.54	0.0000
4.(III).A.1	Forest Land remaining Forest Land	SOM direct	N2O	0.00	0.00	1.23	206.81	206.81	0.0000
4.(V).A.1	Forest Land remaining Forest Land	Forest fires	CH4	6.77	2.91	15.00	35.00	38.08	0.0000
4.(V).A.1	Forest Land remaining Forest Land	Forest fires	N2O	4.46	1.92	15.00	35.00	38.08	0.0000
4.(V).A.1	Forest Land remaining Forest Land	Forest fires	CO2	IE	IE	0.00	0.00	0.00	0.0000
4.(II).A	Forest Land remaining Forest Land	Mineral soils	N2O	NO	NO	0.00	0.00	0.00	0.0000
4.(I).A.1.1	Forest Land remaining Forest Land	Fertilizer	N2O	NO	NO	0.00	0.00	0.00	0.0000
4.A.2.1	Cropland converted to Forest Land	Mineral soils	CO2	297.53	-14.96	9.78	25.00	26.85	0.0000
4.A.2.1	Cropland converted to Forest Land	Organic soils	CO2	56.96	35.11	6.59	24.60	25.47	0.0001
4.(II).A	Cropland converted to Forest Land	Organic soils	CH4	0.80	0.50	6.59	1,011.57	1,011.59	0.0000
4.(II).A	Cropland converted to Forest Land	Organic soils	N2O	4.52	2.78	6.59	200.69	200.79	0.0000
4.A.2.1	Cropland converted to Forest Land	Biomass	CO2	-2,233.08	-1,473.71	9.30	11.57	14.84	0.0330
4.A.2.1	Cropland converted to Forest Land	Litter	CO2	-338.42	-198.16	9.30	3.15	9.82	0.0003
4.A.2.1	Cropland converted to Forest Land	Dead wood	CO2	-24.49	-14.58	9.30	48.69	49.57	0.0000
4.(IV).2	Cropland converted to Forest Land	SOM indirect	N2O	6.96	0.31	9.78	292.14	292.31	0.0000
4.(III).A.2.1	Cropland converted to Forest Land	SOM direct	N2O	30.92	1.37	9.78	207.67	207.90	0.0000

²²¹ The data in this column describe auxiliary data needed to derive the percentage uncertainty in total inventory in the bottommost cell of this column. In order to calculate the data the calculation procedure provided by IPCC (2006)-3.31, Table 3.2, column H, has been used. However, the head of this column as prescribed by IPCC (2006)-3.31, Table 3.2, column H („Contribution to Variance by Category“) does not correctly describe the data in this column. The head could not be adapted to the meaning of the data in the column and should therefore not be used.

A			B	C	D	E	F	G	H ²²¹
Source category		Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015
				[kt CO ₂ equivalent]	[kt CO ₂ equivalent]	[%]	[%]	[%]	[%]
4.A.2.2.1	Grassland i.s.s. converted to Forest Land	Mineral soils	CO2	973.25	423.57	8.96	42.74	43.67	0.0236
4.A.2.2.1	Grassland i.s.s. converted to Forest Land	Organic soils	CO2	156.29	165.36	5.19	24.60	25.14	0.0012
4.(II).A	Grassland i.s.s. converted to Forest Land	Organic soils	CH4	2.20	2.33	5.19	1,011.57	1,011.59	0.0004
4.(II).A	Grassland i.s.s. converted to Forest Land	Organic soils	N2O	12.39	13.11	5.19	200.69	200.75	0.0005
4.A.2.2.1	Grassland i.s.s. converted to Forest Land	Biomass	CO2	-2,508.61	-1,959.75	8.13	21.94	23.40	0.1451
4.A.2.2.1	Grassland i.s.s. converted to Forest Land	Litter	CO2	-389.75	-281.54	8.13	3.15	8.72	0.0004
4.A.2.2.1	Grassland i.s.s. converted to Forest Land	Dead wood	CO2	-28.21	-20.72	8.13	48.69	49.36	0.0001
4.(IV).2	Grassland i.s.s. converted to Forest Land	SOM indirect	N2O	22.05	9.60	8.96	294.19	294.33	0.0006
4.(III).A.2.2.1	Grassland i.s.s. converted to Forest Land	SOM direct	N2O	98.00	42.65	8.96	210.54	210.73	0.0056
4.A.2.2.2	Woody Grassland converted to Forest Land	Mineral soils	CO2	140.07	52.26	23.75	44.52	50.46	0.0005
4.A.2.2.2	Woody Grassland converted to Forest Land	Organic soils	CO2	19.12	12.06	21.34	24.60	32.57	0.0000
4.(II).A	Woody Grassland converted to Forest Land	Organic soils	CH4	0.27	0.17	21.34	1,011.57	1,011.80	0.0000
4.(II).A	Woody Grassland converted to Forest Land	Organic soils	N2O	1.52	0.96	21.34	200.69	201.82	0.0000
4.A.2.2.2	Woody Grassland converted to Forest Land	Biomass	CO2	-170.32	-188.86	22.22	51.22	55.83	0.0077
4.A.2.2.2	Woody Grassland converted to Forest Land	Litter	CO2	-65.26	-43.34	22.22	3.15	22.44	0.0001
4.A.2.2.2	Woody Grassland converted to Forest Land	Dead wood	CO2	-4.72	-3.19	22.22	48.69	53.52	0.0000
4.(IV).2	Woody Grassland converted to Forest Land	SOM indirect	N2O	3.29	1.23	23.75	294.46	295.41	0.0000
4.(III).A.2.2.2	Woody Grassland converted to Forest Land	SOM direct	N2O	14.64	5.46	23.75	210.91	212.24	0.0001
4.A.2.3.3	Other Wetlands converted to Forest Land	Mineral soils	CO2	4.98	1.47	146.21	28.49	148.96	0.0000
4.A.2.3.3	Other Wetlands converted to Forest Land	Organic soils	CO2	30.58	45.57	19.21	24.60	31.21	0.0001
4.(II).A	Other Wetlands converted to Forest Land	Organic soils	CH4	0.43	0.64	19.21	1,011.57	1,011.76	0.0000
4.(II).A	Other Wetlands converted to Forest Land	Organic soils	N2O	2.42	3.61	19.21	200.69	201.60	0.0000
4.A.2.3.3	Other Wetlands converted to Forest Land	Biomass	CO2	-46.42	-78.91	19.21	37.08	41.76	0.0007
4.A.2.3.3	Other Wetlands converted to Forest Land	Litter	CO2	-8.99	-10.56	19.21	3.15	19.47	0.0000
4.A.2.3.3	Other Wetlands converted to Forest Land	Dead wood	CO2	-0.65	-0.78	19.21	48.69	52.34	0.0000
4.(IV).2	Other Wetlands converted to Forest Land	SOM indirect	N2O	0.09	0.03	146.21	292.46	326.97	0.0000
4.(III).A.2.3.3	Other Wetlands converted to Forest Land	SOM direct	N2O	0.41	0.12	146.21	208.11	254.34	0.0000

A			B	C	D	E	F	G	H ²²¹
Source category	Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015	
			[kt CO ₂ equivalent]	[kt CO ₂ equivalent]					[%]
4.A.2.3.2	Flooded Land converted to Forest Land	Mineral soils	CO2	0.00	0.00	23.43	11.25	25.99	0.0000
4.A.2.3.2	Flooded Land converted to Forest Land	Organic soils	CO2	33.10	11.63	7.48	24.60	25.71	0.0000
4.(II).A	Flooded Land converted to Forest Land	Organic soils	CH4	0.47	0.16	7.48	1,011.57	1,011.60	0.0000
4.(II).A	Flooded Land converted to Forest Land	Organic soils	N2O	2.62	0.92	7.48	200.69	200.83	0.0000
4.A.2.3.2	Flooded Land converted to Forest Land	Biomass	CO2	-261.54	-119.93	17.30	25.64	30.93	0.0009
4.A.2.3.2	Flooded Land converted to Forest Land	Litter	CO2	-36.56	-15.39	17.30	3.15	17.58	0.0000
4.A.2.3.2	Flooded Land converted to Forest Land	Dead wood	CO2	-2.65	-1.13	17.30	48.69	51.67	0.0000
4.(IV).2	Flooded Land converted to Forest Land	SOM indirect	N2O	0.00	0.00	23.43	291.29	292.23	0.0000
4.(III).A.2.3.2	Flooded Land converted to Forest Land	SOM direct	N2O	0.00	0.00	23.43	206.46	207.79	0.0000
4.A.2.4	Settlements converted to Forest Land	Mineral soils	CO2	64.38	-15.85	16.72	40.85	44.13	0.0000
4.A.2.4	Settlements converted to Forest Land	Organic soils	CO2	10.97	5.48	20.69	24.60	32.15	0.0000
4.A.2.4	Settlements converted to Forest Land	Organic soils	CH4	0.15	0.08	20.69	1,011.57	1,011.78	0.0000
4.A.2.4	Settlements converted to Forest Land	Organic soils	N2O	0.87	0.43	20.69	200.69	201.75	0.0000
4.A.2.4	Settlements converted to Forest Land	Biomass	CO2	-501.71	-473.61	16.18	38.03	41.33	0.0264
4.A.2.4	Settlements converted to Forest Land	Litter	CO2	-85.94	-64.89	16.18	3.15	16.48	0.0001
4.A.2.4	Settlements converted to Forest Land	Dead wood	CO2	-6.22	-4.78	16.18	48.69	51.30	0.0000
4.(IV).2	Settlements converted to Forest Land	SOM indirect	N2O	1.48	0.02	16.72	293.92	294.40	0.0000
4.(III).A.2.4	Settlements converted to Forest Land	SOM direct	N2O	6.58	0.08	16.72	210.16	210.83	0.0000
4.A.2.5	Other Land converted to Forest Land	Mineral soils	CO2	16.63	-8.07	34.05	43.35	55.13	0.0000
4.A.2.5	Other Land converted to Forest Land	Organic soils	CO2	0.10	0.38	312.66	24.60	313.63	0.0000
4.(II).A	Other Land converted to Forest Land	Organic soils	CH4	0.00	0.01	312.66	1,011.57	1,058.79	0.0000
4.(II).A	Other Land converted to Forest Land	Organic soils	N2O	0.01	0.03	312.66	200.69	371.52	0.0000
4.A.2.5	Other Land converted to Forest Land	Biomass	CO2	-265.63	-134.42	34.04	25.64	42.62	0.0023
4.A.2.5	Other Land converted to Forest Land	Litter	CO2	-37.13	-17.25	34.04	3.15	34.18	0.0000
4.A.2.5	Other Land converted to Forest Land	Dead wood	CO2	-2.69	-1.27	34.04	48.69	59.40	0.0000
4.(IV).2	Other Land converted to Forest Land	SOM indirect	N2O	0.38	0.00	34.05	294.28	296.25	0.0000
4.(III).A.2.5	Other Land converted to Forest Land	SOM direct	N2O	1.67	0.00	34.05	210.66	213.40	0.0000
4.B.1	Cropland remaining Cropland	Mineral soils	CO2	0.00	0.00	1.06	50.50	50.52	0.0000
4.B.1	Cropland remaining Cropland	Organic soils	CO2	5,909.20	7,605.07	1.28	45.65	45.66	8.3215
4.(II).B	Cropland remaining Cropland	Organic soils	CH4	129.33	166.44	1.28	233.93	233.93	0.1046
4.B.1	Cropland remaining Cropland	Biomass	CO2	-28.86	-51.82	1.04	11.08	11.13	0.0000

A			B	C	D	E	F	G	H ²²¹
Source category	Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015	
			[kt CO ₂ equivalent]	[kt CO ₂ equivalent]					[%]
4.B.2.1	Forest Land converted to Cropland	Mineral soils	CO2	-97.38	0.96	15.31	25.00	29.32	0.0000
4.B.2.1	Forest Land converted to Cropland	Organic soils	CO2	184.12	55.15	7.62	45.65	46.28	0.0004
4.(II).B	Forest Land converted to Cropland	Organic soils	CH4	4.03	1.21	7.62	233.93	234.05	0.0000
4.B.2.1	Forest Land converted to Cropland	Biomass	CO2	292.22	82.24	13.53	22.32	26.10	0.0003
4.B.2.1	Forest Land converted to Cropland	Dead organic matter	CO2	257.97	35.34	13.53	6.16	14.87	0.0000
4.(IV).2	Forest Land converted to Cropland	SOM indirect	N2O	0.00	0.08	15.31	287.84	288.25	0.0000
4.(III).B.2.1	Forest Land converted to Cropland	SOM direct	N2O	0.00	0.36	15.31	201.57	202.15	0.0000
4.B.2.2.1	Grassland i.s.s. converted to Cropland	Mineral soils	CO2	2,458.85	2,840.94	4.92	49.10	49.34	1.3558
4.B.2.2.1	Grassland i.s.s. converted to Cropland	Organic soils	CO2	2,576.21	3,543.87	3.34	45.65	45.77	1.8152
4.(II).B	Grassland i.s.s. converted to Cropland	Organic soils	CH4	56.38	77.56	3.34	233.93	233.95	0.0227
4.B.2.2.1	Grassland i.s.s. converted to Cropland	Biomass	CO2	242.07	48.14	4.45	16.44	17.03	0.0000
4.(IV).2	Grassland i.s.s. converted to Cropland	SOM indirect	N2O	55.71	64.36	4.92	295.18	295.22	0.0249
4.(III).B.2.2.1	Grassland i.s.s. converted to Cropland	SOM direct	N2O	247.58	286.05	4.92	211.92	211.98	0.2537
4.B.2.2.2	Woody Grassland converted to Cropland	Mineral soils	CO2	70.57	24.39	30.00	51.10	59.25	0.0001
4.B.2.2.2	Woody Grassland converted to Cropland	Organic soils	CO2	52.63	15.60	21.34	45.65	50.39	0.0000
4.(II).B	Woody Grassland converted to Cropland	Organic soils	CH4	1.15	0.34	21.34	233.93	234.90	0.0000
4.B.2.2.2	Woody Grassland converted to Cropland	Biomass	CO2	215.61	53.85	28.32	47.96	55.70	0.0006
4.(IV).2	Woody Grassland converted to Cropland	SOM indirect	N2O	1.66	0.57	30.00	295.52	297.04	0.0000
4.(III).B.2.2.2	Woody Grassland converted to Cropland	SOM direct	N2O	7.37	2.55	30.00	212.39	214.50	0.0000
4.B.2.3.3	Other Wetlands converted to Cropland	Mineral soils	CO2	0.00	0.00	0.00	36.76	36.76	0.0000
4.B.2.3.3	Other Wetlands converted to Cropland	Organic soils	CO2	132.53	35.73	19.62	45.65	49.68	0.0002
4.(II).B	Other Wetlands converted to Cropland	Organic soils	CH4	2.90	0.78	19.62	233.93	234.75	0.0000
4.B.2.3.3	Other Wetlands converted to Cropland	Biomass	CO2	11.17	0.00	19.62	32.45	37.92	0.0000
4.(IV).2	Other Wetlands converted to Cropland	SOM indirect	N2O	0.00	0.00	0.00	295.64	295.64	0.0000
4.(III).B.2.3.3	Other Wetlands converted to Cropland	SOM direct	N2O	0.00	0.00	0.00	212.56	212.56	0.0000
4.B.2.3.2	Flooded Land converted to Cropland	Mineral soils	CO2	0.00	0.00	32.39	50.50	60.00	0.0000
4.B.2.3.2	Flooded Land converted to Cropland	Organic soils	CO2	28.41	8.72	18.54	45.65	49.27	0.0000
4.(II).B	Flooded Land converted to Cropland	Organic soils	CH4	0.62	0.19	18.54	233.93	234.66	0.0000
4.B.2.3.2	Flooded Land converted to Cropland	Biomass	CO2	-11.82	-0.08	29.24	11.47	31.41	0.0000
4.(IV).2	Flooded Land converted to Cropland	SOM indirect	N2O	0.00	0.00	32.39	295.42	297.19	0.0000
4.(III).B.2.3.2	Flooded Land converted to Cropland	SOM direct	N2O	0.00	0.00	32.39	212.25	214.71	0.0000

A			B	C	D	E	F	G	H ²²¹
Source category		Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015
				[kt CO ₂ equivalent]	[kt CO ₂ equivalent]	[%]	[%]	[%]	[%]
4.B.2.4	Settlements converted to Cropland	Mineral soils	CO2	-16.88	-10.84	15.50	49.15	51.54	0.0000
4.B.2.4	Settlements converted to Cropland	Organic soils	CO2	69.84	40.28	21.22	45.65	50.34	0.0003
4.(II).B	Settlements converted to Cropland	Organic soils	CH4	1.53	0.88	21.22	233.93	234.89	0.0000
4.B.2.4	Settlements converted to Cropland	Biomass	CO2	93.15	23.51	15.00	31.65	35.03	0.0000
4.(IV).2	Settlements converted to Cropland	SOM indirect	N2O	0.00	0.00	15.50	295.19	295.60	0.0000
4.(III).B.2.4	Settlements converted to Cropland	SOM direct	N2O	0.00	0.00	15.50	211.93	212.50	0.0000
4.B.2.5	Other Land converted to Cropland	Mineral soils	CO2	-1.78	-4.01	91.67	51.78	105.28	0.0000
4.B.2.5	Other Land converted to Cropland	Organic soils	CO2	0.74	1.29	180.19	45.65	185.88	0.0000
4.(II).B	Other Land converted to Cropland	Organic soils	CH4	0.02	0.03	180.19	233.93	295.28	0.0000
4.B.2.5	Other Land converted to Cropland	Biomass	CO2	-2.14	0.00	90.15	11.47	90.88	0.0000
4.(IV).2	Other Land converted to Cropland	SOM indirect	N2O	0.00	0.00	90.15	295.64	309.08	0.0000
4.(III).B.2.5	Other Land converted to Cropland	SOM direct	N2O	0.00	0.00	91.67	212.56	231.48	0.0000
4.C.1.1	Grassland i.s.s. remaining Grassland i.s.s.	Mineral soils	CO2	0.00	0.00	1.79	77.87	77.89	0.0000
4.C.1.1	Grassland i.s.s. remaining Grassland i.s.s.	Organic soils	CO2	25,058.33	22,190.24	0.57	55.35	55.36	104.1134
4.(II).C	Grassland i.s.s. remaining Grassland i.s.s.	Organic soils	CH4	531.03	470.25	0.57	258.59	258.59	1.0203
4.C.1.1	Grassland i.s.s. remaining Grassland i.s.s.	Biomass	CO2	0.00	0.00	1.50	30.30	30.33	0.0000
4.C.2.1.1	Forest Land converted to Grassland i.s.s.	Mineral soils	CO2	-259.05	-145.33	20.20	42.74	47.27	0.0033
4.C.2.1.1	Forest Land converted to Grassland i.s.s.	Organic soils	CO2	78.36	152.63	10.17	55.35	56.28	0.0051
4.(II).C	Forest Land converted to Grassland i.s.s.	Organic soils	CH4	1.66	3.23	10.17	258.59	258.79	0.0000
4.C.2.1.1	Forest Land converted to Grassland i.s.s.	Biomass	CO2	232.19	302.01	18.78	22.44	29.26	0.0054
4.C.2.1.1	Forest Land converted to Grassland i.s.s.	DOM	CO2	219.25	130.48	18.78	6.16	19.76	0.0005
4.(IV).2	Forest Land converted to Grassland i.s.s.	SOM indirect	N2O	0.00	0.00	20.20	289.92	290.62	0.0000
4.(III).C.2.1.1	Forest Land converted to Grassland i.s.s.	SOM direct	N2O	0.00	0.00	20.20	204.53	205.52	0.0000
4.C.2.2.1	Cropland converted to Grassland i.s.s.	Mineral soils	CO2	-1,787.24	-1,324.38	6.13	49.10	49.48	0.2963
4.C.2.2.1	Cropland converted to Grassland i.s.s.	Organic soils	CO2	1,580.07	765.70	3.17	55.35	55.45	0.1244
4.(II).C	Cropland converted to Grassland i.s.s.	Organic soils	CH4	33.48	16.23	3.17	258.59	258.61	0.0012
4.C.2.2.1	Cropland converted to Grassland i.s.s.	Biomass	CO2	-175.76	-17.84	5.47	16.44	17.32	0.0000
4.(IV).2	Cropland converted to Grassland i.s.s.	SOM indirect	N2O	0.00	0.00	6.13	295.18	295.25	0.0000
4.(III).C.2.1.1	Cropland converted to Grassland i.s.s.	SOM direct	N2O	0.00	0.00	6.13	211.92	212.01	0.0000
4.C.1.3	Woody Grassland converted to Grassland i.s.s.	Mineral soils	CO2	-45.10	-19.74	19.70	56.92	60.23	0.0001
4.C.1.3	Woody Grassland converted to Grassland i.s.s.	Organic soils	CO2	60.93	54.66	15.70	55.35	57.54	0.0007
4.(II).C	Woody Grassland converted to Grassland i.s.s.	Organic soils	CH4	1.29	1.16	15.70	258.59	259.07	0.0000
4.C.1.3	Woody Grassland converted to Grassland i.s.s.	Biomass	CO2	401.83	42.22	18.88	47.87	51.46	0.0003
4.(IV).2	Woody Grassland converted to Grassland i.s.s.	SOM indirect	N2O	0.00	0.00	19.70	296.58	297.24	0.0000
4.(III).C.1.3	Woody Grassland converted to Grassland i.s.s.	SOM direct	N2O	0.00	0.00	19.70	213.87	214.77	0.0000

A			B	C	D	E	F	G	H ²²¹
Source category		Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015
				[kt CO ₂ equivalent]	[kt CO ₂ equivalent]	[%]	[%]	[%]	[%]
4.C.2.3.3.1	Other Wetlands converted to Grassland i.s.s.	Mineral soils	CO2	-0.50	-1.19	57.40	47.36	74.42	0.0000
4.C.2.3.3.1	Other Wetlands converted to Grassland i.s.s.	Organic soils	CO2	78.39	73.30	49.96	55.35	74.56	0.0021
4.(II).C	Other Wetlands converted to Grassland i.s.s.	Organic soils	CH4	1.66	1.55	49.96	258.59	263.37	0.0000
4.C.2.3.3.1	Other Wetlands converted to Grassland i.s.s.	Biomass	CO2	8.63	20.60	56.85	32.97	65.72	0.0001
4.(IV).2	Other Wetlands converted to Grassland i.s.s.	SOM indirect	N2O	0.00	0.00	57.40	294.90	300.43	0.0000
4.(III).C.2.3.3.1	Other Wetlands converted to Grassland i.s.s.	SOM direct	N2O	0.00	0.00	57.40	211.53	219.17	0.0000
4.C.2.3.2.1	Flooded Land converted to Grassland i.s.s.	Mineral soils	CO2	0.00	0.00	16.50	77.87	79.60	0.0000
4.C.2.3.2.1	Flooded Land converted to Grassland i.s.s.	Organic soils	CO2	314.46	105.12	6.25	55.35	55.71	0.0024
4.(II).C	Flooded Land converted to Grassland i.s.s.	Organic soils	CH4	6.66	2.23	6.25	258.59	258.67	0.0000
4.C.2.3.2.1	Flooded Land converted to Grassland i.s.s.	Biomass	CO2	-55.61	-17.09	13.10	30.30	33.01	0.0000
4.(IV).2	Flooded Land converted to Grassland i.s.s.	SOM indirect	N2O	0.00	0.00	16.50	301.31	301.76	0.0000
4.(III).C.2.3.2.1	Flooded Land converted to Grassland i.s.s.	SOM direct	N2O	0.00	0.00	16.50	220.37	220.99	0.0000
4.C.2.4.1	Settlements converted to Grassland i.s.s.	Mineral soils	CO2	-344.31	-306.77	11.82	57.48	58.68	0.0224
4.C.2.4.1	Settlements converted to Grassland i.s.s.	Organic soils	CO2	127.48	66.87	10.30	55.35	56.30	0.0010
4.(II).C	Settlements converted to Grassland i.s.s.	Organic soils	CH4	2.70	1.42	10.30	258.59	258.80	0.0000
4.C.2.4.1	Settlements converted to Grassland i.s.s.	Biomass	CO2	0.00	0.00	11.22	32.77	34.64	0.0000
4.(IV).2	Settlements converted to Grassland i.s.s.	SOM indirect	N2O	0.00	0.00	11.82	296.69	296.93	0.0000
4.(III).C.2.4.1	Settlements converted to Grassland i.s.s.	SOM direct	N2O	0.00	0.00	11.82	214.02	214.34	0.0000
4.C.2.5.1	Other Land converted to Grassland i.s.s.	Mineral soils	CO2	314.46	105.12	57.40	43.35	71.93	0.0039
4.C.2.5.1	Other Land converted to Grassland i.s.s.	Organic soils	CO2	6.66	2.23	49.96	55.35	74.56	0.0000
4.(II).C	Other Land converted to Grassland i.s.s.	Organic soils	CH4	14.65	4.90	49.96	258.59	263.37	0.0001
4.C.2.5.1	Other Land converted to Grassland i.s.s.	Biomass	CO2	-15.31	0.00	56.85	30.30	64.42	0.0000
4.(IV).2	Other Land converted to Grassland i.s.s.	SOM indirect	N2O	0.00	0.00	57.40	297.12	302.62	0.0000
4.(III).C.2.5.1	Other Land converted to Grassland i.s.s.	SOM direct	N2O	0.00	0.00	57.40	214.62	222.16	0.0000
4.C.1.2	Woody Grassland remaining Woody Grassland	Mineral soils	CO2	0.00	0.00	4.87	83.27	83.42	0.0000
4.C.1.2	Woody Grassland remaining Woody Grassland	Organic soils	CO2	1,001.66	1,109.86	1.59	24.60	24.65	0.0517
4.(II).C	Woody Grassland remaining Woody Grassland	Organic soils	CH4	14.13	15.66	1.59	1,011.57	1,011.57	0.0173
4.(II).C	Woody Grassland remaining Woody Grassland	Organic soils	N2O	79.40	87.98	1.59	200.69	200.69	0.0215
4.C.1.2	Woody Grassland remaining Woody Grassland	Biomass	CO2	0.00	0.00	3.56	55.21	55.33	0.0000

A			B	C	D	E	F	G	H ²²¹
Source category		Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015
				[kt CO ₂ equivalent]	[kt CO ₂ equivalent]	[%]	[%]	[%]	[%]
4.C.2.1.2	Forest Land converted to Woody Grassland	Mineral soils	CO2	-72.52	-34.94	28.51	44.52	52.87	0.0002
4.C.2.1.2	Forest Land converted to Woody Grassland	Organic soils	CO2	15.75	10.87	15.77	24.60	29.22	0.0000
4.(II).C	Forest Land converted to Woody Grassland	Organic soils	CH4	0.22	0.15	15.77	1,011.57	1,011.70	0.0000
4.(II).C	Forest Land converted to Woody Grassland	Organic soils	N2O	1.25	0.86	15.77	200.69	201.30	0.0000
4.C.2.1.2	Forest Land converted to Woody Grassland	Biomass	CO2	-52.61	36.13	25.50	28.07	37.93	0.0001
4.C.2.1.2	Forest Land converted to Woody Grassland	Dead organic matter	CO2	77.18	64.98	25.50	6.16	26.24	0.0002
4.(IV).2	Forest Land converted to Woody Grassland	SOM indirect	N2O	0.00	0.00	28.51	290.19	291.59	0.0000
4.(III).C.2.1.2	Forest Land converted to Woody Grassland	SOM direct	N2O	0.00	0.00	28.51	204.91	206.88	0.0000
4.C.2.2.2	Cropland converted to Woody Grassland	Mineral soils	CO2	-151.60	-150.92	14.00	51.10	52.98	0.0044
4.C.2.2.2	Cropland converted to Woody Grassland	Organic soils	CO2	22.37	14.97	10.69	24.60	26.82	0.0000
4.(II).C	Cropland converted to Woody Grassland	Organic soils	CH4	0.32	0.21	10.69	1,011.57	1,011.63	0.0000
4.(II).C	Cropland converted to Woody Grassland	Organic soils	N2O	1.77	1.19	10.69	200.69	200.97	0.0000
4.C.2.2.2	Cropland converted to Woody Grassland	Biomass	CO2	-456.91	-297.68	13.21	47.96	49.75	0.0151
4.(IV).2	Cropland converted to Woody Grassland	SOM indirect	N2O	0.00	0.00	14.00	295.52	295.85	0.0000
4.(III).C.2.2.2	Cropland converted to Woody Grassland	SOM direct	N2O	0.00	0.00	14.00	212.39	212.85	0.0000
4.C.1.4	Grassland i.s.s. converted to Woody Grassland	Mineral soils	CO2	14.90	50.87	27.89	56.92	63.38	0.0007
4.C.1.4	Grassland i.s.s. converted to Woody Grassland	Organic soils	CO2	24.39	80.07	14.65	24.60	28.63	0.0004
4.(II).C	Grassland i.s.s. converted to Woody Grassland	Organic soils	CH4	0.34	1.13	14.65	1,011.57	1,011.68	0.0001
4.(II).C	Grassland i.s.s. converted to Woody Grassland	Organic soils	N2O	1.93	6.35	14.65	200.69	201.22	0.0001
4.C.1.4	Grassland i.s.s. converted to Woody Grassland	Biomass	CO2	-148.55	-718.10	24.20	47.87	53.64	0.1024
4.(IV).2	Grassland i.s.s. converted to Woody Grassland	SOM indirect	N2O	0.34	1.15	27.89	296.58	297.89	0.0000
4.(III).C.1.4	Grassland i.s.s. converted to Woody Grassland	SOM direct	N2O	1.50	5.12	27.89	213.87	215.68	0.0001
4.C.2.3.3.2	Other Wetlands converted to Woody Grassland	Mineral soils	CO2	0.00	0.03	209.23	49.10	214.91	0.0000
4.C.2.3.3.2	Other Wetlands converted to Woody Grassland	Organic soils	CO2	9.46	9.78	30.11	24.60	38.88	0.0000
4.(II).C	Other Wetlands converted to Woody Grassland	Organic soils	CH4	0.13	0.14	30.11	1,011.57	1,012.02	0.0000
4.(II).C	Other Wetlands converted to Woody Grassland	Organic soils	N2O	0.75	0.77	30.11	200.69	202.93	0.0000
4.C.2.3.3.2	Other Wetlands converted to Woody Grassland	Biomass	CO2	-5.45	-0.28	30.11	34.60	45.87	0.0000
4.(IV).2	Other Wetlands converted to Woody Grassland	SOM indirect	N2O	0.00	0.00	209.23	295.18	361.81	0.0000
4.(III).C.2.3.3.2	Other Wetlands converted to Woody Grassland	SOM direct	N2O	0.00	0.00	209.23	211.92	297.80	0.0000

A			B	C	D	E	F	G	H ²²¹
Source category	Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015	
			[kt CO ₂ equivalent]	[kt CO ₂ equivalent]					[%]
4.C.2.3.2.2	Flooded Land converted to Woody Grassland	Mineral soils	CO2	0.00	0.00	48.90	83.27	96.57	0.0000
4.C.2.3.2.2	Flooded Land converted to Woody Grassland	Organic soils	CO2	4.40	1.64	23.40	24.60	33.95	0.0000
4.(II).C	Flooded Land converted to Woody Grassland	Organic soils	CH4	0.06	0.02	23.40	1,011.57	1,011.84	0.0000
4.(II).C	Flooded Land converted to Woody Grassland	Organic soils	N2O	0.35	0.13	23.40	200.69	202.05	0.0000
4.C.2.3.2.2	Flooded Land converted to Woody Grassland	Biomasse	CO2	-31.18	-7.76	39.98	55.21	68.17	0.0000
4.(IV).2	Flooded Land converted to Woody Grassland	SOM indirect	N2O	0.00	0.00	48.90	302.75	306.67	0.0000
4.(III).C.2.3.2.2	Flooded Land converted to Woody Grassland	SOM direct	N2O	0.00	0.00	48.90	222.34	227.65	0.0000
4.C.2.4.2	Settlements converted to Woody Grassland	Mineral soils	CO2	-71.48	-74.52	26.09	59.71	65.16	0.0016
4.C.2.4.2	Settlements converted to Woody Grassland	Organic soils	CO2	6.32	5.16	20.45	24.60	31.99	0.0000
4.(II).C	Settlements converted to Woody Grassland	Organic soils	CH4	0.09	0.07	20.45	1,011.57	1,011.78	0.0000
4.(II).C	Settlements converted to Woody Grassland	Organic soils	N2O	0.50	0.41	20.45	200.69	201.73	0.0000
4.C.2.4.2	Settlements converted to Woody Grassland	Biomass	CO2	-155.73	-78.59	25.12	44.15	50.79	0.0011
4.(IV).2	Settlements converted to Woody Grassland	SOM indirect	N2O	0.00	0.00	26.09	297.13	298.28	0.0000
4.(III).C.2.4.2	Settlements converted to Woody Grassland	SOM direct	N2O	0.00	0.00	26.09	214.63	216.21	0.0000
4.C.2.5.2	Other Land converted to Woody Grassland	Mineral soils	CO2	-7.68	-10.27	95.98	62.02	114.27	0.0001
4.C.2.5.2	Other Land converted to Woody Grassland	Organic soils	CO2	0.00	0.00	0.00	24.60	24.60	0.0000
4.(II).C	Other Land converted to Woody Grassland	Organic soils	CH4	0.00	0.00	0.00	1,011.57	1,011.57	0.0000
4.(II).C	Other Land converted to Woody Grassland	Organic soils	N2O	0.00	0.00	0.00	200.69	200.69	0.0000
4.C.2.5.2	Other Land converted to Woody Grassland	Biomass	CO2	-18.87	0.00	95.98	55.21	110.73	0.0000
4.(IV).2	Other Land converted to Woody Grassland	SOM indirect	N2O	0.00	0.00	95.98	297.60	312.70	0.0000
4.(III).C.2.5.2	Other Land converted to Woody Grassland	SOM direct	N2O	0.00	0.00	95.98	215.28	235.71	0.0000
4.D.1.3	Other Wetlands remaining Other Wetlands	Mineral soils	CO2	0.00	0.00	41.38	52.48	66.83	0.0000
4.D.1.3	Other Wetlands remaining Other Wetlands	Organic soils	CO2	1,523.36	1,403.22	3.38	59.94	60.03	0.4896
4.(II).D.3	Other Wetlands remaining Other Wetlands	Organic soils	CH4	31.96	29.44	3.38	669.85	669.86	0.0268
4.(II).D.3	Other Wetlands remaining Other Wetlands	Organic soils	N2O	11.97	11.03	3.38	306.18	306.20	0.0008
4.D.1.3	Other Wetlands remaining Other Wetlands	Biomass	CO2	0.00	0.00	6.16	43.49	43.93	0.0000
4.D.2.1.3	Forest Land converted to Other Wetlands	Mineral soils	CO2	-3.29	-1.75	96.26	28.49	100.39	0.0000
4.D.2.1.3	Forest Land converted to Other Wetlands	Organic soils	CO2	19.03	92.46	30.98	59.94	67.47	0.0027
4.(II).D.3	Forest Land converted to Other Wetlands	Organic soils	CH4	0.40	1.94	30.98	669.85	670.57	0.0001
4.(II).D.3	Forest Land converted to Other Wetlands	Organic soils	N2O	0.15	0.73	30.98	306.18	307.74	0.0000
4.D.2.1.3	Forest Land converted to Other Wetlands	Biomass	CO2	3.39	7.88	53.11	21.65	57.35	0.0000
4.D.2.1.3	Forest Land converted to Other Wetlands	Dead organic matter	CO2	7.08	4.56	53.11	6.16	53.46	0.0000
4.(IV).2	Forest Land converted to Other Wetlands	SOM indirect	N2O	0.00	0.00	96.26	288.17	303.82	0.0000
4.(III).D.2.1.3	Forest Land converted to Other Wetlands	SOM direct	N2O	0.00	0.00	96.26	202.03	223.79	0.0000

A			B	C	D	E	F	G	H ²²¹
Source category		Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015
				[kt CO ₂ equivalent]	[kt CO ₂ equivalent]	[%]	[%]	[%]	[%]
4.D.2.2.3	Cropland converted to Other Wetlands	Mineral soils	CO2	-1.02	-0.63	66.19	36.76	75.71	0.0000
4.D.2.2.3	Cropland converted to Other Wetlands	Organic soils	CO2	38.49	15.83	20.21	59.94	63.25	0.0001
4.(II).D.3	Cropland converted to Other Wetlands	Organic soils	CH4	0.81	0.33	20.21	669.85	670.16	0.0000
4.(II).D.3	Cropland converted to Other Wetlands	Organic soils	N2O	0.30	0.12	20.21	306.18	306.84	0.0000
4.D.2.2.3	Cropland converted to Other Wetlands	Biomass	CO2	-6.35	-2.54	22.82	32.45	39.67	0.0000
4.(IV).2	Cropland converted to Other Wetlands	SOM indirect	N2O	0.00	0.00	66.19	293.38	300.76	0.0000
4.(III).D.2.2.3	Cropland converted to Other Wetlands	SOM direct	N2O	0.00	0.00	66.19	209.41	219.62	0.0000
4.D.2.3.1.3	Grassland i.s.s. converted to Other Wetlands	Mineral soils	CO2	0.63	2.45	100.93	47.36	111.49	0.0000
4.D.2.3.1.3	Grassland i.s.s. converted to Other Wetlands	Organic soils	CO2	111.01	257.46	15.26	59.94	61.85	0.0175
4.(II).D.3	Grassland i.s.s. converted to Other Wetlands	Organic soils	CH4	2.33	5.40	15.26	669.85	670.03	0.0009
4.(II).D.3	Grassland i.s.s. converted to Other Wetlands	Organic soils	N2O	0.87	2.02	15.26	306.18	306.56	0.0000
4.D.2.3.1.3	Grassland i.s.s. converted to Other Wetlands	Biomass	CO2	-15.90	-40.87	21.26	32.97	39.24	0.0002
4.(IV).2	Grassland i.s.s. converted to Other Wetlands	SOM indirect	N2O	0.01	0.06	100.93	294.90	311.69	0.0000
4.(III).D.2.3.1.3	Grassland i.s.s. converted to Other Wetlands	SOM direct	N2O	0.06	0.25	100.93	211.53	234.37	0.0000
4.D.2.3.2.3	Woody Grassland converted to Other Wetlands	Mineral soils	CO2	-0.03	-0.01	197.08	49.10	203.11	0.0000
4.D.2.3.2.3	Woody Grassland converted to Other Wetlands	Organic soils	CO2	22.42	9.69	32.28	59.94	68.08	0.0000
4.(II).D.3	Woody Grassland converted to Other Wetlands	Organic soils	CH4	0.47	0.20	32.28	669.85	670.63	0.0000
4.(II).D.3	Woody Grassland converted to Other Wetlands	Organic soils	N2O	0.18	0.08	32.28	306.18	307.87	0.0000
4.D.2.3.2.3	Woody Grassland converted to Other Wetlands	Biomass	CO2	6.42	0.29	40.76	34.60	53.47	0.0000
4.(IV).2	Woody Grassland converted to Other Wetlands	SOM indirect	N2O	0.00	0.00	197.08	295.18	354.93	0.0000
4.(III).D.2.3.2.3	Woody Grassland converted to Other Wetlands	SOM direct	N2O	0.00	0.00	197.08	211.92	289.40	0.0000
4.D.1.6	Flooded Land converted to Other Wetlands	Mineral soils	CO2	0.00	0.00	200.60	52.48	207.35	0.0000
4.D.1.6	Flooded Land converted to Other Wetlands	Organic soils	CO2	7.31	4.84	34.36	59.94	69.09	0.0000
4.(II).D.3	Flooded Land converted to Other Wetlands	Organic soils	CH4	0.15	0.10	34.36	669.85	670.73	0.0000
4.(II).D.3	Flooded Land converted to Other Wetlands	Organic soils	N2O	0.06	0.04	34.36	306.18	308.10	0.0000
4.D.1.6	Flooded Land converted to Other Wetlands	Biomasse	CO2	-4.17	-1.12	123.37	43.49	130.81	0.0000
4.(IV).2	Flooded Land converted to Other Wetlands	SOM indirect	N2O	0.00	0.00	200.60	295.76	357.37	0.0000
4.(III).D.1.6	Flooded Land converted to Other Wetlands	SOM direct	N2O	0.00	0.00	200.60	212.73	292.39	0.0000
4.D.2.4.3	Settlements converted to Other Wetlands	Mineral soils	CO2	-1.12	-0.28	103.58	47.63	114.01	0.0000
4.D.2.4.3	Settlements converted to Other Wetlands	Organic soils	CO2	4.26	18.41	73.04	59.94	94.49	0.0002
4.(II).D.3	Settlements converted to Other Wetlands	Organic soils	CH4	0.09	0.39	73.04	669.85	673.82	0.0000
4.(II).D.3	Settlements converted to Other Wetlands	Organic soils	N2O	0.03	0.14	73.04	306.18	314.77	0.0000
4.D.2.4.3	Settlements converted to Other Wetlands	Biomass	CO2	-0.75	-4.28	83.68	32.38	89.73	0.0000
4.(IV).2	Settlements converted to Other Wetlands	SOM indirect	N2O	0.00	0.00	103.58	294.94	312.60	0.0000
4.(III).D.2.4.3	Settlements converted to Other Wetlands	SOM direct	N2O	0.00	0.00	103.58	211.59	235.58	0.0000

A			B	C	D	E	F	G	H ²²¹
Source category	Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015	
			[kt CO ₂ equivalent]	[kt CO ₂ equivalent]					[%]
4.D.2.5.3	Other Land converted to Other Wetlands	Mineral soils	CO2	0.00	0.00	0.00	49.85	49.85	0.0000
4.D.2.5.3	Other Land converted to Other Wetlands	Organic soils	CO2	0.00	0.00	0.00	59.94	59.94	0.0000
4.(II).D.3	Other Land converted to Other Wetlands	Organic soils	CH4	0.00	0.00	0.00	669.85	669.85	0.0000
4.(II).D.3	Other Land converted to Other Wetlands	Organic soils	N2O	0.00	0.00	0.00	306.18	306.18	0.0000
4.D.2.5.3	Other Land converted to Other Wetlands	Biomass	CO2	0.00	0.00	0.00	43.49	43.49	0.0000
4.(IV).2	Other Land converted to Other Wetlands	SOM indirect	N2O	0.00	0.00	0.00	295.31	295.31	0.0000
4.(III).D.2.5.3	Other Land converted to Other Wetlands	SOM direct	N2O	0.00	0.00	0.00	212.10	212.10	0.0000
4.D.1.2	Flooded Land remaining Flooded Land	Mineral soils	CO2	0.00	0.00	5.77	0.00	5.77	0.0000
4.D.1.2	Flooded Land remaining Flooded Land	Organic soils	CO2	0.00	0.00	4.90	0.00	4.90	0.0000
4.(II).D.2	Flooded Land remaining Flooded Land	Organic soils	CH4	0.00	0.00	4.90	0.00	4.90	0.0000
4.(II).D.2	Flooded Land remaining Flooded Land	Organic soils	N2O	0.00	0.00	4.90	0.00	4.90	0.0000
4.D.1.2	Flooded Land remaining Flooded Land	Biomass	CO2	0.00	0.00	5.62	0.00	5.62	0.0000
4.D.2.1.2	Forest Land converted to Flooded Land	Mineral soils	CO2	0.00	0.00	53.30	11.25	54.47	0.0000
4.D.2.1.2	Forest Land converted to Flooded Land	Organic soils	CO2	0.00	0.00	34.27	0.00	34.27	0.0000
4.(II).D	Forest Land converted to Flooded Land	Organic soils	CH4	0.00	0.00	34.27	0.00	34.27	0.0000
4.(II).D	Forest Land converted to Flooded Land	Organic soils	N2O	0.00	0.00	34.27	0.00	34.27	0.0000
4.D.2.1.2	Forest Land converted to Flooded Land	Biomass	CO2	51.34	14.36	51.22	24.95	56.98	0.0000
4.D.2.1.2	Forest Land converted to Flooded Land	Dead organic matter	CO2	37.07	5.43	51.22	6.16	51.59	0.0000
4.(IV).2	Forest Land converted to Flooded Land	SOM indirect	N2O	0.00	0.00	53.30	286.97	291.88	0.0000
4.(III).D.2.1.2	Forest Land converted to Flooded Land	SOM direct	N2O	0.00	0.00	53.30	200.33	207.30	0.0000
4.D.2.2.2	Cropland converted to Flooded Land	Mineral soils	CO2	0.00	0.00	30.90	50.50	59.21	0.0000
4.D.2.2.2	Cropland converted to Flooded Land	Organic soils	CO2	0.00	0.00	16.53	0.00	16.53	0.0000
4.(II).D.2	Cropland converted to Flooded Land	Organic soils	CH4	0.00	0.00	16.53	0.00	16.53	0.0000
4.(II).D.2	Cropland converted to Flooded Land	Organic soils	N2O	0.00	0.00	16.53	0.00	16.53	0.0000
4.D.2.2.2	Cropland converted to Flooded Land	Biomass	CO2	25.45	7.42	28.91	11.47	31.11	0.0000
4.(IV).2	Cropland converted to Flooded Land	SOM indirect	N2O	0.00	0.00	30.90	295.42	297.03	0.0000
4.(III).D.2.2.2	Cropland converted to Flooded Land	SOM direct	N2O	0.00	0.00	30.90	212.25	214.49	0.0000
4.D.2.3.1.2	Grassland i.s.s. converted to Flooded Land	Mineral soils	CO2	0.00	0.00	22.26	77.87	80.99	0.0000
4.D.2.3.1.2	Grassland i.s.s. converted to Flooded Land	Organic soils	CO2	0.00	0.00	17.41	0.00	17.41	0.0000
4.(II).D.2	Grassland i.s.s. converted to Flooded Land	Organic soils	CH4	0.00	0.00	17.41	0.00	17.41	0.0000
4.(II).D.2	Grassland i.s.s. converted to Flooded Land	Organic soils	N2O	0.00	0.00	17.41	0.00	17.41	0.0000
4.D.2.3.1.2	Grassland i.s.s. converted to Flooded Land	Biomass	CO2	28.96	10.02	20.31	30.30	36.47	0.0000
4.(IV).2	Grassland i.s.s. converted to Flooded Land	SOM indirect	N2O	0.00	0.00	22.26	301.31	302.13	0.0000
4.(III).D.2.3.1.2	Grassland i.s.s. converted to Flooded Land	SOM direct	N2O	0.00	0.00	22.26	220.37	221.49	0.0000

A			B	C	D	E	F	G	H ²²¹
Source category		Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015
				[kt CO ₂ equivalent]	[kt CO ₂ equivalent]	[%]	[%]	[%]	[%]
4.D.2.2.2.2	Woody Grassland converted to Flooded Land	Mineral soils	CO2	0.00	0.00	80.26	83.27	115.66	0.0000
4.D.2.2.2.2	Woody Grassland converted to Flooded Land	Organic soils	CO2	0.00	0.00	68.65	0.00	68.65	0.0000
4.(II).D.2	Woody Grassland converted to Flooded Land	Organic soils	CH4	0.00	0.00	68.65	0.00	68.65	0.0000
4.(II).D.2	Woody Grassland converted to Flooded Land	Organic soils	N2O	0.00	0.00	68.65	0.00	68.65	0.0000
4.D.2.2.2.2	Woody Grassland converted to Flooded Land	Biomass	CO2	29.11	0.50	75.19	55.21	93.28	0.0000
4.(IV).2	Woody Grassland converted to Flooded Land	SOM indirect	N2O	0.00	0.00	80.26	302.75	313.21	0.0000
4.(III).D.2.2.2.2	Woody Grassland converted to Flooded Land	SOM direct	N2O	0.00	0.00	80.26	222.34	236.38	0.0000
4.D.1.5	Other Wetlands converted to Flooded Land	Mineral soils	CO2	0.00	0.00	209.23	52.48	215.71	0.0000
4.D.1.5	Other Wetlands converted to Flooded Land	Organic soils	CO2	0.00	0.00	53.32	0.00	53.32	0.0000
4.(II).D.2	Other Wetlands converted to Flooded Land	Organic soils	CH4	0.00	0.00	53.32	0.00	53.32	0.0000
4.(II).D.2	Other Wetlands converted to Flooded Land	Organic soils	N2O	0.00	0.00	53.32	0.00	53.32	0.0000
4.D.1.5	Other Wetlands converted to Flooded Land	Biomass	CO2	1.45	0.89	70.06	43.49	82.46	0.0000
4.(IV).2	Other Wetlands converted to Flooded Land	SOM indirect	N2O	0.00	0.00	209.23	295.76	362.29	0.0000
4.(III).D.1.5	Other Wetlands converted to Flooded Land	SOM direct	N2O	0.00	0.00	209.23	212.73	298.38	0.0000
4.D.2.4.2	Settlements converted to Flooded Land	Mineral soils	CO2	0.00	0.00	42.13	84.97	94.84	0.0000
4.D.2.4.2	Settlements converted to Flooded Land	Organic soils	CO2	0.00	0.00	52.69	0.00	52.69	0.0000
4.(II).D.2	Settlements converted to Flooded Land	Organic soils	CH4	0.00	0.00	52.69	0.00	52.69	0.0000
4.(II).D.2	Settlements converted to Flooded Land	Organic soils	N2O	0.00	0.00	52.69	0.00	52.69	0.0000
4.D.2.4.2	Settlements converted to Flooded Land	Biomass	CO2	33.09	18.88	41.40	47.87	63.29	0.0001
4.(IV).2	Settlements converted to Flooded Land	SOM indirect	N2O	0.00	0.00	42.13	303.22	306.13	0.0000
4.(III).D.2.4.2	Settlements converted to Flooded Land	SOM direct	N2O	0.00	0.00	42.13	222.98	226.92	0.0000
4.D.2.5.2	Other Land converted to Flooded Land	Mineral soils	CO2	0.00	0.00	83.91	92.86	125.15	0.0000
4.D.2.5.2	Other Land converted to Flooded Land	Organic soils	CO2	0.00	0.00	153.04	0.00	153.04	0.0000
4.(II).D.2	Other Land converted to Flooded Land	Organic soils	CH4	0.00	0.00	153.04	0.00	153.04	0.0000
4.(II).D.2	Other Land converted to Flooded Land	Organic soils	N2O	0.00	0.00	153.04	0.00	153.04	0.0000
4.D.2.5.2	Other Land converted to Flooded Land	Biomass	CO2	0.00	0.00	83.91	0.00	83.91	0.0000
4.(IV).2	Other Land converted to Flooded Land	SOM indirect	N2O	0.00	0.00	83.91	305.52	316.84	0.0000
4.(III).D.2.5.2	Other Land converted to Flooded Land	SOM direct	N2O	0.00	0.00	83.91	226.10	241.17	0.0000
4.D.1.1	Peat Extraction remaining Peat Extraction	Organic soils	CO2	2,146.75	2,183.65	3.06	37.39	37.52	0.4630
4.(II).D.1	Peat Extraction remaining Peat Extraction	Organic soils	CH4	5.56	5.56	3.06	92.86	92.91	0.0000
4.(II).D.1	Peat Extraction remaining Peat Extraction	Organic soils	N2O	7.92	7.92	3.06	63.27	63.35	0.0000
4.D.1.1	Peat Extraction remaining Peat Extraction	Biomass	CO2	0.00	0.00	3.06	0.00	3.06	0.0000

A			B	C	D	E	F	G	H ²²¹
Source category		Pool	Gas	Base year emissions or removals [kt CO ₂ equivalent]	Year 2015 emissions or removals [kt CO ₂ equivalent]	Activity data uncertainty [%]	Emission factor uncertainty [%]	Combined uncertainty [%]	Contribution to Variance by Category in Year 2015 [%]
4.E.1	Settlements remaining Settlements	Mineral soils	CO2	0.00	0.00	2.54	84.97	85.00	0.0000
4.E.1	Settlements remaining Settlements	Organic soils	CO2	636.59	1,011.35	3.06	55.35	55.44	0.2169
4.(II).H.1	Settlements remaining Settlements	Organic soils	CH4	13.49	21.43	3.06	258.59	258.61	0.0021
4.(II).H.1	Settlements remaining Settlements	Organic soils	N2O	29.66	47.13	3.06	222.68	222.70	0.0076
4.E.1	Settlements remaining Settlements	Biomass	CO2	0.00	0.00	2.50	47.87	47.93	0.0000
4.E.2.1	Forest Land converted to Settlements	Mineral soils	CO2	-125.96	53.18	13.85	40.85	43.13	0.0004
4.E.2.1	Forest Land converted to Settlements	Organic soils	CO2	19.12	47.47	21.57	55.35	59.41	0.0005
4.(II).H.1	Forest Land converted to Settlements	Organic soils	CH4	0.41	1.01	21.57	258.59	259.49	0.0000
4.(II).H.1	Forest Land converted to Settlements	Organic soils	N2O	0.89	2.21	21.57	222.68	223.72	0.0000
4.E.2.1	Forest Land converted to Settlements	Biomass	CO2	284.58	716.15	13.71	22.18	26.07	0.0241
4.E.2.1	Forest Land converted to Settlements	Dead organic matter	CO2	361.66	351.12	13.71	6.16	15.03	0.0019
4.(IV).2	Forest Land converted to Settlements	SOM indirect	N2O	0.00	0.84	13.85	289.65	289.98	0.0000
4.(III).E.2.1	Forest Land converted to Settlements	SOM direct	N2O	0.00	3.74	13.85	204.14	204.61	0.0000
4.E.2.2	Cropland converted to Settlements	Mineral soils	CO2	89.40	133.18	8.15	49.15	49.83	0.0030
4.E.2.2	Cropland converted to Settlements	Organic soils	CO2	213.70	317.84	10.34	55.35	56.31	0.0221
4.(II).H.1	Cropland converted to Settlements	Organic soils	CH4	4.53	6.74	10.34	258.59	258.80	0.0002
4.(II).H.1	Cropland converted to Settlements	Organic soils	N2O	9.96	14.81	10.34	222.68	222.92	0.0008
4.E.2.2	Cropland converted to Settlements	Biomass	CO2	-487.40	-620.08	7.98	31.65	32.64	0.0283
4.(IV).2	Cropland converted to Settlements	SOM indirect	N2O	2.09	3.11	8.15	295.19	295.30	0.0001
4.(III).E.2.2	Cropland converted to Settlements	SOM direct	N2O	9.29	13.84	8.15	211.93	212.09	0.0006
4.E.2.3.1	Grassland i.s.s. converted to Settlements	Mineral soils	CO2	569.15	787.56	10.63	57.48	58.46	0.1462
4.E.2.3.1	Grassland i.s.s. converted to Settlements	Organic soils	CO2	173.48	431.55	10.45	55.35	56.33	0.0408
4.(II).H.1	Grassland i.s.s. converted to Settlements	Organic soils	CH4	3.68	9.15	10.45	258.59	258.80	0.0004
4.(II).H.1	Grassland i.s.s. converted to Settlements	Organic soils	N2O	8.08	20.11	10.45	222.68	222.93	0.0014
4.E.2.3.1	Grassland i.s.s. converted to Settlements	Biomass	CO2	-179.12	-267.02	10.23	32.77	34.33	0.0058
4.(IV).2	Grassland i.s.s. converted to Settlements	SOM indirect	N2O	12.89	17.84	10.63	296.69	296.88	0.0019
4.(III).E.2.3.1	Grassland i.s.s. converted to Settlements	SOM direct	N2O	57.31	79.30	10.63	214.02	214.28	0.0199
4.E.2.3.2	Woody Grassland converted to Settlements	Mineral soils	CO2	67.59	35.83	30.75	59.71	67.17	0.0004
4.E.2.3.2	Woody Grassland converted to Settlements	Organic soils	CO2	30.38	15.82	27.26	55.35	61.70	0.0001
4.(II).H.1	Woody Grassland converted to Settlements	Organic soils	CH4	0.64	0.34	27.26	258.59	260.02	0.0000
4.(II).H.1	Woody Grassland converted to Settlements	Organic soils	N2O	1.42	0.74	27.26	222.68	224.35	0.0000
4.E.2.3.2	Woody Grassland converted to Settlements	Biomass	CO2	149.20	113.18	29.45	44.15	53.07	0.0025
4.(IV).2	Woody Grassland converted to Settlements	SOM indirect	N2O	1.59	0.84	30.75	297.13	298.72	0.0000
4.(III).E.2.3.2	Woody Grassland converted to Settlements	SOM direct	N2O	7.06	3.74	30.75	214.63	216.82	0.0000

A			B	C	D	E	F	G	H ²²¹
Source category		Pool	Gas	Base year emissions or removals	Year 2015 emissions or removals	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance by Category in Year 2015
				[kt CO ₂ equivalent]	[kt CO ₂ equivalent]	[%]	[%]	[%]	[%]
4.E.2.4.3	Other Wetlands converted to Settlements	Mineral soils	CO2	0.00	0.00	0.00	47.63	47.63	0.0000
4.E.2.4.3	Other Wetlands converted to Settlements	Organic soils	CO2	52.16	179.34	28.56	55.35	62.29	0.0086
4.(II).H.1	Other Wetlands converted to Settlements	Organic soils	CH4	1.11	3.80	28.56	258.59	260.16	0.0001
4.(II).H.1	Other Wetlands converted to Settlements	Organic soils	N2O	2.43	8.36	28.56	222.68	224.51	0.0002
4.E.2.4.3	Other Wetlands converted to Settlements	Biomass	CO2	2.27	0.70	28.56	32.38	43.17	0.0000
4.(IV).2	Other Wetlands converted to Settlements	SOM indirect	N2O	0.00	0.00	0.00	294.94	294.94	0.0000
4.(III).E.2.4.3	Other Wetlands converted to Settlements	SOM direct	N2O	0.00	0.00	0.00	211.59	211.59	0.0000
4.E.2.4.2	Flooded Land converted to Settlements	Mineral soils	CO2	0.00	0.00	29.78	84.97	90.03	0.0000
4.E.2.4.2	Flooded Land converted to Settlements	Organic soils	CO2	6.90	4.23	34.64	55.35	65.30	0.0000
4.(II).H.1	Flooded Land converted to Settlements	Organic soils	CH4	0.15	0.09	34.64	258.59	260.90	0.0000
4.(II).H.1	Flooded Land converted to Settlements	Organic soils	N2O	0.32	0.20	34.64	222.68	225.36	0.0000
4.E.2.4.2	Flooded Land converted to Settlements	Biomass	CO2	-30.62	-4.70	29.02	47.87	55.98	0.0000
4.(IV).2	Flooded Land converted to Settlements	SOM indirect	N2O	0.00	0.00	29.78	303.22	304.68	0.0000
4.(III).E.2.4.2	Flooded Land converted to Settlements	SOM direct	N2O	0.00	0.00	29.78	222.98	224.96	0.0000
4.E.2.5	Other Land converted to Settlements	Mineral soils	CO2	-4.61	-5.13	57.26	62.80	84.99	0.0000
4.E.2.5	Other Land converted to Settlements	Organic soils	CO2	1.01	0.42	91.47	55.35	106.92	0.0000
4.(II).H.1	Other Land converted to Settlements	Organic soils	CH4	0.02	0.01	91.47	258.59	274.29	0.0000
4.(II).H.1	Other Land converted to Settlements	Organic soils	N2O	0.05	0.02	91.47	222.68	240.74	0.0000
4.E.2.5	Other Land converted to Settlements	Biomass	CO2	-18.85	0.00	56.95	47.87	74.39	0.0000
4.(IV).2	Other Land converted to Settlements	SOM indirect	N2O	0.00	0.00	57.26	297.77	303.23	0.0000
4.(III).E.2.5	Other Land converted to Settlements	SOM direct	N2O	0.00	0.00	57.26	215.51	222.99	0.0000
4.F.1	Other Land remaining Other Land	Mineral soils	CO2	0.00	0.00	40.19	92.86	101.18	0.0000
4.F.1	Other Land remaining Other Land	Organic soils	CO2	0.00	0.00	344.73	0.00	344.73	0.0000
4.(II).H.2	Other Land remaining Other Land	Organic soils	CH4	0.00	0.00	344.73	0.00	344.73	0.0000
4.(II).H.2	Other Land remaining Other Land	Organic soils	N2O	0.00	0.00	344.73	0.00	344.73	0.0000
4.F.1	Other Land remaining Other Land	Biomass	CO2	0.00	0.00	40.19	0.00	40.19	0.0000
Total				-29,708.35	-12,353.60	Percentage uncertainty in total LULUCF			23.26

19.5 Other detailed methodological descriptions for the category "Waste and wastewater" (6)

20 Annex 4: The CO₂ Reference Approach, a comparison of that approach with the Sectoral Approach, and relevant information on the national Energy Balance

General information

In general, the Reference Approach briefly described in Chapter 3.2.1.1 is to be suitable for all reporting countries. Such generalization and abstraction cannot help but lead to considerable discrepancies with the Sectoral Approach.

On the whole, the Sectoral Approach supports calculations that are considerably more differentiated and precise, with results that – especially at a detailed level – differ (sharply, in some cases) from those produced by the Reference Approach.

Efforts to eliminate errors in transfer of country-specific activity data into the Reference Approach structure have gotten underway in recent years. At the level of maximum aggregation, this work, which is being continued with the present submission, has brought the results achieved with the two calculation approaches into excellent agreement (cf. Chapter 3.2.1.1). On the other hand, a number of discrepancies at the *fuel* and *fuel-group* levels still persist. While these can be explained – at least in part – as the result of country-specific circumstances, it has not yet been possible to eliminate them in a satisfactory manner.

The Reference Approach will thus continue to offer room for further improvements. Notably, the comparability of the two approaches would benefit from extensive flexibilization of data management in the CRF Reporter, as well as from review, and any necessary revision, of the input data and calculation approaches used for the area of non-energy-related consumption.

20.1 Comparing the results: The Sectoral Approach and the Reference Approach

The following section compares results obtained in calculating CO₂ emissions via the Sectoral Approach with results obtained via the Reference Approach.

CRF report table 1.A(c) compares results obtained with the Sectoral Approach with results obtained with the Reference Approach. Since the non-energy-related consumption (NEV) of the fuels considered occurs elsewhere (industrial processes and product use), the quantities that must be assigned to such consumption, pursuant to the Energy Balances, are deducted from the Reference Approach. In addition to lubricants, bitumen and naphtha, this procedure is applied to diesel fuel, light and heavy fuel oil, LPG, petroleum coke and other oils, hard coal and lignite, coke and natural gas. For 2015, this approach yields an NEV of about 1,100 petajoules (cf. CRF Table 1.A(d) regarding the non-energy-related consumption).

To date, the CRF-Reporter has not included emissions from combustion of fossil-based waste in Table 1.A(c). For this reason, such emissions have most recently been listed in CRF 1.AB under "Other fossil fuels". The new version of the Reporter now available includes a new material category, "Waste". The existing category "Waste (non-biomass fraction)" has been retained. Since the comparison between CRFs 1.AA and 1.AB also seems to function properly, in this area, when the pertinent figures under CRF 1.AB are directly included in the material category "Waste (non-biomass fraction)", no need was seen to move the figures to 1.AB – "Other fossil fuels – Waste".

For peat, which is listed separately, identical emission factors and input quantities are used in 1.AA and 1.AB. For this reason, Table 1.A(c) shows no discrepancies in this area.

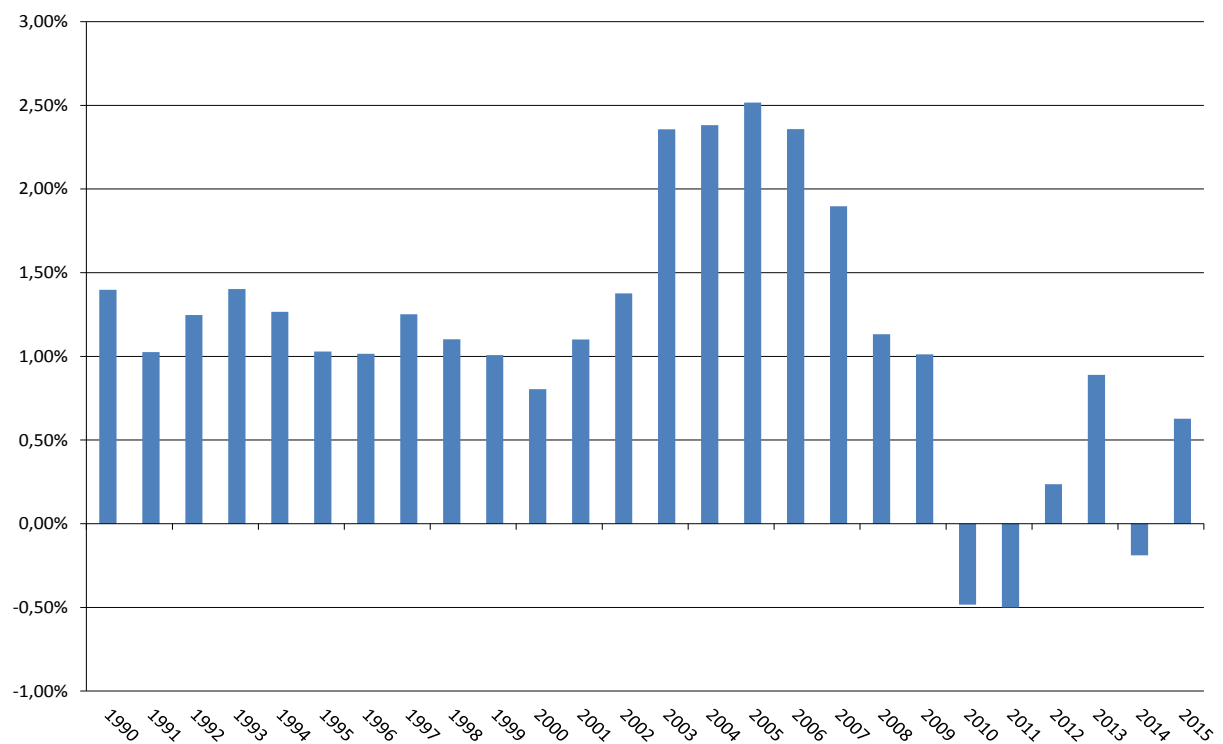
The following tables present further sample results of the comparison between the Sectoral Approach and the Reference Approach. For 2015, the Reference Approach yields fuel inputs that are 0.63 % higher and emissions that are 1.64 % lower (cf. Chapter 3.2.1.1).

Throughout the 1990-2014 period, almost all of the fuel inputs listed under the Reference Approach (less the quantities used for non-energy-related purposes) are higher than those listed under the Sectoral Approach.

Table 518: Comparison of the energy inputs determined via the Sectoral Approach (1.AA) and Reference Approach (1.AB) (in TJ; **boldface**: maximum positive and negative discrepancies)

	1.AA	1.AB (including non-energy-related consumption)	1.AB (excluding non-energy-related consumption)	1.AB (excluding non-energy-related consumption) minus 1.AA	
1990	11,653	12,932	11,818	165	1.40%
1991	11,487	12,657	11,606	119	1.03%
1992	11,025	12,228	11,164	139	1.25%
1993	11,031	12,207	11,188	157	1.40%
1994	10,828	12,067	10,966	139	1.27%
1995	10,896	12,096	11,009	113	1.03%
1996	11,315	12,503	11,431	116	1.02%
1997	10,901	12,188	11,040	138	1.25%
1998	10,856	12,141	10,977	121	1.10%
1999	10,561	11,798	10,668	107	1.01%
2000	10,515	11,791	10,600	85	0.80%
2001	10,795	12,048	10,915	120	1.10%
2002	10,573	11,861	10,720	148	1.38%
2003	10,568	11,880	10,823	255	2.36%
2004	10,375	11,666	10,628	253	2.38%
2005	10,156	11,480	10,419	262	2.52%
2006	10,295	11,617	10,543	249	2.36%
2007	9,882	11,077	10,073	191	1.90%
2008	10,044	11,094	10,159	115	1.13%
2009	9,389	10,306	9,485	96	1.01%
2010	9,854	10,718	9,806	-47	-0.48%
2011	9,524	10,363	9,476	-47	-0.50%
2012	9,558	10,437	9,581	23	0.24%
2013	9,808	10,775	9,896	88	0.89%
2014	9,232	10,105	9,215	-17	-0.19%
2015	9,243	10,172	9,302	58	0.63%

Figure 91: Percentage discrepancies between annual total activity data under the Reference Approach and the corresponding total quantities under the Sectoral Approach

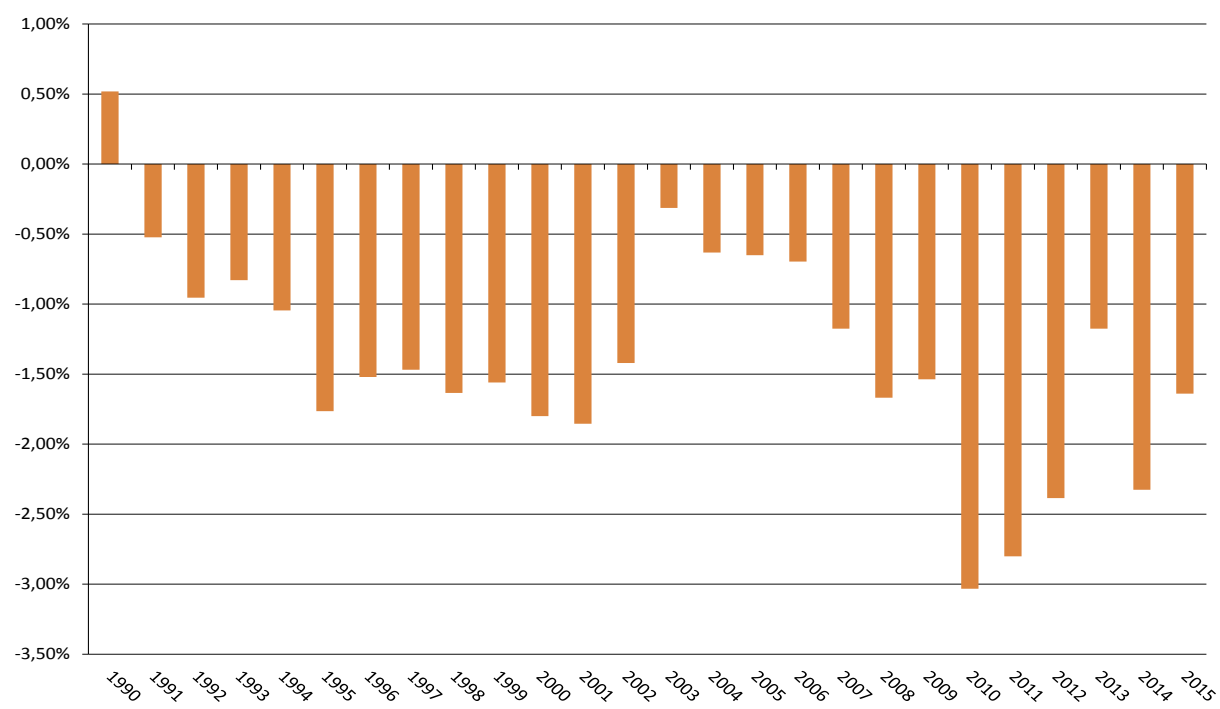


The situation is turned around for the carbon dioxide emissions calculated with the Reference Approach: those emissions are all lower – with the exception of those for 1990 – than those calculated with the Sectoral Approach (cf. Chapter 3.2.1.1).

