Catena-X Automotive Network

Catena-X Product Carbon Footprint Rulebook

CX-PCF Rules

Version 2

Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

Catena-X Automotive Network

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Glossary

Term	Definition	Source
Allocation	Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems	DIN EN ISO 14040, Feb. 2021, p. 12
Attributable process	Those processes that consists of all service, material and energy flows that become, make and carry a product throughout its life cycle.	WBCSD Pathfinder
Biogenic carbon	Carbon derived from biomass	DIN EN ISO 14067, Feb. 2019, p. 29
Carbon offsetting	Mechanism for compensating for a full PCF or a partial PCF through the prevention of the release of, reduction in, or removal of an amount of GHG emissions in a process outside the product system under study	DIN EN ISO 14067, Feb. 2019, p. 18
Closed-loop recycling	In a closed loop, the secondary material from one product system is either reused in the same product system (real closed-loop) or used in another product system without changing the inherent technical properties of the material (quasi closed-loop).	
CO_2e (carbon dioxide equivalent)	Unit for comparing the radiative forcing of a greenhouse gas to that of carbon dioxide	DIN EN ISO 14067, Feb. 2019, p. 20
Co-product	Any of two or more products coming from the same unit process or product system	DIN EN ISO 14067, Feb. 2019, p. 22
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 suppliers' gate	WBCSD Pathfinder
Cut-off criteria	Specification of the amount of material or energy flow or the level of significance of GHG emissions associated with unit process or the product system, to be excluded from a PCF study	DIN EN ISO 14067, Feb. 2019, p. 24
Declared unit	Quantity of a product for use as a reference unit in the quantification of a Cradle-to-Gate PCF	adapted from DIN EN ISO 14067
Direct emissions	GHG emissions from the processes that are owned or controlled by the reporting company	WBCSD Pathfinder
Downstream emissions	Indirect GHG emissions that occur in the value chain following the processes owned or controlled by the reporting company	WBCSD Pathfinder
End-of-waste	The end-of-waste state for waste in Europe is reached when the material is no longer considered waste under the national implementation of the Waste Framework Directive.	EN 15804
Functional unit	Quantified benefit of a product system for use as a comparison unit	
Global warming potential (GWP)	Index, based on radiative properties of GHGs, measuring the radiative forcing following a pulse emission of a unit mass of a given GHG in the present-day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide (CO_2)	DIN EN ISO 14067, Feb. 2019, p. 21

Term	Definition	Source
Greenhouse gases (GHGs)	Gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds	DIN EN ISO 14067, Feb. 2019, p. 19
ILCD Format	International Life Cycle Data Format	
Input	Product, material, or energy flow that enters a unit process	WBCSD Pathfinder
Land use	Human use or management of land within the relevant boundary	DIN EN ISO 14067, Feb. 2019, p. 30
Life cycle	Consecutive and interlinked stages related to a product, from raw material acquisition or generation from natural resources to end-of-life treatment	DIN EN ISO 14067, Feb. 2019, p. 25
Life cycle assessment (LCA)	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle	DIN EN ISO 14067, Feb. 2019, p. 25
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	WBCSD Pathfinder
Life cycle inventory (LCI)	The phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle (such as a product's GHG emissions and sources)	DIN EN ISO 14067, Feb. 2019, p. 25
Life cycle inventory results	GHG impact of the studied product per unit of analysis	WBCSD Pathfinder
Material	Physical good used as input for production processes of goods or services, or physical good supplied to a customer as output	adapted from WBCSD Pathfinder
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	WBCSD Pathfinder
Negative emissions	Removal of greenhouse gases (GHGs) from the atmosphere by deliberate human activities, i.e., in addition to the removal that would occur via natural carbon cycle processes	IPCC glossary
Net negative emissions	A situation of net negative emissions is achieved when, as the result of human activities, more greenhouse gases are removed from the atmosphere than are emitted into it. Where multiple greenhouse gases are involved, the quantification of negative emissions depends on the climate metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential, and others, as well as the chosen time horizon).	IPCC glossary
Net zero CO_2 emissions	Net zero carbon dioxide (CO_2) emissions are achieved when anthropogenic CO_2 emissions are balanced globally by anthropogenic CO_2 removals over a specified period. Net zero CO_2 emissions are also referred to as carbon neutrality.	IPCC glossary
Net zero emissions	Net zero emissions are achieved when anthropogenic emissions of greenhouse gases into the atmosphere are	IPCC glossary

Term	Definition	Source
	balanced by anthropogenic removals over a specified period. Where multiple greenhouse gases are involved, the quantification of net zero emissions depends on the climate metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential, and others, as well as the chosen time horizon).	
Open-loop recycling	In open-loop recycling, the material is reused in other product systems and its inherent properties are changed (e.g., recycled material may have a different chemical composition, a different structure or a higher concentration of dissolved impurities compared to primary material).	
Output	Product, material, or energy that leaves a unit process	WBCSD Pathfinder
Paris Agreement	The Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) was adopted on December 2015 in Paris, France, at the 21st session of the Conference of the Parties (COP) to the UNFCCC. The agreement, adopted by 196 Parties to the UNFCCC, entered into force on November 4, 2016 and as of May 2018 had 195 Signatories and was ratified by 177 Parties. One of the goals of the Paris Agreement is "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels", recognizing that this would significantly reduce the risks and impacts of climate change. […]	IPCC Glossary
Partial PCF	Sum of GHG emissions and GHG removals of one or more selected process(es) in a product system, expressed as carbon dioxide equivalents and based on the selected stages or processes within the life cycle.	DIN EN ISO 14067, Feb. 2019, p. 16
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.	WBCSD Pathfinder
Process	Set of interrelated or interacting activities that transforms inputs into outputs.	DIN EN ISO 14067, Feb. 2019, p. 23
Product	Any good (tangible product) or service (intangible product).	Adapted from WBCSD Pathfinder
Product carbon footprint (PCF)	Total GHG emissions generated during the life cycle of a product, measured in CO_2e. Within the boundary of the CX-PCF Rulebook, emissions related to the product use and end-of-life stages are excluded from the PCF.	WBCSD Pathfinder
Product category	Group of products that can fulfill equivalent functions.	WBCSD Pathfinder
Product category rules (PCR)	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 EN ISO 14040:2006.	WBCSD Pathfinder

Term	Definition	Source
Product system	Collection of unit processes with elementary flows, performing one or more defined functions and which models the life cycle of a product.	DIN EN ISO 14067, Feb. 2019, p. 22
Raw material	Physical primary or secondary good used as input to produce a good or service.	Adapted from WBCSD Pathfinder
Reference flow	Measure of the inputs to or outputs from processes in a given product system required to fulfil the function expressed by the functional unit.	DIN EN ISO 14067, Feb. 2019, p. 24
Renewable Energy	Energy from renewable sources' or 'renewable energy' means energy from renewable non-fossil sources, namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas.	Renewable Energy Directive (2018/2001)
Representative product	The representative product can be a real or an averaged (non-existing) product. The averaged product should be calculated based on sales-weighted characteristics of all technologies/materials used in the company's production system.	
Risk management	Plans, actions, strategies, or policies to reduce the likelihood and/or consequences of risks or to respond to consequences.	IPCC Glossary, p. 45
Secondary data	Secondary data can include data from databases and published literature, default emission factors from national inventories, calculated data estimates or other representative data, validated by competent authorities.	DIN EN ISO 14067, Feb. 2019, p. 28
Supplier gate	Supplier's production site or supplier's distribution site.	
Supply chain	Those involved, through upstream and downstream linkages, in process and activities relating to the provision of products to the user.	DIN EN ISO 14067, Feb. 2019, p. 28
Sustainability	A dynamic process that guarantees the persistence of natural and human systems in an equitable manner.	IPCC Glossary, p. 49
System boundary	Boundary based on a set of criteria representing which unit processes are a part of the system under study.	DIN EN ISO 14040, Feb. 2021, p. 13
Unit process	Smallest element considered in the life cycle inventory analysis for which input, and output data are quantified.	DIN EN ISO 14067, Feb. 2019, p. 23
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.	WBCSD Pathfinder
Use stage	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.	Adapted from WBCSD Pathfinder
Value chain	All the upstream and downstream activities associated with the operations of a company.	WBCSD Pathfinder
Waste	Materials, co-products, products, or emissions without economic value that the holder intends or is required to dispose of.	DIN EN ISO 14067, Feb. 2019, p. 26; WBCSD Pathfinder

1. Introduction

1.1 The automotive industry and the climate crisis

The automotive industry is a customer-facing industry with high visibility at the cutting-edge of climate action and is a solution provider in the current climate crisis driving the transition towards low-emission mobility. Nevertheless, the global challenge to reduce GHG emissions also requires the automotive industry to measure its GHG emissions on the product level for the status-quo as well as any emissions reductions. Measuring the product carbon footprint for vehicles is a challenge, due to the enormous complexity of the international automotive supply chain. A vast number of materials and parts are used for vehicles. Even identical materials and parts are usually produced by different companies in different locations to ensure supply chain resilience and risk management.

1.2 The challenge

For many years, the automotive industry and suppliers have applied well-established methods to calculate the product carbon footprint (PCF) and report the results in line with international standards such as the ISO 14040, 14044 and 14067 standards or the GHG Protocol Product Standard.

For today's portfolio of combustion engine-powered vehicles running on fossil fuel, 70 – 90% of the product carbon footprint is caused by the use stage and 10 - 30% from the production stage, including the supply chain (see also ACEA 2021[1] p. 3). The state of the art in product carbon footprinting has been considered sufficient in addressing the trade-offs between efforts and benefits. However, the latest and future powertrain technologies and fuel pathways will reduce the overall GHG emissions of vehicles and shift for battery electric vehicles some emissions contribution from use to production along the supply chain toward 50% (see also ACEA 2021[1] p. 3). Hence, the majority of GHG emissions in the life cycle of vehicles will occur during the production stage and will require a more precise quantification compared to the current state of the art.

Product carbon footprint and life cycle assessment standards and methods exist in the ISO 14040, 14044 and ISO 14067 standards as well as the GHG Protocol Product Standard, the WBCSD Pathfinder Framework and sector-specific guidelines such as Product Category Rules. However, these standards and methods are not sufficiently prescriptive and thus leave room for interpretation. Therefore, companies are not consistently applying these standards and methods. Consequently, product carbon footprints reported from different companies do not follow one consistent approach and comparability is limited. In addition, the current application of well-established methods is mostly based on industry average data. Hence, the status-quo emissions are not specific to a supply chain and deviations between different supply chains remain unrecognized.

For the automotive industry, this constitutes a major obstacle to reaching emissions reduction goals. Hence, the automotive industry is in great need of consistent product-specific GHG emissions reporting with comparability across the industry.

This awareness of this need for a higher level of accuracy and consistency is shared by several sector initiatives, which have sector-specific product carbon footprint accounting rules which have been published, are under development or are being planned. Those initiatives, however, do not always bring the level of consistency required in the automotive sector, nor the cross-industry comparability which is necessary for reliable and comparable figures at the supply chain level. Combined with increasing product-level regulatory requirements, such as the EU Digital Passport regulation, stronger integration of those initiatives is needed.

The automotive industry is ideally positioned to lead this cross-industry supply chain dialogue given its reach across sectors, the quantities of materials supplied and its focus on high-quality materials, in many instances due to safety requirements. By exchanging comparable and verified product carbon footprints based on product-level primary GHG emissions data, automotive companies will be able to identify, improve and accelerate decarbonization efforts in their supply chains and in particular hard-to-abate sectors, playing their part in ensuring there is a real chance of meeting the Paris Agreement targets.

In the past, these deviations during production did not lead to significant deviations over the entire life cycle due to the high contribution of the use stage.

