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On behalf of the German Environment Agency

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Abstract:

At first glance, organizations and products appear to be very different entities for which greenhouse gas inventories are to be prepared. Yet they are closely interlinked. The aim of this study is to identify the methodological similarities and differences in GHG accounting, which typically arise from different perspectives and objectives.

This approach sharpens our focus on the accounting objects "organization" and "product" by presenting other accounting objects and characterising them based on specific aspects. A common feature of GHG accounting for all analysed objects is that they must be clearly defined, the respective accounting objective must be determined as precisely as possible, and this gives rise to methodological implications for system boundaries, quantification steps, and the presentation of results, which are analysed in this study.

Returning to the focus on the accounting entities 'organization' and 'product', the second part identifies seven key topics that give rise to controversy in the methodological debate and may also have a significant impact on results. Without claiming to provide a comprehensive examination of these topics, the text highlights points of conflict, cites guidelines already implemented in standards, and presents ideas for resolving existing ambiguities as food for thought. These ideas are intended, in particular, to be incorporated into the ongoing revisions of the accounting standards of ISO and the GHG Protocol.

Kurzbeschreibung:

Organisationen und Produkte erscheinen zunächst als sehr unterschiedliche Objekte, für die Treibhausgasbilanzen erstellt werden sollen, und sind dennoch auf das Engste miteinander verknüpft. Die vorliegende Studie hat zum Ziel, die methodischen Gemeinsamkeiten und Unterschiede bei der THG-Bilanzierung zu identifizieren, die sich meist durch verschiedene Blickwinkel und Aufgabenstellungen ergeben.

Der Blick auf die Bilanzierungsobjekte Organisation und Produkt wird dabei geschärft, in dem noch andere Bilanzierungsobjekte präsentiert und anhand bestimmter Aspekte charakterisiert werden. Der THG-Bilanzierung aller analysierten Objekte ist gemeinsam, dass sie klar definiert werden müssen, das jeweilige Bilanzierungsziel möglichst genau bestimmt wird und sich daraus methodische Konsequenzen für Systemgrenzen, Quantifizierungsschritte und Ergebnispräsentation ergeben, die in dieser Studie analysiert werden.

Wieder mit dem Fokus auf die Bilanzierungsobjekte Organisation und Produkt werden schließlich im zweiten Teil sieben Themenschwerpunkte ausgewählt, die zu Kontroversen in der Methodendiskussion führen und zugleich ergebnisrelevant sein können. Ohne den Anspruch einer vollständigen Betrachtung der Themen werden Konfliktpunkte herausgearbeitet, bereits in Normen implementierte Handlungsanweisungen zitiert und Ideen für Lösungen bei vorhandenen Unklarheiten als Denkanstöße unterbreitet. Die Denkanstöße sollen insbesondere Eingang in die laufenden Revisionen der Bilanzierungsnormen von ISO und GHG-Protocol finden.

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List of abbreviations

AHG	Ad-hoc Group
BECCS	Bioenergy with Carbon Capture and Storage
BMUKN	Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN)
CCS	Carbon Capture and Storage
CD	Committee Draft
CEN	European Committee for Standardisation
CFP	Carbon Footprint of Products
CoC	Chain of Custody
COP	Conference of the Parties
DACCS	Direct Air Carbon Capture and Storage
DIN	German Institute for Standardisation, Berlin
DIS	Draft International Standard
GGR	Greenhouse Gas Removals
GHG	Greenhouse Gas
GHGP	Greenhouse Gas Protocol
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standard Organization
JWG	Joint Working Group
NACE	Statistical classification of economic activities in the European Union (Nomen-clature statistique des activités économiques dans la Communauté eu-ropéenne).
NGO	Non-governmental organization
NWIP	New Work Item Proposal
SC	Sub-Committee
TC	Technical Committee
UBA	German Environment Agency
UNFCCC	UN Framework Convention on Climate Change
WBCSD	World Business Council for Sustainable Development
WD	Working Draft
WG	Working Group
WIR	World Resources Institute
WTO	World Trade Organization

Summary

This report examines the methodological similarities and differences in greenhouse gas (GHG) accounting for organizations and products and is intended, in particular, to support the revision of international standards such as ISO 14064-1 and ISO 14067, as well as the further development of the GHG Protocol. The starting point is the central importance of consistent and transparent GHG accounting in supporting the fight against climate change. Only on the basis of robust accounting methods and the resulting data on GHG emissions and their future trends, effective climate protection measures can be planned, verified and communicated. At the same time, there is a multitude of different regulatory frameworks arising from various areas of application, objectives and stakeholder perspectives, and their methodological differences must be transparently acknowledged.

A key finding of the study is that the differences in GHG accounting arise both from the objects under consideration themselves – such as organizations or products – and from the respective objectives and perspectives of the accounting. Regardless of the object of accounting, however, fundamental principles apply: the system to be accounted for must be clearly defined, the objective of the accounting must be clearly formulated, and consistent system and accounting boundaries must be derived from this. Furthermore, it is essential to present and communicate the methods used for quantification transparently and to ensure that the results obtained are comprehensible.

To structure the diverse range of issues, the report distinguishes between various accounting objects, including territories, organizations, products, industrial sectors, materials, waste and climate protection projects. This differentiation enables a more precise analysis, as each of these objects imposes specific requirements on data collection, system boundaries and methodological approaches. This is also intended to ensure that a specific research question is deliberately linked to the selection of the corresponding accounting object. However, the study focuses on organizations and products, as these are particularly relevant both for public perception and for economic decisions.

In the case of GHG accounting for organizations, the focus is on recording both direct emissions from their own activities and indirect emissions along the value chain. These are divided into Scope 1, Scope 2 and Scope 3 in the GHG Protocol. Whilst direct and energy-related indirect emissions can be captured relatively well, the full integration of the value chain poses a significant challenge. At the same time, these indirect emissions are often particularly relevant to the overall balance. Further challenges lie in defining appropriate system boundaries, ensuring consistent data sets over time, and ensuring comparability between different organizations. The latter is particularly problematic, as different reference values and definitions can lead to distorted results and potentially misleading conclusions.

The greenhouse gas (GHG) accounting for products is essentially based on a life-cycle approach, which takes into account all stages of a product's life, from raw material extraction through manufacturing and use to disposal. Stakeholders are seeking the so-called Product Carbon Footprint, which describes the total greenhouse gas emissions of a product relative to a so-called functional unit. This functional approach is necessary to be able to compare products with the same utility, whether through time-series comparisons (performance tracking) or by comparing products with one another. The complexity of the product carbon footprint stems in particular from the need for consistent data collection across global supply chains, as well as from methodological issues such as the definition of system boundaries—for example, the allocation methodology in multi-output situations—or the creation of partial balances. The latter play a role primarily in

communication within supply chains, but carry the risk of misinterpretation if viewed out of context.

A central part of the report is devoted to methodological areas of conflict that are highly relevant for both organizations and products. These include, among other things, the treatment of biogenic emissions and the removal of CO_2 from the atmosphere, where different conceptual frameworks and assessment approaches exist. For example, the temporal dimension of GHG emissions and removals presents a challenge, as they can have different climate impacts at different points in time. Other controversial topics include the application of chain-of-custody approaches to the transfer of certain climate-related properties along the supply chain, the accounting of electricity consumption, and the allocation of emissions in processes with multiple output products, including the distinction between absolute and marginal perspectives. Particular attention must also be paid to the consideration of so-called avoided emissions, which arise solely from the comparison of two different product systems and cannot be attributed to a single organization or product without the risk of double counting.

Another aspect of importance for the development of standards is the inconsistent use of key terms. In particular, the term 'removal' is defined differently in various international contexts, for example with regard to whether it encompasses merely the removal of greenhouse gases from the atmosphere or also their permanent storage. There is also a lack of clarity between the terms "accounting" and "quantification", as they are sometimes used synonymously but at other times with different meanings. The report therefore advocates clear and consistent definitions of terms to avoid misunderstandings and improve comparability.

The study is closely embedded in current international standardization processes. The revision of ISO standards and increased collaboration with the GHG Protocol offer an opportunity to reduce existing inconsistencies and drive forward methodological harmonization. The aim is to create a coherent set of rules that meets both scientific requirements and practical applications.

In summary, the report shows that the GHG accounting of organizations and products is closely interlinked and influences one another. The existing methodological differences are largely attributable to differing objectives, but can be reduced through greater harmonization of standards and a clear definition of key terms. The proposals developed in the report are intended as contributions to the discussion and are designed to help improve the consistency and transparency of GHG accounting, thereby creating a more reliable basis for climate policy and business decisions.

1 Introduction and objectives

1.1 Introduction

Human-induced climate change is one of the greatest challenges of our time. Activities are taking place at many levels, on the one hand to reduce greenhouse gas (GHG) emissions and, on the other, to combat the already inevitable consequences of climate change. In this context, the reduction of GHG emissions and, subsequently, the permanent removal of greenhouse gases from the atmosphere are primary measures to minimize negative climate change. As high levels of carbon dioxide emissions, as well as those of other greenhouse gases, continue to be recorded across all sectors of human activity, efforts to reduce and prevent them must be significantly stepped up.

These obvious findings have led to a wide range of activities taking place at international, national, private-sector and individual levels to combat climate change. A range of international agreements, national legislation and voluntary economic action are working together and offer hope that the worst can be prevented. Nevertheless, the inertia of the economy and society, as well as the clinging to ingrained personal habits, are the obstacles that make the path arduous.

Governments and other climate policy-makers have already adopted a number of decisions on GHG reduction targets and mitigation pathways, on promoting climate-friendly technologies and activities, on introducing economic incentives, on supporting innovation, and many more. What all measures based on these decisions have in common is that they require clear rules for accounting for emissions of the relevant greenhouse gases (GHGs) as well as their removal from the atmosphere. Only with the help of compliant GHG accounting can decisions be made regarding the reduction of greenhouse gases or the achievement of specific targets, and can their implementation be credibly verified and communicated.

Such GHG accounting is now required for various stakeholders, objects of investigation and areas of action. Different purposes and areas of application require different approaches, accounting rules, levels of detail and communication requirements. This is also the reason why there are diverse sets of regulations governing GHG accounting, whether on a private basis, based on national and international agreements of standardization bodies, or on national and international legislation.

GHG accounting is primarily required for national inventories, companies and products. However, other related applications are also outlined below. Whilst national GHG inventories are legally binding under international agreements (UNFCCC) and guidelines (IPCC), it is companies and products in particular that are the focus of public attention in relation to climate-friendly action. In the eyes of conscious consumers, companies and their products are assessed on the basis of their climate impact and are accordingly favored or avoided. For this reason, responsible managers in companies have their important role to contribute to climate protection.

Thus, alongside national GHG inventories, the development of agreements on GHG accounting for companies and products has been promoted. One notable example is the GHG Protocol by the WRI and WBCSD, an important private initiative initially aimed at companies and later also at products. Finally, international standards were developed within the framework of the International Standard Organization (ISO) for the quantification of GHG emissions from organizations (ISO 14064-1) and from products (ISO 14067). The role of ISO standards lies in the rule-based development of standards which, once adopted by the participating national standards organizations, enjoy worldwide recognition and are considered to be in conformity with the rules of the World Trade Organization (WTO).

1.2 Objectives and approach

The aim of this report is to support the relevant standardization bodies of ISO and DIN in the revision of the GHG accounting standards ISO 14064-1 for organizations and ISO 14067 for products. This will be achieved by identifying and further developing specific content and presenting it to the relevant standardization bodies.

Furthermore, the ongoing revision process of the relevant GHG accounting standards of the GHG Protocol (namely the Corporate Standard, the Value Chain (Scope 3) Standard, the Scope 2 Guidance and the Product Standard) is to be indirectly supported. Through collaboration with experts from the German Environment Agency who are involved in the current revision of the GHG Protocol standards, insights regarding content can be contributed. Particular attention should be paid to consistency with regulations within the ISO framework.

To improve the consistency and coherence of the various standards for GHG accounting, the experts involved must be actively supported, primarily by highlighting methodological shortcomings and inconsistencies and by making proposals to address them. However, this can only be achieved through membership of the relevant standardization bodies and in line with the stage of development of the respective standardization or revision projects.

As part of the revision of the GHG accounting standards ISO 14064-1 for organizations and ISO 14067 for products, and the corresponding standards of the GHG Protocol, the following tasks are to be undertaken in relation to the overarching objective of the project:

- Identification and comparison of methodological differences in GHG accounting for organizations and products;
- Review and evaluation of the differences in the methods for organizations and products and, where applicable, of the various standardization and revision projects;
- Formulation of a position on methodological issues and proposal of an approach for the relevant standards;
- Submission of proposals and active participation in shaping the content within the various standardization bodies at national and international level;
- Deriving recommendations for standard users, in particular companies;
- Identifying similarities and differences with GHG accounting for projects.

Specific proposals regarding GHG accounting may also be submitted with regard to related standardization projects, as methodological specifications should certainly be adapted to the objectives of a given issue.

1.3 Embedding into ISO standardization projects and the GHG Protocol

Revision of the GHG quantification standards ISO 14064-1 and ISO 14067

ISO regulations stipulate that a published standard must be reviewed every five years to determine whether it should be confirmed (1), revised (2) or withdrawn (3). In 2023, this review was due for the standards on GHG accounting for organizations (ISO 14064-1), projects (ISO 14064-2) and products (ISO 14067). The review follows a set procedure involving consultations among all participating national standards bodies and decisions by the higher-level ISO bodies (subcommittees) in various stages.

The consultation on the review of the GHG quantification standards was completed by the end of 2023 and resulted in a clear majority in all cases in favor of confirming the standards without revision. As a minority had expressed technical concerns regarding a simple confirmation, the responsible sub-committee leadership (ISO/TC 207/SC 7) set up a task force to advise them on how to proceed. The task force met in early January and recommended a revision to the SC 7 leadership, specifying key points for revision.

In June 2024, the SC 7 leadership voted in favor of revising the standards in question and followed the task force's recommendations. As the majority of national standards organizations had previously been in favour of confirming the existing standards, the decision of the SC 7 leadership had to be put to a vote by all participating member countries. The member countries approved the revision of the standards ISO 14064-1, ISO 14064-2, ISO 14064-3 and ISO 14067 in July 2024 by a two-thirds majority. In October, the revision of the standards ISO 14064-1 was taken up by Working Group 4 (ISO/TC 207/SC 7/WG 4) and ISO 14067 by Working Group 8 (ISO/TC 207/SC 7/WG 8). Work on the GHG quantification standard ISO 14064-2 for projects is to follow, whilst work on ISO 14064-3 for the certification of GHG inventories has been put on hold for the time being and is to be resumed at a later date once sufficient progress has been made on the quantification standards.

Status of work on the GHG quantification standards ISO 14064-1 and ISO 14067

Based on exploratory workshops and the development of the first working drafts (WD 1) for ISO 14064-1 for organizations and ISO 14067 for products in November 2024 in London by TC 207/SC7 WG 4 and WG 8, key methodological issues were identified and further addressed in joint meetings. To mitigate identified inconsistencies, the revision of ISO 14067 for products is to continue in close coordination with the revisions of the ISO 14064-1 standards for organizations.

At the exploratory workshops of WG 4 and WG 8 in London, two ad hoc groups (AHGs) were established to address the methodological areas of chain of custody (see Chapter 3.4) and biogenic emissions (see Chapters 3.2 and 3.3). These AHGs met until March and prepared technical papers, which are also to be taken into account in the revisions of the two standards.

In March 2025, the next face-to-face meetings of SC 7 and the WGs took place in Paris. Once again, WG 4 and WG 8 met jointly and only separately for purely WG-specific matters. This resulted – initiated by the WG chairs – in a new structure for the respective two standards, which were, however, closely aligned in their design.

Based on initial methodological agreements, initial texts from ad hoc groups and the structure, which has been closely aligned for both standards, the first working drafts (WDs) for the revision of ISO 14064-1 and ISO 14067 were then to be drawn up. At the end of June 2025, both WD 1 documents were presented by the chairs and commented on by the WG experts during a two-month comment period.

From 25 to 28 October 2025, during the TC 207 meeting week in Toronto, joint and separate meetings of WG 4 and WG 8 took place once again, focusing on the one hand on further work following decisions regarding cooperation with the GHG Protocol and, on the other hand, on addressing the experts' comments on the WD 1 documents. The substantive part of this report is inspired by the technical content of the Toronto meetings.

Future collaboration between ISO and the GHG Protocol

The World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) joined forces in the late 1990s to develop accounting and reporting standards for greenhouse gases. To this end, they established the Greenhouse Gas Protocol (GHG Protocol) as a non-governmental organization (NGO). With the Corporate Accounting and Reporting Standard, the GHG Protocol presented a globally applicable standard for companies in 2003, developed with the help of an international group of experts. This standard was welcomed by companies and has increasingly established itself as a tool for organizations.

In the years that followed, further GHG accounting standards and guidelines were developed. Four of these in particular are relevant to the subject of this report:

- A Corporate Accounting and Reporting Standard – REVISED EDITION; March 2004
- Product Life Cycle Accounting and Reporting Standard; September 2011
- GHG Protocol Scope 2 Guidance; An amendment to the GHG Protocol Corporate Standard; 2015
- Corporate Value Chain (Scope 3) Accounting and Reporting Standard – Supplement to the GHG Protocol Corporate Accounting and Reporting Standard; September 2011

The global reach and significance of the GHG Protocol's Corporate Standard in particular, and ISO's global reputation as a standardization body with its long-standing activities in the field of climate change, led ISO and the GHG Protocol to collaborate. During 2025, members of the ISO working groups were informed about the negotiations and presented with forms of cooperation.

Finally, in September 2025, the senior management of both organizations agreed on a Memorandum of Understanding defining specific forms of collaboration. This will see the further development of a Corporate Standard led by the GHG Protocol, the development of a standard for the GHG footprint of products under joint leadership as a Joint Working Group, and the GHG standard for projects under the leadership of ISO SC 7.

In October 2025, WG 8 was transformed into the Joint Working Group 8 (JWG), and the role of WG 4 was revised; it is now tasked with overseeing the work on the Corporate Standard with 12 experts and organizing the formation of consensus within ISO. In the opinion of most ISO experts, it would have been preferable for all standards to be developed within Joint Working Groups.

The harmonization of GHG accounting for organizations and products is also to be further advanced within the new structure, as indirect GHG emissions from organizations – or Scope 2 and Scope 3 GHG emissions according to the GHG Protocol nomenclature – largely arise in connection with products, and their accounting methodology should therefore also be developed consistently.

It remains to be seen how the collaboration initiated between ISO and the GHG Protocol should be assessed, given the tension between the differing accounting requirements for organizations (led by the GHG Protocol) and products (jointly led by ISO and the GHG Protocol in a JWG).

Further standardization projects on GHG quantification standards ISO 14064-1 and ISO 14067

In addition to the aforementioned relevant GHG accounting standards from ISO and the GHG Protocol, there are a number of other relevant standards that are directly or indirectly related to

GHG accounting. To illustrate the scope of this work, the following list of such standards is provided, without claiming to be exhaustive:

- ISO 14068-1 “Carbon Neutrality”
- ISO/CD 14060 Net Zero-aligned organizations (in progress)
- DIN SPEC on life cycle assessments of carbon capture and utilization
- ISO 14002-3 Environmental management guidelines with a focus on climate (in progress)
- ISO 32212 Net zero transition planning for financial institutions (in progress)
- ISO TC 265 on CO_2 Capture, Transport and Storage
- ISO/DIS 50100 Energy management systems and energy savings — Decarbonisation — Requirements with guidance for use
- CEN/TC 467 Climate Change with projects such as Industrial Decarbonisation – Requirements and guidelines for sectoral transition plans (in progress)
- ISO and DIN standardization activities on chain of custody (some in progress)
- ISO and DIN standards on specific areas of action such as transport, wood, hydrogen, etc. (some in progress)

1.4 Classification of terminology relating to ‘removal’

There are inconsistencies in the international and national use of terminology relating to ‘removal’, which increasingly give rise to misunderstandings and the need for extensive explanations. As consistent use of terminology is essential both in the various standards and in this report, a preliminary examination of this issue is required.