Table 519: Comparison of the CO₂ emissions determined via the Sectoral Approach (1.AA) and Reference Approach (1.AB; not including non-energy-related consumption (NEV)) (boldface: maximum positive and negative discrepancies)

	1.AA	1.AB (excluding non-energy-related consumption)	1.AB (excluding non-energy-related consumption) minus 1.AA	
1990	985,705	990,816	5,111	0.52%
1991	951,895	946,912	-4,983	-0.52%
1992	906,738	898,086	-8,652	-0.95%
1993	897,065	889,621	-7,443	-0.83%
1994	878,341	869,158	-9,183	-1.05%
1995	877,613	862,119	-15,494	-1.77%
1996	899,631	885,954	-13,677	-1.52%
1997	869,199	856,428	-12,771	-1.47%
1998	862,567	848,464	-14,103	-1.63%
1999	837,299	824,233	-13,066	-1.56%
2000	836,167	821,114	-15,053	-1.80%
2001	858,626	842,707	-15,919	-1.85%
2002	843,864	831,873	-11,991	-1.42%
2003	840,786	838,152	-2,635	-0.31%
2004	826,529	821,303	-5,226	-0.63%
2005	808,180	802,917	-5,263	-0.65%
2006	819,086	813,380	-5,706	-0.70%
2007	793,859	784,529	-9,330	-1.18%
2008	799,054	785,718	-13,336	-1.67%
2009	742,572	731,158	-11,414	-1.54%
2010	781,387	757,690	-23,697	-3.03%
2011	760,961	739,644	-21,316	-2.80%
2012	766,404	748,123	-18,281	-2.39%
2013	784,763	775,535	-9,227	-1.18%
2014	744,253	726,938	-17,315	-2.33%
2015	741,775	729,614	-12,161	-1.64%

Figure 92: Percentage discrepancies between the annual carbon dioxide emissions as calculated with the Reference Approach and as calculated with the Sectoral Approach



21 Annex 5: Assessment of completeness, and of potentially excluded sources and sinks of greenhouse gas emissions

The following two tables show the sources for greenhouse gases that have not yet been directly reported in Germany's greenhouse-gas inventories to date. This refers to emissions for which the necessary bases for calculation are not available or which could be determined only at great effort. At the same time, the emissions need to conform to the negligibility criteria given in the definition of the notation keys "NE." The necessary estimates for such conformance are also listed.

In addition, a summary is provided of CRF Table 9(a), which lists emissions reported as "IE" at other locations in the inventory.

Additional information is presented in Chapter 1.8.

Table 520: Overview, for completeness, of sources and sinks whose emissions are not estimated (NE)

Emissions 2015		
kt CO ₂ equiv.	national total (without LULUCF)	901.932
kt CO ₂ equiv.	thereoff 0,1 %	902
kt CO ₂ equiv.	thereoff 0,05 %	451
Category CRF code	Category description	assumption for estimated emission (in kt CO₂ equiv.)
1.B.2.d	Geothermal Energy	< 1
2.A.4.c	Non-metallurgical magnesium production	< 100
2.B.4.a	Caprolactam*	10.7
2.B.6	Titan dioxid production	< 300
2.D.3	Asphalt - asphalt roofing	0.2
2.D.3	Asphalt - road paving	2.5
3.A.4	Deer	132
3.A.4	Rabbits	3.96
3.A.4	Fur-bearing animals	0.16
3.B(a).4	Deer	1.45
3.B(a).4	Fur-bearing animals	1.08
3.B(a).4	Rabbits	0.88
3.B(a).4	Ostrich	1.08
3.B(b).4	Deer	1E
3.B(b).4	Fur-bearing animals	1.77
3.B(b).4	Rabbits	2.14
3.B(b).4	Ostrich	0.06
3.B(b).5	Indirect emissions	1.02
3.D	Direct and indirect N ₂ O emissions from Agricultural Soils	28.3
5.A	Flaring	0.0006
Sum	≈	589

* (currently not in CRF tables due to late review issue → fixed in next submission)

Table 521: Overview, for completeness, of sources and sinks that are reported elsewhere (included elsewhere, IE)

Source/sink category	GHG	Allocation used by the Party / Explanation
1.A.2 Manufacturing Industries and Construction/1.A.2.a Iron and Steel	CO ₂	The use of reducing agents is part of the carbon balance. Emissions were reported under blast furnace gas incineration (solid fuels).
1.A.2 Manufacturing Industries and Construction/1.A.2.a Iron and Steel/Biomass		
1.A.2 Manufacturing Industries and Construction/1.A.2.a Iron and Steel	CO ₂	The use of reducing agents is part of the carbon balance. Emissions were reported under blast furnace gas incineration (solid fuels).
1.A.2 Manufacturing Industries and Construction/1.A.2.a Iron and Steel/Other Fossil Fuels		
1.A.2 Manufacturing Industries and Construction/1.A.2.b Non-Ferrous Metals/Gaseous Fuels	CO ₂ , CH ₄ , N ₂ O	Emissions were reported in source category 1.A.2.g.viii because of confidential data.
1.A.2 Manufacturing Industries and Construction/1.A.2.b Non-Ferrous Metals		
1.A.2 Manufacturing Industries and Construction/1.A.2.c Chemicals	CO ₂ , CH ₄ , N ₂ O	Reported in source category 1.A.2.g.viii
1.A.2 Manufacturing Industries and Construction/1.A.2.c Chemicals/Gaseous Fuels		
1.A.2 Manufacturing Industries and Construction/1.A.2.c Chemicals	CO ₂ , CH ₄ , N ₂ O	Reported in source category 1.A.2.g.viii
1.A.2 Manufacturing Industries and Construction/1.A.2.c Chemicals/Liquid Fuels		
1.A.2 Manufacturing Industries and Construction/1.A.2.c Chemicals	CO ₂ , CH ₄ , N ₂ O	Reported in source category 1.A.2.g.viii
1.A.2 Manufacturing Industries and Construction/1.A.2.c Chemicals/Other Fossil Fuels		
1.A.2 Manufacturing Industries and Construction/1.A.2.c Chemicals	CO ₂ , CH ₄ , N ₂ O	Reported in source category 1.A.2.g.viii
1.A.2 Manufacturing Industries and Construction/1.A.2.c Chemicals/Solid Fuels		
1.A.2 Manufacturing Industries and Construction/1.A.2.d Pulp, Paper and Print	CO ₂ , CH ₄ , N ₂ O	Reported in source category 1.A.2.g.viii
1.A.2 Manufacturing Industries and Construction/1.A.2.d Pulp, Paper and Print/Gaseous Fuels		
1.A.2 Manufacturing Industries and Construction/1.A.2.d Pulp, Paper and Print	CO ₂ , CH ₄ , N ₂ O	Reported in source category 1.A.2.g.viii
1.A.2 Manufacturing Industries and Construction/1.A.2.d Pulp, Paper and Print/Liquid Fuels		
1.A.2 Manufacturing Industries and Construction/1.A.2.d Pulp, Paper and Print	CO ₂ , CH ₄ , N ₂ O	Reported in source category 1.A.2.g.viii
1.A.2 Manufacturing Industries and Construction/1.A.2.d Pulp, Paper and Print/Solid Fuels		
1.A.2 Manufacturing Industries and Construction/1.A.2.e Food Processing, Beverages and Tobacco	CO ₂ , CH ₄ , N ₂ O	Emissions were reported in source category 1.A.2.g.viii because of confidential data.
1.A.2 Manufacturing Industries and Construction/1.A.2.e Food Processing, Beverages and Tobacco/Gaseous Fuels		
1.A.3 Transport/1.A.3.b Road Transportation/1.A.3.b.v Other (please specify)/CO ₂ from lubricant co-incineration in 2-stroke road vehicles/Other Liquid Fuels (please specify)/lubricant used in 2-stroke mix	CH ₄ , N ₂ O	Already included in CH ₄ emissions from fuel combustion.
1.AD Feedstocks, reductants and other non-energy use of fuels/Liquid Fuels/Natural Gas Liquids	CO ₂	Included in Crude Oil.
1.AD Feedstocks, reductants and other non-energy use of fuels/Liquid Fuels/Orimulsion	CO ₂	Included in Crude Oil.
1.AD Feedstocks, reductants and other non-energy use of fuels/Liquid Fuels/Other Kerosene	CO ₂	Included in Jet Kerosene.
1.AD Feedstocks, reductants and other non-energy use of fuels/Liquid Fuels/Refinery Feedstocks	CO ₂	Included in Other Oil.
1.AD Feedstocks, reductants and other non-energy use of fuels/Solid Fuels/Anthracite	CO ₂	Included in Other Bituminous Coal.
1.AD Feedstocks, reductants and other non-energy use of fuels/Solid Fuels/Coking Coal	CO ₂	Included in Other Bituminous Coal.
1.AD Feedstocks, reductants and other non-energy use of fuels/Solid Fuels/Sub-bituminous Coal	CO ₂	Included in Other Bituminous Coal.
1.B Fugitive Emissions from Fuels/1.B.1 Solid Fuels/1.B.1.a Coal Mining and Handling/1.B.1.a.2 Surface Mines/1.B.1.a.2.ii Post-Mining Activities	CH ₄	already included in 1.B.1.a.2.i
1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.b Natural Gas/1.B.2.b.1 Exploration	CO ₂ , CH ₄	included in 1.B.2.a.i
1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.c Venting and Flaring/1.B.2.c.2 Flaring/1.B.2.c.2.ii Gas	CH ₄	included under 1.B.2.b
1.B Fugitive Emissions from Fuels/1.B.2 Oil and Natural Gas and Other Emissions from Energy Production/1.B.2.c Venting and Flaring/1.B.2.c.2 Flaring/1.B.2.c.2.iii Combined	CO ₂ , CH ₄ , N ₂ O	see 1.B.2.c.2.i and 1.B.2.c.2.ii

Source/sink category	GHG	Allocation used by the Party / Explanation
2.A Mineral Industry/2.A.4 Other Process Uses of Carbonates/2.A.4.d Other	CO2	1.A.1.a, 2.A.1, 2.A.2, 2.A.3, 2.A.4.a, 2.B.7, 2.C.1, 2.H.2, 3.G (all activities of using carbonates are described in NIR)
2.B Chemical Industry/2.B.4 Caprolactame, Glyoxal and Glyoxylic Acid/2.B.4.a Caprolactam	N2O	one plant included in 2.B.2 Nitric Acid production for consistency with ETS data (currently not in CRF tables due to late review issue → fixed in next submission)
2.B Chemical Industry/2.B.8 Petrochemical and Carbon Black Production/2.B.8.a Methanol	CO2, CH4	included in 2.B.8.g Petrochemicals
2.B Chemical Industry/2.B.8 Petrochemical and Carbon Black Production/2.B.8.b Ethylene	CO2, CH4	included in 2.B.8.g Petrochemicals
2.B Chemical Industry/2.B.8 Petrochemical and Carbon Black Production/2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer	CO2, CH4	included in 2.B.8.g Petrochemicals
2.B Chemical Industry/2.B.8 Petrochemical and Carbon Black Production/2.B.8.d Ethylene Oxide	CO2, CH4	included in 2.B.8.g Petrochemicals
2.B Chemical Industry/2.B.8 Petrochemical and Carbon Black Production/2.B.8.e Acrylonitrile	CO2, CH4	included in 2.B.8.g Petrochemicals
2.B Chemical Industry/2.B.9 Fluorochemical Production/2.B.9.a By-Product Emissions/2.B.9.a.1 Production of HCFC-22	HFC-23	The emissions are reported because of confidentiality reasons together with the other emissions from 2B9 as unspecified mix at 2.B.9 By product emissions as unspecified mix.
2.B Chemical Industry/2.B.9 Fluorochemical Production/2.B.9.a By-Product Emissions/2.B.9.a.1 Production of HCFC-22/HFC-23		
2.B Chemical Industry/2.B.9 Fluorochemical Production/2.B.9.b Fugitive Emissions/2.B.9.b.1 Production of HFC-134a	HFC-134a	The emissions are reported because of confidentiality reasons together with the other emissions from 2B9 as unspecified mix at 2.B.9 By product emissions as unspecified mix.
2.B Chemical Industry/2.B.9 Fluorochemical Production/2.B.9.b Fugitive Emissions/2.B.9.b.1 Production of HFC-134a/HFC-134a		
2.B Chemical Industry/2.B.9 Fluorochemical Production/2.B.9.b Fugitive Emissions/2.B.9.b.3 Other (please specify)/CF4/CF4	CF4	The emissions are reported because of confidentiality reasons together with the other emissions from 2B9 as unspecified mix at 2.B.9 By product emissions as unspecified mix.
2.C Metal Industry/2.C.1 Iron and Steel Production/2.C.1.c Direct Reduced Iron	CO2, CH4	is considered in CRF 1A2
2.C Metal Industry/2.C.1 Iron and Steel Production/2.C.1.d Sinter	CO2, CH4	is considered in CRF 1A2
2.F Product Uses as Substitutes for ODS/2.F.5 Solvents/C6F14	C6F14	The emissions are reported because of confidentiality reasons together with other confidential data at unspecified mix of HFCs at 2H3.
2.F Product Uses as Substitutes for ODS/2.F.5 Solvents/HFC-245fa	HFC-245fa	The emissions are reported because of confidentiality reasons together with other confidential data at unspecified mix of HFCs at 2H3.
2.F Product Uses as Substitutes for ODS/2.F.5 Solvents/HFC-365mfc	HFC-365mfc	The emissions are reported because of confidentiality reasons together with other confidential data at unspecified mix of HFCs at 2H3.
2.F Product Uses as Substitutes for ODS/2.F.5 Solvents/HFC-43-10mee	HFC-43-10mee	The emissions are reported because of confidentiality reasons together with other confidential data at unspecified mix of HFCs at 2H3.
2.G Other Product Manufacture and Use/2.G.2 SF6 and PFCs from Other Product Use/2.G.2.a Military Applications/SF6	SF6	The emissions are confidential and are reported at 2H3 as unspecified mix of HFCs.
2.G Other Product Manufacture and Use/2.G.2 SF6 and PFCs from Other Product Use/2.G.2.d Adiabatic Properties: Shoes and Tyres/C3F8	C3F8	The emissions are reported because of confidentiality reasons as Unspecified mix of HFCs at 2H3
2.G Other Product Manufacture and Use/2.G.2 SF6 and PFCs from Other Product Use/2.G.2.d Adiabatic Properties: Shoes and Tyres/SF6	SF6	The emissions are reported because of confidentiality reasons as Unspecified mix of HFCs at 2H3
2.G Other Product Manufacture and Use/2.G.2 SF6 and PFCs from Other Product Use/2.G.2.e Other (please specify)/Medical and cosmetic applications/C10F18	C10F18	The emissions are reported because of confidentiality reasons as Unspecified mix of HFCs at 2H3
2.G Other Product Manufacture and Use/2.G.2 SF6 and PFCs from Other Product Use/2.G.2.e Other (please specify)/Welding/SF6	SF6	The emissions are confidential and are reported at 2H3 as unspecified mix of HFCs
2.G Other Product Manufacture and Use/2.G.3 N2O from Product Uses/2.G.3.b Other/Other (please specify)/Explosives	N2O	The emissions are reported because of confidentiality reasons at 2G3a Medical Applications
2.G Other Product Manufacture and Use/2.G.3 N2O from Product Uses/2.G.3.b Other/Other (please specify)/Semiconductor production	N2O	The emissions are reported because of confidentiality reasons at 2G3a Medical Applications
2.G Other Product Manufacture and Use/2.G.3 N2O from Product Uses/2.G.3.b Other/Propellant for pressure and aerosol products	N2O	The emissions are reported because of confidentiality reasons at 2G3a Medical Applications

Source/sink category	GHG	Allocation used by the Party / Explanation
3.1 Livestock/3.A Enteric Fermentation/3.A.4 Other livestock/Buffalo	CH4	Buffalo: before 1996: NO, since 1996: IE; Buffalo are no longer treated as a separated category (included elsewhere, IE) in the inventory from 2015 onwards. See chapter 5.1.3.2.2
3.1 Livestock/3.A Enteric Fermentation/3.A.4 Other livestock/Mules and Asses	CH4	In the 2010 agricultural census and in the 2013 census, number of horses was raised instead of horse numbers. Their number includes donkeys and mules in an inseparable manner (included elsewhere, ie). See NIR chapter 5.1.3.2.2
3.1 Livestock/3.B Manure Management/3.B.1 CH4 Emissions/3.B.1.4 Other livestock/Buffalo	CH4	Buffalo: before 1996: NO, since 1996: IE; Buffalo are no longer treated as a separated category (included elsewhere, IE) in the inventory from 2015 onwards. See chapter 5.1.3.2.2
3.1 Livestock/3.B Manure Management/3.B.1 CH4 Emissions/3.B.1.4 Other livestock/Mules and Asses	CH4	In the 2010 agricultural census and in the 2013 census, number of horses was raised instead of horse numbers. Their number includes donkeys and mules in an inseparable manner (included elsewhere, ie). See NIR chapter 5.1.3.2.2
3.1 Livestock/3.B Manure Management/3.B.2 N2O and NMVOC Emissions/3.B.2.4 Other livestock/Buffalo	N2O	Buffalo: before 1996: NO, since 1996: IE; Buffalo are no longer treated as a separated category (included elsewhere, IE) in the inventory from 2015 onwards. See chapter 5.1.3.2.2
3.1 Livestock/3.B Manure Management/3.B.2 N2O and NMVOC Emissions/3.B.2.4 Other livestock/Mules and Asses	N2O	In the 2010 agricultural census and in the 2013 census, number of horses was raised instead of horse numbers. Their number includes donkeys and mules in an inseparable manner (included elsewhere, ie). See NIR chapter 5.1.3.2.2
3.I Other Carbon-containing Fertilizers	CO2	IE: Calcium ammonium nitrate is included in Liming. See respective NIR chapter.
4(IV) Indirect N2O Emissions from Managed Soils/Atmospheric Deposition	N2O	4 (IV) indirect emissions, atmospheric deposition: is included under 3.B.2.5 Indirect N2O Emissions (Agriculture)
4.A Forest Land/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Drained Organic Soils	CO2	4.A. (II) Emissions and removals from drainage and rewetting... drained organic soils: IE: under Carbon stock change
4.A Forest Land/4.A.1 Forest Land Remaining Forest Land/4(V) Biomass Burning/Wildfires	CO2	4.A. Biomass, wildfires, CO2 emissions: IE: included in carbon stock change.
4.A Forest Land/4.A.2 Land Converted to Forest Land/4(V) Biomass Burning/Wildfires	CO2, CH4, N2O	4A2 IE: 4.A.2 Biomass Burning: IE: included in forest land remaining forest land (see NIR chapter 6.4.2.7.5).
4.B Cropland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Drained Organic Soils	CO2	4.B (II) emissions and removals from drainage and rewetting drained organic soils: see NIR chapter 6.1.2.2.2 and 6.4.2.7.2, IE: under carbon stock change.
4.C Grassland/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils/Drained Organic Soils	CO2	4.C (II) emissions and removals from drainage and rewetting drained organic soils: see NIR chapter 6.1.2.2.2 and 6.4.2.7.2, IE: under carbon stock change.
4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Flooded Lands/Total Organic Soils/Drained Organic Soils	CO2, CH4, N2O	4.D (II) Emissions and removals from drainage and rewetting...flooded lands...drained organic soils: IE: under [Flooded Lands][Total Organic Soils][Other].
4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Flooded Lands/Total Organic Soils/Rewetted Organic Soils	CO2, CH4, N2O	4.D. (II): Emissions and removals...flooded land...rewetted organic soils: IE: under [Flooded Lands][Total Organic Soils][Other].
4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Other Wetlands (please specify)/Other/Total Organic Soils/Drained Organic Soils	CO2, CH4, N2O	4.D. (II) emissions and removals from drainage...drained organic soils: IE: under [Other Wetlands][Total Organic Soils][Other].
4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Other Wetlands (please specify)/Other/Total Organic Soils/Other (please specify)/Other	CO2	4.D (II) Emissions and removals from drainage... other wetlands...other: CO2 emissions: IE: in carbon stock change.
4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Other Wetlands (please specify)/Other/Total Organic Soils/Rewetted Organic Soils	CO2, CH4, N2O	4.D. (II) emissions and removals from drainage...rewetting organic soils: IE: under [Other Wetlands][Total Organic Soils][Other].
4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Organic Soils/Drained Organic Soils	CO2, CH4, N2O	4.D. Emissions and removal peat extraction...rewetting organic soils, CH4: IE: included in [Peat Extraction Lands][Total Organic Soils][Other].
4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Organic Soils/Other (please specify)/Other	CO2	4.D. (II) Emissions and removals from drainage ... peat extraction...other, CO2 emissions, IE: included in carbon stock change.
4.D Wetlands/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Peat Extraction Lands/Total Organic Soils/Rewetted Organic Soils	CO2, CH4, N2O	4.D. Emissions and removal peat extraction...rewetting organic soils, CH4: IE: included in [Peat Extraction Lands][Total Organic Soils][Other].

Source/sink category	GHG	Allocation used by the Party / Explanation
4.H Other (please specify)/Settlements/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils	CH4	[4.H Other][Settlements][4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils][Total Organic Soils]: CO2 emissions IE: under 4 E, Carbon stock change; CH4 emissions: IE under 4 E.
4.H Other (please specify)/Settlements/4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils/Total Organic Soils	CO2	4.H [4.H Other][Settlements][4(II) Emissions and removals from drainage and rewetting and other management of organic and mineral soils][Total Organic Soils]: CO2 emissions IE: under 4 E, Carbon stock change; CH4 emissions: IE under 4 E
5.D Wastewater Treatment and Discharge/5.D.2 Industrial Wastewater	CH4	Out of statistical reasons CH4-recovery from domestic and industrial treatment cannot be divided. Data are reported under 5.D.1

22 Annex 6: Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information

22.1 Additional information relative to inventory preparation and to the National System

22.1.1 Definitions in the "National System" principles paper on emissions reporting

In the "National System" principles paper on emissions reporting, state secretaries of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB); Federal Ministry of the Interior (BMI); Federal Ministry of Defence (BMVg); Federal Ministry of Finance (BMF); Federal Ministry for Economic Affairs and Energy (BMWi); Federal Ministry of Transport, Building and Urban Affairs (BMVBS) and Federal Ministry of Food and Agriculture (BMEL) defined responsibilities pertaining to the various relevant source and sink categories and to the necessary financing for 2008. The agreement reads as follows:

BMUB, BMI, BMVg, BMF, BMWi, BMVBS, BMEL Berlin, 5 June 2007

"National System" principles paper on emissions reporting

The state secretaries of the ministries concerned have determined as follows, by common consent, with regard to the issue of the "National System" for emissions reporting pursuant to Art. 5(1) Kyoto Protocol:

- 1st The Federal Environmental Agency, Section I 4.6²²² "Emissions Situation", is the responsible "Single national entity" (national co-ordinating agency) for reporting pursuant to the UN Framework Convention on Climate Change and the Kyoto Protocol. A country's Single National Entity is responsible for preparing the country's national inventory, working for continual improvement of the inventory, supporting those persons involved in the national system and preparing decisions of the Co-ordinating Committee.*
- 2nd A Co-ordinating Committee, representing all affected departments, has been established to deal with all questions arising in the framework of the National System, and to be responsible for official discussion and approval of the inventories and the reports required pursuant to Articles 5, 7 and 8 of the Kyoto Protocol. The Committee shall support all pertinent processes in this framework and, in particular, it shall clarify any pertinent uncertainties – for example, in connection with definition of individual emission factors.*

In particular, the Committee shall define key source and sink categories, and the minimum requirements pertaining to quality control and quality assurance for data collection and processing and to the annual quality control and quality assurance plan.

As necessary, the Committee may specify the methods to be used for calculating emissions in the various categories and for calculating storage in sink categories. The Committee is chaired by the BMUB. The Committee shall meet whenever at least one department sees a need for such a meeting. Subordinate authorities and other institutions involved in inventory preparation may be included in meetings as necessary.
- 3rd For preparation of the national inventory, such data shall be used, for calculations of emissions and reductions, as are required pursuant to the provisions of Art. 3 (1) of decision 280/2004/EC and of Art. 2 (1) of the Ground rules for calculating emissions in source categories and storage in sink categories.*

²²² Author's remark: currently, I 2.6.

Inventories shall be prepared on an annual basis. In addition, quality assurance in keeping with the requirements of Art. 12 of the rules shall be carried out. Furthermore, reliable documentation and archiving shall be required.

Existing data-transfer arrangements, such as those made on the basis of voluntary agreements or legal provisions, should not be fundamentally changed; they should only be completed and improved as necessary in order to provide a reliable database. For this reason, the aforementioned responsibilities do not necessarily include data collection and forwarding. With regard to division of responsibilities between BMU/UBA, BMVBS and BMWi, attention is called especially to Annex 1.

The responsibilities for ensuring proper data delivery to the Single National Entity, and for quality control, documentation and data archiving, shall be distributed as follows among the various relevant departments:

a) For category 1 (Energy) – with the exception of categories 1.A.3 (Transport) und 1.A.5a (Energy: other), where emissions sources of the German Federal Armed Forces (Bundeswehr) are concerned – the Federal Ministry for Economic Affairs and Energy (BMWi) has responsibility.

b) For categories 2 (Production processes) and 3 (Use of solvents and other products), the Federal Ministry for Economic Affairs and Energy (BMWi) has responsibility.

c) For category 1.A.3 (Transport), the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) has responsibility.

d) For category 1.A.5a (Energy: other), where emissions sources of the German Federal Armed Forces (Bundeswehr) are concerned – the Federal Ministry of Defence (BMVg) has responsibility. Where data are subject to secrecy provisions, the Federal Environment Agency shall take the relevant secrecy requirements into account.

e) For source and sink categories 4 (Agriculture) and 5 (Land use, land-use changes and forestry), the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) has responsibility.

f) For category 6 (Waste) and category 7, and well as for issues related to greenhouse-gas emissions from biomass combustion, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) has responsibility.

g) The Federal Ministry of Food and Agriculture (BMEL) is also responsible for preparing tables in the standardised reporting format pursuant to Art. 2 (2) letter a of Decision 2005/166/EC (implementation rules) in source and sink categories 4 and 5.

In addition, the relevant authorities, as determined by the pertinent statistics regulations, are responsible for tasks relative to official statistics, including data delivery, quality assurance and data documentation and archiving. Co-operation between a) the statistical offices of the Federal Government and the Länder and b) the agencies concerned with reporting is co-ordinated via the Federal Statistical Office. In the process, secrecy requirements pertaining to statistics are to be observed.

- 4th The responsible departments shall clarify, in the short term, how proper data provision is to be permanently assured, to the extent such clarification has not already been completed. In particular, this requirement shall apply to agreements, ordinances or laws needed for institutionalisation of the National System. In general, for purposes of emissions reporting, voluntary agreements with associations and/or individual companies shall have the same status as pertinent legal provisions. In addition, as agreed in the co-ordination discussion on 12 September 2006, the Federal Environment Agency and the Federal Statistical Office shall determine what data can be provided, for reporting purposes, from the official statistical system, as well as what additional data should be collected via the*

official statistical system. The various relevant departments, the Federal Environment Agency and the Federal Statistical Office shall send their pertinent proposals to the BMU by 15 July 2007.

5. *By 31 July 2007, the BMU shall invite participating departments to co-ordinate pertinent proposals and to establish a schedule for implementing the required instruments. The responsible departments, and the Federal Government, shall arrange for the establishment of the required instruments as quickly as possible.*
6. *Where additional funding is required for execution of the responsibilities mentioned under 3., such funding shall be provided from proceeds from sale of AAUs, via an expansion of the state secretaries' agreement of 22 December 2006 relative to Article 3.4 of the Kyoto Protocol.*

To this end, a budget item for relevant income shall be established within Individual Plan 16 (Einzelplan 16) as of the 2008 fiscal year. Following review by the Federal Ministry of Finance (BMF), the additional requirements requiring financing shall be listed as expenditures within the departments' individual budgets. The departments' additional requirements in this regard must be submitted to the BMF by 6 June 2007.

Should additional budget funding be required in coming years, in addition to the additional requirements determined in connection with the 2008 budget, then suitable relevant amounts of additional AAUs shall be sold in subsequent years.

[...]

Annex: Division of responsibilities between BMU/UBA, BMVBS and BMWi

The BMUB, BMVBS and BMWi have agreed that the existing emissions-reporting structures are to be retained and that the Federal Environment Agency (UBA) shall continue to perform its existing tasks with regard to the categories 1, 1.A.3, 2 and 3. The BMVBS and the BMWi shall ensure that any gaps in the data for those categories for which they are responsible are closed.

Specifically:

BMW:

With regard to category 1: The inventories in this area shall be prepared by the Federal Environment Agency, on a basis that shall include energy data provided by the agency contracted by the BMWi for preparation of energy balances, as well as on the basis of additional relevant statistics and association information.

With regard to category 2: The inventories in this area shall be produced by the Federal Environment Agency on the basis of data that shall include data from statistics of the manufacturing sector (Produzierendes Gewerbe – ProdGewStatG) and from communications of relevant associations / individual companies.

With regard to category 3: The inventories in this area shall be produced by the Federal Environment Agency on the basis of data that shall include data from statistics of the manufacturing sector (Produzierendes Gewerbe – ProdGewStatG), from foreign trade statistics and from communications of relevant associations / individual companies.

Existing requirements for further optimisation shall be clarified, in the short term, by BMWi, BMU and UBA, working in co-ordination. Where data optimisation is required via changes in existing surveys based on the Environmental Statistics Act (UStatG) or on the 13th Ordinance on the Execution of the Federal Immission Control Act (13. BimSchV), the BMU shall be responsible. The Federal Environment Agency shall assume responsibility for recording and archiving data received by the Federal Environment Agency.

BMVBS:

Emissions relative to category 1.A.3 (Transport) shall be calculated by the Federal Environment Agency, using the TREMOD model. The BMVBS shall provide data/calculations as needed to close data gaps and determine emissions relative to international air transports or shall ensure that such data/calculations are provided by third parties. At present, emissions from ship transports may be calculated from Energy Balance data, using default emission factors. The Federal Environment Agency shall assume responsibility for recording and archiving data received by the Federal Environment Agency.

22.1.2 Additional information about the Quality System of Emissions Inventories

22.1.2.1 Minimum requirements pertaining to a system for quality control and assurance

As described above in the main section, the requirements pertaining to the system for quality control and quality assurance (QC/QA system) and to measures for quality control and quality assurance are defined primarily by Chapter 8 of the *IPCC Good Practice Guidance*.

From those provisions, the Federal Environment Agency has derived its own "General minimum requirements pertaining to quality control and quality assurance in connection with greenhouse-gas-emissions reporting" ("Allgemeine Mindestanforderungen an die Qualitätskontrolle und Qualitätssicherung bei der Treibhausgasemissionsberichterstattung"; last revision: November 2007). These are described below.

22.1.2.1.1 Introduction

Representatives of the departments participating in the co-ordinating committee for the National System of Emissions Inventories define the general minimum requirements, which are described in the present document, for quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions. Such minimum requirements serve as the basis for collection, processing and forwarding of, and reporting on, all data that support the process of reporting on greenhouse-gas emissions.

These minimum QC/QA requirements must be adhered to on all levels of inventory preparation. In many cases, relevant efforts can draw on existing processes and systems, such as the quality standards for public statistics. Annex 1 of the present document describes, by way of example, implementation of the minimum QC/QA requirements and the QC/QA system within the Federal Environment Agency. All participating institutions are required to submit suitable descriptions of their implementation of these minimum requirements; such descriptions are to be published with the inventory report in the framework of reporting in 2009. On request, the Federal Environment Agency supports participating ministries in preparing QC/QA systems in their relevant areas of responsibility.

22.1.2.1.2 System for quality control and quality assurance

The rules (*Commission Decision 2005/166/EC*) implementing *Decision 280/2004/EC* require national greenhouse-gas inventories to conform to the QC/QA requirements of the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC Good Practice Guidance) and the *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (IPCC Good Practice Guidance for LULUCF).

The *IPCC Good Practice Guidance* specifies that QC/QA systems must be introduced, with the aim of enhancing transparency, consistency, comparability, completeness and precision of national emissions inventories and, especially, that such inventories must fulfill requirements pertaining to "good inventory practice". A QC/QA system comprises the following:

- An agency responsible for co-ordinating QC/QA activities

- Development and implementation of a QC/QA plan
- General QC procedures
- Category-specific QC procedures
- QA procedures and
- Reporting procedures
- Documentation and archiving procedures

QC/QA measures can conflict with requirements for punctuality and cost-effectiveness. Available time, and available staffing and financial resources, should thus be taken into account in any QC/QA-system development. In good practice, more stringent data-quality requirements are applied to key categories. For other categories, not all category-specific QC procedures have to be implemented. In addition, not all measures have to be carried out on an annual basis; for example, data-collection methods have to be reviewed only once in detail. Thereafter, it suffices to carry out periodic controls to determine whether the prerequisites for application of relevant methods are still being fulfilled. Data uncertainty is another factor that enters into requirements pertaining to QC/QA measures. In order to reduce an inventory's overall uncertainty, those categories that have high levels of uncertainty should be reviewed in detail.

22.1.2.1.3 Agency responsible for co-ordinating QC/QA activities

As the Single National Entity (national co-ordinating agency), the Federal Environment Agency is responsible for the QC/QA system for the national greenhouse-gas inventory. In this function, it has established the position of co-ordinator for the Quality System for Emissions Inventories (QSE). In good practice, each company and organisation involved in inventory preparation appoints a QC/QA co-ordinator and notifies the QSE co-ordinator of such appointment.

A QC/QA co-ordinator 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 agreement.

In order to ensure that the Single National Entity can efficiently carry out its supporting tasks, the persons responsible for the following additional functions should be announced (by name) to the QSE co-ordinator:

Responsible expert (Fachverantwortlicher) – Person responsible for data collection, data entry and pertinent calculation, in keeping with the prescribed methods, as well as for carrying out QC measures and preparing a relevant textual contribution for the National Inventory Report.

Quality control manager (Qualitätskontrollverantwortlicher) – Person responsible for checking and approving data and report sections (the QC/QA co-ordinator may also perform this function).

22.1.2.1.4 QC/QA plan

The purpose of the 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. The QC/QA plan also defines the primary emphases of such measures. The criteria for selection of categories for detailed review include the following:

- The category's relevance (key category yes/no, uncertainties high/low)
- The time of the last detailed QC/QA measure for the source category, and the results of such measure
- Changes in methods or the pertinent database
- Results of annual inventory review in keeping with the UN Framework Convention on Climate Change and the Kyoto Protocol

- Available resources for execution of QC/QA 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, and of the results of QC/QA measures of which it is aware, the Single National Entity prepares an improvement plan for the entire inventory. On this basis, in turn, it derives proposals for a binding inventory plan for the next report year. Such proposals are then submitted to the co-ordinating committee for approval. The QC/QA co-ordinator, working in co-operation with the QSE co-ordinator in the Single National Entity, defines the procedures, scheduling and scope for inclusion of his institution's QC/QA measures in the inventory plan for the overall inventory.

22.1.2.1.5 General quality control

Pursuant to the definition used by the IPCC (Chapter 8.1 *Good Practice Guidance*), quality control (QC) comprises a system of routine specialised measures for measuring and checking the quality of inventories in preparation.

Consequently, a QC system should achieve the following:

- Facilitate routine, standardised checks in the interest of data integrity, correctness and completeness;
- Identify and eliminate errors and omissions;
- List and archive inventory material and record all QC activities.

Table 8.1 of the *IPCC Good Practice Guidance* includes a complete list of general QC measures. Requirements pertaining to general, Tier-1 QC procedures can be derived from the requirements mentioned in Chapter 8.6 of the *IPCC Good Practice Guidance*. Typical general quality control measures in activity-rate determination include checking data for transfer errors, checking data for completeness, checking formulae for combining data and carrying out plausibility checks with the help of external data sources and earlier calculations. Suppliers of emissions calculations have to carry out additional QC measures – for example, checking formulae for emissions calculation.

Required quality controls should be recorded in checklists. Such lists should include at least the checking measures carried out, the results of checking, any pertinent corrections made and the name of the person(s) responsible for the measures. Annex 2 of the present document includes a sample checklist of the Federal Environment Agency.

Not all quality controls have to be carried out on an annual basis; some may be implemented at longer regular intervals. This applies especially to aspects of data collection that do not change from year to year. Requirements pertaining to the frequency and completeness of QC measures are more stringent for key categories than for other categories. It should be ensured that all categories undergo detailed quality control at least periodically.

22.1.2.1.6 Category-specific quality control

Available resources permitting, particularly relevant categories (such as key categories), in addition to undergoing Tier 1 procedures, should undergo Tier 2 quality control with regard to determination of activity rates, emissions and uncertainties (cf. Chapter 8.7 *Good Practice Guidance*). The chapters of the IPCC Good Practice Guidance that pertain to the various individual categories (Chapter 5) include additional information relative to category-specific QC measures. Such guidelines must be observed in preparation of any QC/QA plan. :

Where combined **activity data** from secondary sources are used, good practice calls for evaluating pertinent QC measures in connection with preparation of such secondary sources. If the level of such measures is adequate, it suffices to call attention to this fact in the documentation. Where secondary sources do not fulfill minimum requirements pertaining to quality control, suitable QC/QA checks should be carried out by the institution that uses the data. Results of subsequent QC/QA checks should enter into determination of uncertainties for activity rates. In addition, wherever possible, a range of different sources should be compared for purposes of determining data quality.

In use of facility-specific activity data, it is good practice to review the methods and QC/QA standards applied to data collection. Where such methods and standards do not meet minimum requirements, the advisability of using the data should be reconsidered and the uncertainties should be adjusted as necessary.

With regard to **emissions data**, it is good practice to review the emission factors that have been used. Such efforts include using national emission factors for key categories and reviewing the validity of IPCC standard factors under the applicable national circumstances. Where emissions data are obtained via direct measurements, it is good practice to review the relevant measurement methods and the quality standards applied. Emissions data and emission factors should be reviewed in light of data from previous years, and from independent sources, and any resulting discrepancies should be explained.

Quality control for uncertainties includes checking to determine whether calculations are free of errors and whether documentation for reproduction of results is adequate. In use of experts' assessments, the pertinent experts' qualifications and estimation methods should be reviewed and documented.

22.1.2.1.7 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 as such and improve them as necessary.

Pursuant to the relevant IPCC definition (Chapter 8.1 Good Practice Guidance), 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. Such measures accomplish the following:*

- Verify that data-quality criteria are fulfilled,
- Ensure that the inventory takes account of the best available estimates of emissions and sinks, in keeping with the latest scientific findings and available data, and
- Promote the efficiency of the QC system".

The required instrument for quality assurance is the peer review. While use of audits is encouraged, audits are not required.

22.1.2.1.8 Reporting procedures

The Single National Entity is responsible for initiating and co-ordinating reporting and carrying out relevant overall organisation. Provision of data and reports by third parties must conform to applicable requirements pertaining to the scope, form and scheduling of/for such provision.

22.1.2.1.9 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. The general requirements pertaining to documentation and archiving for the entire process of preparation of greenhouse-gas inventories are described in Chapter 8.10.1 of the *IPCC Good Practice Guidance*.

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

Data providers:

- Publication / source of activity data, 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 Federal Environment Agency on an annual basis, together with pertinent data, and they are centrally archived by the Federal Environment Agency.

Quality control (QC)

The records kept in the framework of quality control should include the names of the persons responsible for managing and carrying out relevant actions, the types of quality control carried out, the dates on which quality control measures were carried out, the pertinent results, and the corrections and modifications triggered by quality control measures. In each case, record-keeping and archiving for quality control measures are carried out internally, by the institution supplying the pertinent data. A general description of regularly executed quality control measures is provided to the Federal Environment Agency for purposes of the national inventory report and inventory review.

Providers of emissions calculations

For providers of emissions calculations, the minimum requirements pertaining to record-keeping also include the following:

- Description of the pertinent calculation methods and reasons why the methods were selected;
- Assumptions and criteria pertaining to selection of activity data and emission factors;
- Documentation pertaining to emission factors and their sources, with detailed references to the relevant numbers and pages in original sources;
- Calculation models;
- Calculation files, calculation software.

Points 1-4 are recorded and archived along with descriptions provided for the national inventory report. Separate documentation pertaining to calculation models must be provided, in keeping with general scientific practice, and along with internal documentation in the form of manuals or guides. Data suppliers archive calculation files and calculation software, and keep pertinent records, on an internal basis. Such materials should be provided to the Federal Environment Agency as necessary in the framework of inventory review.

Quality assurance

In addition to carrying out quality control measures, providers of emissions calculations are obligated to carry out quality assurance. The records kept in the framework of quality assurance should include the names of the persons responsible for managing and carrying out relevant actions, the types of quality assurance carried out, the dates on which quality assurance measures were carried out, the pertinent results, and the corrections and modifications triggered by quality assurance measures. In addition, records should be kept of category-specific quality controls.

In each case, record-keeping and archiving relative to pertinent quality assurance are carried out internally, by the relevant data-supplying institution. In addition, pertinent quality assurance measures are summarised in the national inventory report.

Confidential data / secrecy

In general, confidential data must be designated as such when they are provided, to ensure that the proper precautions are taken when they are used.

In inventory review, general obligations apply whereby confidential data must be disclosed in cases in which inventory reviewers consider such disclosure to be necessary to ensure that emissions calculations are transparent and clear. The extent to which such disclosure actually must involve disclosure of individual data items should be clarified on a case-by-case basis with the institution providing the data.

22.1.2.1.10 Annex 1: Minimum requirements pertaining to quality control and quality assurance in emissions reporting in the Federal Environment Agency

22.1.2.1.10.1 Introduction

The general minimum requirements, as approved by the co-ordinating committee for the National System of Emissions Inventories, pertaining to quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions apply to all participants. These requirements are the basis for collecting, processing, forwarding and reporting of/on all data that support reporting on greenhouse-gas emissions. They are thus binding for all working groups involved, in the Federal Environment Agency, in fulfillment of this reporting task.

22.1.2.1.10.2 System for quality control and quality assurance

In addition to the general minimum requirements, approved by the co-ordinating committee for the National System of Emissions Inventories, pertaining to quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions, the specific provisions of in-house directive (Hausanordnung) No. 11/2005 also apply at the Federal Environment Agency. Pursuant to that directive, the pertinent procedure defined in the QSE manual is binding for all Federal Environment Agency personnel involved in emissions reporting (Rules of procedure of the Federal Environment Agency (Geschäftsordnung des Umweltbundesamtes), Volume II, Numeral XV).

The in-house directive fully implements the requirements of Chapter 8 of the *IPCC Good Practice Guidance*. Suitable UBA-specific instruments have been established to ensure effective

identification and execution of measures for continual inventory improvement (improvement plan and inventory plan; cf. 22.1.2.1.10.3). That work has led to the development of the Quality System for Emissions Inventories (QSE), via which the points mentioned in Chapter 22.1.2.1.2 have been implemented.

22.1.2.1.10.2.1 Agency responsible for co-ordinating QC/QA activities in the Federal Environment Agency

Pursuant to in-house directive No. 11/2005, section FG I 2.6, "Emissions Situation", is the "Single National Entity" (SNE) within the Federal Environment Agency. In the Federal Environment Agency's organisational diagramme, the so-defined SNE is thus included in the Federal Environment Agency's group of "focal points" and liaison offices for international organisations. In addition, this assignment of responsibility was confirmed by the relevant ministries via a state secretaries' resolution of 5 June 2007.

The roles and responsibilities of the Single National Entity, and of the specialised departments participating in emissions reporting, are described in Chapter 3.2, "Roles and responsibilities", of the QSE manual. The Single National Entity is responsible for updating and managing the QSE manual and its appendices and annexes. In carrying out this responsibility, the SNE is assisted by the contact persons named to it by the relevant specialised departments. The version of the QSE manual and its co-applicable documents published on the Single National Entity's intranet is the binding version of these materials.

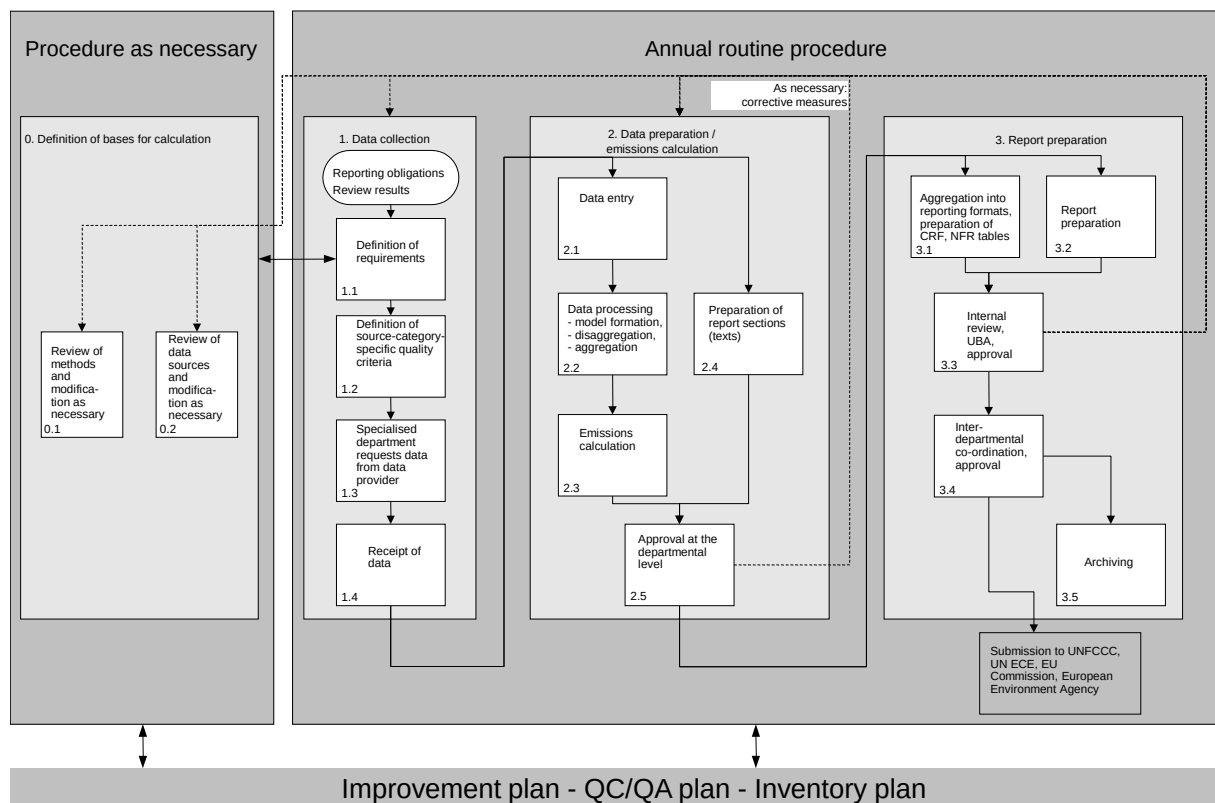
22.1.2.1.10.2.2 Reporting procedures

In many cases, complex activities comprise numerous different, but related and cumulative, activities (processes) that lead to the production of a single product. To manage such processes effectively, one must strive to understand the manner in which the processes function (or should function), to describe such functioning in logical, realistic ways (activities, dependencies, responsibilities, and many more) and to interrelate the processes in a useful way.

In practice, workflows of complex processes cannot always be fit smoothly into the hierarchical, traditional structures of companies and institutions. The required processes are often diametrically opposed to such structures, since they have to cut across different organisational units. To organise interrelated work processes in a manner oriented to production of the desired product, one must look outside of rigid hierarchies and redefine the processes with a view to improvement.

For this reason, emissions reporting was first described as a process that, via a number of interrelated activities, leads to a product (NIR and inventories) (cf. Figure 93). Additional relevant information is provided in the QSE manual, Chapter 4.3.

Figure 93: Overview of the overall emissions-reporting process



Via a role concept, suitable responsibilities have been assigned to cover the activities within the main processes and sub-processes shown. Each responsibility thus involves execution of pertinent processes. To understand this approach, it is useful to consider the situation in which many different people carry out the same basic activities even though they work in different work units and on different categories. In the present case, this situation was approached by defining a certain group of persons (persons with a specific role – for example, responsible experts). That group was then seen to be subordinate to another group of persons (with a different role – for example, specialised contact persons) that ensures that the first group observes and fulfills the requirements pertaining to its work. In addition, a QSE co-ordinator was appointed, in keeping with relevant requirements of the IPCC (cf. Chapter 22.1.2.1.2), to ensure that the system is refined and improved as necessary.

Overall, a comprehensive role concept was developed that addresses the many different requirements applying to the Federal Environment Agency in its task as Single National Entity. The roles involved include the following:

1. Responsible expert at the operational level (FV)

- Main responsibilities: data collection, data entry, calculations with prescribed methods, execution of QC measures, preparation of the NIR text

2. Quality control manager (QKV)

- Is the superior for the FV
- Main responsibilities: checking and approving data and report sections

3. Specialised contact person (FAP)

- Member of the Single National Entity's staff
- Main responsibilities: providing category-specific support for involved experts (inventory work and report preparation) and quality control / quality assurance relative to pertinent categories in the NIR and CSE.

4. Co-ordinator for the national inventory report (NIRK)

- Member of the Single National Entity's staff
- Main responsibilities: co-ordination of supporting textual work, preparation of the NIR from the various relevant contributions, overarching QC and QA for the NIR

5. CSE co-ordinator (ZSEK)

- Member of the Single National Entity's staff
- Main responsibilities: maintenance of databases, emissions calculation and aggregation, overarching QC and QA in connection with data entries and calculations for the inventory

6. QSE co-ordinator (QSEK)

- Member of the Single National Entity's staff
- Main responsibilities: maintenance and refinement of the QSE (system, checklists, improvement plan, inventory plan, QC/QA plan and QSE manual)

7. NaSE co-ordinator (NaSEK)

- Member of the Single National Entity's staff
- Main responsibilities: schedule-conformal, requirements-conformal reporting, providing for involvement of national institutions, establishing/recording legal agreements

As a rule, each of the above-described roles will have tasks in several different main and sub-processes of emissions reporting.

22.1.2.1.10.3 QC plan, QA plan and inventory plan

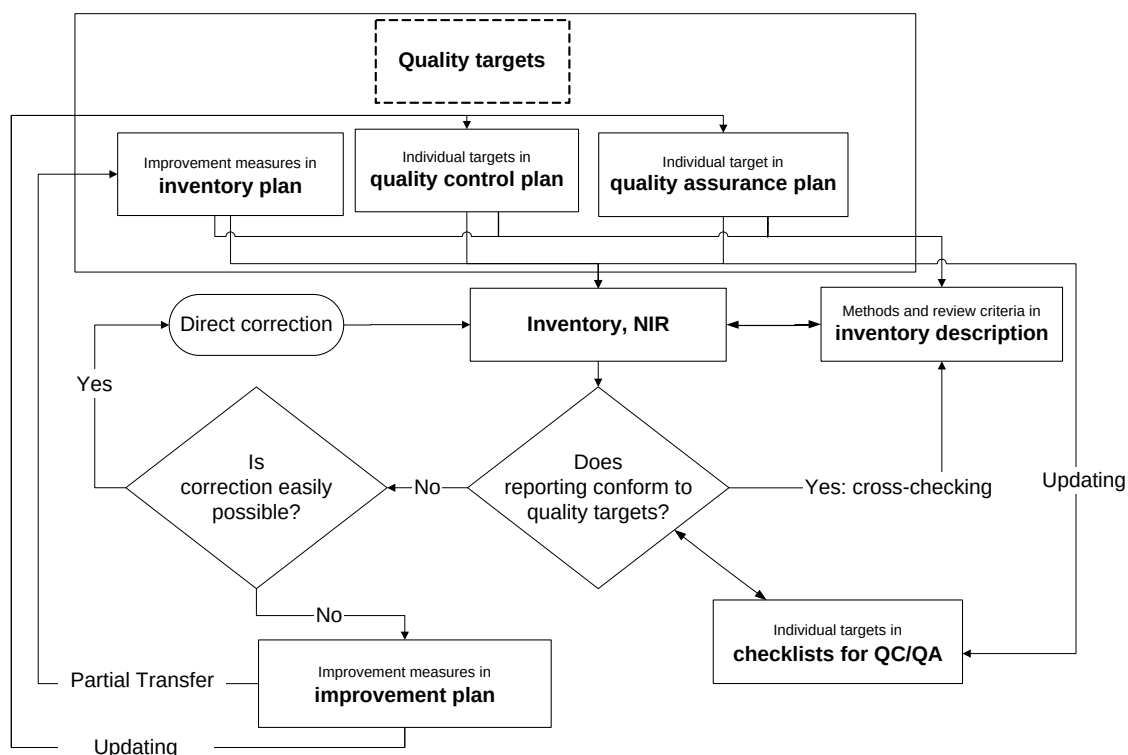
To ensure that all potential improvements identified during the course of inventory work are systematically implemented, identified improvements must be listed in a co-ordinated way. In the process, identified potential improvements should be listed together with all relevant information (origin of the potential improvement, category, pertinent responsibility, priority, etc.) needed for efficient further processing. Planning and arrangements for implementing identified potential improvements (required actions / corrective measures, deadlines, etc.) should then be made on the basis of such information.

In the interest of proper control and record-keeping in the framework of the NaSE and the QSE (cf. Figure 94), procedures have been defined for processing identified potential improvements for their systematic management and further use. The overall aim is to answer the central question of WHO should do WHAT, HOW, WHEN and WHY:

- WHO: This provides the reference to the role concept: A certain person xy is responsible – for example, in the role of responsible expert (FV)
- WHAT: This provides the reference to the object that is to be improved – for example, the CO₂ calculation in category xy needs to be improved

- HOW:** This provides the reference to the aim that is to be achieved – for example, a certain improvement, pursuant to an inventory plan or checklist.
- WHEN:** This provides the reference to the time by which the improvement must be completed, pursuant to the inventory plan
- WHY:** This provides the reference to the origin of the necessary action – for example, the improvement must be carried out as a result of a recommendation via the UNFCCC review process

Figure 94: Control and documentation in the framework of the NaSE and the QSE



The **quality targets** have been derived from the general quality aims of the IPCC Good Practice Guidance (transparency, consistency, accuracy, comparability, completeness). In addition, operational individual objectives, relative to quality control and quality assurance, for the various categories, have to be derived from comparison of the requirements from the *IPCC Good Practice Guidance*, the results of independent inventory review (UNFCCC and EU) and assessment of inventory realities.

In an **improvement plan**, all potential improvements and criticisms resulting from independent inventory review are collected and assigned potential corrective measures. The Single National Entity categorises the corrective measures, prioritises them and then, via consultations with the relevant responsible experts, integrates them as necessary within the **inventory plan**. There, they are linked with deadlines and responsibilities. As an annex to the NIR, the inventory plan undergoes a co-ordination and release process in the Federal Environment Agency and in the co-ordinating committee. It is thus a binding set of specifications for improvements to be carried out in future.

In the interest of transparent, effective control and execution of inventory-improvement measures, such measures, in keeping with the *IPCC Good Practice Guidance* (Chapter 8.5) are defined role-specifically, as well as category-specifically as necessary, in the **quality control plan / quality**

assurance plan (QC/QA plan). The QC plan is oriented solely to quality control aims for the inventory. In the QA plan, quality assurance objectives may be focused on the inventory, the reporting process or the QSE itself. Furthermore, the quality assurance plan includes scheduling of quality assurance measures to be performed by external third parties.

The **checklists for quality control and quality assurance** list all individual objectives in the emissions-reporting process, in keeping with the pertinent quality control and quality assurance plans. The checklists, which are designed to facilitate review of achievement of individual objectives, are made available to all persons responsible for quality control and quality assurance. The checklists are used to record execution of measures for quality control and quality assurance. Where individual objectives are not achieved and direct correction is not possible, a pertinent entry must be made in the improvement plan (see above).

22.1.2.1.10.4 Procedures for general and category-specific quality control

From the requirements set forth in the IPCC Good Practice Guidance, the Federal Environment Agency has developed a checklist concept via which quality requirements are formulated as specific targets. Every effort should be made to achieve such targets. When a target is achieved, such achievement is noted and described in the checklists. The possible entries for such records include "yes" (the target was achieved), "not relevant" (the target as formulated does not correspond to the special situation for the category in question; this answer is seldom a viable option) and "no" (it was not possible to achieve the target).

Each checklist includes a general section that reflects all Tier 1 QC requirements from IPCC Good Practice Guidance and that is used in connection with every instance of reporting. In addition, each checklist contains a category-specific section (Tier 2) that provides concrete objectives for the relevant key category area.

Checklists are provided only for the first five roles within the role concept. Where different roles are responsible for different main and sub- processes of emissions reporting (cf. Chapter 22.1.2.1.10.2.2), pertinent checklists will also be oriented to several different main and sub-processes of emissions reporting. They thus represent a cross-section of emissions reporting. The checklists of the FV and the FAP include a basic common set of goals. The FAP are responsible for checking the work of the FV, and such checking is most effective when both roles are oriented to the same goals.

22.1.2.1.10.5 Quality assurance procedures

In the role concept, procedures are designed to ensure that quality assurance is always supported by a "four-eyes" principle. The specialised contact persons (FAP) have the task of ensuring that the emissions calculations and textual work of the responsible experts (FV) are of the proper quality.

In its section on "Expert Peer Review", the IPCC notes that the (above-described) formal procedure selected by the Federal Environment Agency can complement, but not replace, expert peer review (Good Practice Guidance; Chapter 8.8). In one solution found for addressing the justified call for inclusion of external experts, within the framework of available resources, detailed review of specific issues is carried out by external third parties via research projects and studies. In general, the two sides involved (i.e. FV and FAP) jointly manage the process of commissioning third parties. In another means found for addressing the need for third-party inclusion, workshops on the National System are held at irregular intervals. For such workshops, national experts are invited to come to the Federal Environment Agency for discussion with Federal Environment Agency experts (FV) on current inventory issues relative to selected categories.

No audits have been carried out in the Federal Environment Agency to date, and none are planned at present. According to the Good Practice Guidance, audits are not absolutely required.

22.1.2.1.10.6 Documentation and archiving

Standardised record-keeping and archiving procedures are to be used in preparation of German greenhouse-gas inventories. At the same time, it is important to differentiate between the central record-keeping and archiving carried out by the Single National Entity and the non-central record-keeping and archiving carried out by the specialised departments of the Federal Environment Agency and of other institutions.

Record-keeping procedures for data and context information vary in accordance with specific requirements. In their information storage, they overlap to some degree, with such overlapping consisting partly of redundancies and partly of storage of similar items at differing levels of detail. On a regular basis, consistency must be ensured for both types of overlapping.

To ensure that all of the Federal Environment Agency's working units use basically consistent procedures, the specifications applying to the instruments used in such procedures – including both general specifications and specifications developed especially for emissions reporting – must be complied with. For purposes of "documentation" (i.e. record-keeping), the Federal Environment Agency has access to the instruments described in Table 522. The specifications pertaining to each type of document / record must be observed. Where no special specifications apply, the provisions from the "General minimum requirements for quality control and quality assurance in reporting on greenhouse-gas emissions" ("Allgemeine Mindestanforderungen an die Qualitätskontrolle und Qualitätssicherung bei der Treibhausgasemissionsberichterstattung") apply.

Table 522: Documentation / record-keeping instruments at the Federal Environment Agency

Instrument	Specifications
Publicly available	
National inventory (CRF tables, CRF-Reporter)	Annex 2, QSE manual: instructions for carrying out recalculations in the CRF tables
National Inventory Report	Annex 3, QSE manual: specifications for preparing report sections in the context of the National System
Publication	Rules of procedure of the Federal Environment Agency: Point 6.2 Publications
Published manuals, guides	For IT descriptions: procedural model of the Federal Environment Agency; otherwise: no special specifications
Centralised, and internally available, at the Single National Entity	
CSE database	Annex 5, QSE manual: specifications for data recording within the CSE
Inventory description	Annex 4, QSE manual: requirements pertaining to documentation (record-keeping) and archiving
De-centralised, and internally available	
Files of the central registry	Rules of procedure of the Federal Environment Agency: Point 4.2.10 Handling of files
Reference files	no special specifications
Internal manuals, guides	For IT descriptions: procedural model of the Federal Environment Agency; otherwise: no special specifications

An integrated documentation / record-keeping concept defines what key content should be stored in the aforementioned documentation instruments. It also defines how a suitable referencing

system is to be used to ensure consistency and transparency throughout all such instruments (cf. Annex 4, QSE manual).

22.1.2.1.11 Annex 2: Example of a general checklist for the responsible-expert role

The example presented below (last revision: CHKL 2010) includes only the relevant requirements. Detailed information has been removed in the interest of clarity.

Table 523: General checklist for responsible experts

Process No.	Sub-process name	Individual goal	Optional goal
Main process: 0. Definition of bases for calculation			
0.1	Review of methods, and modification as necessary	The calculation method is in conformance with current key-category analysis.	
0.1	Review of methods, and modification as necessary	The calculation method has been selected in accordance with, or accords with, the pertinent decision tree of the IPCC Good Practice Guidance.	Departures from the decision tree of the IPCC Good Practice Guidance have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.
0.1	Review of methods, and modification as necessary	The calculation method has been selected in keeping with requirements from the inventory plan.	Departures from the inventory plan have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.
0.1	Review of methods, and modification as necessary	The selected calculation method can be applied to the entire time series as of 1990, or is already being consistently applied.	In cases of changes of methods in the time series, recalculation pursuant to the QSE manual (Annex 2), and proper pertinent documentation, are assured.
0.1	Review of methods, and modification as necessary	Departures from the objectives required via 0.1.01-0.1.04 have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.	
0.2	Review of data sources, and modification as necessary	Have new data sources been used?	
0.2	Review of data sources, and modification as necessary	The data source(s) is / are / will be available throughout the long term (for example, on the basis of legal provisions, long-term agreements [> 3 years], etc.).	
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	Gaps in the data available for time series as of 1990 have been properly and logically explained, and have been duly documented.
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	A suitable procedure (interpolation/ extrapolation) has been chosen for dealing with data gaps, in conformance with IPCC Good Practice Guidance (Chap. 7.3.2.2), and the procedure has been logically documented. Note: Continued use of the same value is not extrapolation !
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	Following closure of data gaps, time-series recalculation has been carried out as necessary, pursuant to QSE manual (Annex 2), and such recalculation has been documented and substantiated in the NIR and CRF.
Process No.	Sub-process name	Individual goal	Optional goal

0.2	Review of data sources, and modification as necessary	The data source(s) completely cover the category.	The incomplete coverage has been addressed in an extrapolation and has been taken into account in the uncertainties calculation. All steps have been documented and justified clearly and logically.
0.2	Review of data sources, and modification as necessary	Uncertainties information (amount and distribution) is available for the data source(s).	
0.2	Review of data sources, and modification as necessary	The EF and the AD agree in terms of the manner in which they are tailored to the category.	In the case of discrepancies between the EF and AD, other data sources can establish agreement between the two values. Alternatively, the lack of agreement has been taken into account in an extrapolation, and in the uncertainties calculation, and the entire process has been properly and logically documented.
0.2	Review of data sources, and modification as necessary	The procedures for calculating outset data are clearly described.	
0.2	Review of data sources, and modification as necessary	The data source(s) have been selected in keeping with requirements from the inventory plan.	Any discrepancies have been clearly and logically justified and documented.
0.2	Review of data sources, and modification as necessary	The assumptions and criteria upon which the relevant data source(s) have been selected have been clearly and logically documented.	
0.2	Review of data sources, and modification as necessary	The data provider has carried out routine quality controls of the data source(s). For one-time projects, one-time quality controls have been carried out. Execution of the controls has been duly documented.	
0.2	Review of data sources, and modification as necessary	In use of one/more new data sources, a recalculation pursuant to the QSE manual (Annex 2) was carried out on the basis of this/these other data source(s).	
0.2	Review of data sources, and modification as necessary	In use of IPCC default EF, the manner in which the EF were generated has been reviewed in light of national circumstances, and the EF may be used for Germany. The result of such review has been duly documented.	For IPCC default values that do not fit with national circumstances, the discrepancies have been taken into account in the uncertainties and documented.
0.2	Review of data sources, and modification as necessary	In use of EF other than the IPCC default EF, use of such EF has been clearly and logically justified and substantiated. Note: Use of other EF is permissible only when such EF permit more precise calculation of country-specific emissions.	
0.2	Review of data sources, and modification as necessary	The AD used have been compared with other data sources (for example, EU-ETS, IEA, EPER, etc.), and the result has been duly documented.	

Main process: 1. Data collection

1.1	Definition of requirements	The requirements pertaining to data reflect the information and indications from the inventory plan and the inventory reviews (for example, S&A Report, Centralized Review).	
Process No.	Sub-process name	Individual goal	Optional goal

1.3	The relevant specialised department requests the data from the pertinent data provider(s)	The requirements pertaining to QC and data formats have been forwarded to the data suppliers and/or contracting entities, and such forwarding has been duly documented. Note: Where data suppliers are involved via NaSE agreements, this objective has been achieved.	The data supplier (for example, an association) carries out its own routine quality controls, and the results have been duly documented.
1.4	Receipt of data	The data provider or contracting entity has carried out the required quality controls and made proper records of such action.	The data supplier (for example, an association) carries out its own routine quality controls, and the results have been duly documented.
1.4	Receipt of data	The received data are complete, without any gaps.	All data gaps in the time series as of 1990 have been closed, in accordance with the IPCC Good Practice Guidance, via extrapolation/interpolation (Chapter 7.3.2.2) and duly documented and justified. Note: Continued use of the same value is not extrapolation
1.4	Receipt of data	The data received are consistent with the previous year's data, and they have been properly described.	Any marked discrepancies with the previous year's data have been duly documented and justified.
1.4	Receipt of data	The order of magnitude of the received data is in line with that of comparable data from other sources (such as ETS data, IEA, EPER, etc.). The result of the review has been duly documented.	The reasons for any discrepancies have been clearly and logically explained and duly documented.
1.4	Receipt of data	The methods/assumptions on which the uncertainties determinations are based have been clearly and logically documented.	Where it was not possible to derive assumptions, expert assessment was carried out, and the relevant expert's quantification was clearly and logically documented.
1.4	Receipt of data	The uncertainties determinations are complete and plausible.	

Main process: 2. Data preparation / emissions calculation

2.1	Data entry (preferably into the CSE)	All of the EF have been entered into the CSE.	
2.1	Data entry (preferably into the CSE)	The documentation for the EF data source(s) is complete and conforms to the requirements of the QSE manual (Annexes 3, 4 and 5).	
2.1	Data entry (preferably into the CSE)	Development of the EF within the time series has been plausibly explained and, in the case of unusual effects (such as changes in order of magnitude), has been clearly and logically explained and documented.	Implausible EF have been corrected.
2.1	Data entry (preferably into the CSE)	All of the AD have been entered into the CSE.	
2.1	Data entry (preferably into the CSE)	The documentation for the AD data source(s) is complete and conforms to the requirements of the QSE manual (Annexes 3, 4 and 5).	

Process No.	Sub-process name	Individual goal	Optional goal
2.1	Data entry (preferably into the CSE)	Development of the AD within the time series has been plausibly explained and, in the case of unusual effects (such as changes in order of magnitude), has been clearly and logically explained and documented.	Implausible discrepancies have been corrected.