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[1] https://www.acea.auto/files/ACEA_position_paper-Life_Cycle_Assessment.pdf

Supplier-specific GHG emissions based on an increasing share of primary data can be obtained by accounting and reporting at the product level for each part of the supply chain, i.e., a company. The Catena-X network's eco-system enables data-driven value chains, which will allow companies to efficiently exchange data by maintaining full data sovereignty, which ensures that any sensitive information will be hosted within the respective company.

However, the problem of insufficiently prescriptive standards remains and, thus, reported PCFs may differ significantly between companies, even though identical parts with identical processes have been applied. These differences would not come from factual differences but are related to differing interpretations of PCF standards. Due to the climate goals of companies, product carbon footprints will become a critical KPI in the purchase of parts and materials and, thus, PCFs need to provide a robust basis for decision-making, i.e., differences in PCFs should only be caused by factually deviating emissions. Consequently, a more detailed view of the accounting methods for PCFs in the automotive supply chain is necessary for exchanging PCFs via the Catena-X network.

1.3 The purpose of this document

To reduce the room for interpretation, Catena-X developed this Product Carbon Footprint Rulebook with a focus on the exchange of production carbon footprints from tier to tier with increased consistency for PCF accounting. This increased consistency will ensure comparability for the PCFs of parts and components and allow for part and supplier selection. Consequently, the Catena-X Rulebook focusses on the production stage of vehicles.

At the same time, accounting for product carbon footprints is, for the most, currently part being applied in large companies, and smaller companies lack the knowledge and resources to account for the emissions of their products. Hence, this rulebook needs to carefully balance applicability and comparability of product carbon footprint accounting to ensure the rules are scalable along the entire supply chain. For this purpose, the Catena-X Rulebook foresees the application of some rules after a transition period in order to allow companies to adopt more complex rules. Additionally, guidance materials will be developed and cooperation with stakeholders representing small-to-medium-sized enterprises will be strengthened in the near future.

As data sovereignty prohibits the full disclosure of the information required for PCF accounting, the Catena-X PCF Rulebook defines indicators for data quality and the amount of primary data used for PCF accounting to increase trust along the value chain.

The automotive supply chain has enormous complexity, using materials produced by various industry sectors including steel making, chemical production, electrical parts and computer chips. Therefore, the Catena-X PCF Rulebook allows for the application of existing or new sectoral guidance and product category rules if recommended or accepted by Catena-X. For this purpose, Catena-X is seeking close alignment with other initiatives such as the Together for Sustainability initiative representing the chemical industry and the industry-agnostic overarching Pathfinder Initiative by WBCSD and will engage with other relevant stakeholders in the future. Furthermore Catena-X will establish a governance process and criteria for sector guidance acceptance through Catena-X.

In addition, Catena-X makes its PCF Rulebook available to the public and is open for any feedback to ensure public acceptance of the reported PCFs on the Catena-X network.

This document is not intended to provide guidance to fully cover Corporate Scope 3 Accounting, Scope 3.1. purchased goods (GHG protocol).

2. Setup of the framework

2.1 Version

This is version 2 of the Catena-X Product Carbon Footprint Rulebook released in April 2023. This rulebook will be updated and PCFs shall thus be calculated according to the latest available version of this rulebook.

2.2 Terminology: Shall, should, may, can

Clarification on ISO expressions used in the rulebook

The following definitions apply in understanding how to implement an ISO International Standard and other normative ISO deliverables

- The term "shall" indicate what is required for a CX-PCF to be compliant with this rulebook.
- The term "should" indicate a recommendation rather than a requirement. Any deviation from a "should" recommendation must be justified by the party conducting the study and made transparent.
- The term "may" indicate an option that is permissible.
- The term "can" is used to indicate that something is possible, for example, that an organization or individual is able to do something.

Additional definitions of frequently used terms throughout the rulebook can be found in the Glossary (see page A).

2.3 Topics out of scope

The Catena-X Rulebook focusses on the production of vehicles and, thus, PCF accounting spans from cradle-to-(factory)gate for vehicles and components and all intermediate products. Therefore, recycling is currently only reflected in the PCF through the use of secondary material. To holistically account for recycling and assess recycling strategies, other methods are required, but currently out of scope.

2.4 Transition period

This document foresees a transition period after the official start of the Catena-X PCF exchange network. Sections marked as "after the transition period" are voluntary within the transition period. After the transition period, these sections are planned to be substituted by the section marked as "within transition period" and will thus become mandatory. The transition period will be defined in 2023 and included in Version 3.

3. Existing methods and standards

3.1 Relationship

The Catena-X Product Carbon Footprint Rulebook (CX-PCF rules) is based on the product carbon footprint standard ISO 14067 and the ISO 14040 and 14044 life cycle assessment standards (Figure 1).

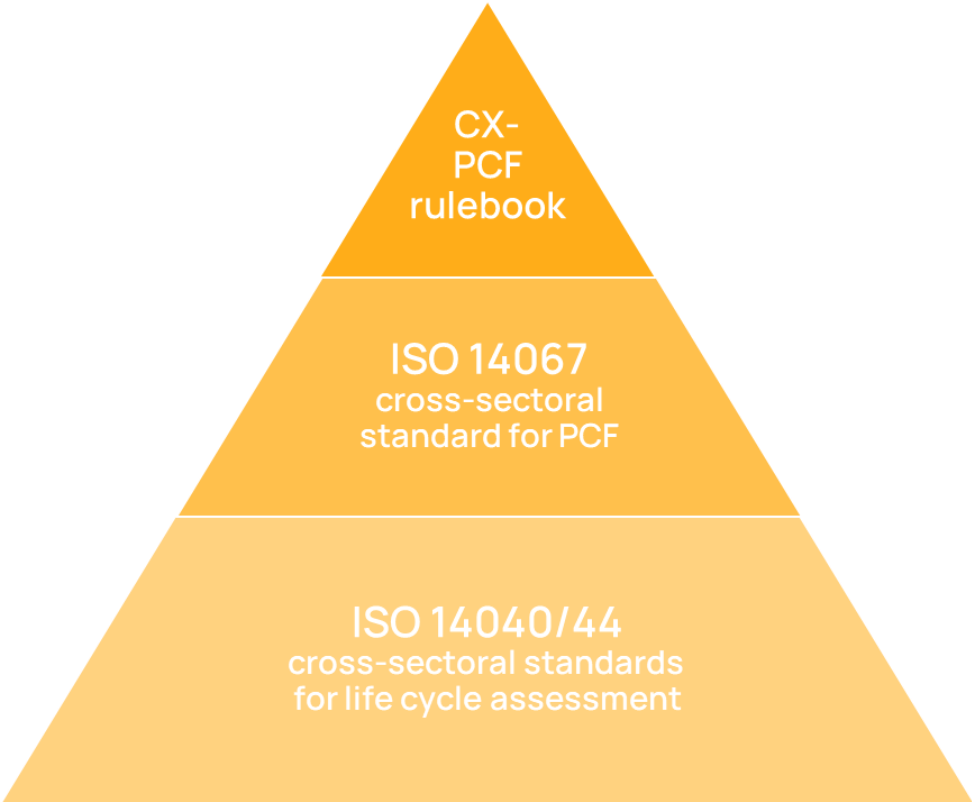


Figure 1: Relationship of standards.

The CX-PCF rules further specify existing standards and, if applicable, refer to sectoral guidance and product category rules for product carbon footprints in automotive supply chains.

If necessary, additional sector-specific and product category rules are prescribed and are referenced within the rulebook.

The CX-PCF-rulebook is closely aligned with the WBCSD Pathfinder Framework. Further alignment with sector initiatives is already ongoing with Together for Sustainability (TfS) and the Global Battery Alliance (GBA), others will be included in the future.

3.2 Hierarchy of conformity

Existing rules shall be applied according to the following hierarchy:

1. The product carbon footprints shall be calculated in accordance with ISO 14067.
2. Automotive supply chain-specific requirements shall be applied as defined in this document.
3. Sector-specific and product-specific rules should be applied if prescribed within this rulebook.

Additional sector-specific or product-specific guidance will be added, if necessary, in future revisions of this document.

Information on the applied methods or standards shall be shared downstream as part of the elements for data exchange (Section 7.1) to create greater transparency and enable comparability.

4. Scope and system boundary

The CX-PCF rules are based on the attributional LCA approach. This approach seeks to determine the environmental impacts associated with a product's life cycle. The global warming potential (GWP), expressed in CO_2 equivalents, is attributed to a specific unit of a product by adding up the CO_2 equivalents of all attributable processes along its life cycle.

4.1 Focus on carbon footprint

The CX-PCF Rulebook provides the methodological framework for assessing the product carbon footprint.

The GHGs that shall be accounted for are identified within the GHG Protocol entitled "Required Greenhouse Gases in Inventories: Accounting and Reporting Standard Amendment". The list includes carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorinated compounds, sulfur hexafluoride (SF_6), nitrogen trifluoride (NF_3), perfluorocarbons (PFCs), fluorinated ethers (HFEs), perfluoropolyethers (e.g., PFPEs), chlorofluorocarbon (CFCs) and hydrochlorofluorocarbon (HCFCs).

The 100-year GWP characterization factors (GWP100y) according to the Intergovernmental Panel on Climate Change (IPCC) shall be used in the PCF calculations, based on the IPCC's Sixth Assessment Report (AR6). These factors include the climate carbon response for non-CO_2 gases, i.e., carbon feedbacks and chemical effects.

The AR 6 characterization factors for the substances that are not listed in Table 7.15 of the IPCC AR6[2] shall be extracted from Table 7.SM.7 in Section 7 Supplementary Materials of the AR6 Climate Change 2021 Physical Science Basis[3].

Currently different GHG accounting schemes, i.e., PCF including (ISO 14067) and excluding biogenic CO_2 (PEF and GHG protocol), are applied.

Since, currently, the biogenic content of products and materials is usually low, the total PCF excluding biogenic CO_2, i.e., the sum of the separate emission values 1+2+3 listed below, shall be reported within the transition period.

In addition, after the transition period, the total PCF including biogenic CO_2, i.e., the sum of the separate emission values 1+3+4, shall be reported. Note that reporting of the total PCF including biogenic CO_2 is mandatory within the transition period if compliance with ISO 14067 is requested.

In addition to the total PCF, the separate emission values shall be reported:

1. Net fossil GHG emissions and removals
2. Net biogenic GHG emissions and removals other than biogenic CO_2 (if applicable)
3. GHG emissions and removals from land use and direct land use change (if applicable)
4. Net biogenic GHG emissions and removals including biogenic CO_2 (if applicable and optional during transition period)
5. GHG emissions resulting from aircraft transportation (if applicable)

If separate emission values do not occur, these emission values may be reported as zero.

Removals in the PCF shall not include any measures not related to the production system usually referred to as offsets (see Section 7.2.7).

In addition, the biogenic carbon content and total carbon content of products shall be reported separately.

If mass-balanced materials are used in the supply, the attributed biogenic carbon content shall additionally be reported to accurately account for emissions from combustion of these materials.

4.1.1 Accounting for carbon uptake (biogenic or fossil)

Uptake of atmospheric CO_2 shall be assigned with a characterization factor of -1 kg CO_2eq per kg CO_2; the emission of CO_2 shall be assigned with a factor of 1 kg CO_2eq per kg CO_2. If plants absorb atmospheric CO_2,

[2] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07.pdf
[3] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_07_Supplementary_Material.pdf.

the CO_2 uptake shall be considered in the separate emission value 4 (Net biogenic GHG emissions and removals including biogenic CO_2).