The inconsistencies relate to

- which greenhouse gases are covered by the respective definition
- whether ‘removal’ already includes permanent carbon storage

Furthermore, there are various German terms used for the meanings of ‘removal’ that are not clearly defined in each case.

Unfortunately, even the IPCC’s Assessment Reports use terminology that can easily lead to misunderstandings, as the definitions leave room for interpretation. In Annex VII of the glossary of the Sixth Assessment Report from 2021, the two terms ‘carbon dioxide removal’ and ‘anthropogenic removals’ are listed:

Carbon dioxide removals (CDR)
Anthropogenic activities removing ***carbon dioxide (CO_2)*** *from the atmosphere* ***and storing it permanently*** *in geological, terrestrial or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical CO_2 sinks and direct air carbon dioxide capture and storage (DACCS), but excludes natural CO_2 uptake not directly caused by human activities. See also Anthropogenic removals, Afforestation, Enhanced weathering, Ocean alkalinisation/Ocean alkalinity enhancement, Reforestation, Bioenergy with carbon dioxide capture*

and storage (BECCS) and Carbon dioxide capture and storage (CCS). (IPCC, 2021: Annex VII: Glossary)

This term refers to the removal of the greenhouse gas carbon dioxide CO_2 from the atmosphere, which is directly linked to the permanent storage of carbon.

Anthropogenic removals
*The **removal of greenhouse gases (GHGs)** from the atmosphere as a result of deliberate human activities. These **include** enhancing **biological sinks of CO_2** and using chemical engineering **to achieve long-term removal and storage**. Carbon dioxide capture and storage (CCS), which on its own does not remove CO_2 from the atmosphere, can help reduce atmospheric CO_2 from industrial and energy-related sources if it is combined with bioenergy production (BECCS), or if CO_2 is captured directly from the air and stored (DACCS). [Note: In the 2006 IPCC Guidelines for national GHG Inventories (IPCC, 2006), which are used in reporting emissions to the UNFCCC, … Inventories.] (IPCC, 2021: Annex VII: Glossary)*

This term now refers to the removal of greenhouse gases (GHG) in general and does not specify why all GHGs are meant. Furthermore, the first sentence of the definition does not immediately establish a link to permanent storage, as is the case with the definition of carbon dioxide removal. It is only with the phrasing "These include …" that storage is mentioned, without it being clear whether this is an exclusive clarification or merely a supplement to the first, general sentence. It should be noted here that an older IPCC publication also contained a definition of greenhouse gas removal (GGR), which no longer appears. However, the IPCC is currently working on a methodological report on CDR for the inventories.

Greenhouse gas removal (GGR)
Withdrawal of a GHG and/or a precursor from the atmosphere by a sink. See also Carbon dioxide removal (CDR) and Negative emissions. (IPCC, 2018: Annex I: Glossary)

Against this background, we shall now examine the definitions in the English-language ISO standards. The definitions of GHG removal in ISO 14064-1 and ISO 14067 are quasi identical:

ISO 14064-1:2018:
3.1.6 greenhouse gas removal
GHG removal
withdrawal of a GHG (3.1.1) from the atmosphere by GHG sinks (3.1.3)

ISO 14067:2018:
3.1.2.6 Greenhouse gas removal
GHG removal
withdrawal of a GHG (3.1.2.1) from the atmosphere

ISO/CD 14060 uses the same definition of GHG removal, but also incorporates the definition of carbon dioxide removal with reference to the IPCC definition. This is because ISO/CD 14060 requires carbon dioxide removal, with its permanent storage characteristic, to serve as an offset for GHG emissions that cannot be further reduced (residual emissions).

3.3.3 Carbon dioxide removal and storage
CO_2 removal
carbon dioxide removal
CDR
anthropogenic activities removing carbon dioxide (CO_2) from the atmosphere and storing it permanently in geological, terrestrial or ocean reservoirs, or in products

Note 1 to entry: carbon dioxide removal and storage includes existing and potential anthropogenic enhancement of biological or geochemical CO_2 sinks and direct air capture, but excludes natural CO_2 uptake not directly caused by human activities
[SOURCE: IPCC AR6 Annex VII Glossary]

This situation is unsatisfactory, as the reference to different GHGs and to different approaches to storage is commingled. This leaves room for misunderstandings.

The GHG Protocol's Corporate Standard contains two definitions relating to 'removal' (GHG Protocol, A Corporate Accounting and Reporting Standard, 2004):

GHG removal
Absorption or sequestration of GHGs from the atmosphere.

Carbon sequestration
The uptake of CO_2 and storage of carbon in biological sinks.

These definitions also require clarification, as 'GHG removal' refers to 'absorption' **or** 'sequestration'. Thus, GHG removal could mean either just absorption or the entire process of removal, including both absorption and storage. Furthermore, the term covers all GHGs and encompasses all types of absorption and storage, without excluding natural processes or specifying storage requirements. The second definition, on the other hand, is more precise, as it clearly links the uptake of CO_2 with the storage of the carbon (…) in biological sinks, albeit without reference to storage requirements.

The ambiguity surrounding the terminology of 'removal' has now been recognized within the expert community and will hopefully be taken into account in the revision of the definitions. The following would be helpful for implementation in standardization projects:

- A term should be found for the purely chemical/physical/biological process of removing a GHG from the atmosphere that does not conflict with other conceptual meanings. Suggestions might include 'uptake', 'absorption' or 'withdrawal'. 'Absorption' appears to be the most suitable, as it is a more technical rather than a general term and fits well within the context of 'emission and absorption'.
- Only if the term "removal" could be consistently supplemented with "storage", the concept of "removal" would stand for a single process rather than a combination of two processes, namely the uptake of a GHG from the atmosphere and its storage. However, as this clarification would necessarily have to come from the IPCC, it would likely be difficult to implement.
- In that case, 'removal' would have to unambiguously refer to both removal and storage and be defined accordingly.
- The choice of terminology should not depend on the type of GHG. A clarification as to whether all GHGs, some GHGs, any CO_2 or a distinction between fossil and non-fossil CO_2 could then be specifically laid down in definitions.

Unfortunately, the translation of the definitions and terminology into German is not without its contradictions either. The translations of ISO 14064-1 and ISO 14067 read as follows:

ISO 14064-1:2018:
3.1.6 greenhouse gas removal
GHG removal
withdrawal of a GHG (3.1.1) from the atmosphere by GHG sinks (3.1.3)

ISO 14064-1:2018 (in German)
3.1.6 Entzug von Treibhausgasen
Entzug von THG
Entzug eines THGs (3.1.1) aus der Atmosphäre durch THG-Senken (3.1.3)

ISO 14067:2018:
3.1.2.6 Greenhouse gas removal
GHG removal
withdrawal of a GHG (3.1.2.1) from the atmosphere

ISO 14067:2018 (in German)
3.1.2.6 entzogene Treibhausgasmenge
entzogene THG-Menge
aus der Atmosphäre entzogenes THG (3.1.2.1

As the definition of a term must not contain that term itself, the translations provided in German are likely to be incorrect and should be amended in the revision.

The terminology in this report is used as follows(only valid for the German version of the report):

- (GHG, CO_2)-Entnahme for (GHG, CO_2) removal with storage
- (GHG, CO_2)-Entzug for (GHG, CO_2) removal without storage; or uptake, withdrawal
- (Carbon or CO_2) Abscheidung for carbon capture
- Speicherung for storage

1.5 Use of the terms ‘accounting’ and ‘quantification’

During the preparation of this report, it became apparent that the terms ‘GHG accounting’ and ‘GHG quantification’ are used interchangeably in the documents examined. It is unclear whether the different terms express different concepts or are used synonymously.

The terminology used in the ISO standards and the GHG Protocol is set out below.

The titles of the **ISO standard for organizations** considered here are, in German and English:

- Treibhausgase — Teil 1: Spezifikation mit Anleitung zur quantitativen Bestimmung und Berichterstattung von Treibhausgasemissionen und Entzug von Treibhausgasen auf Organisationsebene (ISO 14064-1:2018)
- Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals (ISO 14064-1:2018)

The titles of the **ISO standard for products** considered here are as follows in German and English:

- Treibhausgase — Carbon Footprint von Produkten — Anforderungen an und Leitlinien für Quantifizierung (ISO 14067:2018)
- Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification (ISO 14067:2018)

Accordingly, the term 'quantification' is primarily used in ISO standards. Whilst the ISO 14064-1:2018 standard does not contain a definition of quantification, ISO 14067:2018 states in German and English:

- Kapitel 3.1.1.6
  Quantifizierung des Carbon Footprint eines Produkts
  Quantifizierung des CFP
  Tätigkeiten, die zur Bestimmung eines CFP (3.1.1.1) oder eines partiellen CFP (3.1.1.2) führen
  Anmerkung 1 zum Begriff: Die Quantifizierung des CFP bzw. des partiellen CFP ist Teil der CFP-Studie (3.1.1.4)

- Chapter 3.1.1.6
  quantification of a product's carbon footprint
  quantification of the CFP
  activities that result in the determination of a CFP (3.1.1.1) or a partial CFP (3.1.1.2)
  Note 1 to entry: Quantification of the CFP or the partial CFP is part of the CFP study (3.1.1.4)

The terms "Bilanzierung" (German) or "Accounting" are not found in the ISO standards. The term "THG-Bilanz" (German) appears in ISO 14064-1:2018 solely as the German translation of "GHG Inventory".

- Kapitel 3.2.6
  Treibhausgasbilanz
  THG-Bilanz
  Liste der THG-Quellen (3.1.2) und THG-Senken (3.1.3) sowie ihrer quantifizierten THG-Emissionen (3.1.5) und Mengen entzogener THGs (3.1.6)

- Chapter 3.2.6
  greenhouse gas inventory
  GHG inventory
  list of GHG sources (3.1.2) and GHG sinks (3.1.3) and their quantified GHG emissions (3.1.5) and GHG removals (3.1.6)

Whether the German translation of 'GHG inventory' as 'THG-Bilanz' is an appropriate choice is not assessed further.

The relevant **standards of the GHG Protocol** show the following titles:

- A Corporate Accounting and Reporting Standard – REVISED EDITION; March 2004

- Product Life Cycle Accounting and Reporting Standard; September 2011

The following definitions can be found there:

- GHG Protocol Corporate Accounting and Reporting Standard (this document, which provides a step-by-step guide for companies to use in quantifying and reporting their GHG emissions)

- The GHG Protocol Product Life Cycle Accounting and Reporting Standard (referred to as the Product Standard) provides requirements and guidance for companies and other organizations to quantify and publicly report an inventory of GHG emissions and removals associated with a specific product.

The titles of the GHG Protocol Standards and their explanations in the text, used in place of definitions, suggest that the terms ‘accounting’ and ‘quantification’ are used synonymously in the GHG Protocol.

However, the term ‘accounting’ has a further definition in the context of the UNFCCC. There, it refers to comparison with targets. Within the UNFCCC framework, ‘emission accounting’ is defined as the entirety of the systems and processes required for the commitments of the Parties under the Paris Agreement, as well as the progress made in implementing these commitments. The aim of such a framework is to create transparency and understanding of the individual and collective efforts of the Parties to limit or reduce emissions in a manner consistent with the global goal of limiting global warming to below 2 °C (Prag, A., C. Hood and P. Barata, 2013).

Notwithstanding the fact that the terms ‘accounting’ and ‘quantification’ are not finally defined in the ISO standards and the GHG Protocol standards, it is to be expected that a consistent terminology will be sought within the framework of the cooperation. The parallel use of the two terms is not to be criticized, provided that it is clarified whether they are being used synonymously or differently with clear definitions.

Without wishing to pre-empt the outcome of the discussion, the parallel use of the terms with slightly adapted definitions could be helpful. It therefore makes sense to understand the term ‘quantification’ as the more general, comprehensive term for the activity of numerically calculating GHG emissions and removals. In contrast, the term ‘accounting’ could refer more specifically to the generation of a result through numerical calculations of GHG emissions and removals. GHG accounting therefore necessarily requires the inclusion of emissions from individual sources and removals from individual sinks within a scope of accounting, and generates an accounting result such as a GHG inventory for organizations or a GHG footprint for products. The results of GHG accounting, such as an inventory or footprint, must be defined separately and do not necessarily have to relate to a specific accounting object.

This would allow the two terms to continue to be used almost synonymously, with specific distinctions being made only where a distinction is required. For the sake of linguistic consistency and to align with the title of this report, the term ‘accounting’ will be used throughout, as it also captures the comparison of emissions and removals in a GHG inventory. Only when referring to the methods for determining GHG emissions and removals directly specified in ISO 14064-1:2018 and ISO 14067:2018, the term “quantification” is used here.

2 Objects for GHG accounting

2.1 Various accounting objects and their characteristics

Issues relating to GHG accounting are complex. It is therefore necessary to address this complexity with an appropriate structure. Only in this way, accounting rules can be developed, communicated and standardized in a clear and comprehensible manner.

However, there are various structuring options, all of which have their advantages and disadvantages. Possible ways of structuring GHG accounting include:

- Applications such as
  reporting, communication, environmental and sustainability management, advertising, decision-making, action planning, implementation and management of measures, etc.
- Stakeholders such as:
  private companies, legislators and governments (politics), government enforcement agencies, consultancy firms and providers of IT tools for GHG accounting, certification and auditing bodies, industry associations, environmental organizations and other non-governmental organizations, scientific institutions, etc.
- Level of detail
  ranging from broad, overview-style tasks to finely differentiated ones, short- and long-term strategic decisions, etc.
- Overall and tiered sub-analyses
  such as sectors, organizations, parts of organizations, countries, regions, sites, projects, technical processes, etc.
- Accounting objects
  such as organizations, territories, products, etc.
- Further possibilities.

Rather than discussing the rules of GHG accounting in all their complexity and with all their various characteristics, it seems appropriate to select a structuring approach and develop it consistently. For this report, a distinction is therefore primarily made based on **accounting objects**.

This may involve a more technical approach, but the technical perspective can facilitate the handling of GHG accounting whilst still taking relevant issues and stakeholders into account. Furthermore, this also allows for alignment with ISO and DIN standards, which are usually also oriented towards the objects of investigation (organizations, products, financial institutions, etc.).

Essentially, the accounting objects could also be condensed into the two objects that are the subject of this report:

- Organizations, ranging from public and private bodies to other organizations
- Products in the sense of goods and services (according to ISO 14040)

A further reason for this focus also stems from the National Accounting Systems, which are structured according to sectors of production and consumption and, taken as a whole, encompass the relevant organizations. Finally, the interconnection of all sectors of production with one another and with all sectors of consumption describes both monetary and physical quantities, i.e. the flows of money, materials and products.

However, the analytical focus is lost if one attempts to relate all tasks to the accounting objects of organizations and products only. After all, organizations operate in the areas of planning, production, distribution, consumption and disposal, and products encompass raw materials, intermediate products, end products (including services), as well as waste and secondary raw materials.

With the proposed analytical focus, it is suggested that the **accounting objects** be defined and described as follows (without claiming to be exhaustive):

- Territories and local authorities such as states, countries, regions and municipalities
- Organizations, in particular companies
- Products in the sense of goods and services in the strict sense
- Industries and economic sectors (e.g. according to NACE code or other appropriate classifications (in English referred to as Industrial Sector)
- Materials or groups of materials
- Waste and disposal routes
- Projects – particularly climate protection projects
- (Financial products and investments – not covered here)

For all the accounting objects presented, rules apply depending on the intended use, which must be regarded for the corresponding GHG accounting. Such rules cover the specific reference system, the associated accounting boundaries, accounting methods, communication tools and verification/validation processes. Ideally, these rules are set out in regulatory frameworks, which may be legal standards, voluntary institutional standards (e.g. ISO, CEN, DIN) or private standards (e.g. GHG Protocol).

Despite the establishment of standards, the distinction and demarcation between accounting objects cannot always be achieved without contradictions. For instance, territorial approaches cannot, in principle, be reconciled with GHG accounting approaches for organizations operating in different territories and at different times without double counting or omissions.

The selected accounting objects are examined below according to a uniform framework, both to highlight their characteristics and to illustrate the need for a differentiated approach to accounting rules. When deriving rules, the accounting object must always be considered against the background of the intended use.

The evaluation scheme is structured as follows for all accounting objects:

1. Description of the accounting object
   A brief description is provided to identify the accounting object.
2. Typical questions
   Various questions arise in relation to the accounting object, leading to specific accounting objectives. The aim here is simply to identify the most important and typical questions and objectives.

3. Reference system and accounting boundaries
   An accounting object is characterized by a reference system and the associated system boundaries and accounting boundaries. These form an important basis for GHG accounting and must always be chosen carefully. System and accounting boundaries may be of a spatial or temporal nature, or may relate to the degree of accuracy (level of detail).
   The reference system is usually illustrated in a diagram.
4. Relevant system specifications
   Further relevant system specifications arise from the intended use of the GHG accounting, which are important for the development of accounting rules. Elements of such specifications include, for example, the reference units (turnover of an organization, functional unit of a product, etc.), the accounting methods (absolute or marginal calculation methods), delimitation and allocation methods (e.g. allocation for co-products), data handling (data source, data quality), the method of determination (e.g. measurement, calculation or estimation), the nature of the GHG accounting results and how they are handled (single-figure results such as a carbon footprint, multi-figure results, system comparisons), the method of verification/validation, etc.
5. Implications for GHG accounting
   Without claiming to be exhaustive, a few key implications for the GHG accounting of the accounting object are outlined below. These are to be further developed, particularly for organizations and products, in the following chapters.
6. Conclusions for international standardization
   For some accounting objects, such as organizations, products, projects or financial institutions, ISO standards already exist or are under development. Where direct conclusions can be drawn for standardization work, these are listed here. Depending on the accounting object, findings may or may not be listed.

This outline is followed by detailed sections on the specified accounting objects. This does not preclude the possibility of other accounting objects being added as appropriate.

The level of detail varies and can be supplemented as appropriate depending on the object. For the accounting objects ‘organizations’ and ‘products’, important or critical sub-aspects are addressed in the following chapters that appear relevant to the revision of the ISO standards ISO 14064-1 and ISO 14067.

The following remarks are intended to serve as a basis for further discussion.

2.2 Accounting object: Territories

1. Description of the accounting object

The accounting object ‘territory’ refers to an area of the Earth that can be precisely defined, depicted on a map and specified in terms of area in square kilometers.

An area comprises, from largest to smallest:

- the Earth's surface as a whole
- a continent or a region on a continent
- a country (nation state, e.g. according to the IPCC)
- a region within a country (federal states, administrative districts)
- a local authority (city, town, municipality)

- sub-areas of a municipality (neighborhood, district)
- other spatial references (e.g. by land use type such as urban, agricultural, forest or nature conservation areas)

2. Typical questions

Typical territory-related questions in GHG accounting can generally take two different approaches:

a) GHG inventories strictly related to the territory, e.g. the reporting required by the IPCC

- What are the absolute GHG emissions and GHG removals (GHG inventory) for a territory in a specific year?
- What is the trend in the GHG inventory for a territory over a defined period in the past?
- Does the inventory align with climate targets in relation to international commitments (Nationally Determined Contributions), if the territory refers to a national state?
- What is the projected future trend of the GHG inventory in the territory for a specific future scenario?
- What is the marginal change in the GHG inventory for the territory over time following the introduction of specific measures?

b) GHG inventories relating to the inhabitants of a territory; the values calculated according to the so-called domestic principle comprise the GHG emissions and GHG removals of the inhabitants of a territory, plus the imported GHG inventory and minus the exported GHG inventory.