2.1	Data entry (preferably into the CSE)	Following entry of all data into the CSE, all entered figures, units and conversion factors have been checked for correctness and confirmed.	
2.1	Data entry (preferably into the CSE)	All of the uncertainties have been entered into the CSE and have been documented in keeping with the requirements of the QSE manual (Annexes 3, 4 and 5).	
2.2	Data preparation (model formation, disaggregation, aggregation)	The inventory description includes an adequate description of pertinent models, with regard to organisation, structure, calculation procedures, assumptions, etc..	
2.3	Emissions calculation	The current inventory calculations have been checked against calculations from previous reports.	Where any significant changes or obvious deviations from an expected trend have occurred, the pertinent calculation, and the data used in calculation, have been reviewed, and any persisting discrepancies have been properly, clearly and logically explained and duly documented.
2.3	Emissions calculation	The results of emissions calculation for current / previous reports have been checked against other data sources for Germany, especially ETS data, and found to be comparable. The result has been duly documented.	Where comparability has not been found, or no comparison was carried out, the pertinent reasons have been properly, clearly and logically explained.
2.3	Emissions calculation	The national Implied EF (cf. S&A Report I) from the previous report is comparable with the Implied EF of other countries (same order of magnitude).	Extreme Implied EF have been properly, clearly and logically explained, and duly documented, in the NIR, or reference to an existing explanation has been made.
2.4	Preparation of report sections (texts)	The category has been completely and logically described, for the NIR, in terms of the required six sub-chapters for the NIR ("Category description", "Methodological issues", etc.).	
2.5	Approval by the relevant experts	The values of AD, EF and ED, of their uncertainties, are up to date in the NIR and congruent with the pertinent values in the CSE.	
2.5	Approval by the relevant experts	Documentation of the origins for AD, EF and ED data, and for their uncertainties, are up to date in the NIR and congruent with the pertinent values in the CSE.	Lacking or incomplete documentation of data origin has been properly, clearly and logically explained and duly documented.

22.1.3 The database system for emissions – Central System of Emissions

Since 1998, the Federal Environment Agency has maintained and managed an IT tool for inventory preparation: the *Central System of Emissions (CSE)*, an integrated national database. The CSE implements the diverse requirements pertaining to emissions calculation and reporting, and it automates key steps in such work. It supports the processes of inventory planning and reporting (for example, by carrying out emissions calculations and recalculations, and relevant error analysis); inventory management (for example, by carrying out archiving and annual data evaluation); and quality management at the data level (cf. UBA 2003a, Projekthandbuch Decor (Decor project handbook)). The CSE makes it possible to fulfill the key requirements of transparency, consistency, completeness, comparability and accuracy at the data level.

Data documentation plays a central role in the CSE. The CSE stores such information as who is responsible for handling specific tasks; data sources and calculation procedures; and uncertainties in time-series values. The times at which changes are made, and the persons by whom they are made, are also recorded. The system has a history-management function that archives deleted items and can restore them as necessary. This makes it possible to trace back and reconstruct data,

and it enables third parties to carry out independent reviews. The system also provides mechanisms that support quality assurance at the data level (e.g. components for detecting uncertainties and checking plausibility). Above all, transparency is accommodated by ensuring that data are recorded within the same structure in which they are provided, and that all processing and transformations into a reporting format take place first in the CSE itself, and thus remain open to examination. In addition, the CSE manages detailed technology-specific activity data and emission factors that can be processed, via calculation rules (calculation methods), into aggregated, category-specific values for the various reporting formats. Aggregation of individual CSE time series for the CRF report lines, for example, is described in Annex 3 and Chapter 3ff – in each case, with regard to individual categories. In addition to aggregation and model formation for calculations, the CSE also supports scenario and forecast calculations and use of the reference approach.

Data exchange within the framework of the National System – i.e. within the Federal Environment Agency and with third parties – is also organised via the Central System of Emissions. Such processes involve both direct data entry and imports of aggregated values, from existing databases and via a standard interface (for example, TREMOD, for transport data; and GAS-EM, for agricultural data). Ideally, inventory data should be entered into the CSE directly by the relevant responsible experts or should be imported, by the CSE administrator, via the import interface. This applies to in-house UBA employees as well as to external parties involved in the National System. To this end, a range of measures have been implemented:

- Provision of a *standardised import format for the CSE* in 2002 has facilitated the direct import of data from other emissions-relevant databases.
- In September 2002, participating technical experts from the Federal Environment Agency were given direct access to the CSE via the Federal Environment Agency intranet.
- Since November 2002, training courses on CSE procedures have been held on an annual basis for involved Federal Environment Agency staff.
- Since 2005, qualitative and quantitative information about data uncertainties has also been included in the CSE.
- Since 2006, reporting obligations under the Geneva Convention on Long-Range Transboundary Air Pollution and EU legislation (such as the NEC directive) have been fulfilled via the CSE.
- Since 2008, data providers and experts outside of the Federal Environment Agency, and project partners, can work interactively with the CSE via remote access.

22.2 Supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

22.2.1 KP-LULUCF

The CRF tables are reported separately.

22.2.2 Standard Electronic Format (SEF) Tables

22.2.2.1 Standard Electronic Format for the reported year 2015 (Commitment Period 2)

Report Type	RREG1
Registry	DE
Reported Year	2016
Submission Year	2017
CP	2
Version	2
Status	FINAL
Validity	VALID

Party	Germany
Submission Year	2017
Reported Year	2016
Commitment Period	2

Table 1. Total quantities of Kyoto Protocol units by account type at beginning of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1 Party holding accounts	NO	NO	NO	NO	NO	NO
2 Entity holding accounts	NO	NO	NO	526.923	NO	NO
3 Retirement account	NO	NO	NO	NO	NO	NO
4 Previous period surplus reserve account	NO					
5 Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
6 Non-compliance cancellation account	NO	NO	NO	NO		
7 Voluntary cancellation account	NO	NO	NO	153.069	NO	NO
8 Cancellation account for remaining units after carry-over	NO	NO	NO	NO	NO	NO
9 Article 3.1 ter and quater ambition increase cancellation account	NO					
10 Article 3.7 ter cancellation account	NO					
11 tCER cancellation account for expiry					NO	
12 ICER cancellation account for expiry						NO
13 ICER cancellation account for reversal of storage						NO
14 ICER cancellation account for non-submission of certification report						NO
15 tCER replacement account for expiry	NO	NO	NO	NO	NO	
16 ICER replacement account for expiry	NO	NO	NO	NO		
17 ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
18 ICER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
19 Total	NO	NO	NO	679.992	NO	NO

Party	Germany
Submission Year	2017
Reported Year	2016
Commitment Period	2

Table 2a. Annual internal transactions

Transaction type	Additions						Subtractions					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Art6 issuance and conversion												
1 Party verified projects		NO					NO		NO			
2 Independently verified projects		NO					NO		NO			
Art3.3 and 3.4 issuance or cancellation												
3 3.3 Afforestation reforestation			NO				NO	NO	NO	NO		
4 3.3 Deforestation			NO				NO	NO	NO	NO		
5 3.4 Forest management			NO				NO	NO	NO	NO		
6 3.4 Cropland management			NO				NO	NO	NO	NO		
7 3.4 Grazing land management			NO				NO	NO	NO	NO		
8 3.4 Revegetation			NO				NO	NO	NO	NO		
9 3.4 Wetland drainage and rewetting			NO				NO	NO	NO	NO		
Art 12 afforestation and reforestation												
10 Replacement of expired tCERs							NO	NO	NO	NO	NO	
11 Replacement of expired ICERs							NO	NO	NO	NO		
12 Replacement for reversal of storage							NO	NO	NO	NO		NO
13 Cancellation for reversal of storage												NO
14 Replacement for non-submission of certification report							NO	NO	NO	NO		NO
15 Cancellation for non submission of certification report												NO
Other cancellation												
16 Voluntary cancellation							NO	NO	NO	683.504	NO	NO
17 Article 3.1 ter and quater ambition increase cancellation							NO					
18 Subtotal		NO	NO				NO	NO	NO	683.504	NO	NO

Transaction type	Retirement					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1 Retirement	NO	NO	NO	NO	NO	NO
2 Retirement from PPSR	NO					
3 Total	NO	NO	NO	NO	NO	NO

Party	Germany
Submission Year	2017
Reported Year	2016
Commitment Period	2

Table 2b. Annual external transactions

Total transfers and acquisitions		Additions						Subtractions					
		AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1	CH	NO	NO	NO	161	NO	NO	NO	NO	NO	14.517	NO	NO
2	CDM	NO	NO	NO	2.005.905	NO	NO	NO	NO	NO	NO	NO	NO
3	GB	NO	NO	NO	NO	NO	NO	NO	NO	NO	25.082	NO	NO
4	IT	NO	NO	NO	143.455	NO	NO	NO	NO	NO	NO	NO	NO
5	NL	NO	NO	NO	NO	NO	NO	NO	NO	NO	225.636	NO	NO
6	EU	NO	NO	NO	218.209	NO	NO	NO	NO	NO	1.402.960	NO	NO
7	Subtotal	NO	NO	NO	2.367.730	NO	NO	NO	NO	NO	1.668.195	NO	NO

Table 2c. Annual transactions between PPSR accounts

	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1 Subtotal	NO						NO					

Table 2d. Share of proceeds transactions under decision 1/CMP.8, paragraph 21 - Adaptation Fund

	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1 First international transfers of AAUs	NO						NO					
2 Issuance of ERU from Party-verified projects		NO						NO				
3 Issuance of independently verified ERUs		NO						NO				

Table 2e. Total annual transactions

	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1 Total (Sum of sub-totals in table 2a and table 2b)	NO	NO	NO	2.367.730	NO	NO	NO	NO	NO	2.351.699	NO	NO

Party	Germany
Submission Year	2017
Reported Year	2016
Commitment Period	2

Table 3. Expiry, cancellation and replacement

Transaction or event type		Requirement to replace or cancel			Replacement						Cancellation					
Transaction or event type		tCERs	ICERs	CERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Temporary CERs																
1	Expired in retirement and replacement accounts	NO			NO	NO	NO	NO	NO							
2	Expired in holding accounts	NO													NO	
Long-term CERs																
3	Expired in retirement and replacement accounts		NO		NO	NO	NO	NO								
4	Expired in holding accounts		NO													NO
5	Subject to reversal of Storage		NO		NO	NO	NO	NO		NO						NO
6	Subject to non submission of certification Report		NO		NO	NO	NO	NO		NO						NO
Carbon Capture and Storage CERs																
7	Subject to net reversal of storage			NO							NO	NO	NO	NO		
8	Subject to non submission of certification report			NO							NO	NO	NO	NO		
9	Total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Party	Germany
Submission Year	2017
Reported Year	2016
Commitment Period	2

Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1 Party holding accounts	NO	NO	NO	NO	NO	NO
2 Entity holding accounts	NO	NO	NO	542.954	NO	NO
3 Retirement account	NO	NO	NO	NO	NO	NO
4 Previous period surplus reserve account	NO					
5 Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
6 Non-compliance cancellation account	NO	NO	NO	NO		
7 Voluntary cancellation account	NO	NO	NO	836.573	NO	NO
8 Cancellation account for remaining units after carry-over	NO	NO	NO	NO	NO	NO
9 Article 3.1 ter and quater ambition increase cancellation account	NO					
10 Article 3.7 ter cancellation account	NO					
11 tCER cancellation account for expiry					NO	
12 ICER cancellation account for expiry						NO
13 ICER cancellation account for reversal of storage						NO
14 ICER cancellation account for non-submission of certification report						NO
15 tCER replacement account for expiry	NO	NO	NO	NO	NO	
16 ICER replacement account for expiry	NO	NO	NO	NO		
17 ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
18 ICER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
19 Total	NO	NO	NO	1.379.527	NO	NO

Party	Germany
Submission Year	2017
Reported Year	2016
Commitment Period	2

Table 5a. Summary information on additions and subtractions

		Additions					ICERs	Subtractions					
		AAUs	ERUs	RMUs	CERs	tCERs		AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1	Assigned amount units issued	NO											
2	Article 3 Paragraph 7 ter cancellations							NO					
3	Cancellation following increase in ambition							NO					
4	Cancellation of remaining units after carry over							NO	NO	NO	NO	NO	NO
5	Non-compliance cancellation							NO	NO	NO	NO		
6	Carry-over		NO		NO				NO		NO		
7	Carry-over to PPSR	NO						NO					
8	Total	NO	NO		NO			NO	NO	NO	NO	NO	NO

Table 5b. Summary information on annual transactions

		Additions					ICERs	Subtractions					
		AAUs	ERUs	RMUs	CERs	tCERs		AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1	Year 1 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2	Year 2 (2014)	NO	NO	NO	1.761.325	NO	NO	NO	NO	NO	151.074	NO	NO
3	Year 3 (2015)	NO	NO	NO	4.556.137	NO	NO	NO	NO	NO	5.639.465	NO	NO
4	Year 4 (2016)	NO	NO	NO	2.367.730	NO	NO	NO	NO	NO	2.351.699	NO	NO
5	Year 5 (2017)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6	Year 6 (2018)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7	Year 7 (2019)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
8	Year 8 (2020)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
9	2021	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10	2022	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
11	2023	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
12	Total	NO	NO	NO	8.685.192	NO	NO	NO	NO	NO	8.142.238	NO	NO

Table 5c. Summary information on annual transactions between PPSR accounts

		Additions					ICERs	Subtractions					
		AAUs	ERUs	RMUs	CERs	tCERs		AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1	Year 1 (2013)	NO						NO					

2	Year 2 (2014)	NO						NO					
3	Year 3 (2015)	NO						NO					
4	Year 4 (2016)	NO						NO					
5	Year 5 (2017)	NO						NO					
6	Year 6 (2018)	NO						NO					
7	Year 7 (2019)	NO						NO					
8	Year 8 (2020)	NO						NO					
9	2021	NO						NO					
10	2022	NO						NO					
11	2023	NO						NO					
12	Total	NO						NO					

Table 5d. Summary information on expiry, cancellation and replacement

		Requirement to replace or cancel			Replacement						Cancellation					
		tCERs	ICERs	CERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1	Year 1 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2	Year 2 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
3	Year 3 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4	Year 4 (2016)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5	Year 5 (2017)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6	Year 6 (2018)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7	Year 7 (2019)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
8	Year 8 (2020)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
9	2021	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
10	2022	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
11	2023	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
12	Total	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 5e. Summary information on retirement

		AAUs	ERUs	RMUs	CERs	tCERs	ICERs
1	Year 1 (2013)	NO	NO	NO	NO	NO	NO
2	Year 2 (2014)	NO	NO	NO	NO	NO	NO
3	Year 3 (2015)	NO	NO	NO	NO	NO	NO
4	Year 4 (2016)	NO	NO	NO	NO	NO	NO
5	Year 5 (2017)	NO	NO	NO	NO	NO	NO
6	Year 6 (2018)	NO	NO	NO	NO	NO	NO
7	Year 7 (2019)	NO	NO	NO	NO	NO	NO
8	Year 8 (2020)	NO	NO	NO	NO	NO	NO
9	2021	NO	NO	NO	NO	NO	NO
10	2022	NO	NO	NO	NO	NO	NO
11	2023	NO	NO	NO	NO	NO	NO
12	Total	NO	NO	NO	NO	NO	NO

Party	Germany
Submission Year	2017
Reported Year	2016
Commitment Period	2

Table 6a. Memo item: corrective transactions relating to additions and subtractions

Additions						Subtractions					
AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs

Table 6b. Memo item: corrective transactions relating to replacement

Expiry, cancellation and requirement to replace		Replacement					
tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs

Table 6c. Memo item: corrective transactions relating to retirement

Retirement					
AAUs	ERUs	RMUs	CERs	tCERs	ICERs

22.2.2.2 Discrepant transactions

No discrepant transactions occurred in 2016.

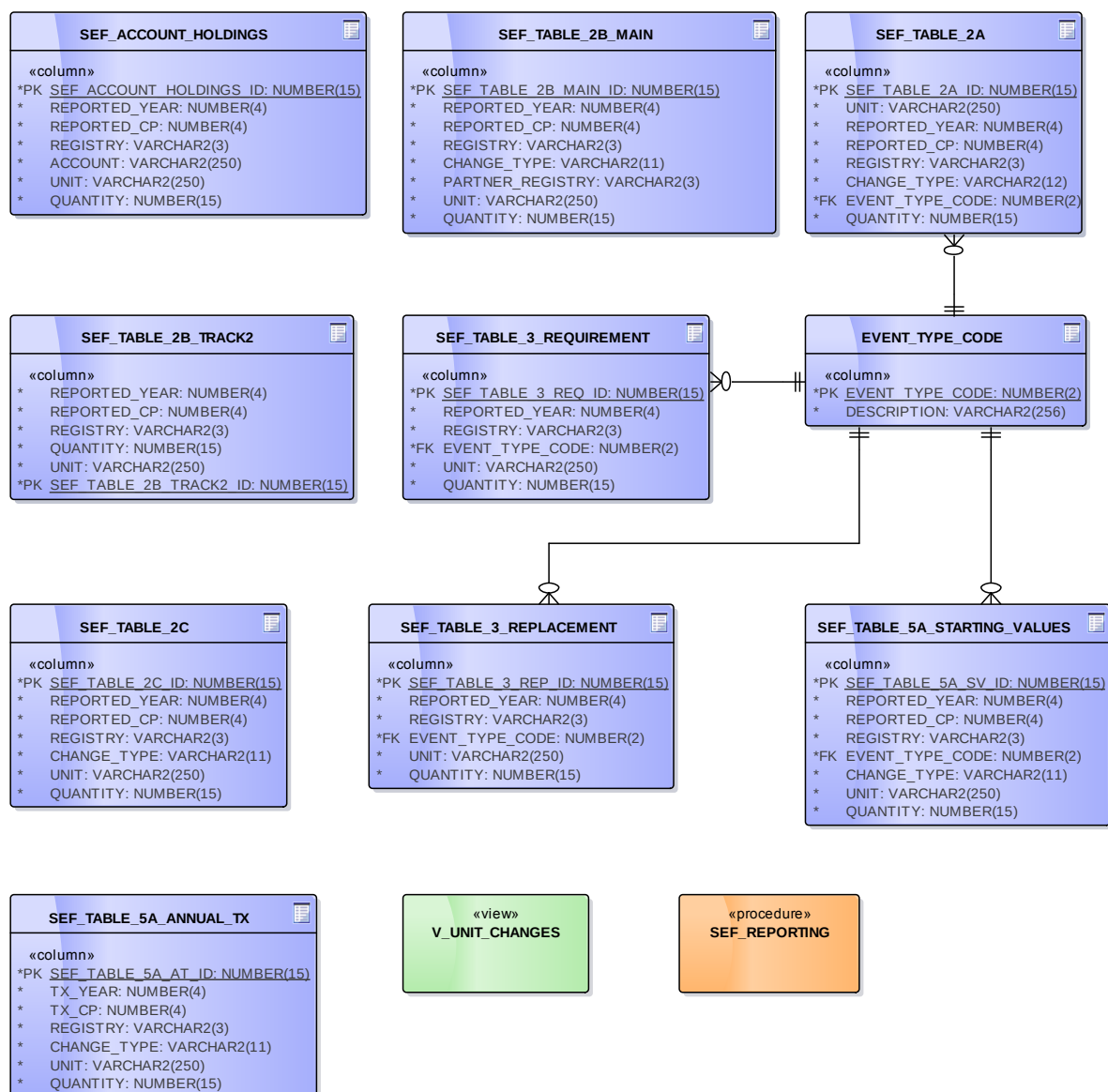
22.2.3 More-detailed information about the National System, and about changes within the National System

All of this information has been provided in the preceding chapters.

22.2.4 Further detailed information about the National Registries and about accounting of Kyoto units

The required documents are confidential and accessible for assessors only. Therefore the documents which are mentioned in the below table are not available within this document.

22.2.4.1 Annex A - CP2 SEF Tables



22.2.4.2 Annex B - Changes from EUCR v7.0.1-v8.0.7

Feature	Summary	Description	Test Cases	SAT Status
JBPM console deployment fails	The JBPM console is non functional in one of two application servers; this has been fixed.	The JBPM console is non functional in one of two application servers.	Solution confirmed by CLIMA	PASSED
Accounts requested to be opened (but not yet approved) can be added in TALs of other accounts. Rejecting these account opening requests should remove these accounts from TALs automatically.	Europe - Account pending for opening approval added to trusted list but not removed after rejection of the opening request	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-2384]	Execute UC_AM_70_TC_08 UC_AM_70_TC_09 UC_AM_70_TC_10	PASSED
Helpdesk users can create new accounts referencing existing account holders.	Helpdesk employees (role: Service Desk) should be able to open an account under an existing account holder	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-5403]		PASSED
An executed allocation did not appear correctly in task history; this is now fixed.	Wrong details in historic tasks 'Approve Allocation Settings Delivery'	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-6726]		PASSED
Incorporation of manual adjustment in ICE values.	Calculation of remaining entitlement for 1.4 cases	Refer to https://webgate.ec.europa.eu/etsis/browse/ETS-6762		PASSED
Account exclusion flag is corrected so as to be propagated to the next year correctly; propagation happens via a job on 1-JAN.	Europe - Account exclusion issue	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-7272]		PASSED
Modify the screen so that monitoring plan cannot be updated.	AOHA - The Monitoring plan first year of applicability should not be updatable.	imported on 23/7/2015 see [https://webgate.ec.europa.eu/etsis/browse/ETS-7345]	Execute UC_AM_220_TC_01	PASSED
If an AR replacement request the user is requested to be un-enrolled and the un-	Account Representative Replacement/removal workflow issue	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-7362] =====		PASSED

Feature	Summary	Description	Test Cases	SAT Status
enrolment request is rejected, then the AR replacement request failed. This is now fixed.		Also -797 One problematic scenario we have spotted is the following: One AR/AAR is requested to be removed/replaced from an account. The user is marked as SUSPENDED on the account. The AR/AAR is proposed to be un-enrolled. The un-enrolment request is rejected The user is marked as ACTIVE on all accounts The request of step 1 is approved. The system searches for SUSPENDED users on the account but all are ACTIVE. Another scenario 1. Log in as NA1 to registry and go to any account 2. Request AR1 to be suspended from given account 3. As User AR1 request un-enrolment. 4. As NA reject un-enrolment task. AR1 accesses are activated including access to account where he was manually suspended		
If all years of an operator become excluded, then aggregate compliance surrenders/emissions do not appear; this is now fixed.	Compliance table is empty after excluding AOHA	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-7457]		PASSED
Change of task description for "Merger of aircraft operators" task	Europe - Wrong information in the "Merger between Aircraft Operators" task	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-7478]	Execute UC_AP_123_TC_01	PASSED
Correction of bug raised when processing an ITL notification update, while the original ITL notification is missing.	ITL Notification Update Error - No acquiring account to fulfil the request	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-7506]	Execute UC_IN_002_TC_01	PASSED
Correction of appearance of dates in transaction PDF	Transaction PDF formats	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-7766]		PASSED
If an allocation task is approved and not yet executed (allocations appearing yellow) then	Yellow boxes in already allocated installations	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-7782]	Execute UC_AP_110_TC_02	PASSED

Feature	Summary	Description	Test Cases	SAT Status
prohibit upload of new allocation for the same installations.				
If an operator does not yet have calculated compliance, then the compliance screen does not show aggregate surrenders/emissions either. This is now fixed.	Missing information on stationary installation compliance tab	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-7808]	Current date = Jan 2018 Test Case 1: - Account with YFE 2014, YLE 2015 and no emissions. The DCS is C - Exclude years 2014, 2015 - The DCS becomes blank Test Case 2: - Account with YFE 2014, YLE blank, emissions entered for 2014 only. The DCS is C - Exclude 2014 - Change YLE to 2014 - The DCS becomes blank Test Case 3: - Account with YFE 2014, YLE blank, emissions entered for 2014 only. The DCS is C - Exclude all years from 2014 to 2018 - The DCS becomes blank Test Case 4: - Account with YFE = 2017, YLE blank, no emissions. The DCS is C - change YFE to 2018 - The DCS becomes blank	PASSED
Correct the account statements so that AAUs and RMUs appear correctly.	Account statements display incorrectly CP1 AAUs	For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-8143]		PASSED
Correct the message explaining an ITL error check.	Missing description for new ITL check	https://webgate.ec.europa.eu/etsis/browse/-1005?filter=10404	Ensure message.properties file contains prescribed messages for 5121 and 5129	PASSED
Regression issue: cancellations reversal crashed due to tokens. This is now fixed.	Cancellations reversal crash	While testing reversals of cancellations: • I entered a new cancellation (GB166) • I tried to reverse it • I get the following red screen I also tried reversing another cancellation and got a similar red screen {code}		PASSED

Feature	Summary	Description	Test Cases	SAT Status
		An unrecoverable error has occurred. Please retry later or contact your help desk if the problem persists. Refer to the error GB-E9B0983F-08/03/2018 10:17:44 in your communications with the help desk. {code}		
Approved "Allocation Delivery Settings" request displayed all allocations not only approved one. This is now fixed.	Approved "Allocation Delivery Settings" request displays all allocations not only approved one.	For details see [https://webgate.ec.europa.eu/etsis/browse/-734]		PASSED
The date after which allocations for past year are allowed is now a parameter. This used to be fixed at 1-FEB.	Allocation minimum date to be a parameter	For details see [https://webgate.ec.europa.eu/etsis/browse/-790]	Execute UC_AL_115_TC_09	PASSED
InstallationId link in "Approve allocation delivery" from History Tab is not working. This is now fixed.	InstallationId link in "Approve allocation delivery" from History Tab is not working	For details see [https://webgate.ec.europa.eu/etsis/browse/-861]		PASSED
Change in the SEF Procedure to Handle CP1 and CP2 separately	Change in the SEF Procedure to Handle CP1 and CP2 separately		UC_SEF_010_TC_01: DISPLAY THE SEF REPORTING PAGE	PASSED
Error while suspending unit blocks; this is now fixed.	IllegalArgumentException while suspending/restoring unit blocks	In our internal version, ETS 6.7.3, this issue is not reproducible.	The issue is not reproducible. Test cases are available in Issue Links tab of EUCR-2196 (linked issue)	PASSED
Enhance system logs so that allocation is better monitored.	Logging requirements	Implement all logging requirements found in the TOKENS specification	Confirm that that the logs for signature with tokens are saved to the DB under the table: REQUEST_SIGNATURE_LOG.	PASSED
Regression issue: Issue when suspending unit blocks.	EUCR-2196 null values stored to the flash will not be available on the next request.		Select UnitBlocks under Administration select a Unit Block and suspend/restore 3 times. the 3rd time there will be the below issue:	PASSED

Feature	Summary	Description	Test Cases	SAT Status
This is now fixed.				
Modification of text pertaining to error 7214.	Modify label of Check 7214	Check 7214 reads now "The number of allowances transferred is not strictly equal to the number foreseen in the NAP for the specified installation and specified year." has to be modified to something else, to be in-line with the implementation of EUTL-34 Check 7214 to read: "The number of allowances transferred is not less or equal to the number foreseen in the NAP for the specified installation and specified year."		PASSED
A single digit change in a message, while suspending unit blocks	A single digit change in a message	In unit block suspension/restoration confirmation, use singular, since only one unit block may be affected.	Connect as NA, navigate to Administration->Unit Blocks and suspend a unit block. Ensure the message appears in singular.	PASSED
Allocation execution job is split into batches. The size of each batch is defined via the parameter allocationBatchSize.	Split Allocation Night Job	Allocation execution job is split into batches. The size of each batch is defined via the parameter allocationBatchSize.	EUCR-2296	PASSED
Allocation logging is enhanced so that NULL permit status and insufficient unit in allocation account are logged.	Issues with the allocation workflow	Execute UC_AL_115_TC_10	EUCR-2300, EUCR-2301	PASSED
Two issues regarding account creation are resolved: * one pertaining to hiding the users connected on account when not applicable * and one issue of Internet Explorer when creating OHA	Account Request > Both panels appear when you add an AR without having selected if the AR is related to the Account Holder or not, AND "Problem with your request" message while creating account	Refer to -297 and -991 Known issue regarding -297: ===== When I set "Account Holder is already recorded in the registry" and I enter an account holder ID and click on the users of this AH, sometimes the users combobox is not initialised correctly and users cannot be added. Note: A fix for this issue has already been prepared and is pending internal testing.	Regarding -297: Executed UC_AM_10_TC_13 as defined in TC.01 Addendum v0.10. Regarding -991: # Create a new OHA using Internet Explorer. # At installation creation, contact person on installation information, click repeatedly on "Address Provided" link. # Enter contact person information and address details and submit # Ensure account creation request is submitted normally by approving as NA and ensuring the new account is created.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
Regression issue: The CSV containing manual adjustment has invalid structure. This is now fixed.	The CSV containing manual adjustment has invalid structure	Refer to the screenshot; the generated CSV has invalid headers	1. Connect to EUCR -> Entitlements and click on Export CSV. 2. Paste the generated file in Excel, distribute text to columns 3. Ensure that columns correspond to data correctly	PASSED
Regression issue: Manual adjustment is not subtracted from the ICE value This is now fixed.	Manual adjustment is not subtracted from the ICE value	Refer to the attachment; manual adjustments are not being subtracted from the ICE value.	1. Ensure that the value uploaded in manualAdjustment column is subtracted from the loaded ICE value, in Account Holdings screen.	PASSED
Regression issue: The entitlement values in the exported XML are wrong This is now fixed.	The entitlement values in the exported XML are wrong	When viewing ICE entitlements and clicking export XML, the generated XML is wrong.	1. Connect to GB which has accounts with ICE values without manual adjustments. 2. Navigate to ETS->Entitlements 3. Click on Export XML; ensure the file contains loaded ICE values and no manual adjustments. 4. Repeat the test for Romania, which has accounts with ICE values and manual adjustments; ensure XML contains that manual adjustments.	PASSED
Regression issue: Holdings screen: entitlement appears equal to remaining entitlement This is now fixed.	Holdings screen: entitlement appears equal to remaining entitlement	Related to EUCR-2273. Testing EUCR-2236	1. Connect as NA and navigate to account holdings of an account with ICE. 2. Ensure entitlement is the loaded ICE value and remaining entitlement contains the IC value minus exchanges minus surrenders minus manual adjustments.	PASSED
Regression testing: Account creation fails. This is now fixed.	Cannot create account via "Account Request" (regression testing)	I submit an account opening request and get red screen. Please see attachment. An unrecoverable error has occurred. Please retry later or contact your help desk if the problem persists. Refer to the error GB-388D79C6-08/03/2018 15:05:54 in your communications with the help desk.	1. Create an OHA; in installation information screen enter Permit Expiry Date = 1/1/20020 2. In the Permit Entry into Force Date set it to 1/1/20015 3. Click on Next, Next, Submit 4. Ensure the mentioned fields are highlighted and validation rule "Invalid date. Date format: dd/mm/yyyy" appears. 5. Correct both of the fields to 1/1/2020 and 1/1/2015 respectively and click on Next, Next, Submit 6. Approve the account open request 7. Ensure the account is created with the entered Permit Expiry Date and Permit Entry into Force Date	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		This is a legacy issue. The cause of this issue has been located; if a date of the form 1/1/20013 is entered while requesting an account opening then an unhandled error is generated.		
Regression testing: ICE XML without manual adjustment failed to upload. This is now fixed.	An ICE XML without manual adjustment is ignored when uploaded	Related to EUCR-2273 and EUCR-2236	1. Upload ICE XML with and without manualAdjustments in EUCR and EUTL. 2. Ensure the upload is successful in each system.	PASSED
Regression issue: Addition to TAL via tokens fails. This is now fixed.	Cannot add to TAL via Tokens	When adding to TAL via tokens, I get the error: *80205: The account EU-100-10002986-0-47 is already on the trusted account list.* The account is added to the TAL in APPROVAL_PENDING state and there is no approval task generated. Refer to the TAL of account 310 for Finland; account EU-100-10002986-0-47 is added in APPROVAL_PENDING state but no task is generated. This issue was due to tokens code integration and was resolved.	Ensure a TAL addition via GSM and Tokens is completed successfully.	PASSED
Regression issue: Exchange reversal crashes This is now fixed.	Exchange reversal	Reverse EU1104042; it crashes with the attached error.		PASSED
Regression issue: ESD entitlement transaction approval crashes. This is now fixed.	At ESD Entitlement trx approval, red screen error	At approval of ESD entitlement transaction, I get red screen error: *An unrecoverable error has occurred.* *Please retry later or contact your help desk if the problem persists.* *Refer to the error ED-1C63D460-12/03/2018 15:07:47 in your communications with the help desk.*	1. Propose an ESD entitlements transaction as ESDCA; sign in ECAS. 2. Approve the transactions as ESDCA1; sign in ECAS. 3. Ensure the transaction is completed.	PASSED
Regression issue: Personal details approval crashes. This is now fixed.	Approve personal details update: red screen (regression testing)	Approve personal details crashes screen at approval.	A. Personal details update 1. Connect as NA and navigate to Administration->Roles 2. Locate a user and click Edit. 3. Modify personal details and click Submit 4. As another NA approve the task 5. Locate again the user and ensure the personal details are updated B. Administration roles update	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			1. Connect as NA and navigate to Administration->Roles 2. Locate a user and click Edit. 3. Add an administration role to the user via the tab "Administration Roles". 4. Click Submit and sign via ECAS 5. Approve the task as another NA and sign via ECAS 6. Locate again the user and ensure the administration roles are updated	
Regression issue: Entitlement calculations are wrong. This is now fixed.	Wrong values in Entitlement Calculation for Account	The formula to add/subtract the manual adjustment as seen in the documentation is: <code>entitlement -= (manualAdj==null?0D:manualAdj.doubleValue());</code> The code for some reason subtracts it from calculatedVE which is the value for the Verified Emissions multiplied by the factor.	1. Exclude year with emissions to force recalculation of entitlements 2. Unexclude year with emissions to "enable" emissions and recalculate entitlements 3. Goto entitlements screen and verify at the Entitlement Calculation for Account that the VE Emissions is 4,5(OHA) or 1,5(AOHA)% of emissions.	PASSED
Regression issue: At account exclusion, errors are logged. This is now fixed.	At account exclusion an error is logged in the logs due to entitlement re-calculation	I exclude OHA 10002975 of GB. The account appears excluded but the attached error is logged. The workflow of account exclusion is stuck in SUSPENDED mode and the remaining ICE is never recalculated.	# Locate OHA 10002975 of GB. # Approve emissions 1000 for 2017 # Upload ICE with flag 1 # Ensure entitlement is 45 # Update entitlement to manualAdjustment -3 # Ensure entitlement is 48 # Exclude year 2017; ensure entitlement becomes zero # Unexclude year 2017; ensure entitlement becomes again 48 # Exchange 5 CERs of CP2 of this account; ensure entitlement becomes 43 # Reverse the exchange; ensure entitlement becomes 48.	PASSED
SEF mechanism did not count correctly all ERU units; this is now fixed.	ERUs not handled correctly by the SEF process	The SEF code is not able to handle the presence of both types of ERUs in a registry i.e. ERU_FROM AAUs and ERU_FROM_RMUs. Only one type is calculated which means that the ERU values are under-reported.	1. Locate a Registry with SEF values for 2013 for ERU_from_RMU and ERU_from_RMU units. This can be done with the query: <pre> select registry, count(*) from sef_table_5c where year=2013 and cp=1 and unit in ('ERU_FROM_AAU', 'ERU_FROM_RMU') group by registry having count(*) > 1; </pre> If such a registry does not exist, the data can be entered as follows (e.g. for Romania): <pre> INSERT INTO sef_table_5c(sef_table_5c_id, year, cp, registry, unit, quantity) VALUES (sef5c_seq.NEXTVAL, 2013, 1, 'RO', 'ERU_FROM_AAU', 10); INSERT INTO sef_table_5c(sef_table_5c_id, year, cp, registry, unit, quantity) VALUES (sef5c_seq.NEXTVAL, 2013, 1, 'RO', 'ERU_FROM_RMU', 20); </pre> 2. Connect as NA and navigate to Administration -> SEF Reporting	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			3. Click on "2013" 4. On the opened text document search for "Table2a" and then for "Retirement" 5. Just below, search for "UnitQty type=ERU" and ensure the ERU value is the sum of the values located or inserted in step [1]. Alternatively, the XML can be opened with the UN SEF tool.	
No user can have more than one admin role; this rule is now imposed via a check and module redesign	One user should only have one admin role.	UNSCONS response: Users possessing multiple administration roles is not explicitly covered in use cases, refer to "UC-UA_060: Request administration roles update". Practically only two users in Production have 2 administration roles. ETS v.7.0.2 handles multiple administration roles; all actions must be performed sequentially due to the tokens mechanism. [FL] Please refer to -8849 and the relevant author's position ("UCS 02 - Users v1 80_rev_DK_FL_CP Authors Position")	Execute UC-UA_060_TC_02 from TC.01.	PASSED
In this release, a log entry is added for the case of aircraft operator with null permit status.	Issues with the allocation workflow	Imported on 22/7/2015 For details see [https://webgate.ec.europa.eu/etsis/browse/ETS-7365].	Execute UC-AL_115_TC_10. Testing for ETS 7.0.4 (allocations.log entry for air operator permit_status=null). 1. Upload a NAAT for an air.operator in EUCR and EUTL. 2. Propose and approve the allocation. 3. Perform the following to set permit status to null: update aircraft_operator set permit_status = null where verified_entity_id = 35757; 4. Ensure entries similar to the following appear in the allocations.log <INFO > <2018-05-22 12:25:02,919> <ALLOCATION_LOG> <> The following is a list of aircraft operators with NULL or REVOKED permit status checked for allocation(Number: 4): <INFO > <2018-05-22 12:25:02,919> <ALLOCATION_LOG> <> AIRCRAFT_NON_ACTIVE_PERMIT- Permit status was null:[Year:(2015), Registry:(RO), Identifier:(10002626), AcquiringAccountId:(36055),Phase 3 Snapshot: Free(99999970) - Reserved(null) - Transitional(null)] See Tests EUCR-2300, EUCR-2355, EUCR-2356, EUCR-2357, EUCR-2358, EUCR-2359, EUCR-2361	PASSED
Screen change for unit blocks.	Suspend/restore unit block: button should be renamed	The button "Suspend/Restore" should be called either "Suspend" or "Restore".	1. Log in as NA in EU registry 2. Navigate to Administration -> Unit blocks 3. Choose a unit block by clicking its Unit Block ID 4. Ensure that below the unit block there exists a "Suspend" button. 5. Click the "Suspend" button and sign via ECAS. 6, Ensure the button "Suspend" does not appear; ensure the button "Restore" appears. 7. Click the "Restore" button and sign via ECAS. 8. Ensure that below the unit block there exists a "Suspend" button. Check with I.E., Firefox, Chrome.	PASSED
With some versions of Internet Explorer there were issues when	"Problem with your request" message while creating account	Regarding -991: # Create a new OHA using Internet Explorer 9 and IE 11; repeat with Chrome and Firefox. # At installation creation, contact person on installation information, click repeatedly on "Address Provided" link.	# Create a new OHA using Internet Explorer 9 and IE 11; repeat with Chrome and Firefox. # At installation creation, contact person on installation information, click repeatedly on "Address Provided" link. # Enter contact person information and address details and submit	PASSED

Feature	Summary	Description	Test Cases	SAT Status
clicking repeatedly on checkbox.		# Enter contact person information and address details and submit # Ensure account creation request is submitted normally by approving as NA and ensuring the new account is created.	# Ensure account creation request is submitted normally by approving as NA and ensuring the new account is created.	
With some versions of Internet Explorer there were issues when requesting a new account and specifying the account holder.	Account Request > Both panels appear when you add an AR without having selected if the AR is related to the Account Holder or not, AND "Problem with your request" message while creating account	When the Step for adding AR loads, two different panels are visible, see attached screenshot. These two panels should load as hidden and each one of them should become visible only when the respective option above ("Representative is Related" vs "Representative is not yet related") is selected. Having both panels visible probably misleads the users, for example we display many different fields as mandatory but whether they really are only depends on which option was selected.	Using I.E.9 and I.E.11 execute the following test cases. Repeat with Chrome 48 and Firefox 43. * UC_AM_10_TC_13 as defined in TC.01 document.	PASSED
Account statement issues; now fixed.	CP1 AAU retirement transaction not covered in account statement PDF and CSV	Imported on: 01/02/2016 From: https://webgate.ec.europa.eu/etsis/browse/-1219	EUCR-2454	PASSED
Account statement issues; now fixed.	CP1 AAU unit displayed as eligible on account statement screen	Imported on: 29/01/2016 From: https://webgate.ec.europa.eu/etsis/browse/-1218	EUCR-2454	PASSED
While an allocation is ticked but not yet allocated, the user cannot upload a new NAT/NAAT for the specific type, year, installation/air.operator	Allocations with no value marked as "to be delivered"	As discussed, we should lock and not allow NAT update once the cells are ticked (even before approving).	A. Upload NAT for uploaded but not yet approved installation allocation (installation 101 of Romania was used) 1. Locate an installation with uploaded but not yet approved allocation 2. Upload NAT file for the specific installation and year and allocation type. 3. Ensure EUCR check 80214 is triggered and upload is prohibited. 4. Repeat the upload for another allocation type for the same installation and year and ensure it can be uploaded. B. Upload NAT for approved and not yet executed installation allocation 1. Locate an installation with approved but not yet executed allocation 2. Upload NAT file for the specific installation and year and allocation type. 3. Ensure EUCR checks 80213 and 80214 are triggered and upload is prohibited. 4. Repeat the upload for another allocation type for the same installation and year and ensure it can be uploaded. C. Upload a NAAT for uploaded but not yet approved aircraft allocation (air.operator 12409 of Romania was used) 1. Locate an air.operator with uploaded but not yet approved allocation 2. Upload NAAT file for the specific air.operator and year and allocation type. 3. Ensure EUCR check 80214 is triggered and upload is prohibited. 4. Repeat the upload for another allocation type for the same air.operator and year and ensure it can	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			be uploaded. D. Upload a NAAT for approved but not yet executed aircraft allocation (air.operator 12409 of Romania was used) 1. Locate an air.operator with approved but not yet executed allocation. 2. Upload NAAT file for the specific air.operator and year and allocation type. 3. Ensure EUCR check 80213 and 80214 are triggered and upload is prohibited. 4. Repeat the upload for another allocation type for the same air.operator and year and ensure it can be uploaded.	
Entitlements export in CSV is fixed to display correctly remaining value.	Inconsistency while displaying "Remaining" value in Entitlement CSV export	Imported on: 01/02/2016 From: https://webgate.ec.europa.eu/etsis/browse/-1210	1. Log in MT registry as NA (this registry has some installations with phase 3 verified emissions but no uploaded ICE values) 2. Go to Entitlements tab 3. Click Search 4. Click Export CSV 5. Check the exported file and ensure it does not contain negative values in the Remaining column, but shows zero instead.	PASSED
ICE screen were enriched to show the calculation method in more detail.	Inconsistent description for entitlement calculation method	Descriptions in the ICE calculation details: Method 0 - Value in XML Method 1 - 4,5% of Phase 3 VE	1. Connect as NA and navigate to EUETS -> Entitlements. 2. Find a record with Calculation Method = 0; click on "View Calculation"; ensure the lowest row which has a number has label: "Entitlement (Value in XML):" 3. Find a record with Calculation Method = 1; click on "View Calculation"; ensure the lowest row which has a number has label: "Entitlement (4,5% of Phase 3 VE)" 4. Find a record with Calculation Method = 2; click on "View Calculation"; ensure the lowest row which has a number has label: "Entitlement (maximum of value in XML and 4.5 % of VE)" 5. Find a record with Calculation Method = 3; click on "View Calculation"; ensure the lowest row which has a number has label: "Entitlement (sum of value in XML and 1.5 % of VE):"	PASSED
A screen was corrected to show remaining entitlement.	Wrongly calculated "Entitlement" in propose Exchange transaction screen	Imported on: 29/01/2016 From: https://webgate.ec.europa.eu/etsis/browse/-1203	1. Log in RO as NA 2. For OHA account with identifier 655, perform an "Exchange transaction" 2.1 First check at Holdings tab, the table with the entitlements, for value Entitlement (4) and Remaining Entitlements (3). 2.2 Propose an Exchange transaction; in the confirmation box check that Entitlement and Remaining Entitlement are identical to those noted in step 2.1.	PASSED
A task approval screen was enriched with current/proposed values.	No current / proposed columns for manual adjustments In "Approve Proposed ICE Table" task screen	Imported on: 21/01/2016 From: https://webgate.ec.europa.eu/etsis/browse/-1200	1. Log in to RO registry, as NA 2. Go to EU ETS tab and click "ICE Upload Table" 3. Click Browse and upload xml with values: -registryCode = "RO" -identifier="101", action = "U", flag="0", ice="6000" 4. Log in as another NA in RO, claim the task, and go to "Approve Proposed ICE Table" page 5. Submitted Value, Calculation Method and Manual adjustment columns should appear with current and proposed values.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
The ICE screen was modified so as to hide the Export XML button under some conditions.	ICE XML export leads to blank page	Imported on: 21/01/2016 From: https://webgate.ec.europa.eu/etsis/browse/-1199	1. Log in to RO registry as NA 2. Go to "Entitlements" page, in EU ETS tab 3. In "Entitlements" drop-down list click "Not set" 4. Ensure export button is disabled and the message "It is not possible to export in XML the installations whose entitlements are not set. Please use the "export in CSV" instead." appears at the top. 5. In "Entitlements" drop-down list click "All" 6. Ensure export button is enabled and the no messages appears at the top. 7. In "Entitlements" drop-down list click "Has Entitlements" 8. Ensure export button is enabled and the no messages appears at the top.	PASSED
The screen of unit block management was modified.	RedBox while creating new UnitBlock	Imported on: 15/01/2016 From: https://webgate.ec.europa.eu/etsis/browse/-1194	1. Log in GB as NA 2. Go to Administration -> Unit Blocks 3. Click Search and then Add 4. Enter the numbers provided for start and end blocks: (12345678901330 and 12345678901340) , unit type: CER 5. Insert an account ID that does not exist in GB (e.g. 383) 6. The following message appears at the top of the screen and the insertion is prohibited: "80102: The holding account does not belong to the registry: 383"	PASSED
The screen of unit block management was modified.	Unit block suspend / restore confirmation window has no enough information	Imported on: 14/01/2016 From: https://webgate.ec.europa.eu/etsis/browse/-1190	1. Log in to registry as NA 2. Navigate to Administration -> Unit Blocks 3. Click on a unit block 4. Click the "Suspend" button. 5. Ensure a confirmation box similar to the one below appears: "This action will change the unit block table of the registry. Please confirm that you want to suspend 1 unit block. - Unitblock start: 35000005 Unitblock end: 35000006 Originating country: Romania (RO)" 6. Confirm and sign the request via ECAS. 7. Ensure the button "Restore" appears now and not the button "Suspend". 8. Click on button "Restore" 9. Ensure a confirmation box similar to the one below appears:"This action will change the unit block table of the registry. Please confirm that you want to restore 1 unit block. - Unitblock start: 35000005 Unitblock end: 35000006 Originating country: Romania (RO)" 10. Confirm and Sign the request via ECAS.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
Suspended ESD AR is not considered privileged user anymore; this is now fixed	Suspended ESD AR is not considered privileged user anymore	Imported on: 14/01/2016 From: https://webgate.ec.europa.eu/etsis/browse/-1187	1. Check that "esdca3" ESD AR user can log in with Token. 2. Log in ESD registry as esdca 3. At Users tab with filter ESD AR, view all accounts of enrolled esdca3 user (check that the user is indeed the one of step 1, ensuring the URID is the same). 4. For each account, suspend the ESD AR user 5. Log in with esdca3 via token; it should not result in message prompting to log in with GSM.	PASSED
Specific flow leads to "Administrative Roles Update" task is locked in "User approved" status; this is now fixed	Specific flow leads to "Administrative Roles Update" task is locked in "User approved" status	There is a flow that leads to situation when "Administrative Roles Update" task is locked in "User approved" status. It happens when a NA requests adding administrative role to the user and before this request is signed, another NA requests the very same thing. In this situation two requests are created to perform same task and when approved, the second one is locked in "User approved" status and can't be completed due to unique constraint violation. As a result there is no way modify user's role anymore ("Only one administration roles update request can be active for the same user at any given time."). This is not a new bug I believe and also not very probable to be seen in real file, hence low priority.	A. No two concurrent admin roles updates can be approved. 1. Locate a user without any admin roles. 2. Propose to add role "National Administrator" to this user 3. Reach ECAS but do not sign yet. 4. Via another browser propose to add role "Central Administrator" to this user 5. Reach ECAS but do not sign yet. 6. Sign the request of step 3 7. Ensure the request is signed and a green message box appears: "Your administration roles update request has been submitted for approval. The request identifier is <<request_id>>." 8. Sign the request of step 5. 9. Ensure an orange alert box appears and this request cannot be approved: "Only one administration roles update request can be active for the same user at any given time." B. No admin role task approval can be approved if the specific user is already administrator. 1. Locate a user without any admin roles. 2. Propose to add role "Service Desk" to this user 3. Reach ECAS but do not sign yet. 4. Add via script the role "National Administrator" to this user: <pre>INSERT INTO ACCESSES (access_id, account_id, profile_id, role_id, state) VALUES (ACCESS_SEQ.NEXTVAL, -1, (select PROFILE_ID from profile where URID = 'EU724332260059'), (select role_id from roles where role_name = 'NATIONAL_ADMINISTRATOR' and registry_code=(SELECT REGISTRY_CODE FROM USERS WHERE urid = 'EU724332260059')), 'ACTIVE');</pre> 5. Sign this task 6. Via another NA claim and approve this task. 7. Ensure the message appears in an orange box: "User has already an admin role. You can only Reject the task" 8. Reject this task. Ensure the task is rejected normally and no further admin roles are applied to the user via the query: <pre>select * from accesses where profile_id = (select PROFILE_ID from profile where URID =</pre>	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			'EU724332260059') order by 1 desc;	
Text of EUTL Check 7861 incorrect; this is now fixed	Text of EUTL Check 7861 incorrect	https://webgate.ec.europa.eu/etsis/browse/-/1180 Text of check to be modified to: "Acquiring Account should be an ESD Compliance account for year *greater or equal to the* Active Year and ESD Member State other than the ESD Member State of the Transferring Account. For reversal Transferring Account should be an ESD Compliance Account for year *greater or equal to the* Active Year and ESD Member State other than the ESD Member State of the Acquiring Account."	Navigate to deployment files, message.properties file: Ensure the following line appears in this file: error.message.check.7861=Acquiring Account should be an ESD Compliance account for year greater or equal to the Active Year and ESD Member State other than the ESD Member State of the Transferring Account. For reversal Transferring Account should be an ESD Compliance Account for year greater or equal to the Active Year and ESD Member State other than the ESD Member State of the Acquiring Account.	PASSED
If the user has different mobile in ECAS and in Union Registry, a 404 error appeared; this is now fixed, presenting a message and two buttons. Idem for changing registry.	At login with GSM, if the GSM in EUCR <> GSM in ECAS, Error 404 appears.	If the user has different mobile in ECAS and in Union Registry, a 404 error appeared; this is now fixed, presenting a message and two buttons. Idem for changing registry.	EUCR-2469, EUCR-2470	PASSED
Screen correction for display of address	Displaying Addresses in Task with HTML tags	When checking Tasks in History Tab for some group of tasks which are displaying information with Addresses of Authorised Representative, or Holders Addresses, then this is displayed with HTML tags. In related places like for example account details/AR tab those address information looks correct.	1. Connect as NA and navigate to task history. 2. Find a task of type "Approve Account Representative Addition" 3. Click it and ensure the address does not appear with bullets 4. The actual data in the database can be confirmed as follows: select * from account_holder_rep_add_req where request_id = <<the request id of the chosen task>>; select * from account_holder_representative where ID = 10062; select * from business_details where business_details_id = 10062; select * from contact where ID = 10123; 5. Ensure the address details of the contact do not contain bullets and the screen does not contain bullets either.	PASSED
Administration roles management issue	Unrecoverable error (FacesException) when changing user role	Given user has a role assigned (e.g. National Administrator) it is possible to attempt to remove this role and assign different one in one step. Example: 1. User is NA in FI 2. As another NA go to FI registry and edit this user 3. Uncheck checkbox next to National Administrator - all checkboxes become enabled 4. Check checkbox next to Auditor for NA 5. Click [Next] button 6. Click [Submit] button	After the implementation of ETS-8849 and the re-design of admin roles management, it is impossible for an end-user to remove and add a role in one request. Via technical means, the following tests were done: The following scenarios were tested: Sign in as 'na' Administration -> Users -> Search -> URID GR9000000000001 Modified directly from National Administrator to Service Desk / SD Agent / Auditor for NA fails with	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		Unrecoverable error is displayed since this operation should be atomic and broken into 2 steps - remove NA role and add Auditor role	the following error message " ERROR You are not allowed to add more than 1 Administration role." When the same was tested from National Administrator to Central / System Administrator the error message is : " ERROR You are not allowed to upgrade your (or another users) role to a higher level than the one you currently have." It seems that the permission check is in higher priority. However when the application was enforced to modify the current role to a role that does not exist in the radio buttons (e.g. TRADER, VERIFIER), the modification fails without any error message to highlight the problem. Finally, attempts to assign double roles by adding two selectionsRadio values in the same HTTP request fail as well. Regarding the aforementioned tests, Burp Suite Pro was utilized https://portswigger.net/burp/download.html Burp is a software operating as a proxy between the browser and the application. It has the ability to intercept HTTP requests and perform man in the middle attacks in terms of replaying modified requests from the web interface to the server. Every request was intercepted for the above scenario. The key test was to understand the reactions of the backend code, based on the manipulated parameter "selectionsRadio" which reflects the choice of the user in the radio button list. This parameter was manipulated as part of the POST data sent with the "Next" button in the role management page. The plan was to test the following: Test case 1: Going from one role (e.g. National Administrator) to ONE other by skipping the "none" mandatory option. To do this, I changed the value of the selectionsRadio in the POST data of the request from 10223 which is the value of the NA, to a value which represents another role (e.g. 10421, SD Agent). Test case 2: Going from one role (e.g. National Administrator) to MANY others. In other words assign multiple roles to the same user. To do that I added two parameters named selectionsRadio, one keeping the value of my current role, and one more with a new valid value (e.g. 10421, SD Agent). With this scenario I wanted to simulate the previous check box functionality under the new radio button list. Test case 3: Going from 'None' role, to multiple users again with the same technique mentioned in the Test case 2 above. Test case 4: Ask for a role that does not exist in the radio button list. I tried to change my role from NA to Trader (value: 10313). Of course this option is not available in the list. The test successfully failed similar to all the previous test cases, but I didn't receive any error message for this situation. Just a short note for the test cases 1,2,3. I received a permission error when I attempted to change from NA -> CA or SA. The error was related to the prohibited change of the higher privileges of the target roles (CA, SA). In modifications that had a lower privilege role as a target, I was correctly receiving the following error: ERROR You are not allowed to add more than 1 Administration role.	

Feature	Summary	Description	Test Cases	SAT Status
Correction of text for check	7214 check text should be aligned with -364 fix for EUTL 6.8.1	After implementing -364 in EUTL 6.8.1 ♦Allocation transacted volume *<=* volume in NAT/NAVAT in EUTL - any already allocated volume + any returned volume♦. It means that text displayed in terminated transaction as a result of check 7214: "7214: The number of allowances transferred is not strictly equal to the number foreseen in the NAP for the specified installation and specified year." is *no longer accurate*	1. Navigate to deployment files, message.properties file: 2. Ensure the following line appears in this file: error.message.check.7214 = 7214: The number of allowances transferred is greater than the number foreseen in the NAT/NAAT for the specified installation/aircraft operator and specified year.	PASSED
Wrongly calculated values for transitional and NER allocations in Allocation Delivery Task	Wrongly calculated values for transitional and NER allocations in Allocation Delivery Task	Given the OHA account that received transitional and NER allowances. When there is a change in NAT related to transitional and NER values. Then values in Allocation Delivery task are wrongly calculated. Example: OHA received allowances per following NAT: Free: 100 Transitional: 200 NER: 300 NAT is updated with following values: Free: 110 Transitional: 210 NER: 310 When Allocation Delivery task is created it will display following summary: Total of allocations to be delivered: 530 (10 free, 210 transitional, 310 the NER) So it seems to work fine for free but transitional nad NER values are wrong. This is only display issues - when allocation transaction is generated, proper number of allowances is transferred (in this case 10 per allocation type).	Installation 12408 of Romania has the following values in allocation tables for 2016: Free: Allocation: 12, Allocated: 10 Transitional: Allocation: 36, Allocated: 30 NER: Allocation: 24, Allocated: 20 1. Connect as NA to RO 2. Navigate to EUETS -> Allocation Phase 3 3. Choose to propose allocation to installation 12408 4. Ensure the quantities 2, 6, 4 appear for each of Free, Transitional, NER 5. Claim the task "Approve allocation delivery settings" as another NA. 6. The task approval task mentions the quantities 2,6,4 and sums the total quantity of 12 units to be allocated. 7. Approve the task. 8. Ensure 12 units are allocated.	PASSED
The "reversal" button should be hidden in voluntary cancellation for all roles and permissions	The "reversal" button should be hidden in voluntary cancellation for all roles and permissions		1. Connect as NA and navigate to EUETS -> Transactions. 2. Search for transactions of type "4-0". 3. Click on a voluntary cancellation which is completed and whose completion date is less than the configuration parameter TRANSACTION_REVERSAL_WORKING_DAYS_LIMIT (because if it was older, it would already be prohibited to reverse it). 4. Ensure no "Reverse" button appears. Repeat for an account's AR, an account's AAR and all administrative roles: SD, SDA, Auditor, CA. Repeat for a voluntary cancellation just completed (executed with EU1160464 of EU).	PASSED

Feature	Summary	Description	Test Cases	SAT Status
Technical issue referring to a directive specifying the compatibility mode of Internet Explorer browser.	Change in compatibility mode only when IE9 is used, and leave it as is when IE10+	for the: EUCR-2008 and for EUCR-2411 (corresponding to -991) the following change was made: the <meta http-equiv="X-UA-Compatible" content="IE=EmulateIE8" />, was added at the main_layout.xhtml. This results to enforcing the change in compatibility mode only when IE9 is used, and leave it as is case of any subsequent IE version.	Use IE 9 to perform this test or alternatively: Use IE11 and click Development Tools. Set compatibility mode to IE9 to emulate IE9. Scenario: 1. Log in to RO registry as NA 2. Request opening the account (OHA) 3. Fill in data until Contact Person Information screen is displayed 4. Click on "Address Provided" checkbox 5. Repeat step 4 many times to check for intermittence 6. Submit the OHA creation request and ensure the account request is normally submitted. Repeat with IE10, Firefox, Chrome.	PASSED
Account statement issues; now fixed.	Conversion of CP1 AAUs are displayed as eligible in account statement screen	Conversion of CP1 AAUs are displayed as eligible in account statement screen. e.g. account PT 643 transaction PT154		PASSED
At issuance of CP1 KP units, these units are now marked ineligible for ETS.	IssueOfAAUsAndRMUs does not set the IS_INELIGIBLE flag	IssueOfAAUsAndRMUs does not set the IS_INELIGIBLE flag in auto_unit_selection_constraint nor in transaction_block.	1. Login as NA in EU and navigate to KP -> Issuance 2. Propose an issuance of KP1 RMU units 3. As another NA approve the issuance 4. Get the transaction identifier of the approved transaction request 5. Browse the transactions and ensure the transaction is COMPLETED. 6. Run the two following queries and ensure the IS_INELIGIBLE flag is 1: select * from transaction_block where transaction_id = (select transaction_id from transactions where transaction_identifier = '<<transaction_identifier>>'); select * from auto_unit_selection_constraint where transaction_identifier = '<<transaction_identifier>>';	PASSED
Account statement issues; now fixed.	EUCR-2407 Correction of Account Statements PDF	Correction of Account Statements PDF		PASSED
Account statement issues; now fixed.	Script which corrects AAUs & RMUs is not correct	Script which corrects AAUs & RMUs is not correct. "case when" in fixed_res are not correct.	This is a technical issue. This issue is implemented via a script which migrates account statement data. It is called via: BEGIN PKG_ACCST_CORR_AFTER_20150331.p_fix_account_statements (to_date('1/4/2015', 'dd/mm/yyyy'); END;	PASSED
Account statement issues; now fixed.	Account statements for AAU and RMU	The following are pending: # Show correctly AAU, RMU at screen and PDF	EUCR-2287, EUCR-2454,	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		# Migration script should include screen and PDF # Migration script should be optimised # New indices should be created for the script to run faster		
It was not possible to allocate to reserve allocation without having transitional allocation.	Red screen when allocating to installation	I have an installation with reserve allocation and no transitional allocation. I try to allocation to reserve and I get red screen.	Find an installation which has Free and NER allocation but not transitional. This is installation 12406 for RO in FAT. 1. Connect as NA for RO and navigate to EUETS->Allocation Phase 3. 2. Filter for year=2016 and allocate the NER quantity to installation 12406. 3. Confirm and approve as another NA. 4. Ensure the allocation is completed. (Transaction EU1160232 in our FAT).	PASSED
Admin roles management screen is modified so as to allow only one admin role per user.	Change of role selection in roles administration		From TC.01 Users-Basic Functionality-Account creation test document, execute the following: * UC_UA_060_TC_01, * UC_UA_060_TC_02, * UC_UA_060_TC_03, * UC_UA_060_TC_04	PASSED
Roles and permissions management screen optimizations.	The refresh following a tick in the Roles and Permission screen takes 5 seconds		Open a web browser and delete cache and all temporary internet files. Restart the browser. Repeat with IE and Firefox and Chrome. 1. Log in EU registry as NA 2. Navigate to Administration -> Roles and Permissions tab tick a box 3. An "update" icon appears; the screen is refreshed to disable all other checkboxes; update of the screen lasts less than 5 seconds. 4. User clicks "Next" button.	PASSED
Suspend/restore unit block pop-up window approval did not appear in Internet Explorer; this is now fixed.	Suspend/restore unit block pop-up window approval does not appear in Internet Explorer		Connect with IE11; repeat with Firefox and Chrome: 1. Log in EU registry 2. Administration -> Unit Blocks 3. Click on a unit block 4. Click suspend or restore 5. Pop-up window must appear	PASSED
Allocations technical issue; it is now fixed	Clicking on a new allocation setting delivery task causes screen to crash	I click on a new allocation in NA's exclusive task list and screen crashes. Refer to attachments.		PASSED
Inclusion of translation strings	Integrate MS translations for v7.0.4 (v6.7.3 --> v7.0.4 delta)			PASSED
Revert the changes performed via EUCR-2459 of EUCR 7.0.4.	Revert APPREQ-23	Remove meta tags added by APPREQ-23	1. Log in EUCR 2. Click "View source" on the browser 3. Ensure the following meta tags have been removed:	PASSED

Feature	Summary	Description	Test Cases	SAT Status
This added some HTTP headers in all pages of the application.			<pre> <meta http-equiv="Cache-Control" content="max-age=0" /> <meta http-equiv="Cache-Control" content="no-cache, no-store" /> <meta http-equiv="expires" content="0" /> <meta http-equiv="expires" content="Tue, 01 Jan 1980 1:00:00 GMT" /> <meta http-equiv="pragma" content="no-cache" /> </pre>	
This package fixes the account statement records for AAU, RMU, ERU_FROM_RMU, ICER, tCER. It accepts a date parameter, which must be greater of equal to 01-APR-2015.	Account statements correction since 01-Apr-2015 for five unit types of KP1	This issue corrects account statements generated from 01-Apr-2015 onwards for the units: * AAU * RMU * ERU_FROM_RMU * LCER * TCER It is tested via a series of SQL statements, and a procedure which is integrated in a package. It must also be tested that the correct package contained in Liquibase in committed in the database.		PASSED
Handling of error in case a wrong XML is uploaded in NAT/NAAT upload screen.	Unrecoverable error on allocation XML upload (incorrect xml)	1. Log in to registry as NA 2. Go to Allocation Tables Phase 3 3. Upload entitlementment xml Description When incorrect xml is uploaded in Allocation Tables Phase 3 unrecoverable error is thrown. This is happened when entitlements xml was used instead of allocations xml (please see attached).	*Test Case 1:* 1. At Allocations Tables Phase 3 link, nat section, upload an entitlements xml. 2. Red screen should not appear, only message "The content of the XML file is invalid" *Test Case 2* (about additional error discovered when uploading nat xml with value e.g. +++ instead of a number) 1. At Allocations Tables Phase 3 link, nat section, upload a nat xml which contains: <pre><ns1:allocation year="2014" type="free">+++</ns1:allocation></pre> 2. Red screen should not appear, only message "The content of the XML file is invalid" *Test Case 3:* Repeat Test Case 1 and Test Case 2 for naat *Test Case 4* (Regression) 1. Upload a nat with correct format in GB registry as NA. Submit some types of units for next allocation job 2. Upload a naat with correct format in GB registry as NA. Submit some types of units for next allocation job	PASSED
A question mark should appear in allocation screen, for installations or aircraft operators which have been	Wrong "Allocation disabled ..." indication in allocation delivery task	1. Create Allocation delivery task 2. Check if question mark appears only if installation is excluded for given year Description In Allocation delivery task every value has question mark icon indicating that "Allocation disabled because	*Test Case 1: Allocation to aircraft operator* - Aircraft case - All years in Compliance are Not Excluded for AOHA 10930 1. Log in GB as NA 2. Find an "Approve Allocation Delivery Settings" task in tasklist (request id = 495579, account	PASSED

Feature	Summary	Description	Test Cases	SAT Status
excluded for the allocation year.		installation is excluded for this year". It doesn't matter if it is really excluded. Same for OHA and AHOA, different years, different allocation types, adding or removing allocation.	identifier = 10930) 3. Check that in the task confirmation window there is no "?" marking in green boxes. 4. Set all years to Excluded for this aircraft operator. 5. Check that in the task confirmation window there is no "?" marking in green boxes. *Test Case 1 - Sub-Case 1* : Check 2015 as Excluded year, and go to task to check that there is not a "?" mark. *Test Case 1 - Sub-Case 2* : Check 2015 as Excluded year, upload allocation xml for 10930 and year 2016, and check there are no "?" marks in job submission page. *Test Case 1 - Sub-Case 3* : Check 2015 as Excluded year, upload allocation xml for 10927 and year 2015, and check there are "?" marks in job submission page. *Test Case 2: Allocation to installation* - All years in Compliance are Not Excluded - Installation case 1. Log in GB as NA 2. Find an "Approve Allocation Delivery Settings" task in tasklist (request id = 495558, account id=102) 3. Check that in the task confirmation window there is no "?" marking in green boxes. 4. Set all years to Excluded for this installation. 5. Check that in the task confirmation window there is no "?" marking in green boxes. *Test Case 2 - Sub-Case 1* : Make 2015 Excluded, upload allocation xml for 102 and year 2016, and check there are no "?" marks in job submission page. *Test Case 2 - Sub-Case 2* : Make 2015 Excluded, upload allocation xml for 102 and year 2015, and check there are "?" marks in job submission page. *Test Case 3 - Regression for allocation to installation* 1. Log in EU as NA 2. Check that account 101 has Excluded year 2015 3. Upload allocation xml for 101 4. Uploaded units can not be submitted - there must be a "?" mark, and checkbox is disabled *Test Case 4 - Regression for allocation to aircraft* 1. Log in EU as NA 2. Check that account 103 has Excluded year 2016 3. Upload allocation xml for 103 4. Uploaded units can not be submitted - there must be a "?" mark, and checkbox is disabled *Test Case 5 - Exclude/Unexclude between phases of proposal-approval of allocation* Installation accounts (FR): 12347, 12349, 12356	