4.2 System boundaries

In general, the life cycle of a product comprises five stages: (1) resource extraction, raw material sourcing, (2) production, (3) distribution and storage, (4) product use and (5) end-of-life (Figure 2). The CX-PCF scope represents a reduced subset of these stages, excluding product use and end-of-life. This partial PCF, exchanged by a company (supplier), can then be used to calculate the PCF, e.g., of a vehicle over the complete life cycle by the customer (e.g., OEM).

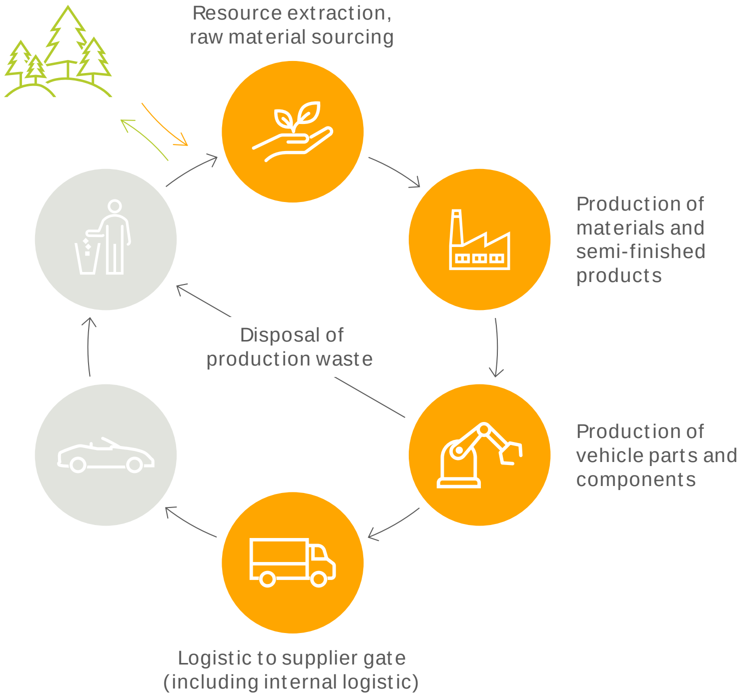


Figure 2: System boundaries for Catena-X PCF.

The cradle-to gate PCF of the CX-PCF Rulebook includes all attributable upstream and direct emissions of producing a product, including all upstream transportation activities. The life cycle emissions that shall be accounted for in this cradle-to-gate PCF exclude downstream emissions related to the product use and end-of-life stages.

When accounting for emissions, companies shall further define their cradle-to-gate boundary by listing all the attributable processes of their studied product.

The CX-PCF rules system boundaries are therefore:

- Resource extraction, raw material sourcing
- Production of materials, semi-finished products
- Production of vehicle parts and components
- Packaging of vehicle parts and components
- Disposal of production waste
- Logistics to supplier gate (including internal logistics) (Section 5.2.1)

In general, GHG emissions not connected directly to the production system relevant for the product, e.g., employee commuting, research and development or administration should be excluded from the system boundaries.

4.2.1 Cut-off rules

In general, all processes and flows that are attributable to the analyzed system shall be included. If, based on the results of a screening study, individual material or energy flows are found to be insignificant for the carbon footprint, these may be excluded for practical reasons (see ISO 14067, PEF method). Process modules, inputs and outputs may only be excluded if their sum represents less than 1% of the total product carbon footprint. This 99% coverage shall be achieved and documented in a screening study.

Screening study

An initial screening of the Life Cycle Inventory (LCI) of (a) representative product(s) shall be performed by the supplier, referred to as the screening step. The screening focusses on data collection activities and data quality priorities. A screening shall include the Life Cycle Impact Assessment (LCIA) for the Impact Category Global Warming Potential and allow further refinement of the life cycle model of the product in scope in an iterative manner as more information becomes available. Within screening, no cut-off is allowed, and readily available primary or secondary data may be used, fulfilling the data quality requirements to the extent possible.

To determine the 99% coverage, the PCF data received from suppliers and emission factors shall be considered as 100%, as verification of the actual coverage over the upstream supply chain is impossible.

Once the screening is performed, the initial scope settings may be refined. The representative product approach and a description of the excluded attributable processes shall be documented.

The screening study shall be updated at the end of the validity period of the CX-PCF (see Section 7.2.1), so that possible changes of significant activities can be taken into account.

Compliance can be proven on a product category or sectoral level and does not have to be executed on a product level. Product category rules or sectoral guidance can specify simplified rules that can be applied after the Catena-X sectoral guidance acceptance process.

4.3 Declared unit

The product carbon footprint shall be assessed for a declared unit. A functional equivalent is established by the data recipient and lies beyond the scope of the Catena-X PCF Rulebook.

For countable products, i.e., a component or part, the declared unit shall be 1 piece as described in the part description including a defined weight and the part ID.

For materials, i.e., mass products or commodities, the declared unit shall be 1 kg of products, regardless of its state (solid, liquid, gas), as its specific density is considered.

If packaging is included, the declared unit is 1 kg or 1 piece of unpackaged product at the factory gate. The PCF however includes the packaging (also refer to 4.3).

5. Guidance for product carbon footprinting

5.1 Accounting for product carbon footprint

System boundaries shall include all attributable processes that comply with the cut-off criteria (see Section 4.1)

5.1.1 Calculation

To be included in the supplementary guidance.

5.1.2 Allocation

Allocation shall be avoided whenever possible. If allocation cannot be avoided, follow the approach in Figure 3.

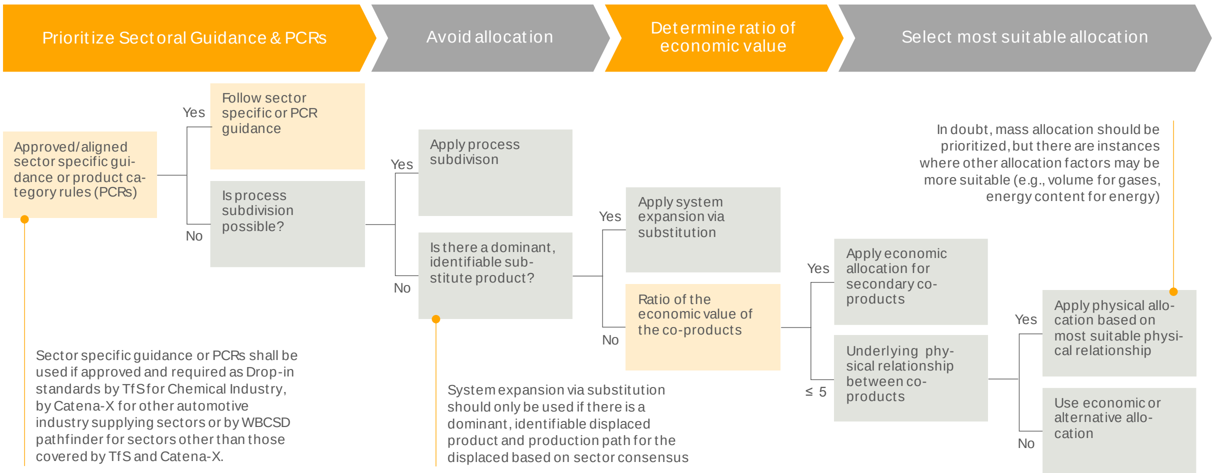


Figure 3: Multi-output allocation decision procedure

If sector-specific guidance or a PCR exists, a legal entity producing a product belonging to a category in this sector shall follow this guidance or PCR to identify the adequate multi-output allocation approach. The prerequisite for the application of the sector-specific or PCR is an alignment and acceptance via the Catena-X governance process or an initiative representing an industry sector and authoring a sector guidance which is accepted by Catena-X as drop-in standard. Any remaining differences or contradictions to the Catena-X Rulebook in an accepted sector guidance or PCR will be handled via the governance process and, if required, additional guidance will be provided.

If no approved or aligned sectoral guidance or PCR is available and subdivision is possible, subdivision shall be applied.

Subdivision refers to disaggregation of multifunctional processes or facilities to isolate the input flows directly associated with each process or facility output.

If subdivision cannot be applied, but a dominant substitute product can be identified, expanding the product system to include the additional functions related to the co-products shall be applied.

System expansion via substitution shall only be used in accordance with the following conditions, also reflected in Notes 1., 2. and 3. In Figure 4:

- 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.
- If in doubt, mass allocation should be prioritized, but there are instances in which other allocation factors may be more suitable (e.g., volume for gases, energy content for energy).
- Sector-specific guidance or PCRs shall be used, if approved and required, as drop-in standards by TfS for the chemical industry, by Catena-X for other automotive industry supplying sectors or by WBCSD pathfinder for sectors other than those covered by TfS and Catena-X.

Double counting shall be avoided. No market-mediated effects shall be applied, as the attributional LCA approach shall be used (see 4.1).

When allocation cannot be avoided, no subdivision is possible and no dominant substitute product can be identified, companies shall calculate the ratio of the economic value of the reference product to each co-product. This ratio is employed in the next step of the decision tree to determine the most suitable allocation approach. For the use of economic values, sales prices shall be averaged over the last 5 years to smooth out fluctuations. If sales prices are not available or not applicable, other economic factors can be applied (e.g., cost).

If the calculated ratio is higher than five, companies shall apply an economic allocation using economic value as criterion to partition inputs and outputs between the studied co-product(s).

If the calculated economic value ratio is equal or lower than five, companies shall apply allocation using a physical relationship to partition inputs and outputs between the studied co-product(s). The physical relationships to choose from are:

- produced pieces
- produced masses
- contained exergy
- contained energy

If no underlying physical relationship between the co-products can be identified economic allocation is an additional option.

[Catena-X, WBCSD and TfS have already aligned on the multi-output allocation approach; this alignment still needs to be reflected in coming updates of the respective sector guidance and framework standard. Further alignment activities with other sectors will be handled via the Catena-X governance process for sector guidance acceptance, which has yet to be established.]

5.2 Additional guidance

5.2.1 Emissions from transportation

In addition to emissions from production and manufacturing, there are also emissions from the transportation of products. All upstream transportation processes shall be included in the product carbon footprint, i.e., included in the cradle-to-gate system boundaries. The same applies to in-house logistics unless cut-off rules apply (see 4.2.1 Cut-off-Rules). This section deals with transportation from a supplier to its customer.