- What are the GHG inventories caused by the residents of a territory relative to a specific year?
- What has been the historical trend in the GHG inventories attributed to the inhabitants of a territory?
- What is the future trend of the GHG inventory according to the 'polluter pays' principle?

Questions derived from this can be applied to the pathways for achieving targets that are either legally binding under international law or political in nature.

3. Reference system and accounting boundaries

The questions regarding the accounting object 'territory' require the exact definition of the territory's area in order to account for all GHG sources and sinks. This applies to both questions a.) and b.). The focus is on a country's GHG inventories. For other areas, as listed under 1. Description of the accounting object, GHG sources and sinks must be described in the same way.

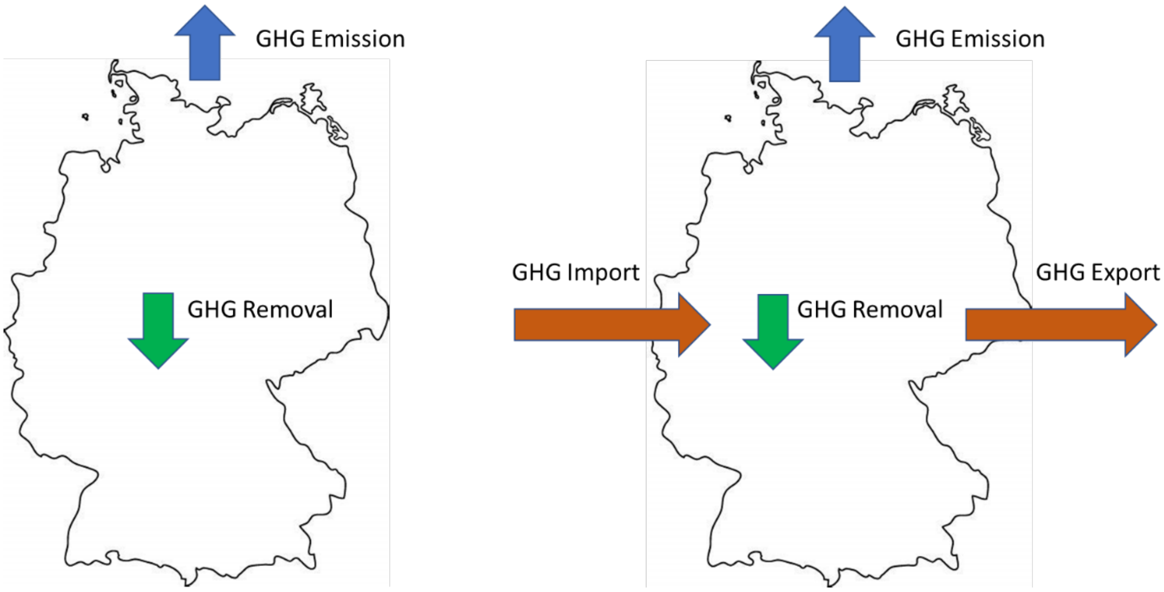
In the context of international law, territories will usually refer to national states as object to reporting obligations such as those under the Paris Agreement and to which the agreed accounting rules according to the IPCC apply (IPCC Guidelines for National GHG Inventories, 2006). The definition of accounting boundaries and the accounting rules for supra- or sub-national territories must be determined and applied consistently. However, questions regarding the domestic polluter-pays principle may lead to data-related difficulties for sub-national territories if import-export statistics are not available.

It is necessary to

- identify the area as a reference system with accounting boundaries
- cartographic representation

The territory of the Federal Republic of Germany has been chosen as an example in the following figure. As described, however, this applies to any other territory selected.

Figure 1: Schematic representation of the territory as accounting object (for Germany)



a) strictly area-based b) area-based according to the domestic principle

Key: blue arrows symbolize GHG emissions and green arrows GHG removals relative to the accounting object; red arrows represent GHG flows associated with imports and exports of goods and services (GHG backpacks)
Source: own illustration

4. Relevant system specifications

The relevant specifications for the reference system include, for example:

- the specification of the unit of measurement for area in square kilometers
- reference year(s) in the past
- activities on the area, classified where applicable according to the IPCC reporting sectors
- ratio of GHG emissions and GHG removals to population size or economic output
- changes in the activities of organizations and the population due to structural developments in production and consumption
- accounting for imports and exports of goods and services, including energy, holidays abroad, etc., for the purposes of b) the domestic polluter principle

5. Implications for GHG accounting

For GHG accounting of the accounting object 'territory', this means

- the recording of all GHG sources and sinks within the area

- the provision of models for calculating specific GHG sources within the territory (e.g. via the sale of fuels)
- the inclusion of GHG emissions from transport that takes place exclusively within the territory, but also cross-border transport, allocated between the source and destination territories depending on the accounting method
- where applicable, the breakdown of GHG inventories by reporting sector according to the IPCC
- Modelling of GHG inventories in accordance with question b) (see above: 2. Typical questions), which are linked to imports and exports; including the GHG inventories resulting from the stays outside the territory by residents of the territory and by non-residents during their stays within the territory (e.g. German holidaymakers in Spain or Spanish holidaymakers in Germany).

6. Conclusions for standardization

The definition of standards for countries and their territories is carried out within the framework of IPCC reporting and can be adapted accordingly to other territorial entities. Conclusions regarding standardization within the framework of ISO are not necessary at this stage.

2.3 Accounting object: Organizations

1. Description of the accounting object

The accounting entity is defined in ISO 14064-1:2018:

Organization (Chapter 3.4.2):

A person or group of persons that has distinct functions with responsibilities, authorities and relationships to achieve its objectives

Note 1 to the term: The term 'organization' includes, but is not limited to, sole traders, companies, groups of companies, firms, enterprises, public authorities, trading companies, associations, charities or institutions, or parts or a combination of the above, whether incorporated or not, public or private.

From: Greenhouse gases — Part 1: Specification with guidance on the quantification and reporting of greenhouse gas emissions and removals at the organizational level (ISO 14064-1:2018)

The definition is, quite rightly, very comprehensive. However, the focus is on companies that, through their manufacturing activities, are most closely associated with greenhouse gas emissions.

It should be noted here that the term 'organization' also includes 'association'. Due to the more complex structure of associations, it was decided in this report to treat them separately as the independent accounting object 'economic sectors and industries'.

2. Typical questions

GHG inventories have long been calculated and published in annual reports for corporate reporting purposes. The GHG Protocol's Corporate Standard was first published in 2001. Furthermore, reporting obligations arise from relevant legal regulations or are provided to consulting firms as part of voluntary surveys (e.g. in accordance with the GHG Protocol).

Typical questions posed to companies regarding their GHG inventories are:

- What are the absolute GHG emissions and removals resulting from activities under an organization's control in a given year – the base year? (direct GHG emissions and removals)
- How does the GHG emissions and removals resulting from activities under an organization's control have developed over a specific period – relating to specific years in the past? (direct GHG emissions and removals)
- What are the absolute GHG emissions and removals for which an organization is directly or indirectly responsible in the upstream and downstream value chain for a base year? (direct and indirect GHG emissions and removals)
- How does an organization's direct and indirect GHG emissions and removals have changed over a specific period – compared to the base year? (direct and indirect GHG emissions and removals)
- What potential exists for reducing GHG emissions or increasing GHG removals in the future
  - for activities under direct control?
  - for activities under direct and indirect responsibility?
- Which pathways for achieving GHG targets, such as net zero, should be implemented?

It should be noted that an organization's direct GHG emissions are designated as Scope 1 emissions by the GHG Protocol, whilst Scope 2 covers indirect GHG emissions from energy consumption, and Scope 3 covers all other GHG emissions within the value chain. Whilst reporting on Scope 1 and Scope 2 inventories is widespread, Scope 3 GHG emissions are often still not reported, or only reported incompletely.

3. Reference system and accounting boundaries

System boundaries are typically defined according to three approaches:

1) the operational control approach

2) the financial control approach, and

3) the ownership/equity approach

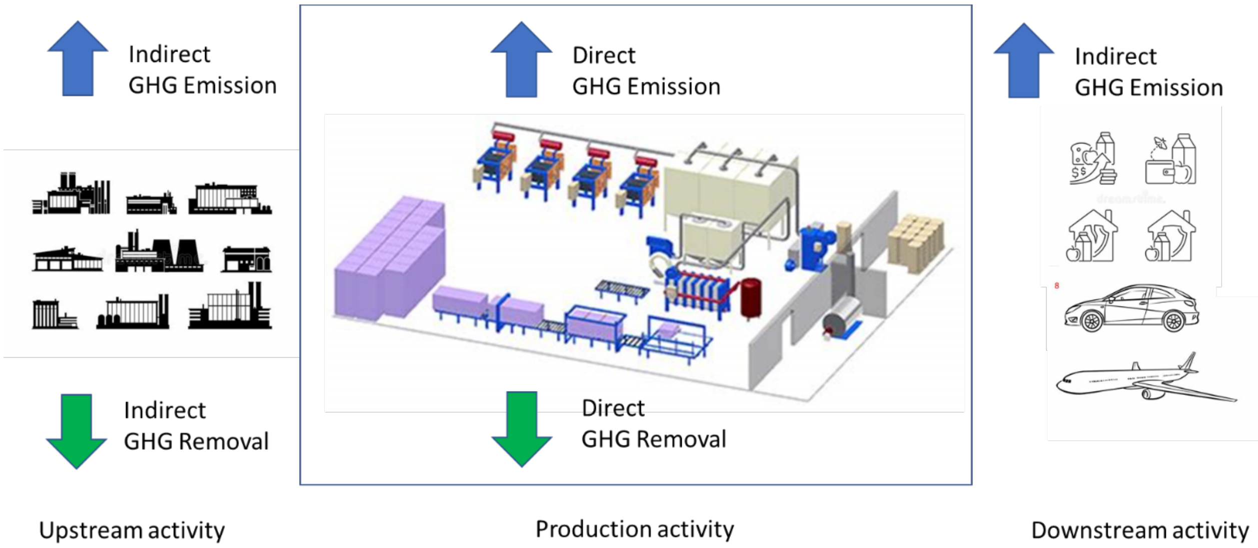
Accounting boundaries, on the other hand, are distinguished according to the scopes already described, which in turn are differentiated into several emission categories (see the GHGP Corporate Standard).

The system and accounting boundaries must be defined for each organization, covering both direct and indirect emissions. As the typical questions indicate, the accounting boundaries should be established step by step for:

- direct emissions from activities under the operational or financial control of the organization
- direct emissions from activities of potential joint ventures
- the organization's direct emissions plus all indirect emissions from the upstream supply chain
- the organization's direct emissions plus indirect emissions from the upstream supply chain and from the placing on the market, use, recycling and disposal of products
- all direct and indirect emissions, including other indirect emissions, e.g. those from employees' commutes, which have not yet been captured via the value chain

The figure below illustrates the individual scopes that must be taken into account when determining GHG inventories.

Figure 2: Diagram of the accounting object 'Organization'



Key: blue arrows symbolize GHG emissions and green arrows symbolize GHG removals in relation to the accounting entity
Source: own illustration

Although examples from the manufacturing sector are used more frequently here, the broad definition means that private and public organizations not belonging to the manufacturing sector must not be overlooked. In particular, public administrations, including local authorities, are endeavoring to carry out GHG accounting and reporting and are encouraged to do so by a legal obligation to act as role models and to organize their administration in a climate-neutral manner (in Germany, for example, through the Federal and State Climate Change Act and corresponding implementing administrative regulations). In this context, it is particularly important, especially in the case of local authority administration, to distinguish whether the administration is meant as an organization or as a territorial local authority (see above), or both. Here too, the distinction between the organization's direct and indirect sphere of influence – in this case, the administration of the local authority – and between direct and indirect GHG emissions and removals must be clarified.

4. Relevant system specifications

The relevant specifications regarding the reference system include, for example:

- the specification of the organization's system and accounting boundaries, in particular the clear definition of direct activities and the inclusion of all or parts of the indirect activities for which the organization is responsible

In principle, GHG inventories serve to compare inventories across different periods. To this end, it is essential to maintain consistent system and accounting boundaries.

There is considerable debate as to whether GHG inventories can also be used to compare different organizations. It is important to critically examine whether a reference unit – such as annual turnover, the type and quantity of products produced or sold, the services associated with the products produced or sold, etc. – is appropriate. Comparing the GHG inventories of different organizations can easily lead to perverse incentives to report figures that are incomplete or as low as possible in order to perform well in comparison with other organizations, for example in ratings.

- ► the determination of a base year for GHG accounting and, where applicable, comparison with base years in the past, taking into account a reference metric (e.g. number of employees or turnover)
- ► geographical localization of direct and indirect emissions or the underlying activities of the organization
- ► Determination of the temporal boundaries of the products placed on the market or the associated services over their entire life cycle, the timeframes of which may extend over many years
- ► Regulations on how any necessary reduction in indirect emissions and underlying activities is to be implemented, in order to capture and assess all relevant activities in their diversity and complexity (keyword: materiality analysis)
- ► Identification of emission reduction pathways to achieve targets (e.g. net zero, climate neutrality, GHG neutrality, etc.)

5. Implications for GHG accounting

For the GHG accounting of the accounting object "organization", this means

- ► Collection of primary data for direct GHG inventories under the organization's control (e.g. fuels and energy consumption)
- ► Development and application of models for GHG accounting of processes and activities under the organization's control, for which data cannot be collected or can only be collected with considerable effort
- ► Data collection and modelling of the processes and activities within the narrow or extended scope, and their accounting in accordance with clear prioritization, should there be reasons for incomplete accounting:
  - direct emissions from processes and activities under the organization's control
  - direct control over upstream processes and activities (upstream chains)
  - downstream processes and activities such as the use and end-of-life of products or associated services
  - all other indirect processes and activities (e.g. business travel, commuting, etc.)
- ► Analysis and reporting based on defined targets, taking into account the base years, the unit of measurement for comparisons, and target achievement for decision-making and action plans

6. Conclusions for standardization

In the forthcoming revision of the ISO 14064-1 standard and the GHG Protocol Corporate Standard, particular attention should be paid to the following:

- ► The intended use of the standard should be clarified in order to enable differentiated regulations depending on the specific application. Such applications for organizations could include:
  1. Determination of the GHG inventory under the organization's control
  2. Determination of the development of the GHG inventory under the organization's control
  3. Determination of the GHG inventory, including the organization's indirectly controlled GHG emissions and GHG removals, as well as their trends over time (performance tracking)

- Clarification of the use of chain-of-custody models in production and upstream supply chains, which ensure the rule-based transfer of material and product properties for GHG accounting (for a description of chain-of-custody models and further details, see Chapter 3.4). Special consideration of chain-of-custody models in the generation and procurement of electrical energy (see Chapter 3.5). Clear regulations on the use of chain-of-custody models, coupled with safeguards (guardrails) for their application, are necessary to avoid double counting or omissions.
- Specific guidelines on the allocation (for a definition of allocation and further details, see Chapter 3.6) of carbon in material and product flows in upstream and downstream chains and of indirect emissions from upstream and downstream activities.

2.4 Accounting object: Products

1. Description of the accounting object

The accounting object is defined in ISO 14067:2018:

Product (Chapter 3.1.3.1)

Goods or services

Note 1 on the term: The product can be classified into the following categories:
- Service (e.g. transport, event organization);
- Software (e.g. computer program);
- Hardware (e.g. mechanical engine parts);
- process-related product (e.g. lubricant, ore, fuel);
- non-process product (e.g. agricultural product).

Note 2 on the term: Services have tangible and intangible components. The provision of a service may, for example, include:
- an activity carried out on a tangible product supplied by the customer (e.g. a car to be repaired);
- an activity carried out on an intangible product supplied by the customer (e.g. the proof of income required to claim a tax refund);
- the delivery of an intangible product (e.g. the provision of information in connection with knowledge transfer);
- the creation of an environment for the customer (e.g. in hotels and restaurants).

From: Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification (ISO 14067:2018)

This very broad definition of a product is necessary to describe a good or service in terms of its function or benefit (use-related benefit, not economic benefit). This ensures a link to a functional unit, which ultimately also allows comparisons between different products with the same function (e.g. the function of ‘dry hands in a public toilet’ provided by an electric hand dryer, a disposable paper towel, a reusable cloth towel, etc.)

The concept of the ‘product system’ is also derived from this perspective and is defined as follows:

Product system (Chapter 3.1.3.2)

A collection of process modules with element flows and product flows that models the life cycle of a product (3.1.3.1) and fulfils one or more specified functions

Note 1 on the term: “Product flow” is defined in ISO 14040:2006, 3.27.

From: Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification (ISO 14067:2018)

2. Typical questions

In the late 1980s, questions began to arise increasingly regarding the environmental advantage of one product over another. This led to the realization that, in such a product comparison, the entire life cycle of a product must be considered, from raw material extraction and the manufacture of the product, through its use phase, to its disposal. To further prevent "apples being compared with oranges", a common basis for comparison had to be chosen, namely the product's benefits. The Life Cycle Assessment (LCA) evaluation method was developed.

In the 2000s, the term 'product carbon footprint' finally emerged, particularly in the English-speaking world, and initially retail chains wanted to label all the products they offered with this carbon footprint. Although this failed due to the complexity of the task, products are still communicated and advertised today using their GHG inventory or GHG footprint. It is based on the life cycle assessment for one environmental impact, namely the greenhouse effect.

This gives rise to the following key questions regarding the 'product' as the subject of the life cycle assessment, where 'product' is understood to mean a specific product benefit:

- What is the GHG inventory of a specific product (GHG footprint) over its life cycle?
- How does a product's GHG footprint evolve over the years?
- Which product has the lowest GHG footprint compared to other products, taking into account its life cycle and product benefit?
- What potential for reducing the GHG inventory can be achieved in relation to a product's benefit?
- How can a product's climate neutrality (GHG neutrality) be achieved in relation to its product benefits and its entire life cycle?

There is also an increasing need for a partial carbon footprint to communicate the GHG inventory along the supply chain. Difficulties in understanding and potential misuse may arise if such partial results are communicated to end consumers without taking the entire life cycle into account. Nevertheless, calculations of partial carbon footprints are useful in addressing the following questions:

- What is the GHG inventory of a raw material, intermediate product or end product without taking the entire life cycle into account?
- How does the partial GHG footprint of a material, intermediate product or end product evolve over the years?
- What reduction potentials can be achieved for a partial GHG inventory, and is it possible to achieve GHG neutrality for the partial balance?

