PACT
PARTNERSHIP FOR
CARBON TRANSPARENCY

PACT Methodology

Methodology for Calculating and Exchanging Cradle-to-Gate Product Carbon Footprints (PCFs)

Version 3.0

Powered by
World Business Council for Sustainable Development

Collaborators

WBCSD would like to thank the following companies and organizations that have supported or contributed to the development of the PACT Methodology:

ABB, Groupe Agéco, Altruistiq, amazon, Asuene, BHSoft, Bacuti

BASF We create chemistry, Bayer, boooost, carbmee, carboledger, carbon trail, Carbon Trust

Cedars Digital, Chiltern TMC, Cirrus Nexus, Clariant, climate camp, CO2 AI, CircularTree

Continental, Dassault Systèmes, Dow, dsm-firmenich, ecoact, Ecochain

ecoinvent, ecovadis, European Aluminium, evalue8 sustainability, forward earth, Fujitsu, Givaudan

GLEIF, Green x Digital Consortium, GS1, Hestia, Hewlett Packard Enterprise, 財團法人資訊工業策進會 Institute for Information Industry, Infineum

InnoBlock, International Copper Association, IPA, LG Chem, life, LyondellBasell, Manufacture 2030

McKinsey Sustainability, Meta, Nexio Projects, Nickel Institute, Normative, Novartis, NRI

Open Footprint Forum, Optel, PepsiCo, Persefoni, PRé, Sage, SAP, sabic

Schneider Electric, Scope 3, Shell, Sika, SBF, slb, Smart Freight Centre, Starbucks

Stora Enso, Syngenta Group, Takeda, tanso, Terrascope, Together for Sustainability, Thermo Fisher Scientific

P&G, uhuru, Unilever, University of Birmingham, Vaayu, ValueChange, variable

WAP Sustainability Consulting, Watershed, We Mean Business Coalition, WormHole 蟲洞科技, WRAP, Yara Knowledge grows

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List of abbreviations

BECCS	Bioenergy carbon capture and storage
CCS	Carbon capture and storage
CCU	Carbon capture and utilization
CFC	Chlorofluorocarbons
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon dioxide equivalent
DAC	Direct air capture
dLUC	Direct land use change
DQI	Data quality indicator
DQR	Data quality rating
EEIO	Extended input-output databases
GHG	Greenhouse gases
GOs	Guarantees of origin
GWP	Global warming potential
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
HFEs	Fluorinated ethers
IPCC	Intergovernmental Panel on Climate Change
IPCC AR	Intergovernmental Panel on Climate Change Assessment Report
ISO	International Standards Organization
LCA	Life cycle assessment
LCIA	Life cycle impact assessment
LUC	Land use change
NF_3	Nitrogen trifluoride
N_2O	Nitrous Oxide
PACT	Partnership for Carbon Transparency
PCF	Product carbon footprint
PCR	Product category rules
PDS	Primary data share
PEF	Product environmental footprint
PEFCRs	Product environmental footprint category rules
PFPEs	Perfluoropolyethers
PFCs	Perfluorocarbons
QA	Quality assurance
QC	Quality control
RECs	Renewable energy certificates
SCFs	Service carbon footprints
sLUC	Statistical land use change
SF_6	Sulfur hexafluoride
SME	Small and medium-sized enterprises
WBCSD	World Business Council for Sustainable Development

Foreword

The climate crisis is no longer a distant threat; 2024's record-breaking temperatures and increasing climate-related disasters confirm it as our present reality. Decisive action is imperative, and businesses have an undeniable role to play in this transition: the time for net-zero pledges has passed, and we must now achieve verifiable, near-term decarbonization.

This transformation demands that carbon data become fundamental to corporate decision-making. Procurement teams must prioritize low-carbon suppliers, research and development (R&D) should select materials based on environmental impact, and sustainability teams need to communicate progress transparently and credibly. However, a significant obstacle remains: accurately calculating Scope 3 emissions. These value chain emissions, often constituting over 80% of a company's total carbon footprint, are notoriously difficult to quantify. Solving this Scope 3 emissions challenge presents one of the most powerful levers to accelerate decarbonization.

Addressing Scope 3 is no longer simply an environmental question. With increasing trade-related measures and emerging regulatory frameworks set to take effect in 2026, including carbon pricing mechanisms like the EU's Carbon Border Adjustment Mechanism, companies will be required to take a closer look at their value chain emissions. Ensuring an accurate understanding of the impact of these products will prove essential for companies to remain compliant with regulations, financially viable, and competitive in the marketplace, benefiting both suppliers and downstream customers.

Despite the clear business case, limited transparency across complex value chains has hindered efforts to quantify and reduce these emissions. A robust solution is essential: one that enables granular, comparable, and consistent product carbon footprint (PCF) calculation, and provides the infrastructure for exchanging verified primary data across value chains.

This solution has been developed by the Partnership for Carbon Transparency (PACT), a global initiative launched in 2020 and hosted by the World Business Council for Sustainable Development (WBCSD). By standardizing the calculation and exchange of supplier-specific PCFs, PACT empowers companies to make carbon-informed decisions. With over 2,500 companies engaged globally, PACT is already accelerating supply chain transparency.

PACT Methodology Version 3 represents a significant advancement in product-level carbon calculation, enhancing accuracy and transparency by building on the feedback received from its users and the latest GHG accounting best practices. This new version emphasizes harmonization with leading standards such as the GHG Protocol and ISO, ensuring consistency and comparability. By reducing ambiguity in emissions reporting and promoting feasibility, PACT also lowers the barrier to adoption.

Version 3 also improves completeness and representativeness of product carbon footprints, notably through expanded guidance on biogenic and land-related emissions, addressing a previously underrepresented 22% of global emissions. Additionally, PACT addresses the crucial role of natural climate solutions and emerging carbon removal technologies. By adopting PACT Methodology v3, companies can ensure complete and precise calculation of product-level carbon impact.

We extend our gratitude to the large number of companies, organizations, and institutions that have contributed to the development of the PACT Methodology v3.

The time for action is now. We invite you to join us in this transformative effort—adopting the PACT methodology within your organizations and value chains is not just a choice; it is a commitment to a sustainable future. Together, let us forge a path towards a greener economy and a healthier planet for generations to come.

Dominic Waughray
Executive Vice President,
WBCSD

1. Introduction

Current efforts to reduce greenhouse gas (GHG) emissions are insufficient to meet the Paris Agreement targets. Calculating and exchanging reliable and consistent GHG emissions data is key to supercharging decarbonization efforts.

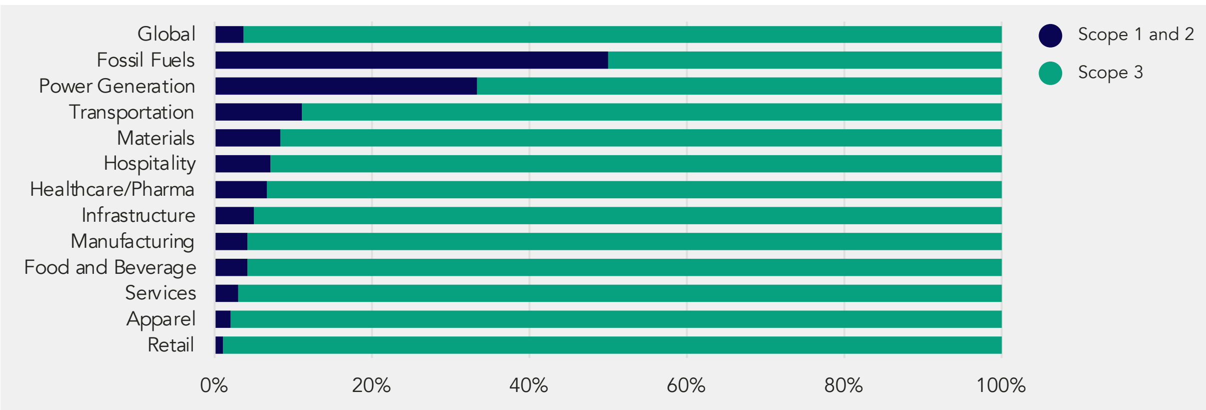
1.1 The Challenge

Accurately quantifying and reducing GHG emissions, particularly those in value chains (Scope 3), are key enablers to change the global warming trajectory and avoid the worst effects of climate change.

However, while Scope 3 emissions often constitute the largest percentage of companies' carbon footprints (Figure 1)[1], organizations are still struggling to adequately understand and address these. When calculating Scope 3 emissions, companies share a common challenge: a lack of sufficiently granular, accurate, and verified primary product-level data.

This is caused by issues with emissions calculation and data sharing as well as by the increasingly complex ecosystem of stakeholders emerging in the emissions calculation space.

Figure 1: Percent of total Scope 1 to 3 emissions based on self-reported CDP data, 2023[2]



1. Based on more than 50 selected stakeholders, including Shell, adidas, Pfizer, 3M, Volkswagen, GreenGauge, CDP, and McKinsey & Company.
2. CDP & BCG. (2024). Scope 3 upstream: Big Challenges, Simple Remedies

Data calculation: Room for interpretation and inconsistency in existing methods and standards

Many companies lack Scope 3 primary data to accurately calculate emissions arising within their value chains. Secondary emission factor databases are used to fill this gap; however the average or typical data these provide are often not specific enough to meet companies' data needs, which range from climate risk assessments to the implementation and tracking of decarbonization strategies and targets.

High-quality product life cycle emissions calculations, considered the most accurate approach to calculate value chain emissions, are also hindered by the inconsistent use of approaches to calculate product emissions. Existing standards and protocols, such as ISO, GHG Protocol, or Product Environmental Footprint standards, leave room for interpretation.

Calculation standards and guidelines that are not fully consistent create challenges for a streamlined and scalable application. This results in inconsistent emissions calculation, which in turn leads to insufficient reporting and exchange of emissions data.

Data access: Complex value chains and lack of interoperability between technology[3] solutions

While value chains often involve multiple (international) stakeholders from different industries, most corporate systems are not able to exchange GHG emissions data with other systems (and across company boundaries). This limitation results in high transaction costs due to manual effort required to complete surveys and spreadsheets. New GHG calculation technology and data exchange platforms, while a step in the right direction, still lack one essential feature: interoperability, i.e., the ability to connect to one another, exchange information, and understand the information exchanged (or "speak the same language"). In practice, this means companies will typically only be able to access each other's data if they use the same technology solution.

Ecosystem alignment: Growing number of stakeholders seeking to tackle the transparency challenge

There has been significant momentum to resolve the challenges around Scope 3 emissions.

Regulatory bodies (e.g., European Commission, International Sustainability Standards Board) and companies are searching for and developing individual approaches, industry-focused associations are addressing their members' most pressing concerns, and the broader ecosystem has also started identifying the role it can play. A lack of integration and harmonization across the ecosystem is a major roadblock to transparency, given that no single company, association, or ecosystem stakeholder can succeed without the others.

As a result of the above challenges, companies' Scope 3 decarbonization efforts are hindered. It is very laborious to track and reduce Scope 3 emissions at scale without determining the emissions associated with products and services transferred within a company's value chain.

1.2 The Solution

A solution developed in close collaboration with stakeholders is needed to enable the consistent calculation and exchange of accurate, primary, and verified product-level emissions data across all value chains and industries.

This solution should be comprised of standardized approaches and common guidelines from both a methodological perspective (product-level emissions calculation) and a technical perspective (product-level emissions data exchange):

- From a methodological perspective, product-level emissions must be calculated in a comparable and consistent manner, resulting in accurate, high-quality emissions data.
- From a technological perspective, there is a need for common data exchange guidelines and technical specifications for interoperable data exchange across global companies and complex value chains.

3. Any reference in this document to the term "technology" shall be taken to refer to IT (as opposed to production technology).

Furthermore, the creation of a free and open digital network will significantly facilitate data exchange (upstream to downstream, but also downstream to upstream) and strengthen quality and credibility.

1.3 The Opportunity

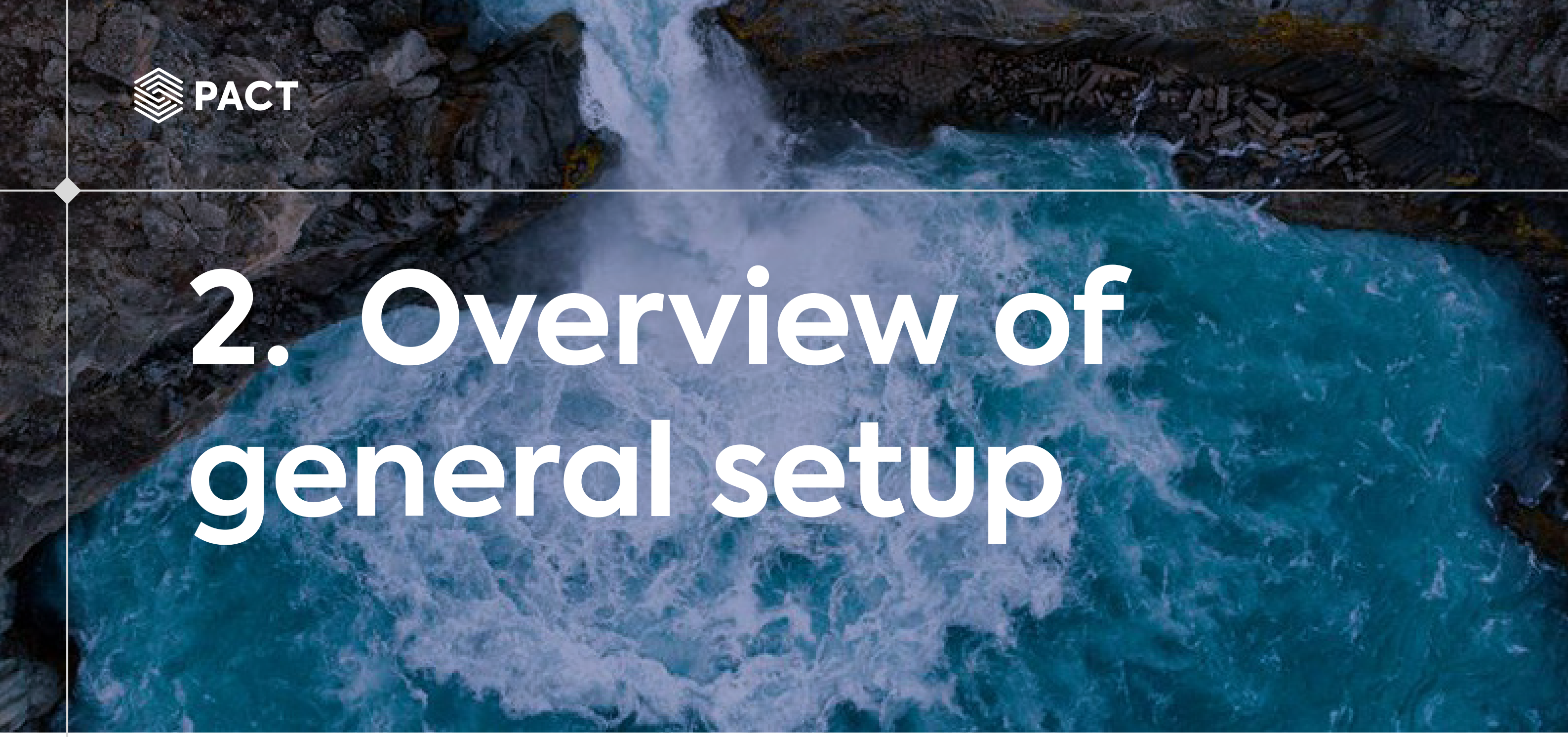
Access to more granular data can unlock a multitude of use cases that reinforce internal business decision-making and support corporate accountability.

Transparency can, for example, positively influence the bottom line, mitigate (climate-related) risk, or drive competitive advantages.

This is precisely why the Partnership for Carbon Transparency (PACT) was established. PACT aims to transform the Scope 3 emissions challenge into an opportunity for companies and organizations by enabling the consistent calculation and exchange of supplier-specific data on product cradle-to-gate GHG emissions among value chain partners.

Specifically, PACT:

- Creates convergence and harmonization on upstream Scope 3 emissions transparency to ensure an integrated and aligned global ecosystem with close collaboration between all stakeholders
- Establishes the PACT Methodology (methodological guidelines) by building on the GHG Protocol, ISO and other existing standards to enable consistent product-level emissions calculation and primary data exchange
- Defines the PACT Network and PACT Technical Specifications for the secure exchange of product carbon footprint (PCF) data across technology solutions, driving interoperability across all industries and value chains. data across technology solutions, linking global value chains and industries.
- Carbon transparency can also set the foundations for greater transparency of additional environmental factors. If organizations are ready to embark on this journey together, the rewards will be significant—not only for the climate, but also for profitability and innovation. This work, therefore, has the potential to be a game changer, shifting the focus from compliance to action and real decarbonization.



2. Overview of general setup

This section gives an overview of the general setup of the PACT Methodology to facilitate navigation and offer essential context.

2.1 Purpose and application

The PACT Methodology was created to address a key existing challenge in carbon calculation: the exchange of consistent supplier-specific product carbon footprint (PCF) data across the value chain. The PACT Methodology builds on existing methodologies and standards to provide guidance on the calculation, verification, and exchange of cradle-to-gate PCFs with the goal of creating more granular, comparable, and consistent emissions data.

The PACT Methodology should be seen as a supplement to the existing methods and standards referenced in Section 3.1 and shall be used in conjunction with these. The PACT Methodology has been drafted as a blueprint applicable to different industries. It is a foundation to build upon to meet additional sector-specific needs. As alignment in this context is critical, PACT has been set up to support this process.

While the PACT Methodology is designed to be a guidance document and is therefore voluntary in nature, its application will lead to greater emissions data consistency for all stakeholders across industries. To further encourage broad application and facilitate scaling, the PACT Methodology has been published openly for everyone to freely access and use.

The PACT Methodology should be applied by stakeholders such as:

- Businesses wishing to better understand and exchange the carbon footprint of their products as well as the products they purchase
- Auditors supporting businesses in the above endeavor by verifying carbon footprint data exchanged
- Technology companies creating solutions for the calculation or exchange of such carbon footprints
- Initiatives driving industry-focused approaches to data transparency and developing additional methodological guidance or technological solutions for data exchange in this context
- Policymakers wishing to align their regulations to PCF methodologies validated and implemented industry wide

2.2 General structure

The PACT Methodology is divided into four key sections, which together drive forward the ambition of creating more transparency: emissions calculation, creating integrity, verification, and data exchange (Figure 2).

While the first section provides some additional context and outlines fundamental guidelines for suppliers' calculation of PCFs by building on existing standards, the second section details key steps in establishing trust in the data and transparency across the value chain. The third section outlines the requirements for third-party verification, while the fourth section provides an overview of how the PACT Methodology can be integrated into IT landscape to facilitate its application and enable the standardized exchange of PCF data (Section 6).

A summary of key takeaways for each section can be found in Figure 2.

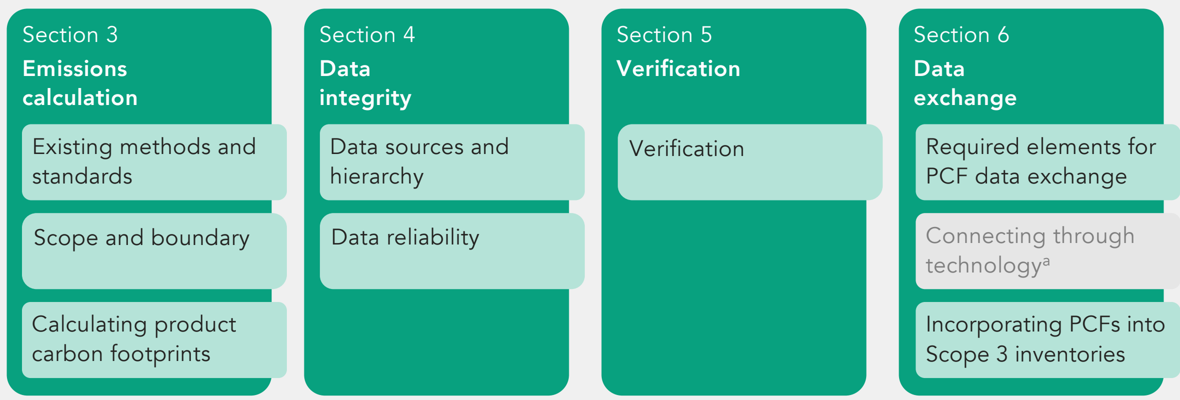
2.3 Approach

The PACT Methodology Version 3 has been developed following a collaborative approach and is the result of an iterative two-year stakeholder consultation process.

This updated version of the PACT Methodology builds on Version 2[4] to incorporate further clarity and additional guidance. Table 1 displays the summary of key updates included in this new PACT Methodology Version 3 (2025) compared to the previous PACT Methodology Version 2 (2023).

PACT recommends several actions regarding the transition to the PACT Methodology Version 3. First, any new Product Carbon Footprints (PCFs) should be calculated using this latest version (i.e., this document)[5]. Second, existing PCFs should be recalculated using Version 3 if emissions related to biogenic sources and the land sector are significant.[6] Furthermore, recalculation is advised following the PCF validity definition (Section 3.2.3), specifically if a PCF is older than three years or if major changes, defined as a variance of 10% or more, have occurred in the production process within the validity period. Finally, PCFs should also be recalculated if customers specifically request doing so.

Figure 2: Overview of sections within the PACT Methodology



a. Out of the Scope of the PACT Methodology, and part of the PACT Technical Specifications

4. PACT (2023). PACT Methodology Version 2 (formerly named Pathfinder Network).
5. This should happen from 2025 or 2026 onwards depending on companies' reporting timeline
6. It is significant when a product is (partly) bio-based and contains over 5% biogenic carbon content (e.g., food, fiber, feed, bio-based feedstock, forest product, biomaterials or bioenergy).

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Table 1: Summary of key updates in PACT Methodology Version 3 (2025) compared to PACT Methodology Version 2 (2023)

Type of Update: New section, Clarification, Change

Type	Section	Description of the update	Rationale behind the update
Clarification	**3.1.2 Hierarchy of application**	A clearer explanation in case of a conflicting situation: a Product Category Rule (PCR) takes precedence over PACT requirements as long as all safeguards are met. The same precedence applies for sector-specific guidance. Additional clarification was added regarding safeguards and key PACT Methodology requirements that should be met or reported when PCRs or sector-specific guidance is used.	PCRs and sector-specific guidance contain additional requirements relevant to the specific product and sector. PCRs provide transparency to better understand the PCFs and their consistency. PCRs enable greater calculation consistency regardless of the level of specificity of the guidelines used.
Clarification	**3.2 Scope and boundary**	Outbound logistics emissions are not part of the PCF but are calculated and reported up to the point another company (e.g., customer) takes over (e.g., owns or pays for the outbound logistics).	Consistency in the PCF scope and boundary, enabling comparability. Alignment with other standards and sector-specific guidance.
New section	**3.2.3 Scope and boundary of the PACT Methodology** Calculation of PCFs related to services or Service Carbon Footprints (SCFs)	High-level guidelines on how to account and report PCFs related to services, with an initial focus on desk-based and IT services.	In line with the GHG Protocol definition, a product is defined as 'any physical good or service'. Further clarity on how to apply PACT to services was requested by the PACT community.
Change	**3.3.1.2 Exemption rules: criteria to exclude certain activities**	From: Possible exclusion of 5% of the total cradle-to-gate PCF, and inclusion of all processes with >1% of total cradle-to-gate PCF. To: Possible exclusion of 3% of the total Cradle-to-Gate PCF.	Alignment with other standards and sectoral guidance.
Change	**3.3.1.4 Allocation** Identification of waste vs co-products	From: Waste has no economic value. To: Follow EU waste directive.[7]	Comprehensive and conservative approach that prevents identification of co-products that are waste.
Change	**3.3.1.4 Allocation** Allocation between co-products	From: Step 1: Avoid allocation Step 2: Prioritize PCRs and sectoral guidance Step 3: Determine ratio of economic value Step 4: Select most suitable allocation To: Step 1: Avoid allocation Step 2: Determine ratio of economic value Step 3: Select most suitable allocation	Prioritization of methods and standardsfrom Section 3.2.1 to be applied first, i.e. PCRs and sectoral guidance take precedence over PACT requirements as long as all safeguards are met. Alignment with other standards and sectoral guidance.
New section	**3.3.2.3 Electricity & contractual instruments**	High-level guidelines on how to account for electricity and contractual instruments (Renewable Energy Certificates (RECs), Guarantees of Origin (GOs)).	Bring additional clarity and consistency to the calculation of electricity & contractual instruments within the PCF.
Change, New section	**3.3.2.4 Biogenic and land sector related emissions and removals**	Comprehensive section on biogenic and land sector accounting and reporting.	Align with upcoming GHG Protocol Land Sector and Removals Standard v.1.0 and other standards.

7. EU Waste Directive 2008/98/EC

Section	Description of the update	Rationale behind the update
3.3.2.5 Technological CO_2 capture, storage and use	Guidance on how to account and report on Carbon Capture and Storage (CCS) and Carbon Capture and Utilization (CCU).	Technological capture, storage and use are part of long-term strategies in achieving net zero, therefore clear accounting rules are required. Due to the maturity of different technologies, limited scope at this stage.
4.1 Data sources and hierarchy	A clearer definition of primary and secondary data (Table 9). Clearer description of illustrative best-, base-, and worst cases (Table 10).	Clear definitions support common understanding and avoid room for interpretation.
4.2 Data Reliability	Primary Data Share (PDS) and Data Quality Rating (DQR) timelines: From: Either PDS or DQR shall be calculated and reported until 2025. From 2025, both metrics shall be calculated and reported. To: PDS shall be calculated and reported DQR shall be calculated and reported from 2027 onwards.[8]	Allow time for companies to adapt to the new data quality assessment matrix.
4.2 Data Reliability	PDS and DQR formula: From: Calculation based on PCF. To: Calculation based on absolute PCF.	Avoid anomalies when negative values are part of the PCF, e.g., through CO_2 removals.
4.2.3 Data quality indicators (DQIs) assessment	New data assessment matrix: From: 3 DQIs for emission factors, 2 DQIs for activity data, ranking from 1 to 3. To: 3 DQIs for emission factors, ranking from 1 to 5.	Clear descriptions enabling the use of the matrix with limited to no room for interpretation. Alignment with other standards and sectoral guidance.
5.3 Verification roadmap	Assurance roadmap changes: From: Medium-term requirements (2025-2030) and long-term requirements (2030 onwards) of representative product or PCF system To: Short-term (2025-2030) PCF Calculation Model requirements and long-term (2030 onwards) PCF program requirements. More clarity and details on PCF Calculation Model	Move away from individual PCF assurance to PCF Calculation Model to ensure feasibility and scalability. Focus on verification options that embrace technology as an enabler.
'PCF questionnaire' Not present in version 3	From: Appendix B: PCF questionnaire, displaying the data attributes. To: Providing link to simplified Technical Specifications data model.	Avoid having an outdated table in the PACT Methodology as the Technical Specifications will evolve faster.

8. While companies should calculate and report this information, it is only required by end of 2027 (i.e., 31.12.2027).

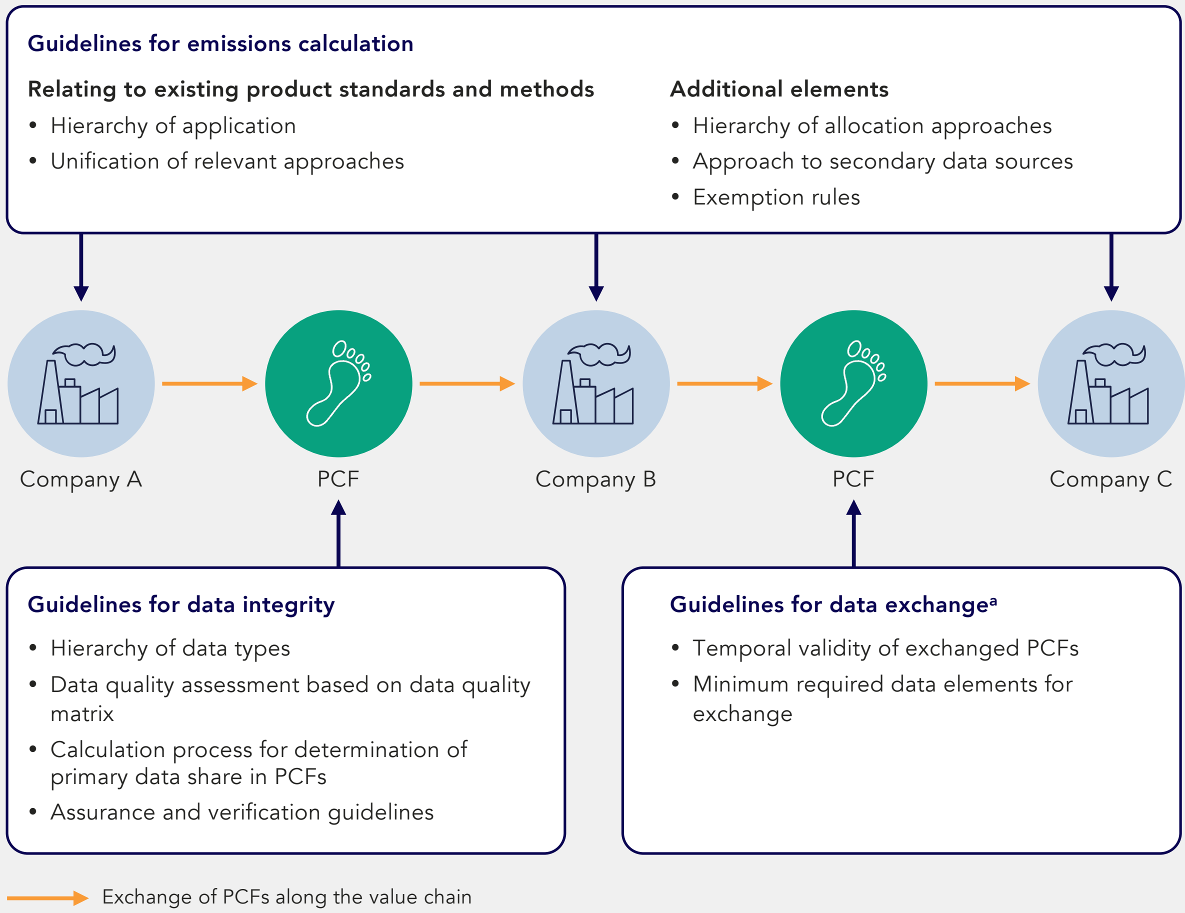
As the development of consistent rules evolves, the PACT Methodology will require periodic revisions. These updates may result from practical implementation or alignment with evolving industry requirements for emission reduction opportunities and the changing landscape of carbon calculation and reporting.

