Railway-X

Product Carbon Footprint Rulebook

Version 1.1
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Glossary

Term	Definition	Source
Activity data	Quantified measures of a level of activity that results in GHG emissions or removals.	WBCSD Pathfinder Version 3.0
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.	EN ISO 14040:2021 – 3.17
Attributable process	Those processes that consist of all service, material and energy flows that become, make and carry a product throughout its life cycle.	WBCSD Pathfinder Version 3.0
Biogenic carbon	Carbon derived from biomass.	ISO 14050:2020(en) Environmental management – Vocabulary, 3.8.24
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.	ISO 14067:2018, 3.1.1.7
Catenary	In overhead electrification equipment, the secondary wire that supports the contact (live) wire and helps to keep the tension necessary for pantographs to draw current from it.	RailNetEurope RNE Glossary - NS_CID_Glossary_2025
Characterization factor	Factor derived from a characterization model, which is applied to convert an assigned life cycle inventory analysis result 3.6.4 to the common unit of the category indicator 3.2.24.	ISO 14050:2020, 3.6.23
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).	ISO 5157:2023(en), 3.2.6.6
CO_2eq (carbon dioxide equivalent)	Unit for comparing the radiative forcing of a greenhouse gas 3.9.1 to that of carbon dioxide.	ISO 14050:2020(en) Environmental management – Vocabulary, 3.9.3
Co-product	Any of two or more products coming from the same unit process or product system.	ISO 14067: 2018, 3.1.3.3
Cradle-to-gate	System boundary that is applied for a partial PCF assessment that includes a part of the product's life cycle. Cradle-to-gate represents the GHG emissions and removals arising from all life cycle stages, up to the point where the product leaves the production site (the "gate"). This explicitly excludes the life cycle stages use and end-of-life.	Catena-X Product Carbon Footprint Rulebook, Version 3.1
Cut-off criteria	Specification of the amount of material or energy flow or the level of significance of GHG emissions associated with unit processes or the product system, to be excluded from a PCF study.	ISO 14067: 2018, 3.1.4.1

Term	Definition	Source
Date of issue	Time stamp at which the PCF has been declared, regardless of when it was shared. Date of issue represents the start of the validity period unless otherwise stated.	Catena-X Product Carbon Footprint Rulebook, Version 3.1
Declared unit	Quantity of a product for use as a reference unit in the quantification of a Cradle-to-Gate PCF.	Catena-X Product Carbon Footprint Rulebook, Version 3.1
Direct emissions	Data on emissions released from a process (or removals absorbed from the atmosphere) determined through direct monitoring, stoichiometry, mass balance, or similar methods.	WBCSD Pathfinder Version 3.0
Downstream emissions	Indirect GHG emissions that occur in the value chain following the processes owned or controlled by the reporting company.	WBCSD Pathfinder Version 3.0
Emission factor(s)	Amount of GHGs emitted, expressed as CO_2eq and relative to a unit of activity (for example, kg of CO_2 eq per declared unit).	WBCSD Pathfinder Version 3.0
Functional unit	Quantified performance of a product system 3.1.3.2 for use as a reference unit.	ISO 14067: 2018, 3.1.3.7
Global warming potential (GWP)	Index, based on radiative properties of GHGs 3.1.2.1, 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).	ISO 14067: 2018, 3.1.2.4
Greenhouse gas (GHG)	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.	ISO 14050:2020(en) , 3.9.1
Input	Product, material or energy flow that enters a unit process.	WBCSD Pathfinder Version 3.0
IPCC AR	Intergovernmental Panel on Climate Change – Assessment Report.	https://www.ipcc.ch/reports/
Land use	Human use or management of land within the relevant boundary.	Catena-X Product Carbon Footprint Rulebook, V 3.1
Level crossing	Place where railway and road cross each other at the same level (without e. g. overpass or underpass). Level crossings may have gates, barriers, traffic lights or be open.	RailNetEurope RNE Glossary – NS_CID_Glossary_2025
Life cycle	Consecutive and interlinked stages related to a product 3.1.3.1, from raw material acquisition or generation from natural resources to end-of-life treatment.	ISO 14067: 2018, 3.1.4.2
Life cycle assessment (LCA)	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system 3.1.3.2 throughout its life cycle 3.1.4.2.	ISO 14067: 2018, 3.1.4.3
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 Version 3.0