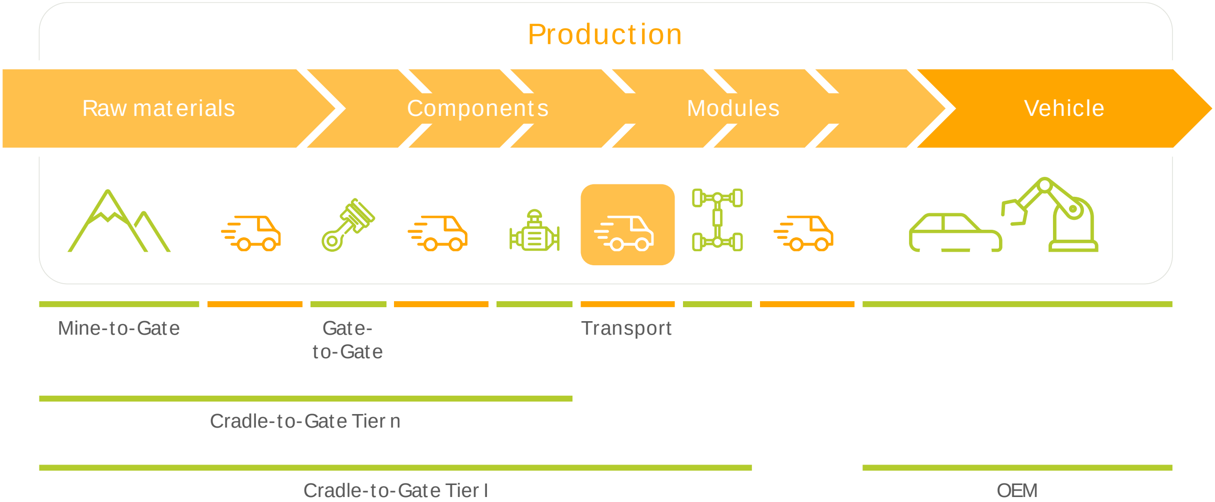


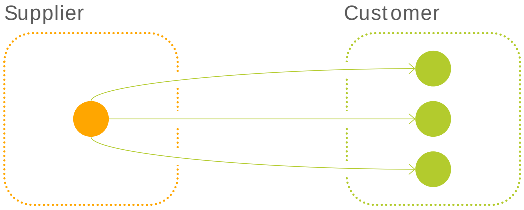
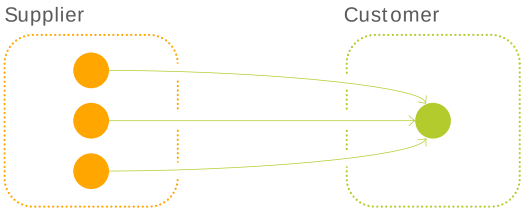
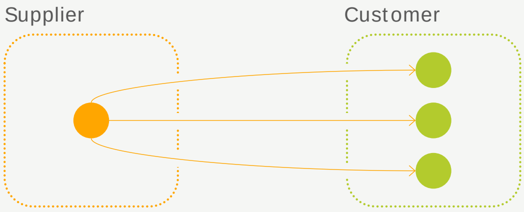
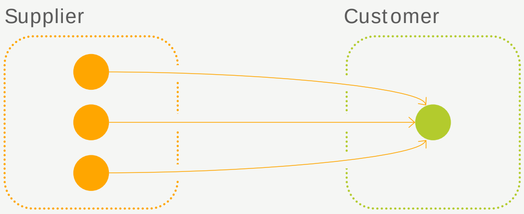
Figure 4: Definition of Scopes.

As for the product carbon footprint, the cradle-to-gate boundaries end at the suppliers' gates (cf. Section 4.2 System Boundaries). This boundary applies independently from the responsibilities in economic or operative terms for transportation processes.

Nonetheless, if a supplier is responsible in economic or operative terms for the outbound logistics (i.e., transportation from the supplier to its customer), the supplier shall report the product carbon footprint from this transportation in addition to and separately from the product carbon footprint (Table 1). Otherwise, the customer shall account for transportation between the supplier's and its own shipping site (factory gate and distribution center, see Figure 5 and Figure 6).

The table below describes different cases of responsibility and accountability for transportation from supplier to customer:

Table 1: Transportation between supplier and customer.
The responsibility to account for GHG emissions from transport depends on which party is responsible in economic or operative terms.

Case	Description	Economic/operative responsibility for transportation from supplier to customer	Accounting for transportation emissions
1	Multiple shipping sites, and/or multiple unloading sites   	Inbound transportation contracted or operated by customer	Customer responsible for quantification of transportation emissions. As for multiple transportation relations, emissions shall be weighted by received product quantities
2	Multiple shipping sites, and/or multiple unloading sites   	Outbound transportation contracted or operated by supplier	Transportation emissions to be reported separately by supplier to the customer (additionally to supplier's PCF). As for multiple transportation relations, emissions shall be weighted by shipped product quantities

Transports from production sites to suppliers' distribution centers are deemed as suppliers' in-house logistics, i.e., the distribution center is regarded as the shipping point (see Figure 5).

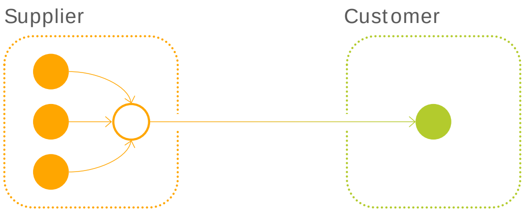


Figure 5: Distribution center on supplier side.

Transports from customers' distribution centers to production sites are deemed as customers' in-house logistics, i.e., the distribution center is regarded as the unloading point (see Figure 6).

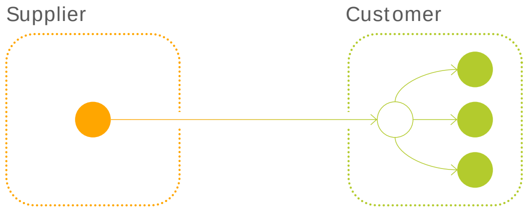


Figure 6: Distribution center on customer side.

Regardless of whether transportation emissions are quantified by a supplier or a customer, they shall be consolidated within the customers' PCFs.

5.2.1.1 Accounting for transportation emissions

Emissions from transportation shall cover emissions from well-to-wheel, i.e., the system boundaries span from energy provision, production and distribution ending at the transportation operation itself. Emissions from the production of the transportation means and infrastructure, e.g., roads, vehicles, ships and railways, shall not be included.

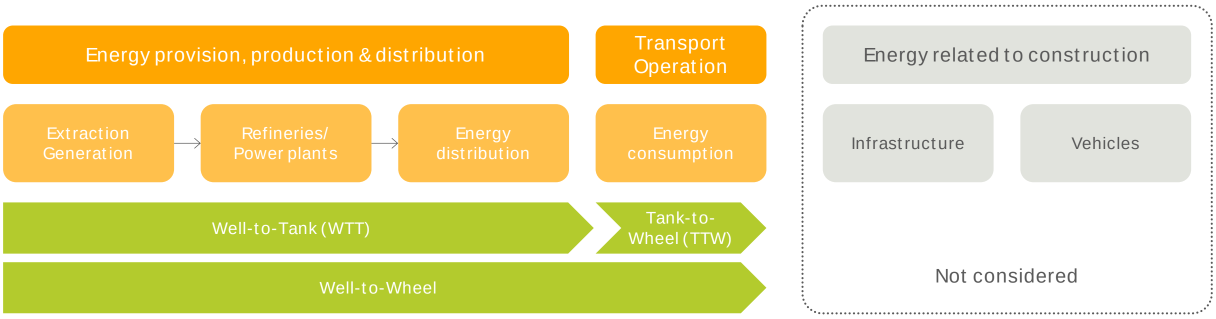


Figure 7: System boundaries for transportation.

Transportation emissions shall be quantified specifically for transported products. In the event that more than one product is involved in one transportation operation, emissions shall be attributed by mass. In the case of distributed transportation operations (e.g., same product on various transports with different routes), allocation shall be by distance and weight. If a transport from departure to destination point requires different transportation modes (e.g., ship and truck or rail and truck) these shall be considered individually and thereafter be reported as one emission sum.

Consistent with the Catena-X goal of basing PCF quantification on primary data, the ultimate approach of quantifying transportation emissions shall be based on measuring the fuel and energy consumption of a trip and multiplying it by the emission factor of the fuel/energy that covers all upstream emissions of the fuel/energy. An increasing number of logistics fleet operators equip their vehicles with onboard data collection systems and can provide fuel/energy consumption data on a highly granular level. Only the measurement of fuel and energy consumption shall be considered primary data.

Direct measurement of fuel/energy may however not always be possible. Therefore, the following hierarchy of quantification approaches shall be followed:

- Measuring the fuel and energy use
- Modelling fuel and energy use using real trip routing and vehicle-specific efficiencies and emissions
- Modelling fuel and energy use via the route provided using planning tools and vehicle-specific efficiencies and emissions
- Calculation based on geographical distance, total load and default load and emissions intensity factors

If fuel/energy consumption cannot be measured, it shall be modelled with vehicle-specific fuel/ efficiency data and the real trip routing.

If the trip has multiple loading or unloading points, the allocation shall consider the total trip length including eventual empty run. If recorded, real load factors of the respective trip shall be applied. If no individual trip can be identified - as it is for transportation networks - empty runs shall be covered by averaged load factors.

To calculate fuel/energy consumption on the basis of vehicle efficiencies and a real route, an assumption regarding the vehicle speed is required, which is usually the maximum allowed speed or fuel consumption/cost-optimized speed for the respective vehicle. This, however, does not reflect typical traffic impediments such as traffic jams, handling times, etc. To ensure conservative emissions modelling, network resistances shall be applied according to the respective transportation mode, which either imply a speed reduction or distance elevation. Resistance factors are documented in the Annex.

In case the real route is not known/available, route planning tools for the respective transport vehicle shall be applied using the minimum trip time and/or cost as optimization criterion. If no route can be determined based on road, rail or other transportation network, the geographical distance between the departure location and destination shall be used with a distance supplement of 50%.

Vehicle efficiency data, if needed, shall be chosen for the specific transport vehicle. For details to determine efficiencies based on vehicle type and load factors, reference may be made to Vecto in the case of heavy-duty road transportation and/or EcoTransitIT in case of other transport vehicles or modes.

As minimum requirements, the calculation of the transportation emissions shall be based on geographical distance plus a 50% distance supplement, transport tonnage, default load and emissions intensity factors differentiated by mode, fuel and distance as stated in Annex A 1.

Emissions reduction from the use of low-carbon fuels may only be claimed if a statement of sustainability (origin and emissions reduction) for the fuel is provided as issued by a bonded warehouse. A tradeable certificate is required.

5.2.2 Accounting for waste treatment

For each product that generates waste, companies need to determine whether such waste will be recycled and turned into co-products or discarded as waste without economic value. Only the latter is considered waste in this section. Any GHG emissions arising from the treatment of production waste shall be included in the total PCF. Since the Catena-X boundaries span from cradle-to-gate, this waste treatment refers to the production life cycle stage and excludes the end-of-life stage of vehicles.

Waste can be generated during different stages of a product's life cycle (cradle-to-gate), including (see Figure 8):

- Resource extraction, raw material sourcing
- Production of materials, semi-finished products
- Production of vehicle parts and components
- Logistics to supplier gate (including internal logistics)

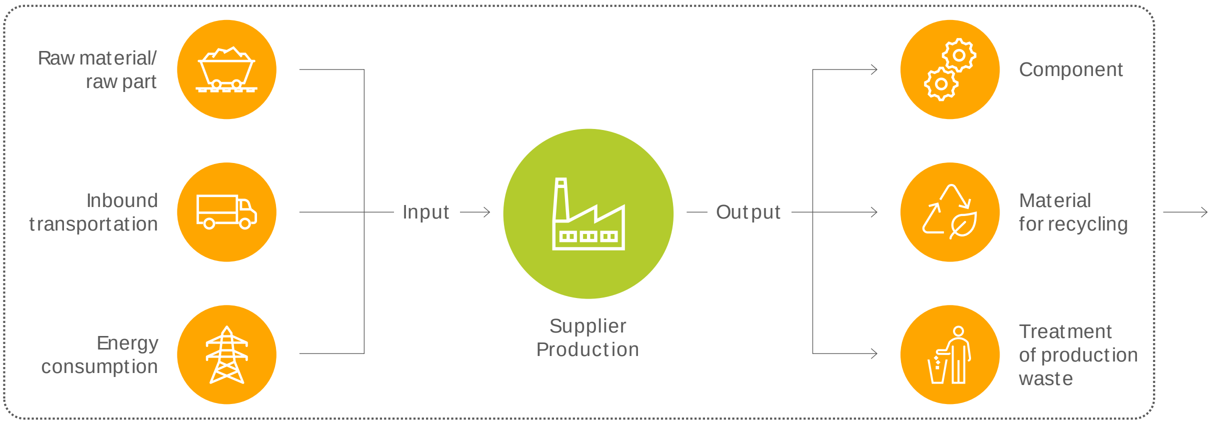


Figure 8: Waste generation during different stages of a product's life cycle.