2.4 Focus

The PACT Methodology builds on existing product-level carbon footprint calculation standards and contains guidance for the calculation of cradle-to-gate PCFs to further enhance consistency, data integrity, and comparability. It also covers requirements regarding the exchange of PCF data, in particular focusing on data quality requirements and the assessment thereof, verification of data, and data elements to be exchanged (Figure 3).

This Methodology focuses on GHG emissions and removals generated during a product's life cycle and does not address avoided emissions or actions taken to mitigate released emissions. This standard is also not designed to be used for quantifying GHG reductions from offsets, credits, or claims of carbon neutrality.

Figure 3: Focus of the PACT Methodology



a. Additional technological guidelines for standardized data exchange have been developed in parallel, including a vision for the PACT Network, PACT Technical Specifications, PACT Conformance requirements, and data model extension guidance.

2.5 Terminology

The PACT Methodology uses different terms to differentiate between requirements, recommendations, and permissible or allowable options (Table 2), as defined by ISO[9]. Additional definitions of frequently used terms throughout the PACT Methodology can be found in the glossary (Appendix A).

Table 2: PACT Methodology terminology

Term	Definition
"Shall"	Indicates which rules need to be followed by companies applying the PACT Methodology
"Should"	Indicates which rules are recommendations
"May"	Indicates an option that is permissible or allowable

9. ISO Resources, Foreword – Supplementary information

2.6 Summary of guidelines

Table 3: Summary of guidelines

Emissions calculation		
3.1 Existing methods and standards		• The PACT Methodology shall be read in conjunction with existing methods and standards listed in Section 3.1 for the assessment of PCFs • PCRs (Product Category Rules) or sector-specific rules shall be prioritized for the calculation and allocation of PCFs • PCRs shall only be considered valid if they comply with the PACT Methodology's quality safeguards described in Section 3.1.2 • If multiple PCRs are applicable, companies shall follow the PCR hierarchy laid out by the PACT Methodology • Where no regulations or product- or sector-specific rules exist, companies shall follow the PACT Methodology requirements • For elements not specifically addressed by the PACT Methodology, the PCF calculation shall be compliant with sector-agnostic standards
3.2 Scope and boundary		• Companies shall at a minimum account for the GHGs required and recommended by the GHG Protocol • Their respective 100-year Global Warming Potential (GWP; including carbon feedbacks) shall be derived from the latest Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR) publication. • Companies shall report cradle-to-gate PCFs, comprising all upstream stages of the product life cycle up to the reporting company's production gate, excluding downstream emissions from product use and end-of-life • PCFs shall be exchanged upstream to downstream, providing kg of CO_2e per unit of analysis • PCFs shall have a maximum validity period of up to three years, provided that no major changes (i.e., a variance of 10% or more compared to the original PCF) to the production process take place within the validity period
3.3 Product Carbon Footprint Calculation Guidance	**3.3.1** Calculation of product GHG emissions	• All attributable processes shall be identified within the defined cradle-to-gate boundary • Companies shall collect relevant activity data and emission factors based on identified attributable processes • Manufacturing of production equipment, buildings and other capital goods, business travel by personnel, travel to and from work by personnel, and research and development activities should not be included within the boundaries of the PCF, unless materially significant (i.e., above the exemption rules detailed in Section 3.3.1.2) • In aggregate, excluded attributable processes shall represent less than 3% of the total cradle-to-gate PCF emissions (Section 3.3.1.2) • Companies shall use the decision tree in Figure 8 to classify whether an output is a co-product or a waste • Allocation of emissions to products and co-products should follow the PACT Methodology allocation hierarchy in Figure 9

Table 3: Summary of guidelines (continued)

Emissions calculation		
3.3 Product Carbon Footprint Calculation Guidance	3.3.2 Additional guidance	**Transportation emissions (Section 3.3.2.1)** • Upstream and direct transportation emissions within the cradle-to-gate boundary, including storage, shall be calculated and included in the PCF. Outbound transportation and storage (i.e., outbound logistics) should be calculated and reported separately up to the point where another company (e.g., customer) takes over responsibility for the product (i.e., owns or pays for the outbound logistics) • Only transportation emissions relating to the fuel, also known as well-to-wheel emissions, and the energy consumed by storage facilities shall be included (i.e., the manufacturing of the vehicles used for the transport of goods shall not be included) **Waste treatment and recycling emissions (Section 3.3.2.2)** • All production emissions shall be allocated to the materials that are defined as product or co-product, rather than to the waste • Emissions resulting from waste treatment as part of the production process (e.g., production waste, packaging waste) shall be calculated and included in the PCF of the company that manufactured the product and generated the waste • Emissions from the end-of-life stage of the products shall not be included in the PCF boundary • Since the PACT Methodology's boundary is cradle-to-gate, the "cut-off approach" should be used for the allocation of emissions from recycling materials and energy recovery **Electricity & contractual instruments (Section 3.3.2.3)** • Companies shall calculate the emissions from electricity use including all GHG emissions from the life cycle of the electricity supply system • Companies shall only use certificates from contractual agreements (e.g., Renewable Energy Certificates (RECs), Guarantees of Origin (GOs)) that meet the quality criteria outlined in Box • Companies that use contractual instruments should use the supplier-specific emission factors outlined in the corresponding contractual agreement • Companies that do not use contractual instruments should use the most accurate emission factors depending on electricity distribution method: – Internally generated electricity - Companies should calculate the emissions associated with their electricity generation including all relevant cradle-to-gate emissions – Directly connected supplier - Companies should use supplier-specific emission factors – Grid-distributed - Companies shall use the residual mix and if unavailable use sub-national or national grid-mix emission factors based on location of operations • If emission factors only cover gate-to-gate emissions, they shall be complemented by an upstream emission factor **Biogenic and land sector related emissions and removals (Section 3.3.2.4)** • Companies shall calculate biogenic and land sector related emissions and removals – These emissions shall only be excluded if the biogenic carbon content of the product is lower than 5% or when biogenic and land sector related emissions are below the exemption rules detailed in Section 3.3.1.2.

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Table 3: Summary of guidelines (continued)

Emissions calculation

Section	Subsection	Guidelines
3.3 Product Carbon Footprint Calculation Guidance	**3.3.2** Additional guidance	**Biogenic and land sector related emissions and removals (Section 3.3.2.4) (continued)** • Calculation of biogenic emissions and removals includes the following categories to be included in the PCF: – Land-use change emissions (LUC) – Land management CO_2 emissions (required from 2027 onwards[10]) – Biogenic non-CO_2 emissions – Fossil – land management (mandatory from 2027 onwards) – Land management CO_2 removals – Biogenic product CO_2 uptake • Two PCFs shall be reported: 1) PCF – excluding biogenic CO_2 uptake and 2) PCF – including biogenic CO_2 uptake • To support transparency, two categories are reported outside of the PCF: – Companies shall report Biogenic carbon content of the product – Companies should report land occupation **Technological CO_2 capture, storage and use (Section 3.3.2.5)** • The net CO_2 stored via Carbon Capture and Storage (CCS) should be accounted for if the defined specific requirements described in Section 3.3.2.5 are met • The "cut-off approach" should be used for the allocation of emissions from Carbon Capture and Utilization (CCU)-derived product

Creating integrity

Section	Guidelines
4.1 Data sources and hierarchy	• PACT Methodology definitions shall be used by companies to determine the nature (i.e., primary or secondary data) of activity data and emissions data • Activity data that is used to calculate a PCF shall be company-specific process-based data (i.e., primary data) • Secondary emission factors used shall be compliant with PACT Methodology safeguards described in Section 4.1.3.2 • Companies may use proxy secondary emission factors data and/or environmentally extended input-output databases (EEIO) to bridge minor data gaps ("worst case")
4.2 Data reliability	• Companies shall assess the primary data share (PDS) of the PCF excluding biogenic CO_2 uptake and; • From 2027 onwards[11], companies shall assess the data quality ratings (DQR) of the PCF excluding biogenic CO_2 uptake • The PDS shall be based on both the nature of the activity data and the emission factors used • If upstream PDS and DQRs are unknown, companies shall apply the worst-case scenario (i.e., 0% PDS and 5 DQR)

10. While companies should calculate and report this information, it is only required by end of 2027 (i.e., 31.12.2027)
11. While companies should calculate and report this information, it is only required by end of 2027 (i.e., 31.12.2027)

Table 3: Summary of guidelines (continued)

Verification **5** **Verification**	• Verification of the PCF shall be done by an independent third party following the considerations laid out in the PACT Methodology's roadmap (Figure 212). • In the short-term (2025-2030) companies shall verify the underlying methodology used by any tools (software, excel, platform etc.) to generate PCFs, called the 'PCF Calculation Model'. • In the long-term (2030 onwards) companies shall certify their PCF Program, which is the system governing how a company generates and manages PCFs.
Creating integrity **6.1** **Requirements for PCF data exchange**	• Companies shall exchange their cradle-to-gate PCFs alongside a set of minimum required data elements listed by the PACT Methodology and PACT's Technical Specifications
6.1 **Requirements for PCF data exchange**	• Companies that have calculated their PCFs should exchange these using interoperable PACT Conformant solutions that are part of the PACT Network
6.3 **Incorporating product-level data into Scope 3 calculations**	• Companies should incorporate PCFs into their corporate Scope 3 footprints by multiplying the PCFs provided by suppliers with the number of product units purchased.

3. GHG Emissions calculation

To foster a better understanding of GHG emissions, companies shall calculate their cradle-to-gate PCFs and exchange this data along the value chain.

3.1 Existing methods and standards

The PACT Methodology builds on existing methods and standards to provide guidance on which methods to use and when to provide additional guidance where existing guidelines offer flexibility.

3.1.1 Relationship

The PACT Methodology leverages and builds on existing methods and standards for the calculation and allocation of product-level emissions, including:

- Product Life Cycle Accounting and Reporting Standard (GHG Product Standard) and Corporate Value Chain Standard (GHG Scope 3 Standard)
- ISO standards (14044, 14040, 14067, 14025, 14083)
- Product Environmental Footprint (PEF) method and Product Environmental Footprint Category Rules (PEFCRs) by the European Commission
- Product Category Rules (PCRs) by Environment Product Declaration (the International EPD System) and other program operators (see Box 1)
- Any other product- or sector-specific rules that are compliant with the GHG Protocol rules

The PACT Methodology builds on these with the aim of ensuring PCF calculation consistency and comparability across sectors and geographies. Please refer to Appendix B for examples.

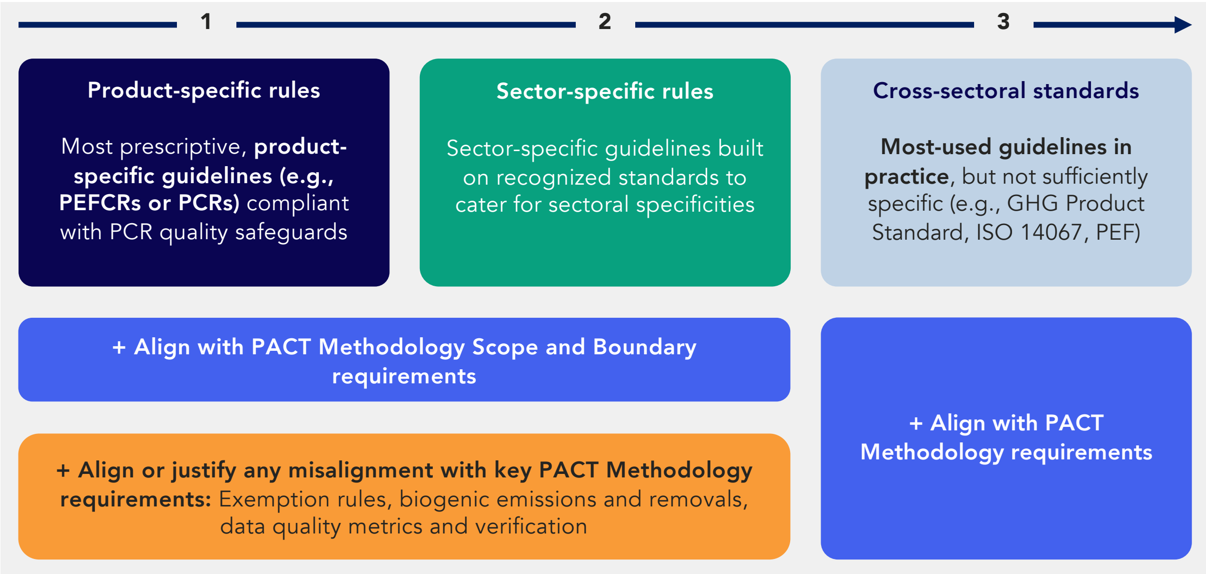
3.1.2 Hierarchy of application

In general, existing methods and standards can be classified into three types:

1. Product-specific rules (e.g., PEFCRs)
2. Sector-specific rules (e.g., Together for Sustainability (TfS), Catena-X, Global Battery Alliance (GBA), ISO 14083, GHG Protocol Land Sector and Removals Standard)
3. Overarching sector-agnostic or cross-sectoral protocols and standards (e.g., GHG Protocol standards, ISO standards, PEF method)

Application of these rules follows the hierarchy shown in Figure 4, whereby three scenarios are envisioned. Please note that product-level regulations applicable to any given product or company (e.g., depending on the sector they operate in) should be prioritized over other existing methods and standards.

Figure 4: Prioritization of methods and standards



Product-specific rules exist

According to ISO 14067[12], a PCR is a "set of specific rules, requirements and guidelines for carbon footprint of a product or partial carbon footprint of a product quantification and communication for one or more product categories."

Where valid product-specific rules exist, their application should always be prioritized for the cradle-to-gate PCF calculation, as they provide the most detailed guidance in relation to a specific product and hence can contribute to increasing the accuracy and consistency of data exchanged across value chains[13].

PCRs will most likely overlap with the requirements of Section 3.3 of this document. In such cases, in line with the recommended hierarchy, PCFs calculated following a valid PCR shall be prioritized and shall align with the PACT Methodology's scope and boundary (e.g., ensuring the PCF remains cradle-to-gate). If the exemption rules, biogenic emissions, land-sector-related emissions and removals, data quality metrics, or verification requirements are not aligned with the PACT Methodology, then any discrepancies should be clearly noted in the comment section when exchanging the PCF.

12. ISO. (2018). ISO 14067 - Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification.
13. Existing overarching methods and standards, in contrast, do not provide a sufficient level of specificity. For instance, under the GHG Product Standard, two companies producing similar products can choose two different methods for allocating emissions, leading to incomparable results.

To ensure robustness and reliability, only PCRs meeting the following safeguards shall be considered valid for the purpose of this guidance:

1. PCRs shall be developed in accordance with the ISO 14000 series or other cross-sectoral guidance
2. PCRs shall be developed through a multistakeholder process and independently peer reviewed.
3. PCRs shall be reviewed at least every five years to ensure they are up to date with the latest methodological developments, standards, and market expectations.
4. PCRs shall be applicable to the geography where the product is being marketed or produced.

Please note that in some cases, the methodology presented by a PCR may be relevant and appropriate for a given product while their accompanying databases may not be. For example, the methodology presented by a PEFCR may be relevant for a product manufactured in a non-European region, whereas the European datasets may not be the most accurate for that given region. In such cases, companies shall communicate whether they have followed only the methodological requirements of a PCR but not the accompanying data set.

Box 1: Hierarchy of Product Category Rules (PCRs)

While the aim of PCRs is to provide more granular product-specific guidance to facilitate accuracy and consistency, in some instances several PCRs compliant with the quality safeguards may exist for a product or product category (e.g., two PCRs covering the same product but in different regions). The applicability of these different PCRs for companies may vary depending on the purpose for developing the PCR. For example, a region-specific PCR may be able to better capture nuances related to the manufacturing process of a product in a given region, while a PCR from a global operating association may be better suited to ensure calculation consistency worldwide. For the purpose of this guidance, companies should thus base their choices on the following hierarchy:

1. If the calculation is to be done for compliance purposes, PCRs compliant to relevant regulations should be followed.
2. If there is a global sector-specific initiative validating PCRs, these should be prioritized (e.g., Together for Sustainability, Catena-X).
3. If the calculation is to be done for commercial purposes and no sector-specific guidance on PCRs exists, companies should base their PCR choice on the market in which the product is intended to be manufactured or sold. For instance, if products are intended for the global market, companies should prioritize PCRs from global program operators (e.g., EPD International Program), but if the intended market is a specific country or region, companies should prioritize PCRs applicable to that given geography (e.g., PEFCRs being used for EU market).
4. If the intended market is unclear, companies should prioritize more globally accepted PCRs in order to prioritize consistency and broader acceptance.

Sector-specific rules exist

Where no product-specific rules exist, companies shall prioritize the use of sector-specific rules built on cross-sectoral standards (i.e., ISO, GHG Protocol, PEF) for the calculation of PCFs. Please note that the development of new sector-specific guidance should build on and seek alignment with the proposed PACT Methodology requirements and further refine them to cater to sectoral specificities (e.g., Together for Sustainability guidance for the chemical sector).[14]

Similarly with PCRs, sector-specific rules will most likely overlap with the requirements of Section 3.3. In such cases, in line with the recommended hierarchy, PCFs calculated following sector-specific rules shall be prioritized and shall align with the PACT Methodology's scope and boundary (e.g., ensuring the PCF remains cradle-to-gate). If the exemption rules, biogenic emissions, land-sector-related emissions and removals, data quality metrics, or verification requirements are not aligned with the PACT Methodology, then any discrepancies should be clearly noted in the comment section when exchanging the PCF.

Only overarching rules exist

Where no product- or sector-specific rules exist, companies shall follow the PACT Methodology calculation requirements (e.g., allocation, data quality and verification requirements). For aspects not explicitly addressed by the PACT Methodology, the methodology used to calculate PCFs shall be compliant with cross-sectoral standards (GHG Product Standard, ISO 14067, or PEF).

All PCRs, sector-specific rules and overarching rules used to calculate the PCF shall be compliant with ISO 14040 and ISO 14044, which provide foundational requirements and guidelines for life cycle assessments (LCAs) and may be consulted as a reference. In parallel, businesses are encouraged to develop, based on PACT Methodology requirements, more detailed product- or sector-specific rules in collaboration with other stakeholders to address any product- or sector-specific needs and drive further consistency in the PCF calculation of any given product.[15]

3.2 Scope and boundary

Understanding the scope and boundary of the PACT Methodology is an essential starting point for the calculation of PCFs.

3.2.1 Life Cycle Assessment (LCA) approach

The PACT Methodology is based on the attributional LCA approach. This approach seeks to determine the ex-post environmental impacts associated with a product's life cycle. GHG emissions are attributed to a specific unit of a product by adding up the emissions of all attributable processes along its life cycle. A PCF represents the potential life cycle impact of a product on the environmental impact category of climate change. This impact category considers that different GHGs have different impacts on climate change, expressed as their Global Warming Potential (GWP) with the unit kg CO_2 equivalent (CO_2e).

The basic equation to calculate GHG emissions (CO_2e) for activity data is:

$$\text{Activity GHG emission (kg } CO_2e) = \text{Activity data (amount of activity)} \times \text{Emission factors (kg GHG/ unit of activity)} \times \text{GWP (kg } CO_2e\text{/ kg GHG)}$$

14. To drive consistency, PACT is collaborating with sectoral initiatives globally to build sector- and product-specific guidance in alignment with the PACT Methodology.
15. Prior to commencement, the list of work-in-progress PCRs by relevant program operators shall be consulted to avoid duplication. Any new development activities should be communicated to PACT.

3.2.2 Focus on GHG emissions

The PACT Methodology provides the methodology for calculating GHG emissions of products.

Companies shall at a minimum account for the following GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorinated compounds, sulfur hexafluoride (SF_6), nitrogen trifluoride (NF_3) (required by the GHG Protocol), perfluorocarbons (PFCs), fluorinated ethers (HFEs), perfluoropolyethers (e.g., PFPEs), chlorofluorocarbons (CFCs), and hydrochlorofluorocarbons (HCFCs) (recommended by the GHG Protocol).[16] Following common practice, the global warming impact of these gases can be converted into and expressed as CO_2e. Their respective characterization factors (100-year GWP, including carbon feedbacks) shall be derived from the latest version of the IPCC Assessment Report (AR).

When a new IPCC AR is released, the following reporting year shall be considered a grace period to give companies sufficient time to update their calculations and systems. During that period, companies may calculate and report PCFs that incorporate characterization factors from multiple versions of the IPCC AR. Companies shall disclose which AR(s) were used to calculate the PCF.

Following the one-year grace period, companies shall exclusively calculate and report new or updated PCFs using the latest IPCC AR. Existing PCFs are valid until the end of their validity period as per Section 3.2.3.

3.2.3 Scope and boundary of the PACT Methodology

The life cycle of a product is in principle composed of five stages: (1) material acquisition and preprocessing (including extraction), (2) production, (3) distribution and storage (inbound and outbound logistics), (4) product use, and (5) end-of-life. Companies may elaborate or classify the stages differently to better reflect a specific product's life cycle.[17]

The boundary of the PACT Methodology—i.e., the processes and their associated GHG emissions that shall be taken into consideration during the PCF calculation—is a cradle-to-gate PCF, covering stages 1 to 3 above. Please note that stage 3 contains product storage and shipping processes, including transportation and storage within and between these life cycle stages. GHG emissions associated with the outbound transportation and storage (i.e., outbound logistics) are not included in the PCF. However, they should be calculated and reported separately up to the point where another company (e.g., customer) takes over responsibility for the product (i.e., owns or pays for the outbound logistics). This means that the scope is cradle-to-production-gate, and any downstream logistics are calculated and exchanged when more specific data are available due to operational control.

Box 2: Example of adoption of characterization factors following new IPCC AR release

If the 7th Assessment Report (AR7) were to be released in 2026, companies would need to exclusively start using the characterization factors from AR7 from 2028 onwards when calculating a new PCF or updating a PCF. In 2026 and 2027, companies would be allowed to use characterization factors from both the 6th Assessment Report (AR6) and the 7th Assessment Report (AR7), and would always disclose what ARs were used in the PCF calculation. From 2028 onwards, companies would need calculate new or updated PCFs using characterization factors from AR7 only.

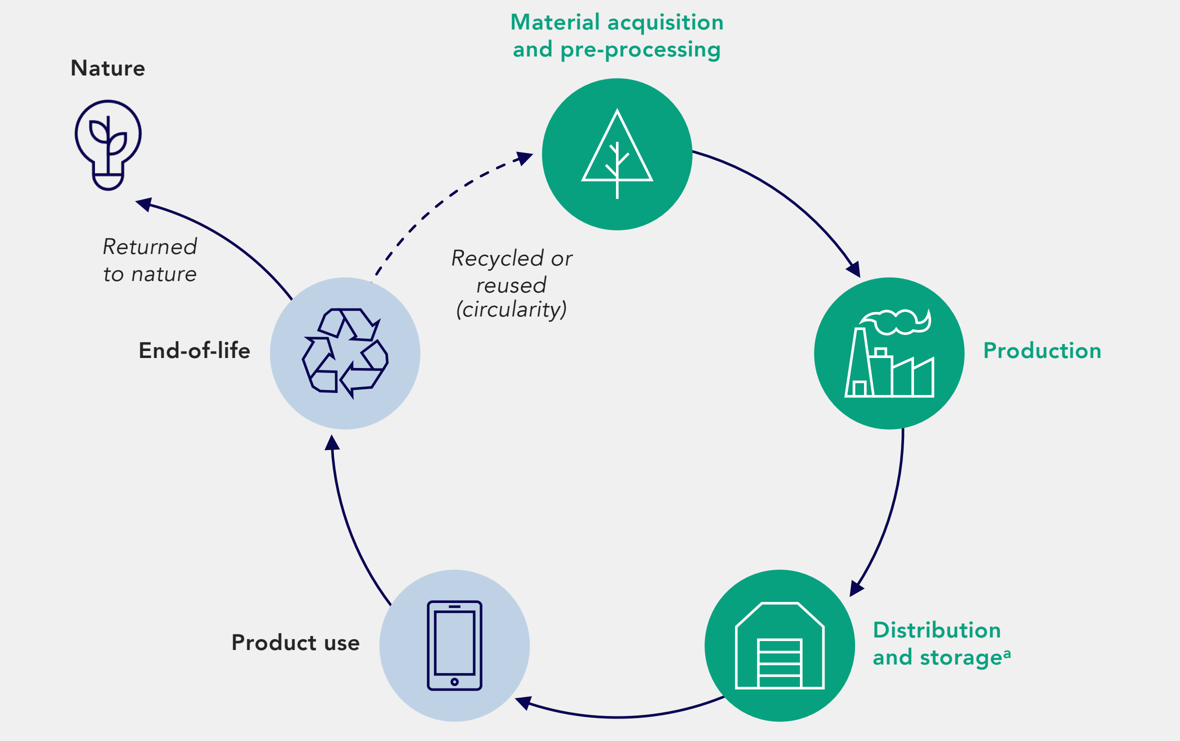
16. PACT acknowledges inconsistencies with current Life Cycle Impact Assessment (LCIAs) and will investigate creating a PACT LCIA to be implemented in LCA software. In the meantime, PACT recommends the IPCC 2021 LCIA Method.
17. GHG Protocol. (2011). Product Life Cycle Accounting and Reporting Standard.

The cradle-to-gate boundary includes all the attributable upstream and direct emissions[18] of a product, including all upstream transportation activities.[19] The boundary excludes downstream emissions related to the product use and end-of-life stages.

When calculating emissions, companies shall further define their cradle-to-gate boundary by categorizing the attributable processes of their studied product into the defined life cycle stages (Figure 5).

The selected system boundary enables companies to leverage PCFs received from their suppliers to calculate more accurate PCFs of the products they produce, ultimately enabling them to exchange even more accurate PCFs downstream. To increase the transparency of data exchange and to prevent double counting or excluding emissions, the PACT Methodology requires companies to report on the attributable processes included in each of the life cycle stages covered by the PCF. The requirements and recommendations for data exchange are explained further in Section 6.

Figure 5: Lifecycle stages included in the boundary of the PACT Methodology



a. Contains product storage and shipping processes, including transportation and storage within and between these life cycle stages. Outbound transportation and storage should be calculated and reported separately up to the point where another company takes over responsibility for the product (i.e. own or pay for outbound logistics).

18. The PACT Methodology uses a value chain perspective to account for and exchange product life cycle emissions. As such, the PACT Methodology organizes a company's emissions into two major categories. The first category, upstream emissions, are indirect GHG emissions that occur in the value chain prior to the processes owned or controlled by the reporting company. All upstream transportation emissions are also included as part of upstream emissions. The second category, direct emissions, are GHG emissions from the processes that are owned or controlled by the reporting company.
19. Accounting for and reporting for transportation emissions is described further in Section 3.3.2.1.

Product Carbon Footprints related to services or Service Carbon Footprints (SCFs)

In line with the GHG Protocol definition, products are defined as 'any physical good or service'.[20] However, due to their significantly higher emissions intensity compared to services, the initial focus of the PACT Methodology has been on physical goods. Acknowledging that services represent for many companies an increasingly large proportion of procurement spend and therefore potentially Scope 3 emissions, Box 5 in Section 3.3.1 includes high level guidance on how to calculate Service Carbon Footprints (SCFs).

To enable data exchange, declared units relevant to SCFs have also been incorporated into the list of accepted units. In future versions of the PACT Methodology, depending on feedback from the PACT community, service-related guidelines included in Section 3.3.1 may be further expanded. Additionally, further details and standardization may be addressed by PACT-aligned industry-specific initiatives that may be better positioned to define common sectoral SCF accounting principles.

Time boundary

The time boundary of a PCF refers to the time period for which the PCF value is considered to be representative.[21]

PCFs shall have a maximum validity period (period of time during which a PCF can be used in calculation) of up to three years, provided that no major changes to the production process take place within the validity period. Companies may update their PCFs more regularly (e.g., annually). Major changes are defined as a variance of 10% or more compared to the original PCF. After three years or if a variance of more than 10% is identified, PCF values shall no longer be considered representative and shall be recalculated and exchanged.

The validity of the PCF starts automatically after the reference period[22] (if not specified otherwise). The reference period is the period between the start date of the earliest activity data used to calculate the PCF and the end date of the latest activity data used. This covers the time period during which the activity data used to calculate the PCF is representative. When exchanging PCFs, the PCF of the supplier needs to be valid within the customer's PCF reference period, in other word, a company may only use a supplier's PCF if the PCF's validity period is within the reference period of the calculated PCF.[23]

The PCF's reference period shall always be disclosed. Emissions that were averaged over several years may be reported, e.g., to reduce the effect of revisions, turnarounds, or other untypical production conditions.

Geography considerations

Companies should report information on the geographical representation of their PCF. However, it is at the discretion of the company to choose the level of granularity of geographic information (e.g., at a plant, region, or country level). ISO 3166-1 alpha-2— defining the most widely used country codes (such as US for the United States or FR for France)—shall be used to indicate specific countries or regions. If the same product is produced in various locations and the data owner chooses to provide regional information, the data owner may provide several PCFs pertaining to each respective geography. As an alternative, it is possible to report a single footprint for products that are produced in various locations. When following this approach, a weighted average of the respective product-specific emissions according to each geography's production quantity shall be calculated and exchanged.