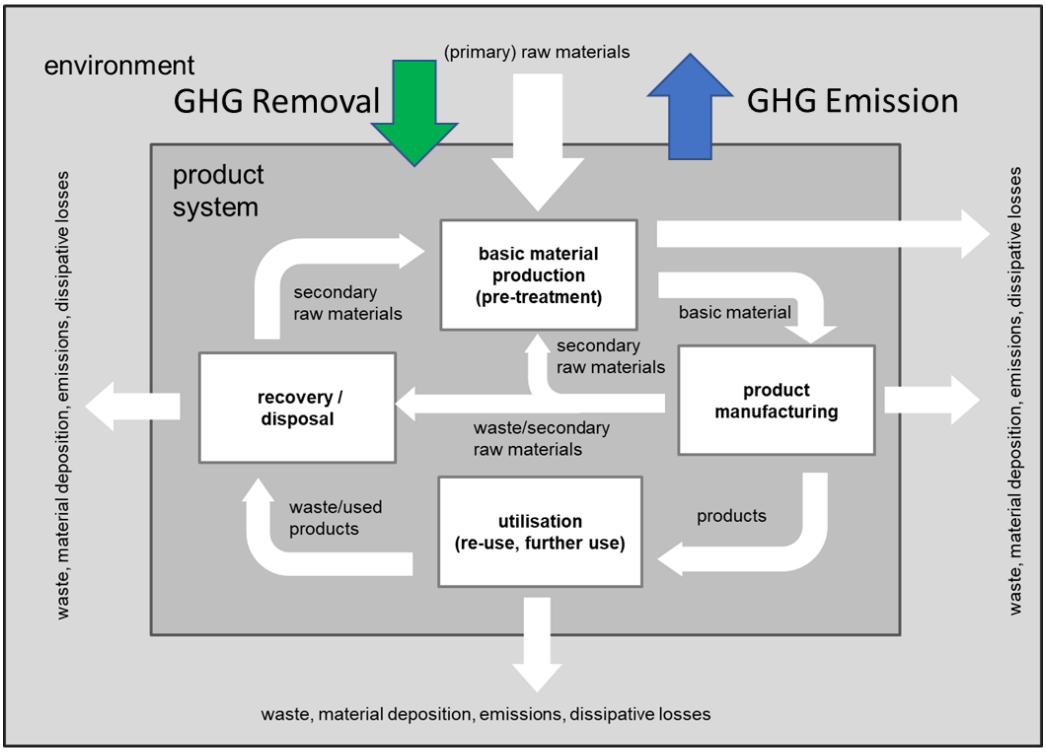
3. Reference system and system boundaries

The reference system is derived from the remit of the product life cycle assessment, in which the entire product system (see definition above) – from raw material extraction, through product manufacture and its use phase, to disposal – must be determined and modelled for all its individual processes (unit processes). A distinction between system and life cycle boundaries, as is common in organizational contexts, is not typically made here, as the product perspective focuses on the product's life cycle and is not, from the outset, geared towards the control approaches of various stakeholders.

As there are diverse links within a material-product system to other co-products and associated co-product benefits, system demarcation using allocation rules is of great importance (e.g. the allocation of CO_2 emissions from chlor-alkali electrolysis to its products: chlorine, sodium hydroxide and hydrogen).

An important special case of such co-product benefits arises when a product, following its original intended use, can be made available for a second or multiple product benefits through reuse, further use or recycling at the end of its respective life cycle. To this end, appropriate accounting boundaries must be drawn, and the jointly generated GHG inventories must also be apportioned in line with the multiple product benefits.

Figure 3: Schematic of the product as an accounting object



Key: the blue arrow symbolizes GHG emissions and the green arrow GHG removals in relation to the product as the accounting object
Source: VDI Guideline 4800-Sheet 1; blue and green arrows added

4. Relevant system specifications

The relevant specifications for the reference system include, for example:

- Definition of a product benefit – expressed in the functional unit (e.g. drying hands once)
- Modelling of a product system based on this functional unit, including all processes 'from cradle to grave' and the corresponding material and energy flows
- Spatial system boundaries of the product system with global geographical localization of the production processes and, in particular, the use phase

- Temporal boundaries of the product system, covering everything from material extraction (e.g. the growth of a tree) through the duration of the use phase (e.g. the average lifespan of a car) to the start date and duration of further life cycles of product components or materials
- Definition of the level of detail for the product system to ensure efficient work

Separately, appropriate reference systems must also be established for partial GHG footprints:

- Precise identification and delineation of the subsystem
- Definition of a material or product stream as a so-called 'declared unit' as an input or output reference value for the partial GHG footprint, as a complete life cycle is not available here
- Furthermore, all spatial, temporal and level of detail system boundaries analogous to the total GHG footprint

5. Implications for GHG accounting

For the GHG accounting of the accounting object "products", this means

- Collection of plant-specific primary data throughout the product's life cycle, where possible
- Collection of other primary data from the value chain and secondary data from databases that meet the quality requirements
- Modelling of the entire product life cycle in relation to a functional unit or a sub-section of the life cycle in relation to a declared unit
- Special due diligence when comparing the GHG footprints of several products in determining the common functional unit and system boundaries; in accordance with ISO 14044, 'independent critical review' procedures must be followed
- Appropriate communication of the results in accordance with the requirements of the respective study objectives and taking into account the standards ISO 14040, ISO 14044, ISO 14067 and ISO 14026

6. Conclusions for standardization

In the forthcoming revision of the ISO 14067 standard, particular attention should be paid to the following:

- Clearer definition of requirements for the allocation of co-products (i.e. the attribution of GHG emissions from a manufacturing process to different products or co-products) and the multiple uses of products and materials in different life cycles, depending on the study's objectives (for the definition of allocation and further details, see Chapter 3.6)
- Clarification of the use of chain-of-custody models in the product life cycle, which ensure a rule-based transfer of material and product properties for GHG accounting (for a description of chain-of-custody models and further details, see Chapter 3.4). Special consideration of chain-of-custody models in the generation and procurement of electrical energy (see Chapter 3.5). Clear regulations on the use of chain-of-custody models, coupled with safeguards (guardrails) for their application, are necessary to avoid double counting or omissions.
- Handling of biogenic carbon in the process chains of product manufacturing, use and disposal, taking into account the same rules for CO_2 removal, the flow of biogenic carbon in the value

chain and the release of greenhouse gases such as methane and carbon dioxide at the end of the chain.

2.5 Accounting object: Industrial Sector

1. Description of the accounting object

The accounting object is defined in accordance with CEN 18047:2026 (CEN):

Industrial sector (Chapter 3.1.4.5)

An economic sector that produces goods or services or transforms materials, typically corresponding to a 3- or 4-digit ISIC classification or the Statistical Classification of Economic Activities in the European Community (NACE),

whereby the value chain represents the entire sequence of activities or parties that provide or receive value in the form of a product.

Note 1 to the entry: Parties that provide value include employees, suppliers, outsourced workers, contractors and others.

Note 2 to the entry: Parties that receive value include customers, consumers, clients and other users.

Note 3 to entry: In this document, products are defined as goods or services offered by a provider.

Own translation from: C EN 18047:2026, Industrial decarbonisation — Requirements and guidelines for sectoral transition plans

It should be noted that the term 'economic sector' is usually expressed as 'Industrial Sector' in English usage, whilst other legal definitions also exist for the term 'sector' (e.g. in the Federal Climate Change Act, where a distinction is made between the sectors of energy supply, housing and buildings, transport, land use, industry and manufacturing, etc.).

'Associations' have already been mentioned under the accounting object 'organizations'. It seems appropriate to treat industrial sectors as a separate accounting object due to their significance and complexity in relation to climate protection measures.

2. Typical questions

At present, GHG accounting for industrial sectors is mostly discussed in the context of the development of 'Sectoral Transition Plans' (STPs). According to the recently published CEN standard 18047:2026, such a sectoral transition plan is defined as follows:

Sectoral Transition Plan (Chapter 3.1.4.1)

A strategic plan developed in collaboration with stakeholders and containing actionable measures to achieve a sector's decarbonization targets

Own translation from: CEN 18047:2026, Industrial decarbonisation — Requirements and guidelines for sectoral transition plans

This raises typical questions such as:

- ► What GHG emissions and GHG removals are caused by a particular economic sector?
- ► How have the GHG inventories of specific industrial sectors developed in recent years?

- How can sectoral transition plans be developed and implemented for specific sectors to achieve sectoral GHG targets?

3. Reference system and accounting boundaries

The reference system is derived from the sum of all organizations and their production that are attributed to a particular industrial sector. As stated in the definition, the term 'industrial sector' is primarily understood as the classification used by international institutions such as the UN, OECD or the EU. The International Standard Industrial Classification (ISIC) is, for example, a UN classification system for categorizing economic activities and, building on this, economic units such as companies into industrial sectors. Each sector from the primary, secondary and tertiary economic sectors is assigned, according to ISIC, to one of 21 main groups, which are in turn divided into sub-groups. Just as ISIC operates at the international level, NACE is the European Union's corresponding classification system for economic sectors (Nomenclature statistique des activités économiques dans la Communauté européenne).

If the reference system relates to an industrial sector according to an existing classification scheme, the scheme and its exact designation must be specified. Furthermore, the geographical classification must be defined, which may encompass individual countries as well as supranational or sub-national economic areas. If the reference system is not based on a classified industrial sector, a precise delimitation is required to specify which organizations fall within the economic framework under consideration.

It should be noted once again here that 'association' has also been referred to as 'organization' and may be understood as such. However, due to the specific nature of an economic sector, it seems appropriate to consider the accounting object 'industrial sector' separately.

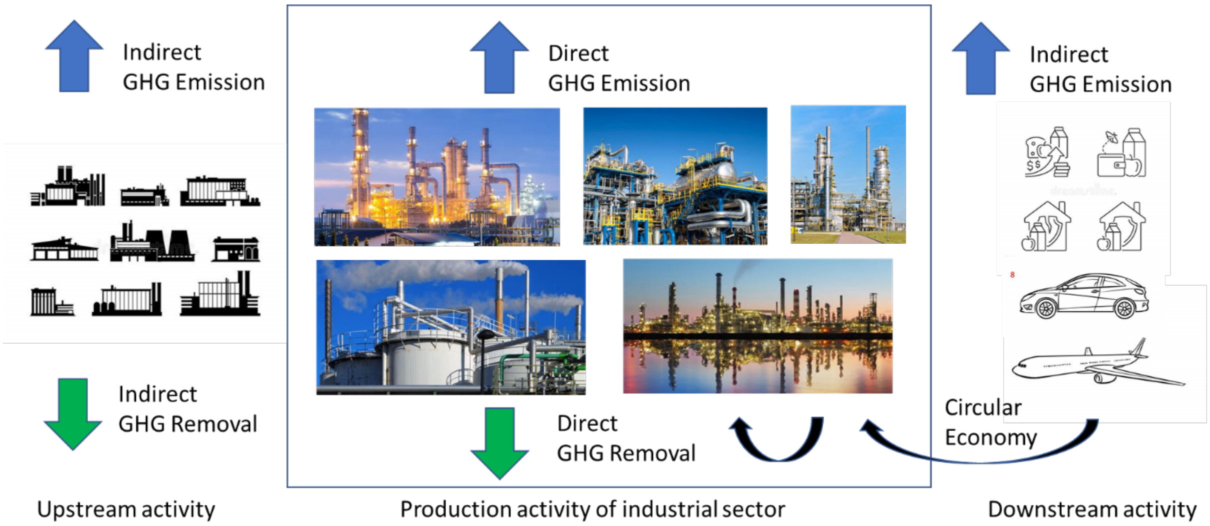
Once the reference system has been defined with sufficient precision, the accounting boundaries must be identified. As with organizations, the accounting boundaries for GHG emissions and GHG removals from industrial sectors should be selected according to:

- Activities under the direct sphere of influence of the industrial sector
- Activities within the sector's sphere of influence plus upstream activities insofar as these emissions arise outside the sector
- Activities within the sector's sphere of influence plus upstream activities plus downstream activities involving the use of the sector's products, insofar as these emissions arise outside the sector
- Activities within the sector's sphere of influence plus indirect activities, with particular emphasis on closing loops (circular economy)

The CEN standard CEN 18047:2026, Industrial decarbonization — Requirements and guidelines for sectoral transition plans, provides relevant guidance.

The figure below illustrates the sector's reference framework and the boundaries that must be taken into account when compiling GHG inventories, depending on the specific question being addressed.

Figure 4: Schematic representation of the accounting object 'industrial sectors'



Key: blue arrows symbolize GHG emissions and green arrows symbolize GHG removals in relation to the accounting object
Source: own illustration

4. Relevant system specifications

The relevant specifications for the reference system include, as partly outlined above, e.g.:

- the identification of the industrial sector according to the chosen classification or other precise definition
- the identification of which organizations belong to the industrial sector, based on economic activity and the associated geographical scope
- the specification of the system boundaries of the activities under the direct control of the industrial sector, including the organizations within it
- the specification of the system boundaries of the activities under the direct control of the industrial sector and the indirect upstream and downstream activities, with particular mention of the internal material and energy cycles within the system
- the determination of a base year for GHG accounting and, where applicable, comparison with past base years, taking into account a reference unit such as the number of organizations, sector turnover, etc.

5. Implications for GHG accounting

For the GHG accounting of the accounting object 'industrial sector', the following aspects/prerequisites are appropriate and necessary

- Appointment of a coordinating body, e.g. at the level of an association; identification of the organizations that form part of the industrial sector; identification of activities within the direct sphere of influence of the industrial sector; identification of the sector's upstream and downstream activities, including the circulation of materials and energy
- Collection of information and data for the direct GHG inventories under the control of the industrial sector, assuming that the organizations within the industrial sector have the relevant information

- Development of models for pragmatically determining the GHG inventories of upstream and downstream activities within the sector
- Evaluation and reporting of GHG inventories by the steering committee, taking into account year-on-year comparisons for the reference years and the achievement of targets for the Industrial Sector Transition Plan (STP)

6. Conclusions for standardization

The first step is to gain experience with sectoral plans. In doing so, it should be assessed whether a standard such as 'CEN/TC 467, CEN 18047:2024, Industrial decarbonization — Requirements and guidelines for sectoral transition plans' delivers added value once it has come into force and been applied by industrial sectors. Only then it can be determined whether further standards for economic sectors are appropriate and advisable.

2.6 Accounting object: Materials and Material Groups

1. Description of the accounting object

In addition to the accounting object 'products', material-related GHG inventory calculations often feature. The relationship between an organization and an economic sector can also serve as the basis for the relationship between products and a material-based approach. The more complex nature of a material and its associated material flows and GHG inventories justifies treating the accounting object 'material' as a separate entity. Essentially, a material-based approach involves accounting for many or all products that contain a specific material.

A more precise definition of the accounting object 'material' is difficult, as it can occur both at the start of a value chain and in the middle of it, and is also subject to change. Some materials, such as wood, glass, concrete, iron/steel, etc., lend themselves to clear identification more readily than metal alloys, chemical raw materials or other material mixtures. Nevertheless, statements are often made regarding the use and recycling of materials.

There is a certain overlap between the approach to GHG accounting via a material and the approach via industrial sectors. Therefore, a certain similarity can be assumed in the definition of reference systems, system boundaries and accounting boundaries, even if the perspective on the system and the associated GHG accounting differs.

2. Typical questions

Typical questions for the accounting object 'material' are:

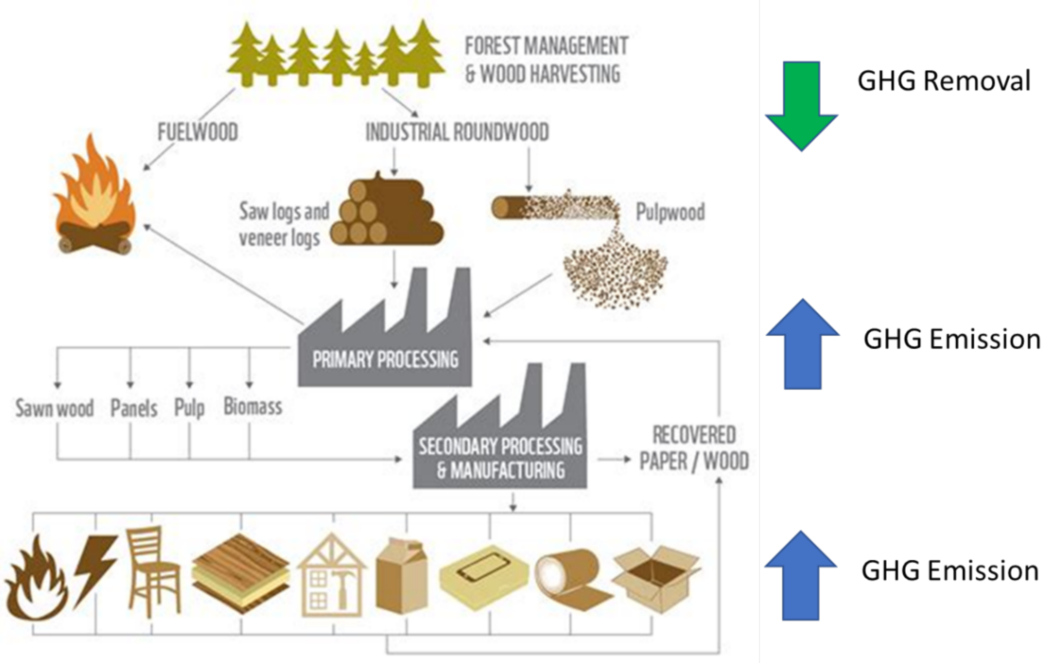
- Which GHG inventories are associated with the extraction, placing on the market, use and disposal of a material?
- What options for recycling or cascading use exist for a material, and how do these options affect the GHG inventories?
- How do the GHG inventories of a material system and the associated material flows have developed over recent years?
- What will the future GHG inventories of a material system look like, and which limits on GHG reduction and additional GHG removals, if any, are material-specific?

3. Reference system and accounting boundaries

The reference system for the 'material' accounting object is the extraction, processing, manufacture and use of products, the recycling of the material, and its final destination or disposal. The reference system for materials thus follows the life cycle principle, and the accounting boundaries encompass all activities and processes within the life cycle. Consequently, there is no distinction between activities and processes directly under an organization's control and those upstream or downstream, as is the case for an industrial sector.

The following diagram illustrates the material and product flows of 'wood as a material'. It begins with GHG removal through photosynthesis, followed by process steps in forestry, woodworking, the wood-processing industry, the pulp industry, the use of wood materials for energy generation, and finally the utilization of the products. The diagram does not show the final fate of durable wood products, which may enter a further life cycle or, through incineration with or without energy generation or disposal, mark the end of the material flow.

Figure 5: Diagram of the accounting object 'Material' and material groups



Key: blue arrows symbolize GHG emissions and the green arrow symbolizes GHG removals in relation to the material accounting object – here using the example of products made from wood

Source: WWF LIVING FORESTS REPORT: CHAPTER 4 FORESTS AND WOOD PRODUCTS; 2012; Published in December 2012 by WWF – World Wide Fund for Nature, Gland, Switzerland.

4. Relevant system specifications

Relevant system definitions for a material are:

- Clear definition of the material or material group
- Identification of the product benefits generated by the material or material group at a specific point in time. Definition of the material-related product benefit as a reference unit (sum of the benefits of all products of the material; also referred to as a 'benefit basket')
- Based on the unit of reference, accounting boundaries must be defined; these are of a spatial nature (geographical reference, including associated imports and exports) and of a temporal nature (product lifespans, use in cascades)

- Definition of levels of detail to ensure clarity and to exclude insignificant contributions
- The determination of a base year for GHG accounting, e.g. regarding the placing on the market of products containing the defined material and, where applicable, comparison with base years in the past, taking into account the reference unit such as the total material-related product benefit

5. Implications for GHG accounting

The following consequences arise for the GHG accounting of the accounting object 'material':

- Compilation of all processes occurring throughout the material's life cycle and the associated GHG emission factors, using organization-specific and sector-specific data sources and databases
- Modelling of the material-related process chains with the material flows relevant to the reference system and, based on this, the calculation of GHG inventories in relation to the material-related product benefits within the reference system
- Analysis of the GHG inventories for the material's material flows in relation to the total product benefits (basket of benefits) and in comparison with figures from previous years
- Evaluation of the GHG inventories for the material's material flows in relation to the total product benefits (basket of benefits) and in comparison with optimization scenarios for enhanced recycling and the highest possible level of recovery.

6. Conclusions for standardization

There has not yet been any explicit demand for a standalone standard for the 'material' as an accounting object with regard to its GHG inventory. However, the standard 'ISO 59014:2024 Environmental management and circular economy – Sustainability and traceability of the recovery of secondary materials – Principles, requirements and guidance' provides a document on the sustainability and transparent use of secondary materials.