All auxiliaries and energy inputs and waste outputs shall be fully considered in the calculation of the product carbon footprint. Cut-off rules as described in Section 4.2.1 shall be applied.

The company generating waste is responsible for treatment until final disposal (for example, incineration or landfill). This is also referred to as the "polluter pays principle". If additional processes follow the end-of-waste state, then these are attributed to the company using the recycled or reused material flow as a secondary material.

The impact of preparatory steps and supporting activities such as collection, transportation, sorting, dismantling, or shredding shall be added to the inventory results of the product system generating the waste.

- The impact of the process treating waste with energy recovery (e.g., incineration) shall be added to the inventory results of the product system that generated the waste treated in the process.
- The energy recovered from the waste-to-energy process shall be treated as free of burdens. Burdens or credits associated with previous or subsequent life cycles are not considered.

Production processes may also generate material scrap that is recycled. In this case, please see Section 5.2.3 Allocation in case of recycling.

5.2.2.1 Calculation

GHG emissions shall be calculated using primary data regarding the type of waste, its composition and type of waste treatment activity. Depending on the type of waste treatment (for example landfill or incineration), companies may use waste treatment emission factors based on internal primary data. If no primary emission factors are available, emission factors derived from accepted secondary databases can be employed (section 6.1).

If companies do not have access to primary data from third-party waste treatment facilities, they shall estimate waste treatment emissions based on primary data on the waste type and composition and specific emission factors according to the quantity and type of waste treatment and final disposal (landfill, incineration).

5.2.3 Accounting for recycling (within the transition period)

Recycling plays a crucial role in enabling a circular economy and reaching climate protection goals. In particular, recycling of currently unused or inefficiently used material streams is key to reducing primary material use as well as environmental burdens related to current waste treatment. The environmental burden of the recycling process needs to be distributed between the systems receiving and providing the secondary material.

Catena-X acknowledges steering effects of selecting different allocation approaches. Shifting the environmental burden of the recycling process may create an increasing demand for recycled material. These steering effects can lead to technology shifts, enabling emission reductions and/or increased material efficiency in the industry.

The allocation hierarchy in ISO 14044 does not account for the steering effects and no specific allocation hierarchy for recycling is provided. In principle, ISO 14044 applies the same allocation hierarchy for multi-output systems. However, specific assessment approaches for recycling are described in ISO 14044: Avoided burden for the primary production route and cut-off. Avoided burden of the primary production route usually incentivizes the provision of material for recycling at the end-of-life and, thus should only be applied if these incentives lead to overall emission reductions. However, if environmental incentives can lead to overall emission reductions, this highly depends on the market situation and requires a detailed analysis. Consequently, the cut-off approach shall be applied due to the following reasons:

- Ease of use in a CX network
- Avoidance of double counting
- Higher comparability of PCFs within CX

The impact of preparatory steps and supporting activities such as collection, transportation, sorting, dismantling, or shredding has been accounted for in the inventory results of the waste generating system, also see Section 5.2.2, therefore recycled, to be re-used, to be re-manufactured or secondary materials enter free of burden.

5.2.3.1 Accounting for recycling (after the transition period)

Catena-X acknowledges the environmental steering effects of selecting allocation approaches and hence may prescribe other allocation approaches to specific materials and regions in the future.

The allocation methods described in more sector-specific guidelines, e.g., Together for Sustainability, Worldsteel, Global Battery Alliance or others, may serve as the basis for deciding if other allocation methods are prescribed.

If an overall acceptance of a PCF sector-guidance as a drop-in standard for Catena-X is reached during the transition period or earlier, this sector-specific guidance shall apply to the respective sector.

5.2.4 Accounting for GHG emissions from electricity

For each process step within the Catena-X boundaries that requires electricity, companies must determine which GHGs were emitted by this specific energy use. All GHG emissions resulting from the use of the required electricity during the production process (cradle-to-gate) shall be included in the product carbon footprint.

To calculate the share of electricity consumption in the product carbon footprint, generator-specific emission factors shall be used. Depending on the type of electricity generation, different amounts of greenhouse gases are emitted. The factors used shall take into account upstream emissions (e.g., the mining and transport of fuel to the electricity plant or the growing and processing of biomass for use as an energy source), emissions during the generation of electricity (e.g., combustion of fossil fuels) and downstream emissions (e.g., the treatment of waste arising from the electricity plants).

5.2.4.1 Electricity from a directly and dedicated connected generator

If electricity is produced on site with a direct connection to the power generator (e.g., photovoltaic plant on the roof, wind park beside the production facility, own fossil power plant) or a direct connection to a power generator operated by a power supplier, the amount of electricity consumed by this power generator and the related emission factor shall be used if no contractual instruments have been sold to a third party. Otherwise, the country-specific residual grid mix shall be used.

As verification of using electricity from the company's own facilities, proof of installation of the company's own generation technology as well as a meter reading shall be available. The amount of electricity and the period of the meter reading shall be equal to the amount of electricity required and the respective period. In addition, the meter reading should be confirmed by a third party to prove that the specified generation technology, the respective period and the amount of electricity generated are in fact as stated.

5.2.4.2 Electricity (from a power supplier or) via contractual instruments

If electricity is accessed via a contractual instrument, the following electricity mix shall be used in hierarchical order:

- Supplier-specific electricity product shall be used if
  - a tracking system is installed in the country.
  - the set of minimum criteria to ensure the contractual instruments are reliable is met, i.e., no double counting and no exclusions.
- Total supplier-specific electricity mix, i.e., the share of electricity supply specific to the supplier, shall be used if
  - the set of minimum criteria to ensure the contractual instruments are reliable is met.
- The country-specific residual grid mix (consumption mix) shall be used (such as AIB[4] for Europe). Country-specific means the country in which the activity occurs.
- The regional residual grid mix (consumption mix), e.g., EU+EFTA, or region representative residual grid mix, consumption mix, shall be used.

If residual grid mixes are not available, grid-specific consumption mixes may be used.

In general, three different reference types can be defined for contractual instruments:

- Utility Tariffs
  When using an electricity supply contract, electricity is purchased from a supplier via the public grid.
- Energy Attribute Certificates (EACs)
  EACs should enable renewable energy to be tradable. An EAC is a certificate that proves that one megawatt hour of electricity was generated from renewable energy and transferred into the electricity grid. EACs can be separated from the physical quantity of electricity and therefore traded independently. Depending on the region, different systems are in place for trading Energy Attribute Certificates. For example, International Renewable Energy Certificates (iRECs) are traded through an international registry as a renewable energy instrument. In contrast, Renewable Energy Certificates (RECs) or Guarantees of Origin (GoOs) are examples of verification instruments in specific regions.

[4] Available at https://www.aib-net.org/facts/european-residual-mix

- Power Purchase Agreements (PPAs)
  A PPA is an electricity supply contract concluded directly between an electricity producer (plant operator) and an electricity consumer. The contract specifies the delivery of a certain amount of electricity over a particular period at an agreed price. In general, the types of PPAs can be differentiated. There are physical PPAs, which can be further subdivided into on-site and off-site, and virtual PPAs.

The contractual instrument used to calculate the related emission factor shall meet the following minimum criteria:

- It shall convey the information associated with the unit of electricity delivered together with the characteristics of the generator.
- It shall be assured with a unique claim and therefore be the only instruments that carry the environmental attribute claim associated with that quantity of electricity generated.
- It shall be tracked and redeemed, retired or cancelled by or on behalf of the company (e.g., by an audit of contracts, third-party certification, or may be handled automatically through other disclosure registries, systems, or mechanisms).
- It shall refer to the same year to which the contractual instrument is applied.
- The attribute tracking instrument shall refer to an electricity production asset located in the same regional market (within which a synchronous interconnection can be proven).

If the electricity consumed comes from more than one electricity mix, each mix source shall be used in terms of its proportion in the total kWh consumed. If a certificate of origin covers only a part of the consumed electricity, the residual grid mix shall be used for the uncovered amount.

In addition to the emission factors as shown in the contractual instrument of the electricity, the following GHG emissions shall be taken into account:

- Upstream emissions (e.g., the mining and transport of fuel to the electricity plant, the growing and processing of biomass for use as an energy source or construction and maintenance)
- Downstream emissions (e.g., the treatment of waste arising from the electricity plants)

5.2.5 Homogeneous parts

While many parts in the automotive supply chain are considered identical and require sampling strategies, there is also the related issue: Products are nearly identical, but differ systematically in a single (or very few) aspect(s). This very often brings about a product carbon footprint that is identical or differs systematically with that aspect. If this applies, products are called homogeneous parts from a homogenous product family.

PCF results obtained for homogeneous parts may be used after interpolation regarding the differentiating aspect for further parts of that product family.

To belong to a homogenous product family, the products shall have the following characteristics:

- The same main function
- The same product standards
- The same manufacturing technology, processes, and materials
- The same supply routes

A homogenous product family can be substantiated if a

- product parameter (physical characteristic) can be identified that differentiates otherwise identical parts systematically with respect to PCF and is proven by a sensitivity analysis.
- PCF results for homogeneous parts allow for a linear regression with respect to the differentiating parameter that renders a coefficient of determination R2 > 95%. Cut-off rules apply for the calculated PCF.
- The sample size to prove interpolation quality shall be n > 20.

A PCF for a part from a homogeneous product family shall be calculated by interpolation only. A homogeneous product family may be defined on the basis of an intermediate product if the final product to market is produced by varying add-on parts to the intermediate product or additional process steps, e.g., specific painting processes, additional leak tests or washing processes. For the additions in parts or processes to the intermediate product the respective CO_2 contribution shall be added to the final PCF. For the calculation of the primary data share, data does not need to originate from the product system under study, because primary data might relate to a homogeneous part.

The proof of a homogeneous product family shall be documented and provided to customers on request. A review of the proof shall be performed after five years at the latest.

5.2.6 Accounting for Chain of Custody models

Chain of custody is an administrative process by which information about materials is transferred, monitored and controlled as those materials move through supply chains [ISO 22095:2020]. There are, in principle, four possible chain of custody models, illustrated in Figure 9. Their common objective is to guarantee correct accounting and corroborate a link between ingoing content, e.g., 'sustainable', 'recycled' or 'organic' by harmonized definitions, and the final outgoing product. They differ whether it is a physical or administrative link. Furthermore, they differ in the set of rules for balancing, and the option to keep materials streams segregated or not[5].