3.2.4 Unit of analysis

The unit of analysis of the product serves as the basis for all data collection and inventory results. Final PCF inventory results shall thus be disclosed as kg of CO_2e per unit of analysis. Please note that cradle-to-gate PCFs typically use a "declared unit" approach (Box 3).

20. GHG Protocol. (2011). Product Life Cycle Accounting and Reporting Standard
21. ISO. (2018). ISO 14067 - Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification.
22. May also be referred to as reference year.
23. The reference period of the supplier's PCF is not limited by the reference period of the customer's PCF. The validity period of the PCF of a customer is not limited by the validity period of PCFs received from suppliers.

Box 3: Distinction between functional and declared unit

LCA inventory results are provided in terms of functional units[a]. A functional unit describes the function of a product in question. For example, for a laundry detergent, the functional unit could be defined as "washing 4.5 kg of dry fabric with the recommended dosage with medium-hard water". Understanding the functional unit is essential for comparability between products with the same function, as it provides the reference to which the input (materials and energy) and output (such as products, co-products, waste) are quantified.

Intermediate products, i.e., products that will still be processed further to create a final product, can, however, have several functions based on their eventual end use. In this case (and where an LCA does not cover the full life cycle), the term declared unit—typically referring to the physical quantity of a product, e.g., "1 liter of liquid laundry detergent with 30% water content"—can be used instead.

a. This term is used in ISO 14044 and PEFCRs.

The declared units accepted are: liter (L), kilogram (kg), cubic meter (m^3), kilowatt hour (kWh), megajoule (MJ), tonne kilometer (t.km), square meter (m^2), and piece. For PCFs related to services, companies shall use hour (h) or Megabyte second (Mb.s). Additional information on mass shall be reported for volume- and quantity-based units (e.g., L, m^3, m^2, piece) but not for mass-based (kg), energy (MJ), transport (t.km), or SCF units (Table 4). This ensures consistency and comparability.

Please note that the declared unit does not include the weight of the packaging, i.e., the declared unit is associated with the unpackaged product. The PCF, however, should include the emissions associated with the packaging.

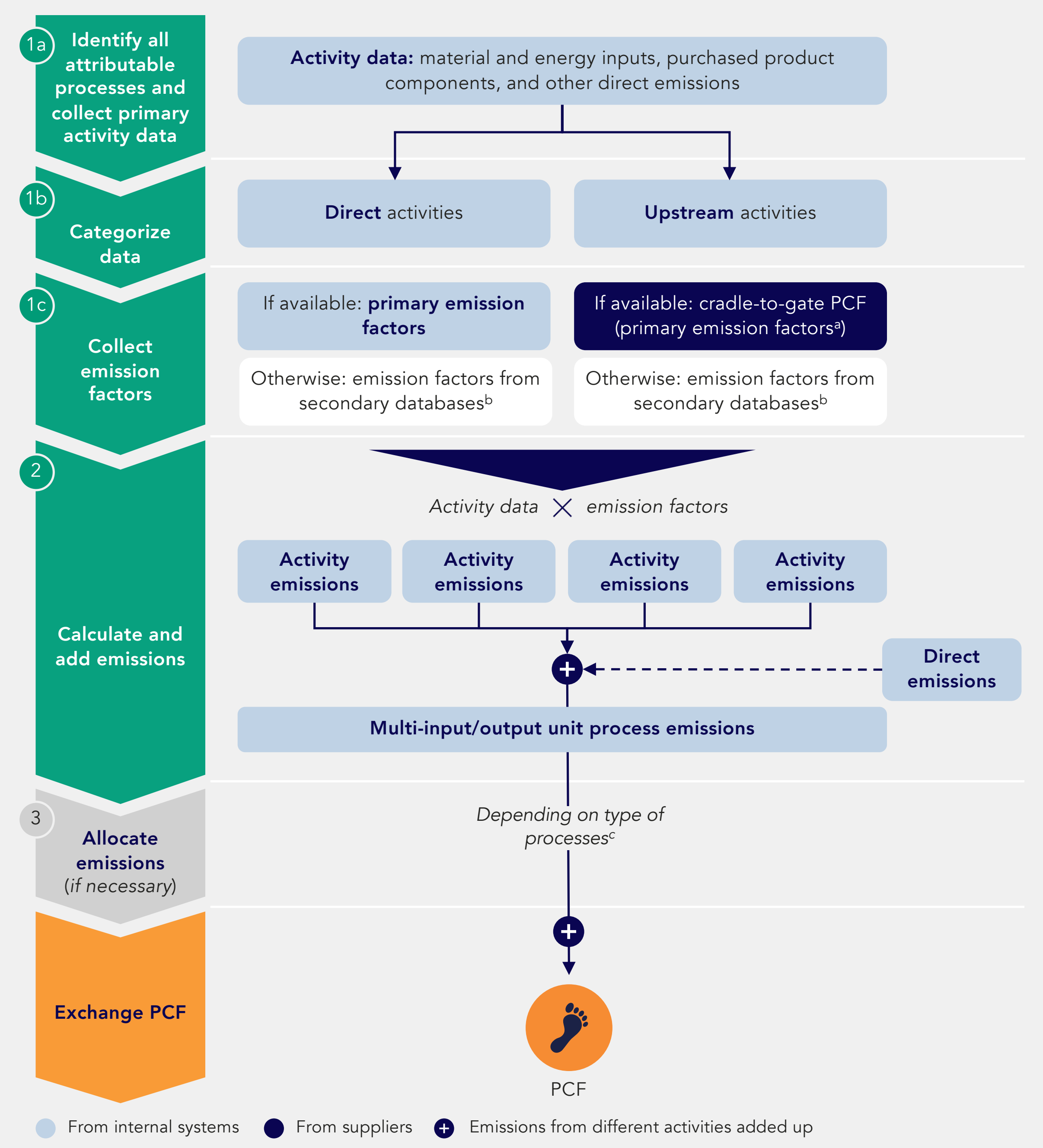
Table 4: List of accepted declared units

Category	Accepted Declared Unit	Mass information required
Physical goods	Liter (L)	Yes
	Kilogram (kg)	No
	Cubic meter (m^3)	Yes
	Megajoule (MJ)	No
	Tonne kilometer (t.km)	No
	Square meter (m^2)	Yes
	Piece	Yes
Services	Hour (h)	No
	Megabyte second (Mb.s)	No

3.3 Product Carbon Footprint Calculation Guidance

This section provides guidance on how to calculate a PCF, which should be used in conjunction with existing methods and standards. Companies calculating their PCF in accordance with a PCR or sector-specific guidance may skip this section.

Figure 6: Overview of steps for PCF calculation



a. E.g., x kg CO_2e per y tons of steel.
b. Using secondary database(s) according to agreed upon guidelines.
c. Companies shall avoid allocation whenever possible.

3.3.1 Calculation of product GHG emissions

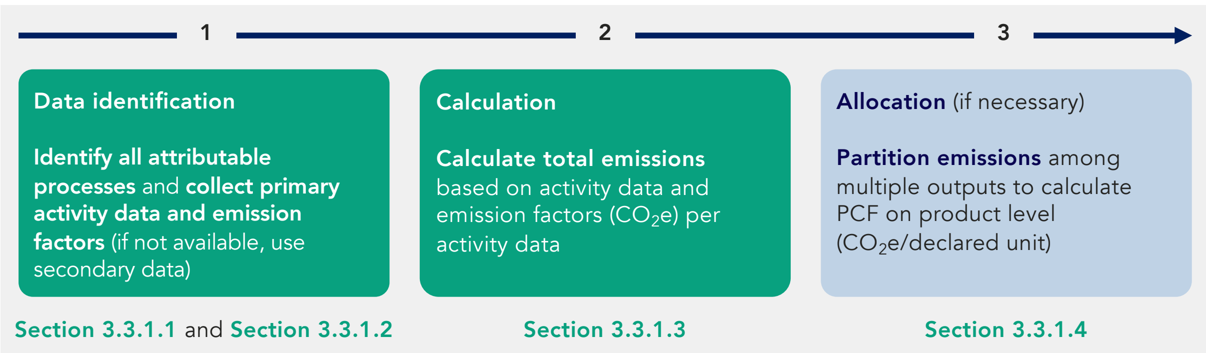
The following steps shall be followed to calculate a PCF: (i) identify and collect necessary data, (ii) calculate emissions using relevant emission factors, and, if relevant, (iii) allocate emissions to specific products or materials (Figure 7).

Note that the PACT Methodology requires the calculation and exchange of two distinct PCFs to ensure interoperability with other standards and guidance while promoting greater transparency:

- PCF – excluding biogenic CO_2 uptake
  - Includes
    - All fossil emissions (CO_2, CH_4, N_2O, HFCs, SF_6, NF_3, PFCs, HFEs, PFPEs, CFCs and HCFSs) from stationary/ mobile combustion, industrial processes and fugitive emissions
      - All fossil land sector-related related emissions (CO_2, N_2O, PFCs)
    - All biogenic emissions (biogenic CH_4, biogenic CO_2)
    - Land management removals (biogenic CO_2) and technological removals
  - Excludes
    - Biogenic Product CO_2 uptake
- PCF – including biogenic CO_2 uptake
  - Includes
    - All fossil emissions (CO_2, CH_4, N_2O, HFCs, SF_6, NF_3, PFCs, HFEs, PFPEs, CFCs and HCFSs) from stationary/ mobile combustion, industrial processes and fugitive emissions
    - All fossil land sector-related related emissions (CO_2, N_2O, PFCs)
    - All biogenic emissions (biogenic CH_4, biogenic CO_2)
    - Land management removals (biogenic CO_2) and technological removals
    - Biogenic Product CO_2 uptake

The difference between these two PCFs is the inclusion of biogenic product CO_2 uptake. Biogenic CO_2 product uptake measures the amount of biogenic CO_2 that has been removed from the atmosphere during biomass growth and (temporally) stored in the product (for further guidance see Section 3.3.2.4). In exchanging both PCFs, PACT aligns with the two dominant approaches used to calculate biogenic CO_2 uptake in products (Box 4).

Figure 7: General steps for the calculation of a PCF



Box 4: Background on PCF including and excluding biogenic CO2 uptake

There are two dominant approaches to calculate biogenic CO_2 uptake in products:

1. **Neutral approach:** Assumes the biogenic CO_2 in the product is zero (neutral approach) over the full product life cycle as CO_2 uptake during biomass growth are balanced by CO_2 release at the end of life[a] . A characterization factor of 0 $kgCO_2/kgCO_2$ is used. This approach is endorsed by the European Commission Product Environmental Footprint method.

2. **–1/+1 approach:** Biogenic CO_2 uptake in products is characterized with –1 $kgCO_2/kgCO_2$. Upon end-of-life of the product, the CO_2 contained in the product is released and characterized as +1 $kgCO_2/kgCO_2$. This approach is endorsed by ISO 14067 (2018).

When adopting a cradle-to-grave perspective, both approaches result in identical PCFs. However, in the cradle-to-gate boundary adopted in the PACT Methodology, the difference between the two cradle-to-gate PCFs is the inclusion of biogenic net product CO_2 uptake in the –1/+1 approach.

To ensure transparency, both approaches shall be calculated and reported in two separate categories when exchanging PCF data. When reporting "PCF excluding biogenic CO_2 uptake", companies shall follow the neutral approach. When reporting "PCF including biogenic CO_2 uptake" companies shall follow the –1/+1 approach. When companies choose to use PCF including biogenic CO_2 uptake, they should ensure the calculation of biogenic CO_2 emissions at end of life (which is out of the scope of PACT).

a. Any biogenic CO_2 emitted as methane (biogenic CH_4) at end-of-life within the PCF excluding biogenic CO_2 uptake, in line with the 0/0 approach—must be calculated. Companies shall apply a characterization factor for biogenic methane that does not account for biogenic CO_2 uptake. According to the AR6 – Table 7.15, this characterization factor is 27.

3.3.1.1 Data identification

First, all the attributable processes linked with the Scope and Boundary identified in Section 3.2 (cradle-to-gate) should be identified. This guidance defines "attributable processes" as any processes associated with services, materials, or energy flows that become, make, or carry a product throughout its life cycle.

In alignment with the GHG Product Standard, only processes that are immediately related to the production of the studied product are part of the assessment. In light of this, the following activities should not be included within the boundary of the PCF, unless materially significant (i.e., above the exemption rules defined in Section 3.3.1.2) for the studied product: manufacturing of production equipment, buildings and other capital goods, business travel by personnel, travel to and from work by personnel, and research and development activities. While all of these activities are linked to company operations and should be calculated within a companies' Scope 3 inventories in line with the GHG Scope 3 Standard, they do not tend to be specific to any given product and should therefore not be included in PCFs unless materially significant (i.e., above the exemption rules defined in Section 3.3.1.2). For example, in the case of wind or solar power generation, where the building of the panels and turbines may not be negligible on a per kWh basis over the lifetime of the equipment, or in the case of service carbon footprints, where business travel emissions may represent a material percentage. Please note that as per the hierarchy defined in Section 3.1.2, sector- and product-specific guidance provide relevant direction on the inclusion or exclusion of such activities. Additionally, if some activities such as capital goods requirements are included in a secondary database, it may be used as it is considered to be aligned with the PACT Methodology.

In accordance with the exemption rules defined in Section 3.3.1.2 of this guidance, emissions due to packaging of the product (primary, secondary, or tertiary) should be included in the PCF calculation unless they fall below the exemption rules. If packaging emissions are included, it should be visible in the description of the product. Packaging emissions should be reported separately and its biogenic carbon content may also be reported.

To determine unit process emissions, relevant activity data and emission factors based on a company's own processes (direct activities) as well as the relevant material or energy input flows from suppliers upstream (upstream activities) shall be collected.

Inventory data shall be compiled taking into consideration the following processes:

- Material inputs (e.g., 10 tonnes of steel, 300 kg of aluminum)
- Energy inputs[24] such as purchased electricity, cooling, and heating (e.g., 100 kWh)
- Purchased materials or feedstocks (e.g., chemical component, unit, amount)
- Inbound transport and storage-related inputs (e.g., 10 km transport of 0.01 tonnes of chemical components from supplier to manufacturing site in a diesel-fueled truck)
- Production waste and treatment (e.g., 10 kg of cardboard waste sent to landfill)
- Processes generating any other direct emissions not otherwise included (e.g., CO_2 formed during the production process)

After identification of the data, all data shall be categorized as direct or upstream activities (Figure 6).

Box 5: Calculation of PCFs related to services or Service Carbon Footprints (SCFs)

With services representing a significant portion of companies' procurement spend, it is within PACT's mission to ensure that the calculation and exchange of SCFs also take place in a consistent way across value chains.

While the range of services that companies may purchase vary widely, and with them the variety of calculation approaches and declared units, this guidance takes into consideration two main group of services: desk-based services (such as consulting, legal, and marketing services) and IT-related services (such as software services).

To enable the calculation and exchange of SCFs related to these services, two declared units may be used:

- Time in **hour** for desk-based services
- Usage in **Mb.s** for IT-related services

Calculating SCFs of desk-based and IT-related services follows the same steps as for the calculation of a PCF, outlined in Figure 6. This starts with the identification of attributable processes, which for SCF focuses on e.g., energy consumption and identification of the capital goods required to deliver the service that may have a material GHG impact. The identification and prioritization of these capital goods is at the discretion of companies calculating PCFs, unless a sector-specific guidance exists, which should be prioritized.

Additionally, please note that while SCF aligns to the cradle-to-gate boundary, service production and consumption are inseparable, i.e., services are consumed at the same time as they are produced.

24. If bioenergy biomass is used as a feedstock material, please refer to Section 3.3.2.4 for reporting guidance.

Box 5: Calculation of PCFs related to services or Service Carbon Footprints (SCFs) (continued)

Example 1: Calculating SCF of desk-based services

A consulting company has been asked to calculate the SCF associated to a client project. To do so, they need to identify which activities were required to deliver the project's outcomes (e.g., employee commuting, business travel, office materials, consulting firm's purchased services, energy and water consumption) at the specific locations where the employees perform the service. They do a screening assessment and identify which of these activities need to be included in the SCF based on the exemption rules defined in Section 3.3.1.2. The consulting company shares the SCF per declared unit (i.e., in this case 'hour') for the project to their client by allocating these emissions based on the hours dedicated to the project.

Example 2: Calculating SCF of IT-related services

A company wants to calculate the SCF of their cloud computing services. Following the same requirements as other physical goods, the attributable processes of IT-related services include the raw material extraction needed to construct the hardware, manufacturing and transportation of the hardware, as well as usage and disposal of hardware. The company should identify which activities need to be included in the SCF or can be excluded following the criteria defined in Section 3.3.1.2. To exchange the SCF with their customers, the cloud computing service provider shall allocate the emissions per the customers' cloud usage.

3.3.1.2 Exemption rules: criteria to exclude certain activities

While cut-off criteria, cut-off rules and exemption rules are terms that can be used interchangeably, the PACT Methodology uses the term 'exemption rules' throughout this document.

Companies should seek to incorporate all attributable cradle-to-gate processes into their PCF. However, there are instances where the lack of data availability or the effort and resources required to calculate certain attributable processes can far outweigh their overall GHG contribution to the PCF. In these cases, companies may exclude certain processes if they disclose and justify these based on their degree of significance to the final PCF.

To do so, companies may conduct an initial screening of the product to identify all attributable processes and their contribution to the total PCF to understand whether, in the most conservative case, a process may be deemed insignificant (e.g., via a sensitivity analysis). In aggregate, exclusions shall represent less than 3% of the total cradle-to-gate PCF emissions. Should no major product modifications occur, companies can employ the results of the initial screening in future revisions of the PCF.

Companies receiving supplier-specific PCFs as part of their own PCF calculation shall take into consideration the percentage of emissions exempted by the supplier in the calculation. PACT acknowledges that no more than 3% of emissions may be excluded in total, e.g., when the upstream exempted percentage is not available, and recognizes this as an accepted uncertainty that will be revised in future methodology iterations once the market evolves.

To justify any exclusions, companies shall provide the percentage of emissions excluded from the PCF and may provide a description of the excluded attributable processes and the estimation technique used to determine insignificance.

Box 6: Example demonstrating a justified exclusion

Consider a process for which no primary or secondary data is available on material inputs X and Y. The company estimates that even if materials X and Y have the highest possible GHG intensities based on conservative proxy data, their aggregate impact, based on the total amount present in the product, does not exceed 3% of the total product carbon emissions impact. Therefore, the material inputs X and Y are justified exclusions. If, in aggregate, their emissions resulted in more than 3% of the total PCF, companies shall ensure at least one of the materials is assessed and included to avoid surpassing the 3% exemption rule.

3.3.1.3 Calculation

GHG emissions arising from attributable processes are determined by multiplying activity data with the relevant emission factor (CO_2e per declared unit). The resulting activity emissions can then be added to direct emissions, if any, to obtain multi-input/output unit process GHG emissions (Figure 6). Emission factors, used to convert a given amount of activity data into GHG emissions, are not to be mistaken with characterization factors, which in the context of emissions assessments refer to the 100-year GWP of the GHGs included in the assessment based on a CO_2e amount.

Please refer to Section 4.1.1 for detailed definitions of the different types of activity data and emission factors.

3.3.1.4 Allocation

Allocation refers to splitting multi-input/output processes into single-output processes by using physical, economic, or other criteria to partition the emissions between the studied product system (also known as studied product) and one or more other product systems (also known as co-products).[25] All cradle-to-gate emissions shall be allocated to the materials that are defined as product or co-product, rather than to the waste.

Identification of waste vs co-products

Companies shall define co-products as per criteria defined per industry, product-type or national regulation. If not present, companies shall follow the decision tree in Figure 8 based on EU's Guidance on the interpretation of key provisions of Directive 2008/98/EC on waste.

Identifying whether an output is a co-product or waste includes a thorough analysis that consists of four decision criteria. An output shall be considered a co-product if all of the following conditions are met:

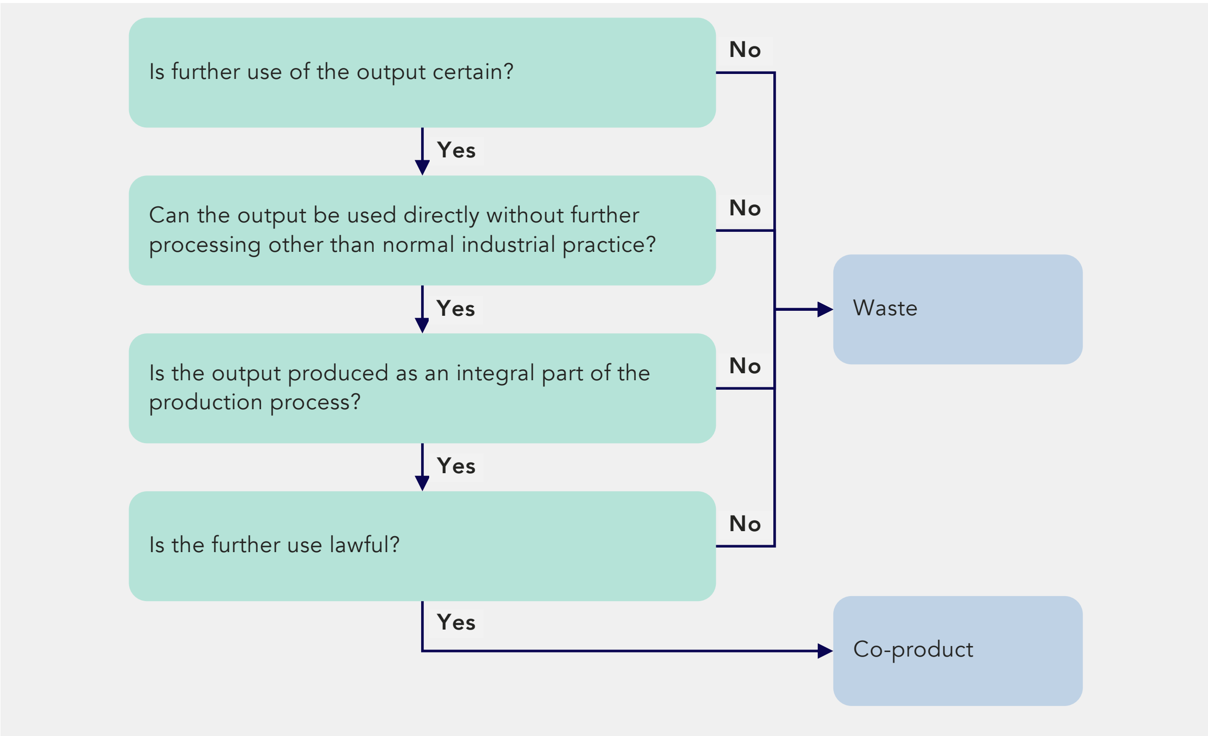
i. Its further use is certain, supported by evidence such as contracts or the existence of a market.

ii. It requires no further processing (waste treatment operations including recycling) beyond standard industrial processing like reuse, washing, and filtering.

iii. It is an integral part of the production process, meaning the output does not require separate processing outside of the core manufacturing process.

iv. Its use is lawful (e.g., fulfills national health protection requirements).

Figure 8: Decision tree to determine whether an output is a co-product or waste



For more guidance please consult Guidance on the interpretation of key provisions of Directive 2008/98/EC.

25. ISO. (2006). ISO 14044 Environmental management – Life cycle assessment – Requirement and guidelines

Allocation between co-products

Note that in this section and associated examples, it is assumed that companies have identified the co-products following the decision tree in Figure 8.

Once the co-product(s) are identified, and where allocation cannot be avoided, the inputs and outputs of the system should be partitioned between its different products.[26]

As defined in Section 3.1.2, in the absence of a PCR or sector-specific guidance on allocation rules, companies should allocate the emissions in line with the hierarchy presented by recognized cross- sectoral standards (i.e., ISO 14067 and the GHG Protocol) and reflected in Table 5. These standards state that companies are to prioritize physical allocation (e.g., mass, volume, energy content) if an underlying physical relationship can be established and is applicable, or to allocate the inputs and emissions based on economic or other established and justifiable relationships if an underlying physical relationship does not exist or is not applicable.

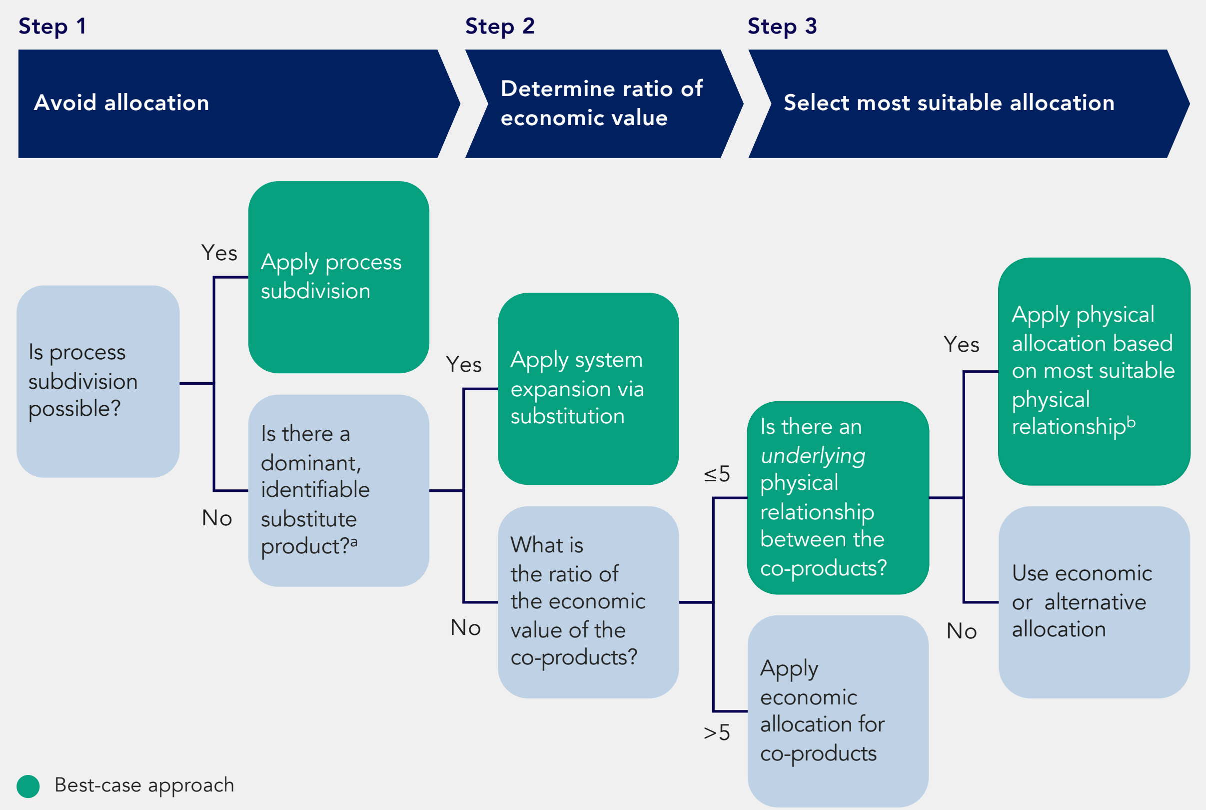
However, the flexibility these standards provide means that in many cases it may not be clear whether a physical relationship is applicable or not (see examples on Figure 10, Figure 11, and Figure 12). Companies may therefore struggle to determine if an economic relationship should be prioritized instead. To promote a consistent decision-making process and minimize room for interpretation, the PACT Methodology has developed a cross-industry allocation hierarchy (Figure 9) that companies should follow to increase the consistency and automatization of PCF calculations.

Table 5: Allocation methods presented by ISO and the GHG Protocol

Method	Definition
Physical allocation	Allocating the inputs and emissions of the system based on an underlying physical relationship between the quantity of product and co-product(s), and the quantity of emissions generated
Economic allocation	Allocating the inputs and emissions to the product and co-product(s) based on the market value of each when they exit the common process
Other relationships	Allocating the inputs and emissions to the product and co-product(s) based on established and justifiable relationships other than physical or economic

26. ISO. (2018). ISO 14067 - Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification

Figure 9: PACT Methodology decision-making tree to consistently implement ISO and GHG Protocol allocation rules



a. System expansion via substitution should only be used if there is a dominant, identifiable displaced product and production path for the displaced product based on sector consensus.

b. In doubt, mass allocation should be prioritized, but there are instances where other allocation factors may be more suitable (e.g., liters for liquids, energy content for energy).

Step 1: Avoid allocation

In accordance with the LCA International Standard (ISO 14044) and the GHG Product Standard, allocation shall be avoided whenever possible by using process subdivision, i.e., disaggregating the common processes into subprocesses that separately produce the studied product and co-products. The common process needs to be subdivided only to the point at which the studied product and its function are isolated, not to the point that every co-product has a unique and distinct process.[27]

If the multi-output situation cannot be avoided by subdivision, companies shall apply system expansion via direct substitution only when companies have “direct knowledge of the function and eventual use of the co-product.”[28] This entails defining a dominant, identifiable displaced product and production path for the displaced product for which sector consensus exists.

Step 2: Determine the ratio of economic value

When allocation cannot be avoided and there are no established product- or sector-specific allocation rules, companies shall calculate the ratio of the economic value of the co-products. To calculate the ratio, the highest-value product is placed in the numerator, regardless of whether it is the reference product or not. This ratio is employed in the next step to determine the most suitable allocation approach.

When there is a significant disparity in market value among products from a common process—specifically, when the economic

27. GHG Protocol. (2011). Product Life Cycle Accounting and Reporting Standard
28. GHG Protocol. (2011). Product Life Cycle Accounting and Reporting Standard

value ratio exceeds five—the product(s) with substantially higher economic value may be regarded as the primary driver(s) of the process. In other words, production would not take place in the absence of the product with the highest economic value.