2.7 Accounting object: Waste and Disposal Routes

1. Description of the accounting object

A different perspective from that of organizations and products arises from the viewpoint of waste streams and associated disposal routes. Since the 1990s, the German Circular Economy Act has stipulated that "high-quality recovery" should be the aim, and that the more environmentally sound disposal of waste takes precedence. In the context of the climate debate, this approach has increasingly been applied to the disposal routes of specific waste streams. It is therefore proposed to include a 'Waste and Disposal Routes' accounting object, which, however, has some distinctive features.

The definition of waste is based on the German Circular Economy Act (KrWG) (own translation):

§ 3(1) Waste within the meaning of this Act is any substance or object of which the owner disposes, intends to dispose or is required to dispose. Waste for recovery is waste that is recovered; waste that is not recovered is waste for disposal.

From: Act on the Promotion of the Circular Economy and the Ensuring of Environmentally Sound Waste Management (Circular Economy Act – KrWG); Circular Economy Act of 24 February 2012 (Federal Law Gazette I p. 212), last amended by Art. 5 of the Act of 2 March 2023 I No. 56

The definition of waste from the standard ISO 59004 “Circular Economy — Terminology, principles and guidance for implementation” is considered insufficient from the legislator’s perspective because it addresses only the nonexistent value of waste to the waste owner, but not the owner’s intention to dispose of it (… has disposed of, intends to dispose of) nor the obligation to dispose of it (… or must dispose of) as in the German Circular Economy Act.

Waste (clause 3.3.6)

a resource that is no longer considered to be an asset as it, at the time, provides insufficient value to the holder

From: Standard ISO 59004 Circular Economy — Terminology, principles and guidance for implementation

An important point regarding the accounting object ‘waste’ must be highlighted before proceeding. Under the UNFCCC, national GHG emissions must be reported according to specific categories. According to the Common Reporting Format (CRF), this includes the category ‘Waste and wastewater’ (CRF sector 5, waste).

According to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, this category covers only:

- Solid waste disposal
- Biological treatment of solid waste; (Note: excluding energy recovery)
- Incineration and open burning of waste (Note: excluding energy recovery)
- Waste water treatment and discharge

This CRF category ‘Waste’ in national reporting in line with IPCC is a sub-aspect of the accounting object ‘Territory’ and is included therein.

However, the waste disposal pathways must be understood in a much broader context with regard to the CRF category ‘Waste’, as waste recovery has a direct impact on the GHG inventories of other CRF categories. It is clear that the material recovery of waste leads to substitution effects in the production of primary materials and thus influences the CRF category ‘Industry’. Similarly, the use of waste for energy through biological and thermal waste treatment processes leads to substitution effects in energy generation and thus influences the GHG inventory of the CRF category ‘Energy generation’.

Thus, waste recovery and disposal activities affect many production activities within the material cycles and the associated GHG emissions. A separate approach to GHG accounting for waste management activities is justified; however, care must be taken to ensure that no methodologically incorrect conclusions are drawn (…) resulting from the overlap of other accounting objects such as territory, organization or products.

2. Typical questions

The links between waste management and many other sectors give rise to very specific questions for GHG accounting. Apart from the territorial reporting for the ‘waste’ category (which is very limited under IPCC CRF 5), **no conclusions** can be drawn on certain issues:

- **No methodologically sound statements** can be made **regarding absolute GHG inventories** for the waste management sector, as the effects arising from substitution effects across all material cycles are of far greater relevance; consequently, **only relative statements regarding reference scenarios** can be meaningfully derived.

- It is not possible to compare GHG inventories across different years, as waste volumes and compositions typically change over time, and analyzing the difference in conjunction with substitution effects leads to misleading conclusions regarding GHG inventories. (An increase in waste volume over the years, assuming consistent waste treatment and taking into account substituted primary materials, leads to higher 'avoided' GHG emissions; however, absolute GHG emissions have very likely increased due to the higher material throughput. This leads to the absurd conclusion: the more waste is generated, the better it is for climate protection.)

Rather, the typical questions regarding waste management and disposal routes are as follows:

- Which disposal route, which disposal scenarios relating to a clearly defined waste stream, have the lowest GHG inventories?
- What is the GHG inventory of waste disposal in a specific disposal area at a given point in time compared to alternative courses of action?

3. Reference system and accounting boundaries

The reference system is determined by the handling of a specific, clearly defined quantity of waste with a clearly defined, unchanging composition. The emissions from waste treatment activities constitute the GHG inventory of the waste system. This waste system then yields a range of secondary products, secondary materials and energy sources, which are fed back into the economic system.

Thus, the recycled waste generates secondary products and materials within the economic system which, whilst offering the same functional benefit, can substitute products, materials and energy sources derived from primary raw materials. To determine the equivalent functional benefit derived from primary raw materials, the GHG inventories of the substituted primary production system can now be calculated.

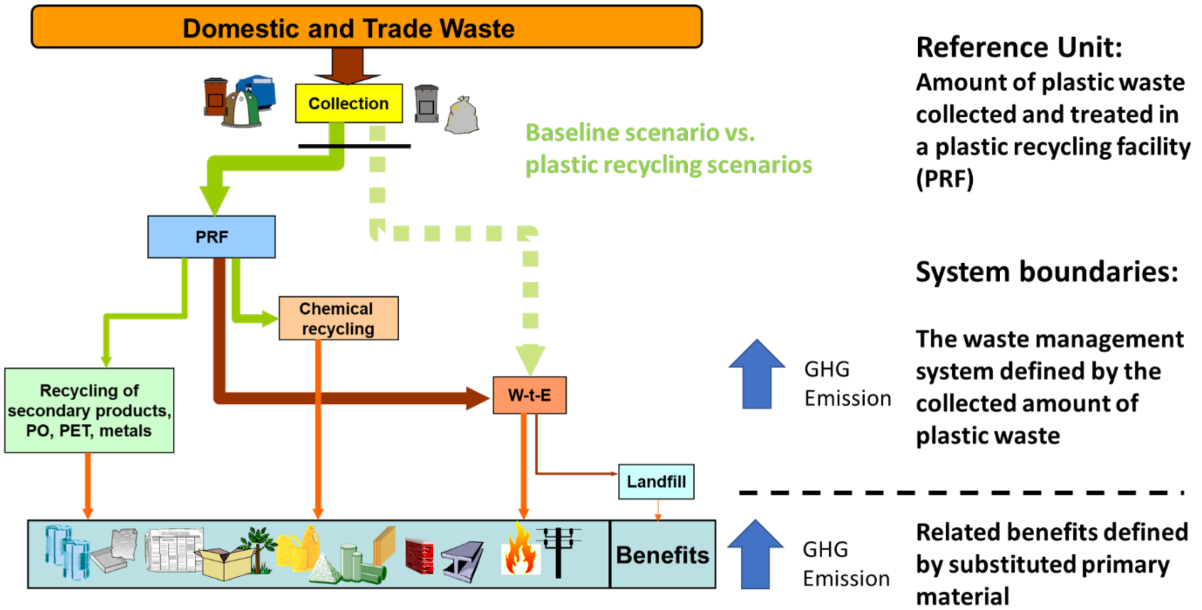
Determining the GHG inventory of the waste system and the substituted primary production system yields a GHG difference that is typical of a specific disposal route. This ultimately allows different disposal scenarios to be compared – including an existing disposal situation (baseline scenario) with corresponding alternative courses of action.

The boundaries of the waste system's life cycle assessment should be selected on the basis of the clearly defined waste quantity and composition, encompassing all processes up to the functional benefits generated from the waste. The primary production system to be substituted, with all equivalent functional benefits to the waste system, thus encompasses all processes involved in the manufacture of materials, products and energy carriers as a scope of assessment that are equivalent to the benefits of the waste system.

The following figure illustrates the example of the recovery of the plastic fraction in household and commercial waste. The waste system encompasses all activities from waste collection through to recoverable products such as secondary polyolefins (PO), raw materials from chemical recycling and energy generated from waste-to-energy (WtE) plants, such as electricity and heat.

In contrast, the primary production system must encompass all production processes and energy supply processes required to generate the benefits substituted by plastic recycling. Both the waste system and the primary production system are associated with GHG emissions.

Figure 6: Diagram of the accounting object 'waste' and disposal pathways



Key: blue arrows symbolize GHG emissions relating to the accounting object 'waste and disposal routes', using the example of 'mixed plastic waste in municipal waste'

Source: own illustration based on the GIZ/KfW Solid Waste Management – Greenhouse Gas Calculator tool; 2022

4. Relevant system specifications

Important system specifications for the issues described are:

- Definition of the waste volume established for the comparison of different disposal routes
- Description of the waste composition, which is also fixed for the comparison of different disposal routes
- Determination of the utility value of the products generated by the waste system (e.g. products made from recycled material, secondary fuel)
- Definition of the products, materials and energy sources made from primary raw materials that are replaced by the utility value derived from waste recovery
- Identification of the processes for the manufacture and supply of the replaced products, materials and energy carriers
- Separate modelling of the process chains of the waste system and the primary material system in relation to the identical utility

5. Implications for GHG accounting

For the implications of GHG accounting for the accounting object 'Waste and disposal pathways', this means:

- A strict distinction should be made between the two systems – the waste system and the primary production system – and they should be modelled accordingly, in order to ensure that the respective assumptions can be understood as transparently as possible.
- It must be made clear in communication that the result of a GHG accounting exercise for waste management initially represents a comparison of the benefits generated in a disposal

scenario and the associated GHG emissions, against the assumed substitution of primary materials and the resulting avoided GHG emissions.

- Under no circumstances should the absolute figures from GHG inventories be offset against organizations' GHG inventories, as they are derived using different calculation methods.
- The significance of GHG accounting for waste lies in the fact that two or more disposal scenarios are compared with one another based on the same waste quantities and waste compositions. Only the GHG differences between such disposal scenarios are meaningful and reflect the GHG reduction achieved by the alternative courses of action.

6. Conclusions for standardization

There are currently no standardization activities aimed at independently standardizing GHG accounting for waste and disposal systems. (However, a proposal to this effect was recently presented to a DIN working committee.)

Nevertheless, it is clear that the comparison of emissions between two scenarios corresponds to the methodological approach of 'avoided emissions', which could also be applied to the comparison of disposal routes.

2.8 Accounting object: Climate protection projects

1. Description of the accounting object

The discussion is limited to projects that serve climate protection and does not apply to projects with other objectives, e.g. the construction of buildings and transport routes or development aid. The accounting object can initially be identified by the definition in ISO 14064-2:2019:

Climate protection project (Chapter 3.2.3)
GHG project
An activity or activities that alter the conditions of a GHG baseline scenario and result in reductions in greenhouse gas emissions or increases in the removal of greenhouse gases.

Note 1 to the term: The activity may include technologies used to alter the conditions of the greenhouse gas baseline scenario.

From: Greenhouse gases — Part 2: Specification with guidance on the quantification, monitoring and reporting of greenhouse gas emission reductions or increases in greenhouse gas removals at project level (ISO 14064-2:2019)

Climate protection projects serve to identify opportunities for GHG reductions at project level and to apply them to various issues. The primary market-based interest lies in making the GHG reductions available to the voluntary carbon market upon implementation of a climate protection project. It would also be conceivable to develop projects in accordance with Chapter 6.4 of the Paris Agreement, should corresponding CDM successor arrangements be established under the Agreement.

It remains to be seen exactly, which projects will be covered by this, and this needs to be clarified further in consultation with the relevant stakeholders. Possible examples include climate protection projects aiming at:

- GHG reduction, including CO_2 capture from industrial processes and storage
- GHG removal through CO_2 extraction from the atmosphere and permanent storage

- GHG avoidance through measures that draw on alternative, additional options for action which cannot be directly classified as GHG reduction or GHG removal, e.g. measures for the high-value recovery of waste; see above: waste management as an accounting object (avoidance is not included in the definition cited above)

Overall, it may prove difficult to define climate protection projects, as potentially any project that results in a GHG reduction compared to a reference scenario is a climate protection project. It is therefore recommended that the nature of the projects be better characterized. One necessary characteristic could be that CO_2 credits are generated for the voluntary carbon market. It could also be specified which types of CO_2 credits (reduction credits, removal credits, avoidance credits) should be traded at all, and at what points in time.

2. Typical questions

Typical questions for the accounting object 'project' are:

- Which projects are eligible as climate protection projects?
- How high is the GHG reduction of a specific project and what type of reduction (reduction, removal, avoidance) does it address?
- Which and how many CO_2 credits can be generated through a specific project on the voluntary carbon market?

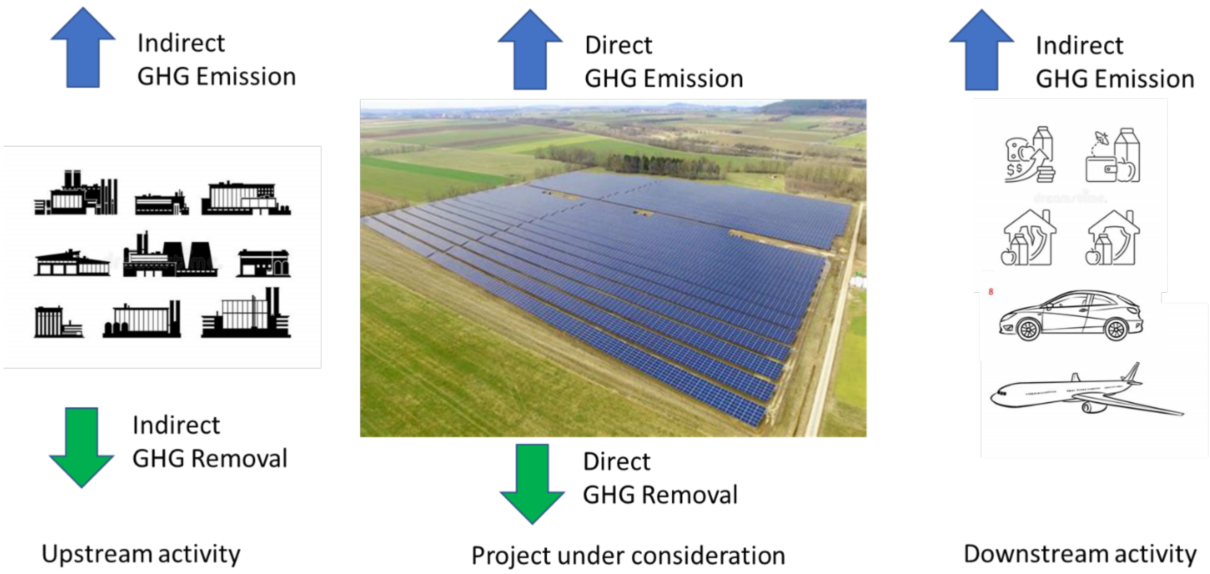
3. Reference system and accounting boundaries

In fact, requirements for accurate and traceable GHG accounting must also be met for the accounting object "project", even though the relevant ISO standard (ISO 14064-2:2019) avoids the term "accounting boundaries". These include:

- Clear identification of the project and the objectives of the activities (measures) to be implemented
- Function or benefit of the project, on the basis of which a reference scenario without the project can be selected
- Scope of the project and the baseline scenario, including the direct spatial and indirect systemic scope (see figure).
- Levels of detail for project activities to ensure the practicability of GHG accounting.
- Duration or validity period of the project
- Time validity of the project's measures, particularly for GHG removals

In this context, it is surprising that the project standard ISO 14064-2 avoids the term 'system or accounting boundaries' and instead refers to GHG sources, sinks and storage (QSS). In fact, the accounting boundaries should be defined first, followed by the QSS within it.

Figure 7: Diagram of the accounting object: climate protection projects



Key: blue arrows symbolize GHG emissions and green arrows GHG removals in relation to the accounting object, using the example of an open-space solar plant
Source: own illustration

4. Relevant system specifications

The key system specifications for a project have already been outlined under 'Reference System' and 'Scope of Accounting', as ISO 14064-2 does not go into much detail on this.

In addition to the aspects already mentioned, particular attention should be paid to the careful selection of reference scenarios, as these define the quality and quantity of the actual climate protection projects. Rules for selecting reference scenarios should be established.

5. Implications for GHG accounting

It is essential that GHG accounting for projects also follows the fundamental rules of the standards established for other accounting objects. Due to the politically controversial issuance of CO_2 certificates, the methodological steps of GHG accounting and other criteria for projects must be capable of generating credible certificates. Methodological consistency and alignment between the GHG accounting of organizations and products must be ensured.

6. Conclusions for standardization

ISO 14064-2:2019 "Greenhouse gases — Part 2: Specification with guidance for the quantification, monitoring and reporting of greenhouse gas emission reductions or increases in greenhouse gas removals at project level" is due for revision. As this standard remains under the sole management of ISO within the framework of the cooperation between the GHG Protocol and ISO, the revision will receive special attention and should see significantly greater involvement in SC 7 WG 5.

3 Selected methodological issues in GHG accounting for organizations and products

3.1 Areas of conflict in GHG accounting

This chapter focuses on methodological issues relating to GHG accounting for organizations and products. The applicability of the methodological discussion to other accounting objects (see above) is not the subject of this report.

The need for GHG accounting for organizations and products is driven by legal and market pressures for transformation, which are reflected in stricter legal regulations and changing preferences among market actors such as suppliers, customers and lenders.

This is also the reason for the wide variety of regulatory frameworks governing the calculation of GHG inventories, whether on a voluntary basis, based on national or international standards, or on the basis of binding legislation. Examples include the voluntary standards of the GHG Protocol for organizations and products, as well as the corresponding ISO standards for GHG quantification and reporting – foremost among these being ISO 14064-1 for organizations and ISO 14067 for products.

GHG accounting for organizations and products is closely interlinked, yet serves different purposes and thus implies different perspectives.

Organizations – i.e. companies – therefore have a particular responsibility for their production facilities. However, through their products, they also have a far-reaching impact on supply chains and consumer behavior, influencing the GHG emissions of their suppliers, contractual partners and customers to an extent that goes far beyond the GHG inventory of their own production processes.

Product-based accounting refers to a specific product (goods and services) and, by definition, covers the entire life cycle of a product, from the extraction of raw materials through production and distribution to the fulfilment of the product's purpose, consumption, and disposal. The focus is not directly on a single production step and thus on a specific company, even though individual organizations, as actors in the product's value chain, have an interest in gaining insights and exploring potential courses of action.

Even though GHG accounting for organizations and products follows different questions and perspectives, the same methodological problems often arise. These are addressed in the existing standards and regulated more or less clearly within their respective contexts. As organizational and product standards are developed in different standardization processes involving various experts, methodological regulations may be formulated in a consistent manner but may also be contradictory. In the past, a lack of clarification has certainly led to uncertainty among companies, consumers and policy-makers regarding the informative value, comprehensibility and credibility of GHG inventories.

After many years of organization-specific and product-specific frameworks coexisting side by side, the members of the relevant standardization bodies have come to the conclusion that they must identify the differences and eliminate inconsistencies, or at least transparently justify divergent approaches to GHG accounting. It remains to be seen whether the collaboration between ISO and the GHG Protocol will prove to be beneficial or detrimental in the context of the differing revisions to the accounting standards for organizations (led by the GHG Protocol) and products (jointly led by ISO and the GHG Protocol in a Joint Working Group).

Based on exploratory workshops and the development of initial working drafts (WD 1) for ISO 14064-1 for organizations and ISO 14067 for products from November 2024 to November 2025 by the relevant ISO bodies – TC 207/SC7 WG 4 and WG 8 – key methodological issues were identified, which were further addressed in joint meetings. This approach should also be continued within the new structure, as indirect GHG emissions from organizations – Scope 2 and Scope 3 GHG emissions according to the GHG Protocol nomenclature – largely follow a product-based logic and should therefore also be developed consistently.