Feature	Summary	Description	Test Cases	SAT Status
			1. Go to allocation screen, check three installations to receive allocation and submit request (the request XML is created with info that all accounts are not excluded) 2. Go to one of the accounts and exclude the year you just previously checked. 3. Go to tasklist and check that this account does not appear with question-mark (information is read from request XML and not from DB) 4. Approve the request, go to history and check that this account does not appear with question-mark and the others not (information is read from request XML and not from DB) 5. Go to this account and unexclude the excluded year. 6. Go to tasklist history and check that this account does not appear with a question-mark (information is read from request XML and not from DB) Repeat for aircraft. (FR accounts: 12358, 12359, 12360)	
Addition of permission for SDA in ESD registry.	'Manage ESD Account Search' should be granted to SERVICE_DESK_AGENT role	1. Check the script 2. Check if 'Manage ESD Account Search' is granted to SERVICE_DESK_AGENT role Description Liquibase changeset "7_0_4_EUCR-956_PERM_ESD_ACCOUNT_SEARCH1" doesn't cover granting 'Manage ESD Account Search' permission to SERVICE_DESK_AGENT role. If this change was done in PROD, script should be updated to reflect that.	Execute the following query (which returns the roles of ESD who have the permission PERM_ESD_ACCOUNT_SEARCH) and ensure the Service Desk Agent role appears in the resultset. <pre>select a.*, role_name from permissions a, role_permission b, roles c where a.permission_id = b.permission_id and b.role_id = c.role_id and perm_key = 'PERM_ESD_ACCOUNT_SEARCH' and registry_code = 'ED' order by 3;</pre>	PASSED
New transactions of CER or ERU_FROM_AAU will be characterized as ineligible in account statements.	Ineligible units shown as eligible on account statement page	This issue corrects account statement calculations for new transactions for the units types: * CER * ERU_FROM_AAU New transactions must be entered with the above units in CP1 in positive and negative lists, and ensure that always the units appear as ineligible in account statements.	*Test Case 1: CER* 1. Log in GB as NA 2. Transfer 2 CER of CP1 from account with identifier=356 to trusted account with id=360 3. At Holdings tab of acquiring account, there should be 2 more CER units, as ineligible 4. Account statement of account 360 shows 2 CER ineligible *Test Case 2: ERU_FROM_AAU* 1. Repeat with same data except from unit type which will be ERU_FROM_AAU. 2. Transfer 3 units from account with identifier=356 to trusted account with id=360 3. Check new 3 units are added as ineligible in acquiring account. 4. Account statement of account 360 shows 3 ERU_FROM_AAU ineligible *Test Case 3: CERs which are in General Positive list* Repeat Test Case 1 but for a project which is in General Positive List. The transacted units are characterised as red (ineligible, because they are in CP1) in account holdings, account statement screen and account statement PDF. Transaction EU1190910 is completed between account 356 and 360 and transfers CP1 CER contained in GB1 project, which is in General Positive List. The units are marked as red in account statements of both accounts.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
In NAAT allocation, special reserve value to be allocated did not appear correctly in allocation delivery approval screen. This is now fixed.	Value for AOHA Special Reserve allocation not displayed in Allocation Delivery Task	1. Upload NAAT with vales for Free and Special reserve 2. Tick and submit allocations 3. Display Allocation Delivery task and check if Special Reserve value is taken into account in summaries and grid *Description* When NAAT with value for Free and Special Reserve allocations is uploaded for aircraft operator and Allocation Delivery task created than Special reserve value is not taken into account on task display page. What is interesting that if Special reserve is the only allocation type it is displayed properly.	1. Upload the following NAVAT in FAT, Romanian registry: <pre><?xml version="1.0" encoding="UTF-8"?> <ns1:navat registry="RO" xsi:schemaLocation="urn:eu:europa:ec:clima:ets:1.0 ../navat.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:ns1="urn:eu:europa:ec:clima:ets:1.0"> <ns1:aircraftOperator action="A" identifier="12453"> <ns1:allocation year="2016" type="free">46</ns1:allocation> <ns1:allocation year="2017" type="reserve">16</ns1:allocation> <ns1:allocation year="2018" type="free">10</ns1:allocation> <ns1:allocation year="2018" type="reserve">20</ns1:allocation> </ns1:aircraftOperator> </ns1:navat> 2. Upload the same file in EUTL. 3. Perform an allocation for 2018, ensure the value in approval screen appearing is Free=10, Reserve=20 4. Perform an allocation for 2017, ensure the value appearing in approval screen is Reserve=16 5. Perform an allocation for 2016, ensure the value appearing in approval screen is Free=46</pre>	PASSED
A user who is un-enrolled from ESD and does not hold any other administrative role should not be considered as privileged. This is now enforced.	User still considered as privileged after un-enrolling from ESD	If given user is AR in EUCR registry and AR in ESD, than it is considered privileged. Now when this user un-enrols from ESD, than should be considered as non-privileged. Unfortunately this is not the case and user still needs to have record in TMS. The reason for that is the query in Authentication Provider doesn't take into account ESD user status at all.	For below cases, a new user creation in userDatabase.xml, is proposed (nadmin11, nadmin12 already exist, also make sure that the chosen nadmin in unenrolled in ESD and GR) *Test Case 1* 1.Register the user nadmin11 in GR and enrol. 2.As NA in GR, grant user an admin role. 3. In FAT DB enter flag=T for the user 4. User should be able to log in with Token *Test Case 2* 5. Unenrol the user 6. Cannot log in with Token *Test Case 3* 7. For the above user, give role=None if needed, and assign him as AR of an account in GR (GR-121-383-0-27) 8. In ESD, log in as the new user and enrol. 9. Make him an AR of an ESD account (EU-100-10001864-0-31) 10. User should log in with Token *Test Case 4*	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			12. Unenrol from ESD, 13. User shouldn't be able to log in with Token anymore	
Under some circumstances the ICE XML did not contain full data. This is now fixed.	ICE XML export takes into account only items currently displayed in the list	1. Upload and approve IE for more than 10 installations 2. Go to Entitlements screen display only 10 items in the list 3. Export XML and check if all installations have been exported.	*Test Case 1* 1. In GR registry as NA, in Entitlements, click Search. 2. Results are returned, but only 3 records have an ICE value uploaded 3. Go to 7th page (where only one row will appear in XML) 4. Click Export XML 5. Check in XML that 3 entitlements appear 6. Repeat by paging in other pages, exporting always creates a file with 3 records. 7. Return to the ICE screen and ensure paging works normally, after creating and closing the XML file. Repeat the above for CSV file generation but all the records are returned, both those having ICE value and those not having ICE value.	PASSED
When a user is logged in ECAS with both GSM in Token the system detected this and prompted to return to a wrong page of ECAS. This is now fixed, and used is returned to the standard ECAS logout screen.	User logged in ECAS with both GSM in Token - inconsistent logout procedure	Two issues for this: 1.1. As privileged user log in to EUCR with Token 1.2. Log out from EUCR (bot not from ECAS) 1.3. Log in using GSM (expected behaviour - user cannot log in with GSM) 1.4. Check the error description page 1.5. Logout from EUCR and ECAS 2.1 As non-privileged user with Assigned token log in using GSM 2.2. Log out from EUCR (bot not from ECAS) 2.3. Log in using Token (expected behaviour - user cannot log in with Token) 2.4. Check the error description page 2.5. Logout from EUCR and ECAS Refer to -1224	A. Test a privileged user having logged in with both Token and GSM 1. As privileged user log in to EUCR with Token 2. Log out from EUCR (bot not from ECAS) 3. Log in using GSM 4. Check the error description page; the main Logout screen of ECAS is depicted 5. Click the Logout button presented on the EUCR screen 6. Ensure the screen reached in ECAS is the one depicted in step 4 above. 7. Click Logout in ECAS. The user is now logged out of both systems. B. Test a non-privileged user who has a token in ECAS and has logged in ECAS with both GSM and Token. This can be accomplished by assigning a token to a user who is NOT defined with flag T in TMS. 1. Log in with GSM 2. Log out from EUCR (but not ECAS) 3. Log in with Token 4. Check the error description page; the main Logout screen of ECAS is depicted 5. Click the Logout button presented on the EUCR screen 6. Ensure the screen reached in ECAS is the one depicted in step 4 above. 7. Click Logout in ECAS. The user is now logged out of both systems.	PASSED
The prefix "00" or "+" is now mandatory at edit or insert of user's GSM.	Mobile phone update issues	1. As NA go to "Edit your personal details" page and update phone with one that is not starting with + nor 00 2. As NA go to "Edit your personal details" page and check if there is reminder that GSM number should be the same as in ECAS 3. As NA using token go to new registry and request new user to be created	A. Test "Edit your personal details" screen 1. Log in as NA to a registry where you have a profile 2. Click on "Edit your personal details" 3. Enter telephone: 123456789 and click Next.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		3.1 Fill all required data including GSM 3.2 Click Next and then Back button 3.3 Check is GSM field is enabled *We reproduced only step 1. Step 1 is in scope for fixing*	4. Ensure the validation rule for telephone fires: "International format including country code (prefix: "00" or "+"), e.g. for Belgium +32123456789" B. Test "Fill in your personal details" screen 1. Log in with Token 2. Switch to a registry to which you do not have a profile 3. Click "Fill in your personal details" 4. Enter telephone: 123456789 and click Next. 5. Ensure the validation rule for telephone fires: "International format including country code (prefix: "00" or "+"), e.g. for Belgium +32123456789" C. Test personal details update screen 1. Log in as NA 2. Navigate to Administration-->Users--> Search and locate a user. 3. Click on a user and navigate to Personal Details tab. 4. Click Edit 5. Enter telephone: 123456789 and click Next. 6. Ensure the validation rule for telephone fires: "International format including country code (prefix: "00" or "+"), e.g. for Belgium +32123456789" For all the above cases A,B,C ensure the only allowed telephone format is the following, parentheses are omitted: (+ or 00)(1 digit of 1..9)(9,10 or 11 numeric digits) +1123456789 is permitted +11234567891 is permitted +112345678911 is permitted +1123456789111 is not permitted 1123456789 is not permitted 0123456789 is not permitted 11234a6789 is not permitted a123456789 is not permitted 112345678a is not permitted z12345678a is not permitted -1123456789 is not permitted ++112345678 is not permitted 00112-456789 is not permitted 00112.456789 is not permitted 00112456789 is permitted 000000000000 is not permitted 001000000000 is permitted 00z000000000 is not permitted	

Feature	Summary	Description	Test Cases	SAT Status
Reversal of allocation crashed at submission. This is now fixed.	Reversal of Allocation - RedBox - Unrecoverable Error	While proposing Reversal of Allocation units in EUCR-DEV (v 7.0.4, REGISTRY=BG) on OHA account I got few times "Unrecoverable Error". See the pictures attached. This is happening when user will open specific Allocation transaction and there is displayed [Reverse] button,	A. Reverse an allocation to installations. 1. Successfully reversed allocation EU1188316 for GB. 2. Approval was done by NA (Token), NADMIN1 (Token), CA (GSM) B. Reverse an allocation to aircraft operators. 1. Successfully reversed allocation EU1188401 for GB. 2. Approval was done by NA (Token), NADMIN1 (Token), CA (GSM) C. Regression testing: Reverse a surrender 1. Successfully reversed surrender EU1188413. 2. Approval was done by NA (Token), NADMIN1 (Token), CA (GSM)	PASSED
Split of user's details in four tabs: personal details, business details, admin roles, accounts.	Unrecoverable error when requesting change of user contact data	1. Log in as NA with token (same flow for GSM) 2. Go to Users and open user details 3. Go to Administration roles tab 4. Click [Edit] button 5. Change any Contact details and click [Next] 6. Click [Submit] 7. Unrecoverable error is thrown	General test data: New users: nadmin11, nadmin12 Registry tested: GR *Test Case 1* View user details: -For NA user, Auditor, CA, Service Desk, Service Desk Agent -For simple user (AR, AAR) *Test Case 2* Personal details update -Request approved and applied -Request rejected -Double submissions are not permitted *Test Case 3* Business details update -Request approved and applied -Request rejected -Double submissions are not permitted *Test Case 4* Admin roles update -Request approved and applied -Request rejected -Double submissions are not permitted -If applied on REGISTERED user, user becomes VALIDATED and enrolment keys are generated. -Remove a role -Add an admin role -Cannot add an admin role while having another admin role.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			Test Case 5 Repeat tests in ESD --> Administration --> Users. -Personal details -Business details -Admin roles *Test Case 6* -Unenrol enrolled user -Cannot Edit any of the Personal Details, Business Details or Administration Roles tabs *Test Case 7 - Task History - Old tasks* -Log in GR as NA -In Task List History, open request 366572 -There should be a Business Details tab *Test Case 8 - Task History - New tasks* -Log in GR as NA -In Task List History, open request 499029 (type is Update Of User Business Details) -There should be only a Business Details tab -Repeat for type: "Administration Roles Update", check newest -There should be only Role and User tabs	
During log in, the system could mix user's profiles, if user held more than one profile; this is now fixed.	Authenticator Provider query which returned EUCR user info returns wrong row	The query which returns the EUCR user info selects all rows of user, even rows with status Unenrolled. The query does not have an order by clause and therefore it is possible that the first row is not the correct one since oracle returns the rows in an arbitrary way. Modify query FIND_EUCR_USER_BY_EID_AND_REGISTRY, and add an order by clause to bring first the non unenrolled status row.		PASSED
It is not possible to generate CAPTCHA images, used during account request for not logged-in user.	Unrecoverable error when requesting new account as not-logged-in user (CAPTCHA issue)	As not logged-in user: 1. Go to registry page and click on "Account request" 2. Check if Captcha image is properly displayed on "Account Opening Account Details" 3. Select account, fill all required data and request new account Description When not logged-in user tries to request new account unrecoverable error is thrown. There seems to be 2 bugs which might be related. When not logged-in user goes to registry page and click on "Account request" link "Account Opening Account Details" page is displayed. Now: 1. Captcha image is broken (NoClassDefFoundError) 2. When user selects any type of account unrecoverable error is thrown (IndexOutOfBoundsException) This issue also exists in version 7.0.4	Deploy EUCR in Production mode. 1. Navigate to a registry's homepage without having logged in. 2. Click on "Account Request" 3. Type an invalid CAPTCHA code and click "Next" 4. Ensure the error "Invalid code typed" appears 5. Click "Try another image" 6. Type the correct CAPTCHA code; enter account type and name and click "Next" 7. Enter new account holder details 8. Provide the rest of the account details, according to the account type chosen. 9. Submit the account creation request. 10. As an NA approve the account creation request and note the new account identifier. 11. Ensure the account has been created by searching for the new account identifier.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			Repeat for OHA (EU section), trading account (EU section), person account in national registry (KP section).	
Business details update task does not contain user details; this is now fixed.	There is no user information on Business Details Update task details screen	There is no user information on Business Details Update task details screen	1. Log in as NA1 2. Propose Business Details Update 3. Verify there is user related information on task details screen in the form of a table containing URID, name, login. 4. Log in as NA2 5. Approve the task 6. Verify there is user related information on task details screen in the form of a table containing URID, name, login. 7. Search the task in history 8. Verify there is user related information on task details screen in the form of a table containing URID, name, login.	PASSED
CP2 requirements	CLONE - Unrecoverable error when requesting change of user contact data	1. Log in as NA with token (same flow for GSM) 2. Go to Users and open user details 3. Go to Administration roles tab 4. Click [Edit] button 5. Change any Contact details and click [Next] 6. Click [Submit] 7. Unrecoverable error is thrown	General test data: New users: nadmin11, nadmin12 Registry tested: GR *Test Case 1* View user details: -For NA user, Auditor, CA, Service Desk, Service Desk Agent -For simple user (AR, AAR) *Test Case 2* Personal details update -Request approved and applied -Request rejected -Double submissions are not permitted *Test Case 3* Business details update -Request approved and applied -Request rejected -Double submissions are not permitted *Test Case 4* Admin roles update -Request approved and applied -Request rejected -Double submissions are not permitted -If applied on REGISTERED user, user becomes VALIDATED and enrolment keys are generated. -Remove a role	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			-Add an admin role -Cannot add an admin role while having another admin role. *Test Case 5* Repeat tests in ESD --> Administration --> Users. -Personal details -Business details -Admin roles *Test Case 6* -Unenroll enrolled user -Cannot Edit any of the Personal Details, Business Details or Administration Roles tabs *Test Case 7 - Task History - Old tasks* -Log in GR as NA -In Task List History, open request 366572 -There should be a Business Details tab *Test Case 8 - Task History - New tasks* -Log in GR as NA -In Task List History, open request 499029 (type is Update Of User Business Details) -There should ne only a Business Details tab -Repeat for type: "Administration Roles Update", check newest -There should be only Role and User tabs	
KP2 requirements	Message enrichment when logging out due to Token+GSM	The message "Please authenticate using your GSM" should be enriched as: "Please logout from ECAS and then authenticate with your GSM." The button "Login" to be renamed as "Go to ECAS". The same for the message "Please authenticate using your Token"	Test Case 1: 1.User is configured to log with GSM 2.User logs in with Token. 3.System informs the user with the "GSM Expected" screen (result1.png): - Title: "Authentication Error" - Message: "Please logout from ECAS and then authenticate with your GSM." - Button 1: "Go to ECAS" - Button 2: "OK" Test Case 2: 1.User is configured to log with Token. 2.User logs in with GSM. 3.System informs the user with the "Token Expected" screen (result2.png): - Title: "Authentication Error" - Message: "Please logout from ECAS and then authenticate with your Token."	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			•Button 1: "Go to ECAS" •Button 2: "OK"	
KP2 requirements	New Account - PPSR	Create PPSR Account, only by NA of MS, only one open per registry, account type code 130, applicable for CP2 only	Possible CP is only 2. Can be created in any KP registry, including EU registry. Related use case: UC_AM_10: REQUEST ACCOUNT OPENING	PASSED
KP2 requirements	PPSR - Allowed unit types	PPSR Accounts can only hold AAUs with originating CP = (current CP = 1) and applicable CP = 2 (Check 7029)	Executed UC_HT_170_TC_01: Transfer AAUs from GB PPSR account to FR PPSR account	PASSED
KP2 requirements	PPSR - Available transactions	Allow only transactions retirement and transfer to another PPSR	Executed UC_HT_170_TC_01: Transfer AAUs from GB PPSR to FR PPSR account	PASSED
KP2 requirements	Carry-Over of CP1 AAUs - Transaction availability	Carry-Over AAU transaction is not available if PPSR account does not exist		PASSED
KP2 requirements	Unit block flag Subject / Not subject to SOP	New flag in unit block for all AAUs with Originating CP2 must bear either "Subject to SOP" or "Not subject to SOP" - Unit block - add flag	UI flag: See EUCR-2482 DB flag: IN FAT database, check if table unit_block has column "SOP" with values 1="Subject to SOP", 2="Not Subject to SOP"	PASSED
KP2 requirements	Unit block view - add "Subject to SOP" or "Not subject to SOP" flag	Unit block view/add/edit - add "Subject to SOP" or "Not subject to SOP" flag The name of the column will be "SOP", the same column could be used by ERU_FROM_AAUs to mark "Converted for SOP" units Changes must be made to export CSV as well	1. Connect as NA and navigate to Administration -> unit blocks. 2. Click on a unit block hyperlink 3. Ensure the fields "Subject to SOP" and "Converted for SOP" exist. 4. Locate an account with both Subject to SOP and Not Subject to SOP and export its unit blocks as CSV. 5. Copy and paste the exported file in Excel and ensure a new right-most column exists, SOP, which contains the SOP value appearing on screen.	PASSED
KP2 requirements	Unit block search - add "Subject to SOP" or "Not subject to SOP" flag	Unit block search - add "Subject to SOP" or "Not subject to SOP" flag	*Test Case 1* 1. Log in GR as NA 2. In Unit Blocks click Search 3. In column "SOP" there should be some records with values "Subject to SOP" / "NotSubject to SOP"	PASSED
KP2 requirements	Holding screen - CP2 AAUs must be split into two rows	Holding screen - CP2 AAUs must be split into two rows There are various versions of this screen depending on the account type, all versions must be changed	Prerequisite: For account PT-643 exist AAU units with both markings (Subject to SOP, Not Subject to SOP) *Test Case 1* 1. Log in PT as NA 2. Go to account 643 -> Holdings 3. There should be rows with: AAU (Not Subject to SOP), and AAU (Subject to SOP) unit type columns	PASSED
KP2 requirements	Auto/Manual unit selection constraint - add "Subject to SOP" or "Not subject to SOP" flag	Auto/Manual unit selection constraint - add "Subject to SOP" or "Not subject to SOP" flag	Type "select * from auto_unit_selection_constraint;" Ensure a new last column exists named: "SOP"	PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 requirements	Transaction Block - add "Subject to SOP" or "Not subject to SOP" flag	Transaction Block - add "Subject to SOP" or "Not subject to SOP" flag	1. Check column SOP exists in table TRANSACTION_BLOCK. 2. Check a transaction which transferred AAU units subject to SOP --> units must be marked as Subject to SOP. 3. Check a transaction which transferred AAU units Not subject to SOP --> units must be marked as Not Subject to SOP. 4. Check a transaction which transferred ERU units Converted for Transfer to SOP --> units must be marked as Converted for Transfer to SOP. Note: the exact value of column SOP can be queried via: select * from transaction_block where transaction_id = (select transaction_id from transactions where transaction_identifier = 'PT184');	PASSED
KP2 requirements	Transaction Details - add "Subject to SOP" or "Not subject to SOP" flag	Transaction Details - add "Subject to SOP" or "Not subject to SOP" flag	1. Locate a transaction with AAU units (subject to SOP) as located via the transaction_blocks table with SOP = 1 --> Ensure it appears as Subject to SOP on transaction details screen. 2. Locate a transaction with AAU units (subject to SOP) as located via the transaction_blocks table with SOP = 0 --> Ensure it appears as Not Subject to SOP on transaction details screen. 3. Locate a transaction with AAU units (subject to SOP) as located via the transaction_blocks table with SOP = null --> Ensure it appears as Not Subject to SOP on transaction details screen. 4. Locate a transaction with ERU units (subject to SOP) as located via the transaction_blocks table with SOP = 1 --> Ensure it appears as Converted for SOP on transaction details screen.	PASSED
KP2 requirements	Transaction PDF - add "Subject to SOP" or "Not subject to SOP" flag	Transaction PDF - add "Subject to SOP" or "Not subject to SOP" flag	1. Locate a transaction with AAU units (subject to SOP) as located via the transaction_blocks table with SOP = 1 --> Ensure it appears as Subject to SOP on transaction PDF. 2. Locate a transaction with AAU units (subject to SOP) as located via the transaction_blocks table with SOP = 0 --> Ensure it appears as Not Subject to SOP on transaction PDF. 3. Locate a transaction with AAU units (subject to SOP) as located via the transaction_blocks table with SOP = null --> Ensure it appears as Not Subject to SOP on transaction PDF. 4. Locate a transaction with ERU units (subject to SOP) as located via the transaction_blocks table with SOP = 1 --> Ensure it appears as Converted for SOP on transaction PDF.	PASSED
KP2 requirements	Account Statements - add "Subject to SOP" or "Not subject to SOP" flag (db, code, screen, pdf)	Account Statements - add "Subject to SOP" or "Not subject to SOP" flag - add extra columns for amount & balance - add code to support breaking of amount/balance - modify account statement PDF		PASSED
KP2 requirements	Issuance of CP2 AAUs - default marking is "subject to SOP"	Issuance of CP2 AAUs - default marking is "subject to SOP"		PASSED
KP2 requirements	Database Script to mark CP2 AAUs when installation of application	Database Script to mark CP2 AAUs when installation of application - A script will be created which will run at the GO LIVE of the version which will update all CP2 AAUs for NON-ETS registries with the flag "Not subject to SOP". - Also, all CP2 AAUs from ETS registries which have left ETS and returned back will be marked as "Not subject to		PASSED

Feature	Summary	Description	Test Cases	SAT Status
		SOP". The latter units can be found as AAU units contained in TRANSACTION_BLOCK table where the transferring registry is a NON-ETS registry		
KP2 requirements	"Transfer to SOP Adaptation Fund for First External Transfer of AAUs" - New transaction	- New transaction "Transfer to SOP Adaptation Fund for First External Transfer of AAUs" - Acquiring account for "Transfer to SOP Adaptation Fund for First External Transfer of AAUs" is "SOP Adaptation Fund " - The acquiring account is prefilled and cannot be changed - The "SOP Adaptation Fund " account must be kept in a parameter - Only available to NA, subject to 4 eyes principle - is NOT reversible - is immediate - Only available to Account type with code 100 that holds Orig & Applic CP2 AAUs marked as "Subject to SOP" (check UC for all rules) - Check UC for the visibility of the link for the transaction - Check UC for all checks that need to be enforced for the creation of the account proposal - MUST SHOW all AAU units on the screen, BUT only those marked as "Subject to SOP" must be editable - PPSR accounts do not have this type of transaction - At finalization: - Units changed to "NOT Subject to SOP" - Entitlement for first external transfer of AAUs is increased by the amount of the transfer - On completion of "Transfer to SOP Adaptation Fund for First External Transfer of AAUs" the units that were transferred are marked as "not subject to SOP". - The units that are "NOT subject to SOP" must be stored in a different table as they leave the ETS - The value "Entitlement for First External Transfer of AAUs" is increased by 49x the amount of the transaction	Executed UC_HT_180_TC_01: Transfer to SOP for First External Transfer of AAUs	PASSED
KP2 requirements	Incoming external transfers - mark CP2 AAUs as "not subject to SOP"	- Incoming external transfers - mark CP2 AAUs as "not subject to SOP" - All CP2 AAUs that are inserted in unit block from an external transfer with a transferring account outside Union Registry will be marked as "not subject to SOP"	Executed UC_HT_180_TC_01: Transfer to SOP for First External Transfer of AAUs	PASSED
KP2 requirements	Create table - handling for registry values	- Create table - BE handling for registry values - Create enumeration with various values - Main table with registry - value type - value, child table with movements and statuses pending, completed etc (like exchange info) - value list contains: - "Entitlement for First External Transfer of AAUs" - "Remaining Entitlement for First External Transfer of AAUs"		PASSED
KP2 requirements	Check at proposal & Transaction finalization - transfer of Kyoto units with orig & applic CP2 AAUs - update value	- For each Transfer of Kyoto units with Orig & Applic CP2 AAUs with marking "Subject to SOP", if Hosting registry of transferring and acquiring accounts is different, the value of "Remaining Entitlement for First External Transfer of AAUs" must be checked for all "subject to SOP" units - information like exchange_info should be kept for value "Remaining Entitlement for First External Transfer of AAUs" - at the finalization of the transaction the remaining entitlement should be decreased.		PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 requirements	"Transfer to SOP Adaptation Fund for First External Transfer of AAUs" - Finalization of transaction	- On completion of "Transfer to SOP Adaptation Fund for First External Transfer of AAUs" - The similar exchange_info table is updated - the value of "Remaining Entitlement for First External Transfer of AAUs" is updated - the unit blocks are marked as "NOT subject to SOP" in the unit block table and other table	Executed UC_TF_040_TC_232	PASSED
KP2 requirements	New menu under "Kyoto Protocol" with name "KP2 Entitlements" - new screen for NA	- New menu for NA under "Kyoto Protocol" with name "KP2 Entitlements" - The NA views only the values of Share of Proceeds transferred, Entitlement, Used Entitlement, Pending Entitlement, and Remaining Entitlement for First External transfer of AAUs.		PASSED
KP2 requirements	New screen/functionality to upload PPSR / CER/ERU Entitlements	New screens functionality to upload PPSR (AAU) and one for CarryOver (CER/ERU_FROM_AAUs) Entitlements for registries, available only to EU-CA Script to add permission to CA The CER/ERU screen should have a drop down with the two types of entitlements (UC were modified), an extra check should be made that the value from the drop down corresponds to the uploaded XML. Check UC for all the checks that need to be enforced on xml upload. History data must be kept. All three types of entitlements must be kept in the same table.	TC.26 UC_EN_040_TC_01: Upload KP2 entitlements in Union Registry	PASSED
KP2 requirements	PPSR Account - Holdings tab - add table with entitlement values	PPSR Account - Holdings tab - add table with entitlement values ("PPSR Initial Transfer Entitlement", "Available PPSR Entitlement")		PASSED
KP2 requirements	"Transfer AAU to PPSR account" - Finalization - update value of "Available PPSR Entitlement"	- On the finalization of the transfer from one PPSR to another PPSR, the "Available PPSR Entitlement" of the acquiring account is DECREASED with the quantity of the transaction - This will create a row on the child table of entitlements, with movement type DECREASE, and also update the parent table with the correct amount (sum of all children)		PASSED
KP2 requirements	Transfer AAU to PPSR account - New transaction	- New transaction Transfer AAU Between PPSR Accounts (either within ETS or outside) - EUCR will NOT check on the proposal of transfer from one PPSR to another PPSR that the "Available PPSR Entitlement" of the acquiring account does not go below 0 - The screen is another issue - Check UC for screen + finalization actions		PASSED
KP2 requirements	Transfer AAU to PPSR account - Proposal/Confirmation Screen	Transfer AAU Between PPSR Accounts - Proposal /Confirmation Screen - The screen includes a list of all OPEN PPSR accounts	*Test Case 1 - Transfer 1 unit to EU PPSR account* : UC_HT_170_TC_01: Transfer AAUs from GB PPSR account to FR PPSR account 1. Log in GB as NA 2. Accounts -> Type:PPSR -> Holdings -> Propose transaction -> Transfer AAU to PPSR account 3. Choose 1st radio button, and select GB account. Quantity to Transfer =1. 4. Complete the proposal and the approval 5. GB account now should have 1 less, and FR 1 more AAU unit. *Test Case 2 - Transfer externally* : UC_HT_170_TC_02: Transfer AAUs from GB PPSR account to Japanese PPSR account	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			- Repeat process of Test Case 1 except for choosing 2nd radiobutton and providing an account e.g. "JP-130-4444-[0,1,2]" - Check unit distribution *Test Case 3 - Retirement* : UC_TF_080_TC_01: RETIRE UNITS - Repeat process of previous test case 1, except for choosing "Retirement" instead of "Transfer AAU to PPSR account", for 1 unit. - Check loss of 1 unit *Test Case 4 - Transfer from any other PHA is not possible* - Send units from GB PHA to GB PPSR. It is not possible. - Send units from FR PHA to GB PPSR. It is not possible. - Send units from Japan to GB PPSR. It is possible.	
KP2 requirements	Incoming transaction from PPSR account - check Available PPSR Entitlement	- When non-EU PPSR is the transferring account, if Available PPSR Entitlement of the acquiring account goes below 0, the transaction must be rejected - Missing ITL error		PASSED
KP2 requirements	"PPSR account" - Retirement transaction available from PPSR account	- Retirement transaction from PPSR account subjects to 4-eyes principle - Some checks concerning the amount are checked by ITL		PASSED
KP2 requirements	New screen for NA (same screen as REQ-46) - add conversion values	- New menu for NA under "Kyoto Protocol" with name "KP2 Entitlements" (same as REQ-46) - The NA views only the values of Converted for Transfer to SOP, Transferred to SOP for Conversion, Entitlement for Conversion, Used Entitlement for Conversion, Pending Entitlement for Conversion and Remaining Entitlement for Conversion. The NA should see these values in total for his registry, as well as a breakdown per each project		PASSED
KP2 requirements	JI Projects - edit limit for TRACK 2 projects	- NA can view and modify limit for track 2 projects - NA can view the Conversion Limits of track 2 projects per project (JI project search screen) - add logging, history - Permission	Tested by: UC_CV_010_TC_03: EDIT PROJECT LIMIT from TC.15 JI Projects document	PASSED
KP2 requirements	New transaction "Conversion of AAUs or RMUs to ERUs prior to Transfer to SOP" (Conversion A)	- New transaction "Conversion of AAUs or RMUs to ERUs prior to Transfer to SOP" (Conversion A) - Available to all type 100 accounts with orig & applic CP2 AAUs or RMUs, except PPSR accounts - Acquiring account of conversion is the same as the transferring account - It is not permitted to convert AAUs and RMUs in the same transaction, also only one project - Outcome is ERU_FROM_AAUs or ERU_FROM_RMUs depending on the original units (like CP1 conversion) - AAUs involved in conversion may have marking "subject to SOP" or "NOT subject to SOP" (i.e. we do not care if they have been subjected to SOP) - The user must be able to choose "subject to SOP" or "NOT subject to SOP" units (different rows on the screen) - On completion (transaction finalization) of the conversion transaction for ERUs, the ERUs are marked as	Tested by executing UC_HT_195_TC_01: CONVERT UNITS TO ERUS PRIOR TO TRANSFER TO SOP ("CONVERSION A"). In addition, the steps defined in this issue's description were followed. Unit blocks created in EUCR were tested via the EUCR screens. Unit blocks created in EUCR were tested via the query: select end_block-start_block+1, sop from unit_block where block_id in (select block_id from account_holding where account_id =	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		"Converted for SOP"; - unit block marking "subject to SOP", "not subject to SOP" is removed from converted ERUs - Check UC for more info about preconditions, and list of available projects. - Each project corresponds to a unit type (it must be shown next to the project number in the drop down) - Only host country of JI project can initiate conversion - Conversion screen includes some calculation display (check UC) - Screen is a different jira	(select account_id from account where account_identifier = 643)) and unit_type_code = 3; Note1: Conversion A of Track 2 projects returns the following ITL error codes which are due to ITL configuration. Correct ITL configuration with regard to JI projects will allow this transaction to complete: * 5063 * 5061 Note2: Conversion entitlements are reviewed via EUCR screens and EUTL screens.	
KP2 requirements	Conversion A - Proposal /Confirmation Screen	Conversion A - Proposal /Confirmation Screen	Tested by executing UC_HT_195_TC_01: CONVERT UNITS TO ERUS PRIOR TO TRANSFER TO SOP ("CONVERSION A").	PASSED
KP2 requirements	Conversion A - Finalization	Conversion A - Finalization	Tested by executing UC_HT_195_TC_01: CONVERT UNITS TO ERUS PRIOR TO TRANSFER TO SOP ("CONVERSION A").	PASSED
KP2 requirements	Holdings screen - display number of units with the marking "Converted for SOP"	- Holdings screen, display number of units with the marking "Converted for SOP"	tested successfully UC_HT_195_TC_01 & UC_HT_200_TC_01	PASSED
KP2 requirements	"Converted for SOP" units can ONLY be used in "Transfer to SOP for Conversion" - exclude from other "Transfer Kyoto Units" or related transactions	- "Converted for SOP" units can ONLY be used in "Transfer to SOP for Conversion" Those units must be EXCLUDED from other "Transfer Kyoto Units" etc transactions. Many transactions involved. This must be implemented in a) filter the unit blocks when proposing transaction b) new extra check in all transactions related to ERUs c) unit block reservation		PASSED
KP2 requirements	New transaction "Transfer to SOP for Conversion"	- New transaction "Transfer to SOP for Conversion" - Available only if "Converted for SOP" units exist on account - Available only from KP accounts of type 100, except PPSR - Unit types: ERU_FROM_AAU or ERU_FROM_RMU with marking "Converted for SOP" - Only one unit type must be present in the transaction - The quantity of the transaction must match a previous Conversion A for the respective project (user selects project) (for track 2 projects) - Destination account is a preselected and not modifiable(parameter in system) (New check must be created to check acq account) - not reversible, not subject to delay, holidays, working hour, 4 eyes, NA --> NA - Check UC for full set of checks which must run - transaction finalization: - increase the variable "Transferred to SOP for Conversion" - increase the variable "Entitlement for Conversion" with 49x the value of the transition "Transfer to SOP for Conversion" of the same project		PASSED

Feature	Summary	Description	Test Cases	SAT Status
		- removal of the marking "Converted for SOP" - new check: - For track 2 projects, conversion quantity must be EXACTLY EQUAL TO the quantity of the last successful "Conversion A" - The value of "Entitlement for Conversion" should always be 49x the value "Transferred to SOP for Conversion"		
KP2 requirements	Transfer to SOP for Conversion - Proposal/Confirmation screen	Transfer to SOP for Conversion - Proposal/Confirmation screen		PASSED
KP2 requirements	Transfer to SOP for Conversion - Finalization	Transfer to SOP for Conversion - Finalization		PASSED
KP2 requirements	New parameter for the target account of "Transfer to SOP for Conversion"	- New parameter for the target account of "Transfer to SOP for Conversion" - Check UC for name		PASSED
KP2 requirements	New transaction "Conversion of AAUs or RMUs into ERUs" ("Conversion B", 2_57)	- New transaction "Conversion of AAUs or RMUs into ERUs" ("Conversion B") - For track 2 projects, the conversion quantity must be equal to the project conversion limit (i.e. entitlement because someone may modify the limit) - any KP 100 account that holds CP2 AAUs (marked "subject to SOP" or "not subject to SOP") or CP2 RMUs - only one project - only possible after "Transfer to SOP for Conversion" - there is no pending "Transfer to SOP for Conversion" - After proposal - increase "Pending entitlement for conversion" - decrease ""Remaining entitlement for conversion" for project - decrease "Remaining entitlement for conversion" - After completion - decrease "Pending entitlement for conversion" for project - increase "Used Entitlement for Conversion" - not reversible, not subject to delay, holidays, working hours, NA --> NA, 4 eyes - Mandatory cycle: "Conversion A" --> "Transfer to SOP" --> "Conversion B" - check UC for full check list - conversion quantities: - Track 1 (no limit) - conversion A amount X - Transfer to SOP amount X - Conversion B amount 49X - Track 2 (with limit) - conversion A amount = 2% of Limit	Tested successfully UC_HT_205_TC_01 without Track 2 (it was no possible to specified track2 project on ITL)	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		- Transfer to SOP amount = same as conversion A amount - conversion B amount = 49x Conversion A amount		
KP2 requirements	Conversion B - Proposal/Confirmation screen	Conversion B - Proposal/Confirmation screen	tested successfully UC_HT_205_TC_01 (with Track1 projects)	PASSED
KP2 requirements	Conversion B - Finalization	Conversion B - Finalization	Tested successfully UC_HT_205_TC_01 (only for track 1 projects)	PASSED
KP2 requirements	Carry-Over of CP1 AAUs - New transaction	- New transaction "Carry-Over of CP1 AAUs" - Available to accounts PHA, Former OHA, Personal HA (100, 120, 121) with AAU applicable CP1 units - Target account is the CP2 PPSR account that is hosted by the same KP registry of the transferring account - PPSR account must exist and OPEN - transaction available between dates - no limit - on completion - unit type applicable CP modified from CP1 to CP2 - not reversible, not subject to delay, holidays, working hours, NA --> NA, 4 eyes - Check UC for full check list (other issue)		PASSED
KP2 requirements	Carry-Over of CP1 AAUs - Proposal/Confirmation screen	Carry-Over of CP1 AAUs - Proposal/Confirmation screen		PASSED
KP2 requirements	Carry-Over of CP1 AAUs - Finalization	Carry-Over of CP1 AAUs - Finalization		PASSED
KP2 requirements	Carry-Over of CP1 AAUs - Checks for transaction	- Checks for transaction "Carry-Over of CP1 AAUs" - For the full check list check UC		PASSED
KP2 requirements	"Carry-Over of CP1 ERUs and CERs" - New parameter for availability of transaction	- New parameter for availability of transaction "Carry-Over of CP1 ERUs & CERs" - Used by transaction "Carry-Over of CP1 ERUs & CERs"		PASSED
KP2 requirements	"Carry-Over of CP1 ERUs and CERs" - New transaction	- New transaction "Carry-Over of CP1 ERUs and CERs" - Available to 100, 120, 121 accounts that hold CP1 ERU_FROM_AAU and CER - Not available for EU-hosted accounts - Transaction available between dates (check parameter) - Transaction not available if there is no "Carry-Over Entitlement" - Acquiring account is the same as transferring account - The quantity of ERUs and CERs that may be carried-over is limited by the "Carry-Over Entitlement" loaded by CA		PASSED
KP2 requirements	"Carry-Over of CP1 ERUs and CERs" - Proposal/Confirmation screen	Carry-Over of CP1 ERUs and CERs - Proposal/Confirmation screen		PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 requirements	"Carry-Over of CP1 ERUs and CERs" - Finalization	Carry-Over of CP1 ERUs and CERs - Finalization		PASSED
KP2 requirements	"Carry-Over of CP1 ERUs and CERs" - Checks	Checks for transaction "Carry-Over of CP1 ERUs and CERs" - For the full check list check UC includes - new check if a "Carry-Over" exceeds the remaining Carry-Over Entitlement is proposed, the transaction will not be allowed to begin		PASSED
KP2 requirements	New screen for NA under "Kyoto Protocol" to view various Carry-Over /Entitlement values	- New screen for NA under "Kyoto Protocol" to view: - For CERs and ERUs: Carry-Over Entitlement, Pending Carry-Over-Entitlement, Used Carry-Over Entitlement - For AAUs: Quantity carried over, Pending carry-over quantity		PASSED
KP2 requirements	"Carry-Over of CP1 ERUs and CERs" - Display values in proposal screen	- Proposal screen of "Carry-Over of ERUs & CERs" shows the following values: ERU Remaining Carry-Over Entitlement, CER Remaining Carry-Over Entitlement		PASSED
KP2 requirements	"Carry-Over of CP1 ERUs and CERs" - Transaction proposal affects variables	Proposal of "Carry-Over of ERUs & CERs" affects the following variables: * Pending Carry-Over Entitlement (for CERs or ERUs depending on the units selected) is increased by the amount of the respective unit type in the transaction * Remaining Carry-Over Entitlement is decreased with the quantity of the transaction		PASSED
KP2 requirements	"Carry-Over of CP1 ERUs and CERs" - New check: If a proposed "Carry-Over" exceeds the remaining Carry-Over Entitlement, then the transaction will not be allowed to begin	new check if a "Carry-Over" exceeds the remaining Carry-Over Entitlement is proposed, the transaction will not be allowed to begin		PASSED
KP2 requirements	"Carry-Over of CP1 ERUs and CERs" - Finalization of transaction	Transaction finalization "Carry over of ERUs & CERs" - After approval from EUTL the following variables change: - Pending Carry-Over entitlement (for ERUs and CERs) is decreased - Used Carry-Over entitlement (for ERUs and CERs) is increased - At finalization of transaction, the unit blocks of the transaction change from applicable CP1 to applicable CP2		PASSED
KP2 requirements	Carry-Over of CP1 AAUs - Finalization of transaction	Transaction finalization "Carry over of CP1 AAUs" After approval from EUTL the following variables change: * Quantity Carried-Over (for AAUs) is increased * At finalization of transaction, the unit blocks of the transaction change from applicable CP1 to applicable CP2		PASSED
KP2 requirements	New LULUCF activity	- New LULUCF activity - add in enumeration - visible at unit block search/edit - visible wherever else there exists a LULUCF list - issuance screen	Tested by: UC_IS_003_TC_01: ISSUE KP UNITS of TC.09 Issuance Allocation document Repeat testing by selecting the last radiobutton: "RMU - Wetland, Drainage and Rewetting (WDR)"	PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 requirements	Issuance Limit Screen - Edit RMU issuance limits	- New screen (or modify existing one?) for NA to modify CP2 RMU issuance limits - Message to NA explaining that it is his responsibility - For EU, CA modifies issuance limits	Tested by: UC_IS_020_TC_01:EDIT ISSUANCE LIMIT UC_IS_020_TC_02: EDIT ISSUANCE LIMIT – NEGATIVE TESTING from TC.09 Issuance-Allocation document	PASSED
KP2 requirements	CY & MT have their own Kyoto Registries	- CY & MT have their own Kyoto Registries - modification in the code is simple, more complex is the testing which should include: - creation of the same account types as other Kyoto Registries - connection with ITL, certificates - ESD behaviour as all other Kyoto Registries. ESD specific internal transfers will be obsolete, and also the two parameters with EU KP accounts must be removed	1. Test issuance limits for CY, MT 2. Test issuance for CY, MT 3. Create all KP accounts for CY, MT 4. KP transfers FR-->CY 5. KP transfers FR-->MT 6. KP transfers CY-->FR 7. KP transfers MT-->FR 8. Test Translations <-- why ? 9. Test Reconciliations both ITL & EUTL 10. Check that KP menu is visible 11. Check creation of JI Projects 12. Check notifications 13. Check export Government Accounts 14. Check conversion of AAU / RMU 15. Transfer from CY KP account to ESD-CY account 16. Transfer from ESD-CY account to CY KP account 17. Transfer from MT KP account to ESD-MT account 18. Transfer from ESD-MT account to MT KP account 19. Transfer from JP to CY 20. Transfer from JP to MT	PASSED
KP2 requirements	Investigate if a script is needed for CY & MT	Investigate if a script is needed for CY & MT e.g. for setting up issuance limits default rows etc - create script		PASSED
KP2 requirements	Screen Issuance Limits - Edit AAU issuance limits	- New screen (or modify existing one?) for NA to modify CP2 AAU issuance limits - Message to NA explaining that it is his responsibility - For EU, CA modifies issuance limits - Script to add permissions	Tested by: UC_IS_020_TC_01:EDIT ISSUANCE LIMIT UC_IS_020_TC_02: EDIT ISSUANCE LIMIT – NEGATIVE TESTING from TC.09 Issuance-Allocation document	PASSED
KP2 requirements	Liquibase script to initialize CP2 issuance limit to 0 for all registries	Liquibase script to initialize CP2 issuance limit to 0 for all registries (if needed)		PASSED
KP2 requirements	Liquibase script to give permissions to NA/CA to edit issuance limits	Liquibase script to give permissions to NA/CA to edit issuance limits		PASSED
KP2 requirements	Screen issuance limits	- Screen CP2 issuance limits - Menu under Kyoto Protocol for NA / CA of EU - will display the values:		PASSED

Feature	Summary	Description	Test Cases	SAT Status
		- issuance limit - issuance level (the sum of all issue CP2 AAUs)		
KP2 requirements	New account "AAU Account" (27)	- new account "EU AAU Account" - holds originating CP2 AAUs - Kyoto type 100 - only one - cannot initiate new if there exists a pending request - can open in EU, LI, NO - Account names: "EU AAU Account", "LI AAU Account", "NO AAU Account" - EU opened by CA, LI, NO opened by NA	1. Can be opened in EU, NO, LI only (/) 2. Only one AAU account can be created per registry. (/) - Request one AAU account; a second one cannot be requested. (/) - Create one AAU account; a second one cannot be requested. (/) - Close the AAU account; a new AAU account can be created. (/) 3. It cannot be opened in any other registry. (/) 4. In EU it is created by CA (/) 5. In NO, LI it is created by NA (/) 6. Can only hold CP2 AAUs. (/) - Try to send from another PHA allowances to an AAU account --> transfer must fail. - Try to send from another PHA CP1 AAU units to an AAU account --> transfer must fail. - Try to send from another PHA CER units to an AAU account --> transfer must fail. - Try to send from another PHA ERU units to an AAU account --> transfer must fail.	PASSED
KP2 requirements	"Carry-Over of CP1 ERUs and CERs" - New configuration parameter "End of Carry-Over CP1 -> CP2"	- Configuration parameter "End of Carry-Over CP1 -> CP2". After that date all CERs, ERUs, ICERs, tCERs will become ESD ineligible - affects a lot of transactions/parameters/account statements/account holdings etc (other issues)		PASSED
KP2 requirements	Holdings screens - after comfit param "End of Carry-Over CP1 -> CP2" all CERs, ERUs, ICERs, tCERs will become ESD ineligible	Holdings screen - after config param "End of Carry-Over CP1 -> CP2" all CERs, ERUs, ICERs, tCERs will become ESD ineligible	FAT LV-100-551 has: - CER 1-1 appearing as Limit 1 - CER 1-2 appearing as Limit 1 - CER 2-2 appearing as Limit 1 Modify parameter carry.over.end.date to a date before "now" in FAT Check that - CER 1-1 do not have a Limit specification under column ESD Eligibility - CER 1-2 appearing as Limit 1 - CER 2-2 appearing as Limit 1	PASSED
KP2 requirements	Transaction proposal screens where ESD ineligible is applied- after config param "End of Carry-Over CP1 -> CP2" all CERs, ERUs, ICERs, tCERs will become ESD ineligible	Transaction proposal screens - after config param "End of Carry-Over CP1 -> CP2" all CERs, ERUs, ICERs, tCERs will become ESD ineligible		PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 requirements	Add all new transactions in drop down of related screens	Add all new transactions in drop down of related screens + labels.properties		PASSED
KP2 requirements	New transactions - add in TransactionType Enum	New transactions - add in TransactionType Enum	By navigating to a PHA with CP1 AAU and CER and ERU units, of a registry possessing open PPSR accounts, we see the respective transactions appearing as possible transaction types, given that the rest of the conditions are met (e.g. Conversion A, Conversion B etc.)	PASSED
KP2 requirements	Insert Check7889 description in EUCR	"Amount of CERs or ERUs transferred by "Carry Over" should be up to the Remaining Carry-Over Entitlement of transferring registry"		PASSED
KP2 requirements	KP2 Entitlements Upload - DB Tables	KP2 Entitlements Upload - DB Tables	In FAT's DB mentioned tables(3) and sequences(3) must exist	PASSED
KP2 requirements	RedBox - Account Request when error appears on first step	A RedBox appears when trying to create a new Account Request and an error appears on the first step. How to reproduce: Login as CA in EU registry Click "Account Request" Select "International Credit Account" Write some name Click "Next" The message " ERROR CODE:10148It is not permitted to have more than two open accounts of types: International Credit Account, Credit Exchange Account " appears. If the user clicks "Next" or any menu item, a Red Screen appears. In the logs the following appears: javax.faces.FacesException: Unexpected error restoring state for component with id mainForm:accountCreationCaptcha:captcha. Cause: java.lang.IndexOutOfBoundsException: Index: 1, Size: 1.	Tested successfully. 1. Give CA of EU permission with name "Open management account" 2. Follow steps of Description section. No red screen appears, and no exception is produced in logs.	PASSED
KP2 requirements	Forbid project limit update when between Conversion A and Conversion B	It is not possible to update a project's limit when a Conversion A has been proposed and its Conversion B has not been completed yet.	Tested successfully UC_CV_015_TC_01: DELETE PROJECT	PASSED
KP2 requirements	Unit block reservation - after config param "End of Carry-Over CP1 -> CP2" all CERs, ERUs, ICERs, tCERs will become ESD ineligible	Unit block reservation - after config param "End of Carry-Over CP1 -> CP2" all CERs, ERUs, ICERs, tCERs will become ESD ineligible		PASSED
KP2 requirements	Transaction proposal screens - add "Subject to SOP" or "Not subject to SOP" flag	Transaction proposal screens - add "Subject to SOP" or "Not subject to SOP" flag	tested successfully UC_HT_180_TC_01	PASSED
KP2 requirements	Forbid project deletion when between		Tested successfully UC_CV_015_TC_01: DELETE PROJECT	PASSED

Feature	Summary	Description	Test Cases	SAT Status
	Conversion A and Conversion B			
KP2 requirements	New KP2 Entitlements link screen	New KP2 Entitlements link screen Check UC. this is the main CA/NA screen for KP2 entitlements with links to all other screens		PASSED
KP2 requirements	JI Projects Delete Check - cannot delete if pending CP2 Conversion	JI Projects Delete Check - cannot delete if pending CP2 Conversion. It is not possible to delete a project if there is CP2 Conversion pending for that project. - a pending Conversion A - a completed Conversion A (/) - a pending Transfer to SOP for Conversion - a pending Conversion B - remaining entitlement to be finalized when db tables for conversion are created	Tested successfully UC_CV_015_TC_01: DELETE PROJECT	PASSED
KP2 requirements	KP2 Entitlements - Export CSV	KP2 Entitlements - Export CSV In all KP2 Entitlement screens there exists a button "Export CSV" which should export in CSV format the contents of the respective table.	Tested by executing UC_EN_030_TC_01: View KP2 entitlements in Union registry	PASSED
KP2 requirements	Auto/Manual unit selection constraint - add "Subject to SOP" or "Not subject to SOP" flag - Proposal/Confirmation Screens	Auto/Manual unit selection constraint - add "Subject to SOP" or "Not subject to SOP" flag - Proposal/Confirmation Screens		PASSED
KP2 requirements	Project limit must be >= converted quantity	I should not be able to updated project limit to a value < converted quantity. Refer to GB in FAT	1. Log in GB registry 2. In JI Projects change the value of Conversion Limit column to be less than Converted Quantity column. 3. Message should appear:" 80407: The conversion limit cannot be less than the converted quantity"	PASSED
KP2 requirements	Forbid JI Project limit update, when new limit is less than Converted Quantity		To be tested by EUCR-2507 test case	PASSED
KP2 requirements	JI Projects - The column Limit to be renamed to "Conversion Limit".	While reviewing Test Cases, CLIMA asked the column Limit to be renamed to "Conversion Limit".	To be tested by: To UC_CV_010_TC_01: DISPLAY THE PROJECTS LIST PAGE of TC.15 JI Projects document	PASSED
KP2 requirements	Conversion CP1 - Remove from drop down CP2 option	Conversion CP1 - Remove from the drop down CP2 In the transaction proposal for Conversion of CP1 units (existing screen), remove from the drop down CP2. CP1 should be preselected. Make sure that CP2 cannot be "added" by non conventional means, used to select unit blocks and create a transaction request.	1. Navigate to an account with CP1 and CP2 KP units. 2. Propose a transaction 3. Choose "Conversion of AAU or RMU to ERU" and ensure CP2 does not appear in the Commitment Period drop-down list. When a CP is selected, ensure that unit blocks of this CP appear in the holdings screen. 4. Choose "Conversion of AAUs or RMUs to ERUs prior to Transfer to SOP (Conversion A)" and ensure	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		Add extra check to the original Conversion transaction which will forbid the creation of the request if the selected unit blocks are CP2	only CP2 appears in the Commitment Period drop-down list. Ensure that unit blocks of CP2 appear in the holdings screen.	
KP2 requirements	Acquiring Accounts list in Issuance screen - Add AAU Account type in list	In issuance screen, the drop down should contain accounts of type AAU Account.	1. Kyoto Protocol --> Issuance (GR registry) 2. Choose Commitment Period 2 3. Check that all the OPEN AAU Accounts appear	PASSED
KP2 requirements	Transfer PPSR --> PPSR out of ETS, enable CP field	Rightmost field is enabled. Validation: must a valid CP period UPDATE TC, UC		PASSED
KP2 requirements	EUCR-2512 Converted for SOP - unit block reservation	Converted for SOP units must be only used in Transfer to SOP for conversion transaction - modify unit block reservation	Tested by executing UC_HT_200_TC_01: Transfer to SOP for Conversion	PASSED
KP2 requirements	EUCR-2512 Converted for SOP - transaction proposal	Converted for SOP units must be only used in Transfer to SOP for conversion transaction - modify transaction proposal of all transactions which relate to ERU_FROM_AAU and ERU_FROM_RMU	Tested by executing UC_HT_200_TC_01: Transfer to SOP for Conversion	PASSED
KP2 requirements	EUCR-2512 Converted for SOP - extra check in all transactions	Converted for SOP units must be only used in Transfer to SOP for conversion transaction - extra check in all transactions that the selected unit block should not be flagged as "Converted for SOP"		PASSED
KP2 requirements	Insert Check7871 description in EUCR	Check Message: Only one Account of this Account type can be open per Registry.		PASSED
KP2 requirements	Insert Check7872 description in EUCR	Check Message: PPSR Account can only hold AAUs with originating CP =(current CP-1) and applicable CP = current CP		PASSED
KP2 requirements	Insert Check7876 description in EUCR	Check Message: Destination Account for Transfer to SOP for Conversion and Transfer to SOP for First External Transfer of AAUs should be "SOP Adaptation Fund" Account in CDM Registry		PASSED
KP2 requirements	Insert Check7878 description in EUCR	Check Message: Transfer to SOP for Conversion and Transfer to SOP for First External Transfer of AAUs should include units marked as "Subject to SOP" or "Converted for SOP" accordingly.		PASSED
KP2 requirements	Insert Check7879 description in EUCR	Check Message: Amount of CP2 AAU transferred by a Transfer of Kyoto Units between different hosting registries, should be up to the "Remaining Entitlement of First External Transfer of AAU" of the transferring registry.		PASSED
KP2 requirements	Insert Check7880 description in EUCR	Check Message: Transfer to PPSR Account should be up to the remaining "PPSR Entitlement" of the acquiring registry.		PASSED
KP2 requirements	Insert Check7882 description in EUCR	Check Message: AAUs and RMUs cannot be converted in the same transaction.		PASSED
KP2 requirements	Insert Check7883 description in EUCR	Check Message: Conversion A can only convert a single project per transaction		PASSED
KP2 requirements	Insert Check7884 description in EUCR	Check Message: Units marked as "Converted for SOP" can only be transferred by a "Transfer to SOP for Conversion" transaction		PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 requirements	Insert Check7884 description in EUCR	Check Message: Units marked as "Converted for SOP" can only be transferred by a "Transfer to SOP for Conversion" transaction		PASSED
KP2 requirements	Insert Check7885 description in EUCR	Check Message: Conversion A not allowed if converted for transfer to SOP quantity minus transferred to SOP for conversion quantity is not 0		PASSED
KP2 requirements	Insert Check7886 description in EUCR	Check Message: Conversion A and Transfer to SOP for Conversion not allowed if remaining conversion entitlement is not 0		PASSED
KP2 requirements	Insert Check7887 description in EUCR	Check Message: Conversion B amount should be up to the remaining conversion entitlement. For track 1 projects it should be exactly equal to the remaining conversion entitlement		PASSED
KP2 requirements	Insert Check7888 description in EUCR	Check Message: Unit Type is not valid for the transaction type		PASSED
KP2 requirements	Insert Check7897 description in EUCR	Check Message: Only one Account of this ETS Account Type can be open per EU, NO, LI KP Registry		PASSED
KP2 requirements	Insert Check7898 description in EUCR	Check Message: EU AAU Account can only hold CP2 AAUs issued by EU		PASSED
KP2 requirements	Insert Check7899 description in EUCR	Check Message: CERs, ERUs, tCERs and ICERs with applicable period CP1 are ESD ineligible after the "End Of Carry Over CP1 CP2 date"		PASSED
KP2 requirements	Transaction Request Approval - add "Subject to SOP" or "Not subject to SOP" flag	Screen Transaction Request Approval - add "Subject to SOP" or "Not subject to SOP" flag		PASSED
KP2 requirements	Net Source Cancellation Notification - managed to transfer units from PPSR account	Net Source Cancellation Notification - managed to transfer units from PPSR account Try to fulfil a Net Source Cancellation Notification, select as source the PPSR account of the registry. The transaction is completed and units are removed from PPSR account. Check must be added in Notification check package to forbid such a transfer		PASSED
KP2 requirements	PPSR Account - Create from EU can be opened by CA and not NA	PPSR Account - Create from EU can be opened by CA and not NA. DES should be modified accordingly Use Case should be updated as well. UC does not mention that this account is NA only!	Testing component: "UC_AM_10_TC_14:OPEN ACCOUNT REQUEST"	PASSED
KP2 requirements	Screen - First External Transfer of AAU Entitlements View	New screen to display First External Transfer of AAU Entitlements The screen shows values for "Remaining entitlement for First External Transfer of AAUs", "Pending entitlement for First External Transfer of AAUs", "Used entitlement for First External Transfer of AAUs". If the user is a CA, the screen will have a drop down with all registries to serve as a filter for the table with all registries	Tested by executing UC_EN_030_TC_01: View KP2 entitlements in Union registry	PASSED
KP2 requirements	Screen - Conversion Entitlements	New Screen to display Conversion Entitlements The screen is split into two tables. The top table shows values of the following values for all projects of each registry: "Registry Code", "Remaining Entitlement for Conversion", "Converted for Transfer to SOP",	Executed UC_EN_030_TC_01: View KP2 entitlements in Union registry confined to Conversion entitlements.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		"Transferred to SOP for Conversion", "Pending Entitlement for Conversion" and "Used Entitlement for Conversion". There will be a filter with all the registries. The bottom table shows the same values, but per project. A column with the "Registry Code" must always be present in the table. Also, unit type of project, track and project limit if needed. Entity KP2ConversionEntitlements can be used to view all the necessary data for this screen.		
KP2 requirements	Screen - AAU Carry-over Quantities	New Screen to display AAU Carry-over Quantities AAU Carry-over quantities screen shows values for the value "Quantity carried over (for AAU)". If the user is the CA of EU, values for all registries are shown and if the user is the NA of some other registry, only value for the registry of the user is shown.	Tested by executing UC_EN_030_TC_01: View KP2 entitlements in Union registry	PASSED
KP2 requirements	Issuance limit update should consider also "Pending" column	When updating limit in Issuance tab, new limit should be equal or greater than Issued + Pending column units		PASSED
KP2 requirements	Unit block search / CSV - after config param "End of Carry-Over CP1 -> CP2" all CERs, ERUs, ICERs, tCERs will become ESD ineligible	Unit block search / CSV - after config param "End of Carry-Over CP1 -> CP2" all CERs, ERUs, ICERs, tCERs will become ESD ineligible		PASSED
KP2 requirements	Import message description of validation rules of ITL	The following message descriptions were imported from ITL database into EUCR, so that error descriptions appear correctly. Wherever a description already existed, it was overlapped by the new definition.	Ensure the above messages appear in message.properties.	PASSED
KP2 requirements	Insert Check7881 description in EUCR	"Transfer to SOP for Conversion" should include only ERUs marked as "Converted for SOP".		PASSED
Change in transaction pages sorting.	Filter transaction list by default on starting date (most recent ones at the top)	added by: Pieter Baeten impacted env: UR-PROD version: 3.2.3.5 Scenario to reproduce: Look at the transaction list. Incident Description: Transactions seem to be sorted randomly by default. This is very confusing for everyone. Possible cause: - Solution: Please sort transactions on their start date, from recent towards old ones (most recent ones should be shown at the top).	1. Navigate to Accounts-->Transactions and click "Search" 2. Ensure the records presented are initially sorted descending on the column "Started"	PASSED
Change in permissions for closure of Person account in National Registry	We have a customer who is trying to close their Person Account National Registry down. We have the permission "Close person holding account or verifier or trading platform account" enabled for ARs. However, they have sent us a screenshot which	Imported on: 16/12/2014 \\ From: [https://webgate.ec.europa.eu/etsis/browse/ETS-2051]	Tested successfully. 1. Locate a user who is only AR on a registry. 2. Ensure the AUTHORISED_REPRESENTATIVE has permission PERM_ACC_REP_CLS_REQUEST but not permission PERM_ACC_ADM_CLS_REQUEST. Permissions can be browsed via the query: <pre>select distinct perm_level, role_name, b.* from permissions a, role_permission b, roles c where a.permission_id = b.permission_id and b.role_id = c.role_id and perm_key = 'PERM_ACC_REP_CLS_REQUEST' and role_name = 'AUTHORISED_REPRESENTATIVE' and registry_code in ('MT') order by 1;</pre>	PASSED

Feature	Summary	Description	Test Cases	SAT Status
	clearly shows there is no "Close" hyperlink showing against their GB-121-xxxx-0-yy account. There is one against their EU-100-nnnnnnnnnn-0-pp account which confirms that the permission is workign correctly. We can't give ARs "Close account (of any type)" as that would also enable the permission to close an (A)OHA which we don't want as that is reserved for us. Although we don't have anyone trying to close a FOHA we suspect the same might be true there as well. Have we missed something? We know the work around is for us to submit the Account Close request on their behalf, which we have done, but that is not how we wish to work in the long term. ARs ought to be able to submit account closure requests for all accounts excelt for OHAs and AOHA as all the rest can be closed voluntarily by the Account Holder at any time.		3. Log in as this user and navigate to an account which is of type "Person Account in National Registry" and has no holdings. 4. Ensure the button "close" appears in the account details. 5. Remove the permission PERM_ACC_REP_CLS_REQUEST from the role AR in this registry. 6. Repeat steps 3-4; the "close" button should not appear for the same account.	
Change in date depiction in transaction list	Transactions - Date started and last updated	Hi, The date in which a transaction is started and last updated should have the time. Currently it has only the DD-MM-YYYY.	Tested successfully. Navigate to Accounts -> Transactions.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
	date should have the time	This is important to help predict when a transaction will be completed. Thanks.	Ensure the columns Started and Last Updated contain value in the form: 30/08/2018 18:20 EEST	
Addition of information in account holdings screen	Account holdings should show number of units per unit type	Imported on: 16/12/2014 \\ From: [https://webgate.ec.europa.eu/etsis/browse/ETS-5098]	*Test Case 1* 1. Log in EU, as NA 2. In account 285 check sum of units of second table with each unit quantity in first table (with columns: Unit Type and Balance)	PASSED
Request to have possibility to add comment to deletion/cancellation	Request to have possibility to add comment to deletion/cancellation	It is currently not possible to add comments to a deletion or a cancellation. As account holders often perform these type of transactions on behalf of someone else, it would be very nice if they could add a comment (e.g. deletion of 1.000 allowances on behalf of company X) which they could then use to proof that the transaction has been performed.	The following transactions have enabled comments functionality. The comment is visible by the approved while approving and in history. Voluntary Cancellation Art 3.7ter Cancellation Deletion of Allowances Mandatory Cancellation Surrender of Allowances Ambition Increase Cancellation	PASSED
Add transaction comment - Surrender	EUCR-2807 Add transaction comment - Surrender	Add transaction comment - Surrender	*Test Case* 1. Log in EU as NA 2. For EU 285 perform a surrender of 1 unit with comment 3. Check in transactions the comment integration after it's completed	PASSED
Add transaction comment - Voluntary Cancellation	EUCR-2807 Add transaction comment - Voluntary Cancellation	Add transaction comment - Voluntary Cancellation	*Test Case 1* Repeat test of EUCR-2807 with account 296 and transaction: Voluntary cancellation	PASSED
Add transaction comment - Delete Allowances	EUCR-2807 Add transaction comment - Delete Allowances	Add transaction comment - Delete Allowances	*Test Case 1* - Delete Allowances comment 1. Log in EU, as NA 2. In account 291 delete 1 allowance after entering a comment 3. Approve and in Transactions page, check that comment exists and remaining units are reduced by 1.	PASSED
Request to add information to the 'Enter Emissions' screen	Request to add information to the 'Enter Emissions' screen	Imported on: 16/12/2014 \\ From: [https://webgate.ec.europa.eu/etsis/browse/ETS-6521]	*Test Case* 1. Log in PT, as NA 2. For account 642 (OHA), click Compliance 3. Click in an icon of a year. 4. There should be: installation and account holder name, also for all types of emissions there should be explanatory sentences with asterisk. Finally, user shouldn't be allowed to enter other than positive or zero value.(orange error message) Repeat for an AOHA.	PASSED
Improvement on account list: make account nr, balance and	Improvement on account list: make account nr, balance and	In the account list it would make sense to make the "account number", the "balance" and the "installation/aircraft operator ID" hyperlinks. Each link would bring the user to the account details, but to a different tab: hence respectively to the tab "Account main", "Holdings" and "Installation" tab. This avoids scrolling to the right and reduces the number of clicks if one would link to consult for example the balance of	*Test Case 1* 1. Log in PT, as NA 2. In Accounts, click Search. Each row should contain hyperlinks: account id, balance,	PASSED