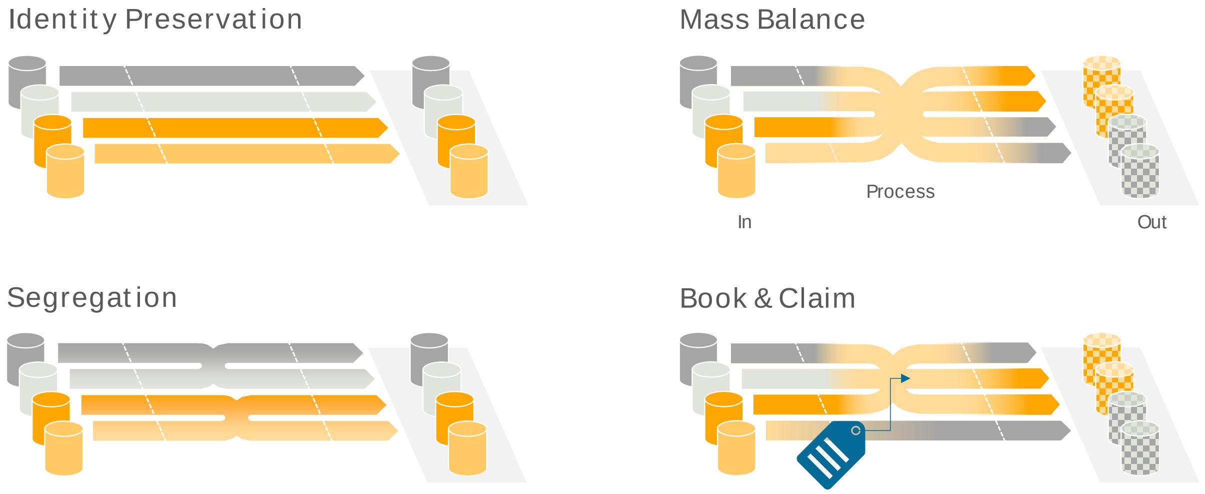


Figure 9: Overview of chain of custody models

The following table was adapted from the above-cited Whitepaper and provides high-level explanations and differentiations for the four chain of custody models:

Table 2: Explanation chain of custody models
[adapted from the above-cited EMF Whitepaper Table 1, page 11]

Model	Explanation	Example
Identity preservation	It is possible to physically track the product to its desired origin, ensuring unique traceability and physical separation of products from other sources along the supply chain.	Buying food from a single certified producer.
Segregation	Consists in the aggregation of volumes of products of identical origin or produced according to the same standards in one stock item.	Buying food from a trader that exclusively handles identically certified supplies

[5] Source: https//ellenmacarthurfoundation.org/white-papers-and-articles

Model	Explanation	Example
Mass balance	Considering the output, no physical or chemical difference exists between in-scope and out-of-scope. It involves balancing volume reconciliation to ensure the exact volumes of in and out-of-scope source is maintained along the supply chain. Given that the volume or the ratio of sustainable material integrated is reflected in the product produced and sold to customers. This model requires that a reconciliation period is defined (e.g., a month, a year).	Buying a certain percentage of a supply from certified origin. Applies to, e.g., sustainable forestry for wooden materials, recycled, bio-based or renewable materials, organic cotton
Book and claim – restricted certificate trading	The certified product/component is disconnected from the certification data, but belongs to the same production system or value chain. The certified product evolves in separate flows from the certified supply. Certificates are issued at the beginning of the supply chain by an independent body reflecting the sustainable content of supplies. The intended outcome is that outputs from one supply chain is associated with total claims corresponding to the certified input.	Buying material with renewable/recycled/ biobased content. Certificates with guarantee of origin or comparable certifications declaring e.g., recycled, renewable, biobased content. CO_2 capture certificates from a production system controlled by the company, e.g., carbon capture and storage.

To calculate the PCF according to the Catena-X rulebook, all types of models may be taken into account if the requirements listed below are met and an independent third-party chain of custody verification for the balance of materials is available. The balance between input and output shall be correct.

The mass balance approach helps enable fossil raw materials to be replaced by more sustainable alternative materials (e.g., with recycled content, bio-content). In contrast to a segregated use of alternative raw materials, mass balance enables the use of existing production networks with low or no investments into new process technologies and production facilities. A book and claim model can be applied when there is no direct connection between the final product and the certified supply. An example of a book and claim model is applied in green electricity markets and receives more attention in other sectors as way to support circular transformation of the industry; therefore, it is accepted as a solution. There will be a regular review by Catena-X to decide about the further necessity.

5.2.6.1 Guiding principles

In implementing chain-of-custody methods, including the mass balance one, following set of guiding principles shall be fulfilled:

1. The use of chain-of-custody approaches shall achieve significant changes and an effective transition towards a more circular, more bio-based and lower GHG emissions production in complex value chains.

2. The choice and implementation of chain-of-custody approaches and models shall be transparent, clear, and credible – abiding by relevant standards such as ISO and CEN. Such credibility can also be achieved but is not limited to accepted third-party certification schemes, e.g., ISCC PLUS, REDCert2 and RSB.

Note: Certification schemes are not yet available in all sectors.

3. Labels and claims referring to chain-of-custody controlled specified characteristics and used on products shall fulfill the following requirements:
   - description of the chain-of-custody approaches and models
   - accurate and appropriate implementation of the chain-of-custody model
   - compliant with existing standards and regulations
   - non-misleading

If the "specified characteristic" content in products cannot be measured and verified, labels and claims products may reflect this in ways that clearly differentiate and specify the actual content.

4. No double counting: A reliable accounting system shall be installed at each operating site to avoid the sales of a greater amount of alternative attributed products than physically available in the company.

Additional requirements for a mass balance chain of custody approach:

5. The operating sites in the spatial boundaries for mass balancing are under the operational control of the same company/corporate group/joint venture.
6. It shall be technically possible according to standard industry practice to produce a mass-balanced product from an alternative feedstock. Share of mass-balanced material can be technically lower than the attributed share.
7. Applied emissions factors for the mass-balance system boundaries shall be product and process specific.

6. Data sources and hierarchy

Primary data is a quantified value of a process, an activity obtained from a direct measurement, or a calculation based on direct measurements.

Primary data shall be used instead of secondary, if available, and if it meets or complies with the data quality requirements according to Section 7.2.

Primary data shall include primary activity data, i.e., a technical flow, and primary GHG emission factor, i.e., the carbon footprint of the corresponding activity expressed in $kgCO_2e$ per unit (Table 3). Consequently, the measured materials consumptions and a secondary GHG emission factor is not considered primary (see Figure 10 in section 7.2.5). 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. A single calculation might include both primary, secondary data and a mix of both expressed by the primary data share (see Section 7.2.4). For example, calculating emissions from the consumption of electricity could involve primary activity data, such as data on consumption in kWh, multiplied by a secondary emission factor provided by national GHG inventories representing GHG emission intensity (CO_2e per kWh).

Table 3: Definition of primary and secondary data.

<table>
<tr><th>Approach</th><th colspan="4">Direct emission measurement</th></tr>
<tr><td>Primary data, if</td><td colspan="4">Source of emission is within company boundaries and is measured</td></tr>
<tr><th rowspan="2">Approach</th><th colspan="2">Activity data source</th><th colspan="2">Emission factor source</th></tr>
<tr><th>Energy</th><th>Material</th><th>Energy</th><th>Material</th></tr>
<tr><td>Primary data, if</td><td colspan="2">Consumption measured (primary)</td><td>For on-site production
▪ Emission measured (primary)
▪ For supplier-specific electricity
  ▪ Primary with guarantee of origin</td><td>Measured and reported as a share by supplier</td></tr>
<tr><td>Secondary data, if</td><td colspan="2">Consumption/production measured (primary)</td><td colspan="2">Secondary databases, data proxy</td></tr>
</table>

The data may need to be scaled, aggregated, or otherwise mathematically processed to relate it to the declared unit or the reference flow of the process (see Section 5.1.2). Algorithms may be used to fill in the missing data, or data aggregation may be required to attenuate the effect of revisions, turnarounds, or other atypical production conditions.

If no product-specific measurement or calculation of activity data or emission factors are available, feasible site-specific or even company-specific data must be used, which might incorporate more than production related emissions, e.g., emissions related to research and development.

6.1 Secondary data

Catena-X pursues the goal of calculating PCF based on primary data. This, however, will not be feasible from the onset of Catena-X but will require a transition period. At least during this transitional phase, secondary data is required to ensure the information chain on PCF is not interrupted.

Ideally, the use of secondary data warrants the following crucial requirements:

- When using secondary data, a conservative estimate shall be applied to avoid a lower PCF compared to a PCF based on respective primary data. With this, the motivation to replace secondary by primary data shall be strengthened.

- The use of secondary data shall avoid any competitive distortion due to ambiguous data for identical input information (if knowledge of a material is limited to virgin aluminum from Canada produced in 2020, this should result in an unequivocal CO_2eq intensity for that material).
- The selection of secondary data shall be guided by the representativeness criteria (see Section 7.2.5) to limit errors introduced into the PCF calculation. The effort to search for data with the fewest errors needs to be balanced with economic feasibility to the extent that misleading results are avoided.
- Secondary data shall be accessible to all Catena-X members, regardless of size, economic power or experience in life cycle assessment.

For use within Catena-X, there are three principal approaches to harmonize the use of secondary data with respect to the requirements mentioned above:

- Definition of CX-prescriptive secondary data
- Definition of a whitelist of data sources
- Definition of hierarchy for secondary data sources

Combinations of the approaches are also feasible.

With regard to the above-mentioned requirements, the first option is clearly the superior approach. By prescribing the use of specific secondary data with adequate precision and following a conservative approach, comparability of results and avoiding underestimation of PCFs can be ensured. Harmonized and prescribed data sources ensure that unequivocal CO_2eq intensities are applied, and each CX-member has access to the same data. A fully harmonized prescribed set of data provided by Catena-X would also eliminate the need to define and do any data quality rating.

The obvious issue is the effort required to research and prepare the likely large amount of data which is needed to cover the full supply chain and to keep such data up to date over the years to come. One has to keep in mind however, without a CX-prescriptive database, the effort to define criteria for appropriate data is still required and the time required to identify and research appropriate and accepted data will be spent multiple times by every PCF/LCA expert in each company in need of secondary PCF data. Most likely, data quality checks and reviews will increase individual efforts further with no guarantee that competitive distortion can be avoided. The risk of a race to the lowest possible PCF results that can be argued with permissible creativity needs attention.

The actual drawback is thus not the high effort to provide CX prescriptive data, but the need to provide this effort upfront and centrally from the CX side. A pragmatic solution with the support of various associations seems to be the most viable way forward.

For a web application that allows SMEs to calculate PCFs a CX prescriptive database with no or moderate licensing fees seems to be the only solution.

Defining a hierarchical list of secondary data sources starting with association data already follows the logic of a CX prescriptive database. The shortcomings are possible multiple references to the same material from different associations and the opening clause to universal databases whenever one seems to find no appropriate piece of data in the associations data. This already indicates that avoiding arbitrary evasion of universal databases will require a set of rules/criteria regarding which approximations are permissible and CX-compliant and which are not.

A non-hierarchical list or whitelist of data sources would require the set of rules/criteria with approximations of the real data by secondary data is sufficient to an even larger extent. To ensure a conservative data choice that does not undermine the use of sound primary data seems hardly possible. A whitelist of data sources would even require CX to review and approve the data content and ensure completeness.

As a bottom line, providing a harmonized set of industry association data as prescriptive for CX is the superior approach. As of now, this harmonized data does not yet exist and CX will thus require hierarchical use of secondary data sources in the following sequence:

1. Industry association data
2. General LCA data, e.g., commercial LCA databases
3. Other documented references, e.g., scientific literature

If secondary data is not available within the references listed in, other sources can be used to fill data gaps. If no data is available at all, proxy data may be used. The employment of proxy data sources shall be documented and made transparent to auditors and recipients of any data (see Section 7).

The particular value of association data is the higher certainty that the CO_2 intensities represent an industry/sector average and, in some cases, even indicate the dispersion of CO_2 intensities around the average value. CX will initiate the work on harmonized industry association data.

Additional quality rules for secondary data usage

Secondary data that is used as emission factors shall be selected according to the following criteria:

- Temporal representativeness:
  The reference year for the secondary data shall correspond to the assessment period of the activity data. For instance, the electricity consumption mix corresponding to the year of assessment, or the most representative year shall be employed for the calculations.
- Geographical representativeness:
  The geography of the data shall correspond to the activity data most geographically relevant to the process. For instance, the electricity consumption mix corresponding to the geography of the product (country or state if available) shall be employed for the calculations.
- Technological representativeness:
  The secondary data source shall correspond to the activity data that is technologically representative of the process. For instance, the electricity or heating generation mix shall be representative of the source of energy used.

7. Required elements for PCF data exchange

Standardized PCF accounting and data exchange constitutes an important step toward creating comparable and consistent emissions data. Another factor to enhance comparability and consistency is the standardized sharing of elements of meta data relating to the PCF between stakeholders within the supply chain, as this is a prerequisite for more granular and accurate calculations by each stakeholder.