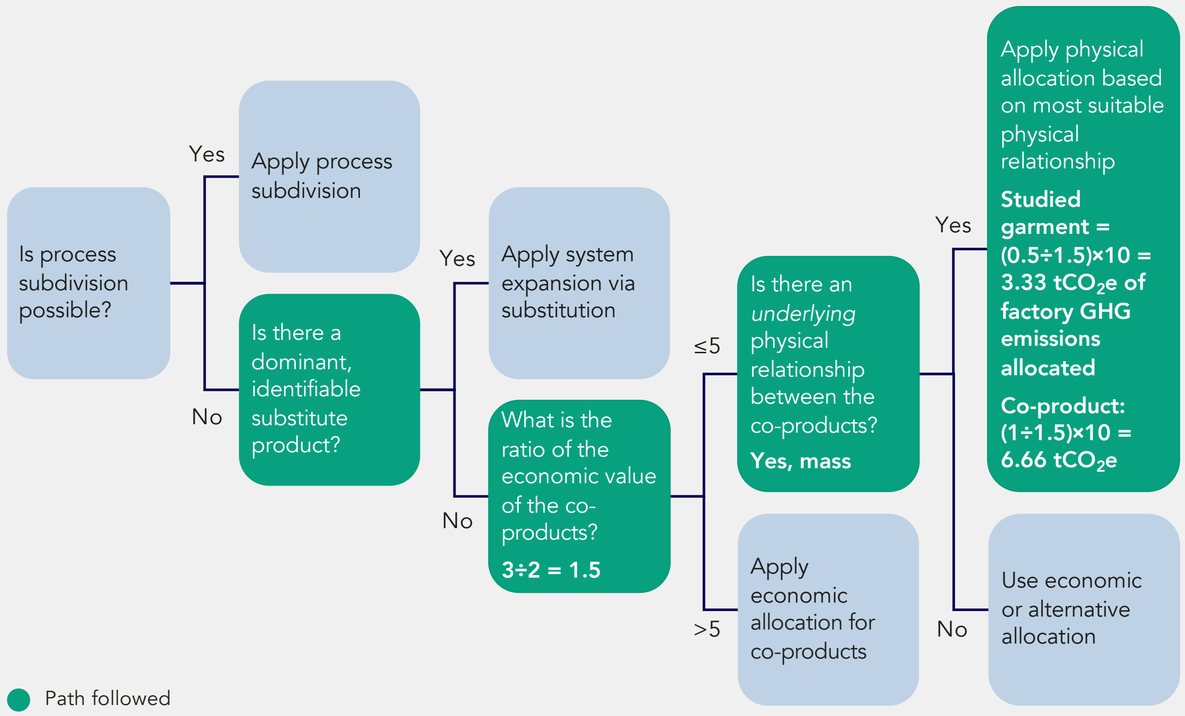
The economic value of products should be calculated based on stable market prices. In case of high year-on-year price fluctuation (i.e., over 100%), companies should use the average market price of products over ideally the last five years, and, if not possible, over the last three years in order to reduce the economic value fluctuations. If market prices are not available, other financial metrics (e.g., costs) may be used as long as they are justified and transparently communicated. Additionally, only one type of economic allocation factor (global market price, regional market price, or other financial metrics (e.g., costs)) shall be chosen and applied consistently per PCF.

Step 3: Select most suitable allocation method

If the calculated economic value ratio is equal to or lower than five[29], companies should apply physical allocation between the studied product and the co-product(s). That is, allocating the inputs and emissions of the system based on the most relevant underlying physical relationship (e.g., material or energy flows) between the product and co-product(s). For this, the physical property used as the allocation factor should most accurately reflect the underlying physical relationship between the studied product and co-product (see example in Figure 10). Should no underlying physical relationship exist, companies shall allocate emissions based on the economic value and amount of each co-product that is produced or based on alternative factors established by the sector, company, academia, or other sources of conventions and norms.

Figure 10: Example a of physical allocation based on mass

Case study: *A factory produces two different clothing garments in equal measure but is unable to perform process subdivision. No PCRs exist. Our studied garment weighs 0.5 kg and has an economic value of $2, while the co-product weighs 1 kg and has an economic value of $3. There are 10 tCO_2e to be allocated.*

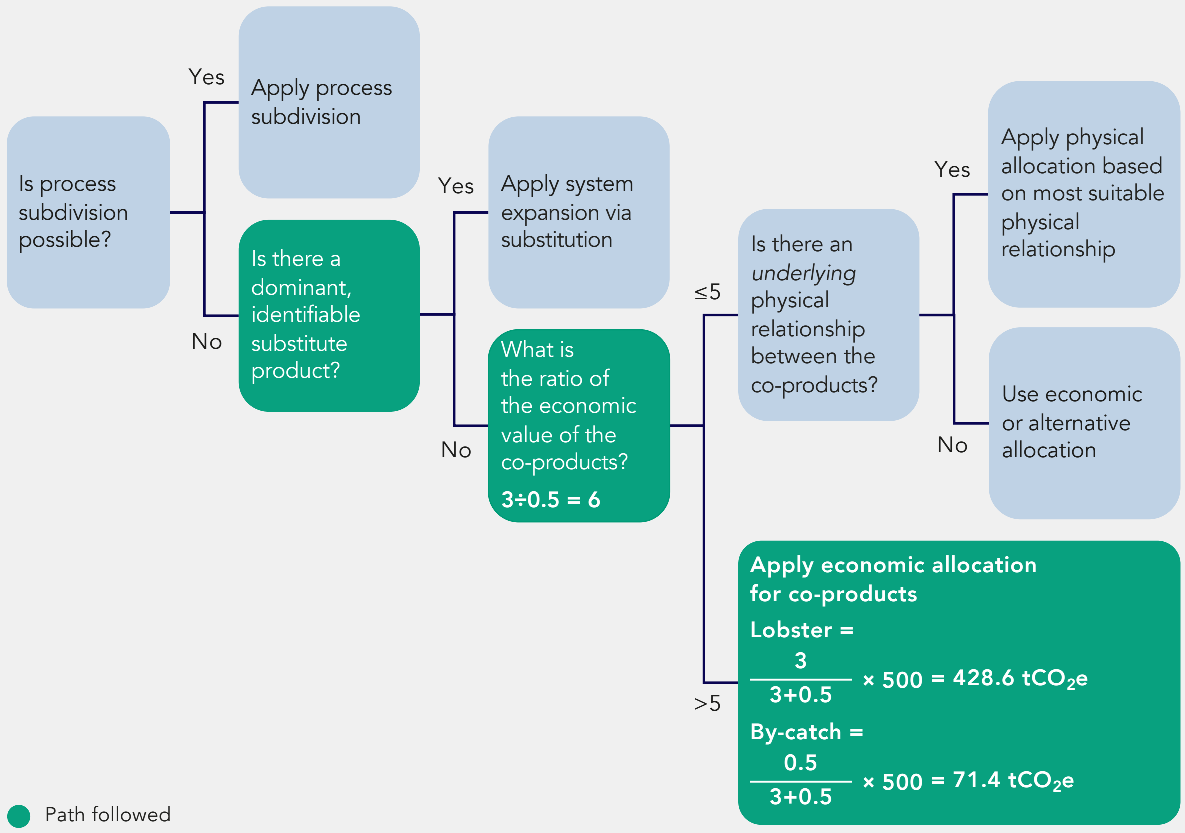


29. Please note that 5 is an arbitrary number agreed on with other PCF calculation initiatives that is intended to reflect a significant divergence in the value of the different co-products.

When the calculated economic value ratio is higher than five, companies shall directly apply an economic allocation between the studied product and the co-product(s). That is, allocating the inputs and emissions to the product and co-product(s) based on the economic value and the amount of each that is produced when they exit the common process (see Step 2 for more detailed guidance on how to calculate the economic value) (see example in Figure 11).

Figure 11: Example of economic allocation

Case study: *A lobster fishing company has caught significant amounts of fish (by-catch) alongside lobsters during the studied year. When seeking to allocate 500 tCO_2e emissions associated to the yearly activity, they account for 10 t of by-catch and 2 t of lobster (our studied product). A lobsters' economic value is \$3, compared to \$0.5 for the by-catch.*



Allocation with more than two co-products

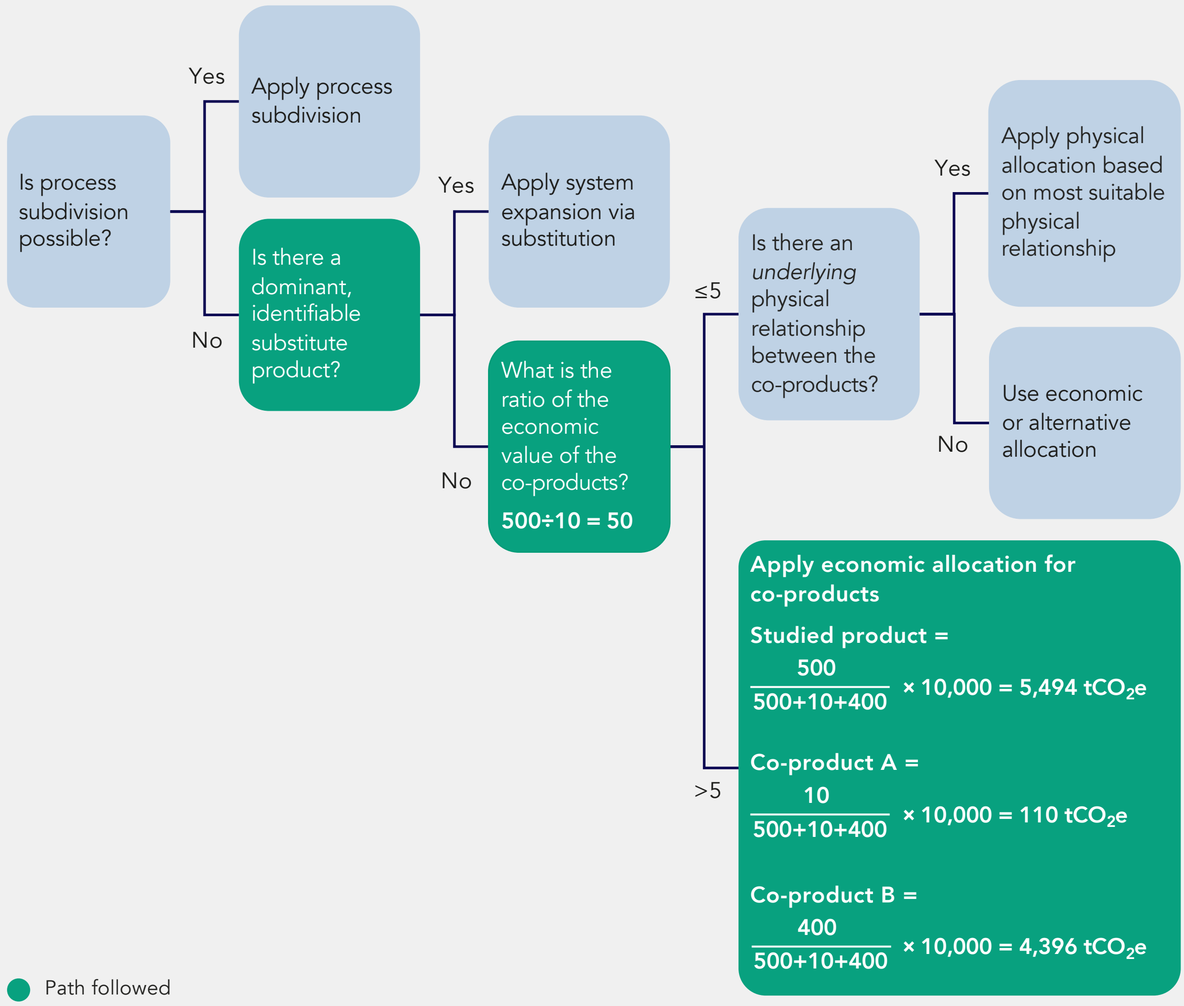
In the case of more than one co-product, the economic value ratio shall be calculated based on the ratio between the highest-valued and the lowest-valued co-product, regardless of whether that includes the studied product. This approach aims to ensure consistency in the allocation followed regardless of which product becomes the studied product.

Similar to above, if the difference between the highest and lowest valued co-products is lower than five, emissions shall be allocated following physical allocation if possible, and economic or alternative allocations if physical allocation (e.g., mass, volume, energy content) is not possible. See Figure 12 for a more visual representation of this process.

Regardless of which allocation methods are used to avoid or perform allocation, companies should disclose and justify these, including why the methods and factors most accurately reflect the studied product's or co-product's contribution to the common process' total emissions.

Figure 12: Example of allocation with more than one co-product

Case study: *A mining company extracts and sells three products from a single mine. Process subdivision is not possible, and no PCRs are available. The studied product's economic value is $500 M and has a mass of 1.5 t, and has two co-products with values of $10 M and 30 t (co-product A), and $400 M and 0.5 t (co-product B) respectively. There are 10,000 tCO_2e to be allocated.*



3.3.2 Additional guidance

3.3.2.1 Transportation and distribution emissions

Transportation and storage of products can take place either internally or externally, with respect to the company calculating the PCF:

- Internally and as part of direct activities in vehicles and sites owned by the company undergoing the assessment, e.g., the transportation of intermediate or final products between different sections within the factory or agricultural mobile emissions such as tractors.
- Externally between different tiers in the supply chain in vehicles or facilities owned by third-party companies, e.g., the transportation of raw materials to the company site (upstream) or transportation of the final product to customers/consumers (downstream).

All significant upstream and direct transportation emissions within the cradle-to-gate boundary—i.e., transportation and storage emissions related to a company's direct activities and distribution activities—shall be accounted for. For all these activities, emissions pertaining to the fuel life cycle (well-to-wheel emissions) and the energy consumed by storage facilities shall be included (Figure 13).[30]

Figure 13: Transportation emissions accounted for within the transportation boundary of the PACT Methodology

Storage

Emissions related to the energy consumed by the storage facilities

Fuel life cycle emissions (well-to-wheel)

Emissions related to:

- Well-to-tank: upstream fuel production and transportation
- Tank-to-wheel: fuel combustion

Vehicle construction

Emissions related to construction of vehicle transportation equipment

Infrastructure construction and maintenance

Emissions related to maintenance of infrastructure for transportation services (e.g., road or port infrastructure)

Included in PACT Methodolgy boundary

Not included in PACT Methodolgy boundary

Please note that GHG emissions associated with outbound transportation and storage (i.e., outbound logistics) are not included in the PCF. However, they should be calculated and reported separately up to the point where another company (e.g., customer) takes over responsibility for the product (i.e., owns or pays for the outbound logistics). To this end, the following data and information should be collected and used:

- Fuel usage
- Mode of transportation, such as road or rail
- Mass of transported product in tonnes (expressed per unit of analysis)
- Distance covered
- Load specifications (if available)
- Energy consumed by storage facility
- Area contracted to store reference product (in case of third-party storage).

A. Accounting for storage emissions

If material (i.e., above the exemption rules as defined in Section 3.3.1.2) and under the responsibility of the company (i.e., owns or pays for it), calculation of storage emissions are calculated by multiplying the percentage of the total area covered by the reference product by the total energy consumption of the storage facility. This product is then multiplied by the emission factors associated with the various energy sources used on site (see the formula below).

$$\text{GHG emissions}_{\text{storage}} = \frac{\text{Area}_{\text{product}}}{\text{Area}_{\text{storage site}}} \times \text{Energy consumption}_{\text{site}} \times \text{Emission factor}_{\text{energy type}}$$

30. Please note that aircraft GHG emissions under certain circumstances in high altitudes have additional climate impacts because of physical and chemical reactions with the atmosphere. For more information on GHG emissions from aircraft, see the IPCC Guidelines for National Greenhouse Gas Inventories and the IPCC Special Report on Aviation. Radiative forcing should not be included in the PCF as per ISO 14067:2018.

Should no information be available regarding the total energy usage of the facilities, companies may use industry benchmarks based on the site's total floor area.

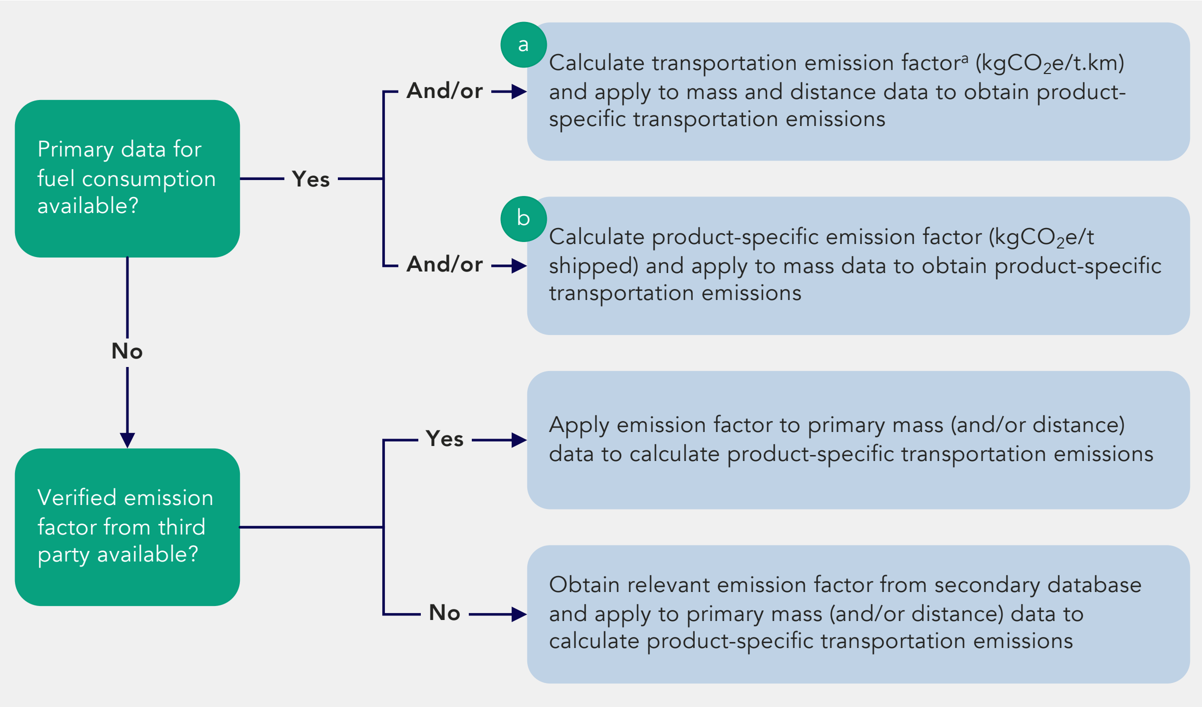
B. Accounting for transportation emissions

Calculation of product transportation emissions depends on the availability of data on fuel consumption, mass, distance, and load factor (Figure 14).

The prevalent unit of measure used for the calculation and the exchange of logistics emissions is t.km, reflecting the mass of the shipment (in tonnes) and distance transported (in kilometers).

For further guidance, please refer to the Global Logistics Emissions Council (GLEC) Framework version 3[31], ISO 14083 and GHG Protocol standards.

Figure 14: Steps for calculating product transportation emissions based on data availability



a. Emission factors are always per transportation mode and type.

3.3.2.2 Waste treatment and recycling emissions within the cradle-to-gate boundary

In alignment with the GHG Product Standard and the International EPD System, responsibility for waste processing is placed on the company that generates the waste during the production phase until the waste is returned to nature (e.g., incinerated, landfilled) or has reached its end-of-waste state,[32] e.g., is used in another product's life cycle (i.e., recycled).

For each product that generates waste within the cradle-to-gate boundary (e.g., production waste, packaging waste), companies need to determine whether such waste will be recycled or discarded as waste. If it is discarded, any emissions arising from the treatment of waste during the production process shall be included in the total PCF.

Since the PACT Methodology's boundary does not include the end-of-life stage (see Section 3.2.3), the cut-off approach, also known as the "recycled content" method from the

31. Smart Feight Centre. (2024). Global logistics Emission Council Framework (GLEC) v3.1
32. See EPD International for detailed criteria on when the end-of-waste state is achieved.

GHG Product Standard[33] should be used for the allocation of emissions associated with used recycled materials or materials to be recycled. The cut-off approach stipulates that companies using recycled material as an input in their production shall account for the emissions from the recycling stage as well as any collection, sorting and pre-processing (e.g., shredding), and not for initial production emissions (Figure 15). The cut-off approach should also be used when calculating waste treatment with energy recovery (i.e., the emissions from the energy recovery process are allocated to the recovered energy user). Companies following a different approach shall communicate this when exchanging the data to ensure all waste- related emissions are calculated and allocated among the different value chain players. Companies should report the recycled carbon content in the product.

The cut-off approach is preferable as it is applicable to most use cases, including complex supply chains or where the product system includes many recycled material inputs and outputs.[34] Additionally, it is recommended for Scope 3 inventories due to its ease of implementation and consistency with inventory calculation methods and secondary emission factors.[35] Finally, the approach also prevents emissions from being double counted if a company both purchases and sells recycled products.

Regardless of the approach followed, avoided emissions shall not be included in the final PCF.

Emissions from the treatment of waste generated during production shall be allocated to the studied product or co-products following the hierarchy stipulated in Section 3.3.1.4. No production emissions are allocated to the actual waste generated during production.

The applicable approach to calculating emissions depends on where the waste is treated.

A. Waste treated by the company that generates it

Emissions shall be calculated using primary activity data regarding the type of waste, its composition, and type of waste treatment activity. Depending on the type of waste treatment (e.g., incineration, landfill), companies may use waste treatment emission factors calculated based on internal primary data. Internal emission factors should be verified by an independent auditor prior to being used. If no primary emission factors are available, emission factors derived from accepted secondary sources can be employed (Section 4.1.3.2).

B. Generated waste sent to a third party for waste treatment

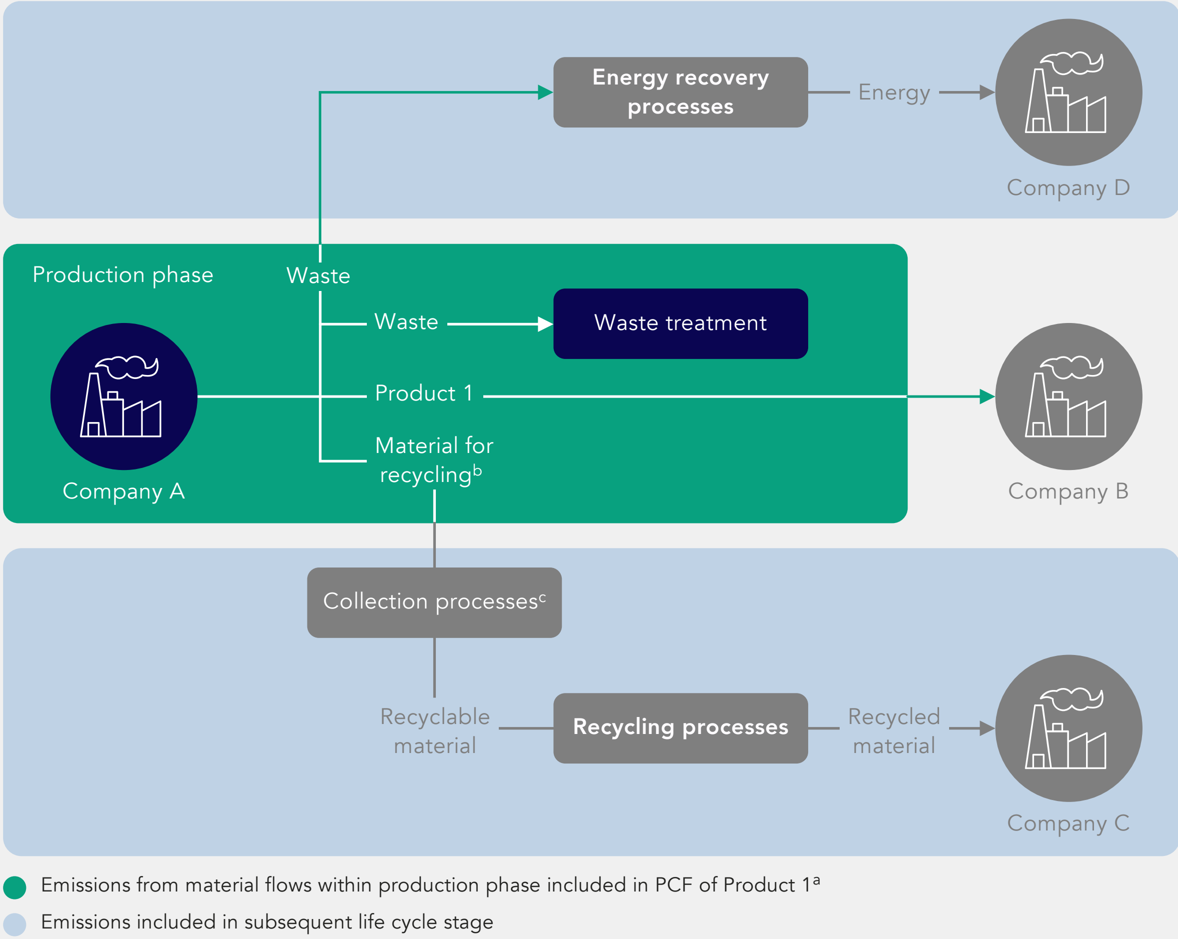
Waste treatment facilities should calculate their waste treatment emissions (Scope 1 and 2), develop emission factors, and verify and communicate these to either the company that generated the waste in instances where the waste is not recycled or the company making use of the recycled material in instances where it is. This approach is consistent with the cut-off approach detailed above.

Alternatively, the waste treatment facility may exchange primary data via the supplier-specific method.[36] This involves collecting certified emissions data from waste treatment companies and allocating the corresponding emissions to the products in question (if required) using the same allocation decision tree used to allocate direct emissions across the products (Section 3.3.1.4).

If companies do not have access to primary data from waste treatment facilities, they shall estimate waste treatment emissions using primary activity data on the waste type and composition and secondary emission factors according to the type of waste treatment and disposal (landfill, incineration, or recycling). The criteria used to determine valid secondary emission factors in Section 4.1.3.2 shall be referred to in this context.

33. This method is also known as the 100-0 method.
34. GHG Protocol. (2013). Technical Guidance for Calculating Scope 3 Emissions
35. GHG Protocol. (2013). Technical Guidance for Calculating Scope 3 Emissions
36. GHG Protocol. (2013). Technical Guidance for Calculating Scope 3 Emissions

Figure 15: Allocation of waste treatment and recycling emissions



a. Waste and recyclable material streams are not burdened by production impacts (exit burden-free). Direct emissions should be only allocated to main products and by-products (Product 1).

b. Material that would otherwise have been considered waste.

c. Can include collection, sorting and preprocessing.

C. Recycling of bio-based products

Companies can use recycled bio-based materials or divert bio-based waste to a recycling process. Special considerations apply to these materials regarding the calculation of biogenic CO_2 uptake—the absorption of atmospheric CO_2 into the product (see Section 3.3.2.4). Recycled bio-based materials shall use the cut-off approach (see Section 3.3.2), except for the treatment of biogenic CO_2 (biogenic carbon content of the product).

To ensure consistent accounting of biogenic CO_2 uptake and release throughout both the initial and subsequent life cycles, companies should:

- Consider the biogenic CO_2 uptake in product as released when bio-based products leave the system boundary as post-consumer waste for recycling. This shall be calculated and reported based on the biogenic carbon content of the recycled bio-based product (see Section 3.3.2.4 for further guidance).
- Account for the biogenic CO_2 uptake when using recycled bio-based products. This shall be calculated and reported based on the biogenic carbon content of the recycled bio-based product (see Section 3.3.2.4 for further guidance).

With that, the biogenic carbon will be balanced within each product life cycle and double-counting of biogenic CO_2 uptake amongst multiple life cycles is avoided.

Given that the PACT Methodology excludes the end-of-life stage from its system boundary (see Section 3.2.3), this approach applies specifically to companies using recycled bio-based content in the product under assessment and considering the amount of biogenic CO_2 uptake in products (PCF – including biogenic CO_2 uptake).

Companies shall report the biogenic carbon content and total carbon content in the product, to enable the users of the PCF data to account for emissions at ultimate disposal of the product.

For any pre-consumer bio-based waste within the cradle-to-gate boundary (e.g., production waste, packaging waste), the biogenic CO_2 uptake or release shall not be measured and assumed neutral over its life cycles.[37]

3.3.2.3 Electricity & contractual instruments

In calculating emissions from electricity, heating, and cooling, PACT aligns with the GHG Protocol Scope 2 Guidance and GHG Protocol Scope 3 – category 3: fuel-and energy-related activities. The scope of these calculations shall therefore include all GHG emissions from the life cycle of the electricity supply system, including upstream emissions (e.g., extracting of energy sources or well-to-tank, transmission & distribution (T&D losses)), emissions for the generation of electricity (e.g., combustion of fossil fuels), and downstream emissions (e.g., treatment of waste from power plants).

When calculating emissions from electricity, companies shall use the market-based method (GHG Protocol Scope 2 Guidance)[38]. The market-based method derives emission factors from contractual instruments, which include any type of contract between two parties for the sale and purchase of energy, bundled with attributes detailing the energy generation, or including unbundled attribute claims.[39] Markets differ as to what contractual instruments are commonly available or used by companies when purchasing energy. These instruments can include energy attribute certificates (Renewable Energy Certificates (RECs), Guarantees of Origin (GOs), etc.), direct contracts (for both low-carbon, renewable, or fossil fuel generation), or supplier-specific emission rates. Other instruments may use other default emission factors representing the untracked or unclaimed energy and emissions if a company does not have other contractual information that meets the Quality Criteria outlined in Box 7 (termed the "residual mix"). Regardless of the instrument used, companies should procure contractual instruments that result in additional renewable energy production, thereby directly contributing to grid decarbonization.

Selecting emission factors for electricity

The selection of emission factors depends on the energy distribution scenario and treatment of energy attribute certificates (described in Table 6). If companies have access to multiple market-based emission factors for each energy-consuming operation, they should use the most precise for each operation based on the market-based hierarchy list in GHG Protocol Scope 2, Table 6.3.