Feature	Summary	Description	Test Cases	SAT Status
installation/AO id clickable	installation/AO id clickable	an account. If a compliance symbol would be added to the account list (other JIRA issue raised earlier), clicking on this symbol could then direct to the "Compliance" tab in the account details.	installation/aircraft id 3. Click on each link, user should redirect to Account Main, Holdings, Installation tab, respectively.	
Add estimated time of execution as tiptext to delayed status in transactions screen	Add estimated time of execution as tiptext to delayed status in transactions screen	added by: Pieter Baeten impacted env: UR-PROD; UR-UT version: 6.2.6.4 Scenario to reproduce: - Incident Description: It is hard for users and administrators to determine when a transaction will be executed if the delay is applicable. The estimated time of execution is already displayed when the transaction is approved by the AAR (or introduced by an AR if no AAR is needed) as described in ETS-4153. It would therefore be very valuable if the estimated time of execution would be displayed in the transaction details. This time has now been added to the transaction details screen. This is fine already, but the user needs to click through to the transaction details to get this time. It would even be more user-friendly if the user could just hover the "30-Delayed" status of the transaction in the transaction overview list (Page ref. #061) and directly get the estimated time of completion as tiptext. This would avoid an additional click and is very useful if one has multiple transactions in status delayed. Possible cause: - Proposed solution: It would even be more user-friendly if the user could just hover the "30-Delayed" status of the transaction and directly get the estimated time of completion as tiptext. This would avoid an additional click and would be very useful if one has multiple transactions in status delayed.	*Test Case 1* 1. Log in PT as NA 2. Perform a transfer of units from PT 643 to GR 383 3. In Transactions, locate transaction and hover over status. 4. Completion info must be provided	PASSED
Request approval for account holder VAT change.	Account Holder VAT number changed without NA approval	Imported on: 16/12/2014 \\ From: [https://webgate.ec.europa.eu/etsis/browse/ETS-6868]	Tested successfully. 1. Navigate to an account and to its "Account Main" tab. 2. Click on "Update" button below the account holder details. 3. Modify the VAT number. 4. Ensure an AH update request is created. 5. Approve the request as another NA. 6. Ensure the requested change is applied by navigating to the account of step 1.	PASSED
Typo in ESD permission label	Typo in ESD permission label	We spotted a typo in an ESD label in the Production database, inside the Permissions table: Permission Key Permission Label PERM_ESD_TR_ENT_APPROVE {color:red}Propose{color} Esd entitlements Transfer transaction	Perform the following query and ensure there are values in all columns: select * from permissions where perm_key = 'PERM_ESD_TR_ENT_APPROVE';	PASSED
Request approval for some business details	Business details update without approval	General ticket to gather all business updates that need to be set as major change, so that NA approval will be required.		PASSED
It was not possible to cancel CP1 units if no open CP2 cancellation account existed; this is now fixed.	Cannot Voluntarily Cancel CP1 units although CP1 cancellation account exists	FAT, registry IT. If I suspend the CP2 Voluntary Cancellation account (or if CP2 Volun. Canc. account does not exist), I cannot propose a Voluntary Cancellation (the link is no longer available) for units of CP1 of account with identifier 460	*Test Case 1* 1. Log in EU as NA 2. Suspend the 2 voluntary cancellation accounts 3. Should be unable to see transaction voluntary cancellation of EU 296	PASSED
Transaction towards a requested account was possible; this is now fixed.	Transaction to requested account stuck in proposed		Tested successfully. 1. Request the creation of an OHA and do not approve it yet. 2. Find the details of the just requested account via the query: select * from account order by account_id desc; and note the identifier and check digits. 3. Navigate to a PHA and enter a transfer towards the requested account.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			4. Ensure this validation rule appears and forbids the transaction submission: 80756: The acquiring account must be active	
Change in the "About this site" destination link	Wrong Link - About this site	On EUCR there is the "About this site" link. This shows to http://ec.europa.eu/clima/policies/ets/registries/index_en.htm , but this gives an error message. This is because there is a typo in the link: I assume this page was meant: http://ec.europa.eu/clima/policies/ets/registry/index_en.htm	Tested successfully. From any page of the site, ensure the link "about this site" leads to: http://ec.europa.eu/clima/policies/ets/registry/index_en.htm	PASSED
Change in the "Contacts" destination link	EUCR Contacts link	EUCR Contacts link should direct here: http://ec.europa.eu/clima/contact/index_en.htm . Currently it directs here: http://ec.europa.eu/dgs/clima/contact_en.htm	*Test Case 1* 1. Log in EU, as NA 2. Click Contact link 3. Click again Contact link 4. Should get redirected to http://ec.europa.eu/clima/contact/index_en.htm	PASSED
Allow SD users to view more task types in the tasklist.	SD cannot see others accounts' tasks	Our ServiceDesk staff workers should be able at least to see tasks of type "personal details update"/"business details update". Currently this seems not to be the case. Currently the verification of the documents received for these kind of updates is done by our ServiceDesk staff worker, hence she would need to be able to access the corresponding task in the registry. Can you confirm these tasks are not available for ServiceDesk staff workers (has this changed recently)? It seems as well that these tasks kind not be assigned to ServiceDesk staff workers neither, can you please confirm (probably this is related to our first question)? Is there any role besides the RegAdmin who can see (and act) for these kind of tasks? Thank you for the clarifications! KR, Pieter	1. Connect as NA and locate a user who is only SD in a registry. 2. Navigate to Roles and Permissions and give permission "Read-only" to role SD; approve it as another NA. 3. Navigate to Roles and Permissions and give permission "Approval of AR Addition" to role SD; approve it as another NA. 4. As NA, submit an addition of AR to an account. 5. Connect as SD and locate this task in the tasklist. Claim and ensure it cannot be approved or rejected via the buttons, the message "You are not authorised for this action" appears instead.	PASSED
Add a footnote in External Transfers of Kyoto Units	Footnote - External Transfers of Kyoto Units	In External Transfer of Kyoto Units proposal screen a footnote should be added: "Kyoto units with originating CP1 are not eligible for use in ETS".	In External Transfer of Kyoto Units proposal screen a footnote is added: "Kyoto units with originating CP1 are not eligible for use in ETS".	PASSED
Wrong time depiction for some transactions; this is now fixed.	Incorrect time displayed for transactions	If a transaction is proposed or approved between midnight and 1am hour part of the time shows as 24 instead of 00 Example - look at EU347852 from the "Transactions" side menu. Click on the "Request Details" tab and look at the "User Approved" Action date and time.	*Test Case 1* 1. Log in EU, as NA 2. In Transactions click Search and navigate through the page results 3. There should be no greater value than 23:59 in Started and Last Updated column	PASSED
The system now detects and warns if an AR attempted to be attached on an account is already an AR for a verified connected on the same account.	Inconsistent view of whether or not a user is already related to an account holder	Imported on: 26/01/2016 From: https://webgate.ec.europa.eu/etsis/browse/-1008?filter=10404	1. Attach a verifier on an OHA. 2. Attach the AR of the verifier on the OHA of step 1. 3. Ensure the error message appears: "The relationship with the Account Holder already exists, please consult the available list" and step 2 is not allowed.	PASSED
Country code entered in external transfer screen should be	Country code should be automatically upper-cased	Raised to replace SDB-277 When entering a transaction of Project Credits/AAUs etc. the user has to enter the countrycode of the acquiring Registry. This is case sensitive and error 10120 is generated if the user enters all details of the transaction correctly apart from the fact that the have entered the countrycode in lowercase	1. Connect as NA 2. Navigate to a PHA and enter a transaction towards the account "jp-100-999"	PASSED

Feature	Summary	Description	Test Cases	SAT Status
automatically upper-cased.		letters. This really should not be an error. In fields such as this the application should automatically uppercase the countrycode for the user and only display 10120 if the user has entered something incorrect in this field. It is unusual behaviour because it allows a completely invalid countrycode to be entered provided it is uppercase (e.g. ZZ) but throws an error if the user has entered something correct but in lowercase (e.g. gb). If anything it should have rejected the ZZ completely and uppercased the gb.	3. Approve the transaction request 4. Ensure the transaction is received in ITL --> Transaction Mgt screen	
Correction in export of government accounts functionality.	incorrect Export of Government Accounts	Imported on: 26/01/2016 From: https://webgate.ec.europa.eu/etsis/browse/SDB-3170	Tested successfully. 1. Propose and do not approve a Party Holding Account. 2. Query the just created accounts and locate identifier and check digits. select * from account order by account_id desc; 3. Export Government Accounts and ensure the identifier is not contained. Note: Accounts in any STATE other than ACTIVE will not be contained (e.g. REQUESTED, REMOVED etc.) because this clause has been added in the query.	PASSED
Enable mandatory cancellations	Mandatory Cancellation enabling (4-48)		Tested successfully. Refer to transaction MT225.	PASSED
Correction in emissions correcction screen.	Correct Emissions says Enter Emissions	When you open up the little tick to correct emissions figures the box says Enter Emissions. It should really say Correct Emissions or Update Emissions: It would also be good to have a view of the current and corrected figures just before you send the request to the task list;	Tested successfully. 1. Navigate to an OHA with submitted emissions. 2. Click on the little pencil icon. 3. Ensure the screen is titled "Correct emissions" Repeat with AOHA	PASSED
Correction in ITL notifications screen	ITL Notifications screen - next page/filter does not work	ITL Notifications screen - next page/filter does not work in FAT-BE there exist > 20 notifications. Click select, go to page 2, it displays only 2, go page 3 it displays none, go to page 1 again, it displays none. Filter not working: go to ITL Notification screen, choose "Non Submission Of Certification Report" and click select. 20 found. go to page 2, it displays only two instead of 10 with one being "Unit Carry Over".	1. Locate a registry with several ITL notifications, more than 10 of one specific type (e.g. Non Submission Of Certification Report). 2. Filter for Non Submission Of Certification Report. 3. Go to the next page. 4. Return to the first page 5. Confirm the filter set in step 1 is still applicable.	PASSED
Correction in ITL notifications search mechanism	ITL Notifications - sorting search results disregards filter values	When search is performed in ITL Notifications with specified filter value (e.g. Identifier = 1005406359) and then results are sorted, all results are displayed again disregarding filter value. Same happens after any change to result list component such as increasing number of visible rows or moving to next page.	1. Navigate to Kyoto Protocol -> ITL Notifications. 2. Search for record with and without entering criteria 3. Sort the records and ensure the provided search criteria are respected.	PASSED
Error detection when importing ICE XML.	Wrong error message while importing ICE to holding account	Imported on: 02/02/2016 From: https://webgate.ec.europa.eu/etsis/browse/-1214	1. Log in EU registry as na 2. In EU ETS tab, click ICE Table Upload 3. Browse and Import xml: <pre><?xml version="1.0" encoding="UTF-8" standalone="no"?> <entitlements registryCode="EU" xmlns="urn:eu:europa:ec:clima:ets:1.0"> <installation identifier="101"> <action>U</action> <flag>0</flag> <ice>6066</ice> </installation> <installation identifier="103"></pre>	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			<pre><action>A</action> <flag>0</flag> <ice>7077</ice> </installation> </entitlements></pre> 4. After uploading xml, message is: The content of the XML file is invalid 90101: The Installation identifier 103 does not exist in the registry.	
Correction in KP2 entitlements screens	Registry filter in "Transfer to PPSR Entitlements" (EU) doesn't work	Given I'm logged as CA in EU When I go to KP2 entitlement / Transfer to PPSR Entitlements page And select one MS in Registry filter And press Search button Then values for all Member States are displayed (instead of one line just for selected MS)	*Test case* 1. Log in EU as CA 2. At KP2 Entitlements, Transfer to PPSR, check that filter works.	PASSED
JI projects screen correction	NumberFormatException when trying to update JI project conversion limit with empty value	Given I'm logged in as NA in registry And there are JI projects Track 2 defined When I go to JI projects page And update conversion limit of given track 2 project with empty value Then unrecoverable error is thrown <INFO > <2016-05-11 16:59:12,304> <EU> <HRHC:8543768 SHC:903856848 UN:kierecki1 REG:EU> [20160511165912.303][BF_UC04_LOG10][kierecki1][10.219.40.205][EUCR_TESTmanaged1][EU][Unrecoverable error][ERROR_ID: DBFC139C][ERROR_DETAIL: ----- # Unknown macro: {jiProjectListViewBean.submitLimitUpdate} : java.lang.NumberFormatException: null ----- javax.faces.FacesException: # : java.lang.NumberFormatException: null	*Test Case 1* 1. In EU registry, JI Projects tab, click Search 2. Select a row with conversion limit, click on the pencil mark, delete the value 3. Click Submit 4. Should get error message:" Unit quantities may only be positive integers."	PASSED
Addition of label for permission	No label for PERM_KP_ISS_LIMITS permission	There is no label for PERM_KP_ISS_LIMITS permission. Instead of label such as "Set Kyoto Protocol issuance limits", following text "?permission_PERM_KP_ISS_LIMITS?" is displayed.	Ensure the following query returns a value in all fields: select * from permissions where perm_key = 'PERM_KP_ISS_LIMITS';	PASSED
No title displayed in confirmation popup box - deletion of allowances; this is now fixed	No title displayed in confirmation popup box - deletion of allowances	While performing Transaction of Deletion of Allowances there is not displayed title in confirmation popup. This was in the previous version. The correct title which was before: "Transfer Confirmation"	*Test Case* 1. Log in Germany, as NA 2. Initiate a allowance deletion for account 199 3. After clicking Next the pop-up appears. 4. Title "Transfer Confirmation" should exist	PASSED
Corrections in voluntary cancellation screen	Red Screen - Voluntary Cancellation from Trading Account - Check 80741	Red Screen - Voluntary Cancellation from Trading Account - Check 80741 It crashes with "nested exception is: java.lang.RuntimeException: java.lang.IllegalArgumentException: Transferring account must be present on the check context."	*Test Case 1* - Perform Voluntary cancellation 1. Log in GR as NA 2. In Accounts, Trading Accounts, select EU-100-10040-0-77	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		CheckContextParam.TRANSFERRING_ACCOUNT has not been added to the context.	3. Perform a voluntary cancellation of e.g. 10 units. 4. After transaction completion, units should be removed and no red screen should appear.	
Correction in ESD entitlement transactions	Red Box Error while Performing Entitlement Transfer/CarryOver in Phase 3 (After Compliance Status Calc.)	Perform Proposal for Transaction of Transfer of Credit Entitlement or CarryOver of Credit Entitlement for ESD Compliance Account while having actual phase in period after compliance status calculation. All of those propositions are resulting with RedBox error. See attached pictures and log file *This happens only with disabled ECAS signature*	1. Set the parameter registryConfig.ALL.ECAS_SIGNATURE_ENABLED = true 2. Perform an ESD transaction and ensure it is submitted with signature 3. Approve the ESD transaction and ensure it is approved with signature 4. Perform an ESD entitlement transaction and ensure it is submitted with signature 5. Approve the ESD entitlement transaction and ensure it is approved with signature 6. Set the parameter registryConfig.ALL.ECAS_SIGNATURE_ENABLED = false 7. Perform an ESD transaction and ensure it is submitted without signature 8. Approve the ESD transaction and ensure it is approved without signature 9. Perform an ESD entitlement transaction and ensure it is submitted without signature 10. Approve the ESD entitlement transaction and ensure it is approved without signature	PASSED
CP1 RMU activity codes are removed from Conversion A screen because these units cannot be converted any more.	CP1 RMU LULUCF displayed in Conversion A proposal screen	Given I'm logged in as NA And there is PHA account with CP1 RMU (Forest management (FM)) and CP2 RMU (Wetland, Drainage and Rewetting (WDR)) When I propose Conversion A Then on transaction proposal screen I can choose one of above LULUCFs In this case only LULUCFs related to CP2 RMU units should be displayed. When user tries to propose Conversion A using LULUCF that is not related to CP2 RMU units, transaction is not proposed but there is no error displayed (nothing happens).	1. Locate an account with RMUs. 2. Set all its RMUs to orig CP1 and appl CP1. 3. Ensure the Conversion A is not possible to be submitted for this account. 4. Set all its RMUs to orig CP2 and appl CP2. 5. Ensure the Conversion A is not possible to be submitted for this account. 6. Set some RMUs to orig CP1 and appl CP1 and some RMUs to orig CP2 and appl CP2. 7. Ensure the Conversion A is possible to be submitted only for the CP2 RMU units for this account (with originating country code the current MS). The following queries were users for these updates. select * from unit_block where account_id in (select account_id from account where identifier = 644) and unit_type = 'RMU' order by last_modified_time desc; update unit_block set original_period = 2, applicable_period = 2 where ID in (480, 479, 478, 477);	PASSED
KP2 Demo Comment: Issuance: the "Available Limit" should be replaced with "Initial Limit"	KP2 Demo Comment: Issuance: the "Available Limit" should be replaced with "Initial Limit"	In the Issuance section the label "Available Limit" is used incorrectly. It should read "Initial Limit" as that is the Issuance Limit that was initially defined.		PASSED

Feature	Summary	Description	Test Cases	SAT Status
CP1 issuance and issuance limits are disabled	KP2 Demo Comment: For CP1 we should not be able to set the limits nor to issue units	For CP1 we should not be able to set the limits nor to issue units. It is obsolete and confusing to have this functionality included in the release, as the CP1 issuance is no longer available.	1. Connect as NA and navigate to Kyoto Protocol -> Issuance Limits 2. Choose CP1 and ensure the screen is view-only 3. Choose CP2 and ensure the issuance limits for PC2 and chosen unit type is set normally. 4. Navigate to Kyoto Protocol -> Issuance 5. Choose CP1 and ensure the screen is view-only 6. Choose CP2 and ensure the issuance request is submitted normally; after approval by another NA the units are issued normally in the acquiring account. Note: The screen no longer allows setting issuance limits for CP1. In case the user tampers the DOM of the page using Firebug and manages to submit a proposal for CP1, then the following message is displayed: "Cannot set issuance limits for Commitment Period 1."	PASSED
Transfers to SOP account (except the explicit transaction Transfer to SOP) are disabled.	KP2 Demo Comment: Any direct normal 03-00 transfer to the SOP account in the CDM registry should be forbidden	Any direct normal 03-00 transfer to the SOP account in the CDM registry should be forbidden. It would create massive confusion if a member state tries to pay his SoP dues by a normal transfer to the SoP account (maybe he knows the number from a previous transaction or from another MS or from the ITL directly) and does not get any entitlement for first external transfer of AAUs.	1. Connect as NA and navigate to a PHA with KP units. 2. Propose an external transfer towards the SOP account as defined in eucr-configuration.properties. 3. Ensure the following validation rule appears and the transaction cannot be submitted: 80215: External Transfers cannot have CDM SOP Adaptation Fund as an acquiring account	PASSED
KP2 Demo Comment: On the transfers of KP Units page you should see the Available Entitlement for First Transfer of AAUs	KP2 Demo Comment: On the transfers of KP Units page you should see the Available Entitlement for First Transfer of AAUs	On the transfers of KP Units page you should see the Available Entitlement for First Transfer of AAUs. We should see it only on the transfer of KP units page, not on transfer of allowances or other transactions.	1. Propose a transfer to SOP for first external transfer 2. Ensure in the proposal screen that the entitlement appears in the form: "Remaining Entitlement for First External Transfer of AAUs: <<entitlement>> "	PASSED
KP2 Demo Comment: In the drop down list of PPSR accounts the account numbers should not be displayed	KP2 Demo Comment: In the drop down list of PPSR accounts the account numbers should not be displayed	When you choose a transfer from a PPSR account to another European PPSR account the account number is displayed in parenthesis. This should not happen for confidentiality reasons. We should see GR PPSR Account.	*Test Case 1* 1. Log in PT as NA 2. From PPSR account transfer unit to EU PPSR: In Transfer AAU to PPSR account panel, the drop-down list (enabled when choosing first radiobutton) should contain no identifiers.	PASSED
KP2 Demo Comment: conversion of CP1 units should be obsolete.	KP2 Demo Comment: conversion of CP1 units should be obsolete.	Conversion of CP1 units should not be available in the transactions anymore.	Tested successfull. 1. Navigate to an account with CP1 units. 2. Navigate to the account holdings and propose a transaction 3. Ensure "Conversion for CP1" does not appear as an option	PASSED
KP2 Demo Comment: - In JI Projects instead of Limit = -1, track 1 projects should have the label Not Applicable	KP2 Demo Comment: - In JI Projects instead of Limit = -1, track 1 projects should have the label Not Applicable	In JI Projects instead of Limit = -1, track 1 projects should have the label "Not Applicable"	*Test Case* 1. Log in PT as NA 2. Perform a conversion A,B with track 1 project, for PT 643 3. There should be N/A in Limit column	PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 Demo Comment: The word transferred has a type in a message. It's written tranfered	KP2 Demo Comment: The word transferred has a type in a message. It's written tranfered	.	1. Conect as NA 2. Propose a Conversion A, a Transfert to SOP for Conversion and a Conversion B. 3. Ensure the word "transferred" appearing in messages is spelled correctly.	PASSED
Screen change	KP2 Demo Comment: conversion B quantity	Conversion B should have a mandatory quantity, not a recommended one. Q = Limit – Transferred to SOP – quantity converted in previously completed cycles. This is no longer recommended; any other quantity you would enter would trigger the rejection of the transaction.	1. Perform a Conversion A -> Transfer to SOP for Conversion -> Conversion B for a Track 2 project 2. Ensure the messages below the Conversion A and Conversion B screen refer to "mandatory" quantity and not to "recommended" quantity.	PASSED
Screen change	KP2 Demo Comment: in Conversion A / B proposal screen there is combobox with commitment period – this should be replaced by label	In Conversion A / B proposal screen there is combobox with commitment period – this should be replaced by label because only CP2 units undergo conversion A or B.	1. Perform a Conversion A -> Transfer to SOP for Conversion -> Conversion B. 2. Ensure the CP appears as a label and not as a drop-down box in Conversion A and Conversion B.	PASSED
Upload of PPSR entitlements created an error if a section was missing; this is now fixed.	NPE when uploading PPSR entitlement without entitlement tag	1. Log in to EU as CA 2. Got to KP2 Entitlements / PPSR entitlement 3. Upload xml that misses entitlements tag Description When user uploads PPSR entitlement xml with missing entitlement tag there is NullPointerException thrown: <pre><?xml version="1.0" encoding="UTF-8" standalone="no"?> <kp2Entitlements unitType="AAU" xmlns="urn:eu:europa:ec:clima:ets:1.0"> <kp2Entitlement> <registryCode>EU</registryCode> <action>A</action> </kp2Entitlement> </kp2Entitlements></pre>	1. Connect as EU-CA and navigate to Kyoto Protocol --> KP2 Entitlements 2. Upload the following file and ensure the validation error appears: "The content of the XML file is invalid" <pre><?xml version="1.0" encoding="UTF-8" standalone="no"?> <kp2Entitlements unitType="AAU" xmlns="urn:eu:europa:ec:clima:ets:1.0"> <kp2Entitlement> <registryCode>EU</registryCode> <action>A</action> </kp2Entitlement> </kp2Entitlements></pre>	PASSED
Screen change	IllegalArgumentException in Unit Blocks when sorting by SOP flag	1. Log in to registry as NA 2. Go to Administration / Unit Blocks 3. Search for unit blocks 4. Click on "SOP" column header to sort unit blocks by SOP flag 5. Click [Search] button again When user tries to sort Unit blocks by SOP flag there are two failures: 1. After clicking the table header "SOP" all values from table disappear 2. Then, if user clicks [Search] button again, unrecoverable error is thrown	1. Log in to registry as NA 2. Go to Administration / Unit Blocks 3. Search for unit blocks 4. Click on "SOP" column header to sort unit blocks by SOP flag 5. Click [Search] button again 6. Browse through pages and reach the last page then back to the first page; ensure the provided search criteria remain as set during step [4].	PASSED

Feature	Summary	Description	Test Cases	SAT Status
Change in account statements for AAU units which are subject to SOP	AAU Subject to SOP units displayed as Not Subject to SOP on Transaction request tab of Account Statement	TC1. Given there is a transaction request for transfer of CP2 AAUs that are subject to SOP and CP2 AAUs that are Not subject to SOP When I go to Account statement page of transferring account And Search for this transaction request using start/end date filters Then request data is displayed And AAU Subject to SOP units are displayed in Subject to SOP column And AAU Not Subject to SOP units are displayed in Not Subject to SOP column TC2. Given there is a transaction pending for transfer of CP2 AAUs that are subject to SOP and CP2 AAUs that are Not subject to SOP When I go to Account statement page of transferring account And Search for this pending transaction using start/end date filters Then transaction data is displayed And AAU Subject to SOP units are displayed in Subject to SOP column And AAU Not Subject to SOP units are displayed in Not Subject to SOP column Description Given there is a transaction request for transfer of CP2 AAUs that are subject to SOP When I go to Account statement page of transferring account And Search for this transaction request using start/end date filters Then request data is displayed And AAU Subject to SOP units are displayed in Not Subject to SOP column Same issue is with Pending Transactions tab of Account statement. The result if this bug is also that if there are CP2 AAU Not Subject to SOP units in request/transaction they are not displayed at all.	Tested successfully with the following data: Transferring account: PT 643 Acquiring account: GR 383 The following are visible in the account statement of the transferring account: * Transaction Request phase 22 units requested for transfer units with flag Subject to SOP, are visible in Account Statements' Transaction Request tab, at the column of Subject to SOP. Not Subject to SOP column is unaltered. * Pending transaction phase After approving, 22 units exists in Pending tab, as Subject to SOP. Not Subject to SOP column is unaltered. * Completed transaction phase After approving the transaction request, 22 units are visible only in Completed tab, as Subject to SOP. Not Subject to SOP column is unaltered.	PASSED
Correction in account statements for carry-over	Carry over account statements: wrong balance	After a CER carry-over I get an account imbalance.	1. Connect as NA and navigate to an account with CER carry-over entitlement and CP2 CERs. 2. Carry-over 1 CER. 3. Approve the transaction and ensure it is completed. 4. Generate the account statement of the account for the specific date. 5. Ensure the account statement correctly adds up, i.e. the CER quantity BEFORE is equal to the CER quantity AFTER. Repeat the same for ERU.	PASSED
Remaining CER/ERU carry-over entitlement is 0 until first transaction is proposed (EU view only)	Remaining CER/ERU carry-over entitlement is 0 until first transaction is proposed (EU view only)	Given I'm logged as EU CA When I upload new CER / ERU entitlement for some registry e.g. BG Then value for remaining entitlement should be set to uploaded (initial) value Given I'm logged as EU CA When I upload new CER / ERU entitlement for some registry e.g. BG Then value for remaining entitlement is not set to uploaded (initial) value	*Test Case* 1. Log in EU as NA 2. At KP2 entitlements, upload CER entitlements for EU with xml: <pre><?xml version="1.0" encoding="UTF-8"?> <kp2Entitlements xmlns="urn:eu:europa:ec:clima:ets:1.0" unitType="CER"> <kp2Entitlement> <registryCode>EU</registryCode></pre>	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		This issue is a display issue observed only in EU registry (in MS registry remaining entitlement is displayed properly). The value displayed in EU is updated after proposal of first carry-over transaction in given registry for particular unit type.	<code><action>A</action></code> <code><entitlement>9000</entitlement></code> <code></kp2Entitlement></code> <code></kp2Entitlements></code> 4. After submitting the import, value 9000 should be visible in CER Initial Carry-Over Entitlement and CER Remaining Carry-Over Entitlement columns	
Message logs table screen functionality change	Message logs table screen functionality change	Loading the message logs screen is very slow. We guess it has to do with the number of records in the table. There is only a primary index on the message_logs table. Maybe an extra index is needed, as we have the impression that a full table scan is happening. there could be a relative quick win by: Add index: CREATE INDEX "MSG_LOG_IDX" ON "MESSAGE_LOG" ("DATE_TIME" DESC, "REGISTRY_CODE" DESC) We suggest using a solution similar to the one we use in Task List. Once the user clicks "Message Logs" he just sees the filters. Here he needs to fill in From and To and he gets the list. If he leaves the fields blank it will still work, but it will be very slow. After 3-4 tries the user will understand it's better to fill in From and To and get used to it. Creating an index on the time field will also help.	*Test Case 1* 1. Log in GR, as NA 2. In Message Logs, fill From and To fields and click Filter 3. There should be a minimal delay on displaying the results	PASSED
User lost access to Task List page before it's AAR removal request was accepted; this is now fixed	User lost access to Task List page before it's AAR removal request was accepted	At AAR removal submission request and while approval is still pending. AAR can still access the tasklist page AAR cannot view any task related to the account from which the AAR is being removed.	1. In browser (a) login as AAR and make sure there are some "Add to TAL list" requests which AAR can pick and execute, get Account number from one that request 2. In browser (b) login as NA and remove this AAR from account - do not approve this removal AAR, leave this task in "waiting for approval state" 3. Go back to browser (a) and click home page in menu, then click Task List in menu Result: Every time Task Page is clicked in menu - The tasks related with the account from which the AAR is being removed are not shown	PASSED
CDM accounts implementation	Create the three CDM account types, configuration parameters, add in transaction search	- New account type CCS Net Reversal Cancellation Account (241) (only visible in transaction search) - belongs to CDM - New account type Non-submission of Verification Report Cancellation Account (242) (only visible in transaction search) - belongs to CDM - Account type for SoP Adaptation Fund is 100 - belongs to CDM - Parameter for CCS Project Reserve Account in CDM to be used as prefilled acquiring account for notification - Method to return the account identifier stored in parameter - Search transactions must be able to search with this account type - check UC Notifications for parameter name	1. Navigate to Accounts->Transactions 2. Ensure the account type Non-submission of Verification Report Cancellation Account exists as an option 3. Ensure the account type CCS Project Reserve Account exists as an option 4. Navigate to EUTL->Transaction Mgt 5. Ensure the above mentioned account types exist in both originating and destination account types drop-down lists.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
PPSR checks	Acquiring account check for PPSR account - for all transactions	- PPSR accounts can receive AAUs from ONLY another PPSR account - Transfers between PPSR accounts are NOT subject to "Share of Proceeds"(SOP) levy - Transfers between PPSR accounts subject to 4-eyes principle	Tested successfully. Refer to transaction: EU1218338	PASSED
KP2 accounts/transactions setup	CP1 ETS Central Clearing Account - Allowed transaction - Carry-Over AAU	CP1 ETS Central Clearing Account - Allowed transaction - Carry-Over AAU Carry-Over of AAUs transaction is allowed from CP1 ETS Central Clearing Account to the CP2 PPSR Account in EU Registry	Tested successfully. Refer to transaction: EU1218338	PASSED
KP2 accounts/transactions setup	EU AAU Account - Available unit types	EU AAU Account - Available unit types EU AAU account should be able to receive/transfer only CP2 AAUs of the same registry.	*Test Case 1 - AAU account sends CP2 AAU units* (/) 1. Log in EU, as NA 2. Transfer AAU CP2 from AAU account to EU 296 3. Check transaction status is completed and units are transferred. *Test Case 2 - AAU account receives CP2 AAU units* (/) 1. Log in EU, as NA 2. Transfer AAU CP2 from EU 296 to AAU account 3. Check transaction status is completed and units are transferred. *Test Case 3 - AAU account cant receive CP1 AAU units* (/) 1. Log in EU, as NA 2. Transfer AAU CP1 from EU 296 to AAU account 3. Check transaction status is terminated/haulted (error code: 7029) and units are not transferred. *Test Case 4 - AAU account cant receive from external registry* (/) 1. Log in PT, as NA 2. Transfer AAU CP2 from PT 643 to EU AAU account 3. Check transaction status is terminated(error code: 7898) and units are not transferred.	PASSED
KP2 accounts/transactions setup	EUCR-2850 EU AAU Account - Available transactions	EU AAU Account - Available transactions	*Test cases* (EU, NA admin) 1. Issue AAU CP2 units to EU AAU account, check new units. 2. Transfer from EU 296, AAU CP2 units, to EU AAU account 3. Retire unit from AAU account, check units reduction. 4. Repeat for cancellation.	PASSED
KP2 accounts/transactions setup	New transactions - confirm permissions and roles	New transactions - add permissions		PASSED
KP2 accounts/transactions setup	Article 3.7ter Cancellation - New Account	Create Art 3.7ter Cancellation Account, only by NA of MS, in any MS, only one, account type code 270, applicable for CP2 only	Refer to account PT-270-10003400-2-23	PASSED
KP2 accounts/transactions setup	Article 3.7ter Cancellation - Available transactions	Art 3.7ter Cancellation Account can only be an acquiring account, no transactions can be initiated from this account	Test Case 1. Log in PT as NA	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			2. Locate an Article 3.7ter Cancellation account with units. 3. Check that for Article 3.7ter Cancellation account, no transaction can be initiated.	
KP2 accounts/transactions setup	Article 3.7ter Cancellation - New transaction	- New transaction from any KP account "Article 3.7ter Cancellation", only if account exists in MS (similar to Voluntary Cancellation) - Initiated by NA only - Any kyoto unit type except "Former EUA" - Units must not be "ESD Used" - add other rules and checks from UC	Tested successfully (LV196). Known Issue: ===== In order to complete the transaction and not get ITL errors only CP2 AAUs with originating country code = transferring registry had to be used. All the unit blocks of the account with different originating country code were marked as "RESERVED_FOR_TX" from the database, so that only the desired ones were available. It would be beneficial if this was added as a filter to the unit blocks presented to the user.	PASSED
KP2 accounts/transactions setup	Article 3.7ter Cancellation - Transaction proposal/confirmation screen	Transaction proposal/confirmation screen - Article 3.7ter Cancellation Should be similar or the same as voluntary cancellation	Tested successfully with execution transaction "512189-Art 3.7ter cancellation of Kyoto Units" from PHA PT (643) to PT-270-10003435-2-42(as acquiring account).	PASSED
KP2 accounts/transactions setup	Ambition Increase Cancellation - New Account	Create Ambition Increase Cancellation Account, only by NA, any KP registry, only one, account type code 280, applicable for CP2 only	Refer to account : PT-280-10003401-2-25	PASSED
KP2 accounts/transactions setup	Ambition Increase Cancellation - Allowed unit types	Ambition Increase Cancellation Account - Allowed unit types - check UC	Refer to PT-280-10003401-2-25 The NA-PT registry supports a new KP account type called Ambition Increase Cancellation Account. The account type code – 280. (second part of account number) This account type is applicable only for CP2. This constraint enforces at account opening request.(no display drop down list & display on the account number)	PASSED
KP2 accounts/transactions setup	Ambition Increase Cancellation - Account available transactions	No transactions can be initiated from this account, can only be an acquiring account	No transactions can be initiated from an Ambition Increase Cancellation .(the button "Propose a transaction" is not available). These accounts types are only acquiring accounts.(executed transaction Ambition Increase Cancellation from a PHA (PT) to the specific account PT-280-10003401-2-25)	PASSED
KP2 accounts/transactions setup	Ambition Increase Cancellation - New transaction	- New transaction from any KP account "Ambition Increase Cancellation" (similar to Voluntary Cancellation) - Initiated by NA only - for unit types and other rules check UC	tested successfully UC_AM_70_TC_01: APPROVE ACCOUNT OPENING REQUEST Created account : PT-280-10003401-2-25	PASSED
KP2 accounts/transactions setup	Ambition Increase Cancellation - Transaction proposal/confirmation screen	Transaction proposal/confirmation screen - Ambition Increase Cancellation Should be similar or the same as voluntary cancellation	- executed transaction for transaction type called "Ambition Increase Cancellation" by the National Administrator (PT) from any KP account (PHA -PT-643) (the correspondingTransaction proposal/confirmation screen is displayed) This transaction had as destination account the Ambition Increase Cancellation account (PT-280-10003401-2-25)	PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 accounts/transactions setup	Export Government Accounts - CSV - add new accounts	- PPSR, Article 3.7ter Cancellation Account and Ambition Increase Cancellation account are considered "Government Accounts" and should be exported in the CSV file 'Export Government Accounts'	1. Propose and approve an ambition increase cancellation account. 2. Propose and approve an Art3.7 cancellation account. 3. Propose and approve a PPSR account. 4. Navigate to Accounts -> Export Government Accounts 5. Ensure the identifiers of the accounts created in step 1,2,3 are included in the list of accounts of step 4.	PASSED
Implementation of Unit block CSV functionality	Search unit blocks - add new CSV - des-req-21	- New CSV file containing serial numbers of all KP units held in accounts of account type (100, 120, 121) for specific unit types - Button visible for NA only in Unit Block Search screen - Contents of the CSV are the same as the existing unit block CSV	1. Navigate to Administration -> unit blocks to a registry with retirement account. 2. Click on "export KP units in KPaccounts" 3. Copy the contents of the created file 4. Ensure the contents are identical to the records returned via the following query: select end_, start_, unit_type, unit_block.* from unit_block where account_id in (select account_id from account where registry_code = 'MT' and kyoto_account_type = 'HOLDING_ACCOUNT', 'PERSON_ACCOUNT_NATIONAL_REG', 'FORMER_OPERATOR_HOLDING_ACCOUNT') and unit_type in ('CER', 'ERU_FROM_AAU', 'AAU', 'LCER', 'TCER');	PASSED
Implementation of Unit block CSV functionality	Search unit blocks - add new CSV - des-req-22	- New CSV file containing serial numbers of all KP units held in retirement account for specific unit types. All retirement accounts of all commitment periods - Button visible for NA only in Unit Block Search screen - Contents of the CSV are the same as the existing unit block CSV - Retirement accounts maybe of type 300	1. Navigate to Administration -> unit blocks to a registry with retirement account. 2. Click on "export KP units in retirement accounts" 3. Copy the contents of the created file 4. Ensure the contents are identical to the records returned when searching units blocks via the account identifier of the retirement account.	PASSED
KP2 accounts/transactions setup	New / Fulfill notification - "Net Reversal of Storage of a CDM CCS Project"	- New notification type "Net Reversal of Storage of a CDM CCS Project" (type code 12) - Fulfill notification "Net Reversal of Storage of a CDM CCS Project", target account is "CCS Net Reversal Cancellation Account (type 241)" - External transfer - transferring account is any KP account from the registry (with some exceptions) - if the parameter for the acquiring account is not filled, then we cannot fulfill the notification - Unit types AAU, CER, ERU_FROM_AAU, ERU_FROM_RMU and RMU - The notification fulfillment has to be done in ONE transaction - Check that the transferring account holds enough units of notification project - Subject to 4-eyes principle, proposed by NA, approved by NA - The acquiring account must be prepopulated and cannot be changed by the user	Executed UC_IN_012_TC_01: FULFIL NET REVERSAL OF STORAGE OF A CDM CCS PROJECT	PASSED
KP2 accounts/transactions setup	New / Fulfill notification "Non-submission of Verification Report for a CDM CCS Project" unit type AAU, CER, ERU, AAU	- New notification type "Non-submission of Verification Report for a CDM CCS Project" (code type 13) - Fulfill notification "Non-submission of Verification Report for a CDM CCS Project" creates an external transfer - Transferring account is any KP account from the registry (with some exceptions) - Acquiring account is "Non-Submission of Verification Cancellation Account (type 242)" - if the parameter for the acquiring account is not filled, then we cannot fulfill the notification - The notification fulfillment has to be done in ONE transaction - Check that the transferring account holds enough units of notification project - Subject to 4-eyes principle, proposed by NA, approved by NA - The acquiring account must be prepopulated and cannot be changed by the user	Executed UC_IN_013_TC_01: FULFIL NON SUBMISSION OF VERIFICATION REPORT FOR A CDM CCS PROJECT	PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 accounts/transactions setup	Modify all notification transactions to 4 eyes	Modify all notification transactions to 4 eyes	1. Connect as NA and navigate to Kyoto Protocol -> Notifications. 2. Locate an ITL Notification (in our example: Net source cancellation) and click "fulfill". 3. Enter transferring account by typing its full identifier. 4. Locate an acquiring account and enter quantity on the desired acquiring account. 5. Click "Submit" and ensure a request is created, for approval by another NA (the green confirmation box appears referencing a transaction request ID). 6. As another NA approve the transaction request. 7. If the business rules pertaining to this notification are met, then this notification is completed, otherwise it is terminated.	PASSED
KP2 accounts/transactions setup	New account type: "ESD AAU Deposit Account"	- New account type: "ESD AAU Deposit Account" - Holds only originating CP2 AAUs - Kyoto Type 100 - only one - in any KP - if there exists a pending opening request do not allow a new one to initiate - opened by NA	Account Request 1. Login to Union Registry (Role : NA) Go to «Accounts»- «Account Request» to open a new account. 2. At the screen «Account Opening Account Details» choose theType "ESD AAU Deposit Account" 3. Enter the name (ESD_AAU_NA) 4. Click on the button "Next" 5. At the screen "Account Opening Account Holder Information" choose Account Holder is already linked to the user 6. Select Account Holder from drop-down list 7. Click on the button "Next" 8. At the screen choose the "Account Opening - Authorised Representative Information" 9. Select any Representative from the corresponding list 10. Click on the button "Add" 11. At the screen choose the "Account Opening - Authorised Representatives Linked to Creation Request" 12. Click on the button "Next " 13. At the screen "Account Opening - Authorized Representatives - click on the button "next" with default value 14. At the screen " Account Opening - Additional Authorized Representatives" with default value Expected Results Union Registry validates the entered data and displays the request id. Forwards the request for approval. Approval Request • Login to Union Registry (as nadmin1) • Select the Task List page, • Claim the specific request, and • Click the "Request id" link. • Click on "Approve" button. Expected Results	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			Union Registry receives the approval of the update request from the Administrator, forwards the request to EUTL, receives the approval from EUTL and: • Sets the status of the account type to "EUTL approved" and completes the request process.	
KP2 accounts/transactions setup	ESD AAU Deposit Account - Allowed unit types	ESD AAU Deposit Account - Allowed unit types	The specific scenario has covered from test cases of EUCR-2575	PASSED
KP2 accounts/transactions setup	EUCR-2850 ESD AAU Deposit Account - Available transactions	ESD AAU Deposit Account - Available transactions - "Retirement Transaction" available anytime from account ESD AAU Deposit Account	Tested successfully. Refer to transaction PT363	PASSED
KP2 accounts/transactions setup	Holdings tab of "ESD AAU Deposit Account" - display clearing values	- holdings tab of "ESD AAU Deposit Account" displays the following values: - ESD Clearing Value - AAUs to Retire - AAUs available for transfers	1. Connect as NA and navigate to an ESD AAU deposit account. 2. Navigate to its holdings. 3. Ensure a table appears at the bottom containing ESD clearing value, AAUs to retire, AAUs available for transfers.	PASSED
KP2 clearing implementation	ESD/ETS clearing values BE	ESD clearing value BE -		PASSED
KP2 clearing implementation	EUCR-2838 "ESD Clearing Value" - Update ESD Clearing value - Finalization of AEA Transfer	- at the finalization of AEA transfers with transferring registry different than acquiring registry the ESD clearing value of the two registries is affected	1) Search transaction for the specific type 'EsdAEATransfer' 2) Search ent_type_cd = 'ESD_CLEARING_VALUE' with STATUS='COMPLETED' 3) check the result for the specific country "CY" (31 increase + 6 decrease) The above steps describes on the following screens select sum(k.tr_amount) k_amnt , sum(t.quantity)tr_amt, k.registry_code, k.action from kp2_ent_transaction_log k, transactions t where t.request_id = k.request_id and t.status_code = 'COMPLETED' and k.ent_type_cd = 'ESD_CLEARING_VALUE' AND K.STATUS='COMPLETED' and type='EsdAEATransfer' group by k.registry_code, k.action;	PASSED
KP2 clearing implementation	EUCR-2838 "ESD Clearing Value" - Update ESD Clearing value - Finalization of External Transfer Kyoto Units	At the finalization of an "External Transfer of Kyoto units" from ESD AAU Deposit Account to ESD Central Clearing Account a RegistryEntitlementTransactionLog entity will be created with action "INCREASE" and status "COMPLETED". At the finalization of an "External Transfer of Kyoto units" from ESD Central Clearing Account to ESD AAU Deposit Account a RegistryEntitlementTransactionLog entity will be created with action "DECREASE" and status "COMPLETED".	test successfully refers to transaction ID NO114	PASSED
KP2 clearing implementation	Update actions of "AAUs to Retire"	The following actions affect the value of "AAUs to Retire". Transaction From Phase Record Action Status Registry EsdKPUnitsReturnAfterCompliance ESD Compliance Finalization New DECREASE COMPLETED Transferring ESD Member State Retirement ESD AAU Deposit Proposal New DECREASE PENDING Current Retirement ESD AAU Deposit Cancellation Update DECREASE REJECTED Current Retirement ESD AAU Deposit Finalization Update DECREASE COMPLETED Current	test successfully the below script check the test successfully the below screen on the related tables select sum(k.tr_amount) k_amnt , sum(t.quantity)tr_amt from kp2_ent_transaction_log k, transactions t	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			where t.request_id = k.request_id and t.status_code = 'COMPLETED' and k.ent_type_cd = 'AAUS_TO_RETIRE' AND K.STATUS='COMPLETED' and k.registry_code ='IT';	
KP2 clearing implementation	Calculation of "AAUs to Retire"	- value of AAUs to Retire is increased by a formula	test successfully refer to MS-BE (see screen) - AAUst_to_Retire=0 & MS-IT (-87) select sum (tr_amount),registry_code, status, action from kp2_ent_transaction_log where ent_type_cd = 'AAUS_TO_RETIRE' --and status ='COMPLETED' --and action = 'INCREASE' group by registry_code,registry_code, status, action; select COMP_DATE_EMISSIONS, a.account_id, a.esd_member_state, a.esd_year, d.* from ESD_COMPLIANCE_HISTORY ch, account a, esd_compliance_dates d where ch.account_id = a.account_id and sysdate >= d.comp_closure_date and a.esd_year = d.comp_year and a.esd_member_state = 'BE'; and also test successfully the below script check the select sum(k.tr_amount) k_amnt , sum(t.quantity)tr_amt from kp2_ent_transaction_log k, transactions t where t.request_id = k.request_id and t.status_code = 'COMPLETED' and k.ent_type_cd = 'AAUS_TO_RETIRE' AND K.STATUS='COMPLETED' and k.registry_code ='IT'; (also BE) (on the corresponding tables)	PASSED
KP2 clearing implementation	footnote - Holdings screen of ESD AAU Deposit Account	footnote	1. Connect as NA and navigate to an ESD AAU deposit account. 2. Navigate to its holdings. 3. Ensure the footnote appears at the bottom: "AAUs to Retire = AAUs that correspond to ESD emissions that had not been covered by other international credits."	PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 clearing implementation	New check for "Retirement Transaction" from ESD AAU Deposit Account	- Maximum amount for "Retirement Transaction" from ESD AAU Deposit Account is the value of the parameter AAUs to Retire	Tested successfully refers to ESD AAU Deposit Account of Portugal (PT-100-10003434-0-31) , which has available AAU (Not Subject to SOP) - 18 with the parameter value "AAU to Retire" is equal to "98" 1) Select the transaction "Retirement" 2) Enter the value 99 on the "Quantity to retire" 3) Click on the button "Submit" Result The Union Registry display the following message 80757: The quantity to retire (99) must be less or equal to the value of "AAUs to Retire" for this registry (98). Repeat the above steps with value on the field quantity to retire "98" that equal to the value of "AAUs to Retire" for this registry (98). Result : The request is submitted successfully Notice: we suggest to discuss if we need to enhancement the current implementation with new check on the field quantity in order to retire must be less or equal to the value of available units of the ESD AAU Deposit Account	PASSED
KP2 clearing implementation	Retirement transaction from ESD AAU Deposit account proposal/finalization	Retirement transaction from ESD AAU Deposit account proposal/finalization should do the following: - value AAUs to Retire is decreased when retirement transaction is initiated (a pending value will be kept) - NA may choose AAUs that are "subject to SOP" or "not subject to SOP", both must be visible on screen	Refer to transaction PT-363.	PASSED
KP2 clearing implementation	Calculation of "AAUs Available for Transfers"	- calculation method of value "AAUs Available for Transfers"	a1. sum the calculation with the ent_type_cd = 'AAUS_AVAILABLE_FOR_TRANSFERS' <pre> select sum (tr_amount),registry_code, status, action from kp2_ent_transaction_log where ent_type_cd = 'AAUS_AVAILABLE_FOR_TRANSFERS' group by registry_code,registry_code, status, action; </pre> a2. calculation emission (see field COMP_DATE_EMISSION) <pre> select COMP_DATE_EMISSIONS, a.account_id, a.esd_member_state, a.esd_year, d.* from ESD_COMPLIANCE_HISTORY ch, account a, esd_compliance_dates d where ch.account_id = a.account_id --and sysdate >= d.comp_closure_date and a.esd_year = d.comp_year and a.esd_member_state = 'GB'; </pre>	PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 accounts/transactions setup	New check to be added to Cancellation, Internal Transfers, External Transfers initiated from ESD AAU Deposit Account	- new check to be added to Cancellation, Internal Transfers, External Transfers initiated from ESD AAU Deposit Account	test successfully 1. external transfer from PT ESD AAU Deposit Account ---> any registry parameteAAUs available for Transfers 49219 80758: The quantity (49220) must be less or equal to the value of "AAUs Available for Transfer" for this registry (49219). & also cancellation with 80000: The amount 49220 of AAU is not available in the account: 10003434 80758: The quantity (49220) must be less or equal to the value of "AAUs Available for Transfer" for this registry (49219).	PASSED
KP2 accounts/transactions setup	Creation of ESD AAU Deposit Account - initialize various values	- Values of "AAUs to Retire" and "AAUs available for transfers" must be initialized based on all existing ESD transactions - ESD Clearing Values are 0 by default		PASSED
KP2 accounts/transactions setup	New Account Type "ESD Central Clearing Account"	- new Account Type "ESD Central Clearing Account" - holds only originating CP2 AAUs - Kyoto Type 100 - opened in EU KP registry - opened by CA	Account Request 1. Login to Union Registry (Role : CA) Go to «Accounts»- «Account Request» to open a new account. 2. At the screen «Account Opening Account Details» choose theType "ESD Central Clearing Account" 3. Enter the name (ESD_CCA). Ensure only CP2 can be chosen. 4. Click on the button "Next" 5. At the screen "Account Opening Account Holder Information" choose Account Holder is already linked to the user 6. Select Account Holder from drop-down list 7.Click on the button "Next" 8. At the screen choose the "Account Opening - Authorised Representative Information" 9. Select any Representative from the corresponding list 10. Click on the button "Add" 11. At the screen choose the"Account Opening - Authorised Representatives Linked to Creation Request" 12. Click on the button "Next " 13. At the screen "Account Opening - Authorized Representatives - click on the button "next" with default value 14. At the screen " Account Opening - Additional Authorized Representatives" with default value Expected Results Union Registry validates the entered data and displays the request id. Forwards the request for approval. Approval Request • Login to Union Registry (as nadmin1) • Select the Task List page, • Claim the specific request, and • Click the "Request id" link.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			• Select the Request , • Claim the specific request, and • Click on "Approve" button. Expected Results Union Registry receives the approval of the update request from the Administrator, forwards the request to EUTL, receives the approval from EUTL and: • Sets the status of the account type to "EUTL account approval" and completes the request process. • The account is created for CP2.	
KP2 clearing implementation	Checks looking parameter "AAUs Available for Transfer" should allow transfers from MS ESD Deposit Account to ESD Central Clearing Account	Checks looking parameter "AAUs Available for Transfer" should allow transfers from MS ESD Deposit Account to ESD Central Clearing Account	test successfully refers to transaction ID NO114	PASSED
KP2 clearing implementation	EUCR-2838 "ESD Clearing Value" - Transaction finalization of transfer from ESD AAU Deposit to ESD Central Clearing Account	- Finalization of transactions from MS ESD AAU Deposit Accounts to ESD Central Clearing Account, the ESD Clearing Value of the ESD AAU Deposit Account will increase with the value of the transaction - exceptions may exist!	test successfully refer to transaction ID NO114	PASSED
KP2 clearing implementation	EUCR-2850 ESD Central Clearing Account to an ESD AAU Deposit - allowed transfers	- For a given MS transfers from ESD Central Clearing Account to an ESD AAU Deposit Account is allowed	*Test Case* 1. Log in EU as NA 2. Transfer AAU units from ESD Central Clearing 1000 3408 to ESD AAU Deposit 10003404. 3. Check transferred units.	PASSED
KP2 clearing implementation	EUCR-2838 "ESD Clearing Value" - Transaction finalization of transfer from ESD Central Clearing to ESD AAU Deposit Account	- Finalization of transfers from ESD Central Clearing Accounts to an ESD AAU Deposit Account, the ESD Clearing Value of the respective ESD AAU Deposit Account is decreased with the quantity of the transaction	test successfully refer to transaction id EU1218401	PASSED
KP2 clearing implementation	Calculation of "ESD Clearing Value"	ESD Clearing value is impacted by AEA transfers between ESD Compliance accounts belonging to different MS Transaction finalization, Transaction proposal CHECKS	test successfully as below a1.sum the calculation <pre>select sum (tr_amount),registry_code from kp2_ent_transaction_log where ent_type_cd = 'ESD_CLEARING_VALUE' and status ='COMPLETED' and action = 'INCREASE' group by registry_code;</pre>	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			a2. sum the calculation (decrease) select sum (tr_amount),registry_code from kp2_ent_transaction_log where ent_type_cd = 'ESD_CLEARING_VALUE' and status ='COMPLETED' and action = 'DECREASE' group by registry_code;	
KP2 clearing implementation	EUCR-2838 Transfers of AAUs from and to ESD Central Clearing Account	Transfers of AAUs from and to ESD Central Clearing Account - transaction proposal, transaction finalization	Tested successfully as duplicate of issue EUCR-2600	PASSED
KP2 clearing implementation	New ESD Clearing Screen showing various values / comments - add footer	- new clearing page showing various values / comments	*Test Case* 1. Log in IS registry as NA 2. In Kyoto Protocol, ESD Accounting And Clearing for CP2, check that these labels exist: - Negative ESD Clearing Value: The Member-State needs to send AAUs to the ESD Central Clearing Account - Positive ESD Clearing Value: The Member-State needs to receive AAUs from the ESD Central Clearing Account	PASSED
KP2 clearing implementation	No blocking for transfers from and to ESD Central Clearing Account	- no blocking for transfers from and to ESD Central Clearing Account - transactions are manual	*Test Case 1* 1. Log in EU as NA 2. Transfer CP2 AAU from 10003408(clearing) to 296 3. Check transaction is completed and units are transferred *Test Case 2* 1. Log in EU as NA 2. Transfer CP2 AAU from 296 to 10003408 3. Check transaction is completed and units are transferred	PASSED
KP2 clearing implementation	New Account Type "ETS AAU Deposit Account"	- new Account Type "ETS AAU Deposit Account" - holds originating CP2 AAUs - Kyoto type 100 - only one open - if pending cannot create new request - open only in NO, LI, EU - only NA can open this account or CA for EU	The specific scenario also covers the EUCR-2602 Account Request 1. Login to Union Registry (Role : CA) Go to «Accounts»- «Account Request» to open a new account. 2. At the screen «Account Opening Account Details» choose theType "ETS AAU Deposit Account" 3. Enter the name (ETS_AAU) 4. Click on the button "Next" 5. At the screen "Account Opening Account Holder Information" choose Account Holder is already linked to the user 6. Select Account Holder from drop-down list 7.Click on the button "Next" 8. At the screen choose the "Account Opening - Authorised Representative Information" 9. Select any Representative from the corresponding list 10. Click on the button "Add"	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			11. At the screen choose the "Account Opening - Authorised Representatives Linked to Creation Request" 12. Click on the button "Next " 13. At the screen "Account Opening - Authorized Representatives - click on the button "next" with default value 14. At the screen " Account Opening - Additional Authorized Representatives" with default value Expected Results Union Registry validates the entered data and displays the request id. Forwards the request for approval. Approval Request • Login to Union Registry (as nadmin1) • Select the Task List page, • Claim the specific request, and • Click the "Request id" link. • Click on "Approve" button. Expected Results Union Registry receives the approval of the update request from the Administrator, forwards the request to EUTL, receives the approval from EUTL and: • Sets the status of the account type to "EUTL approved" and completes the request process.	
KP2 clearing implementation	ETS AAU Deposit Account - Allowed unit types	ETS AAU Deposit Account - Allowed unit types	Account Request 1. Login to Union Registry (Role : CA) Go to «Accounts»- «Account Request» to open a new account. 2. At the screen «Account Opening Account Details» choose theType "ETS AAU Deposit Account" 3. Enter the name (ETS_AAU) 4. Click on the button "Next" 5. At the screen "Account Opening Account Holder Information" choose Account Holder is already linked to the user 6. Select Account Holder from drop-down list 7. Click on the button "Next" 8. At the screen choose the "Account Opening - Authorised Representative Information" 9. Select any Representative from the corresponding list 10. Click on the button "Add" 11. At the screen choose the "Account Opening - Authorised Representatives Linked to Creation Request" 12. Click on the button "Next " 13. At the screen "Account Opening - Authorized Representatives - click on the button "next" with default value 14. At the screen " Account Opening - Additional Authorized Representatives" with default value	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			Expected Results Union Registry validates the entered data and displays the request id. Forwards the request for approval. Approval Request • Login to Union Registry (as nadmin1) • Select the Task List page, • Claim the specific request, and • Click the "Request id" link. • Click on "Approve" button. Expected Results Union Registry receives the approval of the update request from the Administrator, forwards the request to EUTL, receives the approval from EUTL and: • Sets the status of the account type to "EUTL approved" and completes the request process.	
KP2 clearing implementation	EUCR-2850 ETS AAU Deposit Account - Allowed transactions	ETS AAU Deposit Account - Allowed transactions - Retirement transaction available from ETS AAU Deposit Account	1. Navigate to an ETS AAU deposit account which holds KP units. 2. Ensure retirement transaction is available. 3. Refer to EU1218341	PASSED
KP2 clearing implementation	New screen - ETS Accounting and Clearing for CP2 + JBPM to transfer to EUTL	- new ETS screen Accounting and Clearing for CP2 - displays value - if the user has the upd role, can update that value (CA can update for EU, NO, LI) - CA only can view values for all registries including NO & LI. - New JBPM to transfer ETS Clearing Values to EUTL - values must not be saved unless an OK is received from EUTL (like account exclusion)	see attached file related to TC_CL_020_MODIFY_ETS_CLEARING_CP2_INFO	PASSED
KP2 clearing implementation	Holdings tab of ETS AAU Deposit Account - show the value of ETS Clearing Value	- holdings tab of ETS AAU Deposit Account must show the value of ETS Clearing Value	1. Connect as NA and navigate to ETS AAU Deposit Account of the registry. 2. Navigate to account holdings. 3. Ensure that below the account holdings a table appears containing Initial and Current ETS Clearing Value	PASSED
KP2 clearing implementation	ETS Clearing values are default = 0	ETS Clearing values are default = 0		PASSED
KP2 clearing implementation	New account "ETS Central Clearing Account for CP2"	- new account "ETS Central Clearing Account for CP2" - holds originating CP2 AAUs - Kyoto type 100 - created only in EU - opened by CA	The specific scenario also covers the EUCR-2608. Account Request 1. Login to Union Registry (Role : CA) Go to «Accounts»- «Account Request» to open a new account. 2. At the screen «Account Opening Account Details» choose theType "ETS Central Clearing Account for CP2" 3. Enter the name (ETS_CCA_CP2) 4. Click on the button "Next" 5. At the screen "Account Opening Account Holder Information" choose	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			Account Holder is already linked to the user 6. Select Account Holder from drop-down list 7. Click on the button "Next" 8. At the screen choose the "Account Opening - Authorised Representative Information" 9. Select any Representative from the corresponding list 10. Click on the button "Add" 11. At the screen choose the "Account Opening - Authorised Representatives Linked to Creation Request" 12. Click on the button "Next " 13. At the screen "Account Opening - Authorized Representatives - click on the button "next" with default value 14. At the screen " Account Opening - Additional Authorized Representatives" with default value Expected Results Union Registry validates the entered data and displays the request id. Forwards the request for approval. Approval Request • Login to Union Registry (as nadmin1) • Select the Task List page, • Claim the specific request, and • Click the "Request id" link. • Click on "Approve" button. Expected Results Union Registry receives the approval of the update request from the Administrator, forwards the request to EUTL, receives the approval from EUTL and: • Sets the status of the account type to "EUTL approved" and completes the request process.	
KP2 clearing implementation	ETS Central Clearing Account for CP2 - Allowed unit types	ETS Central Clearing Account for CP2 - Allowed unit types	Account Request 1. Login to Union Registry (Role : CA) Go to «Accounts»- «Account Request» to open a new account. 2. At the screen «Account Opening Account Details» choose theType "ETS Central Clearing Account for CP2" 3. Enter the name (ETS_CCA_CP2) 4. Click on the button "Next" 5. At the screen "Account Opening Account Holder Information" choose Account Holder is already linked to the user 6. Select Account Holder from drop-down list 7. Click on the button "Next" 8. At the screen choose the "Account Opening - Authorised Representative Information" 9. Select any Representative from the corresponding list	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			10. Click on the button "Add" 11. At the screen choose the "Account Opening - Authorised Representatives Linked to Creation Request" 12. Click on the button "Next " 13. At the screen "Account Opening - Authorized Representatives - click on the button "next" with default value 14. At the screen " Account Opening - Additional Authorized Representatives" with default value Expected Results Union Registry validates the entered data and displays the request id. Forwards the request for approval. Approval Request • Login to Union Registry (as nadmin1) • Select the Task List page, • Claim the specific request, and • Click the "Request id" link. • Click on "Approve" button. Expected Results Union Registry receives the approval of the update request from the Administrator, forwards the request to EUTL, receives the approval from EUTL and: • Sets the status of the account type to "EUTL approved" and completes the request process.	
KP2 clearing implementation	EUCR-2850 ETS Central Clearing Account for CP2 - Allowed transactions	ETS Central Clearing Account for CP2 - Allowed transactions	*Test Case* 1. Log in EU as NA 2. In Accounts panel choose ETS Central Clearing account type, and Search 3. In available transactions below types should exist: "Transfer of AAU, RMU, ERU, CER, ICER and tCER" and "Transfer to SOP for First External Transfer"	PASSED
KP2 clearing implementation	EUCR-2839 Transaction finalization for ETS AAU Deposit Account to ETS Central Clearing Account must increase the value of ETS Clearing Value	- Finalization of transfers from ETS AAU Deposit Account to ETS Central Clearing Account must increase the value of ETS Clearing Value	test successfully. Refers to transaction EU1218382 see attached file increase ETS Clearing parameter	PASSED
KP2 clearing implementation	Transfers between ETS Central Clearing Account and ETS Deposit Account and the reverse will be allowed and they will	- All transfers between ETS Central Clearing Account and ETS Deposit Account and the reverse will be allowed and they will ignore ETS Clearing Values		PASSED

Feature	Summary	Description	Test Cases	SAT Status
	ignore ETS Clearing Values			
KP2 clearing implementation	Transfers to/from ETS Central Clearing Account and ETS AAU Deposit Account will not be blocked by ETS Clearing Value	Transfers to/from ETS Central Clearing Account and ETS AAU Deposit Account will not be blocked by ETS Clearing Value		PASSED
KP2 clearing implementation	EUCR-2839 Transaction finalization from ETS Central Clearing Account to ETS AAU Deposit Account decreases the value of ETS Clearing value	- Finalization of transfer from ETS Central Clearing Account to ETS AAU Deposit Account decreases the value of ETS Clearing value	test successfully Refers to corresponding accounts EU-100-10003407-0-76 ETS AAU DEPOSIT EU-100-10003403-0-96 ETS Central Clearing Account for CP2 execution the below transactions EU1218344 (2 units) EU1218346 (1 unit) results check the print screen	PASSED
KP2 clearing implementation	Calculation of "ETS Clearing Value"	ETS clearing value is affected by transfers of AAUs from and to the ETS Central Clearing Account	test successfully step1 execution two transaction from ETS AAU DEPOSIT(EU-100-10003407-0-76) to ETS Central Clearing Account for CP2 (EU-100-10003403-0-96) (2 units) and reverses step 2 checks the transfers amounts select sum (tr_amount),registry_code, action from kp2_ent_transaction_log where ent_type_cd = 'ETS_CLEARING_VALUE' and status ='COMPLETED'group by registry_code,action; 2 records (2 units - increase & 1 unit decreases) select * from KP2_REGISTRY_ENTITLEMENT where ent_type_cd = 'ETS_CLEARING_VALUE' (there is no exist record) step 3 checks the corresponding screen (see attached file)	PASSED
Enable cancellations from Aviation Surrender Set-Aside	Cancellation transaction from Aviation Surrender Set-Aside for CERs and ERUs will be allowed without any time limit	- Cancellation from Aviation Surrender Set-Aside for CERs and ERUs will be allowed without any time limit	Tested successfully. Refer to transaction EU1218347.	PASSED
Ensure CER, ERU units become ESD ineligible	ESD related transaction checks - after config	ESD related transaction checks - after config param "End of Carry-Over CP1 -> CP2" all CERs, ERUs, ICERs, tCERs will become ESD ineligible	1. Set the configuration parameter carry.over.end.date to a date later than current server date. 2. Upload in ESD registry -> ESD Eligibility List upload a General list containing projects and unit types.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
after the lapse of the relevant config parameter	param "End of Carry-Over CP1 -> CP2" all CERs, ERUs, ICERs, tCERs will become ESD ineligible		3. Locate an account in a registry containing the projects/unit types contained in the list uploaded in step 2. 4. Ensure the uploaded unit type/project contains "Limit 1" in column "ESD Eligibility" 5. Update the parameter set in step 1 to a past date. 6. Wait 5 minutes. 7. Repeat step 4 and ensure the holdings contained in the list do NOT contain a reference to a list type.	
Translations	Duplicate i18n entries	The following entries in messages.properties have duplicate values. "Your request to update your mobile phone number has been recorded with identifier" * info.message.update.mobile.number.request.submitted * info.message.update.mobile.number.request.submitted.detail "Your request to update your mobile phone number has not been submitted, because there is a pending personal details update request for this user" * info.message.update.mobile.number.request.pending * info.message.update.mobile.number.request.pending.detail This fact causes confusion to the client, who considers that two different messages have the same text. Actually, these texts are not two separate messages; the first key is the summary and the second key is the details of the same message. These entries are used as error messages inside /EUCR/eucr-ui/src/main/webapp/index.xhtml, where it is clear that the message details are ignored: <pre>{code:title=index.xhtml borderStyle=solid} <p:messages id="errors" globalOnly="true" showSummary="true" showDetail="false"/> {code}</pre>		PASSED
KP2 accounts/transactions setup	Check 80000 - Add SOP flag - bring up to date	Check 80000 - Add SOP flag - bring up to date check how TransactionServicesBean.reserveUnitsAutoSelected reserves unit blocks. This check must be in synch with that method. Most probably must use constructSelectionCriteria (change to public) and then selectUnitBlocks as the reserveUnitsAutoSelected Various flags regarding esd are missing also.	*Test Cases* 1. Log in PT as NA 2. Check for all transaction types(see comment), proposal and approval phase, that there are no errors/red screens.	PASSED
Addition of account type as possible destination for issuance	Acquiring Accounts list in Issuance screen - Add ESD AAU Deposit account	ESD AAU Despotit accounts must be added in the drop down of issuance screen	*Test Case 1* 1. Log in EU, as NA 2. Make sure account(ESD AAU Deposit) 10003404 exists 3. In Issuance the above should exist in drop-down list	PASSED