Emissions data calculated in line with the CX Framework shall therefore be shared in accordance with the guidelines set out in this section.

7.1 Data model

The data model contains the information that companies shall include to report their PCF according to this Catena-X PCF Rulebook. A report on the full technical specification will be included in a separate document.

7.2 Details on the required data elements

7.2.1 Time period

Emissions shall by default be reported averaged over the period of one year (reporting or calendar year) to avoid seasonal fluctuations and reflect typical production conditions.

Shorter periods may be considered if data on a full year are not yet available. Longer averaging periods may be considered but shall not exceed three years. Any averaging period deviating from the default shall be flagged and justified.

7.2.2 Temporal validity

Emissions shall by default be reported for the most recent year (reporting or calendar year). An annual check is mandatory to ensure data actuality. An update of data is mandatory if the reported emission increases by 5% or more based on the screening study compared to the previous reporting period.

7.2.3 Geography

Emissions shall by default be reported on the plant level. Averaging over a region or country may be considered but shall be flagged as such.

7.2.4 Primary data share

To create visibility on the share of primary data in PCF calculations, the primary data share (PDS) indicator in each data set shall be determined and shared. This can be done by calculating the proportion (percentage) of the total PCF in (kg CO_2e per declared unit) that is derived using primary data (as defined in Section 6.1):

$$PDS_{PCF} = \frac{Part\ of\ PCF\ based\ on\ primary\ data\ [kg\ CO_2\ e]}{Total\ PCF\ [kg\ CO_2\ e]}$$

$$PDS = \frac{\sum(|PCF_i| \cdot PDS)}{\sum|PCF_i|}$$

As an example, three suppliers, Company A, Company B and Company C, provide parts to Company D. Each part has a different primary data share and contribution to the PCF of the part of Company D (cf. Figure 10). According to formula above, the primary data share of Company D’s part is calculated from the primary data share and contribution to the PCF of the part of Company D (see Table 4).

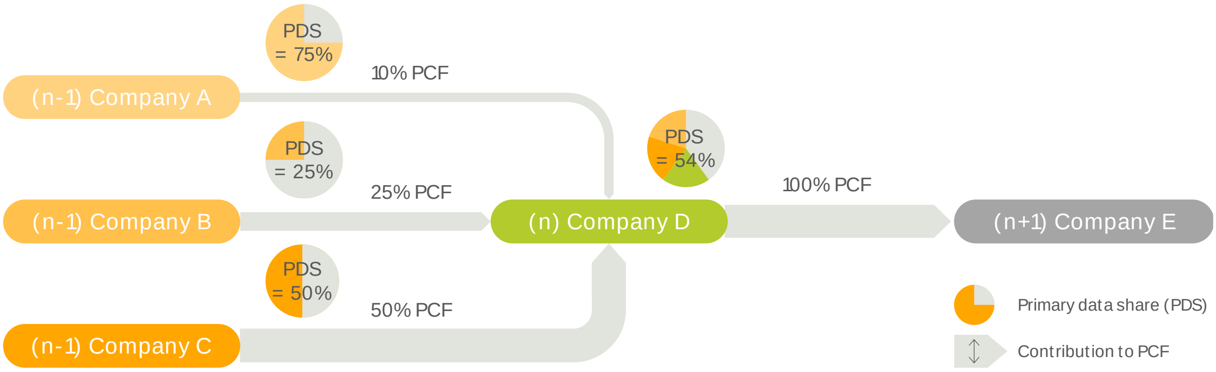


Figure 10: PCF cascade of primary data for an exemplary supply chain.

Table 4: Primary data share of the example as in Figure 10.

	PDS input	PCF share	PDS output
Tier A	75%	10%	75% * 10% = 7.5%
Tier B	25%	25%	25% * 25% = 6.3%
Tier C	50%	50%	50% * 50% = 25%
Tier D	100%	15%	100% * 15% = 15%
Total		100%	7.5% + 6.3% + 25% + 15% ≈ 54%

To increase transparency on primary data use, the overarching PDS (PDSPCF product) shall be shared downstream (Tier n+1), together with the PCF.

7.2.5 Data quality rating

In Catena-X, companies calculate the product carbon footprint of products from (compare Figure 11):

1. Primary data owned by the company calculating PCF, i.e., data on processes run by the company,
2. Primary data of third parties in the supply chain, i.e., data on processes not run by the company, but data received from its suppliers,
3. Secondary data sources, i.e., the process is not run by the company and no data is received from its suppliers.

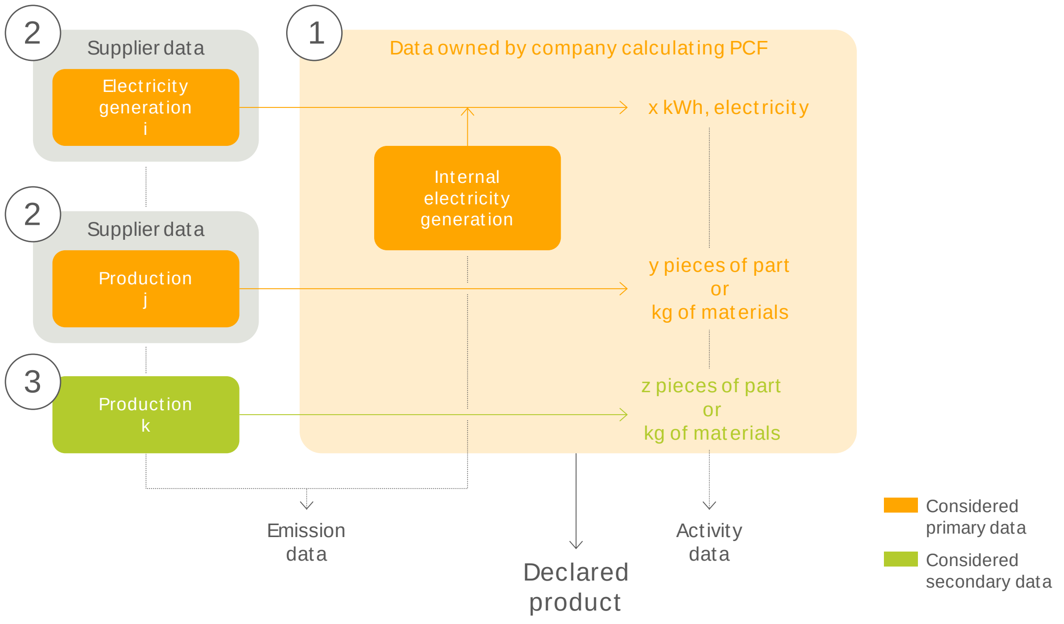


Figure 11: Data sources for PCF calculation.

During data collection, companies shall assess the data quality of direct emissions data, activity data and emission factors used from secondary data sources for the data quality criteria described below.

As data quality assessment is currently not common practice, Catena-X has decided to begin data collection with a single direct quality rating (DQR) for both primary and secondary data (Section 7.2.5.1).

After a transition period, Catena-X will require a more detailed assessment accounting for the different characteristics of primary and secondary data (Section 7.2.5.2). This detailed assessment will require a separate assessment of primary and secondary data as well as separate reporting of data quality.

7.2.5.1 Data quality assessment (within the transition period)

During the data collection process, companies shall assess the data quality of activity data, emission factors, and/or direct emissions data by using the data quality ratings (DQR).

The standard defines the five data quality indicators to use in assessing data quality. They are:

- Technological representativeness: the degree to which the data reflect the actual technology(ies) used in the process
- Geographical representativeness: the degree to which the data reflects actual geographic location of the processes within the inventory boundary (e.g., country or site)
- Temporal representativeness: the degree to which the data reflect the actual time (e.g., year) or age of the process
- Completeness: the degree to which the data are statistically representative of the process sites
- Reliability: the degree to which the sources, data collection methods, and verification procedures used to obtain the data are dependable

Assessing data quality during data collection allows companies to make data quality improvements more efficiently than if data quality is assessed after collection is complete.

Data quality shall be assessed for both primary and secondary data in terms of how well they represent the actual production of the product under study. In the case of secondary data, the data quality rating reported for the original data taken from a database may not be directly used. Instead, the reported data quality rating should serve as the basis to assess the representativeness of the product under study, i.e., how well the secondary data represents actual production in the supply chain.

The data quality of each PCF shall be calculated and reported. The DQR calculation shall be based on five data quality criteria where TeR is the technological representativeness, TiR is the time/temporal representativeness, GeR is the geographical representativeness, C is completeness and R is reliability. Table 5 shall be used to determine a semi-quantitative data quality rating.

The quality levels are expressed in three categories from 1 ‘Good’, 2 ‘Fair’ and 3 ‘Poor’. The representativeness (technological, geographical, and time-related) characterizes the degree to which the processes and products selected depict the system analyzed, while the completeness and reliability addresses the quality of the PCF result produced.

The data quality criteria, scoring and related definitions listed in Table 5 are aligned between Together for Sustainability, Catena-X and WBCSD Pathfinder Framework.

Table 5: Sample scoring criteria for performing a qualitative data quality assessment .

Data quality rating	1 – Good	2 – Fair	3 – Poor
Technology (TeR)	Same technology	Similar technology (based on secondary data)	Different or unknown technology
Time (TiR)	Data from reporting year	Data less than 5 years old (creation date of dataset)	Data more than 5 years old (creation date of dataset)
Geography (GeR)	Same country or country subdivision	Same region or subregion	Global or unknown
Completeness (C)	All relevant sites for specified period	<50% of sites for specified period or >50% of sites for shorter period	Less than 50% of sites for shorter time period or unknown
Reliability (R)	Measured activity data	Activity data partly based on assumptions	Non-qualified estimate

The data quality rating for activity data or an emission factor shall then be calculated from the five data quality indicators as an arithmetic mean.

$$DQR = \frac{TeR + GeR + TiR + C + R}{5}$$

For example:

Table 6: Example Data Quality Rating

	Product 1	Product 2
Technological representativeness (TeR):	2	3
Temporal representativeness (TiR):	1	3
Geographical representativeness (GeR):	2	2
Completeness (C):	3	3
Reliability (R):	2	3
Total	10	15
DQR total (Total/5)	2	3

The data quality rating of the PCF shall be calculated as a weighted mean with the product carbon contribution as weight:

$$DQR_{total} = \frac{\sum(DQR_i \cdot |PCF_i|)}{\sum|PCF_i|}$$

The data quality shall be propagated through the supply chain in the same manner as the primary data share (PDS).

7.2.5.2 Data quality assessment (after the transition period)

During the data collection process, companies shall use the data quality rating to assess the data quality of activity data, emission factors, and/or direct emissions data.

This standard defines the five data quality indicators to use in assessing data quality:

- Technological representativeness (TeR): the degree to which the data reflect the actual technology(ies) used in the process
- Geographical representativeness (GeR): the degree to which the data reflects actual geographic location of the processes within the inventory boundary (e.g., country or site)
- Temporal representativeness (TiR): the degree to which the data reflect the actual time (e.g., year) or age of the process
- Completeness (C): the degree to which the data are statistically representative of the process sites
- Reliability (R): the degree to which the sources, data collection methods, and verification procedures used to obtain the data are dependable

Assessing data quality during data collection allows companies to make data quality improvements more efficiently than if data quality is assessed after the collection is complete.

Data quality shall be assessed separately for primary and secondary data in terms of how well they represent the actual production of the product under study. In the case of secondary data, the data quality rating reported for the original data taken from a database may not be directly used. Instead, the reported data quality rating shall serve as the basis to assess the representativeness of the data with respect to the product under study, i.e., how well the secondary data represents actual production in the supply chain.