Companies using the market-based method shall ensure that any contractual instrument from which an emission factor is derived meets the Scope 2 Quality Criteria (described in Box 7). Where contractual instruments do not meet the Scope 2 Quality Criteria requirements, and no other market-based method data are available, the national, sub-national or regional grid-average emission factors shall be used, prioritizing the most granular emission factor data where available (i.e., prioritizing national over regional emission factors).

Companies using electricity from more than one electricity source shall calculate a weighted average based on the proportion of kWh consumed from each source for the product. Similarly, if a contractual agreement only covers part of the consumed electricity, the emission factor from the residual grid mix shall be used for the uncovered amount.

37. Companies shall calculate the biogenic CO_2 uptake by measuring the biogenic carbon content in their final product. This means companies shall not measure CO_2 uptake into other biomass, production aids or waste.
38. Companies may use location-based methods in markets where no contractual instruments are present.
39. Bundled energy instruments are traded with the underlying energy produced and unbundled instruments may be traded separately from the underlying energy produced.

Table 6: Selection of emissions factors from electricity

	Primary	Secondary
Internally generated electricity (e.g., company owns solar panels)	Emissions calculated based on energy generated and consumed	If renewable energy certificates are sold to 3rd party but energy is consumed, refer to market-based hierarchy (GHG Protocol Scope 2 Guidance Table 6.3) to calculate emissions
Direct-line (e.g., company receives power directly from generator)	Use specific emissions source, supplier-specific emission factor or supplier-specific electricity mix from contractual instruments	If renewable energy certificates of the energy that was purchased are sold to a 3rd party, then please calculate emissions following the market-based hierarchy listed in GHG Protocol Scope 2 Guidance Table 6.3
Grid-distributed	Use of supplier-specific emission factor or supplier-specific electricity mix from contractual instruments	Use of residual mix, sub-national or national grid-mix. For more information, please refer to market-based hierarchy (GHG Protocol Scope 2 Guidance Table 6.3)

Box 7: Contractual instruments Quality Criteria (GHG Protocol Scope 2 Guidance)

All contractual instruments shall:

1. Convey the direct GHG emission rate attribute associated with the unit of electricity produced
2. Be the only instruments that carry the GHG emission rate attribute claim associated with that quantity of electricity generation
3. Be tracked and redeemed, retired, or canceled by or on behalf of the reporting entity.
4. Be issued and redeemed as close as possible to the period of energy consumption to which the instrument is applied
5. Be sourced from the same market in which the reporting entity's electricity-consuming operations are located and to which the instrument is applied

In addition, utility-specific emission factors shall:

6. Be calculated based on delivered electricity, incorporating certificates sourced and retired on behalf of its customers. Electricity from renewable facilities for which the attributes have been sold off (via contracts or certificates) shall be characterized as having the GHG attributes of the residual mix in the utility or supplier-specific emission factor

In addition, companies purchasing electricity directly from generators or consuming on-site generation shall:

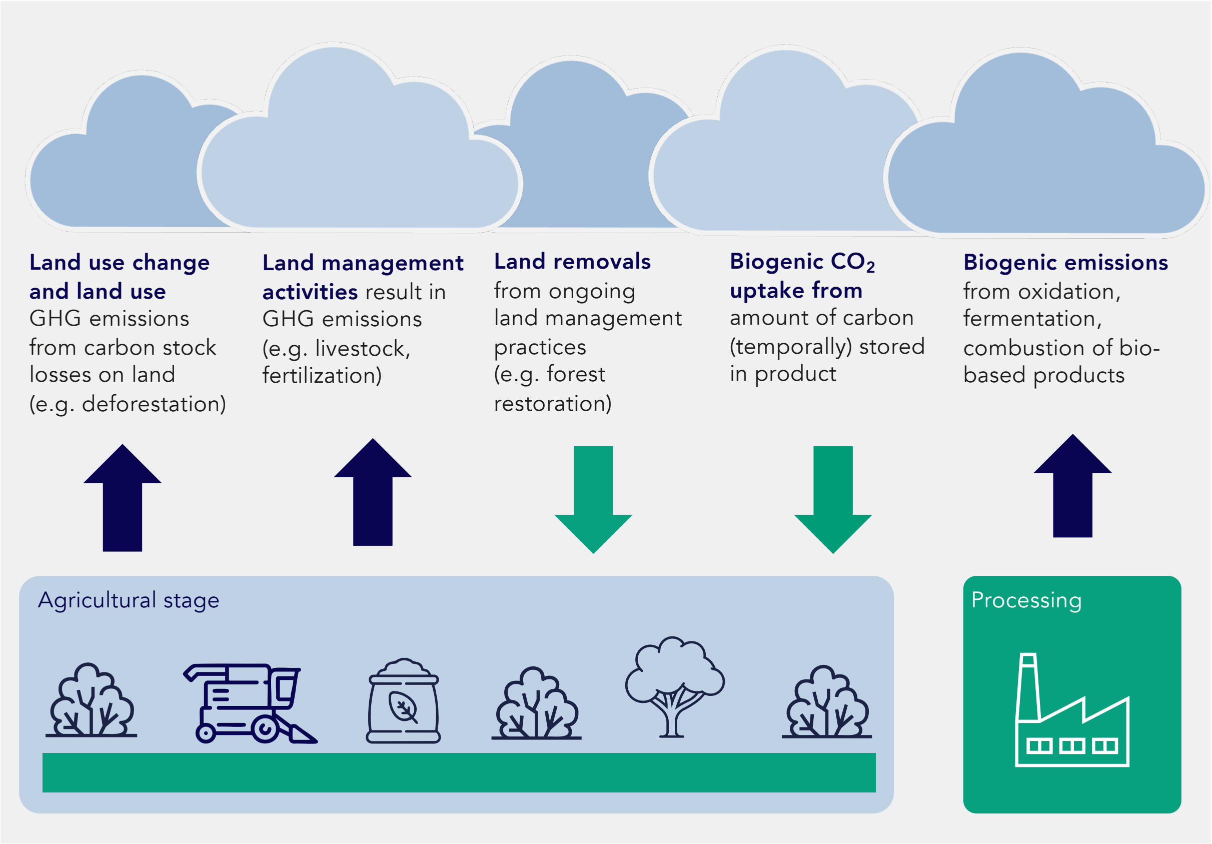
7. Ensure all contractual instruments conveying emissions claims be transferred to the reporting entity only. No other instruments that convey this claim to another end user shall be issued for the contracted electricity. The electricity from the facility shall not carry the GHG emission rate claim for use by a utility, for example, for the purpose of delivery and use claims

3.3.2.4 Biogenic and land sector related emissions and removals

This section provides guidance and requirements on how to calculate and report biogenic and land sector related emissions and removals associated with land-based products. On one hand, the land sector (including agriculture, forestry and other land use), is responsible for approximately 22% of global annual net anthropogenic GHG emissions[40] On the other hand, the sector also has great potential to reduce emissions and remove carbon from the atmosphere.[41] It is therefore critical to ensure accurate and transparent emissions accounting from agricultural activities. This section represents an updated approach for calculating and exchanging biogenic and land sector related emissions and removals, building on the GHG Protocol Land Sector & Removals Standard v.1.0 (GHGP LSRS).

Biogenic and land sector related emissions include different types of emissions and removals as shown in Figure 16. These include GHG emissions from land use and land use change, GHG emissions from land management practices such as enteric fermentation, manure and fertilizer management, as well as GHG emissions resulting from combustion, biodegradation or fermentation of biogenic products. Besides emissions, the land sector also includes net CO_2 removals resulting from net increases to carbon stored in land-carbon pools. Finally, the temporary biogenic CO_2 uptake in the final product resulting from photosynthesis during biomass growth is also included.

Figure 16: Emissions and removals covered in biogenic and land emissions & removals section



40. IPCC. 2023. Climate Change 2023: Synthesis Report (Summary for Policymakers).
41. IPCC WG III report

This section applies to all products reliant on land sector activities within their value-chain. Biogenic and land sector related emissions and removals may be excluded if the product's total mass contains less than 5% biogenic carbon or when these emissions are below the exemption rules detailed in Section 3.3.1.2.[42]

Calculating biogenic and land sector related emissions & removals

Biogenic and land sector related emissions and removals can be divided into six categories (Table 7), each consisting of various sub-categories that companies shall report on, when applicable.

Table 7: Overview of calculation categories in biogenic and land sector related emissions and removals

Category	Sub-category	Unit	Shall/ Should/ May	Part of PCF	Short description	Examples
A. Land use and land use change emissions	LUC emissions	$kgCO_2e$	Shall	Yes	GHG emissions due to change in land use type	GHG and biogenic CO_2 emissions due to conversion of forest to cropland (deforestation)
	Land management CO_2 emissions	$kgCO_2e$	Shall-2027	Yes	Biogenic CO_2 emissions due to recurring management actions on land in the same land use category	Biogenic CO_2 emissions from carbon stock losses due to management practices such as fertilization, pest control and fire
B. Biogenic non-CO_2 emissions	Biogenic non-CO_2 emissions	$kgCO_2e$	Shall	Yes	CH_4 emissions from land management practices and the oxidation and transformation or degradation of biomass	Livestock CH_4 emissions, manure, CH_4 emissions, CH_4 emissions from rice cultivation
C. Fossil emissions	Fossil emissions – total	$kgCO_2e$	Shall	Yes	Fossil emissions resulting from stationary/mobile combustion, industrial processes and fugitive emissions. Includes land management and all other industrial emissions	CO_2 from combustion of fossil fuels from industrial processes
	Fossil emissions – land management	$kgCO_2e$	Shall-2027	Yes	Separately reported Fossil CO_2 and N_2O emissions due to land management practices. These values are also reported in Fossil emissions – total	CO_2 and N_2O emissions from fertilization and liming
D. Land removals	Land management CO_2 removals	$kgCO_2e$	May	Yes	CO_2 removals from a net increase in carbon stored in land-based carbon pools. Subject to reporting requirements	Soil carbon sequestration, reforestation, afforestation
E. Biogenic product CO_2 uptake	Biogenic product CO_2 uptake	$kgCO_2e$	Shall	Yes/ No*	Net biogenic CO_2 uptake of biomass in the product	Biogenic CO_2 uptake from photosynthesis in wood product
	Biogenic carbon content	kgC	Shall	No	The amount of biogenic carbon contained within the product	Amount of biogenic carbon in bio-plastic
F. Land tracking	Land occupation	M^2.yr	Should	No	Amount of agricultural land occupied in a land use category	Amount of cropland occupied by wheat

* Biogenic product CO_2 uptake is excluded in PCF excluding biogenic CO_2 uptake and included in PCF including biogenic CO_2 uptake

42. Note the following exceptions: 1) Materials that are entirely fossil-based (such as metals and minerals like coal, copper, or aluminium), as well as infrastructure or facility development, can have substantial impacts on land use. Companies working in these sectors may exceed the exemption threshold and shall therefore calculate biogenic and land sector-related emissions. 2) Biofuels used in processing may carry significant biogenic and land sector-related emissions and removals that may require calculation of these emissions.

A variety of methods and data sources can be used to quantify biogenic and land sector related emissions and removals. Companies should seek to improve value-chain traceability and accuracy by increasing the primary data share over time (Section 4.2.2). In cases where primary data is not available, secondary data may be used to estimate biogenic and land sector related emissions and removals. In Appendix D, PACT provides a mapping of biogenic and land sector related emissions and removals to support the use of secondary datasets.

Companies may use farm-level calculation tools to aid in calculations. Examples of publicly available, product-level calculation tools can be found in Table 8. Information on the use of such farm-level calculation tools shall be included in the comment section when exchanging the PCF.

Agricultural production systems (e.g., farms, crops, crop rotations, animals) often produce multiple outputs (e.g., sugarcane produces sugar and sugar bagasse). Allocation is necessary to allocate the emissions of a joint system between various outputs. Section 3.3.1.4 on allocation provides guidance on how to allocate emissions amongst crops, crop rotations, cover crops and animals. Further details can be found in product-specific rules (if present for the product) or in sector-specific rules such as the upcoming GHGP LSRS.

Table 8: Examples of publicly available farm-level calculation tools[43]

Database	Geographic coverage	Sector	Link
Cool Farm tool	Global	Agriculture	Cool Farm Tool
Ex-Ante Carbon-Balance tool (EX-ACT)	Global	All sectors	FAO – EX-ACT
Farm Carbon Calculator	United Kingdom	Agriculture	Farm Carbon Calculator
GWPbio Tool	Global	Forestry	WWF

Box 8: GHG Protocol Land Sector and Removals Standard

This section of the PACT Methodology allows for reporting in line with the upcoming GHG Protocol Land Sector and Removals Standard v1.0 (GHGP LSRS), which will offer the latest standard to accurately and transparently calculate and report biogenic and land emissions and removals across the value chain. The GHG Protocol LSRS focuses on corporate-level accounting with a cradle-to-grave perspective, whereas PACT focuses on product-level cradle-to-gate accounting. Appendix C presents an overview of how companies can use PACT to report in alignment with the GHGP LSRS reporting.

The GHG Protocol Land Sector and Removals Standard will offer a dedicated calculation guidance to support companies on data collection and calculation, including an overview of databases and tools. This standard will initially apply to agricultural lands only and will be updated with forest carbon accounting guidance. PACT will update the calculation guidance for forest accordingly.

Please find these resources on the GHG Protocol website.

43. This Table presents a non-exhaustive list of farm-level calculation tools companies may find helpful when calculating biogenic and land sector related emissions and removals. Note however that PACT neither endorses these tools nor has validated the tools align with the PACT Methodology.

A. Category A: Land use and land use change emissions

Land use and land use change emissions address a loss of carbon stock on land caused by conversion and degradation of landscapes due to human activities and ongoing land management practices. The category consists of two sub-categories: Land Use Change (LUC) and Land Management CO_2 emissions.

LUC emissions shall be calculated and reported, while Land Management CO_2 emissions shall be calculated and reported from 2027 onwards[44], following the release of the GHGP LSRS v1. Removals due to LUC (e.g., reforestation or afforestation) are accounted for and reported separately under Category D: Land Removals (Table 7).

Land Use Change (LUC)

Emissions from LUC constitute a release of GHG emissions due to a change in land use from one land use category or subcategory to another (Figure 17), such as primary forest to agricultural land, or peat land (type of wetland) to cropland.

Companies shall account for CO_2, CH_4 and N_2O emissions caused by LUC and account for LUC CO_2 emissions based on the total land carbon stock decrease across all land carbon pools (i.e., above-ground and below-ground biomass, dead organic matter and soil carbon pools). Companies shall account for LUC that took place in the last 20 years, or longer if the cultivation cycle or rotation period is over 20 years. These emissions are allocated to all products grown on the land during the 20-year timeframe, not only in the year when the conversion took place. Data collection for LUC depends on the level of traceability. Companies shall select the most accurate calculation approach based on data availability and the level of value chain traceability, as explained below:

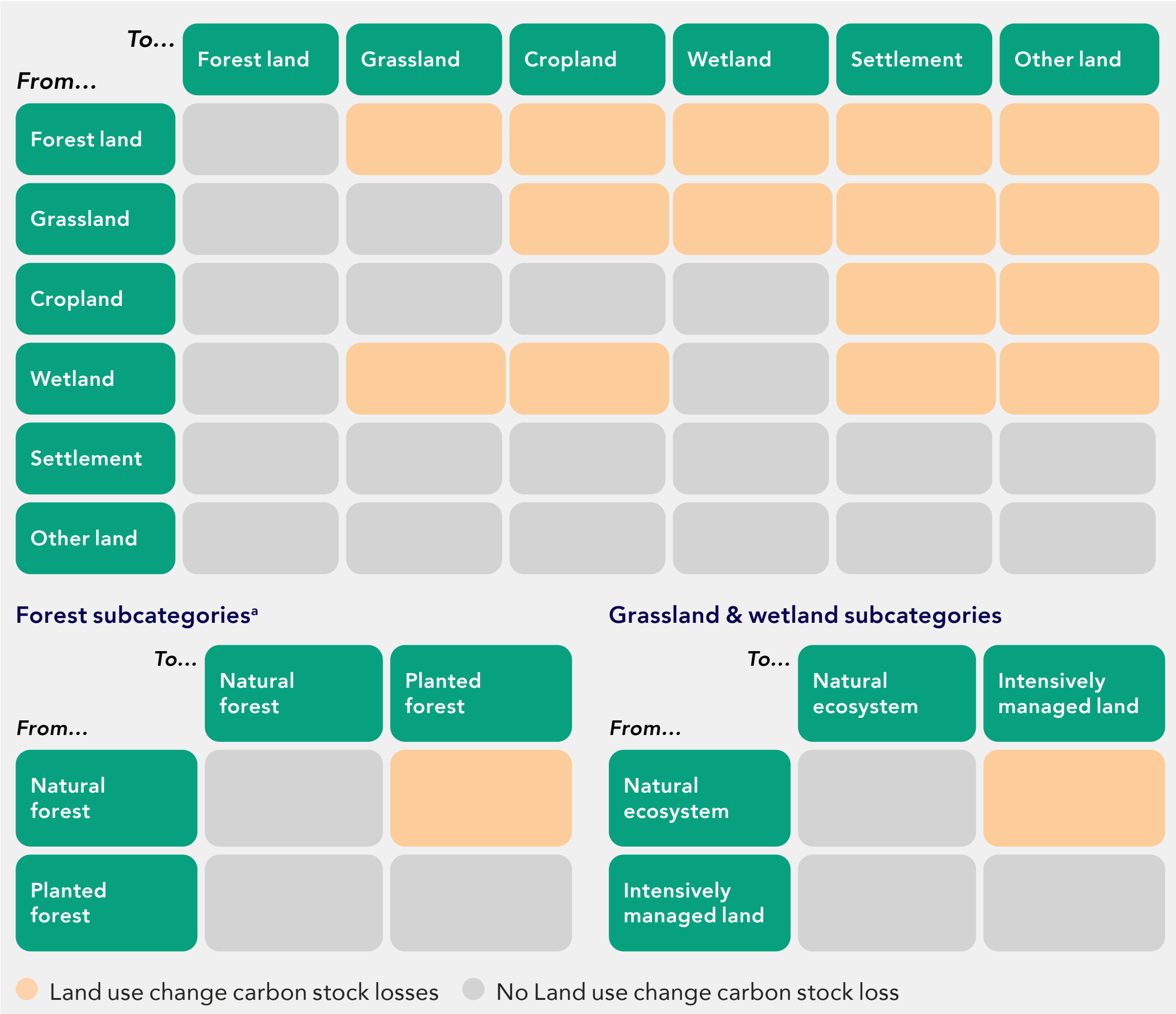
- **Full traceability of harvest areas:** Companies that own or directly control land should calculate direct LUC (dLUC) emissions based on carbon stock losses and GHG emissions from observed land use changes within the harvested areas. This can be based on remote sensing techniques, data on historic land use for the given area, physical measurement, or research on the area.
- **Traceability of sourcing region or jurisdiction:** Companies should use the "jurisdictional" dLUC approach when they have traceability to the sourcing region (the first point of aggregation or first processing facility) or jurisdiction, and relevant spatial data for the jurisdiction is available for at least the first and the last sourcing year of the assessment period. If that data is not available, companies should account for LUC using statistical land-use change (sLUC) emissions. sLUC is calculated by taking the total LUC emissions in the area and allocating these to the product based on relative crop expansion in the sourcing region. National data on crop production expansion can be found in databases such as FAOSTAT. Alternatively, the GHG Protocol website provides a non-exhaustive list of tools to calculate LUC.
- **Limited traceability:** Companies with limited to no traceability should use country-specific sLUC emission factor databases based on the country, product and sourcing year. PAS 2050:2011 Annex C lists default values per land use type for selected countries. If the country is not known, companies should estimate the most likely location or apply global sLUC emission factors by product and year. Such default values are published by IPCC and represent carbon stock change impacts as well as land management CO_2 emissions impacts.

If it can be demonstrated that no LUC occurred within the last 20 years (i.e., there has been no crop expansion), no emissions from LUC shall be included and it shall be specified that no LUC occurred.

LUC data obtained from secondary datasets might contain LUC removals. However, these removals do not meet the requirements for reporting land management CO_2 removals (See Category D: Land management removals) and cannot be used for reporting to the GHGP LSRS. This is especially relevant for perennial crops or forest products. PACT recommends using primary data to calculate LUC emissions instead.[45]

44. While companies should calculate and report this information, it is only required by end of 2027 (i.e., 31.12.2027)
45. PACT will investigate creating a PACT LCIA methodology that is able to ensure consistent and accurate reporting on LUC emissions.

Figure 17: Categories and Subcategories Land use Change (GHGP LSRS)[46]



* Planted forest is synonymous with 'tree plantation' (Source: Accountability Framework. n.d. definitions)

Land management CO_2 emissions

Besides GHG emissions from Land Use Change, carbon stock losses can occur within the same land use category or subcategory due to agricultural practices such as tillage, field preparations, pruning and harvest. Land Management CO_2 emissions measures biogenic CO_2 emissions from a net loss in carbon stock within one land use category or subcategory. This includes impact on the land-carbon pools, including above- and below-ground biomass, dead organic matter, and soil carbon pools. If the carbon stock increases within the same land use category and the conditions to report removals are met, this may be calculated as a Land management CO_2 removal.

Land management CO_2 emissions is a new category in PACT and shall become mandatory for reporting from 2027[47], following the release of GHGP LSRS v1. This will give companies time to adapt to this new category and leverage the GHG Protocol calculation guidance.[48]

46. IPCC. 2006. Guidelines for National Greenhouse Gas inventories Volume 4 – Agriculture, Forestry and Other Land use, Chapter 3
47. While companies should calculate and report this information, it is only required by end of 2027 (i.e., 31.12.2027). This timeline may be revised based on the release date of the GHGP LSRS.
48. It should be noted that reporting of land management CO_2 emissions is necessary for a complete biogenic and land sector related emissions inventory. It is therefore highly recommended that companies begin to calculate land management CO_2 removals upon release of this methodology.

Land management CO_2 emissions are calculated using a stock-change accounting method that measures the carbon stock changes per year, crop rotation or crop cultivation cycle. When estimating net land carbon stock change, companies shall, at a minimum, include changes in the following carbon pools:

- **Biomass carbon stock changes**, including above- and below-ground biomass on:
  - all forest lands, and
  - grasslands, croplands, wetlands and/or settlements with woody or permanent cover.
- **Dead organic matter carbon stock changes**, including dead wood and litter on:
  - forest lands, grasslands and croplands where management practices significantly impact woody residues.
- **Soil carbon stock changes**, including soil organic carbon in mineral and organic soils on:
  - all grasslands, croplands, forest lands, wetlands, and settlements where management practices significantly disturb soils.

Companies may use several approaches to calculating Land Management CO_2 emissions, including activity-, remote sensing-, model- and measurement-based approaches. The use of farm-level calculation tools can aid in these calculations (Table 8).

Companies can assume no land management CO_2 emissions if management practices (e.g., field preparations, harvest, pruning, replanting, pest control and fire) have minimal impacts on biomass carbon stocks, dead organic matter carbon stocks and soil carbon stock change.

B. Category B: Biogenic non-CO_2 emissions

Biogenic non-CO_2 emissions are CH_4 emissions resulting from agricultural activities, land management actions and the oxidation, transformation and degradation of biomass. Besides biogenic non-CO_2 emissions, biogenic CO_2 emissions are considered within the scope of 'Category E: Biogenic product CO_2 uptake'

Biogenic non-CO_2 emissions include the following emissions:

- CH_4 emissions from livestock, including emissions due to enteric fermentation, manure managed in controlled settings, and manure deposited by livestock on pasture, paddock, and range
- CH_4 emissions from biomass burning and fires
- CH_4 emissions from rice production
- CH_4 emissions from transformation and degradation (e.g., combustion, digestion, composting, landfilling)

Companies shall report biogenic non-CO_2 emissions. Please note this category only covers CH_4 emissions. Fossil CO_2 emissions shall be calculated and reported in 'Category C: Fossil Emissions – land management'.

C. Category C: Fossil emissions – land management

Besides biogenic emissions, land activities result in emissions from fossil sources (i.e., fossil CH_4, N_2O, fossil CO_2, hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs)). Such activities include:

- N_2O from fertilizer application
- N_2O from livestock
- N_2O and fossil CO_2 emissions from soil management (such as from peat soil) including N_2O emissions due to nitrogen inputs and internal soil processing on managed soils, as well as CO_2 emissions resulting from soil amendments, such as lime, urea and other inputs
- Land management production emissions, including CO_2 emissions from on-site machinery (e.g., tractors, feller-bunchers, irrigation pumps), and emissions from manufacturing of production inputs (e.g., fertilizer, chemical inputs)
- Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) emissions (e.g., from air-conditioning and refrigerant use)
- Emissions from on-site waste or wastewater management
- Indirect emissions from purchased energy associated with land management production activities

This category should be calculated and separately reported as 'fossil emissions – land management', and shall be reported from 2027 onwards.[49] Companies that directly own or control land areas shall calculate these emissions already. Emissions from this category shall always be reported in the overall fossil emissions category together with non-land based fossil emissions (see Section 6.1 for further information on required elements for data exchange).

D. Category D: Removals – Land management CO_2 removals

Land management removals are net CO_2 removals resulting from net increases to carbon stored in land-based carbon pools (biomass, dead organic matter and soil carbon pools) due to ongoing land management practices. This extra net carbon stock is gained over the crop rotation or crop cultivation cycle (e.g., multiple years for perennial crops and multiple years in a rotation that includes annual crops). These type of removals can result from a move from one land use type to a land use type with higher carbon stock (e.g., from cropland to forest land) or a move to a higher carbon stock within the same land use category.

Companies may report land management CO_2 emissions and in doing so shall meet the following conditions:

1. Company reports all cradle-to-gate emissions associated with the studied product
2. Company has physical traceability to the exact location or sourcing region[50]
3. Company uses primary data that is specific to sinks and pools[51]
4. Company ensures no double counting of removals[52]
5. Company meets the permanence principle by ensuring CO_2 removals are monitored and any losses of stored carbon are accounted for and reported
6. Company only calculates land management removals over attributable productive lands that contribute to producing the relevant product

There are two approaches to calculate land management CO_2 removals: direct measurement and calculation models. Direct measurement approaches include direct monitoring of GHG fluxes on land, mass balance or stoichiometry. Calculation models include remote sensing-based calculation approaches, models and activity-based calculation approaches. Companies should prioritize use of higher accuracy methods and collection of primary data for the GHG sources and sinks that are most material across their operations and value chain.

Unless secondary datasets align with these reporting requirements, removals claimed via these datasets shall not be reported as land management CO_2 removals. In line with the principle of conservativeness[53], companies uncertain of whether all conditions listed above are met shall not report removals.

If the ongoing monitoring is lost or the previously reported removals are reversed, the PCF shall become invalid and companies shall recalculate the PCF. The recalculation shall also include the reversals (expressed as land management CO_2 emissions).

49. While companies should calculate and report this information, it is only required by end of 2027 (i.e., 31.12.2027)
50. Traceability to sourcing region means having traceability to the first point of aggregation or first processing facility in the sourcing region.
51. Carbon stock changes are accounted for using empirical data, which is data based on observation or experience from instrumental (usually monitoring equipment) or manual methods (through counts in a survey or census)
52. Companies may use the 'Right to report approach', an approach that provides traceability and prevents double counting of GHG removals with other companies in the same value chain tier
53. PACT aligns with the GHG Protocol accountancy principles of relevance, accuracy, completeness, consistency, transparency, conservativeness and representativeness

E. Category E: Biogenic product CO_2 uptake and biogenic product carbon content

During biomass growth, CO_2 is removed from the atmosphere, stored in biomass carbon pools and, when harvested, transferred into product carbon pools. Products that contain biogenic carbon have the potential to keep carbon out of the atmosphere for the duration of the product's lifetime. Biogenic carbon content is defined as the biomass-derived carbon contained in the product[54], while biogenic carbon CO_2 uptake is the biogenic carbon content[55] of the product converted to CO_2, using the following formula:

Biogenic product CO_2 uptake
kg Biogenic carbon × (44/12)

Companies can measure the biogenic carbon content of their product directly, use secondary datasets or default values. Besides an analysis in a laboratory, biogenic carbon content can be determined based on the lignin, cellulose, carbohydrate, protein, fat fiber and ash content in a product (also known as dry biomass components).[56] These values can be found per crop on USDA National Nutrient Database and Feedipedia. The content of these ingredients in the crop can be converted to carbon using the World Food LCA Database (2020), Table 30. If no information is available, 47.5% biogenic carbon/kg dry matter biomass can be used as a default value.[57]

Companies shall report the biogenic product CO_2 uptake and the biogenic carbon content[58] of their product at point of leaving factory gate. Biogenic product CO_2 uptake of associated production aids and waste shall not be measured.

Two predominant approaches exist for the consideration of biogenic product CO_2 uptake in the PCF, as detailed Section 3.3.1.3. To provide transparency on both approaches, companies shall disclose two PCF metrics, one excluding biogenic CO_2 uptake – known as PCF excluding biogenic CO_2 uptake – and one including it – PCF including biogenic CO_2 uptake[59]. Both these PCFs shall be calculated and exchanged.

Box 9: Considerations of biogenic CO_2 emissions

PACT requires two PCFs: PCF excluding biogenic CO_2 uptake and PCF including biogenic CO_2 uptake (See Section 3.3.1). Both approaches assume biogenic CO_2 emissions are zero over a products lifetime. The upcoming GHGP LSRS v.1.0 will require a complete biogenic and land-related emissions inventory (including land management CO_2 emissions and all other biogenic and land sector related emissions categories). Companies may only exclude biogenic CO_2 emissions from their PCF provided that they have reported on all these categories. In PACT, companies should include all biogenic and land-related emissions (i.e., including land management CO_2 emissions), and doing so will become mandatory following the release of the GHGP LSRS v.1.0.