It is not the task of this report to examine all possible methodological issues, but rather to shed light on the key methodological aspects identified. During the deliberations of WG 4 and the now JWG 8 in Toronto in October 2025, the following topics were identified:

- Treatment of biogenic CO_2 emissions and CO_2 removals (Chapter 3.2)
  The role of fossil and non-fossil carbon in GHG accounting
- Temporal trends in CO_2 emissions and CO_2 removals (Chapter 3.3)
  Accounting for time-dependent climate effects in GHG accounting
- Chain-of-Custody (CoC) approaches in accounting (Chapter 3.4)
  Transfer of properties in the material chain in CoC models and their application
- Treatment of electricity consumption as a special case of a CoC approach (Chapter 3.5)
  Application of CoC models to electricity use, including consideration of location-based versus market-based electricity data (use of local electricity production data versus use of specific electricity products)
- Allocation of GHG removals and emissions across multiple products or intermediate products in multi-output situations (Chapter 3.6)
  Handling the allocation of GHG removals and emissions in processes or life cycle stages that have multiple outputs and require a breakdown into individual products or intermediate products
- Avoided GHG emissions (Chapter 3.7)
  Consideration of GHG emissions relating to a hypothetical comparator

In the following chapters, the topics mentioned will be analyzed according to the following scheme.

- Methodological issues
  The methodological issues underlying the topic are outlined, along with the reasons why conflicts arise from them. Attention is drawn to the risks of misuse.
- Current approach to the issue in practice and in standards
  This section describes the provisions already in place in the ISO standards ISO 14064-1, ISO 14067 and the relevant standards of the GHG Protocol on the respective topic. In addition, guidance is provided on current practice in the application of standards or on deviations from these in the implementation of the topic. Attention is drawn to the risks of misuse. Where helpful, methodological suggestions that are considered effective are addressed.
- Proposed approach
  From a technical and methodological perspective, proposals are put forward on how the methodological issues raised should be addressed in the revisions of the standards. An analysis

is also carried out to determine whether organizations and products are treated in the same or different ways in the accounting framework.

3.2 Dealing with biogenic CO_2 emissions and CO_2 removals

1. Methodological issues

GHG accounting began with the compilation of national emissions inventories, which became an obligation first for industrialized nations and later for all state actors worldwide, at the latest since the Kyoto Protocol. The IPCC drove forward the methodological developments for this, which ultimately culminated in the sector-specific guidelines of 2006.

These territorial GHG accounting approaches focused on anthropogenic GHG emissions

- Emissions of greenhouse gases (GHGs), GHG precursors and aerosols caused by human activities. These activities include the burning of fossil fuels, deforestation, land use and land-use changes (LULUC), livestock production, fertilisation, waste management, and industrial processes. (IPCC, 2021: Annex VII: Glossary)

and anthropogenic CO_2 removals

- Anthropogenic activities that remove carbon dioxide (CO_2) from the atmosphere and store it permanently in geological, terrestrial or ocean reservoirs, or in products. This includes existing and potential anthropogenic enhancement of biological or geochemical CO_2 sinks and direct air carbon dioxide capture and storage (DACCS), but excludes natural CO_2 uptake not directly caused by human activities. (IPCC, 2021: Annex VII: Glossary).

This approach is appropriate for territorial GHG inventories as it focuses on anthropogenic activities. Thus, the CO_2 removal, which is not directly caused by human activities, is explicitly excluded from CO_2 removals. Consequently, anthropogenic GHG emissions include fossil fuels but do not explicitly cover GHG emissions from non-fossil fuels.

The territorial GHG inventory is taken into account for the corresponding reporting of non-anthropogenic sources and sinks, as CO_2 removal, e.g. through photosynthesis, is offset by the release of non-fossil carbon, e.g. through the burning of wood. Unfortunately, the IPCC definitions are not entirely consistent, as there is a grey area particularly regarding anthropogenic activities; for example, 'durable storage in products' on the removal side (…) and 'industrial processes' on the emissions side are not sufficiently described without further clarification.

Based on these definitions, two approaches are conceivable:

- Emitted non-fossil CO_2 has a GWP of 'zero', which is justified by the exclusion of natural CO_2 removal from the total CO_2 removal, as all CO_2 removal is also assigned a value of 'zero'.
- If all CO_2 emissions are fully accounted for as climate-relevant – whether fossil or non-fossil CO_2 – with a GWP of "1", then CO_2 removal from the atmosphere – whether natural or anthropogenic – must logically be calculated with a negative GWP of "–1".

When conducting GHG accounting for products (and organizations), more complex relationships may arise that require each step in the value chain to be considered separately. Biogenic carbon can enter various sub-streams of a product, can be emitted as CO_2 or, for example, as CH_4, or can be stored and released with different temporal characteristics (e.g. as paper or a timber house).

Both of the approaches mentioned are suitable for accurately determining the GHG inventories of products and organizations, provided that fossil carbon and non-fossil carbon are carefully tracked.

2. Current approach to the issue in practice and in standards

Both approaches to dealing with biogenic CO_2 emissions and CO_2 removals are used in practice and, taken individually, lead to consistent results in the GHG accounting for each accounting object.

However, confusion and, moreover, inconsistent results could arise if the two approaches are used simultaneously when calculating a GHG inventory. This is the case, for example, when partial balances are drawn up along value chains and it is not clearly documented which approach was used.

As the methodological issue regarding the treatment of biogenic CO_2 emissions and CO_2 removals is most strikingly evident in the GHG accounting of products, ISO 14067 contains comprehensive provisions.

Firstly, the standard ensures a high degree of transparency regarding fossil and biogenic GHG emissions and removals. Furthermore, information on the biogenic carbon content in intermediate products and products must be provided. ISO 14067 states:

Fossil *GHG emissions and removals shall be included in the CFP or the partial CFP and documented separately as a net result.* ***Biogenic*** *GHG emissions and removals shall be included in the CFP or the partial CFP and should each be expressed separately." (6.4.9.2 Fossil and biogenic carbon)*

Information on biogenic carbon content shall be provided when performing cradle to gate studies, as this information may be relevant for the remaining value chain." (6.4.9.3 Biogenic carbon in products)

In the section on impact assessment, ISO 14067 explicitly demands the "−1/+1 approach" and further specifies the procedure for accounting for the impact assessment in a note:

6.5.2 Impact assessment of biogenic carbon

Removals of CO_2 into biomass shall be characterized in the LCIA as −1 kg CO_2e/kg CO_2 in the calculation of the CFP when entering the product system. Emissions of biogenic CO_2 shall be characterized as +1 kg CO_2e/kg CO_2 of biogenic carbon in the calculation of the CFP.

NOTE The amount of CO_2 taken up in biomass and the equivalent amount of CO_2 emissions from the biomass at the point of complete oxidation results in zero net CO_2 emissions integrated over time, except when biomass carbon is not converted into methane, nonmethane volatile organic compounds (NMVOC) or other precursor gases.

The standard for GHG quantification by organizations, ISO 14064-1, includes a normative Annex D entitled 'Treatment of biogenic greenhouse gas emissions and CO_2 removals'. This annex also sets out rules for the separation of anthropogenic and biogenic GHG emissions and removals, but does not specify requirements for the method of calculating the impact assessment.

The GHG Protocol Corporate Standard also addresses the topic in a chapter entitled "Sequestered atmospheric carbon", but without prescribing an accounting method in accordance with the question at hand (A Corporate Accounting and Reporting Standard – REVISED EDITION; 2004):

"During photosynthesis, plants remove carbon (as CO_2) from the atmosphere and store it in plant tissue. Until this carbon is cycled back into the atmosphere, it resides in one of a number of 'carbon

pools'." These pools include (a) above-ground biomass (e.g., vegetation) in forests, farmland and other terrestrial environments, (b) below-ground biomass (e.g., roots), and (c) biomass-based products (e.g., wood products) both whilst in use and when stored in a landfill.

Accounting for sequestered carbon in the context of the GHG Protocol Corporate Standard Consensus methods have yet to be developed under the GHG Protocol Corporate Standard for accounting for sequestered atmospheric carbon as it moves through the value chain of biomass-based industries."

3. Proposed approach

It is essential that the accounting rule of the "−1/+1 approach" be explicitly mandated when dealing with biogenic CO_2 emissions and CO_2 removals (including Direct Air Capture). Only in this way misunderstandings can be sufficiently ruled out. This applies equally to the GHG accounting of products and organizations.

In addition to this key proposal, the following aspects should be taken into account when formulating both product-related and organization-related GHG accounting standards:

- Separate and transparent recording of all carbon flows of any carbon compound, from removal from the atmosphere to emissions into the atmosphere, for all sources and sinks, and differentiated by process. Given the high relevance of this information in the context of climate change, a high level of transparency should be ensured.
- Separate and transparent documentation of carbon flows in products and organizations, differentiated by fossil and non-fossil (including biogenic) sources. Here too, the aim of preventing misuse justifies a high level of transparency.
- Clear distinction between inventory analysis and impact assessment in accounting, and their transparent documentation, to avoid conflating physical/chemical conditions based on material flows with subsequently calculated climate impacts.
- For the impact assessment of methane (CH_4), the GWP characterization factors for fossil methane must always be used in accordance with the "–1/+1 approach", as the conversion of methane into CO_2 s in the atmosphere and its climate impact must always be taken into account. For methane emissions from biogenic sources, the climate impact of CO_2 is corrected by the negative sign when accounting for removals. Note: The opposite applies to the 0/0 accounting approach.
- The distinction between inventory analysis and impact assessment, and the transparent communication of this distinction, is particularly necessary when calculating partial balances (e.g. partial carbon footprint), especially when biogenic (non-fossil) CO_2 removals do not occur within the same accounting boundaries as their emissions.
- Communication of the inventory analysis and, where applicable, the impact assessment of partial GHG inventories should be directed solely at stakeholders in the value chain and not at consumers. When communicating with consumers, the entire life cycle of products must be taken into account.

3.3 Temporal trends in CO_2 emissions and removals

1. Methodological issues

Climate change is an environmental impact with a strong temporal dimension, characterized by the timing of GHG removals and emissions, the residence time of GHGs in the atmosphere, and the temporal pattern of the climate-relevant effect (modelling of radiative forcing).

Accordingly, temporal considerations such as the storage duration and temporal characteristics of CO_2 removals and emissions are the focus of many GHG inventories, which, depending on the rules applied when accounting for temporal aspects, can lead to very different results. Consequently, there is also a risk of inadequate or even incorrect handling of these temporal aspects.

Significant methodological debates arose in particular during the development of the ISO 14067 product standard, when the climate impact of carbon storage in products was under consideration. A document (PAS 2050:2011) available at the time of the development of ISO 14067 contained an accounting rule that takes into account 'delayed emissions' resulting from the temporary storage of biogenic carbon in products, thereby leading to a reduction in the product's climate impact.

For example, a rule was discussed whereby a product is not attributed a reduced climate impact due to the storage of biogenic carbon if its lifespan is less than 10 years. Conversely, a product with a lifespan of over 100 years would be regarded as a permanent carbon sink, and would be treated as a CO_2 removal – i.e. the storage of the specific amount of carbon converted into CO_2 would be counted as a reduction in the GHG footprint. Finally, the storage period in the product between 10 and 100 years should be treated as linear discounting, meaning that partial amounts of carbon would be included in the calculation of the GHG footprint as a full CO_2 removal. The lifespan of a wooden product, such as a wooden table, of 55 years (100 years – 10 years = 90 years; 90 years / 2 = 45 years; 10 years + 45 years = 55 years) would therefore be calculated in the GHG footprint as a CO_2 sequestration of half the carbon content of the wooden table – converted into CO_2 as a reduction – in the GHG footprint. A product's lifespan of 55 years thus results in an improvement in the GHG footprint of 50% of the carbon content via 'delayed emissions'.

Without wishing to downplay the effect of delayed CO_2 release in long-lasting biogenic products – and thus to undervalue the benefits of such products – this simplistic approach met with much criticism. As the members of the relevant ISO Working Group were unable to reach an agreement at the time, it was decided that delayed emissions should not be included in the GHG footprint. However, it should remain permissible to report and communicate such effects separately – though not within the GHG footprint claim itself.

The current revision of ISO 14067 is seeking a different solution.

2. Current approach to the issue in practice and in standards

Firstly, it must be noted that the GHG accounting of organizations and products generally has different time frames.

For organizations, GHG reporting for a specific year is usually understood as a typical task in relation to a base year. It must be clarified whether exactly one reference year is used for accounting, or whether upstream and downstream activities may be included with their GHG inventories (e.g. CO_2 uptakes with long-term effects as CO_2 removals). Consequently, the consideration of delayed emissions is not relevant for Scope 1 and Scope 2 accounting. However, this does not apply to Scope 3 calculations, and the provisions of the product standard should apply.

For products, the time frame refers, on the one hand, to the service life of a product *("period of time during which a product in use meets or exceeds the performance requirements"; ISO 14067)* and, furthermore, to the temporal extent of a product's life cycle *("consecutive and interlinked stages related to a product, from raw material acquisition or generation from natural resources to end-of-life treatment"; ISO 14067)*. In most cases, the time reference is also referred to as a temporal system boundary, analogous to geographical or spatial system boundaries.

Only a thorough investigation could determine the extent to which the calculation of the effect of delayed emissions is carried out and communicated for products as such or as part of Scope 3.

Let us now consider the provisions set out in the ISO 14067:2018 standard regarding delayed emissions from products:

6.4.8 Assessing the effect of the timing of GHG emissions and removals

All GHG emissions and removals shall be calculated as if released or removed at the beginning of the assessment period without taking into account an effect of delayed GHG emissions and removals.

Where GHG emissions and removals arising from the use stage (see 6.3.7) and/or from the end-of-life stage (see 6.3.8) occur over more than 10 years (if not otherwise specified in the relevant PCR) after the product has been brought into use, the timing of GHG emissions and removals relative to the year of production of the product shall be specified in the life cycle inventory. The effect of timing of the GHG emissions and removals from the product system (as CO_2e), if calculated, shall be documented separately in the CFP study report. The method used to calculate the effect of timing shall be stated and justified in the CFP study report.

NOTE The time period of 10 years has been selected to avoid undue burden in data collection and additional reporting of GHG emissions and removals over shorter time periods and to achieve comparability in reporting. This value might be revised in future based on experience or improved scientific knowledge.

The stipulation that all GHG emissions and removals must be calculated as if they had been released or removed at the start of the assessment period has been met with criticism and is to be amended. The term 'start of the assessment period' is not specific enough and, according to recent agreements in Toronto, is to be defined as the 'date of placing on the market' of the product.

Furthermore, the agreements imply that a de minimis threshold should apply to products with a life cycle of 10 years, and that no time-related effects should be taken into account in this regard. In addition, it should be permissible to take into account front-loading or back-loading effects without – as yet – any methodological rules being prescribed. Users should be allowed to select a method and be able to justify and apply it transparently. This would essentially bring the questionable discounting model back into play.

3. Proposed approach

Discussions to date have shown that there is dissatisfaction with the existing regulation and that new solutions should be sought. In doing so, several aspects require urgent attention:

- There is a great deal of confusion surrounding the concept of the 'temporal effects of GHG removals and emissions'. Consequently, in future standard development, the time-related aspects should first be clarified in a manner that is transparent to the user of the standard. At a minimum, the following distinctions must be made:
  - the **temporal characteristics** of GHG removals and emissions at the pure **inventory level**, specifying the individual greenhouse gases and the temporal progression of all GHG removals and emissions

- the **integration period** used in calculating **the radiative forcing** of individual greenhouse gases relative to CO_2 when the same quantity of the greenhouse gases and CO_2 is released simultaneously. Integration is usually carried out over 20 years, 100 years or 500 years (GWP 20, GWP 100 or GWP 500). This parameter has nothing to do with the effect of the temporal behavior of delayed emissions.
- the **impact on the climate** when CO_2 is continuously removed from the atmosphere over a longer period, or when GHGs are not released, or are released continuously or spontaneously with a delay, over a longer period.

► A clear distinction must be made between the time-related information and methodologies used in inventory analysis and impact assessment. The requirements should be placed in the relevant chapters and also separated in terms of communication.

► Time-related effects of GHG removals and emissions include not only delayed emissions but also delayed removals, as well as potentially accelerated emissions and removals. The full picture must be taken into account, not just potential positive effects, insofar as they play a role.

► From a purely product-based perspective, the temporal characteristics of CO_2 removal from the atmosphere, e.g. through photosynthesis, would correspond to the time taken to build up biomass. If the purely product-based perspective is abandoned and the organization is included in the assessment (e.g. long-term sustainable forest management), this must be communicated transparently and the relevant evidence should be made available.

► If the product perspective is abandoned, the wider context should also be consistently taken into account during the use and end-of-life phases. Can we assume that there will be climate impacts if a product with a long lifespan merely replaces the same product, or is there an increase in the number of products that sequester carbon?

► The extension of the service life of products containing fossil carbon should not be included in the GHG footprint as a time-dependent climate effect of the environmental impact, but should instead influence the GHG footprint **solely through the extended service life of the product** (e.g. doubling the service life leads to a halving of the life-cycle energy consumption and the associated GHG emissions).

► However, if the temporal effects **of the climate impact** are to be taken into account based on the varying storage times of the biogenic carbon itself rather than on changes in a product's function, the methods used and necessary assumptions must be transparently documented in addition to the results obtained. Additional information should be provided on the GHG footprint excluding the temporal effects of the climate impact.

3.4 Chain-of-Custody approaches in accounting (CoC)

1. Methodological issues

An important question has arisen in the context of GHG accounting for electricity products involving the use of green electricity. The question arises as to how a specific proportion of green electricity with a low GHG footprint is incorporated into the various production stages of materials and products via electricity generation and passed on as information along the value chain. This is not a chemical/physical measurement parameter, but rather an attributed property (attribution).

The underlying considerations apply not only to green electricity, but also to materials such as green hydrogen, bio-based raw materials, sustainably produced wood, etc., whose origin and method of production do not necessarily translate into measurable material properties, but convey information that is relevant for GHG accounting.

This raises the question of whether attributes – separate from chemical or physical properties – can be passed on and processed at all within the value chain. And if this is accepted, it must be demonstrated which models are actually available for this purpose and, where applicable, under what conditions they may be used.

On the one hand, it is a legitimate interest of companies to develop climate-friendly solutions, incorporate them into materials and products, and in turn offer them as a benefit to their customers, even if a property such as a GHG footprint is not immediately apparent in the form of the material or product. However, there must also be no situation in which positive climate characteristics are passed on multiple times or other products with a more climate-damaging footprint are concealed. These practices are also criticized as double counting or cherry-picking and must be prevented.

In addition to the supply of materials and products with climate-related properties, communication along the value chain often encompasses other characteristics, usually expressed through certificates, such as the proportion of recycled material or organic farming, as well as requirements relating to animal welfare, child labor, conflict minerals, etc. What all these characteristics have in common is that they cannot be directly verified on the product, or only with considerable effort (such as the determination of biogenic carbon using the C-14 method), but rather represent an indirect attribute. The transfer of characteristics – attribution – should also not be confused with the solution to the allocation problem in a multi-output problem – allocation – even though similarities exist (see below and Chapter 3.6).

2. Current approach to the issue in practice and in standards

The growing market demand for low-GHG materials and products and the interest of businesses in offering such products has created a need for suitable operational models within the value chain. These models are referred to as chain-of-custody models, which could best be described in German as 'product chain monitoring' models.

Given the significance of this topic – even beyond the climate debate – a fundamental standard was developed in 2020, ISO 22095:2020 "Chain of custody — general terminology and models", which defines terminology and describes methodological approaches. This standard also establishes a general definition for chain of custody.