Term	Definition	Source
Life cycle inventory (LCI) analysis	Phase of life cycle assessment 3.1.4.3 involving the compilation and quantification of inputs and outputs for a product 3.1.3.1 throughout its life cycle 3.1.4.2.	ISO 14067: 2018, 3.1.4.4
Material	Physical products supplied from a supplier upstream, used as input for production processes of products.	WBCSD Pathfinder Version 3.0
Negative emissions	Removal of *greenhouse gases (GHGs)* from the *atmosphere* by deliberate human activities, that is, in addition to the removal that would occur via natural carbon cycle or atmospheric chemistry processes.	IPCC Glossary AR6
Net negative emissions	A situation of net negative greenhouse gas emissions is achieved when metric-weighted anthropogenic greenhouse gas (GHG) removals exceed metric-weighted anthropogenic GHG emissions. Where multiple GHG are involved, the quantification of net emissions depends on the 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 AR6
Net zero CO_2 emissions	Condition in which anthropogenic carbon dioxide (CO_2) emissions are balanced by anthropogenic CO_2 removals over a specified period.	IPCC Glossary AR6
Net zero greenhouse gas emissions	Condition in which metric-weighted anthropogenic greenhouse gas (GHG) emissions are balanced by metric-weighted anthropogenic GHG removals over a specified period. The quantification of net zero GHG emissions depends on the GHG emission metric chosen to compare emissions and removals of different gases, as well as the time horizon chosen for that metric.	IPCC Glossary AR6
Output	Product, material or energy that leaves a unit process.	WBCSD Pathfinder Version 3.0
Packaging	Product to be used for the containment, protection, handling, delivery, storage, transport and presentation of goods, from raw materials to processed goods, from the producer to the user or consumer, including processor, assembler or other intermediary.	ISO 21067-1:2016(E), 2.1.1
Partial PCF	Sum of GHG emissions 3.1.2.5 and GHG removals 3.1.2.6 of one or more selected process(es) (3.1.3.5) in a product system 3.1.3.2, expressed as CO_2 equivalents 3.1.2.2 and based on the selected stages or processes within the life cycle 3.1.4.2.	ISO 14067: 2018, 3.1.1.2
PPA	Power purchase agreement On-site PPA: With an on-site power purchase agreement, a direct physical (and not just a balance sheet) supply of electricity takes place. Off-site PPA: Off-site PPAs do not involve a direct physical supply of electricity between the generator and a nearby consumer, but rather merely an agreement for the purchase of a physical	Catena-X Product Carbon Footprint Rulebook, Version 3.1