54. ISO. (2018). ISO 14067 - Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification
55. After applying economic allocation, biogenic CO_2 uptake may not align with the product's physical biogenic carbon content. In such cases, a biogenic CO_2 correction must be applied to ensure consistency with the product's carbon content.
56. Nemecek, T., Bengoa, X., Lansche, J., Roesch, A., Faist-Emmenegger, M., Rossi, V., ... & Riedener, E. (2019). World food LCA database. *Methodological Guidelines for the Life Cycle Inventory of Agricultural Products, 3.*
57. Same reference as above
58. Besides biogenic carbon content, fossil carbon content in product should be reported
59. For Scope 3.1 reporting under the GHG Protocol, companies using PACT shall exclude biogenic CO_2 uptake from cradle-to-gate PCFs before incorporating them. PACT recommends using PCFs that exclude biogenic CO_2 uptake for corporate reporting.

F. Category F: Land occupation

Use of agricultural land can lead to the loss of carbon compared to the native vegetation and soils. The total quantity of agricultural land required by a company is an important contribution to global emissions. Land occupation measures the contribution of the product to global agricultural land use.

Land occupation is calculated by measuring the amount of land needed for a certain time to produce a product (including land needed to grow crops, livestock, forestry products). This requires companies to calculate the occupied land area per year (m^2.yr) reported per land use type (e.g., cropland, grassland).

This is calculated using the formula:

$$\text{Land occupation } (m^2.yr) = \left(\frac{\text{Quantity of product produced or purchased (kg)}}{\text{Yield of product } (kg/m^2) / \text{ time of occupation (yr)}} \right)$$

Data on yields can be accessed from databases such as FAOSTAT or LCA databases. More specific yield information covering regional-, national-, or farm-level can also be used if primary data is unavailable.

3.3.2.5 Technological CO_2 capture, storage and use

Several technologies are being developed to capture, store and use CO_2 (e.g., Carbon Capture and Storage, also known as CCS, or Carbon Capture and Utilization, also known as CCU), and ultimately hold significant potential to drive decarbonization.

CO_2 can be captured from industrial and energy sources, or directly from the air. This guidance refers exclusively to 'point source CCS/CCU' from industrial and energy sources, excluding direct air capture (DAC) technologies.

While several full-scale applications exist, these technologies are still nascent. Therefore, this section only addresses 'point source' CCS and CCU due to their higher technological maturity and market presence. Clear accounting rules can support research and development in calculating climate benefits from these technologies. In the future, additional guidance will be provided to reflect relevant technological developments and meet future market needs.

3.3.2.5.1 Carbon Capture & Storage (CCS)

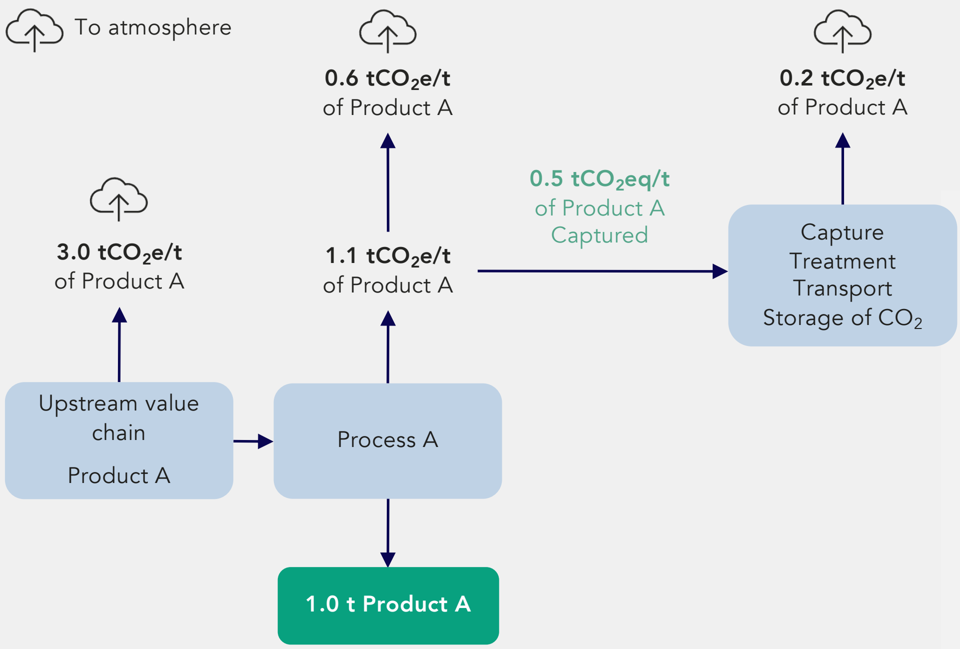
CCS refers to the separation of CO_2 and its injection into a geological formation, resulting in long-term isolation from the atmosphere. "Long-term" means the minimum period necessary to be considered an effective and environmentally safe climate change mitigation option[60]. CCS may be included in the PCF calculation if:

- A permanent and complete storage in storage facilities is guaranteed. The time frame is 100 years for permanent storage[61], but any leakages must be identified, monitored, reported and considered in the PCF calculation of the product
- The CCS technology is active whenever the product is being produced[62]
- Companies shall account for all life cycle GHG emissions associated with the CCS, including emissions from product life cycles associated with the stored CO_2
- Companies shall have traceability from the point of CO_2 capture to the injection site
- Companies shall use data specific to the sink and pools
- Companies shall ensure ongoing storage and monitoring and report any CO_2 losses. In case ongoing monitoring is lost, the PCF containing the removals shall become invalid and require recalculation

The cradle-to-gate PCF including CCS is the sum of upstream GHG emissions, own GHG emissions, and GHG emissions associated to the capture, treatment, transportation and storage of the CO_2 minus the net CO_2 stored (Figure 18).

60. ISO. (2017) ISO 27917 – Carbon dioxide capture, transportation and geological storage & ISO. (2020) ISO Guide 84 Guidelines for addressing climate change in standards
61. ISO. (2018). ISO 14067 - Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification
62. Together for Sustainability. (2024). The Product Carbon Footprint Guideline of the Chemical Industry

Figure 18: CCS example assuming 0.5 tCO_2 storage per tonne of product A



Company A: For 1 tonne of Product A

- Upstream GHGs emissions: 3.0 tCO_2e/t of Product A
- Own GHGs emissions: 1.1 tCO_2e/t of Product A
- GHGs emissions associated with the capture, treatment, transportation, and storage of CO_2: 0.2 tCO_2e/t of Product A
- Net CO_2 stored: 0.5 tCO_2e/t of Product A

Cradle-to-gate $PCF_{Product\ A}$= 3.0 + 1.1 + 0.2 - 0.5 = 3.8 tCO_2e/t of Product A

OR

Cradle-to-gate $PCF_{Product\ A}$= 3.0 + 0.6 + 0.2 = 3.8 tCO_2e/t of Product A

For transparency, companies calculating PCFs including CCS shall report additional information needed to understand how the PCF was calculated, namely:

- The CCS technological CO_2 capture with geologic storage ($kgCO_2$ stored per declared unit)
- The CCS technological CO_2 removals with geologic storage ($kgCO_2$ removed per declared unit)[63]
- CCS traceability data, i.e., information on location injection site, geological reservoir[64].

In the CCS approach described in this section, only fossil and other anthropogenic captured CO_2 emissions shall be taken into account. If biogenic CO_2 is captured and stored (e.g., bioenergy carbon capture and storage (BECCS)), companies shall also account and report for all life cycle emissions related to the attributed land, demonstrating that there are no significant land use change emissions and that the land carbon stocks are stable or increasing.

Note that the GHG Protocol Land Sector & Removals Standard v.1.0 considers technologies that remove CO_2 directly from the atmosphere or biogenic CO_2 capture & storage as 'removals with geologic storage' and these may be reported in Scope 3. It excludes fossil CO_2 capture with geologic storage.

63. As part of the overall 'technological CO_2 removals' data attribute in the Technical Specifications.
64. As part of the overall 'technological CO_2 capture origin' data attribute in the Technical Specifications.

3.3.2.5.2 Carbon Capture & Utilization (CCU)

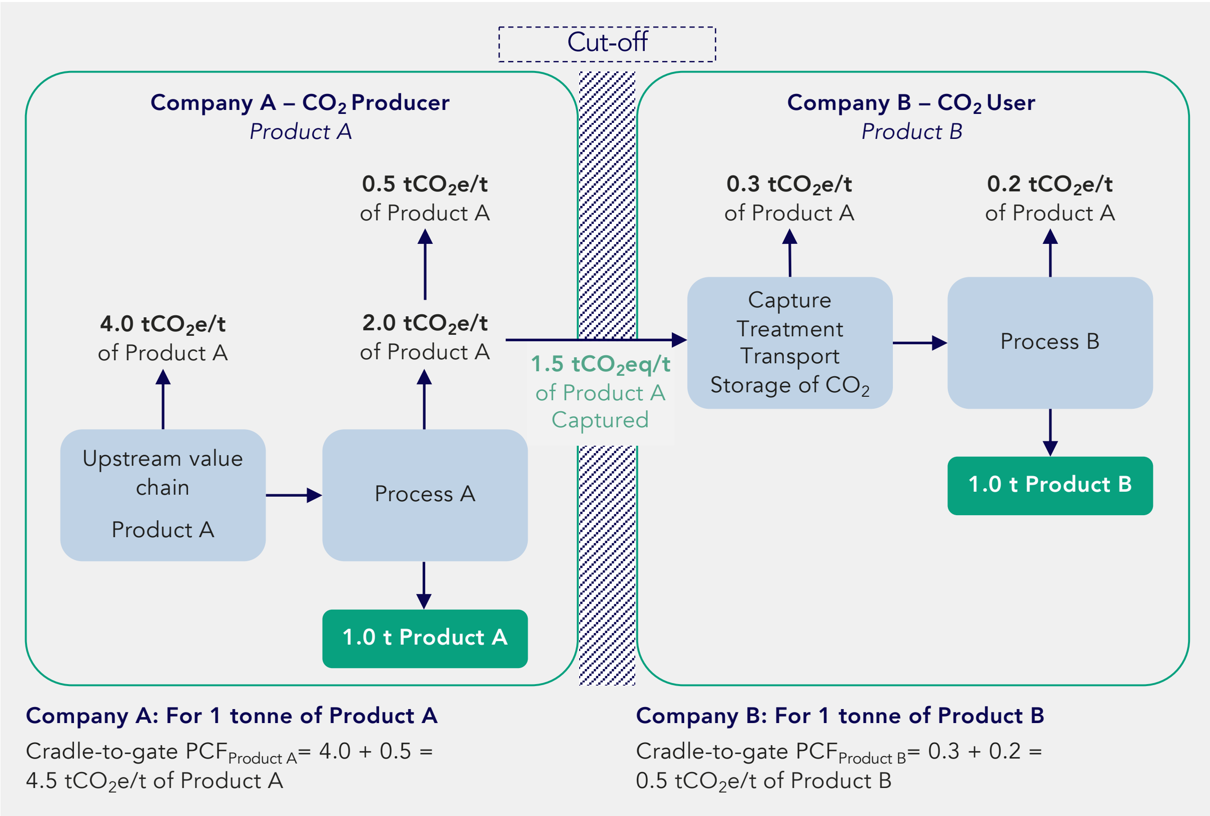
CCU are a diverse set of technologies that allow for the capture and use of CO_2 to make products such as chemicals, building materials or synthetic fuels. For example, CO_2 and hydrogen can be reacted to produce methanol, a building block of materials such as plastics, fabrics or fibers.[65]

CCU is considered as a carbon recycling process and does not result in CO_2 removals. Following the decision tree in Section 3.3.1.4 (Figure 8), CO_2 is classified as a waste that will be recycled through the CCU process. Therefore, as described in Section 3.3.2.2 companies calculating emissions from CCU-derived products or materials should follow the "recycled content" / cut-off approach.

Under the "recycled content" / cut-off approach (Figure 19):

- The CO_2 captured is excluded from the scope of emissions accounted by the CO_2 producer.
- The CO_2 captured is excluded from the scope of emissions accounted by the CO_2 user (i.e. recycler); in other words, the cradle-to-gate PCF of the CO_2 user does not include the emissions associated with the captured CO_2.[66]
- The GHG emissions generated through the carbon capture process, transportation, and storage are accounted for by the CO_2 user, unless the CO_2 capture process is required to make proper specifications of the product generated by the CO_2 producer. In that case, the GHG emissions generated through the carbon capture process, transportation, and storage are accounted for by the CO_2 producer[67]. Note that if the carbon capture process, transportation, and/or storage are not owned and/or paid for by the CO_2 user, data shall be shared by the upstream partner.

Figure 19: CCU example assuming 1.5 tCO_2 captured and used per tonne for product B using the cut-off approach



65. Systemiq and the Center for Global Commons (2022). Planet Positive Chemicals.
66. The captured CO_2 will become a carbon molecule in the product of the CO_2 user, which may eventually be released during use and/or end-of-life phases, depending on downstream processes of the product life cycle manufactured by the CO_2 user.
67. Together for Sustainability. (2024). The Product Carbon Footprint Guideline of the Chemical Industry

This guidance recommends the "recycled content" / cut-off approach, due to its alignment with the GHG Product Standard and consistency with Section 3.3.2.2. Alternatively, companies may use the credit approach. The latter is adapted to current market needs and is also subject to the GHG Protocol actions and market instruments outcomes. As standards and market needs evolve, future versions of this methodology will be refined accordingly.

Under the credit approach:

- The CO_2 captured is accounted for as +1 $CO_2e/kgCO_2$ emissions by the CO_2 producer (i.e., as if hypothetically the CO_2 was not captured but emitted by the CO_2 producer; the carbon reduction credit is passed along to the CO_2 user)
- The CO_2 captured is accounted for as -1 $CO_2e/kgCO_2$ emissions by the CO_2 user (i.e., the carbon reduction is given to the CO_2 user)
- The GHG emissions generated through the carbon capture process, transportation, and storage is accounted for by the CO_2 user, unless the CO_2 capture process is required to make proper specifications of the product generated by the CO_2 producer. In that case, the GHG emissions generated through the carbon capture process, transportation, and storage is accounted by the CO_2 producer[68]. Note that if the carbon capture process, transportation, and/or storage is not owned and/or paid by the CO_2 user, data shall be shared by upstream partner
- For the credit approach, a separate external bookkeeping certification scheme shall be considered (e.g., ISCC).

Regardless of the approach used (cut-off or credit approach), for transparency, companies calculating PCFs including CCU shall report additional information needed to understand how the PCF was calculated, namely:

- The CCU origin, i.e., information about CO_2 origin (fossil or biogenic) and path of captured CO_2 used in CCU, including name and location of capture facility[69]
- The CCU carbon content (kgC/declared unit)
- The CCU calculation approach, i.e., "Cut-off" or "Credit"
- For the credit approach, the CCU credit certification, i.e., URL to documentation verifying certification from an external bookkeeping scheme

In the CCU approach described in this section, only fossil and other anthropogenic captured CO_2 emissions shall be taken into account. If biogenic CO_2 (e.g., CCU from bioethanol fermentation) is captured and utilized, please follow the guidance defined in Section 3.3.2.2.

68. Together for Sustainability. (2024). The Product Carbon Footprint Guideline of the Chemical Industry
69. As part of the overall 'technological CO2 capture origin' data attribute in the Technical Specifications.

PACT

4. Creating integrity

One of PACT's primary objectives is to increase the use of high-quality primary data to calculate PCFs.

4.1 Data sources and hierarchy

This section provides definitions and overarching guidance for the prioritization of data sources and the use of secondary data when primary data is not available.

4.1.1 Defining the data hierarchy

For a PCF calculation to take place, two types of data are required: activity data and emission factors. Both can be derived from different sources, which this guidance categorizes into primary and secondary data. Table 9 presents the definitions that shall be used by companies to determine the nature of activity data and emission factors.

Table 9: Data type definitions

Data type	Activity data: Quantified measures of a level of activity that results in GHG emissions or removals
Primary	Company[a], site- or plant- specific data (i.e. operational control) directly measured, collected, or calculated (e.g., engineering models)
Secondary	Data not directly collected, measured, or calculated based on specific company production data, including proxy data

a. If there are multiple sites for the same product

Data type	Emission factors: Amount of GHGs emitted, expressed as CO_2e and relative to a unit of activity (e.g., kg of CO_2e per declared unit)
Primary	Calculated based on company-owned (i.e. operational control) primary activity emission data or modelled GHGs using primary data input *Example: Direct GHG combustion emissions or well-characterized emission factors based on stoichiometry*
Secondary	Emission factors derived from secondary sources, including proxy data *Example: Default factors, regional industry averages, literature studies, government statistics, financial data, and environmentally extended input-output databases (EEIO)*

Note: Supplier-specific emission factors are data calculated and provided by a supplier. Supplier-specific data might be a combination of primary and secondary data (e.g., from upstream emissions); the share of primary data shall be calculated and reported as explained in section 4.2.2.

One of the core aims of the PACT Methodology is to enable the use of high-quality data for PCF calculations. In line with this ambition, companies are encouraged to directly measure GHG emissions or calculate GHG emissions based on both primary activity data and primary and supplier-specific emission factors ("best case"). However, the use of secondary data is practically unavoidable, especially in the case of missing data or when conducting an initial PCF screening.[70] Table 10 shows a hierarchy of data sources that can be used for energy (electricity, heating, cooling) and material inputs.

Table 10: Data hierarchy for energy and material inputs

	Activity data source		Emission factors source	
Approach	**Energy[a]**	**Material**	**Energy**	**Material**
Best case	**Primary data** In-house/process-based data at plant level		**Primary and/or supplier-specific[c] data** For on-site production: in-house/primary For purchased electricity: supplier-specific or via a certification mechanism (e.g., guarantees of origin)[d] For other purchased energy: supplier-specific or well-characterized emission factors based on stoichiometry	**Supplier-specific data[c]** (e.g., via PACT Network)
Base case[b]	**Primary data** In-house/process-based data at site or company level		**Secondary data** Secondary process-based sources	
Worst case	**Secondary data** Proxy data In-house/spende data[e]		**Secondary data** EEIO databases and data proxies	

a. Electricity, heating/cooling, steam
b. Prevalent approach in practice
c. Assuming supplier uses primary activity data as a minimum
d. Allowed only if mechanism excludes purchased renewable energy from regional grid mix
e. Data based on spend (e.g. $) instead of quantity (e.g. kg)

Note: This table is for illustrative purposes only

70. While this guidance advocates for the use of primary data, in some cases primary data may be associated with high uncertainty and/or measurement inaccuracies, thus making secondary data more representative of activity data or emission factors.

4.1.2 Selecting primary data

Companies shall prioritize the collection of primary activity data and primary and supplier-specific emission data to calculate their PCFs (e.g., by requesting that suppliers report PCFs following PACT Methodology requirements).

In some cases, further polishing and aggregation of data may be required to refine the emissions estimates. Algorithms may be used to fill in the missing data, or data aggregation may be required to dampen the effect of revisions, turnarounds, or other atypical production conditions.

The use of modelling tools to estimate GHG emissions is a common practice in many sectors (such as agriculture), where emissions calculation is complex and affected by several interrelated parameters (such as geography, temperature, type of input, and agricultural practice). For the purposes of this guidance, the results of a model that uses primary data as an input shall also be considered primary.

4.1.3 Selecting secondary data

4.1.3.1 Activity data

As displayed in Table 10, activity data that is used to calculate product-level GHG emissions shall always be company-specific process-based data (i.e., primary data). However, this guidance acknowledges that there may be instances where company-specific process-based activity data may not be available. In these instances, companies may resort to using secondary activity data, i.e., proxy and/or spend-based data ("worst case")).

4.1.3.2 Emission factors

Primary emission factors and supplier-specific data are also not always available. For instance, suppliers may be unable to provide GHG data for a component required to manufacture the product for which Company X wishes to calculate a PCF. In such scenarios, representative emission factors from secondary sources (e.g., LCA databases) should be used ("base case").

When the above is not available, proxy secondary emission factor data or environmentally extended input-output databases (EEIO) may be used to bridge minor data gaps ("worst case"). The selection of proxy datasets is usually based on the knowledge and experience of the LCA practitioners and the subject matter experts for that sector or product category.[71]

The employment of secondary emission factors shall be compliant with the general quality rules for secondary data sources. To ensure the use of verified and credible secondary emission factors while still allowing for flexibility in the data sources used, the PACT Methodology defines a series of safeguards that secondary emission factors shall comply with if they are to be used for the calculation of PCFs:

1. Documentation:
    - Data included in the secondary emission factor shall be validated in line with globally recognized LCA principles.[72]
    - The emission factor source should ensure transparency by providing information on key aspects of the methodology used (i.e., LCA modelling approach, aggregation and allocation approach, if any) and underlying data (time period, geography, technology, representativeness).
2. Management and maintenance:
    - If lifecycle inventory databases are used, they shall be periodically maintained and updated with the latest datasets.
3. Choice of modeling:
    - The modeling of the secondary emission factor shall be consistent with the methodological principles of the PACT Methodology (e.g., attributional approach).

When exchanging a PCF, companies shall provide references to the main sources used for their PCF calculation, including the specific version used. Examples of secondary emission factor sources can be found in Table 11.

71. Canals et al. (2011). Approaches for Addressing Life Cycle Assessment Data Gaps for Bio-based Products.
72. More information on validation of databases can be found in Section 2.3 of the Global Guidance for Life Cycle Assessment Databases (2011).

Table 11: Examples of secondary emission factor databases

Database	Sector	Link
Ecoinvent	All	ecoinvent – Data with purpose
Sphera	All	LCA Database – Sphera
Official National emission factors	All	E.g. US EPA database, UK GHG database
GLEC Framework emission factors	Transportation	Smart Freight Centre
Agrifootprint	Agriculture	Agri-footprint database – SimaPro

4.2 Data Reliability

The PACT Methodology introduces two metrics to track, report, and improve data quality, as well as increase the use of primary data. By managing these metrics, companies can assess and improve the overall quality of PCF calculations.

4.2.1 Introduction

The following metrics assess the reliability of a PCF calculation:

- Primary Data Share (PDS): Percentage of PCF emissions calculated using primary activity data and emissions data (Section 4.2.2)
- Data Quality Ratings (DQRs): Quantitative score for three data quality indicators based on the data quality matrix (Section 4.2.3)

These metrics shall be calculated based on the emissions included in the PCF excluding biogenic CO_2 uptake and intend to provide a fuller picture of both the quality of the PCFs and the amount of primary data used.

Companies shall calculate and report PDS as part of the PCF data exchange. As the data quality assessment matrix has been updated from PACT Methodology Version 2, companies shall calculate and report DQRs from 2027 onwards[73].

4.2.2 Primary Data Share

To create visibility into the share of primary data in PCF calculations, the PDS shall be calculated and exchanged. This shall be done by calculating the proportion (percentage) of the absolute PCF excluding biogenic CO_2 uptake (|PCF|) that is derived using primary data. The absolute PCF excluding biogenic CO_2 uptake is the sum of all GHG emissions and removals. As shown in the formula below, this is different from the PCF excluding biogenic CO_2 uptake calculated and exchanged, where removals are subtracted from emissions.

$$PCF_{\text{excl. biogenic } CO_2 \text{ uptake}} (kgCO_2e \text{ per declared unit}) = \text{GHG emissions} - \text{GHG removals}$$

$$|PCF_{\text{excl. biogenic } CO_2 \text{ uptake}}| (kgCO_2e \text{ per declared unit}) = \text{GHG emissions} + \text{GHG removals}$$

To calculate the PDS, each absolute PCF component ($|PCF_i|$) is multiplied by its corresponding primary data share (PDS_i) and then divided by the sum of all components' absolute values ($\Sigma|PCF_i|$), using the formula:

$$PDS_{PCF\ product}(\%) = \Sigma \frac{(|PCF_i| \times PDS_i)}{\Sigma|PCF_i|}$$

i: Any components (inputs or outputs) within the PCF scope and boundary

|PCF|: Absolute value of the PCF excluding biogenic CO_2 uptake.

73. While companies should calculate and report this information, it is only required by end of 2027 (i.e., 31.12.2027).

In order for an input to be considered primary data, both the activity data and emission factor shall be compliant with the primary data definitions included in Table 9 (see a clarifying example in Figure 20).

For the upstream emissions' PDS to be greater than 0, companies shall request PCFs and their corresponding PDS from their suppliers.

The individual PDS_i received from every input supplier ($PDS_{PCF\ component\ 1}$ and $PDS_{PCF\ component\ 2}$) as well as any other components required to manufacture the studied product, such as energy inputs or direct emissions from production, should be multiplied by their respective relative absolute contribution (in percentage) to the absolute PCF excluding biogenic CO_2 uptake. All weighted PDS components should then be added up to obtain an overarching PDS ($PDS_{PCF\ product}$), as detailed in Figure 20.

To help increase transparency on primary data use, the overarching PDS ($PDS_{PCF\ product}$) shall be exchanged downstream together with the PCF.

The inclusion of an explanation for the share of primary data is encouraged, with the objective of helping businesses support each other in understanding the nature of the exchanged data and promoting an increase in the amount of primary data in use. This process will contribute to more accurate PCFs.

If the PDS of a PCF component is unknown, companies shall apply a 0% PDS score to that specific component.

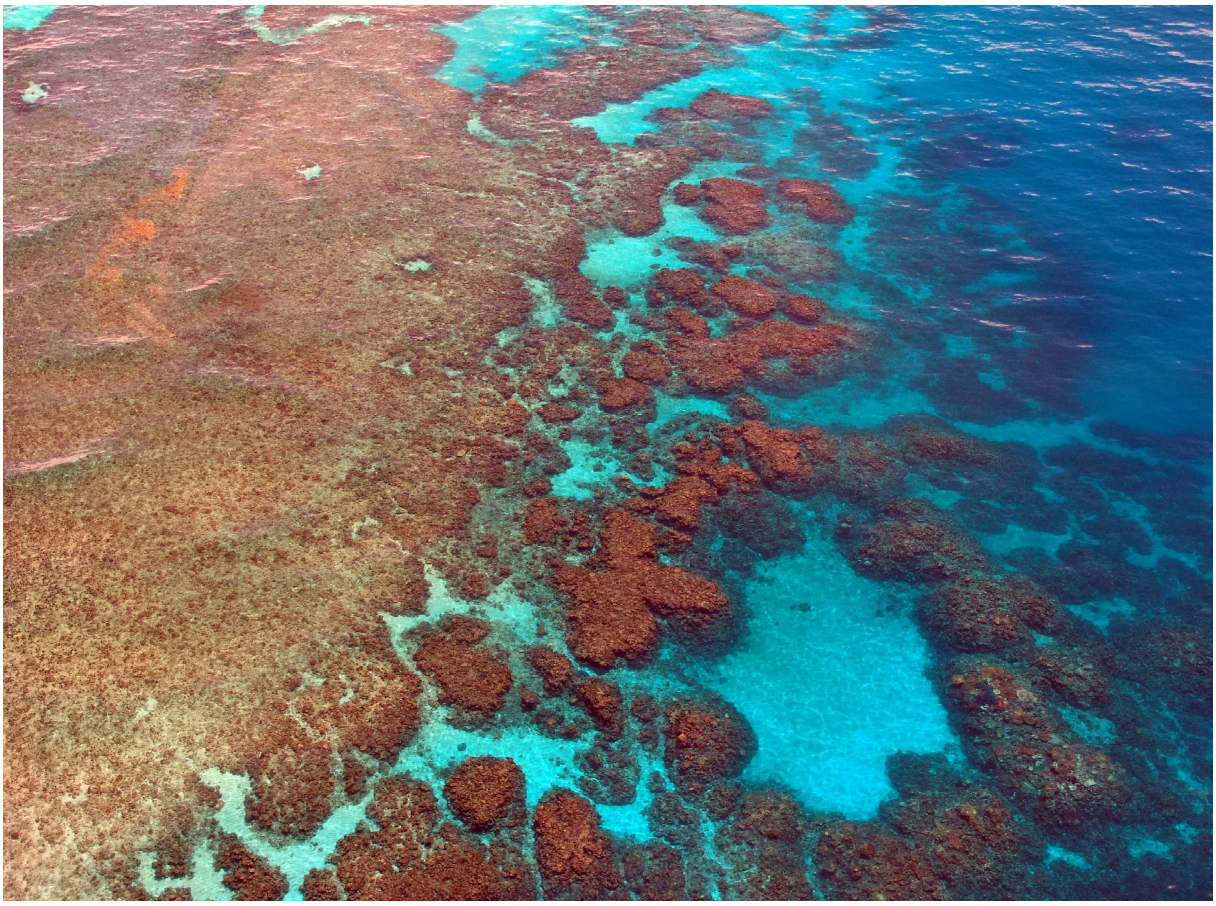
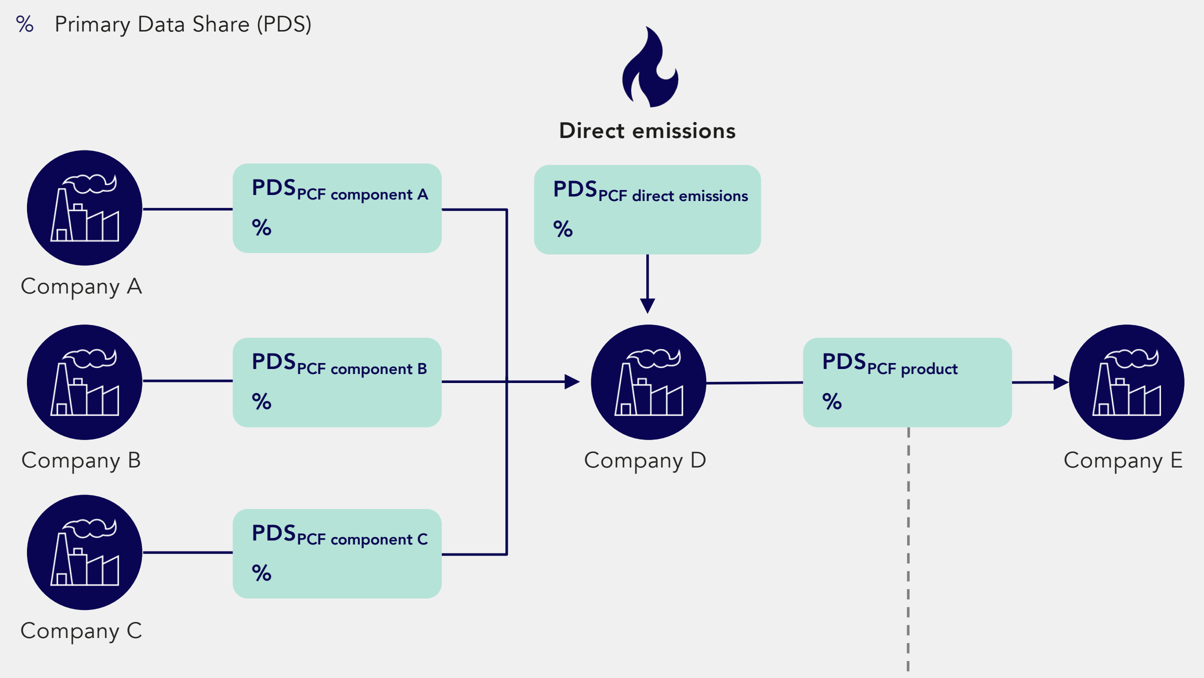


Figure 20: Example of Primary Data Share Calculation



Formula to calculate $PDS_{PCF\ product}$

$$\frac{|PCF_{component\ A}| \times PDS_{component\ A} + |PCF_{component\ B}| \times PDS_{component\ B} + |PCF_{component\ C}| \times PDS_{component\ C} + |PCF_{direct\ emissions}| \times PDS_{direct\ emissions}}{|PCF_{component\ A}| + |PCF_{component\ B}| + |PCF_{component\ C}| + |PCF_{direct\ emissions}|}$$

Component	Data input	Activity data source	Emission factor	Emission factor source	$\lvert PCF_i \rvert$ $kgCO_2e$	% PCF	PDS_i	Total PDS
$PDS_{PCF\ component\ A}$	1,000 kg	Primary	0.8	Primary & Secondary	800	19%	36%	7%
$PDS_{PCF\ component\ B}$	2,000 kg	Secondary	1.2	Primary & Secondary	2,400	56%	0%	0%
$PDS_{PCF\ component\ C}$	500 kWh	Primary	0.18	Secondary	90	2%	0%	0%
$PDS_{PCF\ direct\ emissions}$	5,000 GJ	Primary	0.2	Primary	100	23%	100 %	23%
				$\lvert PCF_{product} \rvert$	**4,290**	$PDS_{PCF\ product}$		**30%**

Note: *For the purpose of this example, please note that direct emissions are considered to have a PDS of 100%, since both the activity data and emission factor data come from primary sources, while component B and C are considered to have a PDS of 0%, since activity data and emission factors data respectively come from secondary sources.*

4.2.3 Data quality indicators (DQIs) assessment

With companies able to calculate their PCFs using several data types, data quality assessments provide users with a better understanding of the overall integrity of the data and the resulting PCF. Additionally, understanding the quality of the data allows companies to identify key secondary data sources that should be improved or replaced with primary data in order for companies to be able to track the impact of emissions reduction initiatives more accurately.