Feature	Summary	Description	Test Cases	SAT Status
Correction in issuance screen	Red Screen - While trying to cancel an issuance of AAU/RMU units	Red Screen - While trying to cancel an issuance of AAU/RMU units unblockIssuanceByCancellingUsersRequest does not have code to handle cancellation of issuance of AAU/RMU units, only allowances.	*Test Case 1* - RMUs 1. Log in Latvia Registry 2. In Kyoto Protocol -> Issuance, select CP2 and account 551 3. Select radiobutton of RMU-Afforestation(AR) and submit 2 units issuance 4. Redirect to Issuance page, check again same radiobutton radiobutton of RMU-Afforestation(AR), and make sure input field is not editable 5. Check anotherRMU radiobutton and make sure to get error: "80300: There can exist no other pending transaction with the same type in the hosting registry" *Test Case 2* - AAUs Repeat above steps in RO registry, account 666 and AAU units issuance(step 3).	PASSED
Correction in KP2 entitlements CSV export	KP2 Entitlements - CSV export should include all rows	This applies to Conversion screen, where a dynamic table with pager is used.	*Test Case 1* 1. Log in EU as CA 2. In KP2 Entitlements, check exported CSV for Conversion and another section, with UI info 3. All rows should be the same.	PASSED
Correction in Transfer to SOP transaction	After submitting a transfer to SOP for first external transfer, user can submit another one	1. Submit a Transfer to SOP for first ext transf 2. Sign in ECAS 3. When returning in the screen shown in the attachment, user can submit another transfer to SOP for first ext transf	1. Submit a Transfer to SOP for first ext transf 2. Sign in ECAS 3. When returning in the screen enter another value and click "submit". 4. The validation rule appears: "The proposal cannot proceed, because its preconditions failed. Please retry starting from the holdings tab." and the second transaction cannot be submitted.	PASSED
KP2 accounts/transactions setup	New check in Cancellation transactions	According to UCS.13 - Holdings and Transfers v2.60.docx: bq. It is not permitted to cancel AAUs more than the quantity "AAUs available for Transfer" This check is involved in the following use cases: * UC_HT_070: CANCEL KYOTO UNITS * UC_HT_071: PERFORM MANDATORY CANCELLATION OF KYOTO UNITS * UC_HT_072: PERFORM AMBITION INCREASE CANCELLATION * UC_HT_073: PERFORM ART3.7TER CANCELLATION	test successfully the UC_TF_070_TC_01: CANCEL KYOTO UNITS for the following cancellation types Voluntary Cancellation UC_TR_071_TC_01: Mandatory cancellation is available from Excluded account for Mandatory cancellation UC_TR_071_TC_01: Ambition Increase Cancellation is available from Excluded account Ambition Increase Cancellation UC_TR_071_TC_01: Art 3.7ter Cancellation is available from Excluded account the AAUs units of cancellation <= current units for CP2 & <= the value of parameter of AAUs available for Transfer for specific country	PASSED
KP2 accounts/transactions setup	Transfer to PPSR: cannot confirm transaction	If I transfer from PPSR --> to PPSR and enter quantity = -5, quantity = 5.5 and click confirm, there is an orange error message If I then re-try and enter quantity = 1 I cannot click confirm.	1. Connect as NA and propose a transfer PPSR --> PPSR 2, Enter quantity = -5, quantity = 5.5 and click confirm, there is an orange error message 3. Enter value 1 and click submit. The transaction is submitted normally.	PASSED
KP2 accounts/transactions setup	Allow only one mandatory canc. account and one volunt. canc.		*Test Case* 1. Log in registry as NA 2. a. If mandatory and cancellation accounts do not exist, make sure only one of each is created for each CP.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
	account is allowed per registry per CP		2. b. If mandatory and cancellation accounts exist already, make sure no second for each type and CP, can be created	
KP2 clearing implementation	New screen - ESD Accounting and Clearing for CP2	New screen for CA - Display all ESD Clearing Values UC does not mention the location of the screen nor the permission. To be defined at implementation.	1. Connect as EU-CA. 2. Navigate to ESD accounting and clearing for CP2. 3. Ensure the screen shows the columns: "ESD Clearing Value", "AAUs to Retire" and "AAUs Available for Transfers".	PASSED
KP2 accounts/transactions setup	Transfer to SOP for First External Transfer of AAUs - Add Originating Country Code	In order to be precise about ITL check 5115 and avoid sending wrongly marked units to CDM, in transaction Transfer to SOP for First External Transfer of AAUs Originating Country Code must be added in the filter of units and be equal to the transferring registry. (ITL check 5115: AAUs transferred to the SOP Adaptation Fund account must be AAUs that have never been transferred and have been issued by the Party concerned.)	Tested successfully. 1. Locate an account with CP2 AAUs. 2. Query its unit blocks via the query: select (end_ - start_ + 1), unit_block.* from unit_block where account_id = (select account_id from account where identifier = 10003336) and unit_type = 'AAU' order by last_modified_time desc; 3. Switch the originating country code to another country and ensure this quantity is not available for Transfer to SOP for first external transfer update unit_block set originating_country_code = 'GB' where ID = 562002; 4. If all such units get another originating country code then this transaction is not available. 5. Restore the originating country code to the country of the current user and ensure the transaction is available again and the unit blocks are available to be transacted. The above test is only applicable to CP2 AAU units. All other units are irrelevant to this test.	PASSED
KP2 accounts/transactions setup	Issuance of CP2 units add extra check for AAU related accounts	A check must be added to the check package "Issuance of Kyoto units 1-0" which will check that issuance to AAU Account or ESD AAU Deposit Account are valid unit types for those two accounts. Check if 7029 can be added or some similar check must be created.	1. Connect as NA and perform an issuance to PHA. 2. Repeat issuing to ESD AAU deposit account 3. Repeat issuing to AAU account Ensure all transactions are completed. All succeeded for EU (EU1218368, EU1218367, EU1218366)	PASSED
"Kyoto Protocol Public Reports" configuration for Malta	If I click on link "Kyoto Protocol Public Reports" from the Home page of Malta I get error (pending configuration)		Tested successfully. Redirection is performed without errors. Note: CSRF Guard configuration is necessary if the file is new.	PASSED
Correction in Conversion B messages	Mutually exclusive messages for Conversion B	When Converting with Conversion B and entitlement = 49 and I enter quantity = 50 then I get two messages for the same quantity.	1. Locate an account which is able to receive a Conversion B. 2. The holdings of the account are 100 and the entitlements 49. 3. Enter 999 as transaction quantity and click Next. 4. Ensure the validation rule 82108 appears only.	PASSED
KP2 clearing implementation	Update actions of "ESD Clearing Value"	The following actions affect the value of "ESD Clearing Value". Transaction From To Phase Record Action Status Registry EsdAEATransfer ESD Compliance - Finalization New DECREASE COMPLETED Transferring ESD Memeber State EsdAEATransfer ESD Compliance - Finalization New INCREASE COMPLETED Acquiring ESD Memeber State	test successfully as below a1.sum the calculation select sum (tr_amount),registry_code from kp2_ent_transaction_log	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		EsdReversalAEATransfer ESD Compliance - Finalization New DECREASE COMPLETED Transferring ESD Memeber State EsdReversalAEATransfer ESD Compliance - Finalization New INCREASE COMPLETED Acquiring ESD Memeber State Internal Transfer ESD AAU Deposit ESD Central Clearing Finalization New INCREASE COMPLETED Transferring Internal Transfer ESD Central Clearing ESD AAU Deposit Finalization New DECREASE COMPLETED Acquiring	where ent_type_cd = 'ESD_CLEARING_VALUE' and status ='COMPLETED' and action = 'INCREASE' group by registry_code; a2. sum the calculation (decrease) select sum (tr_amount),registry_code from kp2_ent_transaction_log where ent_type_cd = 'ESD_CLEARING_VALUE' and status ='COMPLETED' and action = 'DECREASE' group by registry_code; c. a1 - a2 see attached file	
KP2 clearing implementation	Update actions of "ETS Clearing Value"	The following actions affect the value of "ETS Clearing Value". Transaction From To Phase Record Action Status Registry Internal Transfer ETS AAU Deposit ETS Central Clearing Finalization New INCREASE COMPLETED Transferring Internal Transfer ETS Central Clearing ETS AAU Deposit Finalization New DECREASE COMPLETED Acquiring	test successfully the following test cases a. creation two accounts EU-100-10003407-0-76 ETS AAU DEPOSIT EU-100-10003403-0-96 ETS Central Clearing Account for CP2 b. execution two transactions b1 request& transaction_id : 512293 & EU1218344 (transfers 2 units from ETS AAU DEPOSIT --> ETS CENTRAL CLEARING) b2 request& transaction_id :512298 --- EU1218346 (transfers 1 units from ETS CENTRAL CLEARING -> ETS AAU DEPOSIT -->) EU-100-10003403-0-96 (1) to EU-100-10003407-0-76 as nadmin1 After completion the above transaction , checks the table kp2_ent_transaction_log select sum (tr_amount),registry_code, action from kp2_ent_transaction_log where ent_type_cd = 'ETS_CLEARING_VALUE'group by registry_code,action; --> exists 2 records based on the business rule (3.7.2) The value of the parameter ETS Clearing value = 2-1 = 1 check corresponding screen see attached file	PASSED
KP2 clearing implementation	Update actions of "AAUs Available for Transfers"	The following actions affect the value of "AAUs Available for Transfers". Transaction From Phase Record Action Status Registry EsdAEADeletionAfterCompliance ESD Compliance Finalization New INCREASE COMPLETED Transferring	Test case 1) Search request_id from the table kp2_ent_transaction_log select * from kp2_ent_transaction_log	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		ESD Member State EsdAEADeletionAfterOverallocation ESD Compliance Finalization New INCREASE COMPLETED Transferring ESD Member State EsdKPUnitsReturnAfterCompliance ESD Compliance Finalization New INCREASE COMPLETED Transferring ESD Member State Cancellation ESD AAU Deposit Proposal New DECREASE PENDING Transferring Cancellation ESD AAU Deposit Cancellation Update DECREASE REJECTED Transferring Cancellation ESD AAU Deposit Finalization Update DECREASE COMPLETED Transferring Internal Transfer ESD AAU Deposit Proposal New DECREASE PENDING Transferring Internal Transfer ESD AAU Deposit Cancellation Update DECREASE REJECTED Transferring Internal Transfer ESD AAU Deposit Finalization Update DECREASE COMPLETED Transferring External Transfer ESD AAU Deposit Proposal New DECREASE PENDING Transferring External Transfer ESD AAU Deposit Cancellation Update DECREASE REJECTED Transferring External Transfer ESD AAU Deposit Finalization Update DECREASE COMPLETED Transferring	WHERE ent_type_cd = 'AAUS_AVAILABLE_FOR_TRANSFERS' AND STATUS='COMPLETED' and registry_code ='CY'; 2) check the type of the specific transaction select * from transactions where request_id =224782; /*EsdAEADeletionAfterCompliance*/ select * from transactions where request_id =224783; /*EsdAEADeletionAfterCompliance*/ 3) check the action & amount of the action between transaction table & kp2_entitlement table select sum(k.tr_amount) k_amnt , sum(t.quantity)tr_amt, k.registry_code from kp2_ent_transaction_log k, transactions t where t.request_id = k.request_id and t.status_code = 'COMPLETED' and k.ent_type_cd = 'AAUS_AVAILABLE_FOR_TRANSFERS'AND K.STATUS='COMPLETED' group by k.registry_code;	
KP2 clearing implementation	Translation - Mandatory Cancellation missing	see attached file (translation issue)	Translation appears correctly in transaction types.	PASSED
KP2 clearing implementation	ETS Central Clearing & ESD Central Clearing are not valid accounts for Cancellations	ETS Central Clearing & ESD Central Clearing are not valid accounts for Cancellations	1. Ensure Mandatory cancellation and Ambition increase cancellation accounts have been created for EU registry. 2. Navigate to PHA of EU (which has some KP units) and ensure Mandatory cancellation and Ambition increase cancellation are available transaction types. 3. Navigate to ETS Central Clearing (which has some KP units) and ensure Mandatory cancellation and Ambition increase cancellation are NOT available transaction types. 4. Navigate to ESD Central Clearing (which has some KP units) and ensure Mandatory cancellation and Ambition increase cancellation are NOT available transaction types.	PASSED
KP2 accounts/transactions setup	All new 8.0.x accounts are Kyoto Accounts	All five accounts added in 8.0.1 & 8.0.2 will be Kyoto Account: AAU Account ETS AAU Deposit Account ETS Central Clearing Account ESD AAU Deposit Account ESD Central Clearing Account In ETSAccountTypeEnum a new boolean needs to be added and return true for NONE and those five accounts. a new method isKPAccount will be added in the enumeration.	1. Connect as NA of Norway 2. Request an AAU account, an ETS AAU deposit account, an ESD AAU deposit account 3. As another NA approve them 4. Note the identifiers and locate them in the database. 5. Ensure in the database that the hosting registry of all three accounts is Norway. Repeat for Liechtenstein.	PASSED
KP2 accounts/transactions setup	Allowed transactions of KP2 accounts	Parent ticket for allowed transactions of all new KP2 account types. Transactions which a KP2 account can launch: {panel:title=PPSR account} Kyoto Specific: * Retirement	The transactions mentioned in this issue's sub-tasks have been tested successfully.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		* Transfer AAU to PPSR account {panel} {panel:title=AAU Account} Regular Transfers: * Transfer of AAU, RMU, ERU, CER, ICER and tCER Destruction of Units: * Voluntary cancellation of AAU, RMU, CER, ERU, ICER and tCER * Mandatory cancellation of AAU, RMU, CER, ERU, ICER and tCER * Art 3.7ter cancellation of AAU, RMU, CER, ERU, ICER and tCER * Ambition increase cancellation of AAU, RMU, CER, ERU, ICER and tCER Kyoto Specific: * Retirement * Transfer to SOP for First External Transfer {panel} {panel:title=ESD AAU Deposit Account} Regular Transfers: * Transfer of AAU, RMU, ERU, CER, ICER and tCER Destruction of Units: * Voluntary cancellation of AAU, RMU, CER, ERU, ICER and tCER * Mandatory cancellation of AAU, RMU, CER, ERU, ICER and tCER * Art 3.7ter cancellation of AAU, RMU, CER, ERU, ICER and tCER * Ambition increase cancellation of AAU, RMU, CER, ERU, ICER and tCER Kyoto Specific: * Retirement * Transfer to SOP for First External Transfer {panel} {panel:title=ESD Central Clearing Account} Regular Transfers: * Transfer of AAU, RMU, ERU, CER, ICER and tCER Kyoto Specific: * Transfer to SOP for First External Transfer {panel}		

Feature	Summary	Description	Test Cases	SAT Status
		{panel:title=ETS AAU Deposit account} Regular Transfers: * Transfer of AAU, RMU, ERU, CER, ICER and tCER Destruction of Units: * Voluntary cancellation of AAU, RMU, CER, ERU, ICER and tCER * Mandatory cancellation of AAU, RMU, CER, ERU, ICER and tCER * Art 3.7ter cancellation of AAU, RMU, CER, ERU, ICER and tCER * Ambition increase cancellation of AAU, RMU, CER, ERU, ICER and tCER Kyoto Specific: * Retirement * Transfer to SOP for First External Transfer {panel} {panel:title=ETS Central Clearing Account for CP2} Regular Transfers: * Transfer of AAU, RMU, ERU, CER, ICER and tCER Kyoto Specific: * Transfer to SOP for First External Transfer {panel} {panel:title=Ambition increase cancellation account} No available transactions {panel} {panel:title=Voluntary cancellation account} No available transactions {panel} {panel:title=Mandatory cancellation account} No available transactions {panel} {panel:title=Art3.7 Cancellation account} No available transactions {panel}		

Feature	Summary	Description	Test Cases	SAT Status
KP2 accounts/transactions setup	Red Screen - ETS AAU Deposit Account		This issue has been resolved in the context of EUCR-2604.	PASSED
Integration of new ECAS client	Upgrade ECAS Client to latest version 4.6.0		Transactions were signed normally using the new client. Login was performed normally.	PASSED
Addition of time zone in transaction lists	UC comment: CET to appear in transaction dates and times	CLIMA confirmed that the time and "CET" (or the server time zone if this is more correct?) should be added in the transaction search screen.	Tested successfully. 1. Connect as NA and navigate to Accounts --> Transactions. 2. Ensure all references to time are in the format DD/MM/YYYY HH:MM plus the server time zone acronym. 3. Ensure this covers: Transaction details page Transaction status history Transaction details page – Request details Transaction PDF 4. Switch to ESD registry; ensure the same holds for: ESD transactions ESD entitlement transactions	PASSED
Disable fulfillment of a deprecated ITL notificationb	Notification Carry-Over - Hide button Fulfill	Notification - Carry Over button "Fulfill" should be invisible	Tested successfully. 1. Connect as EU NA and navigate to Kyoto Protocol --> ITL notifications. 2. Locate a notification of type "unit carry over" which is incomplete. 3. Click on this notification; ensure the button "Fulfill" does not appear.	PASSED
KP2 accounts/transactions setup	View Account - Close/Suspend/etc buttons do not work if user arrives from screen other than account search	View Account - Close/Suspend/etc buttons do not work if user arrives from screen other than account search If a user navigates to Transaction Search, then clicks on an account and then clicks "Suspend" an error 404 appears. The buttons only work if the user navigates from "Account Search" to the account.		PASSED
KP2 accounts/transactions setup	KP2 New notifications should create Cancellation Transaction Request + run 4-0 checks	KP2 New notifications should create Cancellation Transaction Request + run 4-0 checks	1. Connect as NA and locate an ITL notification 2. Request to fulfill the ITL notification 3. Copy the request ID 4. Query the transaction request as follows: select * from transaction_request where request_id =512442 ; 5. Ensure that the column TRANSACTION_TYPE of the record of step 4 is CancellationKyotoUnits.	PASSED
KP2 clearing implementation	ESD Clearing Values - NA can see values for ALL registries	ESD Clearing Values - NA can see values for ALL registries which is not correct. The NA should see only see values for his own registry.	1. Connect as NA 2. Navigate to "ESD accounting and clearing for CP2" of NO, LI 3. Ensure only one row appears, pertaining to the current registry. 4. For any other registry (PT, DE, GR, FR, RO etc.), also this menu entry does appear for NA, SD, SDAgent. 5. For EU-CA, the menu entry appears, and the screen contains all registries.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
KP2 clearing implementation	ETS Clearing Values - SD, SD Agent, NA Auditor can see values for ALL registries	ETS Clearing Values - SD, SD Agent, NA Auditor can see values for ALL registries Those roles should only see values for their own registry only.	1. Connect as NO-NA, NO-SD, NO-SDA 2. Navigate to ETS-->ETS Accounting and Clearing for CP2 3. Ensure only the values for Norway appear. Repeat as LI-NA, LI-SD, LI-SDA	PASSED
KP2 clearing implementation	AAUS_TO_RETIRE (MS-BE)	During the testing of EUCR-2584, we have identified a different approach on the calculation of the parameter AAUS_TO_RETIRE The below scripts include the calculation on the db level select sum (tr_amount),registry_code, status, action from kp2_ent_transaction_log where ent_type_cd = 'AAUS_TO_RETIRE' --and status ='COMPLETED' --and action = 'INCREASE' group by registry_code,registry_code, status, action; select COMP_DATE_EMISSIONS, a.account_id, a.esd_member_state, a.esd_year, d.* from ESD_COMPLIANCE_HISTORY ch, account a, esd_compliance_dates d where ch.account_id = a.account_id --and sysdate >= d.comp_closure_date and a.esd_year = d.comp_year and a.esd_member_state = 'BE'; the attached screen the display info from corresponding screen	Check the calculation of parameter AAUS_TO_RETIRE 1)Login to Union Registry as (be- no) 2)User navigate to menu Kyoto Protocol ---> ESD Accounting and Clearing for CP2 2) Check the value of AAUS_TO_RETIRE 3) Execute transaction (Retirement) for more value on the pararameter AAUS_TO_RETIRE (step 2)	PASSED
KP2 accounts/transactions setup	Notification Transaction Request - Missing APPROVED BY, APPROVER_ROLE	Notification Transaction Request - Missing APPROVED BY, APPROVER_ROLE When creating a transaction request for a notification - column APPROVER_ROLE must contain NATIONAL_ADMINISTRATOR - column APPROVED_BY must contain the NEW permission PERM_NOTIF_FULFIL_APPROVE - add liquibase script to add to all NAs the permission PERM_NOTIF_FULFIL_APPROVE	1. Connect as NA and fulfill an ITL notification. 2. Copy the request ID in the green box and locate the transaction request via the query: select * from transaction_request where request_id =512442 ; 3. Ensure the APPROVED_BY and APPROVER_ROLE contain PERM_NOTIF_FULFIL_APPROVE and NATIONAL_ADMINISTRATOR respectively.	PASSED
KP2 accounts/transactions setup	Notification Transaction Request - Message after returning from ECAS does not contain request id	Notification Transaction Request - Message after returning from ECAS does not contain request id. The green message which is displayed to the user after returned from ECAS does not contain the request id like the other transactions.	1. Connect as NA and navigate to KP -> ITL Notifications 2. Fulfill a notification, and ensure the green message box states: "Your transfer proposal has been recorded and assigned the identifier PT435 . The transaction request with id 512454 has been submitted for approval."	PASSED
KP2 accounts/transactions setup	Transfer to SOP for First External Transfer - Input text field is displayed for CP1 Units	In DEV: # Log-in as NA/GR. # Open holdings of account GR-100-390-0-84. # Propose a "Transfer to SOP for First External Transfer".		PASSED

Feature	Summary	Description	Test Cases	SAT Status
		# Input field should not be displayed for AAUs with Original CP = 1 and Applicable CP = 1 # See attached image "DEV-390-GR (before)". In FAT: # Log-in as NA/EU. # Open holdings of account EU-100-296-0-6. # Propose a "Transfer to SOP for First External Transfer". # Input field should not be displayed for AAUs with Original CP = 1 and Applicable CP = 1 # See attached image "FAT-EU-296 (before)".		
KP2 accounts/transactions setup	EUTL Message 7892 missing description	The transaction PT387 is failed to transfer units from PT-100-10003434-0-31 to EU-100-10003408-0-71 with the following error code & message 7892 (???error.message.check.7892???) see attached file for futher info		PASSED
KP2 accounts/transactions setup	Incoming transactions - suspended workflow	Incoming transactions - suspended workflow When trying to transfer units from JP to PT, the workflow becomes suspended.	Successfully transferred from JP -> PT CERs via transaction: JP9900021 Successfully transferred from JP -> PT ERUs via transaction: JP9900025	PASSED
KP2 accounts/transactions setup	Notification - Net Source Cancellation - Retrieves wrong target account	Notification - Net Source Cancellation - Retrieves wrong target account The code which retrieves the target account does not take into consideration the account.status column	1. Locate a registry with one Net Source Cancellation Account. 2. Navigate to Kyoto Protocol -> Notifications and locate a Net Source Cancellation notification. 3. Update the account of step 1 to account_status = CLOSED. 4. Fulfill the notification of step 2. 5. The error message appears "Your registry is missing an open Net source cancellation account for the current commitment period.Please try again once this issue has been addressed." and the notification cannot be fulfilled. 6. Update the account of step 1 to account_status = CLOSED. 7. Repeat step 4. 8. Ensure the notification is fulfilled normally using the Net Source Cancellation account of step 1. 1. Locate a registry with no Net Source Cancellation Account. 2. Navigate to Kyoto Protocol -> Notifications and locate a Net Source Cancellation notification. 3. Try to fulfill the notification 4. The error message appears "Your registry is missing an open Net source cancellation account for the current commitment period.Please try again once this issue has been addressed." and the notification cannot be fulfilled. 5. Create a request to open a Net Source Cancellation Account but do not approve. 6. Fulfill the notification of step 2 7. The error message appears "Your registry is missing an open Net source cancellation account for the current commitment period.Please try again once this issue has been addressed." and the notification cannot be fulfilled.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			8. Approve the account opening request 9. Fulfill the notification of step 2 10. The acquiring account is filled with the newly opened Net Source Cancellation Account	
KP2 ITL notifications implementation	Red Screen - ITL Notifications search - enter string in field "Identifier"	Red Screen - ITL Notifications search - enter string in field "Identifier"	*Test Case* 1. Log in EU as NA 2. In ITL Notifications, in Identifier field check that no red error screen is produced due to any string type input.(negative, alphanumeric r, mixed, empty, huge number) 3. Check negative input returns: "An ITL notification identifier must be a number > 0 (maximum 12 digits)." 4. Check alphanumeric returns: "Identifier: the value provided must be numeric." 5. Enter huge number 100000000000 - no message 6. Enter valid and existing 10001 id - should get 1 result	PASSED
KP2 ITL notifications implementation	New ITL Notifications CANNOT be Cancellations - ITL error code 2026	New ITL Notifications CANNOT be Cancellations - ITL error code 2026 2026 For all transactions, except for external transfers, the Initiating and Acquiring Registries must be the same. The two new notifications must be converted to External Transfers. Cancellation transaction needs to have the same transferring and acquiring registry.	1. Fulfill an ITL notificaiton of type "Non-submission of Verification Report for a CDM CCS Project" 2. Locate the transaction request pertaining to this and ensure the column TRANSACTION_TYPE is equal to ExternalTransferKyotoUnits. 3. Fulfill an ITL notificaiton of type "Net Reversal of Storage of a CDM CCS Project" 4. Locate the transaction request pertaining to this and ensure the column TRANSACTION_TYPE is equal to ExternalTransferKyotoUnits.	PASSED
KP2 clearing implementation	Initial ETS Clearing Value may be negative	According to current implementation, in "ETS Accounting and Clearing for CP2" screen, CA can set only zero or positive amounts to "Initial ETS Clearing Value". CA should be able to also set a negative amount for "Initial ETS Clearing Value".	*Test case* 1. Log in EU as CA 2. In ETS Clearing value link, update Initial ETS Clearing value with a negative value. 3. Green box should appear "The update request for registry <Registry> has been sent successfully to EUTL." 4. Log in EUTL and check in ETS Clearing value link that negative value exists.	PASSED
KP2 clearing implementation	Clearing Parameted: ESD AAU for Transfers - Do not affect if transfer is towards EU ESD CCA	Value ESD AAU for Transfers - Do not modify if ESD Dep to ESD CCA	Tested successfully Refer to transaction_id = NO115	PASSED
Allow Unenrol & validate from within a user record	Allow Unenrol & validate from within a user record	We are currently tidying up some validated and enrolled users who no longer have any active account associations. Before finally selecting un-enrol we are going into each user record so we can double check that we are about to un-enrol the correct URID. However, once we have checked all the tabs we then have to go back out to the User Search in order to be able to Un-enrol. It would be useful to have a note of the URID & current status at the top of each tab and then the Un-enrol and Validate buttons available next to the Edit button as well as them being available from the search list as at present.	*Test Case 1 - Check new table data* 1. Log in EU as NA 2. In Users, click one. 3. There should be three new columns: - URID - User Name - User Status 4. Check the above also when navigating on tabs: - Personal Details	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			- Business Details - Administration roles - Accounts *Test Case 2 - Check buttons according to user status* 1. Log in IT, as NA and check that for a registered user, there are two buttons available: Un-enroll and Validate. 2. Log in FI, as NA and check that for a validated and enrolled user, only Un-enroll button appears 3. Log in GR, as NA and check for a Unenrollment-Pending and Unenrolled user, there are no Un-enroll and Validate buttons available. *Test Case 3 - Check Back button functionality* 1. Log in GR, as NA and for a enrolled user, click Unenroll button. 2. Click Cancel 3. Redirection should present User Details page, not User Search. 4. Repeat above 3 steps for Validate button in DE registry, for a registered user *Test Case 4 - Regression* 1. In "User search" screen make sure that all search fields, filtering and paging combinations work as expected. 2. Use Case UC-UA_030: Request Un-Enrolment 3. Use Case UC-UA_012: Validate Use	
Popup-up window on surrender	Popup-up window on surrender	Imported on: 16/12/2014 \\ From: [https://webgate.ec.europa.eu/etsis/browse/ETS-6575]	*Test Case 1 - Propose as AR in account with ACTIVE and ENROLLED AAR* 1. Login as AR: (FR) 2. Propose a Surrender of Allowance of an OHA(10002564) which has at least one active and enrolled AAR → Message B should be displayed after proposal : Your surrender proposal has been recorded and assigned the identifier {0}. The transaction request {1} has been submitted for approval. One of the additional authorized representatives ({2}) needs to approve this task with id {1} via his task list. *Test Case 2 - Propose as AR in account with NOT ACTIVE and ENROLLED AAR* 1. Login as AR: (FR) 2. Propose a Surrender of Allowance of an OHA(10002564) which has no active(suspend the AAR as NA) and enrolled AAR → Message C should be displayed after proposal: Your surrender proposal has been recorded and assigned the identifier {0}. The transaction request {1} has been submitted for approval. The other authorized representative ({2}) needs to approve this task with id {1} via his task list.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			Test Case 3 - Propose as NA in account with ACTIVE and ENROLLED AAR 1. Login as NA (FR) 2. Propose a Surrender of Allowance of an OHA(10002564) which has at least one active and enrolled AAR → Message A should be displayed after proposal: Your surrender proposal has been recorded and assigned the identifier {0}.The transaction request with id {1} has been submitted for approval. *Test Case 4 - Propose as NA in account with NOT ACTIVE and ENROLLED AAR* 1. Login as NA (FR) 2. Propose a Surrender of Allowance of an OHA(10002564) which has no active(suspend the AAR as NA) and enrolled AAR → Message A should be displayed after proposal. Your surrender proposal has been recorded and assigned the identifier {0}.The transaction request with id {1} has been submitted for approval.	
Update Installation Details task is enriched with more information	More information needed on Update Installation Details task needs more information	Imported on: 16/12/2014 \\ From: [https://webgate.ec.europa.eu/etsis/browse/ETS-705]	*Test Case 1 - New installation info* 1. Log in PT as NA 2. Update Installation tab info for PT 632- Propose the task 3. Before approving it check request data panel. 4. There should be the new "installation - Current Details" tab *Test Case 2 - New aircraft operator info* 1. Log in PT as NA 2. Update aircraft operator tab info for PT 10000696- Propose the task 3. Before approving it check request data panel. 4. There should be the new "Aircraft operator - Current Details" tab *Test Case 3 - Check older tasks* 1. Log in PT as NA 2. In Task List, History check tasks with request ids (383611 for installation and 226777 for aircraft operator) 3. Request panel info should be include the new additions	PASSED
Screen detail correction when adding AR/AAR.	Message repeated (when emails do not match)		*Test Case* 1. Log in PT as NA 2. Navigate to "Additional Authorised Representative Addition" page in order to add another AAR, for an open account 3. In "E-mail Address" and "Confirm E-mail Address "fields insert different character sequences. 4. Screen should resemble the attached one (Only one yellow highlighting appears in first field and the message is: "Confirm E-mail Address")	PASSED

Feature	Summary	Description	Test Cases	SAT Status
Screen design issue when proposing transactions with CER/ERU units	Transfer of KP units - wrong balances		1. Navigate to an account with multiple CER or ERU units of multiple projects of CP1 and CP2 (in our test: 643 of Portugal). 2. Click on "Holdings" tab. 3. Ensure CER and ERU holdings appear in multiple lines, one line per project. 4. Click on "Propose a transaction" 5. Click on "Transfer of AAU, RMU, ERU, CER, ICER and tCER" 6. In the next screen ensure that CER and ERU units appear grouped per CP; the units are not grouped per project; the projects appear in the drop-down list "Project".	PASSED
Account statement screen shows CP1 units as eligible if contained in white list; this is now fixed	Account statement screen shows CP1 units as eligible if contained in white list	After 31/3/2015, all CER/ERU_from_AAU of CP1 are ineligible regardless of ICH list. This does not happen in FAT-->account statement screen, where the units are shown eligible if they are in FAT e.g. PT 643 May 2018	Repeat the following for CER, ERU from AAU units *Test Case 1 - Transfer units not belonging to White List* 1. Log in RO as NA 2. Transfer units not belonging to white list from account 666 to 667 (both are PHA) 3. In Transactions, transaction id => Transaction PDF, check that units are ineligible. Repeat for CER *Test Case 2 - Transfer units belonging to White List* 1. Log in RO as NA 2. For account 666, insert a project into ICH Lists (Positive) 3. Repeat the transfer as above, result should be the same - ineligible units *Test Case 3 - Check that only CER/ERU_FROM_AAU have eligible/ineligible flag in Approve Transaction Request* 1. Log in PT as NA. Use account 643 as transferring, and 10000956 as acquiring. 2. Propose transaction for CER and ERU_FROM_AAU units and a third for RMU 3. Check in Approve Transaction Request that in first and second case, there are ineligible and eligible units, while in third, units contain no flag	PASSED
Unrecoverable error proposing a transaction in a trading account with a validated AAR; this is now fixed	Unrecoverable error proposing a transaction in a trading account with a validated AAR	An unrecoverable error occurs when a transaction to a non-trusted account is proposed in a trading account that has an AAR in validated status. The error occurs after clicking on the "confirm" button in the transaction page.	*Test Case - Unrecoverable error* 1. Log in GR as NA 2. In account 10040(Trading) add AAR GR9000000000005 which must be Validated 3. Perform a CER unit transaction from PT 643 to GR 10040. 4. No red screen should appear at Confirm button *Test Case - Regression tests* 1. Log in RO as NA. For RO 655, make sure an exchange transaction is completed. 2. Log in PT as NA. For PT 643, perform an external transaction to JP-100-100. 3. Log in EU as CA, and in EU ETS, Pre-Allocation link, perform a transfer. Approve as another CA and check completion of transaction.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
Change in "Preferred Language" for AH is now submitted without triggering a workflow for approval	Change in "Preferred Language" for AH	Dear service desk Right now when an account holder wants to change Preferred Language in the registry we as NA has to approve this in the task list. That should not be something we should approve. This change has no influence on our work and it is not in any matter a security issue nor something we need documentation for. So I will suggest that this kind of change can be performed by the account representatives without a NA has to approve the task. Kind regards Anita	*Test Case 1 - Update only language* 1. Log in GR as NA 2. In account 383 update only Preferred language field 3. "Preferred language has been successfully set to XX" message should be returned to user and hitting Back should reveal the update. *Test Case 2 - Update postcode and language* 1. Log in GR as NA 2. In account 383 update Postcode field and Preferred Language field. 3. "Your request to update account holder information has been submitted under identifier xxxxx." and "Preferred language has been successfully set to XX." messages should appear 4. Clicking Back should show the change on language. 5. Approve the request and confirm the Postcode change *Test Case 3 - Update only postcode* Repeat above test without dealing with the language. Expected result should exclude any language change. *Test Case 4 - Submit without any edit* 1. Log in GR as NA 2. In account 383 don't update anything and click "Submit" 3. "Please modify some data before proceeding." message should appear in yellow font. *Test Case 5 - Edit only identity document data* 1. Log in GR as NA 2. In account 383 update identity document data and click "Submit" 3. "Your request to update account holder information has been submitted under identifier XXXXX" should be returned and clicking "Back" reveals the identity document change. *Test Case 6 - Regression* Make sure not another request can occur if else is pending Changing the preferred language is forbidden if else request is pending	PASSED
Include information on the AAR approval task as to whether or not the transfer is to a Trusted Account	Include information on the AAR approval task as to whether or not the transfer is to a Trusted Account	Imported on: 16/12/2014 \\ From: [https://webgate.ec.europa.eu/etsis/browse/SDB-1556]	*Test Case 1 - Message when transaction is Transfer Of Allowances* 1. Log in PT as NA 2. For a Trading account, propose a Transfer Of Allowances by writing the full account in appropriate fields. (EU-100-634-0-62) 3. In approval screen, appropriate message must exist: "The acquiring account is outside of the Trusted Account List" Repeat 2 more times, for cases of selecting acquiring account from Trusted accounts, both tabs, with expected message: "The acquiring account is on the Trusted Account List"	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			Test Case 2 - Message when transaction is Transfer of AAU, RMU, ERU, CER, ICER and tCER Repeat first test cases Expected messages are the same as above. *Test Case 3 - Account other than trading* 1. Log in registry as NA 2. Initiate a transaction from 643 to EU-100-637-0-47 3. In approval screen no message (test case 1 - step 3) must exist *Test Case 4 - History tab* 1. Log in registry as NA 2. Propose and approve previous transactions for any account. (Trading and not) 3. In History tab, no message should exist	
If an AR has appointed a verifier to his account and the verifier account is being closed before the appointment has been confirmed the AR cannot appoint a new verifier	If an AR has appointed a verifier to his account and the verifier account is being closed before the appointment has been confirmed the AR cannot appoint a new verifier	I wanted to check what happens when a verifier account is being closed. Result: the verifier gets removed from all accounts where he was appointed verifier and the AR of all these account have to appoint new verifiers. However in one case the appointment was still pending. And here the appointment is not automatically rejected but the account still has the screen showing: "There is already a pending appointment request with id: 19216". This basically means that the account is stuck as no new verifier can be appointed and the only verifier cannot reject any longer as he no longer can no longer access the system.	1. Locate an OHA and request addition of a verifier by clicking "Appoint Verifier" in the Verifier tab. Note the request ID mentioned in the green confirmation window. 2. Repeat for an AOHA, requesting addition of the same verifier. Note the request ID mentioned in the green confirmation window. 3. Close and approve closing of the verifier account. 4. Connect as NA and navigate to tasklist -> History. 5. Search for the request IDs noted in steps 1 and 2 and ensure they have outcome REJECTED.	PASSED
Cancelled tasks appear in the active task list; this is now fixed	Cancelled tasks appear in the active task list	Imported on: 26/01/2016 From: https://webgate.ec.europa.eu/etsis/browse/SDB-2814	*Test Case 1 - Change request to not OPEN and check it does not exist in Exclusive/General Task List* 1. Execute query like: select * from task_item where request_id = 481587; update task_item set IS_OPEN = 0 where request_id = 481587 2. Log in registry and in task list check request 481587 is non existing. *Test Case 2 - Additional testing* (Log in GB registry) 1. Create an account under Account Holder A (account name: SDB-2814_Test) 2. Create an account under Account Holder B (account name: SDB-2814_Test_C) 3. Log in as an AR of "SDB-2814_Test" account and request the addition of "SDB-2814_Test_C" account to your trusted account list 4. Close "SDB-2814_Test_C" account 5. Log in again as the other AR of Account A. 6. On the Trusted Account page you can no longer see the request to add B to the TAL 7. Go to the Task List. You should not see the TAL addition request in a cancelled state. It should not exist at all.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
Login with a 14-digits GSM number was not allowed; this is now fixed.	CLONE - Login is not possible due to mobile phone number length	Dear colleagues, the login to the ACC environment is not possible, as the following error occurs. KR Günter	*Test Case* - Set as GSM number to a user in UserData.xml in ECAS; the user is NA - Set it as MOBILE_PHONE_NUMBER in USER_DETAILS record corresponding to a USER corresponding to the user of step [1]. - Log in normally. - Propose a transaction (use acquiring account PT-100-643-10) and reject it using the GSM. - Click "Edit Personal Details" and propose to change the mobile phone number and add one more digit. - Submit the update request. - Reject the update request. Repeat test case for: +29821 +48510608586111 +298213772 +436648031631380 +43123456789123456789123456789 +431234567891234567891234567891234567891	PASSED
Searching users via wildcard in firstname/lastname is implemented.	CLONE - Using wildcard in user search is not possible anymore	If I search for a user in the acceptance environment by entering part of his first or last name with an asterisk, I receive the attached error "A name may contain maximum 140 characters, dots and dashes". It is important to be able to find a user by entering part of his name.	*Test case* - Log in EU as NA - In Administration tab, in Users, in First and Last name fields, try: - Last name: nadmin* => 2 results - First name: *enafname => 1 result - First name: *adm* => 3 results - First name: *se*, Last name: *change => 1 result - First name: Esd, Last name: CENTRAL => 1 result - First name: Esd, Last name: cEntral => 1 result - Last name: *en*ral => 1 result	PASSED
Update of error messages when pending account management requests exist	List of pending requests per account - (update error messages)	Scenario: Sometimes you need to know whether a request is pending for an account. Problem: This should be done via (the task list #151 and/or) the list of account requests (#047), but you can not search on this page for a specific account or account range. Possible solution: Add the account name and ID in the task list and list of account requests and allow filtering on both.	*Test Case 1 - Personal details update there is pending request* - Log in RO as NA in one browser and as nadmin1 in another browser concurrently. - Navigate NA and nadmin1 in Administration -> User Management, in the personal details of the same user. - Propose a personal detail update - Check green confirmation message - As nadmin1, repeat the process. Ensure the following message appears: "Only one personal details update request can be active for one user at any given time. There is a personal details update request attached to this user which has not yet been completed. Its Request ID is 512890. You can check your task list for who is able to confirm or to reject this task. You may also be able to reject the update request task by yourself, if no longer needed." A Jira issue was created (EUCR-2934) to implement this issue in a future release for the following	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			other requests: - Addition of AAR (also for ESD) - Replacement of AR (also for ESD) - Replacement of AAR (also for ESD) - Removal of AR (also for ESD) - Removal of AAR (also for ESD) - Account closure	
Clicking on URID link in Personal Details task does not let you return; this is now fixed	Clicking on URID link in Personal Details task does not let you return	If you submit a "Personal Details Update" task there is a hyperlink to the full user details. If you click this in order to bring up the users contact details you cannot then get back to the Task other than pressing the browser Back button.	1. Connect as NA and navigate to Administration -> Users 2. Click on a user's URID 3. Submit a modification of personal details 4. Navigate to tasklist -> exclusive tab and click on the top task 5. Click on the URID and ensure a pop-up window appears with the user's personal details, business details and account in three tabs corresponding to the clicked URID. As a regression ensure the user's personal details, business details and business details update function normally.	PASSED
If an ITL request for reconciliation, for a country, does not arrive on EUCR/EUTL the second request from ITL will generate issues on both systems because a reconciliation snapshot does not exist; this is now fixed	If an ITL request for reconciliation, for a country, does not arrive on EUCR/EUTL the second request from ITL will generate issues on both systems because a reconciliation snapshot does not exist.	https://webgate.ec.europa.eu/etsis/browse/-1026 Please find below the concluded approach: {quote}a) If the first request for reconciliation does not exists in our databases {quote} EUTL and EUCR will ensure that in such a case no exception will be thrown. The message will be stored in message log table. No response will be send back to ITL. {quote} b) In the second case, if the first request for reconciliation exists in our databases and the reconciliation snapshot is not created yet {quote} In cases where the message fails to be processed due to missing snapshot data, both in EUTL and EUCR it will be retried as defined by the queues' retry policy and if no success, will finally end up to an error queue, as to be implemented in the scope of -1028, -1029. An email can be send as to be implemented in the scope of -1030, -1031. The queue retry policy for reconciliations in both systems to be analysed and re-configured as needed. These details will be finalized during design and implementation. {quote}c) In the third case, and last one, first request for reconciliation exists in our databases and the reconciliation snapshot was created{quote}	Issue tested with JUnit: ReconciliationProvideTotalsTest	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		Proceed as normal		
CP1 RMU LULUCF displayed in "Conversion A" and "Conversion B" proposal screens; this is now fixed	REGRESSION - CP1 RMU LULUCF displayed in "Conversion A" and "Conversion B" proposal screens	Given I'm logged in as NA And there is PHA account with CP1 RMU (Forest management (FM)) and CP2 RMU (Wetland, Drainage and Rewetting (WDR)) When I propose Conversion A Then on transaction proposal screen I can choose one of above LULUCFs In this case only LULUCFs related to CP2 RMU units should be displayed. When user tries to propose Conversion A using LULUCF that is not related to CP2 RMU units, transaction is not proposed but there is no error displayed (nothing happens).	1. Locate an account with RMUs. 2. Set all its RMUs to orig CP1 and appl CP1. 3. Ensure the Conversion A is not possible to be submitted for this account. 4. Set all its RMUs to orig CP2 and appl CP2. 5. Ensure the Conversion A is possible to be submitted for this account. 6. Set some RMUs to orig CP1 and appl CP1 and some RMUs to orig CP2 and appl CP2. 7. Ensure the Conversion A is possible to be submitted only for the CP2 RMU units for this account (with originating country code the current MS). The following queries were users for these updates. <pre>select * from unit_block where account_id in (select account_id from account where identifier = 644) and unit_type = 'RMU' order by last_modified_time desc;</pre> <pre>update unit_block set original_period = 2, applicable_period = 2 where ID in (480, 479, 478, 477);</pre>	PASSED
Screen design issue for CP2 AAU units.	KP2 Demo Comment: CP2 AAU units has no value in eligibility column on transaction proposal screen (inconsistent with other units e.g. CP1 AAU)	CP2 AAU units has no value in eligibility column on transaction proposal screen (inconsistent with other units e.g. CP1 AAU)	*Test Case* 1. Log in as NA 2. For an account which contains AAUs, propose a transaction of type "Transfer of AAU, RMU, ERU, CER, ICER and tCER" 3. Ensure the "Eligibility" column is blank in the transaction proposal screen, for all AAUs	PASSED
No country code in projects for Transfer to SOP for Conversion; this is now fixed	No country code in projects for Transfer to SOP for Conversion	When choosing the transaction Transfer to SOP for Conversion, the drop down list of projects does not contain the country code. This is inconsistent with conversion A, JI Projects and other places where projects are listed. Projects should have the country code everywhere.	*Test Case* 1. Log in PT as NA 2. Click on Transfer to SOP for Conversion transaction for account 643 3. In dropdown list, country code should be visible (PT302 (TRACK_1))	PASSED
Change of message in footer for conversions	Conversion B of quantity below the mandatory one is allowed by EUCR	1. Project GRXXX has a conversion limit of 100 under track 2 2. Make a conversion A of 2. 3. Try a transfer to SOP. Any quantity other than 2 is forbidden.	1. Initiate a Conversion B for a Track_2 project 2. Ensure below the account holdings, the footer states: The mandatory quantity for this transaction is:	PASSED

Feature	Summary	Description	Test Cases	SAT Status
	(Implementation + Documentation)	4. Make a transfer to SOP of 2. 5. Conversion Entitlement = 98 6. Try a Conversion B Try 20 units. EUCR allows me to propose and approve. It is only ITL check 5065: For the second conversion of AAUs or RMUs for an applicable commitment period for a given track 2 JI project, the quantity to be converted must be equal to the conversion limit for that project less any quantity of ERUs converted under the project during previous conversion cycles and less the quantity of ERUs converted under the associated "conversion A" transaction and transferred to the SOP Adaptation Fund account for that project. that stops the transaction. The behaviour should be consistent. The code below from chapter 29.6.2 of UCS.13 Holdings and Transfers is not implemented. <<new_code>> For Track_2 projects: The quantity must be equal to: Limit – Sum(Completed Conversion A of this Project) – Sum(Completed Conversion B of this Project)	Project Limit - Converted Quantity (including quantity transferred to SOP) = ..	
AAU units are not properly marked on the transaction breakdown screen; this is now fixed	AAU units are not properly marked on the transaction breakdown screen	When the transaction exceeds maximum number of unit blocks, EUCR displays a screen suggesting how transactions should be broken into smaller pieces. In hat screen AAU units are not market neither Subject to SOP nor Not subject o SOP.	1. Locate an account with CP2 AAU units; some are subject to SOP and some are not subject to SOP. 2. Mark all AAU CP2 unit blocks of this account as reserved except 10 unit blocks. This is done with a query such as: <pre>update unit_block set reserved_for_tx = 'PT999' where ID in (561758, 562287, 562286, 505242);</pre> 3. Set the configuration parameter itlIntegrationSettings.maxTransactionUnitBlocks = 5 and restart the application server. 4. Propose a transfer to another registry of all available CP2 AAU units of this account. 5. Afetr ECAS confirmation, EUCR presents an alternative transaction screen where AAU units are characterised as either "Subject to SOP" or "Not Subject to SOP".	PASSED
Screen design issue for account holdings	Please align the unit holdings panel in the holdings tab to the left and set it to 30% of the width of the screen	Please align the unit holdings panel in the holdings tab implemented for ETS-5098 to the left and set it to 30% of the width of the screen. As per mail discussion on 10/06.	*Test Case* 1. Log in GR as NA 2. For an account check in Holdings tab, that view resembles the one in attached file. 3. First table with columns Unit Type and Balance should be placed left and set to 30% of the screen width	PASSED

Feature	Summary	Description	Test Cases	SAT Status
A blank issuance limit produced an error; this is now fixed.	NumberFormatException in Issuance Limits	- Go to EU ac CA - Go to Kyoto protocol / issuance limits - Remove value from Issuance Limit field - press [Submit] button	*Test Case 1: Test empty values* - Go to EU as CA - Go to Kyoto protocol / issuance limits - Remove value from one or more Issuance Limit fields - press [Submit] button 5. Should get message; "Unit quantities may only be positive integers." *Test Case 2 - Regression: Test negative values* Repeat TC1 with negative value and with the same expected message. *Test Case 3 - Regression: Test alphabetic values* Repeat TC1 with value equal to "sddf" and with the same expected message. *Test Case 4 - Regression: Test non alpha-numeric values* Repeat TC1 with value equal to "+-*/" and with the same expected message. *Test Case 5 - Regression: Test numeric values less than issued* - Repeat TC1 with value positive integer, less than Issued quantity. - The error message appears "You cannot enter an issuance limit (2) less than the issued quantity (28247)." - Submission is cancelled *Test Case 6 - Regression: Test numeric values more than issued* - Repeat TC1 with value positive integer, more than Issued quantity. - The green message appears "The KP issuance limits have been updated." - The values are saved.	PASSED
Change in screen message	Correct Emissions says Enter Emissions in confirmation screen	The label in the emissions confirmation screen will be modified to "Correct emissions".	- Locate an OHA with emissions. - Submit an emissions update request - Ensure the confirmation screen title is "Correct Emissions" Repeat for AOHA.	PASSED
Upload of auction table error; this is now fixed	Auction Table Error while uploading XML file - after Confirmation Popup	This problem might be related to other -747, and -750, but looks like RedBox error is happening in different moment - after confirming Popup window. See movie attached. Generally while uploading xml file (attached) there is displayed Popup confirmation window, with proper recognising if on xml there is ADD/UPDATE/DELETE and the xml details are also displayed in datatable on popup window. then while clicking Confirm button I got the redBox error. Part of log file : EU/registry_EU.log is attached as well: Since in -747 the problem was with wrong property "id" instead of "identifier", now in this xml this property is correct, but the problem is in different place. After digging little more on this problem: looks like in EU registry there are 3 Auction Delivery Accounts: 5000187, 5000440 and 5001185. And whenever I upload xml file with giving as auction-delivery-account those first two accounts, then there are no errors. If I will use account 5001185 then this error is happening after displaying popup confirmation	*Test Case 1 - Upload xml with wrong DTYPE of account* - Log in EU as CA - In DB change DTYPE for account identifier 10101 to ineligible value. - Set status to ACTIVE - Upload xml in Auction tables tab, and click Confirm - Should get error: 7760: The account identifier is not that of an Auction Delivery Account. *Test Case 2 - Upload xml with status other than ACTIVE for account* - Log in EU as CA - In DB change STATUS column for account identifier 10101 to "REQUESTED" value.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			3. Set DTYPE to "AuctionDeliveryAccount" 4. Upload xml in Auction tables tab, and click Confirm 5. Should get error: 80209: The account is closed: {0} *Test Case 3 - Upload xml with correct DTYPE and status ACTIVE for account* 1. Log in EU as CA 2. In DB change STATUS column for account identifier 10101 to "ACTIVE" value. 3. Set DTYPE to "AuctionDeliveryAccount" 4. Upload xml in Auction tables tab, and click Confirm 5. Should get success message: "The auction table has been imported."	
Email is created at user validation by NA.	No email sent to registered user after his manual validation by NA	When the new user (status: REGISTERED) is manually validated by NA there is no emails sent to this user informing that his enrolment was accepted. In case of automatic validation (e.g. when REGISTERED user is added as AR to account) Send Enrolment Key task is created and after its approval "Enrolment Confirmation" email is sent. Same email should be sent when user is validate manually.	1. Connect as NA and navigate to Administration->Users 2. Filter for status = "Registered" 3. Locate a user and click his URID 4. Click the button "Validate" 5. The green message box "Confirmation: The users have been validated." appears. 6. Ensure the following email is created and sent to the user "Dear <<first name last name>>, Your enrolment in the <<registry acronym>> registry has been accepted. An enrolment key will be sent to you soon. When you receive this key please click on the link "Enter your enrolment key" above menu and enter the key to fully activate your access to the registry. Sincerely yours, The registry administrator Do not reply to this email address as the mailbox is not monitored. Please contact your national administration should you require further assistance."	PASSED
Problem with final EUTL response status for Entitlement Transactions in ESD; this is now fixed	Problem with final EUTL response status for Entitlement Transactions in ESD	There is situation in ESD (EUCR-DEV, 6.4.4.1) where after performing Entitlement Transaction EUTL final response stuck in "EUTL Approved", but when looking for this transaction in Entitlement Transactions the response is 4-Completed, which mean this transaction was finished and finally the Entitlement is added on the Acquiring account. At the attached picture , you can see that for regular ESD-AEA transfer final EUTL response is "Approved". So why on Entitlement Transactions this response is "EUTL Approved" which mean: "Not entirely completed" On Unisystems FAT EUCR we see also that some transactions stay in this status. See screenshot.	1. Connect to ESD and propose an ESD Entitlement transaction 2. Approve the transaction request 3. Ensure the transaction is completed. 4. Perform the following query and ensure the column STATE of the last record has value APPROVED: select * from request_state where request_id = <<the request ID created at step 1>> order by 1; Tested in FAT with transaction ED220.	PASSED
Unenrollment confirmation page displays empty table of users; this is now fixed	Unenrollment confirmation page displays empty table of users	Unenrollment confirmation page displays empty table of users. See attachment	*Test Case 1* 1. Log in GR as NA 2. For user GR108411640474, start Unenrollment procedure 3. Appearing screen should contain URID, Name and Login columns in User tab	PASSED

Feature	Summary	Description	Test Cases	SAT Status
Add all new transactions in drop down of related screens v2	Add all new transactions in drop down of related screens v2	Add all new transactions in drop down of related screens v2	1. Connect to ETS, choose English language and navigate to Accounts -> Transactions 2. Ensure the Transaction Type drop-down box contains the following transaction types spelled as shown below: 01-00 Issue Of AAUs and RMUs 01-22 Issuance of allowance in Art. 63a registry 01-24 Issuance into Art. 63a pool 01-30 Issuance Aviation Allowance 01-31 Issuance General Allowance 01-32 Decoupling 01-33 Issuance Aviation Allowances Banking 01-34 Issuance General Allowances Banking 01-51 Issuance CPO 01-72 Issuance of Allowances for Exchange 02-00 Conversion 02-56 Conversion of AAUs or RMUs into ERUs (Conversion A) 02-57 Conversion of AAUs or RMUs into ERUs (Conversion B) 03-00 External Transfer Kyoto Units 03-02 Surrender Kyoto Units 03-12 ESD Transfer of 03-16 ESD Return of KP units 03-21 External transfer CPO 03-44 ESD Reversal KP 03-47 Transfer to SOP Adaptation Fund for First External Transfer of AAUs 03-49 Transfer to SOP for Conversion 03-75 Set Aside 03-82 Reversal Surrender Kyoto Units 04-00 Cancellation Kyoto Units 04-02 Surrender Kyoto Units Non KP Registry 04-03 Retirement CPO 04-22 Retirement for Article 63a registries 04-26 Cancellation in Art. 63a registry 04-45 Article 3.7ter Cancellation 04-46 Ambition Increase Cancellation 04-48 Mandatory Cancellation 04-91 Cancellation Against Deletion 05-00 Retirement 05-01 Retirement of surrendered former EUA 05-19 Retirement of ESD Used Units 06-00 Replacement 07-00 Carry Over 07-38 Carry Over of ERUs or CERs	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			07-39 Carry Over of AAUs 08-00 Expiry Date Change 10-00 Internal Transfer 10-01 Cancellation CP0 10-02 Surrender Allowances 10-04 Surrender Kyoto Units (AOHA) 10-104 Reversal Cancellation 10-124 Reversal Cancellation Of Surrender Non Kyoto Units 10-135 Reversal Allocation Aviation Allowances 10-136 Reversal Allocation General Allowances 10-16 ESD Return of KP units (Internal) 10-171 Reversal of Transfer Out of Kyoto Units for Exchange 10-172 Reversal of Receipt of Allowances for Exchange 10-189 Reversal Administrative Deletion 10-190 Reversal Deletion 10-20 Administrative Transfer 10-22 Transfer between Art. 63a registries 10-24 Transfer to Art. 63a gateway 10-25 Transfer from Art. 63a pool 10-26 Transfer from Art. 63a gateway 10-272 Reversal of Issuance of Allowances for Exchange 10-33 Deletion Aviation Allowances Banking 10-34 Deletion General Allowances Banking 10-35 Allocation Aviation Allowances 10-36 Allocation General Allowances 10-37 Auction Delivery 10-41 Cancellation and replacement 10-52 Issuance of former EUA 10-53 Allocation of former EUA 10-54 Issuance of force-majeure allowance 10-55 Correction To Allowances 10-61 Conversion of surrendered former EUA 10-71 Transfer Out of Kyoto Units for Exchange 10-72 Receipt of Allowances for Exchange 10-82 Reversal Surrender Allowances 10-84 Reversal Surrender Kyoto Units (AOHA) 10-86 Return of Excess Allocation 10-89 Administrative Deletion 10-90 Deletion 10-92 Corrective transaction for reversal 10-93 Corrective transaction for reversal	

Feature	Summary	Description	Test Cases	SAT Status
JiProjects datatable doesn't refresh after confirmation dialog close; this is now fixed	JiProjects datatable doesn't refresh after confirmation dialog close	In JiProjects section, after clicking "Confirm" in deletion dialog, table appears not refreshed.	UC_CV_015_TC_01: DELETE PROJECT Refer to Test Case of EUCR-2884	PASSED
ESD Account Search - Forgets filters; this is now fixed	ESD Account Search - Forgets filters	ESD Account Search - Forgets filters when going from one page to another. If year 2015 is selected and the user tries to go to the next screen, all accounts are retrieved.	*Test Case 1 - Year filtering and sorting* 1. Log in ESD as NA 2. In Accounts link, select a Year (2013) and click Search 3. Note the resulting number 4. Click Next (arrow sign button). (Repeat with dropdown row selections: 10,20,50) 5. Rows found sign should be equal to step's 3, and Year equal to 2013. 6. Clicking on columns headers(Identifier, Member State, Year, Balance, Status) should result in the appearance of the same original data of step 2 *Test Case 2 - XML Export* 1. Log in ESD as NA 2. In Accounts link, select a Year (2013) and click Search 3. Click Search and Export 4. XML and UI info should be the same *Test Case 3 - View Details, Suspend and Close actions* 1. Log in ESD as NA 2. In Accounts link, select a Year (2013) and click Search 3. Close and suspend two different accounts. 4. Re-enter screen and check the update for these accounts. 5. Test View Details function.	PASSED
ESD Entitlements Screen - Forgets filters when going to next page; this is now fixed	ESD Entitlements Screen - Forgets filters when going to next page	ESD Entitlements Screen - Forgets filters generally	*Test Case - Year filtering and sorting* 1. Log in ESD as NA 2. In ESD Transactions link, select a Year(2013) and click Search 3. Note the resulting number 4. Click Next (arrow sign button). (Repeat with dropdown row selections: 10,20,50) 5. Rows found sign should be equal to step's 3, and Year equal to 2013. 6. Clicking on columns headers(MS, Year, Entitlement Limit 1, Entitlement Limit 2, Remaining Limit 1, Remaining Limit 2) should result in the appearance of the same original data of step 2 *Test Case 2 - XML Export* 1. Log in ESD as NA 2. In ESD Transactions link, select a Year (2013) and click Search 3. Click Search and Export 4. XML and UI info should be the same	PASSED

Feature	Summary	Description	Test Cases	SAT Status
After JI project deletion, the screen should be refreshed; this is now fixed	After JI project deletion, the screen should be refreshed		*Test Case 1* 1. Log in EU as NA 2. In JI Projects, check a project 3. In another browser, include the project identifier in a conversion A (EU 296). 4. Complete the proposal 5. In first browser, click Delete and Confirm. 6. Below message should be returned and project shouldn't be deleted.: 80402: Cannot delete project EUXXX 80408: Project EUXXX participates in a pending or completed conversion cycle 7. Re-enter JI Projects and click Search 8. Reserved project does not have a selection box available. 9. As another NA, reject the task (in step 3) 10. Re-enter JI Projects, click Search 11. Previously reserved project now has a selection box available. *Test Case 2* 1. Log in EU as NA 2. Check a project in JI Projects, which is not included in any Conversion cycle (e.g. identifier = 445) 3. Click Delete and Confirm. 4. Project should be deleted in DB and UI and page refreshes	PASSED
Missing page reference in Account Delegation Edition Confirmation; this is now fixed	Missing page reference in Account Delegation Edition Confirmation	Steps to reproduce A. Delegate Account In "Account Main", press "Delegate". In "Account Delegation - Select External Platform", select an external platform and press "Next". In "Account Delegation", add a representative and press "Submit". In "Account Delegation Confirmation", press "Back". B. Edit Account Delegation In "Account Main", press "Edit Account Delegation". In "Account Delegation Edition", *_remove all representatives*_ and press "Submit". In "Account Delegation Edition Confirmation", the page number does not exist, as in the attached image.	*Test Case* 1. Log in PT, as NA 2. For PT 632, in "Account Main", press "Delegate". 3. In "Account Delegation - Select External Platform", select an external platform and press "Next". 4. In "Account Delegation", add a representative and press "Submit". 5. In "Account Delegation Confirmation", press "Back". 6. In "Account Main", press "Edit Account Delegation". 7. In "Account Delegation Edition", remove all representatives and press "Submit". 8. In "Account Delegation Edition Confirmation", the page number must exist. as in attached image but with non empty field.	PASSED
Cleanup Script - Add retirement, cancellation	Cleanup Script - Add retirement, cancellation	Cleanup Script - Add retirement, cancellation, esd all all translations should clear KP2_ENT_TRANSACTION_LOG	Repeat the following for retirement, ambition increase cancellation, art3.7 cancellation, mandatory cancellation, voluntary cancellation: 1. Submit a transaction request but do not sign it in ECAS 2. Wait 30 minutes 3. Ensure the latest transaction request for this account is REJECTED via the query: select state, tr.* from transaction_request tr, request_state rs	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			where transferring_account_id = <<the id of the used account>> and tr.request_state_id = rs.request_state_id order by datetime desc;	
"No records found" in un-enrollment confirmation screen	"No records found" in un-enrolment confirmation screen	After proposing un-enrolment of user, his details are not shown. Instead a message "No records found" appears on screen.	*Test Case 1* 1. Log in GR as NA 2. For user GR108411640474, start Unenrollment procedure 3. Appearing screen should contain URID, Name and Login columns in User tab	PASSED
Check 7371 message is added	Check 7371 message	Check 7371 was added in EUTL 8.0.2, but was not included in 7.51 EUTL checks xls. Added in 7.52 checks xls Message to be added in EUCR	1. Locate a terminated transaction in EUCR by navigating to Accounts->Transactions->Filter for status = Terminated. 2. Update the response code so that 7371 response code is simulated for this transaction. This can be done as follows: select * from transactions where transaction_identifier = 'MT192'; select * from transaction_response where transaction_id = 690491; update transaction_response set response_code = 7371 where transaction_id = 690491; 3. Navigate to the transaction's response codes and ensure the code 7371 appears, with details: "7371: Transfers to the CDM SOP Adaptation Fund Account can only be of type "Transfer to SOP for Conversion" or "Transfer to SOP for first External Transfer of AAUs".	PASSED
Parent issue to control all changes in AR/AAR actions on accounts	New logic for performing actions in "Authorised Representatives" and "Additional Authorised Representatives" tabs	This parent ticket groups all individual issues which are related to the new mechanism and logic for rendering action buttons in "Authorised Representatives" and "Additional Authorised Representatives" tabs. These issues should be tested simultaneously. The latest analysis document may be found [here] https://sc136.unisystems.gr:4443/jira/secure/attachment/19864/EUCR-495%20-%20Changes%20in%20user%20rights%20on%20accounts_impl_v6.docx .		PASSED
Checks as per when account management buttons appear	EUCR-2917 Apply mechanism for AR / AAR actions in ESD pages	"Authorised Representatives" and "Additional Authorised Representatives" tabs should be aligned between ETS and ESD. The new mechanism should be applied to ESD as well.	Tested successfully. The cases (see EUCR-495) when each button is rendered is aligned across ETS and ESD.	PASSED
Checks as per when account management buttons work after clicking	EUCR-2917 Post-condition checks for all AR/AAR action buttons in ESD, ETS	After pressing the buttons in AR/AAR tabs, exactly the same checks should be executed, on the post-condition level, according to the new mechanism defined in EUCR-495. It applies to both ESD, ETS and the following buttons: * Remove * Replace * Update * Suspend * Restore	Tested successfully. The related buttons are rendered aligned to the access & user status (see EUCR-495)	PASSED
Allow replacement of unenrolled user	EUCR-2917 Not possible to replace a suspended AR	Imported on: 16/12/2014 \\ From: [https://webgate.ec.europa.eu/etsis/browse/ETS-6577] According to the document on SDB-2139 it should be possible to replace a SUSPENDED AR irrespective of their enrolment statue. This is not possible. The only buttons available (assuming there are at least 2 other ARs) are to REMOVE or RESTORE. If there were only two reps on the account then the only option is to Restore.	*Test Case 1* 1. Log in EU as NA 2. For account 383, suspend authorized representative GR9000000000014, confirm, and replace with another. 3. New AR should exist in the place of the old.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		This means that replacing someone in this state becomes a 2 stage process. The usual scenario is because we have found out that someone has left the company so, if there are only 2 ARs on the account, we suspend the one who has left. the account holder usually wants to replace them but all they can do is add. The removal has to be done as a second change. It ought to be done in one go, exactly as if the AR is not suspended.		
Checks actions on account	EUCR-2917 Changes in user rights on accounts	This is from CMB of 03/12/2013	Tested successfully - all cases are described on the document (EUCR-495 - Changes in user rights on accounts). Please refer to tab SDB-2139 in this document.	PASSED
Checks special cases of actions on accounts	EUCR-2917 CLONE - Removal / Replacement / Update / Suspension of ARs and AARs according to the status	We would like to make a comprehensive review of the actions that can be taken towards ARs and AARs taking into consideration their roles and the number of ARs and AARs per account. In the table attached to the issue it's the behaviour we propose so that we are in line with the legislation and we have a common understanding of the issue. Here are the guidelines: - The ARs in Unenrollment Pending should be treated like the ones in Enrolled Status - View Only ARs never count when deciding on MinNrAR - The Unenrolled users are as good as "dead" since this action is irreversible and they won't have access to the account - When removing an unenrolled so that the account remains with one AR in (Enrolled OR Unenrollment Pending OR Verified) you should get a Warning message explaining that this action is allowed, but you are under the threshold of Minimum Number of ARs, you will not be able to make a certain variety of actions and you are advised to appoint another AR as soon as possible	Please refer to the attachment. Results of Tests (I Tests on user Removal) 1a) The button (Remove") is not rendered on the tab "AR" & "AAR" of the account. (" EU-100-10000504-0-41" with Status "Suspended") , (ETS - Union Registry PT) . Also, the other distinct buttons are not rendered (Replace, Update, Suspend, Restore). 1b) The button (Remove") is not rendered on the tab "AR" & "AAR" of account ("EU-100-10001866-0-21" with Status "Suspended") , (ESD - Union Registry BE) Also, the other distinct buttons are not rendered (Replace, Update, Suspend, Restore). 2a) The button (Remove") is not rendered on the tab "AR" & "AAR" of the account. (" EU-100-10000666-0-7" with Status "Transfer Pending") , (ETS - Union Registry PT) Also, the other distinct buttons are not rendered (Replace, Update, Suspend, Restore). 2b) The button (Remove") is not rendered on the tab "AR" & "AAR" of the account. ("EU-100-10001866-0-21" with Status "Transfer Pending"- on the db layer level - on the real time condition, it is not possible any account to change of status "Transfer pending" , (ESD - Union Registry PT) Also, the other distinct buttons are not rendered (Replace, Update, Suspend, Restore). 3a) The button (Remove") is not rendered on the tab "AR" & "AAR" of the account. (EU-100-633-0-67 with Status "CLOSED" (ETS - Union Registry PT) Also, the other distinct buttons are not rendered (Replace, Update, Suspend, Restore). 3b) The t button (Remove") is not rendered on the tab "AR" & "AAR" of the account. EU-100-10001862-0-41 with Status "CLOSED" (EDS - Union Registry BE) Also, the other distinct buttons are not rendered (Replace, Update, Suspend, Restore). 4 a) The button ("Remove") is not rendered on the tab "AR" & "AAR" of the account. EU-100-10000505-0-36 with Status "Open" (ETS - Union Registry: PT) . We have executed a request to update installation information (Installation Id :10869) has been submitted under identifier 512810. Also, the buttons "Replace" & "Restore are not rendered for the following reasons	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			Replace : the pending request is set to "Installation UpdateRequest" Restore : the suspend button is active 5 a) The button ("Remove") is not rendered on the tab "AR" & "AAR" of the account. EU-100-10000510-0-11 with Status "Blocked " (ETS - Union Registry: PT) - We have executed a request to update installation information (Installation Id :10874) that has been submitted under identifier 512817. Also, the buttons "Replace" & "Restore are not rendered. 5b) The button ("Remove") is not rendered on the tab "AR" of the account for the specific user ED999999911357 with Status "Blocked" (ESD - Union Registry CY) - Update the AR information - (Account HolderRepresentativeUpdateRequest - Refers to specific AR Also, the buttons "Replace" & "Restore are rendered for the other users The specific scenario is repeated on the account EU-100-10001866-0-21 (with same status) for "AccountClosureRequest" with the following results: 1) After the submission of the request, the status of account is set to "Suspended" 2) The distinct buttons are not rendered on the tabs "ESD ARs" & "ESD AARs" 6 a) The button "Replace" is not rendered on the account (PT-121-636-0-50 status : Open) because the number of AR =2. b) You have only rendered the button "Remove" on the View Only Authorised Representative . The specific scenario has been executed on the PT Registry for account (643) and AARs(3) PT9000000000004, PT9000000000003, PT483028062779 with access status = ACTIVE user status = ENROLLED and only view View Only Authorised Representative the last AR The other AARs have rendered the buttons "Replace, Update, Suspend" c) You have rendered the button "Remove" on any ARs. The specific scenario has been executed on the PT Registry for account (643) and AARs(3) PT9000000000004, PT9000000000003, PT483028062779 with access status = ACTIVE user status = ENROLLED (we suggest to execute the following sql command: update accesses set role_id=10115 where access_id=64769; in order to check immediately the behaviour of api) d) You have rendered the button "Remove" on the suspended user (PT483028062779).	