ISO 22095:2020:

3.1.1 chain of custody
process by which inputs (3.2.2) and outputs (3.2.3) and associated information are transferred, monitored and controlled as they move through each step in the relevant supply chain (3.2.1)

As communication regarding chain-of-custody models takes place largely in English, these models will be referred to and described below using their original English terminology. The aforementioned fundamental standard ISO 22095:2020 "Chain of custody — general terminology and models" identifies and describes five fundamental CoC models. The generic standard ISO 22095 is now followed by individual standards for the five defined models, as well as a standard on the application of chain of custody in life cycle assessment (ISO CD 14077).

The five chain-of-custody models are referred to as

- Identity preserved model,

- ► Segregated model
- ► Controlled blending model
- ► Mass balance model and
- ► Book and claim model.

The important mass balance model is further subdivided into

- ► Rolling average percentage method
- ► Credit method

The “identity-preserved” and “segregated” models maintain the identity of a product or intermediate product within the material flow chain in a direct and traceable manner, whereas “controlled blending” represents a technically precise, traceable, quantity-based averaging process within the existing process steps, including the assigned properties under investigation. These are the standard cases in GHG accounting and do not present any methodological difficulties. Double counting and cherry-picking are not a risk.

Figure 8: Chain-of-Custody Models

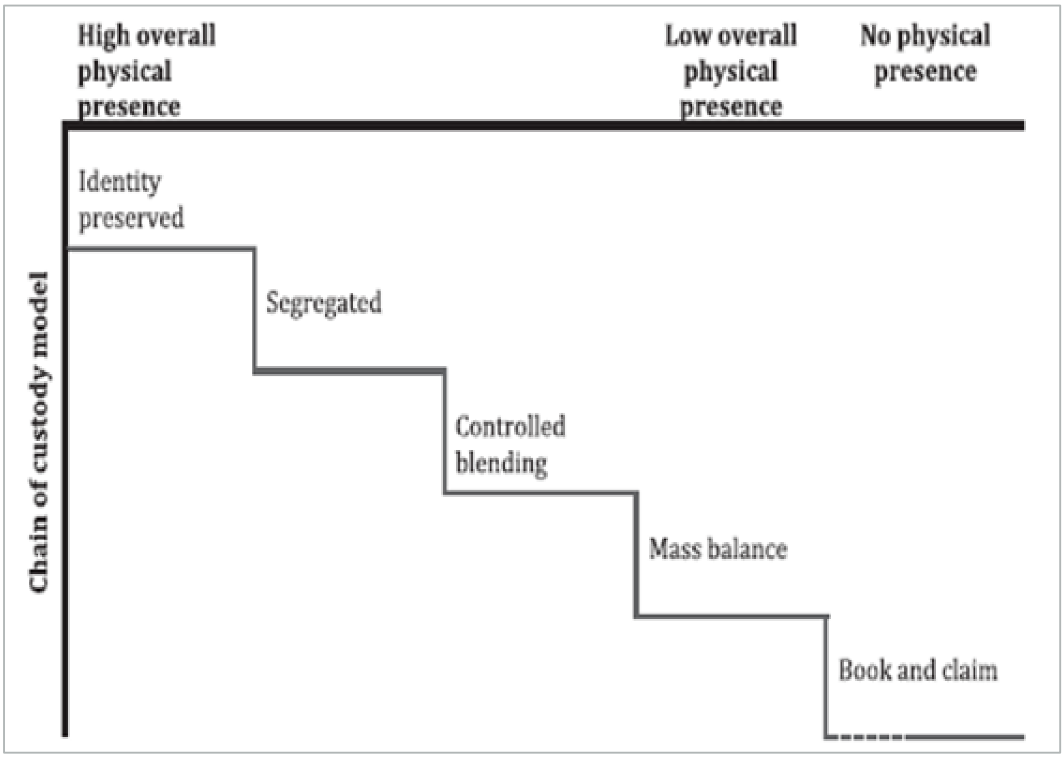


Illustration of the five distinct chain-of-custody models, arranged according to their technical and physical rigor
Source: ISO 22095:2020, Chain of custody — General terminology and models

Particular attention must be paid to the CoC methods ‘Mass balance’ and ‘Book and Claim’. In the Mass balance CoC method, for example, four equal quantities of physically/chemically identical materials are processed in a single production step (see Figure 9), one of which possesses a specific property. If equal quantities of the processed material are produced from this and passed on to the value chain, the mass ratios are clearly defined and the property can be transferred to the products in a transparent and traceable manner.

In the rolling average percentage method, the specific characteristic of a unit of material (e.g. a specific GHG footprint, proportion of secondary material) is transferred via a production process in a mass-equivalent ratio to the products produced, averaged over a certain period of time. This means that all products produced would virtually have the same proportion of the characteristic (attribution), as it is mathematically distributed equally.

The actual output products are, in principle, the same under the rolling average percentage method, but may vary in detail due to the averaging over a certain period. Regardless of the CoC attribution, the manufacturer must in any case guarantee to the purchaser that the material-specific and regulatory requirements for the product (e.g. color, compliance with pollutant limits) are met, which may result from the time-varying nature of production processes. The equally weighted transfer of attributed properties (attribution) is thus still maintained. This CoC model is used as standard when collecting company-specific and product-specific data, which, for example, determines a company's corresponding annual averages or industry averages for a product.

In the Credit method, on the other hand, the specific characteristic is assigned to the units produced according to a subjective distribution key, which may be based on market demand, whereby the mass-related balance of the attributed property must be guaranteed across the produced products. Thus, a unit of the produced product can be characterized entirely without the property, whilst another unit may be assigned the entire property; however, the technical and regulatory characteristics of the product must be the same, as otherwise they would constitute different outputs. The produced products, which are identical in terms of material composition, now receive certificates for the specific property, which may differ significantly. As the credit method differs from the mass-based averaging of the rolling average percentage method, stricter requirements must be imposed on calculation and documentation to prevent misuse.

The assignment of specific properties to a material and its traceability along the value chain (CoC) must be clearly distinguished from allocation. Whilst allocation involves distributing the GHG emissions generated by a process across two or more products according to specific rules, CoC models serve to ensure the traceability of properties. Unfortunately, allocation and the traceability of properties (CoC) can overlap, but must be methodologically separated from one another. Where the mechanisms overlap, allocation steps should be carried out prior to the assignment and tracking of properties in order to ensure transparency.

Figure 9: CoC method: mass balance – rolling average percentage and credit

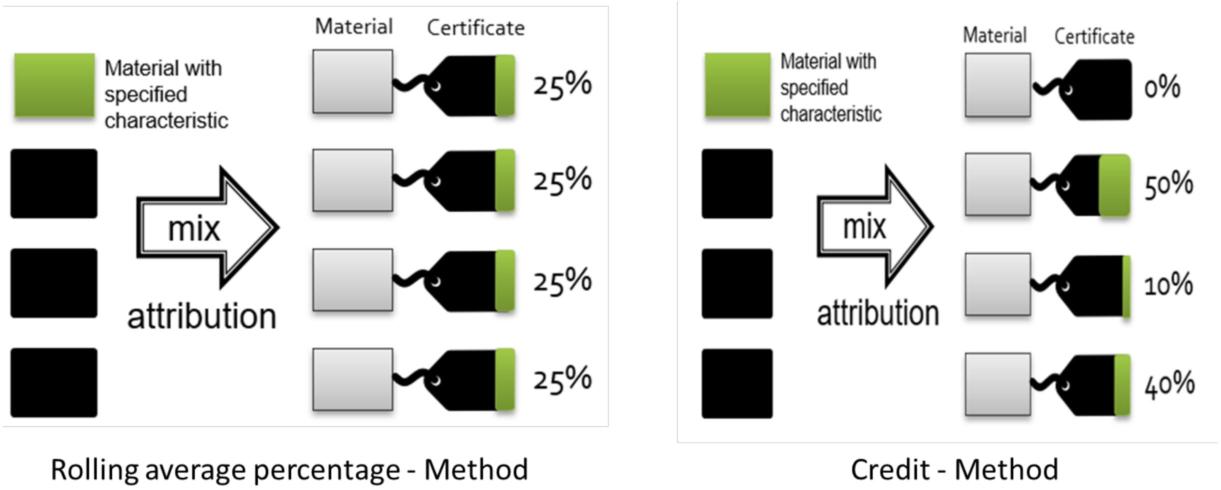


Illustration of the two CoC mass balance models using an example to clarify the effects of distributing a property across products of equal quantity.

With the book-and-claim method, the material flows of the recycling chain and the transfer of the attributed property (attribution) are now completely decoupled. The desired property is generated at one point and can, in effect, be passed on or traded as an independent certificate (as is the case, for example, with some electricity guarantee of origin schemes). The advantage is that a material bearing a property does not have to be physically transported to another location (as with mass balance), but its property can be virtually transferred to a conventional product at a different site.

The disadvantage is that the distribution and whereabouts of the property must be precisely documented and registered. Care must be taken to ensure that a desired property is not passed on multiple times, nor is it counted twice – once at its new location in the market and once at the point of generation. When a property is transferred via certificates, it must in turn be ensured that the property used in the marketplace is booked back to the point of production, together with the replaced, less favorable property, effectively as a counter-certificate. Another problem is that area- and material-specific average values change, and such adjusted average values would need to be created and used to model the residual mix without the property. The question is whether database operators pay attention to this or whether data users handle it carefully.

The great importance of Chain of Custody models has led to the launch in 2024 of a new standardization project, ISO 14077 “Requirements and guidelines for application of Chain of Custody (CoC) approaches in Life Cycle Assessment (LCA)” and reached the status of a Committee Draft in March 2026.

3. Proposed approach

Demand for chain-of-custody applications is high, and current applications are sufficient for GHG accounting ranging from construction products to aviation fuels. Therefore, CoC methods must be further developed and implemented in accordance with guidelines. The following points should be taken into account:

- The further development of regulatory frameworks for CoC models is urgently needed and should be carried out in line with the requirements of Life Cycle Assessment (ISO 14077) and the application standards for GHG accounting for products (ISO 14067) and organizations (ISO 14064-1), with a focus on Scope 3.

- The standardization of Chain-of-Custody models in the field of GHG accounting should be limited to the specific issues of GHG accounting and should not include too many general principles. For example, the need for standardization could be limited to the CoC models 'Mass balance Credit' and 'Book and claim'. The Committee Draft of ISO/CD 14077 takes precisely this approach.
- It is absolutely essential to clearly distinguish between the methodological approaches of co-product allocation and the assignment and tracking of specific product characteristics using CoC models (attribution), given their different objectives (see above). Co-product allocation, which assigns the GHG emissions of a process or life cycle stage to **different** products, is independent of the attribution of various properties (attributes) to technically **identical** products. Allocation steps should be carried out prior to CoC attributions. The individual steps must be documented transparently.
- The normative regulations for the CoC models 'Mass balance credit' and 'Book and claim' must establish the guidelines and IT foundations to prevent double counting and omissions of GHG values in the value chain. Comprehensive registration of transferred attributes and the determination of GHG emission factors for the remaining processes (residual mix) as input into the relevant databases worldwide are certainly a challenge but necessary.
- As already discussed in relation to CoC models in the electricity sector, parallel or dual reporting of producer-related assessments and certificate-related assessments should also be carried out for all other products and attributes of the CoC models 'Mass Balance Credit' and 'Book and Claim', in order to document that emissions trading achieves the desired effects on the real world of producers.
- The development of formats for communicating the results of GHG accounting with and without CoC models must not be neglected. It must be clear to users and stakeholders in which model framework a GHG inventory was generated. This applies equally to products and organizations – including Scope 3 emissions.

3.5 Dealing with electricity consumption as a special case of CoC approach

1. Methodological issues

Electricity consumption is an important emissions category for both organizations and products. To determine the level of associated GHG emissions, it is not only crucial how much electricity is consumed, but also how it is generated and which emission factor is used to account for the associated GHG emissions.

In the past, both for organizations and for products, calculations were usually based on the average generation mix in the national electricity grid, unless electricity or energy was generated directly at a production site. However, even when electricity was sourced from a nearby power station, with or without a direct connection, methodological questions regarding the attribution of GHG emissions arose. Furthermore, electricity supplies are increasingly being claimed via contractual procurement agreements covering a wide range of electricity products. Thus, electricity products may originate directly from the physically existing transmission grid, from the grid without a direct connection, or even from physically decoupled emission certificates as an electricity attribute without a corresponding amount of electricity supplied.

In the ISO accounting standards, the terms used to describe electricity products alongside national generation mixes are 'internally generated electricity' and 'supplier-specific electricity products', supplemented by 'imported' and 'exported' electricity for organizations' generation facilities. In contrast, the GHG Protocol distinguishes between the "location-based method of Scope 2 accounting" and the "market-based method of Scope 2 accounting".

The list of possible electricity products highlights how heavily an accounting result depends on the basis of the respective electricity product and the associated contractual terms when different GHG accounting methods are applied in each case. As an organization's electricity consumption or a product's life cycle accounts for a significant proportion of its GHG accounting, methodological decisions are certainly relevant to the outcome.

Consequently, there is always a risk of intentionally influencing accounting results through the selection of data and methods. However, it is explicitly recognized that the choice of a 'green' electricity product is regarded as a legitimate measure to reduce the organization- and product-related GHG footprint, provided that strict rules to prevent double counting are observed.

With regard to the methodological issue at hand, it becomes clear that the GHG accounting of an organization's or a product's electricity and energy consumption shares analogies with the methods of chain-of-custody models (see Chapter 3.4). The treatment of electricity or energy consumption can, in effect, be handled as a specific application of CoC approaches. Only the term 'mass balance model' is not adequate and would need to be replaced by 'energy', measured in kJ (SI unit), instead of the physical unit 'mass'. This also allows the methodological issues of correctly accounting for electricity consumption to be addressed using the tools of CoC models.

In the discussions here, electricity is used as the lead product for energy in general, meaning that, from a purely methodological perspective, various steam and heat products, including cooling, should be included alongside electricity.

2. Current approach to the issue in practice and in standards

There is a long-standing practice and considerable experience in GHG accounting for energy sources used by organizations and in products. This practice is supplemented by requirements from the relevant ISO standards and the GHG Protocol.

For organizations, the standard ISO 14064-1:2018: "Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals" provides relevant guidelines, as does the widely used "GHG Protocol Corporate Standard".

The latter was supplemented in 2015 by the "GHG Protocol Scope 2 Guidance; An amendment to the GHG Protocol Corporate Standard", which specifically addresses the use of energy products at companies' production sites. Although this document is classified as "guidance", it also contains a wide range of requirements that are more akin to a standard.

For products, the relevant standards are ISO 14067:2018 "Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification" and the "GHG Protocol, Product Life Cycle Accounting and Reporting Standard".

For organizations, ISO 14064-1 stipulates that indirect GHG emissions from purchased energy must be taken into account as a category of GHG accounting (ISO 14064-1 uses the terms "imported" and "exported" electricity in relation to an organization). The following applies to them:

- *The organization shall quantify emissions or removals from imported electricity that is consumed by the organization, and of exported electricity generated by the organization, in accordance with Annex E. (Chapter 6.3)*

- *Annex E (normative) Treatment of electricity*
  The requirements and guidance described below for electricity also apply to imported and exported heating, steam, cooling and compressed air.

- *Annex E.2 Treatment of imported electricity*
  *Emissions from **imported electricity** consumed by the organization shall be quantified by the organization **using the location-based approach** by applying the emission factor that best characterizes the pertinent grid, i.e. dedicated transmission line, local, regional or national grid-average emission factor. Grid-average emission factors should be from the emissions year being reported, if available, or from the most recent year if not. Grid-average emission factors for imported consumed electricity shall be based on the average consumption mix of the grid from which electricity is consumed.*

The GHG Protocol Corporate Standard introduces the concept of "scopes":

- *To help delineate direct and indirect emission sources, improve transparency, and provide utility for different types of organizations and different types of climate policies and business goals, three "scopes" (scope 1, scope 2, and scope 3) are defined for GHG accounting and reporting purposes. Scope 1: Direct GHG emissions; Scope 2: Indirect GHG emissions from electricity; Scope 3: Other indirect GHG emissions*

- *Companies shall account for and report on scopes 1 and 2 separately as a minimum. … Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions.*

- *Standardisation text on Scope 2: Indirect GHG emissions from electricity*
  *Scope 2 accounts for GHG emissions from the generation of **purchased electricity consumed by the company**. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. **Scope 2 emissions physically occur at the facility where electricity is generated.***

- *Guidance for Scope 2 emissions*
  Companies can reduce their use of electricity by investing in energy-efficient technologies and energy conservation. Additionally, emerging green power markets provide opportunities for some companies to switch to less GHG-intensive sources of electricity.

For organizations, ISO 14064-1 clearly stipulates that GHG emissions from imported electricity must be calculated using the localized approach. The requirements of the GHG Protocol Corporate Standard regarding Scope 2 also primarily deal with the localized approach, although the requirement 'occur at the facility where electricity is generated' can be interpreted more broadly. Finally, the Corporate Standard refers to the "emerging green power markets", which are addressed in great detail in the 2025 guidance document "GHG Protocol Scope 2 Guidance".

The GHG Protocol Scope 2 Guidance consistently introduces two accounting methods for electricity, which are also defined accordingly:

Location-based method for scope 2 accounting
A method to quantify Scope 2 GHG emissions based on average energy generation emission factors for defined locations, including local, subnational, or national boundaries.

Market-based method for Scope 2 accounting
A method to quantify Scope 2 GHG emissions based on GHG emissions emitted by the generators from which the reporter contractually purchases electricity bundled with instruments, or unbundled instruments on their own.

The terms "location-based accounting method" and "market-based accounting method" are very broad classifications, which are clarified both in the 2015 Scope 2 Guidelines and in the current revision of these guidelines. Among other things, the location-based approach may be understood to include, for example:

- an electricity mix directly linked to the site ("on-site"),
- or a country-specific generation mix.

The market-based approach is defined very broadly and may consist, amongst other things, of the following electricity products:

- site-specific electricity and energy production that has been outsourced solely for organizational/business reasons (e.g. self-operated energy generation plants at previously integrated production sites),
- specific contractual electricity supplies from a national supplier with existing physically adequate connections,
- contractually agreed electricity supplies that do not necessarily have physically adequate connections available,
- or the procurement of electricity generation certificates with specific characteristics without any actual electricity volumes being supplied.

An important requirement of the 'GHG Protocol Scope 2 Guidance' is the obligation to use a dual reporting approach combining location-based and market-based accounting methods under certain conditions, such as the availability of supplier-specific data via contract-based instruments. Only where no supplier-specific data is available is it sufficient to use the location-based approach.

- *"For companies with any operations in markets that provide product- or supplier-specific data in the form of contractual instruments: […] Companies shall account for and report Scope 2 emissions in two ways and label each result according to the method: one based on the location-based method, and one based on the market-based method." (Scope 2 Guidance, p. 59)*

The requirements of ISO 14067:2018 for the carbon footprint of products are specifically designed for product GHG inventories and also specify market-based accounting approaches:

- *6.4.9.4.2 Internally generated electricity*
  When electricity is internally generated (e.g. on-site generated electricity) and consumed for a product under study and no contractual instruments have been sold to a third party, then the life cycle data for that electricity shall be used for that product.
- *6.4.9.4.3 Electricity from a directly connected supplier*
  A GHG emission factor obtained from the organization's supplier for the consumed electricity may be used if there is a dedicated transmission line between the organization and the generation plant from which the emission factor is derived, and no contractual instruments have been sold to a third party for that consumed electricity.
- *6.4.9.4.4 Electricity from the grid*
  Life cycle data from a supplier-specific electricity product shall be used when the supplier is able to guarantee through a contractual instrument that the electricity product:

— conveys the information associated with the unit of electricity delivered together with the characteristics of the generator;
— is assured with a unique claim;
— is tracked and redeemed, retired or cancelled by or on behalf of the reporting entity
— is as close as possible to the period to which the contractual instrument is applied and comprises a corresponding timespan;
— is produced within the country, or within the market boundaries where consumption occurs if the grid is interconnected.