The quality levels are expressed in five categories from 1 'Excellent', 2 'Very good', 3 'Good', 4 'Fair', and 5 'Poor'.

Based on the criteria, data quality ratings (DQR) shall be assigned with scores between 1-5 based on a qualitative judgement. Scores shall be differently assigned to primary (Section 7.2.5.2.1) and secondary data (Section 7.2.5.2.2). Scores shall be aggregated to achieve a data quality rating according to the formulas below:

For primary data:

$$DQR_{Primary} = \frac{TeR + GeR + TiR + C + R}{5}$$

For secondary data:

$$DQR_{Secondary} = \frac{TeR + GeR + TiR + ? + ?}{3 + ? + ?}$$

7.2.5.2.1 DQR of primary data

When determining the share of CX product carbon footprint based on primary data, the data quality of the primary activity data, e.g., the consumption of electricity, and the primary emission factor, e.g., supply of electricity from the power operator, shall be assessed separately. The DQR provided by the supplier can be used directly.

The primary data DQR calculation shall be based on five data quality criteria, where TeR is the technological representativeness, TiR is the time/temporal representativeness, GeR is the geographical representativeness, C is completeness and R is reliability. Table 7 and Table 5 shall be used to determine a semi-quantitative data quality rating.

Table 7: Sample scoring criteria
for performing a qualitative data quality assessment for primary data.

Data quality rating	1 – Excellent	2 – Very good	3 – Good	4 – 5
Technology (TeR)	Data measured from the production technology under study	Data is measured from similar production of the company under study	Data is approximated from similar production of the company under study	Not applicable
Time (TiR)	The data of the most recent annual administration period.	The data refers to a maximum of 3 annual administration periods.	The data refers to a maximum of 5 annual administration periods.	Not applicable
Geography (GeR)	Production site specific	Same country or region	Same continent	Not applicable
Completeness (C)	All processes run by the company within the reporting period	<50% of processes run by the company within the reporting period or >50% processes run by the company for a shorter period	Less than 50% processes run by the company for a shorter or unknown period	Not applicable
Reliability (R)	Measurements specific to the product and the production process	Measurements specific to a production site and allocation to product	Data partly on assumptions or non-qualified estimate	Not applicable

7.2.5.2.2 DQR of secondary datasets

The procedure for calculating the DQR of secondary datasets used for CX-PCF is different from that used for primary data. For secondary data, it shall be evaluated how well the secondary dataset represents the supply of goods and services accounting for the company's activities. Consequently, Table 8 shall be used for data quality evaluation of secondary data.

Table 8: Sample scoring criteria
for performing a qualitative data quality assessment for secondary data.

Data quality rating	1 – Excellent	2 – Very good	3 – Good	4 – Fair	5 – Poor
Technology (TeR)	Same production technology	Market mix including the production technology under study	Market mix excluding the production technology under study	Similar production technologies to those included in the scope of the PCF	Production technologies are different
Time (TiR)	The publication date of the PCF is within the validity of the dataset	The CX-PCF publication date is no later than 2 years after the time validity of the dataset	The CX-PCF publication date is no later than 4 years after the time validity of the dataset	The CX-PCF publication date is no later than 6 years after the time validity of the dataset	The CX-PCF publication date is more than 6 years after the time validity of the dataset
Geography (GeR)	The technology used in the CX-PCF is exactly the same as the one in scope of the dataset	Same country or region	Same continent	Regions are different, but based on expert judgement estimations that are sufficiently similar	Regions are different or unknown
Completeness (C)	tbd	tbd	tbd	tbd	tbd
Reliability (R)	tbd	tbd	tbd	tbd	tbd

Aggregation of DQR

The DQR for primary and secondary data shall be assessed and reported separately to the customer in the CX data set (cf. Figure 12). The data quality rating for primary and secondary data of the PCF shall be calculated as a weighted average with the primary, respectively secondary data based, product carbon contribution as weight:

$$DQR_{primary} = \frac{\sum(DQR_{primary,i} \cdot |PCF_i \cdot PDS|)}{\sum|PCF_i \cdot PDS|}$$

$$DQR_{secondary} = \frac{\sum(DQR_{secondary,i} \cdot |PCF_i \cdot (1 - PDS)|)}{\sum|PCF_i \cdot (1 - PDS)|}$$

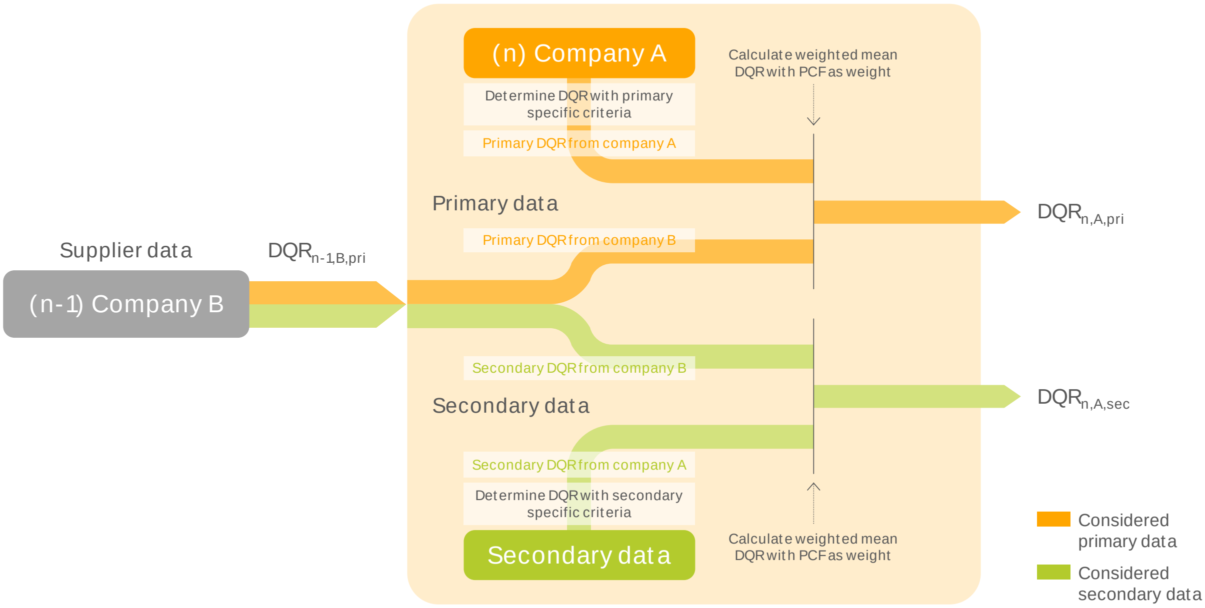


Figure 12: Aggregation of separate primary and secondary DQR.

The data quality shall be propagated through the supply chain in the same manner as the primary data share (PDS).

For example:

Table 9: Example for data quality rating. Primary data.

PRIMARY	PCF	C	TiR	TeR	GeR	Total data quality rating
Unit	kg CO_2eq per declared unit					
Energy	0.5	2	1	2	1	
Waste	0.3	1	1	1	1	
Raw materials/semi-finished parts/parts	0.7	2	2	1	1	
Raw materials/semi-finished parts/parts	0.8	2	3	1	1	
Raw materials/semi-finished parts/parts	0.2	2	2	3	1	
		1.9	2.0	1.4	1.0	1.56

Table 10: Example for data quality rating. Secondary data.

SECONDARY	PCF	C	TiR	TeR	GeR	Total data quality rating
Unit	kg CO_2eq per declared unit	–	–	–	–	
Raw materials	0.9		3	3	3	
Raw materials	0.7		2	3	2	
Raw materials	0.5		4	5	4	
Raw materials	0.8		1	2	3	
			2.4	3.1	2.9	2.8

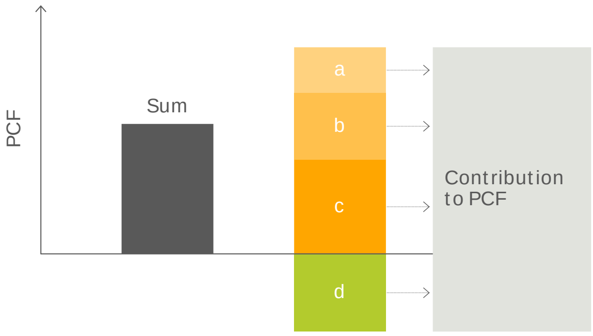
Table 11: Aggregated results.

	PCF	Primary data share
Unit	kg CO_2eq per declared unit	%
Total	5.40	46

The total PCF is 5.4 kg CO_2eq per declared unit. The DQR of the primary data is 1.56 and of the secondary data is 2.8. The primary data share is 46%.

7.2.6 Dealing with negative PCF contributions

Accounting for uptake of biogenic or fossil emissions with a characterization factor of -1 kg CO_2eq per kg CO_2 can lead to negative PCF contributions. Thus, the sum of the PCF can be lower than the positive contributions to the PCF (Figure 13). When calculating the PDS or a DQR, negative contributions would lead to erroneous calculation of the primary data share or data quality rating, e.g., the PDS can add up to more than 100%.



Contribution	PCF	DQR	PDS
a	100	100	0.90
b	150	2.00	0.70
c	2.00	2.00	0.80
d	-175	2.70	0.30
Results	w/o correction w/ correction	1.20 2.00	1.10 0.65

Figure 13: If negative PCF contributions occur, the PDS or DQR shall be calculated using absolute PCF contribution values.

Hence, to calculate the PDS and DQR absolute values of the PCF, the following formula shall be used:

$$PDS = \frac{\sum(|PCF_i| \cdot PDS)}{\sum|PCF_i|}$$

$$DQR = \frac{\sum(|PCF_i| \cdot DQR)}{\sum|PCF_i|}$$

7.2.7 Reporting offsets

Sharing PCF data across the Catena-X network requires the full PCF (cradle-to-gate) to be shared. Any GHG offsets shall be excluded from the reported PCF.

If applicable, the supplier delivering a PCF to a customer shall report any offsets separately from the PCF. This includes both offsets with and without certificates. If offsets have been purchased, they shall transparently mention the origin of reported offsets and refer to the original certificate.

For rules on taking a renewable electricity certificate into account, refer to Section 5.2.4.

Any carbon-neutrality claims based on offsetting for parts and components are out of the scope of this PCF rulebook.

Annex

A 1. Transportation

Network resistance:

Table 12: Resistance of street categories[6].

Street category	Resistance
Highway (Category 0)	1.0
Large country road (Category 1)	1.3
Small country road (Category 2)	1.5
Large urban road (Category 3)	1.67
Urban road (Category 4)	2.5
Small urban road (Category 5-7)	3.33

Table 13: Resistance of ferries in road/railway networks.

Attribute	Resistance
Freight corridor	1.0
Non-freight corridor	1.8
Diesel tracks at electrified calculation	4.0

Table 14: Resistance of ferries in road/railway networks.

Ferry handling resistance	
Standard	5.0
Preferred	1.0
Avoid	100

Fuel Emission Factors: See GLEC 2018 [], table 31 – 34

Default load and emission intensity: See GLEC, Table 35 – 46; Table 35. EN16258 data shall be used.

[6] https://www.ecotransit.org/wordpress/wp-content/uploads/20210531_Methodology_Report_EcoTransIT_World.pdf

A 2. Main contributing companies

BASF SE

BMW Group AG

Henkel AG & Co. KGaA

Mercedes-Benz AG

Robert Bosch GmbH

Siemens AG

Volkswagen AG

ZF Group AG

A 3. Further contributing companies

Deloitte Deutschland GmbH

Ford-Werke GmbH

Schaeffler Group AG

Thyssenkrupp AG

Trumpf Group SE + Co KG

Volvo Trucks AG

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