From 2027 onwards[74], once the GHG calculations for the PCF excluding biogenic CO_2 uptake have been completed, companies shall calculate a data quality rating (DQR)[75] of direct emissions and emission factors data for the following three indicators:

- Technological representativeness: The degree to which the data reflects the actual technology / technologies used in the process
- Geographical representativeness: The degree to which the data reflects the actual geographic location of the processes within the inventory boundary (e.g., country or region)
- Temporal / Time representativeness: The degree to which the data reflects the actual time (e.g., year) or age of the process

Each indicator of the data quality assessment matrix (Table 12) shall be assessed from 1 (best score) to 5 (worst score).

To facilitate clarity and transparency, companies shall report the ratings of each DQI separately. If a company produces the studied product in more than one site, it shall define the DQRs using the weighted average of production volumes of the respective sites.

74. While companies should calculate and report this information, it is only required by end of 2027 (i.e., 31.12.2027)
75. The DQR values are determined at the point in time when the direct emissions and emission factors are mapped to their corresponding activity data.

Table 12: Data quality assessment matrix

Data Quality Indicators (DQIs)

Technological representativeness

1	2	3	4	5
The dataset has been created based on data reflecting the exact technology employed (i.e. plant specific process/equipment data for the plant/ equipment where the product has been manufactured) Note: this quality score can be achieved only in case of use of primary data	The dataset has been created based on data reflecting the company-specific and same technology to the one employed for the actual manufacturing (i.e. same technology, the company/site specific but not necessarily plant specific – it could be an average if several company/site specific data are available) Note: this quality score can be achieved only in case of use of primary data	The dataset has been created based on data reflecting an average for an equivalent technology to the one employed for the actual manufacturing (i.e. same technology, but not company specific) Note: this is the maximum score achievable with secondary data	The dataset has been created based on data reflecting a technological proxy (i.e. similar but not same technology, irrespectively if based on averages or supplier specific data)	The dataset has been created based on different or unknown technology vs technology actually employed

Geographical representativeness

1	2	3	4	5
The dataset has been created based on data reflecting the country subdivision (if applicable) or country in which the product has been manufactured Country subdivision list: States in the USA, Provinces in Canada, Federative units in Brazil, Provinces in Argentina, States in Mexico, Republics in Russia, States in India, Provinces in China, States in Australia	The dataset has been created based on data pertaining the country, in which the product has been manufactured. The area where the dataset is generated is valid for the geographical area where the site is located *Example: The site is in California and the dataset is a US average*	The dataset has been created based on data pertaining to the geographical region (e.g., Europe, Asia, North America), in which the product has been manufactured The area where the dataset is generated is valid for the geographical area where the site is located *Example: The site is in Spain and the dataset is a European average*	The dataset has been created based on global averages *Example: The site is in Japan and the dataset is a global average*	The dataset has been created based on data with a geographical scope which is either unknown or pertaining a country, or region not including the site in which the product has been manufactured *Example: In absence of a global average, the dataset geographical applicability is unknown.*

Temporal / Time representativeness

1	2	3	4	5
The difference between "Reference Period End" of the dataset and "Reference Period End" of the PCF is ≤1 year (i.e., 366d (to count for leap year))	The difference between "Reference Period End" of the dataset and "Reference Period End" of the PCF is >1 year and ≤2 years (i.e., 731d)	The difference between "Reference Period End" of the dataset and "Reference Period End" of the PCF >2 years and ≤3 years (i.e., 1096d)	The difference between "Reference Period End" of the dataset and "Reference Period End" of the PCF is >3 years and ≤4 years (i.e., 1461d)	The difference between "Reference Period End" of the dataset and "Reference Period End" of the PCF is >4 years or unknown

Explanation of Temporal / Time representativeness

- Reference Period End: the latest date for which the dataset is representative (e.g., 31.12.2023 for a data set that represents 2023)
- Calculate Time Difference: "Reference Period End" of the dataset - "Reference Period End" of the PCF ": e.g., 31.12.2023 - 01.06.2024 = 6 months, i.e., rating 1

Similarly to PDS calculations, the contributions of the different PCF components to the final DQRs shall be determined via a weighted average based on their emissions contribution to the absolute PCF excluding biogenic CO_2 uptake (see the formula below).

The absolute PCF excluding biogenic CO_2 uptake is the sum of all GHG emissions and removals. As shown in the formula below, this is different from the PCF excluding biogenic CO_2 uptake calculated and exchanged, where removals are subtracted from emissions.

$$PCF_{\text{excl. biogenic } CO_2 \text{ uptake}} \text{ (kg}CO_2\text{e per declared unit)} = \text{GHG emissions} - \text{GHG removals}$$

$$|PCF_{\text{excl. biogenic } CO_2 \text{ uptake}}| \text{ (kg}CO_2\text{e per declared unit)} = \text{GHG emissions} + \text{GHG removals}$$

$$DQR_{\text{indicator PCF product}} = \Sigma \frac{(|PCF_i| \times DQR_{\text{indicator } i})}{\Sigma |PCF_i|}$$

i: Any components (inputs or outputs) within the PCF scope and boundary

|PCF|: Absolute value of the PCF excluding biogenic CO_2 uptake

Indicator: Technological-, Geographical-, and Temporal/Time representativeness

Every DQR shall be calculated in the context they are assessed for, i.e., the DQR values shall be determined at the point in time when the direct emissions and emission factors are mapped to their corresponding activity data. For instance, DQRs for secondary datasets calculated by a secondary database shall be recalculated based on the context and product for which they are being used, and the DQR matrix and available descriptions provided by PACT.

If upstream DQRs are unknown, companies shall apply the worst-case scenario (i.e., a score of 5 for each DQI).

Table 13: Example of data quality assessment

Data Quality Indicators (DQIs)	Component 1	Component 2	Component 3	Component 4
GHG contribution to absolute PCF	**25%**	**30%**	**45%**	**100%**
Technological representativeness	2	2	1	1.55
Temporal / Time representativeness	1	5	2	2.65
Geographical representativeness	2	2	3	2.45

Example of calculation

Total Technological representativeness DQR: a weighted average based on each component's emissions contribution to the absolute PCF

= 2 * 0.25 + 2 * 0.30 + 1 * 0.45 = 1.55

Box 10: Improving data quality over time

The aim of data collection and quality assessments is to improve the overall accuracy of the product inventory and should be viewed as an iterative process to be completed alongside any calculation updates.

For instance, improving the quality of data for large emission sources can lead to significant improvements in the overall inventory quality.

If significant data sources are identified as low quality using the data quality indicators, companies should focus their data collection and quality improvement efforts on these specific processes. This can involve engaging with their suppliers to request PCFs or researching and assessing more accurate secondary data alternatives.

Please note that in certain cases, reducing PCF emissions may result in a variance in the PDS or DQR scores reported by companies. For instance, if the electricity used to manufacture a product becomes 100% renewable, the share of emissions associated with electricity will decrease to almost zero, thus losing its representation in the PDS and DQR calculations. Any variances caused in PDS and DQR should be communicated to the receiving entities to ensure the changes are not perceived negatively.

5. Verification

Resolving today's Scope 3 challenges requires high-quality data that is credible, comparable, and consistent. Verification helps ensure data reliability, creating trust among stakeholders to drive decarbonization at scale.

5.1 Context

While the PACT Methodology – along with the methods and standards it builds upon – paves the way toward accurate and comparable PCFs, verification is key to ensuring credibility and reliability. Independent third-party verification helps ensure that PCFs are calculated in accordance with the PACT Methodology, relevant standards, sector-specific guidance, product category rules, and associated methods. This section provides guidance and requirements for the verification of PCF results taking place in the context of the PACT Methodology.

5.2 Objectives and scope

5.2.1 Objectives

The overarching objective of this section is to define the requirements for the verification of PCFs in alignment with the PACT Methodology.

By clearly defining requirements, this guidance seeks to:

- Establish a common basis and language around verification for all stakeholders in the ecosystem
- Increase the uptake of product-level verification practices across industries via a phased-in approach
- Clarify future verification requirements to help stakeholders prepare and stay aligned with the methodology's expectations
- Simplify the verification process by offering guidance on the types of evidence companies should prepare in advance

5.2.2 Scope and limitations

This guidance defines the minimum verification requirements companies shall fulfill when exchanging data across value chains. However, companies are strongly encouraged to align with the long-term requirements defined in this guidance as early as possible, increasing emissions data reliability and trust in the overall ecosystem. Going beyond the minimum requirements of verification is possible through additional data transparency (Table 14, Table 15,

Table 16) allowing companies to distinguish themselves through greater data credibility.

From a practical standpoint, verified PCF data obtained from another stakeholder and used for calculations of a company's own PCF also reduces the transactional cost of a company's own verification process. Any PCF already verified shall not require (re)verification, as long as no changes are made to the underlying calculation models and data used by the company that exchanged the PCF.

Finally, this guidance recognizes that verification of emissions disclosures involves many challenges, including:

- The limited control of companies over certain emission sources
- Verifiers' limited ability to obtain sufficient evidence on all necessary items
- The evolving scientific consensus on questions directly affecting emissions disclosures, such as emission intensity factors
- The required subject-matter expertise which not all companies and verifiers may currently have at scale

The PACT Methodology seeks to help mitigate these challenges by providing clarity and a reference point. As verification practices evolve, companies and verifiers should continue to collaborate to refine best practices and ultimately improve the credibility of PCF data exchanged.

5.3 Verification roadmap

5.3.1 Structure

This guidance is structured as a roadmap consisting of two-time horizons (short-term and long-term), each one encompassing requirements across eight verification dimensions, as shown in Figure 21.

Figure 21: Time horizons and dimensions of the verification roadmap

Time horizons			
Short-term 2023–2030		**Long-term**[a] 2030 onwards	
Assurance dimensions			
Coverage Section 5.3.3	**Conformance** Section 5.3.4	**Boundary** Section 5.3.5	**Level of verification** Section 5.3.6
Provider Section 5.3.7	**Process cycle** Section 5.3.8	**Requirements for SMEs** Section 5.4	**Timing and reporting** Section 5.5

a. Long term requirements to be fulfilled for PCFs being updated after 2030

5.3.2 Overview

Figure 22 presents an overview of the PACT's verification requirements for the two time horizons by dimension.

Figure 22: Verification Roadmap Overview

Dimension	Short-term requirements 2025-2030	Long-term requirements 2030 onwards
Coverage Granularity of data to be verified	PCF Calculation Model	PCF Program
Conformance Basis for the verification	PCR or sector-specific guidance, if followed, in addition to PACT Methodology Verification against additional cross-sectoral standards is optional	PCR or sector-specific guidance, if followed, in addition to PACT Methodology Verification against additional cross-sectoral standards is optional
Boundary Depth of the data to be verified	Cradle-to-gate	Cradle-to-gate
Level Degree of confidence	Limited assurance	Certification
Provider Entity providing the verification	Independent third party	Independent third party
Process cycle Temporal validity of the verification	Three years or earlier if variance >10% or if calculation methodology update takes place	Three years or earlier if variance >10% or if calculation methodology update takes place
Application to SMEs SME requirements	**Phased-in approach for SMEs** All requirements above apply identically to SMEs but with a two-year time lag to allow for capacity building	

The following sections provide further detail on each dimension and requirement.

5.3.3 Coverage

Verification coverage defines the type and level of GHG data to be verified (e.g., corporate level, calculation model, PCF program, or PCF level).

Short term

Verification is needed to build trust in PCF integrity. For companies in the early stages of their PCF journey, this Methodology proposes a simplified verification approach that balances rigor with practicality. Rather than verifying individual product calculations, companies shall secure independent verification of their PCF calculation model, as operationalized through tools such as software applications, excel spreadsheets, or digital platforms.

Companies shall verify that their PCF calculation model conforms to a given standard's requirements (refer to Section 5.3.4 for more information on the required standard or guidance companies shall verify against). The elements that shall be reviewed at a minimum as part of the PCF Calculation Model, as well as optional additional elements, are listed in Table 14 and Table 15.

Table 14: Scope of short-term verification requirements of PCF Calculation Model – Methodology

Scope of short-term verification of PCF Calculation Model – Methodology Ensuring calculation methodology or algorithm is aligned to a given standard			
Element	**Description**	**Minimum**	**Optional**
Boundary of approach	Demonstrate alignment to cradle-to-gate scope. All attributable upstream and direct emissions of a product including transport activities shall be accounted for	Inventory of all GHG sources and the relevant activity data broken down by site	N/A
Calculation standard used	Alignment and transparency on calculation standards including: GHG Protocol Product standard, ISO 14067, ISO 14044, cross- sectoral standards as per the PACT Methodology	Comprehensive checklist of standard(s) requirements followed	N/A
Characterization factors	Demonstrated use of 100-year global warming potential (GWP; including carbon feedbacks), characterization factors shall be derived from latest IPCC AR publication	Report what IPCC AR report was used in calculation	N/A
Unit of analysis	Unit of the analysis to be liter, kilogram, cubic meter, kilowatt hour, megajoule, tonne kilometer, piece, hour, square meter, megabits per second	Transparency on unit of analysis for calculation	N/A
Exempted emissions	Exclusion cannot be more than 3% of the total aggregated cradle-to-gate PCF	List of excluded emissions	N/A

Table 14: Scope of short-term verification requirements of PCF Calculation Model – Methodology (continued)

Scope of short-term verification of PCF Calculation Model – Methodology Ensuring calculation methodology or algorithm is aligned to a given standard			
Element	**Description**	**Minimum**	**Optional**
Data quality	Inclusion of requirements on data quality. This includes Primary Data Share or Data Quality Ratings (mandatory from 2027 onwards), per identified material processes	Calculation of PDS and DQR using absolute values of PCF excluding biogenic CO_2 uptake	An individual data quality statement for each GHG source
Data sources	Transparency on primary or secondary data sources used in calculations	Comprehensive list of all primary and secondary data sources used	Additional information on how and when the data was accessed
Calculation	All calculation steps are accurately followed to convert activity data into GHG emissions	Comprehensive list of calculation steps per life cycle stage	N/A

Table 15: Scope of short-term verification requirements of PCF Calculation Model – Results testing

Scope of short-term of PCF Calculation model– Results testing Ensuring that the PCF calculation model generates correct PCFs, based on a set of test input data			
Element	**Description**	**Minimum**	**Optional**
Automated testing	PCF calculation model passes the automated testing suite by calculating several PCFs based on a set of predefined inputs (test vectors) and validating results	Comprehensive list of all intermediate and final results	N/A
Sample PCF Review	Review sample PCFs generated by the PCF calculation model to validate the implementation of the calculation methodology	N/A	N/A

Long-term

In addition to the short-term requirements, from 2030 onwards companies shall certify the system governing how a company generates and manages PCFs (also known as 'PCF Program Certification'). In addition to the elements described in Table 14 and Table 15, companies shall certify the governance elements detailed in Table 16.

Table 16: Additional long-term certification requirements of PCF Program – Governance

Scope of long-term certification of PCF Program – Governance Validation of management practices on data, calculations, and risk management.	
Element	**Description**
Scope of PCF program	Documentation of stakeholders, production sites, and departments contributing to data collection, processing, and calculation. Clarity on what products are covered under the PCF program, and what PCF calculation models and databases are used
Data management	Description of the primary and secondary data collection process and databases used, procedures for data consolidation, processing, aggregation, calculation, and data exchange using the PCF solution. Documentation of all assumptions and estimates, and description of system archiving data and data models
Governance	Documentation of internal procedures for PCF calculations, including processes for calculation and database updates, responding to methodological changes, time validity of calculations, and the quality assessment of both primary and secondary data, among others
Expertise	The team employed to undergo the calculation process has expertise in the subject to minimize PCF misstatements
Risk management	Potential shortcomings or pitfalls associated with the PCF calculation process and mitigation plans need to be identified and addressed
Quality control	Internal mechanism in place to ensure quality control. This can include monitoring and evaluation of PACT compliance, sample calculations, etc. The effectiveness of controls regarding the calculation process should be evaluated and a continuous monitoring for internal controls shall be put in place. The responsibilities associated with quality control are clear

5.3.4 Conformance

This subsection defines the reference standard or guidance that companies shall use as reference when going through the verification process.

Short-term

Companies shall use the PACT Methodology as the basis for verification. Verification may be conducted using any internationally recognized verification framework (see Section 3.1 on existing methods and standards, provided that the verification is explicitly scoped to assess conformance with the PACT Methodology requirements in line with the coverage requirements (see Section 5.3.3).

Long-term

Companies shall follow the same requirements as in the short-term.

5.3.5 Boundary

The boundary of the verification defines which lifecycle stages shall be included in the verification process.

Short-term

Companies shall ensure that the entire cradle-to-gate footprint has been verified, i.e., the entire footprint up to the point where it is passed on downstream (see Figure 5).

Long-term

Companies shall follow the same requirements as in the short-term.

5.3.6 Level of verification

The level of verification defines the degree of confidence in the verification statement.

Short-term

Companies are required to request third party verifiers to conduct a verification following a limited level of assurance. To comply with limited levels of assurance, third party verifiers shall provide a conclusion framed in a negative sense, indicating that the verified did not find any evidence that the emission disclosures contain any material misstatement based on the applicable criteria.

Long-term

Companies shall undergo certification of the PCF Program to fulfill the requirements of this guidance. Certification of the PCF Program is a formal process that confirms compliance with a specific guidance or standard, covering the data management, PCF calculation, and governance elements. Companies are required to request third-party verifiers to conduct the certification. In the context of the PACT Methodology, certification requires the certifier to undertake a comprehensive evaluation of the system governing how a company generates and manages PCFs. For more information on the PCF Program Certification process, please refer to Chapter 6.2.2 of the Catena X and Together for Sustainability Verification Framework.

5.3.7 Provider

The provider of the verification is the entity that verifies the emissions data. When a company submits its processes for internal review, either by compliance, quality assurance or internal audit functions, this is known as first-party assurance. When the assurance exercise is conducted by external parties, this is known as third-party assurance.

Short-term

Companies shall choose an independent third-party to conduct the verification process. While first-party quality controls and plausibility checks are encouraged, they do not suffice to fulfill the verification requirements for this guidance.

Companies may choose any qualified verification provider, given that the provider meets the required expertise to conduct a verification engagement. While this guidance does not include specific requirements around choosing a verification provider, the verification body should demonstrate:

a. Expertise and experience
   - Proven experience conducting third-party verification engagements related to greenhouse gas accounting, life cycle assessment, or product carbon footprinting
   - Documented knowledge of applicable standards, including (as relevant):
     - ISO 14067 (PCF)
     - ISO 14064-3 (GHG verification)
     - ISO 14044 & 14044 (LCA)
     - The PACT Methodology and any applicable sector guidance
   - Personnel qualifications, such as:
     - Educational credentials in environmental science, engineering, sustainability, or equivalent fields
     - Completion of formal training in carbon accounting or life cycle assessment
   - Use of appropriate tools, models, or software platforms to assess and interpret carbon footprint data
   - Required evidence : Verifier CVs or biographies, list of past engagements (including at least three comparable projects in the last three years), training certifications or other qualifications

b. Industry and Sector knowledge:
   - The sector or industry context in which the product operates (e.g., manufacturing, agriculture, energy, etc.)
   - The business operations and supply chain characteristics relevant to the product system under review
   - Required evidence: Engagement history in similar sectors, team composition showing sectoral expertise

c. Independence and impartiality
  - Demonstrate independence from the reporting entity, including no involvement in:
    - Preparation of the PCF
    - Development or implementation of the carbon accounting model
  - Maintain policies to manage conflicts of interest
  - Required evidence: Signed declaration of impartiality, document of conflict-of-interest policy and procedures

d. Operational capacity
  - Have sufficient qualified staff to perform the engagement within agreed timelines
  - Have a quality assurance system in place for internal review and approval of verification statements
  - Maintain internal records and documentation in accordance with good practice standards
  - Required evidence: Staff resource plan or organizational chart, Description of internal Quality Assurance (QA) and Quality Control (QC) procedures, verification timeline or project management plan

Long-term

PCF Program Certification shall be done by an independent third party to be validated by a certification scheme. Further details regarding the certification scheme will be provided before the requirements become mandatory.

5.3.8 Process cycle

The process cycle defines the validity period of the verification statement (e.g., one year or more).

Short-term

The verification statement shall be valid for a maximum of three years or until the PCF Calculation Model's underlying methodology or system build is updated, e.g., by deploying new software or updating the underlying calculation methodology.

Long-term

Companies shall follow the same requirements as in the short-term.

5.4 Requirements for SMEs

While this guidance encourages any company to assure its emissions data according to the requirements laid out in Figure 22, SMEs[76] may face additional challenges in meeting verification requirements due to resource and capability constraints.

To give SMEs time to build the necessary capabilities to fulfil verification requirements, each requirement as defined in Section 5.3.2 shall become applicable for SMEs two years after the requirement will first come into force for larger corporates. For example, short-term requirements as per Figure 22 shall become applicable for SMEs from 2027 onwards.[77]

While these are the minimum requirements, it is strongly encouraged that SMEs begin to meet the verification requirements sooner than they are required to by this guidance.

76. In the context of this guidance, SMEs are defined in accordance with the latest EU recommendation 2006/361 criteria and thresholds, where SMEs are defined as companies that employ fewer than 250 persons and have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million.
77. While companies should calculate and report this information, it is only required by end of 2027 (i.e., 31.12.2027).

5.5 Timing and reporting

5.5.1 Timing

Verification engagements in the context of this guidance shall begin after the result to be verified, e.g., a PCF, has been calculated, and before the result is exchanged through the Network. Given that the verification process may take time, and depending on the complexity of the underlying emissions calculation, it is the company's responsibility to start the verification process early enough to avoid delays.

5.5.2 Reporting

In line with the GHG Product Standard, companies shall include the verification statement in any emission disclosure. A verification statement, at a minimum, shall include:

- The verifier's assertion
- The level of verification
- The verification provider's name and the executing individuals
- A summary of the verification process and work performed
- The relevant expertise of the verifier
- Any potential conflicts of interest
- Scope of work
- The verification standard applied
- A list of criteria that were evaluated to reach the assertion

Companies shall also exchange verification information along with the PCF when exchanging the PCF. The PACT Technical Specifications specify how to include Verification attributes in the data model. It is a company's responsibility to ensure that verification-related information for each PCF exchanged through the PACT Network is up to date and aligned with the requirements of this guidance.

5.6 Special cases

5.6.1 Existing verification

It may be the case that a company needs to verify GHG emissions for purposes other than adherence to this guidance, e.g., to fulfil reporting or regulatory requirements. If verification has already taken place, even if not for the purposes of exchanging data through the PACT Network, the resulting verification may be used towards the verification requirements of the PACT Methodology, provided that the existing verification conforms to the applicable requirements of this guidance at the time the verification is undertaken.

6. Data Exchange

Standardized PCF calculation and exchange is a key step toward creating greater comparability and consistency of information across a supply chain.

6.1 Required elements for data exchange

Emissions data calculated according to the PACT Methodology should be exchanged in accordance with the guidelines set out in this section.

As a companion to the PACT Methodology Version 3, the PACT Technical Specifications Version 3 specifies the set of data attributes to be exchanged when PCF information is shared. Although a summary of these attributes is provided below, see for full details the following resources here:

- PACT Simplified Data Model 3.0
- PACT Technical Specifications 3.0

PACT recommends companies use software solutions to exchange standardized PCF information, for details see Section 6.2.

6.1.1 Minimum data elements required

A high-level summary of the most critical data attributes which should be exchanged is provided below. Please refer to the technical specifications above for further details and the full list of data attributes and associated definitions.

- Product information:
  - Product name and description, relevant product IDs and classification codes
  - Company name and ID
- PCF information:
  - Time attributes (reference period, validity period, created, updated, etc.)
  - Geography
  - Description of boundary processes
  - Declared unit (e.g., mass or energy, depending on the product) and number of declared units contained within the product to which the PCF refers
  - Product-specific PCF (kgCO2e per declared unit), covering cradle-to-gate emissions, including:
    - PCF excluding biogenic CO_2 uptake
    - PCF including biogenic CO_2 uptake

- – Product-related carbon attributes (fossil carbon content, biogenic carbon content, recycled carbon content, etc.)
- – Granular product-related emission attributes (fossil emissions, biogenic non-CO_2 emissions, LUC emissions, etc.)
- – Additional PCF data reported separately (packaging, outbound logistics, CCU, CCS, etc. data)
- – IPCC Characterization Factors
- – Relevant standards used (cross sectoral and/or product or sector specific rules)
- – Key Methodological requirements information (exemption rules percentage, allocation rules, etc.)
- – Secondary emission factor sources

- Data integrity:
  - – Primary Data Share (PDS)
  - – Data Quality Ratings (technological, geographical, and temporal representativeness's) (DQRs)
- Verification information

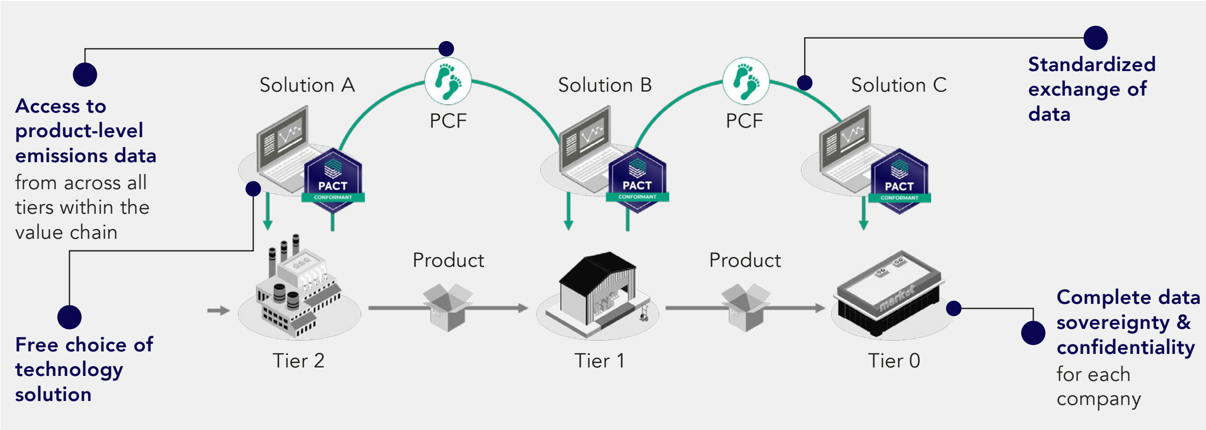
6.2 Leveraging Software Technology to exchange standardized PCF data

To enable data-driven decarbonization decisions, PCF data must be exchanged in a standardized, interoperable way between value chain partners. Although spreadsheets are currently the most common way of exchanging PCF data, this approach poses many challenges for scalability , including ensuring data confidentiality and security, as well as enforcing standardization and interoperability.