Feature	Summary	Description	Test Cases	SAT Status
			The specific scenario has been executed on the PT Registry for account (636) and the 3 related ARs(3) PT900000000004 (with access status = ACTIVE,user status = ENROLLED), PT900000000003 (with access status =ACTIVE,user status = ENROLLED), PT483028062779 (with access status =SUSPENDED, user status = ENROLLED). ----- II. Tests on rejecting a removal request A) Removal of a user SUSPENDED on an account Test Scenario Registry : PT Account : 636 Authorised Representative: PT483028062779 ----> Request_id : 512891. (as as nadmin1) 1) Submit a removal of a suspended user (PT483028062779 Access State : "Suspended") 2) Reject the removal request (512891) as na 3) The (RO636468991414) is set to Access State : "Suspended" on the account (636) B) Removal of a user ACTIVE on an account Test Scenario Registry : RO Account : 655 Authorised Representative: RO636468991414 ----> Request_id : 512889. (as na) --- 1. Submit a removal of active user (AR : RO636468991414 Access State : "Suspended") 2. Reject the removal request (512889) as nadmin1 3. The user (RO636468991414) is set to Access State : "Active" on the account (655)	
Checks actions on users after sequences of actions	EUCR-2917 AR cannot be updated after remove/update/re-add sequence	see: [https://webgate.ec.europa.eu/etsis/browse/-/646]	Tested successfully 1) A) ECUR a) Login to Union Registry (PT) as na b) Navigate to menu Account --> Accountw and searches the Account (643) c) Click on the "tab" AR" and select the button "Update" for the AR1 (PT900000000003 with status "Suspended)) d) Change the values on the fields " Main Phone Number" from 1 --> 4 & Alternate Phone Number on the AR1 (Suspended User) Results : (a) A request to update business details has been submitted under identifier 512828. 1B) ESD - Select the account(EU-100-10001863-0-36 Union Registry : BE Status : Open) - Update the AR information (id ED999999911318 , values on the corresponding Telephone 1 +32774483745 ----> +32774483747 Telephone 2	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			+32123456785 --- > +32123456788 - Submit the request Results Your request to update business details has been submitted under identifier 512835. 1 c) EUTL FOR EUCR 1) Connect to EUTL 2) Navigate to menu Account Mgt 3) Search the specific account (enter start number = 643 and enter number = 643) before submit the above request from EUCR 4) The specific screen presented the specific account 5) Click on the link "Detail" 6) The system presented the relations ARs with the specific account 7) After the execution of the step d , the related columns are updated immediately. 1 d) EUTL for ESD account (EU-100-10001863-0-36) - Executed the above steps with select account number 10001863 before 1 b Result : The system presented the same values on the specific fields with ESD - Executed the steps of scenarios 1b Result : After the execution of the scenario , the related columns of the AR are updated immediately. 2) The button "Update" is not rendered if there is a pending request for removal or replacement for the AR/AAR. 3. In this case, the NA user should not have been able to execute any action on the AR information because the related buttons are not rendered. 4) In this case, the specific validation has already executed on the previous stage ("Submitted request" - see step 3) in order to avoid the creation duplicate request on the same account. The above modifications have been implemented with same approach in both ETS and ESD pages related to ARs/AARs 5) Case 3 : In this case, NA2 is not be able to initiate the account representative update request since AR1 has already been removed from the account. Case 4 : In this case, the removal request is approved before the approval of the update details request.	
Unit Block Search - AAUs do not appear	Unit Block Search - AAUs do not appear correctly	Unit block search - column SOP, screen and CSV does not show correctly "Not subject to SOP" units.	Perform the following query in EUCR: select max(unit_type), SOP, original_period, applicable_period	PASSED

Feature	Summary	Description	Test Cases	SAT Status
correctly in the screen & exported CSV file	in the screen & exported CSV file	Both screen and CSV - AAUs with original period = 1 are shown with BLANK in column SOP - AAUs with original period = 2 are shown with "Subject to SOP" or "Not Subject to SOP" in column SOP depending on flag in Database	from unit_block where unit_type = 'AAU' group by sop, original_period, applicable_period; Ensure in the returned results: * Records of OrigCP1 and ApplCP1 -> have NULL SOP value * Records of OrigCP1 and ApplCP2 -> have NULL SOP value * Records of OrigCP2 and ApplCP2 -> have 1 or 0 SOP value	
The content and structure of the CP2 SEF file is modified so that it can be imported by SEF Tool v6.3.1	CP2 SEF XML format is not compatible with ITL	1. Export CP2 SEF XML from EUCR 2. Import into SEF Report Tool 3. Import CP2 SEF XML from ITL for the same registry. 4. Run the comparison function in the Report Tool. 5. Comparison function does not work. *For inclusion in V8.0.x* The XML exported from the EUCR for CP2 SEF still uses the CP1 years in table 5b to 5e. These need to be updated to CP2 format i.e. the years should run from 2013 to 2023.	1. Export CP2 SEF XML from EUCR 2. Import into SEF Report Tool v.6.3.1 3. The import completes successfully. Note: The SEF report tool does not validate data correctly for CP2. This has been communicated and is followed-up in EUCR-2573.	PASSED
CP2 SEF file contains the new LULUCF activity.	New LULUCF activity - SEF Support	New LULUCF activity - SEF Support	The new LULUCF activity WETLAND_DRAINAGE_AND_REWETTING is referenced in table 2a of SEF report under the section 'Article 3.3 and 3.4 issuance or cancellation'. Test Case 1: Under additions, there should be reported the RMUs issued with the IssueOfAAUsAndRMUs transaction regarding the WETLAND_DRAINAGE_AND_REWETTING LULUCF activity. Test Case 2: Under subtractions, there should be reported the units that are cancelled because of a NET_SOURCE_CANCELLATION notification referencing the WETLAND_DRAINAGE_AND_REWETTING LULUCF activity.	PASSED
Script which corrects CP1 CER/ERU_FROM_AAU balances in account statements needs to be created and set ineligible those units if transaction is after 31/3/2015.	Script which corrects CP1 CER/ERU_FROM_AAU in account statements	Script which corrects CP1 CER/ERU_FROM_AAU balances in account statements needs to be created and set ineligible those units if transaction is after 31/3/2015. The balances of CER/ERU_FROM_AAU were not calculated correctly if the transaction included CP1 units of those types.	1. Execute the CP1 acct. statement correction script Locate an account which has had CP1 CER or CP1 ERU units before 1/4/2015 which are in a positive ICH list. This can be located by querying tmp_fix_accst_log_cp1 where the COMMENTS column begins with "CER FINISHED OK". 2. Browse the holdings of this account and ensure it contains CER units which are in a positive list. 3. Browse the incoming transactions into this account by searching via Accounts -> Transactions and providing the account ID 4. Locate the incoming transaction transferring the specific CERs into this account	PASSED

Feature	Summary	Description	Test Cases	SAT Status
The balances of CER/ERU_FROM_AAU were not calculated correctly if the transaction included CP1 units of those types.			5. Generate an account statement including the located transaction date. Ensure the transferred unit blocks are characterised as INELIGIBLE in the generated account statement.	
EUCR Contacts link from home page to be amended	EUCR Contacts link	EUCR Contacts link should direct here: http://ec.europa.eu/clima/contact/index_en.htm . Currently it directs here: http://ec.europa.eu/dgs/clima/contact_en.htm	Tested successfully. *Test Case 1:ETS, EU registry* 1. Log in EU registry, as NA 2. Click Contact link 3. A pop-up window appears leading to http://ec.europa.eu/clima/contact/index_en.htm *Test Case 2: ESD* Repeat Test Case 1 in ESD as ESD-CA. *Test Case 3:ETS, MS registry* Repeat Test Case 1 as French NA: In this case the destination should be: http://ec.europa.eu/clima/policies/ets/registry/links_en.htm	PASSED
Under certain circumstances, after signature, the system ignores the user's language and reverts to English. This is now fixed.	Messages in wrong language after signature	If the "Preferred language" in the "Edit your personal details" section is "German" then the messages are in English (see attachment). If "Preferred language" is "English" then the messages are in German. It should be the other way around.	The purpose of these test cases is to verify that the language of the messages, after an ECAS signature, always matches the language on the top-right drop-down element. _+Note for Test Cases 1,2,3+: We have used Firefox for proposal and Chrome for approval._ *Test Case 1 - External Transfer - Both users have preferred language English* 1. Make sure menu's language is MT 2. Propose a Transfer Of Allowances from EU-100-754-0-44 (MT) to EU-100-655-0-54 3. Green box's text should be in MT. 4. Change language to English, approve the request, green box's text should be in English. *Test Case 2 - Roles and Permissions change* 1. In NL, make sure proposal user (na) has preferred language "Nederland's" and registry's language is English. 2. Propose a roles and permissions change. 3. Green box's text should be in English. 4. Make sure that approval user (nadmin1) has preferred language "English" 5. Approve the request, green box's text should be in English. *Test Case 3 - TAL addition* 1. In MT, make sure proposal user (na) has preferred language "Malta" and registry's language is	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			English. 2. Propose a TAL addition of EU-100-756-0-34 to MT-121-751-0-62. 3. Green box's text should be in English. 4. Make sure that approval user (nadmin1) has preferred language "English" 5. Approve the request, green box's text should be in English. *Test Case 4 - ESD Transaction* 1. Propose an ESD Transaction 2. Green box should be in English language. 3. Approve the request, green box's text should be in English. _+Note for Test Cases 5,6,7+: We have used Chrome for proposal and Firefox for approval._ *Test Case 5 - Personal details update* 1. In NL, make sure proposal user (nadmin1) has preferred language "English" and registry's language is Nederland's. 2. Propose a personal details update for na's urid 3. Green box should be in NL language. 4. Approval does not present a green box. *Test Case 6 - Administration update* 1. In NL, make sure proposal user (nadmin1) has preferred language "English" and registry's language is Nederland's. 2. Propose an administration role update for a urid (add role of national administrator) 3. Green box should be in NL language. 4. Approval does not present a green box. *Test Case 7 - TAL deletion* 1. In RO, make sure proposal user (na) has preferred language "English" and registry's language is Romanian. 2. Propose a TAL deletion. 3. Green box should be in Romanian language. 4. Approve the request after ensuring that menu's language is English. 5. Green box should be in English. *Test Case 8 - Unit Block suspension/restoration - Firefox* 1. In RO and Firefox, make sure proposal user (nadmin1) has preferred language "Romanian" and registry's language is English 2. Propose a block suspension/restoration. 3. Green box should be in Romanian language. 4. Approve the request after ensuring that menu's language is English.	

Feature	Summary	Description	Test Cases	SAT Status
			5. Green box should be in English. *Additional testing* Above tests should be repeated after changing Firefox's default language to e.g. German The purpose of this additional testing is to make sure that the browser's default language does not affect the language of the messages, after an ECASE signature. In order to add a language to Firefox, please go to {{Options}} & rarr; {{Content}} & rarr; {{Languages}} & rarr; {{Choose...}} & rarr; {{Select a language to add}} & rarr; {{Add}}, and make sure this language is on the top.	
Hide an obsolete ITL notification type.	ITL Notifications - if carry-over notifications have been removed, they should not be displayed in the type (search)	If carry-over notifications have been removed, they should not be displayed in the type (search). Please check picture attached.	1. Connect as NA of a MS and navigate to its registry home page. 2. Navigate to Kyoto Protocol -> ITL notifications 3. Ensure that no notification name in the Type drop-down list contains the term "carry-over:"	PASSED
Configuration of emails of new KP2 transactions.	Transaction emails with new transaction types have !	The automatic emails that are sent from the EUCR about transactions have a ! after the transaction type. This seems to occur to new transaction types. The ! should not be displayed Please see the emails below. Thanks. – From: CLIMA-EU-ETS-REGISTRY-ACC@ec.europa.eu CLIMA-EU-ETS-REGISTRY-ACC@ec.europa.eu Sent: 8 de julho de 2016 09:20 To: jrs@bluefocus.pt Subject: Transaction Outcome Notification The transaction PT30 of type transactionType_CarryOver_CER_ERU_FROM_AAU between: PT-100-16246 and: PT-100-16246 Involving: Unit Type: CER, Unit Amount: 110 ...has ended with a status Terminated. Do not reply to this email address as the mailbox is not monitored. Please contact your national administration should you require further assistance. Their contact details can be found here: http://ec.europa.eu/clima/policies/ets/registry/links_en.htm – From: CLIMA-EU-ETS-REGISTRY-ACC@ec.europa.eu CLIMA-EU-ETS-REGISTRY-ACC@ec.europa.eu Sent: 8 de julho de 2016 09:21 To: jrs@bluefocus.pt Subject: Transaction Outcome Notification The transaction PT32 of type transactionType_AmbitionIncreaseCancellation between: PT-100-16246	1. Connect as NA and perform an AAU Transfer; approve it as another NA. 2. Ensure the transaction is completed. 3. Receive the email generated by the transaction. 4. Ensure the first line of the email is: The transaction <<>> of type 07-39 Carry Over of AAUs between: 5. Retrieve the last email.properties file and ensure the following excerpt is contained within the file: transactionType_ConversionA = 02-56 Conversion of AAUs or RMUs into ERUs (Conversion A) transactionType_ConversionB = 02-57 Conversion of AAUs or RMUs into ERUs (Conversion B) transactionType_TransferToSOPforFirstExtTransferAAU = 03-47 Transfer to SOP Adaptation Fund for First External Transfer of AAUs transactionType_TransferToSOPforConversion = 03-49 Transfer to SOP for Conversion transactionType_Art37Cancellation = 04-45 Article 3.7ter Cancellation transactionType_AmbitionIncreaseCancellation = 04-46 Ambition Increase Cancellation transactionType_MandatoryCancellation = 04-48 Mandatory Cancellation transactionType_EsdRetirementKPUUsed = 05-19 Retirement of ESD Used Units transactionType_CarryOver_CER_ERU_FROM_AAU = 07-38 Carry Over of ERUs or CERs transactionType_CarryOver_AAU = 07-39 Carry Over of AAUs transactionType_ReversalAdminDeletion = 10-189 Reversal Administrative Deletion transactionType_AdminTransfer = 10-20 Administrative Transfer transactionType_AuctionDelivery = 10-37 Auction Delivery transactionType_AdminDeletion = 10-89 Administrative Deletion	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		and: PT-280-17005 Involving: Unit Type: AAU, Unit Amount: 800 ...has ended with a status Terminated. Do not reply to this email address as the mailbox is not monitored. Please contact your national administration should you require further assistance. Their contact details can be found here: http://ec.europa.eu/clima/policies/ets/registry/links_en.htm		
Correction in display of KP2 entitlements.	KP Entitlements format	KP Entitlements should be separated by thousands = commas preferably as used elsewhere in UR. This is applicable in all KP2 entitlements	1. Connect as CA and navigate to EU registry (note: the same screen is used for all registries, but EU contains the sum of all other registries so the figures are bigger). 2. Navigate to KP --> KP2 Entitlements 3. Click on each of the following and ensure presented quantities appear with a thousands separator: * Transfer to PPSR Entitlements * First External Transfer Of AAUs Entitlements * Conversions Entitlements * Carry-Over Entitlements (CER/ERU from AAU) * Carry-Over Quantities (AAU)	PASSED
Some special characters are allowed for users' first name and last name.	Existing LAST NAME in personal details fails validation	First name and last name validation will be changed so that to allow 4 Special Characters, ROUND OPENING BRACKET, ROUND CLOSING BRACKET, - HYPHEN and . DOT and numbers. In addition, ESAPI validation will be used.	Tested via the test cases EUCR-3000, EUCR-3001, EUCR-3002, EUCR-3003, EUCR-3004.	PASSED
For Conversion B for Track_2 projects: A validation rule to be triggered if qty <> mandatory qty	Conversion B validation check for mandatory quantity for Track_2 projects	For Conversion B for Track_2 projects: A validation rule to be triggered if qty <> mandatory qty	Tested successfully. Test Scenario : Conversion of AAUs or RMUs to ERUs after the Transfer to SOP (Conversion B) for Track_02 Project *TC_01 : Submit Request with entered quantity value which is less than the limit* 1) Login to EUCR (Union Registry : MT as na) 2) Select a PHA (Party Holding Account: MT-100-10003336-0-41) 3) Click on the "Holding: tab 4) Click on the "Propose transaction" button 5) Choose one Project (PT661) of Track 2 with limit = 980 6) Enter AAU quantity to be converted equal to 800 (< limit) 7) Click on the "Confirm" button 8) The EUCR displays the error rule 82110 ----- *TC 02: Entered quantity is more than limit* Repeat the steps 6-7 with quantity equal to 981 (> limit) The EUCR displays the error rule 82110, 82106	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			----- *TC_03 : Enter quantity value is equal to limit* Repeat the steps 6-7 with quantity equal to 980 (= limit) The transaction request is submitted normally. Approve the transaction as another NA. The transaction is completed successfully (MT257).	
After logout from ECAS user is redirected to EUCR instance instead of URL	CLONE - After logout from ECAS user is redirected to EUCR instance instead of URL	1. As NA log in with token 2. Log out from EUCR but not from ECAS 3. log in with GSM 4. Log out from ECAS Description When privileged user logged out from EUCR and not from ECAS and then tried o log in with GSM an error is displayed. User is advised to log out from ECAS and then log in again. In such flow user is redirected to EUCR instance instead to EUCR URL. Same issue is in ACC with 7.0.6. This seems to be a bit related to -1006 but neither TEST nor ACC run in Development mode.	The issue has been tested successfully. For the needs of this issue, the following configuration parameters will need to be modified, as stored in ecas-config-eucr-ui.properties: <pre>edu.yale.its.tp.cas.client.filter.serverName= eu.cec.digit.ecas.client.filter.serverProtocol=http eu.cec.digit.ecas.client.filter.serverPort= eu.cec.digit.ecas.client.filter.serverSSLPort=</pre> These are used as destination when returning from ECAS, at both logging in and logging out of EUCR. Choose a user configured in TMS as 'G' so he connects via GSM. *A. Login and logout of EUCR* - A1. Set the serverName parameter to europa.eu/ - A2. Navigate to EUCR and click "Login" - A3. Authenticate via GSM in ECAS and click "Login" - A4. Ensure the next page is an empty page, in server europa.eu - A5. Change manually the current URL so that it points to the EUCR server name - A6. The normal page of EUCR appears and user is logged in normally - A7. Click link "Logout" in EUCR - A8. Click "Logout" from ECAS - A9. Ensure the next page is an empty page, in server europa.eu - A10. Change manually the current URL and point to the EUCR server name - A11. The normal page of EUCR appears and user is logged out normally Repeat the above steps using as serverName the appropriate EUCR server address. The user logs in and logs out normally. *B. Attempt to log in EUCR via Tokens and GSM* Repeat steps A1-A7. - B1. Navigate again to EUCR and click "Login" *without having logged out from ECAS* - B2. Authenticate in ECAS via Tokens.	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			B3. Ensure the next page is an empty page, in server europa.eu B4. Change manually the current URL and point to the EUCR server name B5. The error page specifying the user is logged in with both GSM and Tokens appears. B6. User clicks "Logout" B7. User navigates to ECAS. B8. User clicks logout from ECAS. B9. Ensure the next page is an empty page, in server europa.eu B10. Change manually the current URL and point to the EUCR server name B11. User is navigated to EUCR, being logged off. Repeat the above steps using as serverName the appropriate EUCR server address. The user logs in and logs out normally.	
Roles and Permission checkboxes are disabled after unfinished signature (add to clear-down job)	Roles and Permission checkboxes are disabled after unfinished signature (add to clear-down job)	Propose update of permission in Roles and Permission Stop when comes to providing password and mobile number in ECAS signature. Go back to EUCR and check state of checkbox for the permission There is error in Roles and Permission table when proposing updated of some permission (switching checkbox) and signature is not finished, process of signature breaks in the moment of providing password and mobile number. When from this moment user will click back button and enter again in EUCR to Roles And Permission page, that proposed checkbox is disabled. There are no either pending tasks for Approval R&P Changes. There might be many disabled checkboxes since I can try propose updates many times, and stop before signature.	1. Connect as NA and navigate to Administration -> Roles and Permissions 2. Propose a change in permissions and confirm 3. Do not sign via ECAS; do not approve as another NA 4. Ensure that the modified checkboxes are disabled Get the most recent permissions update request and check its status is SUBMITTED_NOT_YET_APPROVED: <pre>select * from role_perm_conf_request order by request_id desc; select * from request_state where request_id = <<request_id>>;</pre> 5. Wait for 35 minutes 6. Ensure the modified checkboxes are again enabled. Re-execute the query of step 4 and ensure the status is REJECTED and another status record for USER_REJECTED.	PASSED
PHA to AAU Account transfer terminated with 7031 (KP2 accounts rules). This is now fixed.	PHA to AAU Account transfer terminated with 7031 (KP2 accounts rules)	Implement the rules found in the latest attachment of issue -1339	The transaction rules have been tested, and logged in the comments of issue EUTL-425 in Jira.	PASSED
Display "before" and "after" values on emissions confirmation screen	Display "before" and "after" values on emissions confirmation screen	it would be useful for a user to display "before" and "after" values on emissions confirmation screen	Tested successfully. *Test Scenario : Update emission value* *TC_01 Submit the request* 1) Login to EUCR (Union Registry PT as na) 2) Select an OHA account (10000485) with emissions (tab Compliance) and specific year (2014) 3) Click on the corresponding image The Union Registry display the Correct Emissions page with the current values for emissions as has already defined by the user 4) Update the value on the field 'CO2 Emissions' from 6 to 8	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			5) Enter the value on the field 'N2O Emissions' (2) 6) Enter the value on the field 'PFC Emissions' (4) 7) Click on the button "Confirm" 8) The EUCR displays the confirmation screen with values of the above fields before & after .Also, the emissions have been recorded and an approval request created under reference: 513244. You will be notified when the emissions are verified. *TC_02 Approval the request* 1) Login to EUCR (Union Registry PT as nadmin1) 2) Search the specific request from the Task list 3) The EUCR displays the confirmation screen 'Approve emissions' with the corresponding info on the emission before & after 4) Click on the button "Approval" 5) Check the value of submission for the specific year 6) The EUCR displays the updated values on the specific fields	
Wrong label in "Enter Emissions" confirmation screen	Wrong label in "Enter Emissions" confirmation screen	Steps: * Log-in as NA/GR. * Search for account 10148 (OHA). * Open "Compliance" tab. * Propose emissions for a year. * In the "Enter Emissions" screen, enter a value and press "Confirm". * The panel title has changed to "Correct Emissions". The panel title should remain "Enter Emissions". The same happens for an Aircraft Operator.	*Test Case 1* 1.Log-in as NA/GR. 2. Search for account OHA 3. Open "Compliance" tab. 4. Propose emissions for a year. 5. In the "Enter Emissions" screen, enter a value and press "Confirm". The panel title should remain "Enter Emissions". *Test Case 2* Repeat test case 1 for an Aircraft Operator.	PASSED
Filter ESD transaction list by default on Last Updated Date (most recent ones at the top)	Filter ESD transaction list by default on Last Updated Date (most recent ones at the top)	1. Log in to ESD 2. Navigate to ESD--> ESD Transactions and click "Search" 2. Ensure the records presented are initially sorted descending on the column "*Last Updated*"	1. Log in to ESD 2. Navigate to ESD--> ESD Transactions and click "Search" 2. Ensure the records presented are initially sorted descending on the column "Last Updated"	PASSED
Cannot perform mandatory cancellation from OHA account	Cannot perform mandatory cancellation from OHA account	1. Log in to registry 2. Go to OHA account that has KP CP2 units 3. Propose Mandatory cancellation transaction	Tested successfully. Test Scenario 1: Mandatory Cancellation from OHA Account EU-100-10000505-0-36 1. Log in to registry (PT as na) 2. Go to OHA account (EU-100-10000505-0-36 (PT)) that has KP CP2 units 3. Propose Mandatory cancellation transaction (04-48 Mandatory Cancellation)	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		When proposing Mandatory cancellation transaction from OHA account, following error is displayed "80733: The transferring and acquiring registry must be the same". User is not allowed to propose this transaction. Also there seems to be some text missing in the bottom right corner. It says ?cancelPage_MANDATORY_CANCELLATION?	4. The system displays the following message 'Your cancellation proposal has been recorded and assigned the identifier EU1243338. The transaction request with id 513627 has been submitted for approval.' 5. Logout from specific role (na) 6. Login in to registry (as nadmin1) 7. Go to the task list 8. Select the specific request 9. Click on the button "Approve" The status of the transaction is set to "Completed" and the units (2) are transferring to EU-250-10003432-2-50 (EU) Test Scenario 2: Mandatory Cancellation from PHA Account 1. Log in to registry (PT as na) 2. Navigate to a Party Holding Account (account 643) and propose a mandatory cancellation 3. Approve the transaction as another NA 4. The transaction is completed. (Transaction PT518 in Portugal)	
Correct the voluntary cancellation destination accounts	Voluntary cancellation destination accounts	1. Go to BG registry 2. Suspend all Voluntary Cancellation accounts 3. Go to PHA account with KP units 4. Check is you can propose Voluntary Cancellation Description When voluntary cancellation transaction is performed units are sent to EU Voluntary cancellation account (pending confirmation from Andrei MUNGIU this is expected behaviour). However when system decides if this transaction type is available to the user - cancellation accounts specific to the registry are analysed. Example: When in Bulgaria all cancellation accounts are suspended user cannot propose Voluntary Cancellation transaction because there is no such link transaction proposal screen.	A. Voluntary cancellation for PHA cannot start if MS cancellation accounts are suspended 1. Set to suspended the Finnish Voluntary Cancellation accounts 2. Navigate to a PHA of Finland; voluntary cancellation is not available 3. Navigate to an OHA of Finland; voluntary cancellation is available B. Voluntary cancellation for OHA cannot start if EU cancellation accounts are suspended 1. Set to suspended the EU Voluntary Cancellation accounts 2. Navigate to a PHA of Finland; voluntary cancellation is available 3. Navigate to an OHA of Finland; voluntary cancellation is not available C. Voluntary cancellation of MS PHA is the MS voluntary cancellation account 1. Propose a voluntary cancellation for Finnish PHA. 2. Ensure the acquiring account is Finnish voluntary cancellation account D. Voluntary cancellation of MS OHA is the EU voluntary cancellation account 1. Propose a voluntary cancellation for Finnish OHA. 2. Ensure the acquiring account is EU voluntary cancellation account Note 1: Voluntary cancellation accounts can be located via the query: select * from account where registry_code = 'EU' and kyoto_account_type = 'VOLUNTARY_CANCELLATION_ACCOUNT' and commitment_period_code in (1,2); Note 2: Via the located account_id values, the accounts can be set to OPEN or SUSPENDED update account set account_status = 'OPEN'	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			where account_id in (301, 10221);	
Repeated error message when updating account holder data. This is now fixed.	Repeated error message when updating account holder data	1. Log in to registry as NA 2. Go to account that has account holder data task pending 3. Try to update account holder data 4. Check if error message is displayed once Description When there is account holder update task pending and user tries to update account holder data again, error message is displayed: Unfortunately error message is repeated twice.	Tested successfully. *Test case 1* 1. Log in to registry as NA , RO registry. 2. Go to account 666 that has account holder data task pending 3. Try to update account holder data 4. Check if error message is displayed once *Test case 2 - Account holder that is Company* 1. Log in to registry as NA , EU registry. 2. Go to account 285 that has account holder data task pending 3. Try to update account holder data 4. Check if error message is displayed once *Test case 3 - Account holder that is plain* 1. Log in to registry as NA , GR registry. 2. Go to account 10220 that has account holder data task pending 3. Try to update account holder data 4. Check if error message is displayed once	PASSED
Installation / Aircraft Operator links in account list don't respect users permission. This is now fixed.	Installation / Aircraft Operator links in account list don't respect users permission	1. Log in to registry as user who has no permission to see Installation tab 2. Go to accounts and search for OHA accounts 3. Click on installation link Description If the user doesn't have permission to so Installation or Aircraft Operator tab in account view, there should be no links pointing to such tabs in account list. Currently the links are visible and when clicked they point no "next available" tab in accounts view (the tab that user has no access to is not displayed)	1. Locate a user who is only AR in a registry. This can be confirmed with the query: select distinct ro.* from roles ro , accesses acc, profile pro where ro.role_id = acc.role_id and acc.profile_id = pro.profile_id and pro.URID = '<<>>'; 2. Retrieve the permissions of the user in the specific registry: select distinct u.urid, u.state as user_state, a.state as access_state, r.role_name as role, pe.perm_key as permission from users u join profile p on p.urid = u.urid join accesses a on a.profile_id = p.profile_id join roles r on a.role_id = r.role_id join role_permission rp on r.role_id = rp.role_id join permissions pe on pe.permission_id = rp.permission_id where u.urid = '<<>>';	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			3. Ensure the permission PERM_ACC_INST_SEE is included in the list of permissions. 4. Search for OHA accounts and ensure the installation links are visible. 5. Delete the role_permission pertaining to PERM_ACC_INST_SEE via the query: delete from role_permission where role_id = <<>> and permission_id = <<>>; 6. Search for OHA accounts and ensure the installation links are not visible. Repeat for AOHA accounts and PERM_ACC_AIR_SEE.	
Correction of the criteria via which accounts are selected in "Export KP units in KP accounts" functionality	Inconsistencies in "Export KP units in KP accounts" functionality	1. Log in to registry 2. Go to Unit blocks 3. Export unit blocks using "Export KP units in KP accounts" button Description There are 2 inconsistencies in "Export KP units in KP accounts" functionality. 1. Button name says "KP accounts" but since in requirements it was stated that this should cover 100 account type - ETS accounts are included as well. Is this expected behaviour? 2. Requirement says that AAU, CER and ERU unit should be exported. Currently systems exports AAU, CER and ERU_FROM_AAU, ERU_FROM_RMU and RMU units. Is this expected behaviour? What about LCERs and TCERs?	A.1. Connect as NA in Romanian Registry A.2. Navigate to Administration -> Unit Blocks and click on "Export KP units" A.3. Ensure holdings of accounts with KP type HOLDING_ACCOUNT(100), FORMER_OPERATOR_HOLDING_ACCOUNT(120), PERSON_ACCOUNT_NATIONAL_REG(121) and unit holdings of AAU, ERU_from_AAU, CER are exported. B.1. Connect as NA in EU Registry B.2. Navigate to Administration -> Unit Blocks and click on "Export KP units" B.3. Ensure unit holdings of AAU, ERU_from_AAU, CER are exported for the following types of accounts: * AAU account * ETS AAU Deposit account * ESD AAU Deposit account * ETS Central Clearing account for CP2	PASSED
This is a legacy issue for Excess Issuance ITL notification.	Notification "Excess Issuance" does not set correctly acquiring account (LEGACY FUNCTIONALITY)	Notification EXCESS_ISSUANCE_CDM_PROJECT does not set correctly acquiring account This notification should have a CDM account as an acquiring account, but it does not set it correctly. Should we add parameter just like the other two new KP notificaitons ?	1. Set the configuration parameter CDM.EXCESS_ISSUANCE_CANCELLATION_ACCOUNT = CDM-100-3567-0 and restart the application server 2. Connect as NA to a registry (in our FAT: Portugal) and navigate to KP -> ITL Notifications 3. Locate an ITL Notification of type EXCESS_ISSUANCE and click on "Fulfil" 4. Enter an acquiring account; the transferring account is retrieved automatically and is set as: CDM-100-3567-0	PASSED
Correction of error during account delegation confirmation.	NPE while Editing Account Delegation Confirmation	For OHA Account click Delegate Button in Account Main tab - Add all external platforms - confirm by Submitting - go back and remove all confirm by Clicking Confirmation Description https://webgate.ec.europa.eu/CITnet/jira/browse/C-886 According to test steps for item: https://sc136.unisystems.gr:4443/jira/browse/EUCR-2889 I got NullPointerException while testing scenario of Adding and removing all entries from existed Account Delegation (Button Remove All) and confirming emptying the list of external platforms	1. Connect as NA and navigate to Accounts -> Accounts 2. Locate an OHA which is not CLOSED 3. Navigate to Account Main and click on "Delegate Account" 4. Click an external platform and click Next 5. Click all the representatives and click Add All; click Submit 6. Ensure a green confirmation message appears informing on the delegation to the external platform. 7. Click button Back 8. Navigate to Account Main and click on "Delegate Account" 9. Click on all the ARs and click on Remove All 10. Click Submit and Confirm; ensure no error appears on screen	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			Repeat for OHA (EU), AOHA (EU), Trading Account (PT 10000954), Person Holding Account (EU), Auction Delivery Account (EU)	
Correct screen omission when passing from unit block details to account details.	Not displayed all Account Detail Tabs when passing from Unit Blocks page to Account details page	ESD - Accounts Browser : Internet Explorer, Mozilla Firefox, Google Chrome Member State: EU - EUROPE Steps: Find any unit block in Unit block search page. Click Account link in column Holding Account (if link exist) Consult to which page user was redirected Description When user is checking searching Unit Block and at the result there are displayed Account link in the column Holding Account, then clicking on that link user is redirected to Account details page, but instead of all tabs there are displayed only: Account Main Authorised Representatives Additional Authorised Representatives There should be displayed all tab, same way like user is redirected from Account Search Page - after clicking View Details link So, looks like from Unit Block page user is redirected to page: tasklist.xhtml instead of esdAccountDetailsView.xhtml	Repeat for PHA, OHA, AOHA, PeHA. A. Connect as NA in Polish registry 1. Navigate to Administration -> Unit Blocks 2. Click "Search" 3. Click the identifier of a Holding Account 4. Ensure the destination page presents the information of the account using the ETS accounts screen. B. Connect as ESD-CA in ESD registry 1. Navigate to Administration -> Unit Blocks 2. Click "Search" 3. Click the identifier of a Holding Account 4. Ensure the destination page presents the information of the account using the ESD accounts screen.	PASSED
Empty error message when attempting to close an ESD account. This is now fixed.	Empty error message when attempting to close an ESD account	Connect as ESD-CA and navigate to ESD -> Accounts -> Click on a "Close" link of an account without balance. An empty orange box appears (see attachment). You should be able to close accounts as follows: {quote} An ESD-CA can change an account status as follows: • OPEN => CLOSED, if account does not hold any units • OPEN => SUSPENDED • SUSPENDED => OPEN • BLOCKED => SUSPENDED • BLOCKED=> CLOSED • SUSPENDED => BLOCKED The account status change needs an approval by another ESD-CA to become effective only when setting the account status to CLOSED. {quote}	Tested successfully. 1. Connect as ESD-CA and navigate to ESD -> Accounts -> Click on a "Close" link of an account without balance. 2. Sign and submit the account closure request 3. Click again the "Close" link for the same account. 4. Ensure the orange message appears: " Only one account management request can be active for one account at any given time. There is a request attached to this account which has not yet been completed. Its Request ID is <<request_id>>. You can check your task list to see who is able to approve or to reject this task. You may also be able to reject the request by yourself, if no longer needed."	PASSED

Feature	Summary	Description	Test Cases	SAT Status
No signature is requested for Notification transactions. This is now fixed.	No signature is requested for Notification transactions	How to reproduce: * Make sure the signature is enabled in the relevant configuration property. * Fulfil any notification transaction. * A request is created, but *_no*_ signature is requested.	1. Connect as NA in a registry (in our FAT: PT registry) and navigate to Kyoto Protocol -> ITL Notifications. 2. Locate an incomplete ITL notification and click on Fulfil. 3. Provide account identifier and enter units 4. Click Next and Submit 5. Ensure ECAS signature is needed to sign the transaction request and sign it. 6. Ensure a transaction request is created normally for approval by another NA. 7. Connect as another NA and approve the transaction. 8. Sign the approval via ECAS. 9. Ensure a transaction is created and processed normally via ECAS. In our environment: PT527 transaction was created, after being proposed via ECAS and approved via ECAS.	PASSED
Correction of screen omission when clicking on user URID link in Tasks	Clicking on user URID link in Tasks shows popup with errors	Propose update of User Personal Details Before Approving this task, go to Details Page and click URID link on top When proposing update of Personal Details, which results in creating task request to approve. Approver is claiming this request, and went into Personal Details Update page in Tasks. Then on top there is visible link with URID which is clickable, and popup box is displayed. But on this popup there is no Title and there is no displayed Business Details tab - according to Test Cases in https://sc136.unisystems.gr:4443/jira/browse/EUCR-2797	1. Connect as NA and navigate to Administration -> Users. 2. Click on an enrolled user. 3. Propose an update of personal details. 4. Navigate to the tasklist -> exclusive tasklist and click on the generated task id. 5. Click on the URID hyperlink of the affected user appearing on the top-left corner 6. A pop-up window appears with the following tabs, each containing data of the affected user: * Personal details * Business details * Administration roles * Accounts	PASSED
SEF CP2 implementation	New CP2 SEF format	New CP2 SEF format	1. Run the SEF job 2. Connect as NA and navigate to a registry with CP2 transactions and navigate to Administration -> SEF Reporting 3. Click on a hyperlink pertaining to a year and download the file 4. Import the file within the SEF Reporting tool, version 3.6.1 5. Ensure the file is downloaded without an error. Note: the SEF job can be executed as follows: <pre>{code} exec sef_kp2_reporting (2013, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2014, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2015, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2016, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2017, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2018, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2019, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss'));</pre>	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			exec sef_kp2_reporting (2020, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); commit; {code} The last parameter is the end of carry over.	
SEF CP2 implementation	SEF Procedure and carry-over transactions	SEF Procedure - carry-over transactions will be included in CP2 SEF and not CP1 SEF	1. Run the SEF job 2. Connect as NA and navigate to a registry with CP2 transactions and navigate to Administration -> SEF Reporting 3. Click on a hyperlink pertaining to a year and download the file 4. Import the file within the SEF Reporting tool, version 3.6.1 5. Ensure the file is downloaded without an error. 6. Ensure the tables presented follow the calculation formulas defined in the attached document SEF CP2 Reporting_v2_2016-07-08.docx Note: the SEF job can be executed as follows: {code} exec sef_kp2_reporting (2013, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2014, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2015, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2016, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2017, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2018, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2019, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); exec sef_kp2_reporting (2020, 2, to_date('31/12/2021 23:59:59', 'dd/mm/yyyy hh24:mi:ss')); commit; {code} The last parameter is the end of carry over.	PASSED
For some account management requests, the request cannot be submitted when pending request exists for the same account. In that case, the respective button is now hidden.	Message does not appear when pending request exists	A request cannot be submitted if there is another pending request for the same account; this concerns the following request types: * Addition of AAR (also for ESD) * Replacement of AR (also for ESD) * Replacement of AAR (also for ESD) * Removal of AR (also for ESD) * Removal of AAR (also for ESD) * Account closure	*Test Case 1* - Add AAR while same request is pending 1. As NA, submit a AAR addition for RO 666 2. Try to propose a second request for the same account, relevant button should not exist *Test Case 2* - Add AAR while same request is pending (ESD) 1. As NA, submit a AAR addition for ESD 10001864 2. Try to propose a second request for the same account, relevant button should not exist *Test Case 3* - Replace AR while same request is pending 1. As NA, submit a AAR addition for RO 656 2. Try to propose a second request for the same account, relevant button should not exist *Test Case 4* - Replace AR while same request is pending (ESD) 1. As NA, submit a AAR addition for ESD 10001868 2. Try to propose a second request, relevant button should not exist	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			Test Case 5 - Replace AAR while same request is pending 1. As NA, submit a AAR addition for RO 655 2. Try to propose a second request, relevant button should not exist *Test Case 6* - Replace AAR while same request is pending (ESD) 1. As NA, submit a AAR addition for ESD 10001868 2. Try to propose a second request for the same account, relevant button should not exist *Test Case 7* - Remove AR while same request is pending 1. As NA, submit a AR removal for RO 666, after having suspended an AR for this account 2. Try to propose a second request for the same account, relevant button should not exist *Test Case 8* - Remove AR while same request is pending (ESD) 1. As NA, submit a AR removal for ESD 10001863. 2. Try to propose a second request for the same account, relevant button should not exist *Test Case 9* - Remove AAR while same request is pending 1. As NA, submit a AR removal for RO 666 (make sure no pending AR removal exist) 2. Try to propose a second request for the same account, relevant button should not exist *Test Case 10* - Remove AAR while same request is pending (ESD) 1. As NA, submit a AR removal for ESD 10001867 (make sure no pending AR removal exist) 2. Try to propose a second request for the same account, relevant button should not exist *Test Case 11* - Close account while same request is pending 1. As NA, submit a account closure for an account 2. Try to propose a second request for the same account, relevant button should not exist	
Removal of obsolete XML schema files	Removal of obsolete XML schema files	The following XML schema files are obsolete and are no longer used. * eucr-ui/nap.xsd * eucr-ui/caat.xsd * eucr-commons/nap.xsd * eucr-commons/caat.xsd * eucr-commons/surrenderLimits.xsd After CLIMA approves, we will proceed to their permanent removal from the source code.	This is a technical issue	PASSED
Change in screen information from PPSR->PPSR transfer screen	Transfer PPSR to PPSR - Modify radio button label + drop down	Transfer PPSR to PPSR - Modify radio button label + drop down Radio button label for the first option must be renamed to: "Acquiring PPSR account registry"	*Test Case 1* 1. Log in EU as NA 2. For a PPSR account, initiate a transfer to PPSR transaction. 3. In "Transfer AAU to PPSR account" screen, check that first radiobutton is titled "Acquiring PPSR"	PASSED

Feature	Summary	Description	Test Cases	SAT Status
		The drop down must contain only registry codes.	account registry " and that the respective dropdown contains only registries pertaining to OPEN PPSR accounts.	
A set of transactions checking system integrity	Regression: Transactions complete normally	Test transactions complete normally: # OHA -> OHA # ESD -> ESD # PHA -> AAU account # PHA -> PHA # Japan -> PHA (AAU, CER) # Japan -> OHA (AAU, CER)	These transactions were successfully tested. 1. Transaction EU1255876 from OHA -> OHA 2. Transaction EU1255878 from ESD -> ESD 3. Transaction EU1256880 from PHA -> AAU account 4. Transaction PT517 from PHA -> PHA 5. Transaction JP900801 from Japan -> PHA with CER Transaction JP900802 from Japan -> OHA with CER 6. Transaction JP900806 from Japan -> PHA with AAU It is not allowed to send AAU units to OHA; transaction terminated with rule 7036 (correctly)	PASSED
Correction for ITL notification Excess Issuance.	Check 80210 incorrectly fires for ITL notification EXCESS ISSUANCE	I go to PT and fulfil an EXCESS ISSUANCE from PHA 643. The rule 80210 incorrectly fires, PHA 643 has an AAR.	1. Connect as NA and navigate to Kyoto Protocol -> ITL Notifications. 2. Search for an ITL Notification of type "Excess Issuance CDM Project" and click its hyperlink 3. Enter as transferring account the identifier of a PHA of the registry of the user and click Apply. 4. The holdings of the transferring account appear. 5. Enter a quantity of units next to the corresponding unit type and click Next. 6. Click Confirm 7. The green message box appears stating the new transaction request. 8. Navigate to tasklist -> Exclusive Tasklist and ensure a task with request Id equal to the one created in step 7 appears.	PASSED
Correction in text of rule 7892.	Please correct word "except" in rule 7892	Please correct word "except" in rule: 7892: Amount transferred out of "ESD AAU Deposit Account" by Cancellation, Internal and External transfers should not exceed the "AAUs Available for Transfer" limit, except amount transferred to the "ESD Central Clearing Account".	This is a technical issue. Updated relevant message in message.properties file.	PASSED
Three detailed rules for KP2 cancellations are implemented	Additional rules for Cancellations	The following are a series of rules identified during implementation: 1. Art 3.7 Cancellation can only transact AAUs of CP2. 2. Art 3.7 Cancellation can only transact units with originating registry the current user's registry. ~~3. Ambition Increase Cancellation can only transact units with originating registry the current user's registry.~~ 4. Voluntary cancellations are blocked after the end of carry over.	A. Test for Art 3.7 Cancellation (Tasks 1 and 2) 1. Locate an account with units of various unit types, of both CP1 and CP2 and originating country code equal to the current registry and other registries as well (in our environment account 551 of Latvia). 2. Propose an Art 3.7 Cancellation Ensure the proposal screen shows only : * AAU units of originating CP = 2 * Of originating country code = Current registry B. Test for Voluntary Cancellation (Task 4) 1. Locate an account from which the Voluntary Cancellation is available in the list of transactions (in our environment account 551 of Latvia). 2. Change the configuration parameter carry.over.end.date to the value 01/01/2012 23:59:59 3. Restart the application server	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			4. Navigate to the transactions list of the account used in step [1]. 5. Ensure Voluntary Cancellation is not available. 6. Change the configuration parameter carry.over.end.date to the value 31/03/2021 23:59:59 7. Restart the application server 8. Navigate to the transactions list of the account used in step [1]. 9. Ensure Voluntary Cancellation is available. Note: Task 3 was rejected and was not implemented	
While adding an ESD-AR this appears on screen as ESD-AAR. This is now fixed.	There is wrong description in ESD AR Addition Summary.	When you add an ESD-AR to an ESD compliance account, the summary view shows the user to be added with an "ESD-AAR" header.	*Test Case 1* 1. Log in ESD as NA 2. In an open account request the addition of an AR. (Complete proposal) 3. Ensure the addition request specifies the added user labelled "ESD-AR".	PASSED
During XML uploads into EUER, a maximum file size parameter is introduced.	Lack of file size validation in XML file uploads	There will be a property defined in the eucr-configuration.properties named backingBean.maxFileSize with the value (in bytes) to be defined by business that will control the maximum file size (in bytes). Properties are periodically reloaded by the application. The required jsf page will have a javascript function to check the filesize <pre>{code} function checkFileSize(inputFile) { var max = #{backingBean.maxFileSize}; //max size in bytes if (inputFile.files && inputFile.files[0].size > max) { alert ('#{labels.file_upload_exceeds_size}'); } } {code}</pre> The file upload tag will use this like <t:inputFileUpload ... onchange="checkFileSize(this)" /> On the server side the handleXmlImport() method of every upload backing bean will check the fileInpuream for its size like fileInpuream.getChannel().size()	*Test Case 1 - Upload allocation file* 1. Change property backingBean.maxFileSize which is in eucr-configuration.properties to 500 and restart the application server 2. Log in GB as NA and upload an allocation file with file size 700 Bytes (this can be found via the document properties of the NAT file) 3. Ensure an orange message appears: "The uploaded file is bigger than the allowed file size (500)." 4. Upload a NAT file with size 400 bytes. 5. Ensure the file uploads successfully. Repeat for NAAT, ICE, ICH lists, KP2 entitlements, emissions, ESD emissions, ESD allocations, ESD eligibility lists, ESD entitlements. Note1: The property backingBean.maxFileSize is very important because it constraints the size of uploaded XML files. Note2: NAT is uploaded via: NA login -> EUETS -> NAT -> Batch Administration	PASSED

Feature	Summary	Description	Test Cases	SAT Status
			NAAT is uploaded via: NA login -> EUETS -> NAAT -> Batch Administration Emissions are uploaded via: NA login -> EUETS -> Emissions Upload ICE are uploaded via: NA login -> EUETS -> ICE Table Upload ICH lists are uploaded via: CA login -> EU Registry -> Administration -> Initial List Upload KP2 entitlements: CA login in EU registry -> KP -> KP2 Entitlements -> Carry-Over Entitlements (CER/ERU from AAU) ESD allocations: ESDCA in ESD registry -> ESD -> ESD allocations Upload ESD emissions: ESDCA in ESD registry -> ESD -> ESD Emissions Upload ESD entitlements ESDCA in ESD registry -> ESD -> ESD Entitlements Upload ESD eligibility lists ESDCA in ESD registry -> ESD -> ESD Eligibility List Upload	

Feature	Summary	Description	Test Cases	SAT Status
During a search of records, the system did not respond correctly; this is now fixed.	Every action done during ongoing transactions searching causes logout from EUCR	1. Log in to EUCR 2. Go to Accounts -> Transactions 3. Press "Search" Button -> the button is grayed out 4. Before searching is complete again press "Search" button Actual Result: 1. The screen with info message is displayed: "There was a problem with your request. Please follow this link back to the homepage." 2. After pressing the link user is logged out Expected Result: Nothing happens	1. Navigate to to Accounts → Accounts 2. Press the "Search" button and immediately press any link on the left navigation menu (for example "List of account requests") 3. Ensure the accounts' records appear normally Repeat the same test for Accounts → Transactions Repeat the same test for Kyoto Protocol → JI Projects	PASSED

22.2.4.3 Annex H: Test Report – ITL Annex H tests for MT and CY initialization

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Introduction

As part of the initialization of the national registries of Malta (MT) and Cyprus (CY), the registry software they intend to use has to successfully pass qualifications tests. These tests are extracted from the ITL DES Annex H (new draft version v0.4).

For their Annex H testing MT and CY were expected to pass the tests from CP1 and CP2 that are applicable to them.

This document is the report of the testing performed on the EUCR software, to be used by MT and CY. The tests were executed in 2 phases. A first phase in August 2016 (for most of the CP2 tests) and a 2nd phase in Jan-2017 (for the CP1 tests).

Test results

Ref	Description	Outcome Pass/Fail	Notes
3.2.4.1	Receive CP1 CERs, tCERs, ICERs from CDM pending account	PASS	
3.2.4.2	Receive CP1 CERs, tCERs, ICERs from CDM Adaptation Fund (AF) account	PASS	
3.2.5.1	Successful voluntary cancellation of CP1 CERs	PASS	
3.2.5.2	Voluntary cancellation of CP1 CERs with wrong account	PASS	
3.2.5.3	Voluntary cancellation of CERs with an unknown account identifier	PASS	
3.2.5.4	Successful voluntary cancellation of other CP1 units	PASS	
3.2.5.5	Reconciliation	PASS	
3.2.6.1	Successful mandatory cancellation of CP1 CERs	PASS	
3.2.6.2	Mandatory cancellation of CP1 CERs with wrong account	PASS	
3.2.6.3	Mandatory cancellation of CP1 CERs with an unknown account identifier	PASS	
3.2.6.4	Successful mandatory cancellation of other CP1 units	PASS	
3.2.6.5	Reconciliation	PASS	
3.2.7.1	External transfer to fulfil excess issuance notification while acquiring account configured to reject the transaction	FAIL	Unexpected issue encountered. After investigation, the EC concluded that the issue is due to an EUTL check which triggers erroneously. It would never happen in Prod and in the unlikely case where it would occur a workaround is in place. All test cases from the test series should be re-run once the issue is permanently addressed.
3.2.7.2	Reconciliation	SKIPPED	
3.2.7.3	Successful external transfer to partially fulfil excess issuance notification	FAIL	Same issue as in 3.2.7.1
3.2.7.4	Successful external transfer to partially fulfil excess issuance notification with other eligible unit types	BLOCKED	Not tried due to issue uncovered in 3.2.7.1 and 3.2.7.3
3.2.7.5	Notification update and successful external transfer to fulfil excess issuance notification	BLOCKED	Not tried due to issue uncovered in 3.2.7.1 and 3.2.7.3
3.2.7.6	Reconciliation	SKIPPED	
3.2.8.1	Reversal of storage notification fulfilled with cancellation	BLOCKED	Because of a known issue in the processing of the notifications in the EUCR/EUTL. Fix will be provided in the Q1-2017 release of the EUCR software
3.2.9.1	Non-submission of certification report notification fulfilled with cancellation	BLOCKED	Because of a known issue in the processing of the notifications in the EUCR/EUTL. Fix will be provided in the Q1-2017 release of the EUCR software
3.2.13.1	Successful ICER Expiry Date Change	PASS	
3.2.14.1	Internal transfer of CP1 units within registry ZZ	PASS	

Ref	Description	Outcome Pass/Fail	Notes
3.2.14.2	Reconciliation	PASS	
4.2.1.1	Successful CP2 AAU issuance	PASS	
4.2.1.2	CP2 AAU issuance exceeding the limit	PASS	The error scenario couldn't be made to happen in the EUCR software, thanks to the built-in constraints on serial numbers
4.2.1.3	CP2 AAU issuance within the limit	PASS	
4.2.1.4	CP2 AAU issuance exceeding the limit	PASS	
4.2.1.5	Successful CP2 RMU issuance, LULUCF activity 1	PASS	
4.2.1.6	Successful CP2 RMU issuance, LULUCF activity 7	PASS	
4.2.1.7	CP2 RMU issuance exceeding the limit	PASS	
4.2.1.8	CP2 RMU issuance with serial numbers already existing	PASS	The error scenario couldn't be made to happen in the EUCR software, thanks to the built-in constraints on serial numbers
4.2.1.9	Reconciliation	PASS	
4.2.2.1	Initial conversion of CP2 AAU for JI track 2	PASS	
4.2.2.2	Initial conversion of CP2 RMU for JI track 2	PASS	
4.2.2.3	Initial conversion of CP2 AAU for JI track 1	PASS	
4.2.2.4	Initial conversion of CP2 RMU for JI track 1	PASS	
4.2.2.5	Second conversion of CP2 units for JI track 2 projects, before SOP transfer	PASS	This error scenario wasn't possible in the EUCR software, thanks to proper built-in constraints preventing it.
4.2.2.6	Second conversion of CP2 units for JI track 1 projects, before SOP transfer	PASS	This error scenario wasn't possible in the EUCR software, thanks to proper built-in constraints preventing it.
4.2.2.7	Second step of CP2 conversion cycle - SOP transfer	PASS	
4.2.2.8	Second conversion of CP2 AAU for JI track 2	PASS	
4.2.2.9	Second conversion of CP2 RMU for JI track	PASS	
4.2.2.10	Second conversion of CP2 AAU for JI track 1	PASS	
4.2.2.11	Second conversion of CP2 RMU for JI track	PASS	
4.2.2.12	Second conversion cycle of CP2 AAU for JI track 2 with wrong amounts for conversion	PASS	
4.2.2.13	Second conversion cycle of CP2 RMU for JI track 2 with wrong amounts for conversion A	PASS	
4.2.2.14	Second conversion cycle of CP2 AAU for JI track 1 with wrong amounts for conversion B	PASS	
4.2.2.15	Second conversion cycle of CP2 RMU for JI track 1 with wrong amounts for conversion B	PASS	
4.2.2.16	Attempt at conversion of CP2 units for 2 different projects	PASS	
4.2.2.17	Conversion A of CP2 AAU for JI track 2 with rounding amounts	PASS	
4.2.2.18	Conversion A of CP2 RMU for JI track 2 with rounding amounts	PASS	
4.2.2.19	Conversion B of CP2 AAU for JI track 2 where conversion A amount was rounded	PASS	
4.2.2.20	Conversion B of CP2 RMU for JI track 2 where conversion A amount was rounded	PASS	
4.2.2.21	Conversion A of CP2 AAU for JI track 2 with outstanding limit less than 50	PASS	
4.2.2.22	Conversion A of CP2 RMU for JI track 2 with outstanding limit less than 50	PASS	
4.2.2.23	Reconciliation	PASS	
4.2.3.1	First external transfer of CP2 AAU before SOP payment	PASS	This error scenario was prevented from happening in the EUCR thanks to the built-in constraints of the software.
4.2.3.2	SOP payment for CP2 AAU	PASS	
4.2.3.3	First external transfer of CP2 AAU in excess of allowed limit	PASS	This error scenario was prevented from happening in the EUCR thanks to the built-in constraints of the software.
4.2.3.4	Successive external transfers of CP2 AAU within limit	PASS	
4.2.3.5	Attempt at SOP payment with units originating from a different registry	PASS	
4.2.3.6	Attempt at SOP payment with units previously used	PASS	
4.2.3.7	External transfer with CP2 AAU previously used in external transfers	PASS	
4.2.3.8	Reconciliation	PASS	
4.2.5.1	Receive CP2 AAU, ERU from AAU, ERU from RMU and RMU from another registry	PASS	
4.2.5.2	Transfer CP2 AAU, ERU from AAU, ERU from RMU and RMU to another registry	PASS	
4.2.5.3	External transfer to a registry configured to reject them	PASS	

Ref	Description	Outcome Pass/Fail	Notes
4.2.5.4	Reject incoming external transfer of AAUs from another registry	PASS	This error case couldn't actually be tested, because the 2 test registries instances used were both from the EUCR
4.2.5.5	External transfer to a non-responsive registry	PASS	
4.2.5.6	External transfer to a registry rejected by the EUTL	PASS	
4.2.5.7	External transfer through a non-responsive EUTL	PASS	
4.2.5.8	Reconciliation	PASS	
4.2.5.9	Receive CP2 CERs, tCERs, ICERs from another registry when both registries are CP2 QELRC	PASS	
4.2.5.10	Transfer CP2 CERs, tCERs, ICERs from another registry when both registries are CP2 QELRC	PASS	
4.2.5.11	Transfer CP2 CERs, tCERs, ICERs to a non CP2 QELRC registry	PASS	
4.2.5.14	Reconciliation	PASS	
4.2.6.1	Receive CP2 CERs, tCERs, ICERs from CDM pending account	PASS	
4.2.6.2	Receive CP2 CERs, tCERs, ICERs from CDM Adaptation Fund (AF) account	PASS	
4.2.6.3	Reconciliation	PASS	
4.2.7.1	Cancellation to fulfil a net source cancellation notification for LULUCF 2	PASS	
4.2.7.2	Cancellation to fulfil a net source cancellation notification for LULUCF 7	PASS	
4.2.7.3	Cancellation to fulfil a net Source cancellation notification, that exceeds the outstanding amount of the notification	PASS	
4.2.8.1	Cancellation to fulfil non-compliance cancellation notification in CP2	PASS	
4.2.8.2	Reconciliation	PASS	
4.2.9.1	Successful voluntary cancellation of CP2 AAUs	PASS	
4.2.9.2	Voluntary cancellation of CP2 AAUs with wrong account	PASS	
4.2.9.3	Voluntary cancellation of AAUs with an unknown account identifier	PASS	
4.2.9.4	Successful voluntary cancellation of other CP2 units	PASS	
4.2.9.5	Reconciliation	PASS	
4.2.10.1	Successful mandatory cancellation of CP2 AAUs	PASS	
4.2.10.2	Mandatory cancellation of CP2 AAUs with wrong account	PASS	
4.2.10.3	Mandatory cancellation of CP2 AAUs with an unknown account identifier	PASS	
4.2.10.4	Successful mandatory cancellation of other CP2 units	PASS	
4.2.10.5	Reconciliation	PASS	
4.2.11.1	Successful article 3.7ter cancellation	PASS	
4.2.11.2	Cancellation for article 3.7ter less than the limit	PASS	
4.2.11.3	Cancellation for article 3.7ter greater than the limit	PASS	
4.2.11.4	Cancellation for article 3.7ter with non CP2 AAU	PASS	
4.2.11.5	Cancellation for article 3.7ter with CP2 AAU received from another registry	PASS	
4.2.11.6	Transactions with CP2 AAU before the article 3.7ter cancellation	PASS	
4.2.11.7	Transactions with non CP2 AAU before the article 3.7ter cancellation	PASS	
4.2.11.8	Transactions with CP2 AAU when the article 3.7ter amount is 0	PASS	
4.2.11.9	Transactions with CP2 AAU when the article 3.7ter amount is < 0	PASS	
4.2.11.10	Cancellation for article 3.7ter with non CP2 AAU	PASS	
4.2.11.11	Reconciliation	PASS	
4.2.12.1	Successful ambition increase cancellation	PASS	
4.2.12.2	Cancellation for ambition increase less than the limit	PASS	
4.2.12.3	Cancellation for ambition increase greater than the limit	PASS	
4.2.12.4	Cancellation for ambition increase with CP2 AAU received from another registry	PASS	
4.2.12.5	Cancellation for ambition increase with non CP2 AAU	PASS	
4.2.12.6	Reconciliation	PASS	
4.2.13.1	External transfer to fulfil excess Issuance notification while acquiring account configured to reject the transaction	PASS	
4.2.13.2	Reconciliation	PASS	
4.2.13.3	Successful external transfer to partially fulfil Excess Issuance notification	PASS	
4.2.13.4	Successful external transfer to partially fulfil Excess Issuance notification with other eligible unit types	PASS	
4.2.13.5	Notification update and successful external transfer to fulfill excess issuance notification	PASS	
4.2.13.6	Reconciliation	PASS	
4.2.14.1	Reversal of storage notification (Type 4) fulfilled with cancellation	BLOCKED	For the same reasons as 3.2.8.1
4.2.15.1	Non-submission of certification report notification fulfilled with cancellation	BLOCKED	For the same reasons as 3.2.9.1
4.2.16.1	Retirement of AAUs, ERUs and RMUs	PASS	

Ref	Description	Outcome Pass/Fail	Notes
4.2.16.2	Retirement of AAUs with an unknown account identifier	PASS	
4.2.16.6	Retirement attempt of CERs, tCERs, ICERs when registry has CP2 QELRC, but Doha amendment hasn't entered into force	PASS	
4.2.16.7	Retirement attempt of CERs, tCERs, ICERs when registry has CP2 QELRC and Doha amendment has entered into force	PASS	
4.2.16.8	Retirement attempt of tCERs, ICERs in excess of tCER/ICER retirement limit	PASS	
4.2.16.9	Retirement of tCERs, ICERs within tCER/ICER retirement limit	PASS	
4.2.16.10	Reconciliation	PASS	
4.2.17.2	Replacement of retired ICER for reversal of storage notification (Type 4) with Lcer	BLOCKED	For the same reasons as 3.2.8.1
4.2.17.3	Replacement of ICER in holding account for reversal of storage notification (Type 4) with ICER	BLOCKED	For the same reasons as 3.2.8.1
4.2.17.4	Replacement of retired ICER for reversal of storage notification (Type 4) with AAU, RMU, ERU, CER	BLOCKED	For the same reasons as 3.2.8.1
4.2.17.5	Replacement of ICER in holding account for reversal of storage notification (Type 4) with AAU, RMU, ERU, CER	BLOCKED	For the same reasons as 3.2.8.1
4.2.17.6	Replacement of retired ICER for non-submission of certification report (Type 5) with ICER	BLOCKED	For the same reasons as 3.2.9.1
4.2.17.7	Replacement of ICER in holding account for non-submission of certification report (Type 5) with ICER	BLOCKED	For the same reasons as 3.2.9.1
4.2.17.8	Replacement of retired ICER for non-submission of certification report (Type 5) with AAU, RMU, ERU, CER	BLOCKED	For the same reasons as 3.2.9.1
4.2.17.9	Replacement of ICER in holding account for non-submission of certification report (Type 5) with AAU, RMU, ERU, CER	BLOCKED	For the same reasons as 3.2.9.1
4.2.17.10	Replacement of retired ICER upon expiry (Type 3)	BLOCKED	Notification type 3 couldn't be triggered in ITL REG. Issue to follow up on
4.2.17.11	Replacement of retired tCER upon expiry (Type 3)	BLOCKED	For the same reasons as 4.2.17.10
4.2.17.12	Replacement of tCER in holding account upon expiry (Type 3)	BLOCKED	For the same reasons as 4.2.17.10
4.2.17.13	Reconciliation	SKIPPED	
4.2.18.1	Successful ICER expiry date change	PASS	
4.2.18.2	Successful tCER expiry date change	SKIPPED	This test requires to change the end date of CP3, which would affect all the registries using the test environment simultaneously
4.2.19.1	Internal transfer of CP2 units within registry ZZ	PASS	
4.2.20.1	Conversion of CP2 AAU for JI track 1 when eligibility parameter 2 is missing	PASS	
4.2.20.2	Conversion of CP2 AAU for JI track 2 when eligibility parameter 2 is missing	PASS	
4.2.20.3	External transfer to another registry	PASS	
4.2.20.5	Retirement attempt of CERs, tCERs, ICERs when registry has CP2 QELRC and Doha amendment has entered into force	PASS	
4.2.21.1	CPR notification when AAU issuance is less than CPR amount	PASS	
4.2.21.2	CPR notification upon setting the CPR limit	PASS	
4.2.21.3	CPR notification upon updating the CPR limit	PASS	
4.2.21.4	Reconciliation	PASS	
5.1	Multiple simultaneous incoming transfers	PASS	
5.2	Incoming transfer – long transaction identifier	PASS	
5.3	Incoming transfer – long serial numbers and small blocks	PASS	
5.4	Incoming transfer – long transferring account number	PASS	
5.5	Successful Retirement	PASS	
5.6	Numerous successive incoming transfers – large block quantities	PASS	
5.7	Reconciliation inconsistency and manual intervention	PASS	
5.8	Handling numerous unit blocks	PASS	
5.9	Reconciliation	PASS	

22.3 Additional information about greenhouse-gas trends

Here, we provide the detailed tables relative to the trend discussion presented in Chapters 0.2 and 2.