Unfortunately, the regulations are not straightforward or self-explanatory, which suggests that negotiations on this matter were difficult. This has also meant that studies have frequently used the market-based approach, but have paid little attention to the compliance with the guidelines set out.

Double counting of low-GHG electricity generation cannot be ruled out in existing GHG footprint calculations, as market-based electricity data is usually based on lower GHG emission factors, but the deteriorating residual mixes resulting from the separate marketing of green electricity are not applied to all other electricity-consuming processes. Emission factors for the residual electricity mix are available for only a few regions in the world, and these are often inadequately determined by data providers. In Europe, the AIB – Association of Issuing Bodies – has been providing European Residual Mix data for over 10 years, but emphasizes that

- *Not all European electricity is tracked with guarantees of origin yet. The residual mix is a key tool for avoiding double counting of the same amount of electricity from a certain energy source.* The electricity residual mix of a country shows the sources of the electricity supply that is not covered by Guarantees of Origin (or other Reliable Tracking Mechanisms). (https://www.aib-net.org/facts/european-residual-mix)

It is hoped that, with a more informed understanding of CoC models, the quality of GHG accounting for electricity will also improve and misuse will be reduced. Current developments in the implementation of market-based approaches are reflected in the revision of the standards mentioned.

3. Proposed approach

A number of considerations regarding the ongoing discussion on GHG accounting for electricity and energy supply are set out below and will be submitted to the public consultation on the GHG Protocol draft for Scope 2:

- The analysis has shown that the situation regarding the use of GHG emission factors for electricity and energy generation is highly complex and requires further in-depth discussion. Reducing the issue to a few terms such as ‘location-based’ and ‘market-based’ GHG accounting methods obscures the underlying complexity, whether it concerns energy generation or consumption, an absolute or marginal approach, real physical conditions or properties traded independently of the product, the type of averaging used, etc. It is argued that more nuanced approaches and terminology should be employed. A guiding framework should be based on the more general chain-of-custody models.

- As emissions data for energy generation is available for many countries and regions, it has also been incorporated into databases covering industrial processes. It therefore provides an essential basis for a GHG accounting system for energy systems that is, as a first approximation, consistent and comparable. As also stipulated in the GHG Protocol Scope 2 Guidance, parallel or dual reporting should therefore continue to be carried out on this basis, in combination with other consumption-based, certificate-based, consequential and other approaches. This serves the purpose of transparency and should also demonstrate, in the longer term, whether the other approaches – such as certificate-based accounting – lead to an overall improvement. Exactly how this somewhat misnamed 'location-based' approach (market instruments can also be location-based) should be structured remains a subject for further debate. In any case, in line with the life-cycle concept, the entire life cycles of energy generation must be taken into account, and not just the generation itself.

- When using GHG emissions data from electricity products or other contractual energy agreements, the findings of the CoC models must be taken into account. In particular, the 'mass balance credit' method (translated into energy) and the 'book and claim' method must be considered. Their methodological approaches carry the risk of misuse, such as double-counting of climate-friendly aspects. Only clear rules and guidelines, as well as a high degree of transparency, can prevent this. Not all market-based accounting is based on these CoC models, which in turn argues for a differentiation of the terms.
- Guidelines and requirements regarding the two critical CoC models, including for energy systems, include measures such as the use of reliable registries that anchor instruments such as certificates to spatial and temporal reference systems, in order to prevent undefined entries and double counting. In the case of marginal accounting models, requirements regarding the necessary comparison scenario or baseline scenario must be observed, and it may be necessary to verify whether a measure actually provides additionality.
- Furthermore, the use of contractual instruments creates a new population of GHG emission factors, comprising, on the one hand, the GHG emissions of all contractually structured products and, on the other hand, the residual mix. The residual mix should, for consistency's sake, be applied to all processes supplied with 'non-certified energy' in order to avoid double counting. Transparent reporting of GHG accounting results in accordance with these approaches is essential.

3.6 Allocation of GHG emissions in multi-output situations

1. Methodological issues

The starting point is a central methodological problem in life cycle assessment, namely how to deal with a process or life cycle stage (subsystem) when it produces multiple outputs. The question then is how to allocate the GHG emissions or GHG removals of the process or life cycle stage across the various outputs.

To this end, it must first be decided whether an output is desired and thus represents a product with a product benefit, or whether it is an output that no longer has any value and must be disposed of or eliminated, such as waste.

Definition of 'output' according to ISO 14040:2018 (Clause 3.25):
product, material or energy flow that leaves a unit process
NOTE Products and materials include raw materials, intermediate products, co-products and releases.

Definition of 'waste' according to ISO 14040:2018 (Clause 3.35):
substances or objects which the holder intends or is required to dispose of
NOTE This definition is taken from the "Basel Convention on the Control of Transboundary

Movements of Hazardous Wastes and Their Disposal" (22 March 1989), but is not confined in this International Standard to hazardous waste

Such decisions often need to be made in a product-oriented approach, as they are inevitably linked to a systems-based perspective. To this end, the greenhouse gas emissions of a specific product system under consideration must be separated from the emissions of the surrounding systems.

The examples relate to industrial processes such as chlor-alkali electrolysis, which produces three products—chlorine, caustic soda and hydrogen—and in which the GHG emissions generated must be allocated to these products. However, non-industrial processes, such as those in agricultural production, are also affected by the allocation problem, where GHG emissions and removals must be attributed to the various products, such as wheat grains and straw for agriculture, or milk, meat and leather for livestock farming.

The question of appropriate allocation does not initially concern the GHG accounting of organizations, as all GHG emissions of an organization are calculated over a reporting period and are not related to different output streams.

However, allocation problems do arise when procuring energy within the context of Scope 2 emissions. An organization that uses energy products from a shared energy generation plant together with other organizations requires clear methodological rules on how to allocate the GHG emissions from energy generation to the various energy products. In the simplest case of combined heat and power generation, GHG emissions must be allocated to electricity and heat according to agreed rules, e.g. based on parameters such as energy, exergy, enthalpy or revenue generated. In industrial practice, significantly more complex allocation issues arise when an energy plant generates, for example, various steam products (low-, medium- and high-pressure steam), low-temperature heat and industrial cooling alongside electricity, and the GHG emissions must be consistently related to these products in order to be able to allocate them to the receiving organizations.

Allocation issues in the context of organizations' GHG accounting inevitably arise in relation to Scope 3 GHG emissions.

2. Current approach to the issue in practice and in standards

Despite many years of methodological discussion and practical experience, there is no satisfactory consensus on how suitable allocation methods and procedures should be selected for specific tasks.

As a starting point, let us first consider the definition of 'allocation':

Definition of 'allocation' according to ISO 14040:2018 (Chapter 3.17):
partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems

The rules for implementing allocation are still derived from the agreements first laid down in the ISO standards on Life Cycle Assessment in the late 1990s and incorporated unchanged into the standard ISO 14067:2018 Carbon Footprint of Products:

6.4.6.2 Allocation procedure
The CFP study shall include the identification of the processes shared with other product systems and deal with them in accordance with the stepwise procedure presented below. …

a) Step 1: Wherever possible, allocation should be avoided by
1) dividing the unit process to be allocated into two or more sub-processes separately and

collecting the input and output data related to these sub-processes, or
2) expanding the product system to include the additional functions related to the co-products

b) Step 2: Where allocation cannot be avoided, the inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects the underlying physical relationships between them.

c) Step 3: Where physical relationship alone cannot be established or used as the basis for allocation, the inputs should be allocated between the products and the functions in a way that reflects other relationships between them. For example, input and output data might be allocated between co-products in proportion to the economic value of the products.

The following procedures and the order in which they are applied have been derived from these rules, some of which can only be understood in a historical context:

1. <u>Avoiding allocation by a more detailed consideration of sub-processes</u>
   Section a) Step 1 – Sub-point 1) – of the definition of allocation methods indicates that a multi-output process can be avoided by distinguishing sub-processes in greater detail. If, for example, a refinery is viewed as a black box with a wide range of end products, a detailed modelling of the sub-processes – such as the various separation and conversion processes within the refinery – could be more precisely related to individual products such as kerosene, petrol, diesel, bitumen, etc. Experience shows that only in a few cases allocation can be avoided, and in most cases the allocation problem is merely shifted.

2. <u>Avoiding allocation by system space expansion</u>
   Section a) Step 1 – Sub-point 2) – describes the expansion of the system as a way to avoid allocation. “Expansion of the product system to include the additional functions related to the co-products” is implemented by practitioners in two very different ways:

   <u>Avoiding allocation by a genuine expansion of the system</u>
   If a process provides two or more products, further functions are associated with each product. These additional functions can be incorporated into the original product system, thereby expanding the system and demanding the setting of new system boundaries. For example, milk production in livestock farming would also be linked to the production of beef and leather, the use and life cycles of which would need to be integrated into the expanded product system. Ultimately, a product comparison must always be based on the same basket of benefits. Except in rare cases, this approach is not helpful, if the GHG footprint is only required for e.g. one product like milk.

   <u>Avoiding allocation by substitution</u>
   In the case of allocation avoidance through substitution, the first step—as with genuine system expansion—involves identifying all benefits or functions associated with multiple products and calculating their GHG inventories. Alternative product systems are then modelled for all the additional benefits identified, and their GHG inventories are subtracted from the original system containing the multi-product content. The resulting difference ultimately represents the GHG footprint of the single product of interest. In the example of the GHG footprint of 1 liter of milk, alternative products for meat (e.g. meat from a different animal or other foods with the same nutritional value) and for leather (e.g. leather from the hide of a different animal or synthetic leather) would therefore need to be identified, and their GHG accounting results subtracted from the result of the original product system. The remaining result is the GHG footprint of milk. The disadvantage of this approach is that an intended

result for a single product depends on a wide range of assumptions and is strongly influenced by the accounting of substitution alternatives.

3. In the case of allocation by partitioning
In allocation by partitioning, the GHG emissions of a process or life cycle stage involving two or more products are divided according to section b) step 2 based on physical parameters and section c) step 3 based on economic parameters. 100% of the GHG emissions caused by a process or life cycle stage are retained and distributed among the respective products according to the percentage ratio of the selected partitioning parameters.

Allocation by partitioning using physical parameters (section b, step 2)
Suitable physical parameters must be selected as allocation algorithm and their proportion in the various products determined. For example, a refinery's GHG emissions could be allocated on the basis of the energy content or the mass of the refinery products. The refinery's 100% of GHG emissions would then be allocated on a percentage basis to individual products such as kerosene, petrol, diesel and bitumen, in accordance with the selected parameter. The difficulty with this method lies in selecting a suitable parameter, as the GHG footprint of each product depends on this choice.

Allocation by partitioning using economic parameters (Section c, Step 3)
Economic variables must be selected as allocation algorithm, for instance the price achieved on the market for each of the respective products. The total price of all products corresponds to 100% of the GHG emissions of the process or life cycle stage that produces two or more products. The corresponding share of GHG emissions is allocated in proportion to the share of the price of each product related to the total price of all products. In the refinery example, for instance, the prices of the individual products can be used. Even in a case such as the multi-product system of livestock farming, where allocation based on physical parameters is difficult, the prices for milk, beef and leather could be used to achieve an appropriate allocation scheme. The economic allocation method has been criticized because it is sometimes difficult to determine a price for each product, or that prices – and hence their associated GHG emissions – can fluctuate significantly. Solutions do exist, such as the use of long-term rolling averages of prices.

In practice, two of the methodological approaches described here are frequently applied:

- Avoiding allocation by substitution
System expansion with substitution starts with asking the following question: Which alternative product systems can be identified to replace the different outputs from the expanded system besides the on product of interest? The GHG emissions of all alternative systems have to be calculated separately and subtracted from the original expanded system leaving one product of interest. Then, the GHG emissions of the original expanded system minus all subtracted alternative systems reveal the carbon footprint of the product of interest. The problem is to find reasonable alternative product systems for subtraction. This may result in an arbitrary selection with the problem of reliable results for the carbon footprint for the product of interest.

- Allocation by partitioning
In allocation by partitioning, the GHG emissions of the product system or life cycle stage with two or more products are divided according to physical parameters (Step 2) or economic parameters (Step 3). In this approach, 100 % of the GHG emissions of the original multi-output process are retained and allocated by the partitioning parameters. The standards ISO 14040 and ISO 14044 give higher priority to the use of physical parameters, although economic

considerations often dominate the selection and use of a production process. For example, metals are extracted from mixed ores based on the market value of individual metals rather than their weight (e.g. copper, molybdenum, platinum group metals).

The two approaches dealing with allocation can lead to very different results.

The advantage of the substitution method, which avoids the need for allocation, is connected with the disadvantage of having to calculate an alternative production chain for each co-product and subtract it from the initial product system (i.e. substitute it). Depending on the alternative system chosen, very different GHG results can be obtained and subtracted – to the extent that the baseline system may even show negative GHG emission results.

The alternative system should be selected on the basis of economic criteria, addressing the question of which alternative system, from an economic perspective, replaces the production of the co-product in the multi-output product system. However, it is often selected with little effort based on plausibility considerations. A common example: a combined heat and power (CHP) plant supplies only electricity to an organization. The heat generated in parallel could be produced by a selected heating plant using a hypothetical fuel, and its GHG emissions serve to be deducted from the total emissions of the CHP plant. The remaining GHG emissions from the CHP plant are then attributed to the electricity supplied to the organization. Whether the hypothetical heating plant is assumed to use, for example, lignite, biogas or a regional fuel mix, demonstrates the range of variation and the dependence of the GHG calculation on such an assumption.

The advantage of allocation by partitioning is entirely retained and is distributed across the target product and all co-products. The disadvantage lies in the selection of the allocation parameters to be applied. Thus, priority was given to the physical allocation parameters (Step 2) over the economic allocation parameters (Step 3). Here, too, a certain degree of freedom exists for choosing the allocation parameters with obvious effects on the results. A common example: the GHG emissions from a CHP plant could, for instance, be allocated according to the physical parameters of the energy content of the energy flows in the SI unit kJ or the useful energy (exergy), also in kJ, or perhaps according to the price received from the sale of electricity and heat to customers.

The total GHG emissions of the CHP plant are allocated to the energy products electricity and heat. Depending on the selected allocation parameter, the two products will have a defined share of the total GHG emissions from the CHP plant.

The examples highlight a calculation problem that can arise in both accounting objects product system and organization when quantifying Scope 2 emissions. Clear solutions to the allocation problem would be needed to achieve comparable results depending the intended use.

3. Proposed approach

Given the fundamental importance of the allocation method, it is of the utmost importance to adopt more specific rules. Expert opinions also diverge widely on the details, making it very difficult to reach a jointly agreed solution. A statement how to proceed is made here:

- The two allocation methods (substitution, partitioning) are fundamentally different and should only be used within the clear context of the specific task in GHG accounting. Allocation by partitioning should be applied for the calculation of GHG inventories and GHG footprints. The substitution method, on the other hand, should only be applied to questions concerning marginal changes to a product system and its future consequences.

- An important question is whether both methods may be used in a single calculation of GHG inventories. For practical reasons, this is often done; however, it adds a third, hybrid variant to the two methods, which can lead to even greater uncertainty regarding the results. Thus, during the ISO consultations in Toronto, a three-pillar framework was developed comprising these three options. This proposal needs further discussion.
- One finding from the widespread application of partitioning as allocation method is that allocation based on economic parameters is erroneously regarded as the worst option. Allocation parameters based on technical/physical criteria are considered more objective, yet the frequently chosen parameters of mass or energy content are not always applicable. Allocating GHG emissions from the mining and smelting of multi-metal ores based on the mass of the products (e.g. copper, molybdenum, platinum group metals) would disadvantage the product with the highest mass (in this case, copper). Rather, the ore is mined on the basis of its total achievable market value. Consequently, allocating GHG emissions according to the market value of the metals extracted from a unit weight of ore is far more robust, as it reflects the economic incentive for ore mining.
- For standardization of GHG accounting or the calculation of a GHG footprint, clear normative but transparent decisions on steps and procedures for allocation are regarded to be more helpful than more methodological discussions which do not easily provide unambiguous results.

3.7 Avoided GHG emissions

1. Methodological issues

In the discussion of GHG accounting, primarily by organizations, the term 'avoided emissions' has emerged, which was originally defined there as follows:

"Avoided GHG emissions: the potential effect on greenhouse gas emissions that occurs outside the boundaries of the organization and its value chain, but arises through the use of its products or services"

Experts in product GHG accounting raised many questions, for example regarding the underlying system boundaries or the restriction to the use phase. From this a new definition was created, which is currently under discussion as part of the revision of ISO 14064-1:

"Avoided GHG emissions: the estimated difference in life-cycle GHG emissions arising from a scenario with a solution compared to a reference scenario without the solution, where the reference scenario's emissions are higher"

2. Current approach to the issue in practice and in standards

Even though the concept of avoided emissions has not yet been required in the context of product life cycle assessments, it is important to ensure a robust link between organizational and product life cycle assessments. Misuse of the term 'avoided emissions' in communication and calculations can already be observed. Furthermore, the approach associated with the term is used for claims regarding climate friendliness and is being discussed in connection with ISO standards on carbon neutrality (ISO 14068-1) and net zero-aligned organizations (planned ISO 14060).

3. Proposed approach

- Development and establishment of a clear definition of the term ‘avoided emissions’, which makes it clear that this refers to the difference between two scenarios – possibly supplemented by the terms ‘added emissions’, ‘increased emissions’ or ‘amended emissions’.
- Ensuring quality requirements for the determination of avoided emissions through consistent scenario selection, consideration of all life cycle stages, etc.
- Avoided emissions should not be included in organizations’ GHG inventories or in climate labelling.

4 Contribution to the revision of ISO 14064-1 and ISO 14067

Status of work as of November 2025

In Germany, the DIN Standards Committee on the Fundamentals of Environmental Protection (NAGUS) NA 172-00-19 AA Climate Change 01 Working Group was commissioned in 2024 to revise ISO 14064-1.

In addition, a new working group was established in August 2024 to revise ISO 14067 under the DIN-NAGUS NA 172-00-03 AA Life Cycle Assessments and Environmental Labelling, and was designated NA 172-00-03-04 AK.

The author of this report is involved in both working groups and is the technical chair of the 03-04 AK.

By November 2025, the NA 172-00-03-04 working group had held the following meetings:

- 28 August 2024 In-person inaugural meeting of the NA 172-03-04 working group in Berlin
- 2nd meeting to prepare for international consultations via web conference (24 October 2024)
- 3rd meeting to prepare for the WG 8 meeting in Paris (26 February 2025) via web conference
- 4th meeting to prepare for the WG 8 meeting in Toronto (20 October 2025) via web conference

By November 2025, TC 207 SC 7 and its WG 4 Organization Standard and WG 8 Carbon Footprint of Products had held the following meetings and carried out the following work:

- ISO/TC207/SC7 Plenary meetings 28 October – 1 November 2024 in London (in-person)
- WG 4 and WG 8 meetings, partly separate and partly joint, 29–30 October 2024 in London
- Work in ad hoc groups on biogenic emissions and chain-of-custody approaches in WG 4 and WG 8 until the end of February 2025
- Virtual WG 4 and WG 8 meetings in February and early March 2025
- WG 4 and WG 8 meetings, partly separate and partly joint, 21–26 March 2025 in Paris
- June to August 2025: Comments on WD 1 of the ISO 14067 revision
- ISO/TC207/SC7 plenary meetings 25 October – 1 November 2025 in Toronto (in-person)
- WG 4 and WG 8 meetings, partly separate and partly joint, 25–28 October 2025 in Toronto

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