Therefore, PACT envisions leveraging software technology as a key enabler to value chain transparency. The PACT Network establishes an open and global network of interoperable solutions for the secure peer-to-peer exchange of accurate, primary, and verified product emissions data – across all industries and value chains. Since the public release of the PACT Technical Specifications Version 2 in February 2023, more than 40 solution providers across 14 countries globally have implemented the PACT Technical Specifications and become "PACT Conformant" to Version 2, thus able to exchange PCF data on the PACT Network. Companies are now working with these so-called "PACT Conformant Solution Providers" to calculate and exchange PACT conformant PCFs. Whereas PACT Conformance ensures Solution Providers can exchange data in a standardized interoperable way, many of these Solution Providers also facilitate the calculation of PCF information following the PACT Methodology and other standards.

Companies working to adopt the PACT Methodology are encouraged to explore PACT Conformant Solutions and/or develop their own solution to become PACT Conformant. Learn more on the PACT website.

Figure 23: Visual representation of exchanging PCFs using PACT Network



6.3 Incorporating product-level data into Scope 3 calculations

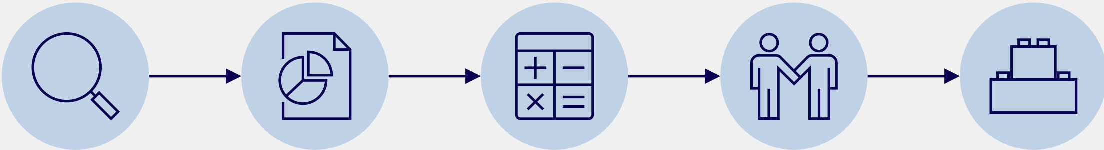
Corporate- and product-level standards are highly interrelated, since emissions resulting from the procurement of products and services represent the largest share of corporate Scope 3 emissions in most sectors. Management of these is therefore highly dependent on high-quality calculation for product-level emissions.

While the GHG Scope 3 Standard accepts several methods to account for upstream Scope 3 emissions Appendix E, obtaining emissions data directly from suppliers is considered best practice. Although this approach requires greater effort, It allows companies to collaborate with their supply chain to improve the efficiency of purchased products and services while accurately monitoring the impact of these improvements on their footprint. This, in turn, can become a procurement criterion that rewards more sustainable suppliers and supports them in their emissions reduction journeys.

It is important to note that the shift to supplier-specific product-level data can be done gradually by combining PCFs with other Scope 3 calculation methods for the less material elements.

By establishing a plan to expand the number of purchased products and services being calculated with validated supplier-specific data, transparency on emissions can be progressively created across upstream emissions of a company. Similarly, by incentivizing Tier 1 suppliers to adopt the same approach, transparency can be expanded across the value chain. With this knowledge, companies can make informed sourcing and product-development decisions, invest in targeted decarbonization activities in their supply chains, measure and track decarbonization progress, and adhere to requirements around environmental transparency. Ultimately, this will create deep visibility into the emissions of hundreds of thousands of companies within global supply chains, providing the missing key to supercharging decarbonization efforts.

Figure 24: Recommendation for use of PACT Methodology to enhance transparency



Step 1
Identify the largest sources of emissions at either the purchased product or supplier level based on the initial Scope 3 calculation

Step 2
Request suppliers associated with the most material sources to calculate and provide the relevant PCFs following the PACT Methodology and PACT Technical Specifications

Step 3
Incorporate PCFs into their corporate footprint by multiplying the PCFs provided by suppliers with the number of product units purchased from them

Step 4
Work with suppliers to understand the PCF emissions trajectory or identify and implement opportunities to further reduce their PCF emissions, ultimately favoring suppliers with lower PCFs for equivalent products

Step 5
Gradually incorporate additional products and suppliers into the PCF data exchange request

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Appendix

Appendix A: Terms and definitions (Glossary)

Definitions	Explanations
Aboveground biomass	Carbon in terrestrial living woody or herbaceous vegetation 2 mm in size or greater.
Activity data	Quantified measures of a level of activity that results in GHG emissions or removals.
Allocation	The process of partitioning GHG emissions from a single facility or other systems (such as a process vehicle or business unit) among its various outputs, in particular products.
Attributable process	Those processes that consists of all service, material and energy flows that become, make and carry a product throughout its life cycle.
Attributional approach	An approach to LCA where GHG emissions and removals are attributed to the unit of analysis of the studied product by linking together attributable processes along its life cycle.
Avoided emissions	Avoided emissions are defined as the positive impact on society when comparing the GHG impact of a solution to an alternative reference scenario where the solution would not be used.
Below ground biomass carbon pool	Carbon in terrestrial live roots 2 mm in size or greater.
Biogenic carbon	Carbon derived from living organisms or biological processes, but not fossilized materials or from fossil sources.
Biogenic CO_2 emissions	CO_2 emissions resulting from the combustion, biodegradation or other losses from biogenic carbon pools to the atmosphere.
Biogenic CO_2 uptake	Biogenic CO_2 sequestered from atmosphere into biomass and (temporally) stored within the product.
Biogenic CO_2 removals	CO_2 removals from atmospheric CO_2 transferred via biological sinks to storage in biogenic carbon pools.

Definitions	Explanations
Biogenic non-CO_2 emissions	CH_4 emissions due to ongoing land management practices (including fertilization, harvest). CH_4 emissions from land management practices and the oxidation and transformation or degradation of biomass.
Boundary	The attributable processes and their associated emissions that should be accounted for and reported by a company as part of its PCF.
Bundled electricity instrument	An energy attribute certificate or other instrument that is traded with the underlying energy produced.
Capital goods	Final goods that have an extended life and are used by the company to manufacture a product, provide a service, or sell, store, and deliver merchandise. In financial accounting, capital goods are treated as fixed assets or plant, property and equipment (PP&E). Examples of capital goods include equipment, machinery, buildings, facilities, and vehicles.
Carbon Capture	CO_2 or other forms of carbon captured and prevented at a source. This can lead to a reduction of CO_2, if the GHG was not captured before.
Carbon Capture & Utilization (CCU)	Diverse set of technologies that allow for the capture and use of CO_2 as a feedstock to make products such as chemicals, building materials or synthetic fuels.
Carbon Capture & Utilization (CCU) carbon content	Amount of carbon in product that is derived from CCU, measured as kgC/ declared unit.
Carbon Capture & Storage (CCS)	Technologies that capture and separate CO_2 from the atmosphere, injecting it into a geological formation to assist in long-term CO_2 isolation from the atmosphere. CO_2 captured directly from the atmosphere or biogenic CO_2 capture at point source are considered 'carbon removals'. Fossil CO_2 emissions captured at point source are not considered carbon removals.
Carbon Reduction	Action(s) that decrease the amount of carbon emissions, compared to prior practices within the value chain.
Carbon Removal	CO_2 removed directly from the atmosphere with technologies such as Direct Air Capture (DAC), or via biogenic CO_2 capture on land. Carbon Capture & Storage (CCS) technologies that remove & store CO_2 emissions directly from the atmosphere or capture & store biogenic CO_2 emissions, can be considered as technological carbon removals with geologic storage.

Definitions	Explanations
Carbon stock	The total amount of carbon stored at any given time in a given carbon pool such as: biomass (above and below ground), dead organic matter (dead wood and litter), and soil organic matter. A change in carbon stock can refer to additional carbon storage within a pool (Land management CO_2 removal) or the emission of CO_2 to the atmosphere (Land management CO_2 emissions). CO_2 that is (temporally) stored in products is referred to as biogenic CO_2 uptake.
Characterization factor	A characterization factor is a quantitative representation of the (relative) importance of a specific intervention, e.g., the GWP (GWP 100) of methane-fossil is 29.8 kg CO_2e/kg.
Corporate-level standards	Corporate-level standards (such as ISO 14064 or the GHG Protocol Corporate Value Chain Standard) focus on aggregate emissions arising from the value chain of a company and apply to company activities as a whole, including business travel and employee commuting.
Cradle-to-gate PCF	Part of a product's full life cycle, covering all emissions allocated to a product upstream of a company plus all emissions resulting from processes within the company until the product leaves the company's gate.
Cradle-to-grave PCF	PCF of a product's full life cycle covering all emissions allocation from raw material acquisition, use to product end-of-life treatment, recycling and final disposal.
Consequential approach	A method that estimates comparative GHG impacts as the total, system-wide change in emissions and removals that results from a given decision or intervention.
Co-product	A product from a multioutput process that is not deliberately produced in a production process and is not a waste; following the 'co-product' criteria outlined in Section 3.3.1.4.
CO_2 removals with geologic storage	Net CO_2 removals resulting from annual net increases to carbon stored in geologic carbon pools from carbon derived from biological or technological CO_2 sinks.
Data quality	Characteristics of data (completeness, reliability and technological, temporal and geographical representativeness) that relate to their ability to satisfy stated requirements (the most common frameworks are the Pedigree Matrix (Ecoinvent) and the Data Quality Matrix/Requirements (Product Category Rules)).
Data semantics	Naming, format and definition of the data attributes required to be exchanged by the company calculating the PCF.
Dead organic matter carbon pool	Carbon in non-living organisms or other non-fossil organic compounds 2 mm in size or greater. Includes dead wood and litter carbon pools.

Definitions	Explanations
Declared unit	Unit of analysis chosen for PCF, which serves as the reference to which the inputs (materials and energy) and outputs (such as products, co-products, waste) are quantified.
Downstream emissions	Indirect GHG emissions that occur in the value chain following the processes owned or controlled by the reporting company.
Direct emissions	Data on emissions released from a process (or removals absorbed from the atmosphere) determined through direct monitoring, stoichiometry, mass balance, or similar methods.
Land use change emissions (LUC)	A transition from one land use category to another, such as from forest to grassland or forest to cropland.
Emission factor(s)	Amount of GHGs emitted, expressed as CO_2e and relative to a unit of activity (for example, kg of CO_2e per declared unit).
Environmentally-extended input output (EEIO)	Models used to estimate energy use and/or GHG emissions resulting from the production and upstream supply chain activities of different sectors and products within an economy. EEIO models are derived by allocating national GHG emissions to groups of finished products based on economic flows between industry sectors.
Fossil emissions	GHG emissions from fossil origin, this include emissions from stationary/mobile combustion, industrial processes and fugitive emissions.
Greenhouse gases (GHGs)	Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, its atmosphere and clouds.
Input	Product, material or energy flow that enters a unit process.
Inventory	Summary of all input and output flows of a system (such as a company's or product's GHG emissions and sources).
Inventory results	GHG impact of the studied product per unit of analysis.
Land carbon leakage	A specific type of leakage, driven by increased demand for agricultural products despite a fixed amount of global land, that occurs when corporate actions displace agricultural production beyond the lands in their operations or value chain, leading to agricultural expansion and land use change at the expense of higher-carbon stock land use types.
Land management CO_2 emissions	Biogenic CO_2 emissions resulting from net carbon stock losses due to ongoing land management practices.

Definitions	Explanations
Land management CO_2 removals	CO_2 removals resulting from net land carbon stock increases due to ongoing land management practices. All land management removals are from biological sinks.
Life cycle	Consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to end-of-life, inclusive of any recycling or recovery activity.
Life cycle assessment (LCA)	Compilation and evaluation of the inputs, outputs and potential environmental impacts of a product throughout its entire life cycle.
Life cycle emissions	The sum of GHG emissions resulting from all stages of the life cycle of a product and within the specified boundaries of the product.
Material	Physical products supplied from a supplier upstream, used as input for production processes of products.
Multi-input-output unit process	Operation or process with multiple inputs, such as materials and energy, and multiple outputs, such as co-products and waste.
Outbound logistics	Transportation and storage from the production gate to the customer gate.
Output	Product, material or energy that leaves a unit process.
PACT Network	An open and global network of interoperable solutions for the secure peer-to-peer exchange of accurate PCF data – across all industries and value chains.
PACT Technical Specifications	The companion standard to PACT Methodology, the PACT Technical Specifications provide a technical specification (data model and REST API) for software solutions to exchange standardized PCF data as calculated by the PACT Methodology.
PCF Program	The system governing how a company generates and manages PCFs.
Primary data	Data pertaining to a specific product or activity within a company's value chain. Such data may take the form of activity data, emissions or emission factors. Primary data is site-specific, company-specific (if there are multiple sites for the same product) or supply chain–specific. Primary data may be obtained through meter readings, purchase records, utility bills, engineering models, direct monitoring, material or product balances, stoichiometry or other methods for obtaining data from specific processes in the value chain of the company.
Product	Any good (tangible product, such as material) or service (intangible product). This includes e.g., services, software, hardware and processed materials.

Definitions	Explanations
Product carbon footprint (PCF)	Total GHG emissions generated during the life cycle of a product, measured in CO_2e. Within the boundary of the PACT Methodology, only material acquisition, pre- processing, production, distribution and storage are included in the PCF.
Product category	Group of products that can fulfill equivalent functions.
Product category rules (PCRs)	A set of specific rules, requirements and guidelines for calculating PCFs (among other things) and developing environmental declarations for one or more product categories according to BS EN ISO 14040:2006.
Proxy secondary data	Data used to bridge data gaps without changing the original values beyond statistical calculations, such as averaging. The selection and use of proxy secondary datasets is usually based on the knowledge and experience of the LCA practitioner, and the possibility to validate such choices is often limited.
Raw material	Primary or secondary material used to produce a product.
Reference Period	Period between the start date and time of the earliest activity data used to calculate PCF and the end date of the latest activity data used. This covers the time for which the data is representative. May also be referred to as reference year.
Residual mix	The mix of energy generation resources and associated attributes such as GHG emissions in a defined geographic boundary left after contractual instruments have been claimed/ retired/canceled. The residual mix can provide an emission factor for companies without contractual instruments to use in a market-based method calculation.
Secondary data	Data that is not from specific activities within a company's value chain but from databases, based on averages, scientific reports or other sources.
Soil carbon pool	Carbon in soil minerals and organic matter less than 2 mm in size. Includes mineral soil organic carbon, organic soil organic carbon and soil inorganic carbon pools.
Stock-change accounting	Accounting approach that estimate the net flux of carbon to or from the atmosphere during a period, based on the net change in carbon stocks in the system at the beginning and end of that period.
Stoichiometry	Method for direct measurement of emissions that uses chemical equations to determine GHG emissions.
Studied product	The product for which the GHG inventory is performed.
Unbundled electricity instrument	An energy attribute certificate or other instrument that is separate, and may be traded separately, from the underlying energy produced.

Definitions	Explanations
Unit process	Smallest part of a product's life cycle for which input and output data is quantified.
Upstream emissions	Indirect GHG emissions that occur in the value chain prior to the processes owned or controlled by the reporting company. All upstream transportation emissions are also included as part of upstream emissions.
Use phase	That part of the life cycle of a product that occurs between the transfer of the product to the consumer and the end-of-life of the product.
Validity period	Period in which the PCF can be used (for reporting or calculation).
Value chain	All the upstream and downstream activities associated with the operations of a company.
Waste	Any substance of object which the holder discards, intends or is required to discard.[78]

Appendix B: Existing standards & guidance

This guidance builds on the work done by the GHG Protocol, ISO, and the European Commission. The table below summarizes a non-exhaustive list of the key standards and geographical focus of these entities.

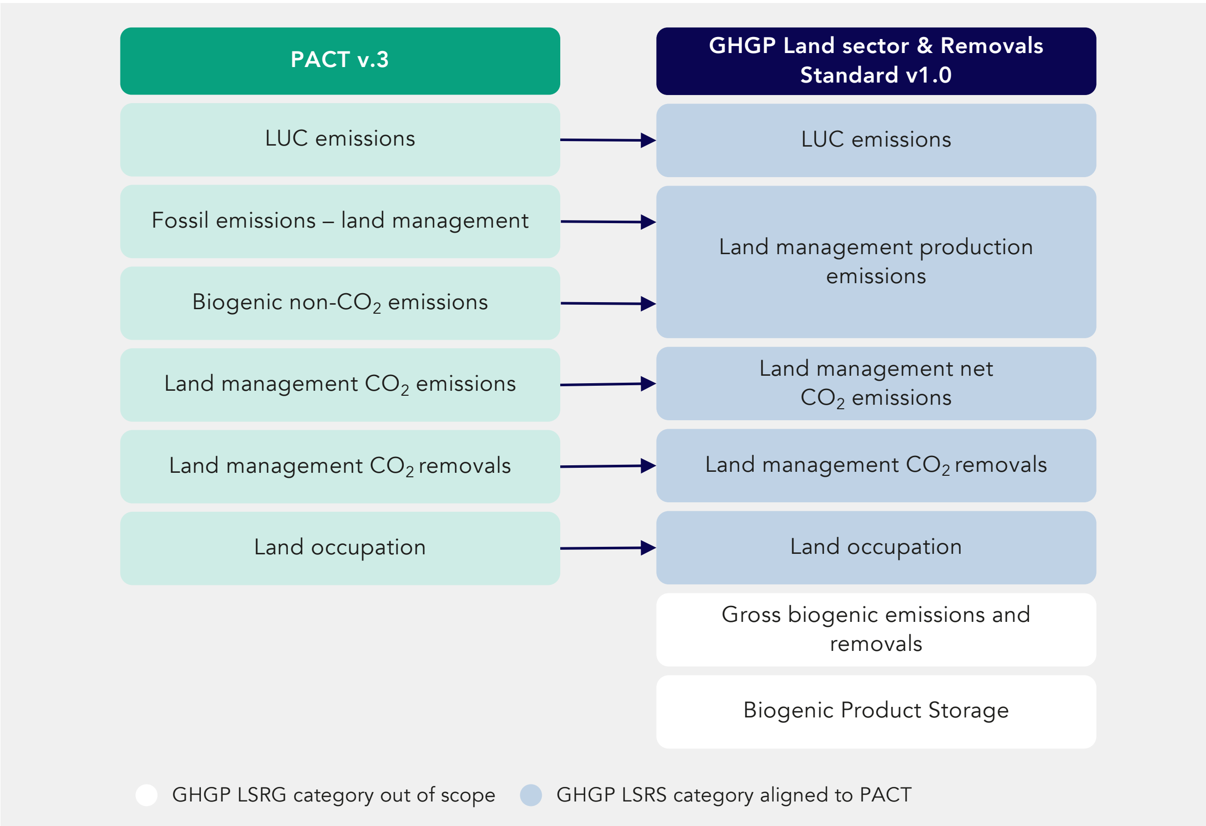
Publisher	Geographical focus	Corporate level	Product level	Specific to given sectors	Description
European Commission	EU	Organizational Environmental Footprint (OEF)	PEF	OEF Sector Rules (e.g., for retail)	PEFCRs (e.g., for IT equipment)
ISO	Global	ISO 14064	ISO 14067 ISO 14040 ISO 14044	ISO 20915:2018 for steel products	PCRs (e.g., ISO 22526 for biobased plastics)
GHG Protocol (WRI/ WBCSD)	Global	Corporate, Scope 2, and Scope 3 standards	Product Life Cycle Standard	E.g., Land Sector and Removals Standard	PCRs (e.g., PCRs for concrete)

78. EU Waste Directive 2008/98/EC

Appendix C: Alignment to GHG Protocol Land sector & removals standard

The biogenic and land sector related emissions & removals section in PACT allows for reporting alignment on the GHG Protocol Land sector & Removals Standard (GHGP LSRS) v.1.0.

As illustrated in the figure below, the LUC emissions, land management CO_2 emissions, and land occupation category align directly with the reporting categories defined in the GHGP LSRS. In PACT's alignment with secondary datasets, the GHGP LSRS category of "land management production emissions" is addressed using data derived from a combination of PACT's "Fossil – Land Management" and "Biogenic non-CO_2 emissions" categories. Since PACT's cradle-to-gate scope (refer to Section 3.2.3 on scope and boundary) does not require companies to report on the use phase or end-of-life stages, it does not provide data on GHGP LSRS gross emissions and removals, nor on product carbon storage.



Appendix D: Elementary flow mapping

The PACT Methodology classifies each 'elementary flow' to a specific PACT reporting category. Elementary flows are exchanges with the natural environment (e.g., emissions of CO_2 to the atmosphere). The elementary flow mapping provides clarity to companies to know what elementary flow is accounted for in what reporting category. This helps directly in mapping own direct GHG emissions, or in the use of secondary datasets. Note that the table contains overlap in categories and might differ based on software of LCIA used.

LCAs are often used to support PCFs calculations and/or other environmental impacts. LCAs include several LCIA methodologies that each have their own set of characterization factors to measure environmental impacts. In order to ensure harmonization, PACT recommends adjusting LCIA for PCF calculation based on the mapping below, or using the IPCC 2021 LCIA Method[79].

LCIAs methods adopt different ways of modelling biogenic CO_2 emissions and uptake. Please note that PACT solely measures biogenic net CO_2 uptake into products (see Section 3.3.2.4 – Biogenic CO_2 uptake) and biogenic CO_2 emissions and removals from net changes in carbon stock on land (see Section 3.3.2.4 – Land use and land use change emissions'). With that, PACT does not measure gross biogenic uptake during biomass growth or gross biogenic CO_2 emissions (e.g., organic waste from pruning). LCIA methods or other guidelines that do measure gross flows, should be adjusted accordingly to ensure alignment with PACT.

Category	Sub-category	Intermediate/ Elementary flows
Fossil Emissions	Fossil emissions	Carbon dioxide, fossil
		Nitrous Oxides, fossil
		Methane, fossil
		Hydrofluorocarbons
		Perfluorinated compounds
		Perfluorocarbons
		Chlorofluorocarbons
		Hydrochlorofluorocarbons
		Fluorinated ethers
Biogenic non-CO_2 emissions	Biogenic non-CO_2 emissions	Methane, non- fossil, biogenic

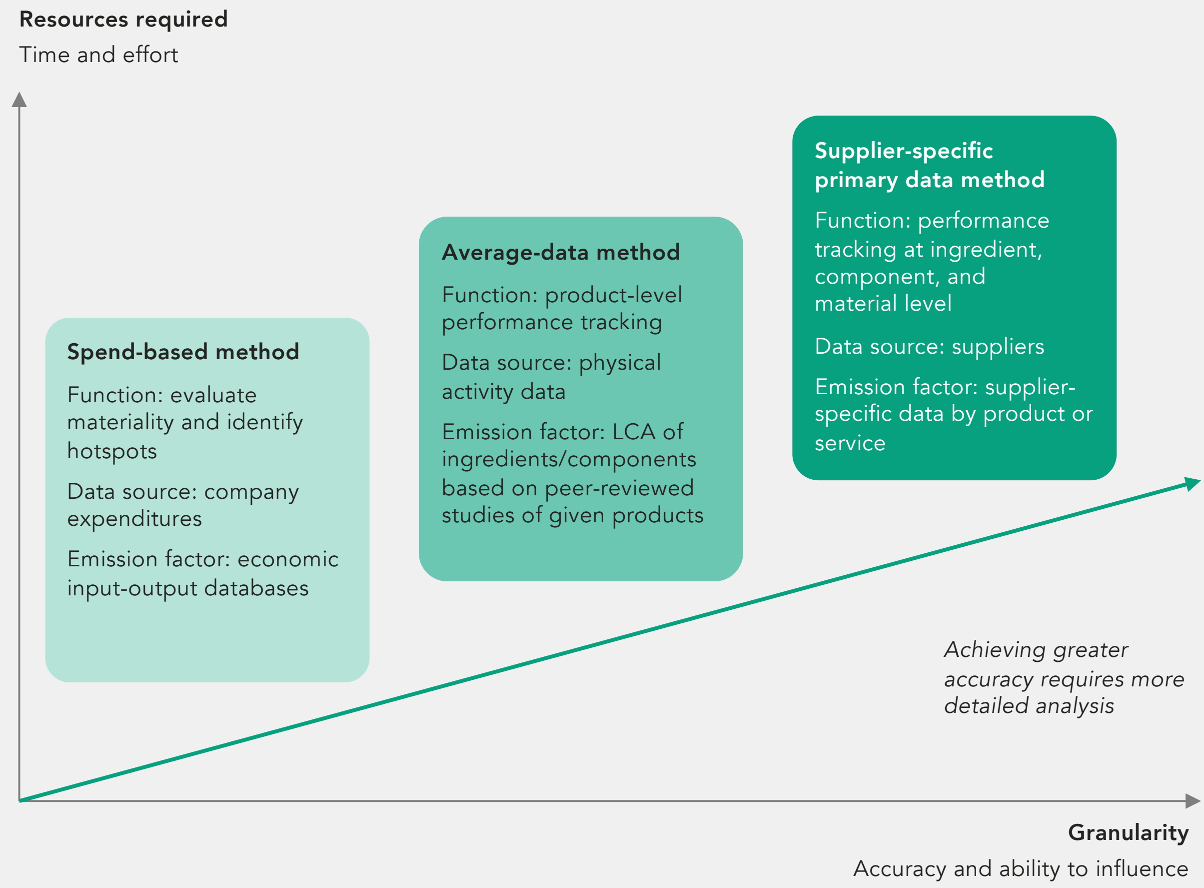
79. PACT acknowledges the current inconsistencies with current Life Cycle Impact Assessment (LCIAs) included different GHGs and will investigate in creating a PACT LCIA to be implemented in LCA software. In the meantime, PACT recommends the IPCC 2021 LCIA Method

Category	Sub-category	Intermediate/ Elementary flows
Land use and Land use change	LUC emissions[a]	Carbon dioxide, land transformation/ Land use change
		Carbon dioxide, peat oxidation[b]
		Methane, land transformation
	Land management biogenic CO_2 emissions	Carbon dioxide, from soil or biomass stock
		Methane, from soil or biomass stock
		Carbon dioxide, peat oxidation[b]
GHG Removals	Land management CO_2 removals[c]	Carbon dioxide, to soil or biomass stock
Biogenic CO_2 uptake	Biogenic product CO_2 uptake[d]	Carbon dioxide, in air
		Carbon dioxide, Renewable resources
		Carbon dioxide, non fossil, resource correction
Land tracking	Land occupation	Land occupation, per land use type

a. The flows listed under 'LUC emissions' are intermediate flows that include a subset of elementary flows including the ones listed as 'land management biogenic CO_2 emissions'.
b. Emissions associated with peat oxidation are carbon dioxide, methane and dinitrogen monoxide and might happen due to LUC or land management practices.
c. Land management CO_2 removals are subject to requirements outlined in Section 3.3.2.4.
d. Biogenic CO_2 uptake only measures the biogenic CO_2 that ends up in the final product (matches the biogenic carbon content in product). As such a resource correction might need to take place to ensure the Biogenic CO_2 uptake matches the physical amount of biogenic carbon content in the product.

Appendix E: Scope 3 upstream accounting methods

Currently, three main methods are used to account for upstream Scope 3 emissions. These methods are defined by their accuracy and the type of data that the calculations are based on.



Source: EcoAct, 2021

Spend-based method

Companies calculating Scope 3 emissions for the first time tend to use data already being collected for other company processes, such as company expenditures, and to multiply these by a revenue intensity factor representing the Scope 1 and 2 emissions per dollar revenue for an activity or sector. While this method is less precise when quantifying emissions, it offers an initial overview of the focus areas within a value chain. This, in turn, allows companies to adapt their strategies to improve data quality based on the activities or products that have a greater impact. This method should only be seen as a first step in the quantification of Scope 3 emissions, after which companies should seek to improve data collection to achieve greater accuracy, as shown in the figure above.

Average-data method

The second method uses physical metrics, i.e., primary activity data on material weight, fuel consumption, or distances traveled that allows the use of relevant secondary emission factors that are more specific to the nature and origin of these components when carrying out the calculations.

These secondary emission factors can be found in process-based life cycle inventory databases and are present in the format of cradle-to-gate emission factors of the purchased good or service per unit of mass or unit of product.

While this is a step in the right direction, it continues to rely on industry averages, which hinders companies' abilities to determine the best- performing supplier for any given product or material or to understand how well company initiatives to reduce emissions (e.g., supplier engagement programs) are performing.

Supplier-specific data method

The ultimate goal, while requiring greater effort, is to obtain product-level emissions data directly from suppliers, as this allows companies to collaborate with their supply chain to improve the efficiency of products and services purchased and accurately monitor the impact of these improvements on the footprint. This, in turn, can become a procurement criterion rewarding companies that are more sustainable or even supporting suppliers in their GHG reduction journeys.

Disclaimer

This paper is released by the Partnership for Carbon Transparency at WBCSD, which is responsible for final conclusions and recommendations. Like other WBCSD-authored papers, it incorporates contributions from WBCSD staff, experts from member organizations, and other key climate ecosystem players. Use of member company logos indicates participation and assistance in developing this guidance document and does not imply endorsement of all concepts presented or a commitment to apply the guidance.

About PACT

PACT offers a streamlined methodology for calculating and exchanging product carbon footprints (PCFs) to promote decarbonization across value chains.

Powered by WBCSD, PACT harmonizes the PCF calculation and exchange through a universal methodology, technical specifications for PCF exchange, and an ecosystem enriched by a network of committed, impact-driven companies.

With participation from more than 150 stakeholders, including businesses, policymakers, and standard setters, PACT collaborates with over 11 industry-specific initiatives. More than 2,500 companies have adopted PACT, striving to accelerate supply chain transparency and foster decarbonization within the private sector, driving sustainable and enduring business practices. If you would like to find out more about PACT, please contact:

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The World Business Council for Sustainable Development (WBCSD) is a global community of over 240 of the world's leading businesses driving systems transformation for a better world in which 9+ billion people can live well, within planetary boundaries, by mid-century. Together, we transform the systems we work in to limit the impact of the climate crisis, restore nature and tackle inequality.

We accelerate value chain transformation across key sectors and reshape the financial system to reward sustainable leadership and action through a lower cost of capital. Through the exchange of best practices, improving performance, accessing education, forming partnerships, and shaping the policy agenda, we drive progress in businesses and sharpen the accountability of their performance.

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