Table 524: Emissions trends in Germany, by greenhouse gas and category

GHG emissions / sinks, in CO ₂ equivalents (kt)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Net CO ₂ emissions / removals	1,019,229	983,619	934,696	925,001	904,971	903,409	923,550	894,927	886,568	858,058	859,653	875,402	893,279	892,484	875,223
CO ₂ emissions (not including LULUCF)	1,052,247	1,014,122	965,793	955,980	939,210	938,150	958,371	930,770	922,780	895,338	899,286	915,636	899,163	900,379	886,211
CH ₄ (including LULUCF)	121,169	115,265	111,613	112,123	108,170	105,831	103,202	98,844	93,566	92,929	88,608	84,960	81,004	77,648	72,600
CH ₄ (not including LULUCF)	120,293	114,392	110,723	111,248	107,296	104,960	102,327	97,973	92,696	92,058	87,736	84,091	80,136	76,775	71,733
N ₂ O (including LULUCF)	65,819	63,323	64,310	61,517	62,372	61,783	63,053	60,168	47,280	43,857	43,890	45,280	44,456	44,071	46,227
N ₂ O (not including LULUCF)	64,989	62,497	63,476	60,694	61,554	60,968	62,238	59,358	46,474	43,053	43,088	44,491	43,677	43,298	45,468
HFC	5,891	5,415	5,638	7,833	8,010	8,217	7,528	8,131	8,710	8,834	7,806	9,129	9,902	9,319	9,618
PFC	3,060	2,655	2,408	2,258	1,920	2,087	2,043	1,656	1,784	1,487	959	872	948	1,018	980
SF ₆	4,428	4,746	5,238	5,974	6,249	6,467	6,162	6,109	5,889	4,290	4,072	3,752	3,087	3,034	3,244
NF ₃	7	7	7	7	7	5	7	8	8	7	9	8	12	19	23
Total emissions / removals, including LULUCF	1,219,604	1,175,030	1,123,910	1,114,712	1,091,699	1,087,801	1,105,545	1,069,843	1,043,805	1,009,460	1,004,997	1,019,402	1,032,688	1,027,593	1,007,915
Total emissions, apart from LULUCF	1,250,915	1,203,834	1,153,282	1,143,993	1,124,246	1,120,856	1,138,677	1,104,005	1,078,341	1,045,067	1,042,958	1,057,978	1,036,925	1,033,843	1,017,276

GHG emissions / sinks, in CO ₂ equivalents (kt)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Net CO ₂ emissions / removals	852,192	863,298	837,241	833,178	768,816	814,391	795,156	800,967	819,417	778,240	775,753
CO ₂ emissions (not including LULUCF)	865,866	877,369	850,743	853,592	788,510	832,437	812,577	817,145	835,459	794,829	792,054
CH ₄ (including LULUCF)	69,344	65,440	63,141	62,201	59,970	59,127	58,002	58,645	58,037	56,874	56,483
CH ₄ (not including LULUCF)	68,478	64,573	62,275	61,333	59,101	58,260	57,136	57,778	57,171	56,009	55,616
N ₂ O (including LULUCF)	44,204	43,935	45,866	46,380	45,603	37,602	39,016	38,190	38,766	39,437	39,933
N ₂ O (not including LULUCF)	43,455	43,175	45,097	45,599	44,807	36,794	38,195	37,354	37,925	38,590	39,078
HFC	9,940	10,162	10,448	10,589	11,170	10,753	10,953	11,140	11,096	11,183	11,356
PFC	839	671	589	568	407	346	279	243	257	235	254
SF ₆	3,320	3,242	3,181	2,971	2,924	3,100	3,163	3,155	3,261	3,396	3,562
NF ₃	34	28	12	30	29	61	61	35	16	20	12
Total emissions / removals, including LULUCF	979,873	986,776	960,478	955,916	888,920	925,382	906,630	912,374	930,851	889,385	887,352
Total emissions, apart from LULUCF	991,933	999,220	972,344	974,682	906,949	941,750	922,363	926,850	945,186	904,262	901,932

GHG emissions / sinks, by source and sink categories, in CO ₂ equivalents (kt)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1. Energy	1,036,736	999,782	951,070	941,978	919,622	917,583	938,611	907,486	897,723	873,283	869,937	890,053	873,672	869,080	852,021
2. Industrial processes	96,643	92,744	92,784	93,826	99,147	97,339	95,529	95,776	81,948	73,875	76,895	73,840	72,627	76,575	78,555
3. Agriculture	79,582	71,960	69,496	68,422	66,515	67,952	67,953	67,045	67,034	67,847	67,563	67,125	65,026	64,080	64,013
4. Land use, land-use changes & forestry	-31,312	-28,804	-29,373	-29,281	-32,547	-33,055	-33,131	-34,162	-34,536	-35,607	-37,960	-38,576	-4,237	-6,249	-9,362
CO ₂	-33,018	-30,503	-31,098	-30,979	-34,239	-34,741	-34,821	-35,843	-36,212	-37,281	-39,633	-40,234	-5,883	-7,895	-10,987
N ₂ O & CH ₄	1,706	1,699	1,725	1,698	1,692	1,686	1,689	1,680	1,676	1,674	1,673	1,657	1,646	1,645	1,626
5. Waste	37,955	39,349	39,932	39,768	38,962	37,982	36,584	33,698	31,635	30,062	28,564	26,960	25,601	24,107	22,687

GHG emissions / sinks, by source and sink categories, in CO ₂ equivalents (kt)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Energy	831,747	841,328	815,120	820,140	761,945	801,653	781,426	788,090	806,182	764,409	762,231
2. Industrial processes	75,488	75,740	76,954	73,149	65,496	62,534	62,463	61,492	61,373	61,446	61,534
3. Agriculture	63,446	62,560	61,973	64,328	63,664	62,853	64,538	64,077	65,242	66,591	66,955
4. Land use, land-use changes & forestry	-12,060	-12,444	-11,867	-18,765	-18,029	-16,369	-15,733	-14,476	-14,335	-14,877	-14,580
CO ₂	-13,674	-14,071	-13,502	-20,414	-19,694	-18,045	-17,421	-16,178	-16,042	-16,589	-16,301
N ₂ O & CH ₄	1,614	1,627	1,636	1,649	1,665	1,677	1,688	1,703	1,707	1,712	1,721
5. Waste	21,251	19,593	18,297	17,065	15,844	14,710	13,937	13,191	12,389	11,816	11,210

Table 525: Contributions to emissions trends in Germany, by greenhouse gas and category

GHG emissions / sinks; shares for various greenhouse gases, not including LULUCF (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO ₂ emissions (not including LULUCF)	84.12	84.24	83.74	83.57	83.54	83.70	84.17	84.31	85.57	85.67	86.22	86.55	86.71	87.09	87.12	87.29	87.81	87.49	87.58	86.94	88.39	88.10	88.16	88.39	87.90	87.82
CH ₄	9.62	9.50	9.60	9.72	9.54	9.36	8.99	8.87	8.60	8.81	8.41	7.95	7.73	7.43	7.05	6.90	6.46	6.40	6.29	6.52	6.19	6.19	6.23	6.05	6.19	6.17
N ₂ O	5.20	5.19	5.50	5.31	5.48	5.44	5.47	5.38	4.31	4.12	4.13	4.21	4.21	4.19	4.47	4.38	4.32	4.64	4.68	4.94	3.91	4.14	4.03	4.01	4.27	4.33
HFC	0.47	0.45	0.49	0.68	0.71	0.73	0.66	0.74	0.81	0.85	0.75	0.86	0.95	0.90	0.95	1.00	1.02	1.07	1.09	1.23	1.14	1.19	1.20	1.17	1.24	1.26
PFC	0.24	0.22	0.21	0.20	0.17	0.19	0.18	0.15	0.17	0.14	0.09	0.08	0.09	0.10	0.10	0.08	0.07	0.06	0.06	0.04	0.04	0.03	0.03	0.03	0.03	0.03
SF ₆	0.35	0.39	0.45	0.52	0.56	0.58	0.54	0.55	0.55	0.41	0.39	0.35	0.30	0.29	0.32	0.33	0.32	0.33	0.30	0.32	0.33	0.34	0.34	0.35	0.38	0.39
NF ₃	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.003	0.003	0.001	0.003	0.003	0.007	0.007	0.004	0.002	0.002	0.001
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

GHG emissions / sinks; shares for source and sink groups, not including LULUCF (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Energy	82.88	83.05	82.47	82.34	81.80	81.86	82.43	82.20	83.25	83.56	83.41	84.13	84.26	84.06	83.76	83.85	84.20	83.83	84.14	84.01	85.12	84.72	85.03	85.29	84.53	84.51
2. Industrial processes	7.73	7.70	8.05	8.20	8.82	8.68	8.39	8.68	7.60	7.07	7.37	6.98	7.00	7.41	7.72	7.61	7.58	7.91	7.50	7.22	6.64	6.77	6.63	6.49	6.80	6.82
4. Agriculture	6.36	5.98	6.03	5.98	5.92	6.06	5.97	6.07	6.22	6.49	6.48	6.34	6.27	6.20	6.29	6.40	6.26	6.37	6.60	7.02	6.67	7.00	6.91	6.90	7.36	7.42
5. Waste	3.03	3.27	3.46	3.48	3.47	3.39	3.21	3.05	2.93	2.88	2.74	2.55	2.47	2.33	2.23	2.14	1.96	1.88	1.75	1.75	1.56	1.51	1.42	1.31	1.31	1.24
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 526: Emissions of direct and indirect greenhouse gases and SO₂ in Germany since 1990

Emissions development (kt)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Net CO ₂ emissions / removals	1,019,229	983,619	934,696	925,001	904,971	903,409	923,550	894,927	886,568	858,058	859,653	875,402	893,279	892,484	875,223
CO ₂ emissions (not including LULUCF)	1,052,247	1,014,122	965,793	955,980	939,210	938,150	958,371	930,770	922,780	895,338	899,286	915,636	899,163	900,379	886,211
CH ₄ (including LULUCF)	4,847	4,611	4,465	4,485	4,327	4,233	4,128	3,954	3,743	3,717	3,544	3,398	3,240	3,106	2,904
CH ₄ (not including LULUCF)	4,812	4,576	4,429	4,450	4,292	4,198	4,093	3,919	3,708	3,682	3,509	3,364	3,205	3,071	2,869
N ₂ O (including LULUCF)	221	212	216	206	209	207	212	202	159	147	147	152	149	148	155
N ₂ O (not including LULUCF)	218	210	213	204	207	205	209	199	156	144	145	149	147	145	153
HFC (CO ₂ -eq.)	5,891	5,415	5,638	7,833	8,010	8,217	7,528	8,131	8,710	8,834	7,806	9,129	9,902	9,319	9,618
PFC (CO ₂ -eq.)	3,060	2,655	2,408	2,258	1,920	2,087	2,043	1,656	1,784	1,487	959	872	948	1,018	980
SF ₆ (CO ₂ -eq.)	4,428	4,746	5,238	5,974	6,249	6,467	6,162	6,109	5,889	4,290	4,072	3,752	3,087	3,034	3,244
NF ₃ (CO ₂ -eq.)	7	7	7	7	7	5	7	8	8	7	9	8	12	19	23
NO _x	2,887	2,644	2,498	2,391	2,203	2,168	2,096	2,030	2,007	1,982	1,928	1,851	1,773	1,717	1,650
SO ₂	5,485	3,969	3,241	2,905	2,418	1,745	1,476	1,226	980	800	644	623	560	532	491
NM VOC	3,389	2,904	2,669	2,517	2,106	2,025	1,957	1,931	1,890	1,746	1,599	1,497	1,429	1,359	1,367
CO	12,498	10,270	8,886	8,088	6,732	6,436	5,984	5,848	5,405	5,061	4,790	4,614	4,340	4,159	3,923
Emissions development (kt)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015				
Net CO ₂ emissions / removals	852,192	863,298	837,241	833,178	768,816	814,391	795,156	800,967	819,417	778,240	775,753				
CO ₂ emissions (not including LULUCF)	865,866	877,369	850,743	853,592	788,510	832,437	812,577	817,145	835,459	794,829	792,054				
CH ₄ (including LULUCF)	2,774	2,618	2,526	2,488	2,399	2,365	2,320	2,346	2,321	2,275	2,259				
CH ₄ (not including LULUCF)	2,739	2,583	2,491	2,453	2,364	2,330	2,285	2,311	2,287	2,240	2,225				
N ₂ O (including LULUCF)	148	147	154	156	153	126	131	128	130	132	134				
N ₂ O (not including LULUCF)	146	145	151	153	150	123	128	125	127	129	131				
HFC (CO ₂ -eq.)	9,940	10,162	10,448	10,589	11,170	10,753	10,953	11,140	11,096	11,183	11,356				
PFC (CO ₂ -eq.)	839	671	589	568	407	346	279	243	257	235	254				
SF ₆ (CO ₂ -eq.)	3,320	3,242	3,181	2,971	2,924	3,100	3,163	3,155	3,261	3,396	3,562				
NF ₃ (CO ₂ -eq.)	34	28	12	30	29	61	61	35	16	20	12				
NO _x	1,575	1,558	1,486	1,412	1,311	1,334	1,314	1,271	1,267	1,220	1,186				
SO ₂	472	473	456	453	396	409	399	381	373	357	352				
NM VOC	1,311	1,316	1,252	1,197	1,101	1,216	1,130	1,105	1,092	1,016	1,020				
CO	3,718	3,621	3,503	3,398	2,952	3,317	3,230	2,855	2,828	2,715	2,678				

Table 527: Changes in emissions of direct and indirect greenhouse gases and SO₂ in Germany, since 1990

Emissions Trends																										
Changes compared to base year (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Net CO ₂ emissions/removals	0.0	-3.5	-8.3	-9.2	-11.2	-11.4	-9.4	-12.2	-13.0	-15.8	-15.7	-14.1	-12.4	-12.4	-14.1	-16.4	-15.3	-17.9	-18.3	-24.6	-20.1	-22.0	-21.4	-19.6	-23.6	-23.9
CO ₂ emissions (without LULUCF)	0.0	-3.6	-8.2	-9.1	-10.7	-10.8	-8.9	-11.5	-12.3	-14.9	-14.5	-13.0	-14.5	-14.4	-15.8	-17.7	-16.6	-19.1	-18.9	-25.1	-20.9	-22.8	-22.3	-20.6	-24.5	-24.7
CH ₄ (including LULUCF)	0.0	-4.9	-7.9	-7.5	-10.7	-12.7	-14.8	-18.4	-22.8	-23.3	-26.9	-29.9	-33.1	-35.9	-40.1	-42.8	-46.0	-47.9	-48.7	-50.5	-51.2	-52.1	-51.6	-52.1	-53.1	-53.4
N ₂ O (including LULUCF)	0.0	-3.8	-2.3	-6.5	-5.2	-6.1	-4.2	-8.6	-28.2	-33.4	-33.3	-31.2	-32.5	-33.0	-29.8	-32.8	-33.2	-30.3	-29.5	-30.7	-42.9	-40.7	-42.0	-41.1	-40.1	-39.3
HFC						0.0	-8.4	-1.0	+6.0	+7.5	-5.0	+11.1	+20.5	+13.4	+17.0	+21.0	+23.7	+27.1	+28.9	+35.9	+30.9	+33.3	+35.6	+35.0	+36.1	+38.2
PFC						0.0	-2.1	-20.7	-14.5	-28.8	-54.1	-58.2	-54.6	-51.2	-53.1	-59.8	-67.9	-71.8	-72.8	-80.5	-83.4	-86.6	-88.4	-87.7	-88.8	-87.8
SF ₆						0.0	-4.7	-5.5	-8.9	-33.7	-37.0	-42.0	-52.3	-53.1	-49.8	-48.7	-49.9	-50.8	-54.1	-54.8	-52.1	-51.1	-51.2	-49.6	-47.5	-44.9
NF ₃						0.0	+36.5	+48.4	+43.4	+26.4	+68.6	+47.8	+131.0	+266.3	+331.3	+552.0	+426.3	+127.3	+459.5	+449.8	+1061.4	+1057.1	+565.6	+203.0	+283.4	+124.7
Total Emissions/Removals with LULUCF	0.0	-3.9	-8.1	-8.9	-10.7	-11.1	-9.6	-12.5	-14.7	-17.5	-17.8	-16.6	-15.6	-16.0	-17.6	-19.9	-19.3	-21.5	-21.8	-27.3	-24.3	-25.9	-25.4	-23.9	-27.3	-27.4
Total Emissions without CO₂ from LULUCF	0.0	-4.0	-8.1	-8.8	-10.4	-10.6	-9.2	-12.0	-14.0	-16.7	-16.8	-15.7	-17.3	-17.6	-18.9	-20.9	-20.3	-22.5	-22.3	-27.7	-24.9	-26.5	-26.1	-24.6	-27.9	-28.1
NO _x	0.0	-8.4	-13.5	-17.2	-23.7	-24.9	-27.4	-29.7	-30.5	-31.3	-33.2	-35.9	-38.6	-40.5	-42.8	-45.5	-46.0	-48.5	-51.1	-54.6	-53.8	-54.5	-56.0	-56.1	-57.8	-58.9
SO ₂	0.0	-27.6	-40.9	-47.0	-55.9	-68.2	-73.1	-77.6	-82.1	-85.4	-88.3	-88.6	-89.8	-90.3	-91.0	-91.4	-91.4	-91.7	-91.7	-92.8	-92.5	-92.7	-93.1	-93.2	-93.5	-93.6
NM VOC	0.0	-14.3	-21.2	-25.7	-37.8	-40.2	-42.3	-43.0	-44.2	-48.5	-52.8	-55.8	-57.8	-59.9	-59.7	-61.3	-61.2	-63.0	-64.7	-67.5	-64.1	-66.6	-67.4	-67.8	-70.0	-69.9
CO	0.0	-17.8	-28.9	-35.3	-46.1	-48.5	-52.1	-53.2	-56.8	-59.5	-61.7	-63.1	-65.3	-66.7	-68.6	-70.3	-71.0	-72.0	-72.8	-76.4	-73.5	-74.2	-77.2	-77.4	-78.3	-78.6

Table 528: Changes in emissions of direct and indirect greenhouse gases and SO₂ in Germany, since the relevant previous year

Emissions Trends																										
Changes compared to previous year (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Net CO ₂ emissions/removals	0.0	-3.5	-5.0	-1.0	-2.2	-0.2	+2.2	-3.1	-0.9	-3.2	+0.2	+1.8	+2.0	-0.1	-1.9	-2.6	+1.3	-3.0	-0.5	-7.7	+5.9	-2.4	+0.7	+2.3	-5.0	-0.3
CO ₂ emissions (without LULUCF)	0.0	-3.6	-4.8	-1.0	-1.8	-0.1	+2.2	-2.9	-0.9	-3.0	+0.4	+1.8	-1.8	+0.1	-1.6	-2.3	+1.3	-3.0	+0.3	-7.6	+5.6	-2.4	+0.6	+2.2	-4.9	-0.3
CH ₄ (including LULUCF)	0.0	-4.9	-3.2	+0.5	-3.5	-2.2	-2.5	-4.2	-5.3	-0.7	-4.7	-4.1	-4.7	-4.1	-6.5	-4.5	-5.6	-3.5	-1.5	-3.6	-1.4	-1.9	+1.1	-1.0	-2.0	-0.7
N ₂ O (including LULUCF)	0.0	-3.8	+1.6	-4.3	+1.4	-0.9	+2.1	-4.6	-21.4	-7.2	+0.1	+3.2	-1.8	-0.9	+4.9	-4.4	-0.6	+4.4	+1.1	-1.7	-17.5	+3.8	-2.1	+1.5	+1.7	+1.3
HFC	0.0	-8.1	+4.1	+38.9	+2.3	+2.6	-8.4	+8.0	+7.1	+1.4	-11.6	+16.9	+8.5	-5.9	+3.2	+3.4	+2.2	+2.8	+1.3	+5.5	-3.7	+1.9	+1.7	-0.4	+0.8	+1.5
PFC	0.0	-13.2	-9.3	-6.2	-15.0	+8.7	-2.1	-19.0	+7.8	-16.6	-35.5	-9.0	+8.7	+7.4	-3.8	-14.3	-20.1	-12.1	-3.7	-28.3	-15.1	-19.4	-13.0	+6.1	-8.8	+8.1
SF ₆	0.0	+7.2	+10.4	+14.0	+4.6	+3.5	-4.7	-0.9	-3.6	-27.2	-5.1	-7.9	-17.7	-1.7	+6.9	+2.4	-2.4	-1.9	-6.6	-1.6	+6.0	+2.0	-0.3	+3.4	+4.1	+4.9
NF ₃	0.0	+0.0	+0.0	+0.0	+0.0	-23.1	+36.5	+8.7	-3.4	-11.9	+33.4	-12.3	+56.2	+58.6	+17.7	+51.2	-19.3	-56.8	+146.2	-1.7	+111.2	-0.4	-42.5	-54.5	+26.5	-41.4
Total Emissions/Removals with LULUCF	0.0	-3.7	-4.4	-0.8	-2.1	-0.4	+1.6	-3.2	-2.4	-3.3	-0.4	+1.4	+1.3	-0.5	-1.9	-2.8	+0.7	-2.7	-0.5	-7.0	+4.1	-2.0	+0.6	+2.0	-4.5	-0.2
Total Emissions without CO₂ from LULUCF	0.0	-3.8	-4.2	-0.8	-1.7	-0.3	+1.6	-3.0	-2.3	-3.1	-0.2	+1.4	-2.0	-0.3	-1.6	-2.5	+0.7	-2.7	+0.2	-6.9	+3.8	-2.1	+0.5	+2.0	-4.3	-0.3
NO _x	0.0	-8.4	-5.5	-4.3	-7.8	-1.6	-3.3	-3.1	-1.2	-1.2	-2.7	-4.0	-4.2	-3.2	-3.9	-4.6	-1.1	-4.7	-5.0	-7.1	+1.8	-1.5	-3.3	-0.3	-3.7	-2.7
SO ₂	0.0	-27.6	-18.3	-10.4	-16.7	-27.9	-15.4	-16.9	-20.1	-18.4	-19.4	-3.3	-10.2	-4.9	-7.7	-4.0	+0.3	-3.5	-0.7	-12.5	+3.2	-2.5	-4.5	-2.2	-4.3	-1.4
NM VOC	0.0	-14.3	-8.1	-5.7	-16.3	-3.9	-3.4	-1.3	-2.1	-7.6	-8.4	-6.4	-4.5	-4.9	+0.6	-4.1	+0.4	-4.9	-4.4	-8.1	+10.5	-7.0	-2.3	-1.2	-6.9	+0.4
CO	0.0	-17.8	-13.5	-9.0	-16.8	-4.4	-7.0	-2.3	-7.6	-6.4	-5.4	-3.7	-5.9	-4.2	-5.7	-5.2	-2.6	-3.3	-3.0	-13.1	+12.4	-2.6	-11.6	-1.0	-4.0	-1.4

Table 529: Changes in greenhouse-gas emissions in Germany, by categories, since 1990 / since the relevant previous year

Emissions change with respect to 1990 (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Energy	0.0%	-3.6%	-8.3%	-9.1%	-11.3%	-11.5%	-9.5%	-12.5%	-13.4%	-15.8%	-16.1%	-14.1%	-15.7%	-16.2%	-17.8%	-19.8%	-18.8%	-21.4%	-20.9%	-26.5%	-22.7%	-24.6%	-24.0%	-22.2%	-26.3%	-26.5%
2. Industrial processes	0.0%	-4.0%	-4.0%	-2.9%	2.6%	0.7%	-1.2%	-0.9%	-15.2%	-23.6%	-20.4%	-23.6%	-24.9%	-20.8%	-18.7%	-21.9%	-21.6%	-20.4%	-24.3%	-32.2%	-35.3%	-35.4%	-36.4%	-36.5%	-36.4%	-36.3%
3. Agriculture	0.0%	-9.6%	-12.7%	-14.0%	-16.4%	-14.6%	-14.6%	-15.8%	-15.8%	-14.7%	-15.1%	-15.7%	-18.3%	-19.5%	-19.6%	-20.3%	-21.4%	-22.1%	-19.2%	-20.0%	-21.0%	-18.9%	-19.5%	-18.0%	-16.3%	-15.9%
4. Land use, land-use changes & forestry (N ₂ O & CH ₄)	0.0%	-8.0%	-6.2%	-6.5%	3.9%	5.6%	5.8%	9.1%	10.3%	13.7%	21.2%	23.2%	-86.5%	-80.0%	-70.1%	-61.5%	-60.3%	-62.1%	-40.1%	-42.4%	-47.7%	-49.8%	-53.8%	-54.2%	-52.5%	-53.4%
5. Waste	0.0%	3.7%	5.2%	4.8%	2.7%	0.1%	-3.6%	-11.2%	-16.7%	-20.8%	-24.7%	-29.0%	-32.6%	-36.5%	-40.2%	-44.0%	-48.4%	-51.8%	-55.0%	-58.3%	-61.2%	-63.3%	-65.2%	-67.4%	-68.9%	-70.5%
Emissions change, in each case with respect to the previous year; change in %	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Energy	0.0%	-3.6%	-4.9%	-1.0%	-2.4%	-0.2%	2.3%	-3.3%	-1.1%	-2.7%	-0.4%	2.3%	-1.8%	-0.5%	-2.0%	-2.4%	1.2%	-3.1%	0.6%	-7.1%	5.2%	-2.5%	0.9%	2.3%	-5.2%	-0.3%
2. Industrial processes	0.0%	-4.0%	0.0%	1.1%	5.7%	-1.8%	-1.9%	0.3%	-14.4%	-9.9%	4.1%	-4.0%	-1.6%	5.4%	2.6%	-3.9%	0.3%	1.6%	-4.9%	-10.5%	-4.5%	-0.1%	-1.6%	-0.2%	0.1%	0.1%
3. Agriculture	0.0%	-9.6%	-3.4%	-1.5%	-2.8%	2.2%	0.0%	-1.3%	0.0%	1.2%	-0.4%	-0.6%	-3.1%	-1.5%	-0.1%	-0.9%	-1.4%	-0.9%	3.8%	-1.0%	-1.3%	2.7%	-0.7%	1.8%	2.1%	0.5%
4. Land use, land-use changes & forestry (N ₂ O & CH ₄)	0.0%	-8.0%	2.0%	-0.3%	11.2%	1.6%	0.2%	3.1%	1.1%	3.1%	6.6%	1.6%	-89.0%	47.5%	49.8%	28.8%	3.2%	-4.6%	58.1%	-3.9%	-9.2%	-3.9%	-8.0%	-1.0%	3.8%	-2.0%
5. Waste	0.0%	3.7%	1.5%	-0.4%	-2.0%	-2.5%	-3.7%	-7.9%	-6.1%	-5.0%	-5.0%	-5.6%	-5.0%	-5.8%	-5.9%	-6.3%	-7.8%	-6.6%	-6.7%	-7.2%	-7.2%	-5.3%	-5.4%	-6.1%	-4.6%	-5.1%

22.4 Recalculations: detailed consideration on the basis of CRF Table 8

The following tables provide a numerical overview of the revised emissions figures for the years 1990 and 2014, pursuant to CRF tables 8s1 through 8s4 of the current CRF submission. For remarks regarding the reworked revisions for the 2015 submission, please refer to Chapter 10.1 of the present report and to the relevant category-specific chapters.

22.4.1 Overview for report year 1990

Table 530: Detailed numerical overview of the revised CO₂ emissions for 1990

Carbon dioxide CO ₂	Re2016	2017	Change	Effect on total EM		
					not includ- ing LULUCF	includ- ing LULUCF
		[kt]			[%]	
National total emissions and removals	1,019,252.80	1,019,229.00	-23.81	-0.002	-0.002	-0.002
1. Energy	989,769.47	989,771.64	2.17	0.000	0.000	0.000
A. Combustion of fuels	985,704.89	985,704.89	0.00	0.000	0.000	0.000
1. Energy generation	423,905.78	423,905.78	0.00	0.000	0.000	0.000
2. Manufacturing	185,088.53	185,107.47	18.93	0.010	0.002	0.002
3. Transport	161,882.41	161,882.41	0.00	0.000	0.000	0.000
4. Other sectors	203,030.67	203,011.74	-18.93	-0.009	-0.002	-0.002
5. Other	11,797.50	11,797.50	0.00	0.000	0.000	0.000
B. Fugitive emissions from fuels	4,064.58	4,066.75	2.17	0.053	0.000	0.000
1. Solid fuels	1,832.80	1,832.80	0.00	0.000	0.000	0.000
2. Oil and natural gas	2,231.78	2,233.94	2.17	0.097	0.000	0.000
2. Industrial processes & product use	59,285.15	59,291.55	6.40	0.011	0.001	0.001
C. Metal production	25,073.48	25,079.88	6.40	0.026	0.001	0.001
3. Agriculture	3,183.61	3,183.61	0.00	0.000	0.000	0.000
4. Land use, land-use changes, forestry	-32,985.43	-33,017.81	-32.38	0.098		-0.003
A. Forest land	-75,539.23	-75,542.09	-2.85	0.004		0.000
B. Cropland	12,469.90	12,436.44	-33.46	-0.268		-0.003
C. Grassland	25,538.08	25,543.59	5.50	0.022		0.001
D. Wetlands	4,064.27	4,063.95	-0.32	-0.008		0.000
E. Settlements	1,811.90	1,810.65	-1.25	-0.069		0.000
5. Waste & wastewater	NO,NA,NE	NE,NA,NO				
6. Other	NA	NA				
and, reported for information purposes only:						
International transports	18,364.98	18,364.98	0.00	0.000	0.000	0.000
Multilateral operations	NA	NO				
CO₂ from biomass	21,793.87	22,101.38	307.51	1.411	0.029	0.030

Table 531: Detailed numerical overview of the revised CH₄ emissions for 1990

Methane CH ₄	Re2016	2017	Change	Effect on total EM		
				<i>not includ- ing LULUCF</i>	<i>includ- ing LULUCF</i>	
				[kt CO ₂ -eq.]		
				[%]		
Total national emissions	120,110	121,169	1,059	0.881	0.880	0.874
1. Energy	39,174	40,224	1,050	2.680	0.873	0.867
A. Combustion of fuels	5,270	6,324	1,055	20.014	0.877	0.870
1. Energy generation	280	280	0	0.000	0.000	0.000
2. Manufacturing	250	250	0	0.012	0.000	0.000
3. Transport	1,329	1,329	0	-0.014	0.000	0.000
4. Other sectors	3,131	4,186	1,055	33.694	0.877	0.871
5. Other	279	279	0	0.000	0.000	0.000
B. Fugitive emissions from fuels	33,904	33,899	-5	-0.014	-0.004	-0.004
2. Oil and natural gas	8,351	8,346	-5	-0.057	-0.004	-0.004
2. Industrial processes & product use	343	351	9	2.502	0.007	0.007
C. Metal production	5	13	9	183.923	0.007	0.007
3. Agriculture	42,737	42,737	0	0.000	0.000	0.000
4. Land use, land-use changes, forestry	876	876	0	0.000		0.000
E. Settlements	NO	24	24	100.000		0.020
H. Other	24	NO,IE	-24	-100.000		-0.020
5. Waste & wastewater	36,981	36,981	0	0.000	0.000	0.000
6. Other	NA	NA				
and, reported for information purposes only:						
International transports	3	3	0	0.000	0.000	0.000
Multilateral operations	NA	NO				

Table 532: Detailed numerical overview of the revised N₂O emissions for 1990

Nitrous oxide N ₂ O	Re2016	2017	Change	Effect on total EM		
				not including LULUCF	including LULUCF	
				[kt CO ₂ -eq.]		[%]
Total national emissions	66,019	65,820	-200	-0.302	-0.307	-0.303
1. Energy	6,741	6,741	0	0.001	0.000	0.000
A. Combustion of fuels	6,740	6,740	0	0.001	0.000	0.000
1. Energy generation	3,167	3,167	0	0.000	0.000	0.000
2. Manufacturing	1,342	1,343	0	0.016	0.000	0.000
3. Transport	1,193	1,192	0	-0.036	-0.001	-0.001
4. Other sectors	976	976	0	0.029	0.000	0.000
5. Other	61	61	0	0.000	0.000	0.000
B. Fugitive emissions from fuels	1	1	0	0.000	0.000	0.000
1. Solid fuels	NA	NA				
2. Oil and natural gas	1	1	0	0.000	0.000	0.000
2. Industrial processes & product use	23,614	23,614	0	0.001	0.000	0.000
C. Metal production	27	27	0	1.039	0.000	0.000
3. Agriculture	33,849	33,661	-188	-0.557	-0.290	-0.286
D. Agricultural soils	28,764	28,575	-188	-0.655	-0.290	-0.286
4. Land use, land-use changes, forestry	830	830	0	0.000		0.000
C. Grassland	2	87	86	5,728		0.131
H. Other	139	53	-86	-61.943		-0.131
5. Waste & wastewater	986	974	-11	-1.159	-0.018	-0.017
D. Wastewater treatment	970	958	-11	-1.178	-0.018	-0.017
6. Other	NA	NA				
and, reported for information purposes only:						
International transports	194	194	0	0.000	0.000	0.000
Multilateral operations	NA	NO				
Indirect N ₂ O	NA,NO,IE	NO,IE				

Table 533: Detailed numerical overview of the revised HFC emissions for 1990

HFCs	Re2016	2017	Change	Effect on total EM		
				<i>not including LULUCF</i>	<i>including LULUCF</i>	
				[kt CO ₂ -eq.]	[%]	
Total national emissions	50.32	50.32	0.00	0.000	0.000	0.000
2.B.9. Production of PFC & SF ₆	C	IE				
2.E.1. Electronics industry	50.32	50.32	0.00	0.000	0.000	0.000
2.F.2. Foam production	C, NO	NO, IE				
2.F.4. Aerosols	C, NO	NO, IE				
2.F.5. Solvents	C	IE				

Table 534: Detailed numerical overview of the revised PFC emissions for 1990

PFCs	Re2016	2017	Change	Effect on total EM		
				not including LULUCF	including LULUCF	
		[kt CO ₂ -eq.]		[%]		
Total national emissions	3,060.23	3,060.42	0.18	0.01	0.01	0.01
2.E.4. Heat transfer fluids	C	0.18	0.18	100.00	0.01	0.01

Table 535: Detailed numerical overview of the revised SF₆ emissions for 1990

Sulphur hexafluoride SF ₆	Re-Subm.	Subm.	Change	Effect on total EM		
	2016	2017		not including LULUCF	including LULUCF	
		[kt CO ₂ -eq.]		[%]		
Total national emissions	4,343.64	4,428.00	84.36	1.94	1.91	1.91
2.E.1. Electronics industry	NO	84.36	84.36	100.00	1.91	1.91

Table 536: Detailed numerical overview of the revised *unspecified-mix* emissions for 1990

Unspecified mix of HFCs and PFCs	Re2016	2017	Change	Effect on total EM		
				not including LULUCF	including LULUCF	
		[kt CO ₂ -eq.]		[%]		
Total national emissions	5,705.72	5,840.68	134.96	2.37	3.05	3.05
2.H. Other	138.64	273.60	134.96	97.34	3.05	3.05

Table 537: Detailed numerical overview of the revised NF₃ emissions for 1990

Nitrogen trifluoride NF ₃	Re2016	2017	Change	Effect on total EM		
				not including LULUCF	including LULUCF	
		[kt CO ₂ -eq.]		[%]		
Total national emissions	6.88	6.88	0.00	0.00	0.00	0.00
2.C.3. Aluminium production	NA	NO				
2.E.1. Electronics industry	6.88	6.88	0.00	0.00	0.00	0.00

22.4.2 Overview for report year 2014

Table 538: Detailed numerical overview of the revised CO₂ emissions for 2014

Carbon dioxide CO ₂	Re2016	2017	Change	Effect on total EM		
				not including LULUCF	including LULUCF	
		[kt]		[%]		
National total emissions and removals	1,019,253	1,019,229	-23.81	-0.002	-0.002	-0.002
1. Energy	989,769	989,772	2.17	0.000	0.000	0.000
A. Combustion of fuels	985,705	985,705	0.00	0.000	0.000	0.000
1. Energy generation	423,906	423,906	0.00	0.000	0.000	0.000
2. Manufacturing	185,089	185,107	18.93	0.010	0.002	0.002
3. Transport	161,882	161,882	0.00	0.000	0.000	0.000
4. Other sectors	203,031	203,012	-18.93	-0.009	-0.002	-0.002
5. Other	11,797	11,797	0.00	0.000	0.000	0.000
B. Fugitive emissions from fuels	4,065	4,067	2.17	0.053	0.000	0.000
1. Solid fuels	1,833	1,833	0.00	0.000	0.000	0.000
2. Oil and natural gas	2,232	2,234	2.17	0.097	0.000	0.000
2. Industrial processes & product use	59,285	59,292	6.40	0.011	0.001	0.001
C. Metal production	25,073	25,080	6.40	0.026	0.001	0.001
3. Agriculture	3,184	3,184	0.00	0.000	0.000	0.000
I. Other C-containing fertilisers	NO	IE				
4. Land use, land-use changes, forestry	-32,985	-33,018	-32.38	0.098		-0.003
A. Forest land	-75,539	-75,542	-2.85	0.004		0.000
B. Cropland	12,470	12,436	-33.46	-0.268		-0.003
C. Grassland	25,538	25,544	5.50	0.022		0.001
D. Wetlands	4,064	4,064	-0.32	-0.008		0.000
E. Settlements	1,812	1,811	-1.25	-0.069		0.000
5. Waste & wastewater	NO,NA,NE	NE,NA,NO				
6. Other	NA	NA				
and, reported for information purposes only:						
International transports	18,365	18,365	0.00	0.000	0.000	0.000
Multilateral operations	NA	NO				
CO₂ from biomass	21,794	22,101	307.51	1.411	0.029	0.030

Table 539: Detailed numerical overview of the revised CH₄ emissions for 2014

Methane CH₄	Re2016	2017	Change	Effect on total EM		
					not including LULUCF	including LULUCF
	[kt CO ₂ -eq.]				[%]	
Total national emissions	120,110	121,169	1,059	0.881	0.880	0.874
1. Energy	39,174	40,224	1,050	2.680	0.873	0.867
A. Combustion of fuels	5,270	6,324	1,055	20.014	0.877	0.870
1. Energy generation	280	280	0	0.000	0.000	0.000
2. Manufacturing	250	250	0	0.012	0.000	0.000
3. Transport	1,329	1,329	0	-0.014	0.000	0.000
4. Other sectors	3,131	4,186	1,055	33.694	0.877	0.871
5. Other	279	279	0	0.000	0.000	0.000
B. Fugitive emissions from fuels	33,904	33,899	-5	-0.014	-0.004	-0.004
2. Oil and natural gas	8,351	8,346	-5	-0.057	-0.004	-0.004
2. Industrial processes & product use	343	351	9	2.502	0.007	0.007
C. Metal production	5	13	9	183.923	0.007	0.007
3. Agriculture	42,737	42,737	0	0.000	0.000	0.000
4. Land use, land-use changes, forestry	876	876	0	0.000		0.000
E. Settlements	NO	24	24	100.000		0.020
H. Other	24	NO, IE	-24	-100.000		-0.020
5. Waste & wastewater	36,981	36,981	0	0.000	0.000	0.000
and, reported for information purposes only:						
International transports	3	3	0	0.000	0.000	0.000
Multilateral operations	NA	NO				

Table 540: Detailed numerical overview of the revised N₂O emissions for 2014

Nitrous oxide N₂O	Re2016	2017	Change	Effect on total EM		
					not including LULUCF	including LULUCF
	[kt CO ₂ -eq.]				[%]	
Total national emissions	66,019	65,820	-200	-0.302	-0.307	-0.303
1. Energy	6,741	6,741	0	0.001	0.000	0.000
A. Combustion of fuels	6,740	6,740	0	0.001	0.000	0.000
1. Energy generation	3,167	3,167	0	0.000	0.000	0.000
2. Manufacturing	1,342	1,343	0	0.016	0.000	0.000
3. Transport	1,193	1,192	0	-0.036	-0.001	-0.001
4. Other sectors	976	976	0	0.029	0.000	0.000
5. Other	61	61	0	0.000	0.000	0.000
2. Industrial processes & product use	23,614	23,614	0	0.001	0.000	0.000
3. Agriculture	33,849	33,661	-188	-0.557	-0.290	-0.286
D. Agricultural soils	28,764	28,575	-188	-0.655	-0.290	-0.286
4. Land use, land-use changes, forestry	830	830	0	0.000		0.000
C. Grassland	2	87	86	5,729		0.131
H. Other	139	53	-86	-61.943		-0.131
5. Waste & wastewater	986	974	-11	-1.159	-0.018	-0.017
D. Wastewater treatment	970	958	-11	-1.178	-0.018	-0.017
6. Other	NA	NA				

Table 541: Detailed numerical overview of the revised HFC emissions for 2014

HFCs	Re2016	2017	Change	Effect on total EM		
					not including LULUCF	including LULUCF
	[kt CO ₂ -eq.]				[%]	
Total national emissions	50.32	50.32	0.00	0.000	0.000	0.000
2.B.9. Production of PFC & SF ₆	C	IE				
2.F.2. Foam production	C, NO	NO, IE				
2.F.4. Aerosols	C, NO	NO, IE				
2.F.5. Solvents	C	IE				

Table 542: Detailed numerical overview of the revised PFC emissions for 2014

PFCs	Re2016	2017	Change	Effect on total EM		
				not including LULUCF	including LULUCF	
				[kt CO ₂ -eq.]	[%]	
Total national emissions	3,060.23	3,060.42	0.18	0.01	0.006	0.006
2.E.4. Heat transfer fluids	C	0.18	0.18	100.00	0.006	0.006

Table 543: Detailed numerical overview of the revised SF₆ emissions for 2014

Sulphur hexafluoride SF ₆	Re2016	2017	Change	Effect on total EM		
				not includ- ing LULUCF	includ- ing LULUCF	
				[kt CO ₂ -eq.]	[%]	
Total national emissions	4,343.64	4,428.00	84.36	1.94	1.91	1.91
2.E.1. Electronics industry	NO	84.36	84.36	100.00	1.91	1.91

Table 544: Detailed numerical overview of the revised *unspecified-mix* emissions for 2014

Unspecified mix of HFCs and PFCs	Re2016	2017	Change	Effect on total EM		
				<i>not includ- ing LULUCF</i>	<i>includ- ing LULUCF</i>	
				[kt CO ₂ -eq.]	[%]	
Total national emissions	5,705.72	5,840.68	134.96	2.37	3.05	3.05
2.B.10. Other: EM from other production processes	NA	NO				
2.H. Other	138.64	273.60	134.96	97.34	3.05	3.05

Table 545: Detailed numerical overview of the revised NF₃ emissions for 2014

Nitrogen trifluoride NF ₃	Re2016	2017	Change	Effect on total EM	
				<i>not including LULUCF</i>	<i>including LULUCF</i>
		[kt CO ₂ -eq.]			[%]
Total national emissions	6.88	6.88	0.00	0.00	0.00

23 Annex 7: Table 6.1 of the IPCC Good Practice Guidance

The uncertainties for the German greenhouse-gas inventories have been determined completely, for all categories.

Efforts in this area, which began with determination of uncertainties pursuant to Tier 1, are being carried out by data-supplying experts of Federal Environment Agency departments and by external institutions.

At the same time, additional uncertainties have been determined via experts' assessments and added to the CSE database. An uncertainties data set is now available in which most of the uncertainties have been determined via expert estimation. In cases in which experts' assessments are not yet available, a complete data set is obtained by adopting uncertainties from data reported

in the relevant technical literature. The expert assessment process is being continued, systematically and completely.

Germany carries out Tier 2 uncertainties analysis every 3 years.

The results of this year's Tier 1 uncertainties analysis are shown, in keeping with the specifications given in Table 3.2 of the 2006 IPCC Guidelines, in Table 546.

Table 546: Table 6.1 of the IPCC Good Practice Guidance – details

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC category	Gas	Base year emissions or removals	Year x emissions or removals	Activity data uncertainty	Emission factor / estimation parameter uncertainty	Combined uncertainty	Contribution to Variance by Category in Year x	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor / estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input data	Input data	Input data	Input data	$\sqrt{E^2 + F^2}$	$\frac{(G \times D)^2}{(\sum D)^2}$	Note B	$\left \frac{D}{\sum C} \right $	$I * F$	$J * E * \sqrt{2}$	$K^2 + L^2$
		kt CO ₂ equivalent	kt CO ₂ equivalent	%	%	%		%	%	%	%	%
1 A 1 a	Methane	244770.58	2559966.75	0.0000	71.0906	71.0906	3.26E-02	1.90E-03	2.06E-03	2.07E-01	0.00E+00	4.27E-02
1 A 1 a	Carbon dioxide	304600122.51	301705650.80	0.0000	4.6445	4.6445	1.93E+00	4.43E-02	2.42E-01	1.59E+00	0.00E+00	2.53E+00
1 A 1 a	Nitrous oxide	2109962.22	2423300.96	0.0000	20.7043	20.7043	2.48E-03	5.75E-04	1.95E-03	5.70E-02	0.00E+00	3.25E-03
1 A 1 b	Carbon dioxide	19131150.13	18154030.06	0.0000	5.7356	5.7356	1.07E-02	2.15E-03	1.46E-02	1.18E-01	0.00E+00	1.40E-02
1 A 1 b	Methane	14926.14	13704.45	0.0000	17.1506	17.1506	5.44E-08	1.31E-06	1.10E-05	2.67E-04	0.00E+00	7.2E-08
1 A 1 b	Nitrous oxide	62566.66	55832.25	0.0000	30.2204	30.2204	2.80E-06	4.19E-06	4.48E-05	1.92E-03	0.00E+00	3.67E-06
1 A 1 c	Methane	135624.34	171852.71	0.0000	137.7831	137.7831	5.52E-04	4.99E-05	1.38E-04	2.69E-02	0.00E+00	7.23E-04
1 A 1 c	Nitrous oxide	357751.55	154231.64	0.0000	21.9779	21.9779	1.13E-05	1.09E-04	1.24E-04	3.85E-03	0.00E+00	1.48E-05
1 A 1 c	Carbon dioxide	40220524.02	10157932.32	0.0000	5.5004	5.5004	3.08E-03	1.80E-02	8.16E-03	6.34E-02	0.00E+00	4.02E-03
1 A 2 a	Methane	61215.46	68610.95	0.0000	27.3973	27.3973	3.48E-06	1.53E-05	5.51E-05	2.13E-03	0.00E+00	4.56E-06
1 A 2 a	Nitrous oxide	118100.49	118516.09	0.0000	37.0079	37.0079	1.90E-05	1.85E-05	9.52E-05	4.98E-03	0.00E+00	2.48E-05
1 A 2 a	Carbon dioxide	33097558.64	38576031.16	0.0000	6.1025	6.1025	5.46E-02	9.47E-03	3.10E-02	2.67E-01	0.00E+00	7.15E-02
1 A 2 b	Carbon dioxide	2051868.53	1513285.75	0.0000	11.3486	11.3486	2.91E-04	1.18E-04	1.22E-03	1.95E-02	0.00E+00	3.80E-04
1 A 2 b	Methane	1730.36	1693.81	0.0000	71.4351	71.4351	1.44E-08	2.36E-07	1.36E-06	1.37E-04	0.00E+00	1.89E-08
1 A 2 b	Nitrous oxide	13862.87	7679.60	0.0000	67.9640	67.9640	2.68E-07	2.84E-06	6.17E-06	5.93E-04	0.00E+00	3.51E-07
1 A 2 d	Carbon dioxide	6869.00	6074.31	0.0000	5.6766	5.6766	1.17E-09	4.16E-07	4.88E-06	3.92E-05	0.00E+00	1.53E-09
1 A 2 d	Methane	1099.83	2891.88	0.0000	44.5671	44.5671	1.64E-08	1.61E-06	2.32E-06	1.46E-04	0.00E+00	2.14E-08
1 A 2 d	Nitrous oxide	4719.59	12409.61	0.0000	53.4099	53.4099	4.33E-07	6.90E-06	9.96E-06	7.53E-04	0.00E+00	5.66E-07
1 A 2 e	Carbon dioxide	1986645.42	290202.10	0.0000	5.4817	5.4817	2.49E-06	1.06E-03	2.33E-04	1.81E-03	0.00E+00	3.26E-06
1 A 2 e	Methane	2040.08	222.68	0.0000	41.0938	41.0938	8.25E-11	1.15E-06	1.79E-07	1.04E-05	0.00E+00	1.08E-10
1 A 2 e	Nitrous oxide	18655.95	2548.03	0.0000	58.1220	58.1220	2.16E-08	1.01E-05	2.05E-06	1.68E-04	0.00E+00	2.83E-08
1 A 2 f	Carbon dioxide	18595352.46	13145432.17	0.0000	3.8463	3.8463	2.52E-03	1.52E-03	1.06E-02	5.74E-02	0.00E+00	3.30E-03
1 A 2 f	Methane	18003.83	15109.63	0.0000	22.9892	22.9892	1.19E-07	4.39E-07	1.21E-05	3.94E-04	0.00E+00	1.56E-07
1 A 2 f	Nitrous oxide	173555.06	119834.04	0.0000	26.9375	26.9375	1.03E-05	1.65E-05	9.62E-05	3.67E-03	0.00E+00	1.34E-05
1 A 2 g	Carbon dioxide	88738029.54	72445409.48	0.0000	3.7681	3.7681	7.34E-02	5.34E-04	5.82E-02	3.10E-01	0.00E+00	9.61E-02
1 A 2 g	Methane	138248.12	184921.34	0.0000	29.9210	29.9210	3.02E-05	5.87E-05	1.48E-04	6.28E-03	0.00E+00	3.95E-05
1 A 2 g	Nitrous oxide	645387.83	549897.32	0.0000	15.7638	15.7638	7.40E-05	2.24E-05	4.42E-04	9.84E-03	0.00E+00	9.69E-05
1 A 3 a	Carbon dioxide	2427698.79	2214546.94	7.4675	3.7345	8.3493	3.37E-04	2.01E-04	1.78E-03	9.39E-03	1.88E-02	4.41E-04
1 A 3 a	Methane	2395.22	1960.48	9.4256	94.3895	94.8590	3.41E-08	1.85E-08	1.57E-06	2.10E-04	2.10E-05	4.46E-08
1 A 3 a	Nitrous oxide	24289.81	22068.11	7.3026	109.5616	109.8047	5.79E-06	1.94E-06	1.77E-05	2.75E-03	1.83E-04	7.57E-06
1 A 3 b	Methane	728038.96	137835.66	0.0000	41.7476	41.7476	3.26E-05	3.62E-04	1.11E-04	6.53E-03	0.00E+00	4.27E-05
1 A 3 b	Nitrous oxide	1680885.54	1496893.49	0.0000	27.9911	27.9911	1.73E-03	1.10E-04	1.20E-03	4.76E-02	0.00E+00	2.26E-03
1 A 3 b	Carbon dioxide	166437327.50	152955140.73	0.0000	9.3944	9.3944	2.03E+00	1.47E-02	1.23E-01	1.63E+00	0.00E+00	2.66E+00
1 A 3 c	Carbon dioxide	2331398.96	919325.37	0.0000	10.1028	10.1028	8.50E-05	7.76E-04	7.38E-04	1.05E-02	0.00E+00	1.11E-04
1 A 3 c	Methane	1916.97	337.01	0.0000	32.0587	32.0587	1.15E-10	9.74E-07	2.71E-07	1.23E-05	0.00E+00	1.50E-10
1 A 3 c	Nitrous oxide	5332.48	2261.59	0.0000	67.2370	67.2370	2.28E-08	1.65E-06	1.82E-06	1.73E-04	0.00E+00	2.98E-08
1 A 3 d	Carbon dioxide	2851323.06	1798401.61	19.8951	1.9046	19.9861	1.27E-03	4.08E-04	1.44E-03	3.89E-03	4.06E-02	1.67E-03

Climate Change: National Inventory Report, Germany – 2017

A	B	C	D	E	F	G	H	I	J	K	L	M
1 A 3 d	Methane	1488.08	691.03	22.5225	23.9075	32.8456	5.08E-10	4.12E-07	5.55E-07	1.88E-05	1.77E-05	6.64E-10
1 A 3 d	Nitrous oxide	24755.59	17080.04	11.1949	81.5601	82.3248	1.95E-06	2.36E-06	1.37E-05	1.58E-03	2.17E-04	2.55E-06
1 A 3 e	Carbon dioxide	1323713.91	1223711.87	0.0000	2.9564	2.9564	1.29E-05	1.23E-04	9.83E-04	4.11E-03	0.00E+00	1.69E-05
1 A 3 e	Methane	6486.96	5975.34	0.0000	70.1704	70.1704	1.73E-07	5.85E-07	4.80E-06	4.76E-04	0.00E+00	2.27E-07
1 A 3 e	Nitrous oxide	17686.30	10686.49	0.0000	48.4665	48.4665	2.64E-07	2.91E-06	8.58E-06	5.88E-04	0.00E+00	3.46E-07
1 A 4 a	Carbon dioxide	53101145.13	34518831.77	0.0000	7.9031	7.9031	7.33E-02	6.77E-03	2.77E-02	3.10E-01	0.00E+00	9.60E-02
1 A 4 a	Methane	265194.18	25138.24	0.0000	166.5912	166.5912	1.73E-05	1.52E-04	2.02E-05	4.76E-03	0.00E+00	2.26E-05
1 A 4 a	Nitrous oxide	166142.06	81430.58	0.0000	91.3670	91.3670	5.45E-05	4.25E-05	6.54E-05	8.45E-03	0.00E+00	7.14E-05
1 A 4 b	Carbon dioxide	128972932.52	85363670.80	0.0000	8.3921	8.3921	5.06E-01	1.52E-02	6.85E-02	8.13E-01	0.00E+00	6.62E-01
1 A 4 b	Methane	873486.92	743802.11	0.0000	134.7899	134.7899	9.90E-03	2.99E-05	5.97E-04	1.14E-01	0.00E+00	1.30E-02
1 A 4 b	Nitrous oxide	457117.85	298309.77	0.0000	78.3521	78.3521	5.38E-04	5.74E-05	2.40E-04	2.65E-02	0.00E+00	7.04E-04
1 A 4 c	Carbon dioxide	7734555.97	5811678.63	0.0000	13.5356	13.5356	6.10E-03	3.57E-04	4.67E-03	8.93E-02	0.00E+00	7.98E-03
1 A 4 c	Methane	62006.05	361737.62	0.0000	71.7133	71.7133	6.63E-04	2.50E-04	2.90E-04	2.95E-02	0.00E+00	8.68E-04
1 A 4 c	Nitrous oxide	52293.62	77576.04	0.0000	90.1088	90.1088	4.81E-05	2.83E-05	6.23E-05	7.94E-03	0.00E+00	6.30E-05
1 A 5	Carbon dioxide	4004618.27	975849.12	0.0000	4.5899	4.5899	1.98E-05	1.82E-03	7.84E-04	5.09E-03	0.00E+00	2.59E-05
1 A 5	Methane	14035.80	1541.97	0.0000	33.6462	33.6462	2.65E-09	7.88E-06	1.24E-06	5.89E-05	0.00E+00	3.47E-09
1 A 5	Nitrous oxide	27281.32	4211.12	0.0000	85.2446	85.2446	1.27E-07	1.43E-05	3.38E-06	4.08E-04	0.00E+00	1.66E-07
1 B 1	Carbon dioxide	933058.59	704791.06	0.0000	36.0436	36.0436	6.36E-04	4.01E-05	5.66E-04	2.88E-02	0.00E+00	8.32E-04
1 B 1	Methane	19347784.96	3095942.83	0.0000	37.2430	37.2430	1.31E-02	1.01E-02	2.49E-03	1.31E-01	0.00E+00	1.71E-02
1 B 2 a	Carbon dioxide	279398.46	312829.25	0.0000	29.4296	29.4296	8.35E-05	6.97E-05	2.51E-04	1.05E-02	0.00E+00	1.09E-04
1 B 2 a	Methane	313308.42	229537.61	0.0000	27.2378	27.2378	3.85E-05	1.92E-05	1.84E-04	7.10E-03	0.00E+00	5.04E-05
1 B 2 b	Carbon dioxide	1762275.40	1152229.54	0.0000	22.3202	22.3202	6.52E-04	2.19E-04	9.25E-04	2.92E-02	0.00E+00	8.53E-04
1 B 2 b	Methane	8360911.40	4824670.52	0.0000	16.1665	16.1665	5.99E-03	1.56E-03	3.87E-03	8.86E-02	0.00E+00	7.84E-03
1 B 2 c	Carbon dioxide	437759.96	380508.75	0.0000	126.6476	126.6476	2.29E-03	2.12E-05	3.06E-04	5.47E-02	0.00E+00	2.99E-03
1 B 2 c	Methane	1851.64	2725.50	0.0000	37.2284	37.2284	1.01E-08	9.86E-07	2.19E-06	1.15E-04	0.00E+00	1.33E-08
1 B 2 c	Nitrous oxide	547.28	152.10	0.0000	15.2482	15.2482	5.30E-12	2.33E-07	1.22E-07	2.63E-06	0.00E+00	6.93E-12
2 A 1	Carbon dioxide	15408313.70	12377994.18	2.5000	2.0000	3.2016	1.55E-03	6.88E-05	9.94E-03	2.81E-02	3.51E-02	2.02E-03
2 A 2	Carbon dioxide	6159875.94	4976025.11	2.3922	10.5975	10.8641	2.88E-03	5.33E-06	4.00E-03	5.99E-02	1.35E-02	3.77E-03
2 A 3 glass	Carbon dioxide	881306.26	919846.90	0.0000	11.5999	11.5999	1.12E-04	1.66E-04	7.39E-04	1.21E-02	0.00E+00	1.47E-04
2 A 4 other	Carbon dioxide	759810.71	465408.70	0.0000	21.5359	21.5359	9.90E-05	1.20E-04	3.74E-04	1.14E-02	0.00E+00	1.30E-04
2 B 1	Carbon dioxide	6528000.00	4135000.00	0.0000	1.0000	1.0000	1.68E-05	9.20E-04	3.32E-03	4.70E-03	0.00E+00	2.20E-05
2 B 10	Nitrous oxide	C	C	C	C	C	C	C	C	C	C	C
2 B 2	Nitrous oxide	3325908.76	503578.77	1.0000	5.0000	5.0990	6.50E-06	1.76E-03	4.04E-04	2.86E-03	5.72E-04	8.50E-06
2 B 3	Nitrous oxide	20234334.32	250896.61	2.0000	6.0000	6.3246	2.48E-06	1.29E-02	2.01E-04	1.71E-03	5.70E-04	3.25E-06
2 B 5	Carbon dioxide	25806.00	7241.96	10.0000	10.0000	14.1421	1.03E-08	1.09E-05	5.81E-06	8.22E-05	8.22E-05	1.35E-08
2 B 7	Carbon dioxide	537004.51	456153.63	0.0000	2.5000	2.5000	1.28E-06	1.75E-05	3.66E-04	1.29E-03	0.00E+00	1.68E-06
2 B 8	Carbon dioxide	875017.08	972696.02	0.0000	18.0806	18.0806	3.05E-04	2.13E-04	7.81E-04	2.00E-02	0.00E+00	3.99E-04
2 B 8	Methane	428414.10	485327.35	16.1255	13.1191	20.7881	1.00E-04	1.11E-04	3.90E-04	7.23E-03	8.89E-03	1.31E-04
2 B 9	Sulphur hexafluoride	159600.00	96698.35	0.0000	3.0000	3.0000	8.29E-08	2.60E-05	7.76E-05	3.29E-04	0.00E+00	1.09E-07
2 B 9 a	HFC-23	C	C	C	C	C	C	C	C	C	C	C
2 B 9 b	HFC-134a	C	C	C	C	C	C	C	C	C	C	C
2 B 9 b	HFC-227ea	C	C	C	C	C	C	C	C	C	C	C
2 C 1	Methan	6997.29	5299.37	0.0000	67.3954	67.3954	1.26E-07	2.90E-07	4.25E-06	4.06E-04	0.00E+00	1.64E-07
2 C 1	Carbon dioxide	19270069.51	16731125.21	0.0000	8.3900	8.3900	1.94E-02	9.18E-04	1.34E-02	1.59E-01	0.00E+00	2.54E-02
2 C 1	Nitrous oxide	16777.50	16463.22	0.0000	59.2995	59.2995	9.39E-07	2.32E-06	1.32E-05	1.11E-03	0.00E+00	1.23E-06
2 C 2	Carbon dioxide	9107.45	5995.00	0.0000	50.4876	50.4876	9.03E-08	1.10E-06	4.81E-06	3.44E-04	0.00E+00	1.18E-07
2 C 2	Methane	2483.85	1635.00	0.0000	70.7107	70.7107	1.32E-08	3.00E-07	1.31E-06	1.31E-04	0.00E+00	1.72E-08
2 C 3	CF4	1544510.00	79102.56	0.0000	15.0000	15.0000	1.39E-06	9.40E-04	6.35E-05	1.35E-03	0.00E+00	1.82E-06
2 C 3	Sulphur hexafluoride	11400.00	15831.52	0.0000	50.0100	50.0100	6.18E-07	5.31E-06	1.27E-05	8.99E-04	0.00E+00	8.08E-07
2 C 3	C2F6	256200.00	15799.00	0.0000	15.0300	15.0300	5.56E-08	1.54E-04	1.27E-05	2.70E-04	0.00E+00	7.27E-08
2 C 3 a	Carbon dioxide	786025.00	740065.09	1.0000	50.0000	50.0100	1.35E-03	8.37E-05	5.94E-04	4.20E-02	8.40E-04	1.77E-03
2 C 4	Sulphur hexafluoride	176631.60	10533.60	0.0000	30.0375	30.0375	9.86E-08	1.06E-04	8.46E-06	3.59E-04	0.00E+00	1.29E-07
2 C 4	HFC-134a	0.00	48027.98	0.0000	30.0375	30.0375	2.05E-06	3.86E-05	3.86E-05	1.64E-03	0.00E+00	2.68E-06
2 C 5	Carbon dioxide	116494.00	83037.90	0.0000	50.4876	50.4876	1.73E-05	8.99E-06	6.67E-05	4.76E-03	0.00E+00	2.27E-05
2 C 6	Carbon dioxide	612320.00	293696.88	0.0000	50.2494	50.2494	2.15E-04	1.62E-04	2.36E-04	1.68E-02	0.00E+00	2.81E-04
2 D 1	Carbon dioxide	553672.28	589829.21	16.4409	40.1890	43.4219	6.46E-04	1.14E-04	4.74E-04	2.69E-02	1.10E-02	8.46E-04

A	B	C	D	E	F	G	H	I	J	K	L	M
2 D 2	Carbon dioxide	337164.66	586731.58	20.0000	50.0000	53.8516	9.84E-04	2.52E-04	4.71E-04	3.33E-02	1.33E-02	1.29E-03
2 D 2	Nitrous oxide	822.43	1431.19	20.0000	50.0000	53.8516	5.85E-09	6.15E-07	1.15E-06	8.13E-05	3.25E-05	7.66E-09
2 D 3	Carbon dioxide	2042612.00	1317086.83	0.0000	7.3953	7.3953	9.35E-05	2.69E-04	1.06E-03	1.11E-02	0.00E+00	1.22E-04
2 E	Sulphur hexafluoride	47281.67	19608.00	0.0000	12.2000	12.2000	5.64E-08	1.50E-05	1.57E-05	2.72E-04	0.00E+00	7.38E-08
2 E	Nitrogen trifluoride	5289.72	11885.20	0.0000	12.2000	12.2000	2.07E-08	6.11E-06	9.54E-06	1.65E-04	0.00E+00	2.71E-08
2 E	C3F8	0.00	19602.60	0.0000	12.2000	12.2000	5.64E-08	1.57E-05	1.57E-05	2.72E-04	0.00E+00	7.37E-08
2 E	CF4	102615.00	64773.35	0.0000	10.0190	10.0190	4.15E-07	1.46E-05	5.20E-05	7.37E-04	0.00E+00	5.43E-07
2 E	c-C4F8	0.00	11886.20	0.0000	12.2000	12.2000	2.07E-08	9.54E-06	9.54E-06	1.65E-04	0.00E+00	2.71E-08
2 E	HFC-23	17112.33	14208.00	0.0000	12.2000	12.2000	2.96E-08	2.94E-07	1.14E-05	1.97E-04	0.00E+00	3.87E-08
2 E	HFC-32	0.00	37.13	0.0000	12.2000	12.2000	2.02E-13	2.98E-08	2.98E-08	5.14E-07	0.00E+00	2.64E-13
2 E	C2F6	162484.67	54436.40	0.0000	12.2000	12.2000	4.35E-07	6.18E-05	4.37E-05	7.54E-04	0.00E+00	5.69E-07
2 F	HFC-125	147558.73	2217847.41	0.0000	7.9202	7.9202	3.04E-04	1.68E-03	1.78E-03	1.99E-02	0.00E+00	3.98E-04
2 F	C2F6	0.00	2313.94	0.0000	17.5439	17.5439	1.62E-09	1.86E-06	1.86E-06	4.61E-05	0.00E+00	2.12E-09
2 F	HFC-134a	2268299.36	6361681.10	0.0000	5.7230	5.7230	1.31E-03	3.63E-03	5.11E-03	4.13E-02	0.00E+00	1.71E-03
2 F	HFC-143a	68076.48	2025533.84	0.0000	10.2100	10.2100	4.21E-04	1.58E-03	1.63E-03	2.35E-02	0.00E+00	5.51E-04
2 F	HFC-152a	90070.08	30607.71	0.0000	2.4558	2.4558	5.57E-09	3.39E-05	2.46E-05	8.53E-05	0.00E+00	7.28E-09
2 F	HFC-23	16253.62	85422.28	0.0000	13.4099	13.4099	1.29E-06	5.80E-05	6.86E-05	1.30E-03	0.00E+00	1.69E-06
2 F	HFC-227ea	646.63	54284.20	0.0000	4.1476	4.1476	4.99E-08	4.32E-05	4.36E-05	2.56E-04	0.00E+00	6.54E-08
2 F	HFC-245fa	C	C	C	C	C	C	C	C	C	C	C
2 F	HFC-365mfc	C	C	C	C	C	C	C	C	C	C	C
2 F	HFC-236fa	0.00	31151.55	0.0000	9.3274	9.3274	8.32E-08	2.50E-05	2.50E-05	3.30E-04	0.00E+00	1.09E-07
2 F	HFC-32	724.17	132544.72	0.0000	7.9094	7.9094	1.08E-06	1.06E-04	1.19E-03	0.00E+00	0.00E+00	1.42E-06
2 F	C3F8	19911.19	5753.37	0.0000	18.9110	18.9110	1.17E-08	8.31E-06	4.62E-06	1.24E-04	0.00E+00	1.53E-08
2 F	C6F14	C	C	C	C	C	C	C	C	C	C	C
2 F	HFC-43-10mee	C	C	C	C	C	C	C	C	C	C	C
2 G	Methane	11374.09	36521.49	20.0000	20.0000	28.2843	1.05E-06	2.19E-05	2.93E-05	8.29E-04	8.29E-04	1.38E-06
2 G	Nitrous oxide	C	C	C	C	C	C	C	C	C	C	C
2 G	Sulphur hexafluoride	C	C	C	C	C	C	C	C	C	C	C
2 G	HFC-134a	0.00	200.20	0.0000	22.3600	22.3600	1.97E-11	1.61E-07	1.61E-07	5.08E-06	0.00E+00	2.58E-11
2 G	HFC-245fa	0.00	8843.91	0.0000	21.3932	21.3932	3.53E-08	7.10E-06	7.10E-06	2.15E-04	0.00E+00	4.62E-08
2 G	HFC-365mfc	0.00	671.30	0.0000	22.2283	22.2283	2.19E-10	5.39E-07	5.39E-07	1.69E-05	0.00E+00	2.87E-10
2 G	C10F18	C	C	C	C	C	C	C	C	C	C	C
3 A 1 a	Methane	16266832.39	14579072.80	4.0000	20.0000	20.3961	8.71E-02	1.14E-03	1.17E-02	3.31E-01	6.62E-02	1.14E-01
3 A 1 b	Methane	11753310.83	9045399.35	2.3652	11.8262	12.0604	1.17E-02	3.71E-04	7.26E-03	1.21E-01	2.43E-02	1.53E-02
3 A 2 - 4	Methane	1292034.36	1157075.90	0.0000	12.8351	12.8351	2.17E-04	8.99E-05	9.29E-04	1.69E-02	0.00E+00	2.84E-04
3 B 1 a	Methane	2778569.97	2225637.46	4.0000	20.0000	20.3961	2.03E-03	1.76E-05	1.79E-03	5.05E-02	1.01E-02	2.66E-03
3 B 1 a	Nitrous oxide	1168637.88	993932.98	4.0000	100.0000	100.0800	9.75E-03	3.90E-05	7.98E-04	1.13E-01	4.51E-03	1.28E-02
3 B 1 b	Methane	2133718.35	1445532.79	2.3184	11.5918	11.8213	2.88E-04	2.25E-04	1.16E-03	1.90E-02	3.81E-03	3.76E-04
3 B 1 b	Nitrous oxide	1236763.83	1000342.83	2.2260	55.6498	55.6943	3.06E-03	5.14E-08	8.03E-04	6.32E-02	2.53E-03	4.00E-03
3 B 2_4	Methane	140254.75	188165.25	4.6477	10.0051	11.0319	4.25E-06	6.00E-05	1.51E-04	2.14E-03	9.93E-04	5.56E-06
3 B 2_4	Nitrous oxide	305168.99	260713.90	6.0118	175.4903	175.5932	2.06E-03	1.11E-05	2.09E-04	5.20E-02	1.78E-03	2.70E-03
3 B 3	Methane	2233023.07	2341816.86	3.1730	15.8647	16.1789	1.41E-03	4.30E-04	1.88E-03	4.22E-02	8.44E-03	1.85E-03
3 B 3	Nitrous oxide	433852.81	546736.50	3.0297	75.7309	75.7914	1.69E-03	1.57E-04	4.39E-04	4.70E-02	1.88E-03	2.21E-03
3 B 5	Nitrous oxide	1045631.19	1031682.90	10.0000	400.0000	400.1250	1.68E-01	1.49E-04	8.28E-04	4.69E-01	1.17E-02	2.20E-01
3 D	Nitrous oxide	24937338.35	27527082.36	26.1780	89.1952	92.9573	6.45E+00	5.90E-03	2.21E-02	2.79E+00	8.18E-01	8.44E+00
3 G	Carbon dioxide	1744900.17	2214730.98	4.5744	2.8957	5.4139	1.42E-03	6.45E-04	1.78E-03	7.28E-03	1.15E-02	1.85E-04
3 H	Carbon dioxide	477245.21	856270.64	1.0000	1.0000	1.4142	1.44E-06	3.78E-04	6.88E-04	9.72E-04	9.72E-04	1.89E-06
3 J	Methane	3438.20	1295971.45	10.0000	40.0000	41.2311	2.81E-03	1.04E-03	1.04E-03	5.89E-02	1.47E-02	3.68E-03
3 J	Nitrous oxide	1499.16	245009.19	9.5237	97.1007	97.5666	5.63E-04	1.96E-04	1.97E-04	2.70E-02	2.65E-03	7.37E-04
4 A	Methane	17011.07	19815.66	0.0000	674.8888	674.8888	1.76E-04	4.86E-06	1.59E-05	1.52E-02	0.00E+00	2.31E-04
4 A	Nitrous oxide	215371.76	146427.78	0.0000	119.1652	119.1652	3.00E-04	2.23E-05	1.18E-04	1.98E-02	0.00E+00	3.93E-04
4 A	Carbon dioxide	-76148692.02	-57927011.85	0.0000	37.2560	37.2560	4.59E+00	2.95E-03	4.65E-02	2.45E+00	0.00E+00	6.01E+00
4 B	Nitrous oxide	254954.41	288962.43	0.0000	209.8546	209.8546	3.62E-03	6.64E-05	2.32E-04	6.89E-02	0.00E+00	4.74E-03
4 B	Methane	198954.52	247431.62	0.0000	173.6154	173.6154	1.82E-03	6.95E-05	1.99E-04	4.88E-02	0.00E+00	2.38E-03
4 B	Carbon dioxide	12563020.11	14348327.71	0.0000	28.1824	28.1824	1.61E-01	3.36E-03	1.15E-02	4.59E-01	0.00E+00	2.11E-01
4 C	Methane	588908.16	513525.44	0.0000	238.9593	238.9593	1.48E-02	2.98E-05	4.12E-04	1.39E-01	0.00E+00	1.94E-02

A	B	C	D	E	F	G	H	I	J	K	L	M	
4 C	Nitrous oxide	89348.12	102813.45	0.0000	172.5506	172.5506	3.10E-04	2.45E-05	8.25E-05	2.01E-02	0.00E+00	4.06E-04	
4 C	Carbon dioxide	25391663.22	22092165.46	0.0000	43.0485	43.0485	8.91E-01	1.25E-03	1.77E-02	1.08E+00	0.00E+00	1.17E+00	
4 D	Methane	41282.01	43357.75	0.0000	463.6092	463.6092	3.98E-04	8.00E-06	3.48E-05	2.28E-02	0.00E+00	5.21E-04	
4 D	Nitrous oxide	21369.85	22331.00	0.0000	155.7451	155.7451	1.19E-05	4.05E-06	1.79E-05	3.95E-03	0.00E+00	1.56E-05	
4 D	Carbon dioxide	4217482.98	4006728.12	0.0000	28.9045	28.9045	1.32E-02	4.78E-04	3.22E-03	1.32E-01	0.00E+00	1.73E-02	
4 E	Methane	25193.19	42553.35	0.0000	149.3945	149.3945	3.98E-05	1.78E-05	3.42E-05	7.22E-03	0.00E+00	5.21E-05	
4 E	Nitrous oxide	129059.50	194197.27	0.0000	108.4489	108.4489	4.37E-04	7.21E-05	1.56E-04	2.39E-02	0.00E+00	5.72E-04	
4 E	Carbon dioxide	1924844.10	3302004.62	0.0000	16.7276	16.7276	3.01E-03	1.40E-03	2.65E-03	6.27E-02	0.00E+00	3.93E-03	
4 G	Carbon dioxide	-2688893.09	-2123512.49	0.0000	28.2587	28.2587	3.55E-03	4.14E-05	1.70E-03	6.81E-02	0.00E+00	4.64E-03	
4 H	Nitrous oxide	104269.85	100042.48	0.0000	199.4967	199.4967	3.92E-04	1.26E-05	8.03E-05	2.27E-02	0.00E+00	5.14E-04	
5 A	Methane	35875000.00	8950000.00	0.0000	50.0000	50.0000	1.97E-01	1.61E-02	7.19E-03	5.08E-01	0.00E+00	2.58E-01	
5 B	Methane	180880.00	776580.00	1.4472	190.7284	190.7339	2.16E-02	5.06E-04	6.24E-04	1.68E-01	1.28E-03	2.83E-02	
5 B	Nitrous oxide	113964.74	326310.00	1.4354	167.4726	167.4787	2.94E-03	1.88E-04	2.62E-04	6.21E-02	5.32E-04	3.85E-03	
5 D 1	Methane	1240680.26	583787.72	0.0000	24.0303	24.0303	1.94E-04	3.37E-04	4.69E-04	1.59E-02	0.00E+00	2.54E-04	
5 D 1	Nitrous oxide	516667.41	427359.83	33.3640	3904.4611	3904.6037	2.74E+00	7.57E-06	3.43E-04	1.89E+00	1.62E-02	3.59E+00	
5 D 2	Methane	15520.73	43087.36	0.0000	50.0000	50.0000	4.57E-06	2.45E-05	3.46E-05	2.45E-03	0.00E+00	5.98E-06	
5 D 2	Nitrous oxide	27692.33	25105.26	50.0000	300.0000	304.1381	5.74E-05	2.17E-06	2.02E-05	8.55E-03	1.43E-03	7.52E-05	
5 E	Methane	718.13	4301.66	2.0000	60.0000	60.0333	6.57E-08	2.99E-06	3.45E-06	2.93E-04	9.77E-06	8.60E-08	
5 E	Nitrous oxide	10842.73	73967.47	2.0000	60.0000	60.0333	1.94E-05	5.23E-05	5.94E-05	5.04E-03	1.68E-04	2.54E-05	
Total		$\sum_C$ 1087799155	$\sum_D$ 887:			$\sum_H$					$\sum_M$ 26,43		
Percentage uncertainty in total inventory:							$\sqrt{\sum_H}$ 4,5	Trend uncertainty:					$\sqrt{\sum_M}$ 5,1

Uncertainties for categories have been determined successively, within the framework of UBA sections' data deliveries for current emissions reporting. In addition, external experts have carried out additional uncertainties determination, in research projects, for categories for which no uncertainties information, or incomplete information, has been available to date. The results of such uncertainties analysis have been integrated within the current report.

The uncertainties in the category Agriculture (CRF 4) were estimated by experts of the Thünen Institute (TI).

Current work planning calls for Tier 2 uncertainties analysis to be carried out every three years. Uncertainties are determined pursuant to Tier 1, and reported, every year.

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