Term	Definition	Source
	amount of electricity defined in the PPA. Unlike on-site PPAs, the generator delivers the electricity to the consumer via the public grid. Virtual or synthetic PPA: Synthetic PPAs decouple physical power flows from financial power flows, thus allowing for flexible contract designs. In virtual power purchase agreements, as with physical PPAs, producers and consumers agree on a price per kilowatt-hour of electricity. However, the electricity is not delivered directly from the energy-generator to the consumer. Instead, the producer's energy service provider (such as an electricity trader) includes the produced electricity in its balancing group and trades it further, for example, on the spot exchange.	
Primary data	Quantified value of a process 3.1.3.5 or an activity obtained from a direct measurement or a calculation based on direct measurements.	ISO 14067: 2018, 3.1.6.1
Process	Set of interrelated or interacting activities that transforms inputs into outputs.	ISO 14067: 2018, 3.1.3.5
Product	Any good (tangible product, such as material) or service (intangible product). This includes e.g., services, software, hardware and processed materials.	WBCSD Pathfinder Version 3.0
Product carbon footprint (PCF)	Total GHG emissions generated during the life cycle of a product, measured in CO_2 eq.Within the boundary of the PACT Methodology, only material acquisition, pre- processing, production, distribution and storage are included in the PCF.	WBCSD Pathfinder Version 3.0
PCF system model	Mathematical representation of a physical system and the incorporated processes to calculate a PCF. Either complex, automated but also simple calculation solutions are referred to as PCF system models.	Catena-X Product Carbon Footprint Rulebook, Version 3.1
Product category	Group of products that can fulfill equivalent functions.	WBCSD Pathfinder Version 3.0
Product category rules (PCRs)	A set of specific rules, requirements and guidelines for calculating PCFs (among other things) and developing environmental declarations for one or more product categories according to BS EN ISO 14040:2006.	WBCSD Pathfinder Version 3.0
Product system	Collection of unit processes 3.1.3.6 with elementary flows 3.1.3.10 and product flows, performing one or more defined functions and which models the life cycle 3.1.4.2 of a product 3.1.3.1.	ISO 14067: 2018, 3.1.3.2
Prospective PCF	Product carbon footprint quantified for a production date in the future.	Railway-X PCF Rulebook (derived from Catena-X PCF Rulebook, Version 4)
Raw material	Primary or secondary material that is used to produce a product.	DIN EN ISO 14040:2021, 3.15
Reference flow	Measure of the inputs to or outputs from processes 3.1.3.5 in a given product system 3.1.3.2 required to	ISO 14067: 2018, 3.1.3.9

Term	Definition	Source
	fulfil the function expressed by the functional unit 3.1.3.7.	
Reference period	The time period of primary data collection for a PCF. For a prospective PCF, the reference period refers to the period for which the PCF is reported and which includes the expected production date.	Railway-X PCF Rulebook (derived from Catena-X PCF Rulebook, Version 4)
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) Article 2 Definitions
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.	Catena-X Product Carbon Footprint Rulebook, Version 3.1
Residual mix	The mix of energy generation resources and associated attributes such as GHG emissions in a defined geographic boundary left after contractual instruments have been claimed/retired/canceled. The residual mix can provide an emission factor for companies without contractual instruments to use in a market-based method calculation.	GHG Protocol Scope 2 Guidance, p106
Retrospective PCF	Product carbon footprint quantified for a production date in the past.	Catena-X Product Carbon Footprint Rulebook, Version 3.1
Risk management	Plans, actions, strategies or policies to reduce the likelihood and/or magnitude of adverse potential consequences, based on assessed or perceived risks.	IPCC Glossary
Signaling system	Railway signaling is a system used to control railway traffic safely, essentially to prevent trains from colliding. The main purpose of signaling is to maintain a safe distance at all times between all trains on the running lines.	RailNetEurope RNE Glossary - NS_CID_Glossary_2025
Secondary data	Data which does not fulfil the requirements for primary data 3.1.6.1.	ISO 14067: 2018, 3.1.6.3
Secondary material	Material 3.12 that has previously been processed or used, has been captured by a recovery system and has completed all recovery process steps and can be used as an input to produce new materials and products 3.15.	ISO 59014:2024, 3.19
Sectoral guideline	PCF reporting rules issued by industry associations or initiatives as guidance for their members.	Catena-X Product Carbon Footprint Rulebook, Version 3.1
Supplier gate	The supplier's factory (out-bound) gate, through which the product leaves the production site and is ready for shipment to the customer.	Catena-X Product Carbon Footprint Rulebook, Version 3.1

Term	Definition	Source
Supply chain	Those involved, through upstream and downstream linkages, in processes 3.1.3.5 and activities relating to the provision of products 3.1.3.1 to the user.	ISO 14067: 2018, 3.1.5.2
Sustainability	A dynamic process that guarantees the persistence of natural and human systems in an equitable manner.	IPCC Glossary
System boundary	Boundary based on a set of criteria specifying which unit processes are part of the system under study.	EN ISO 14040:2021 – 3.32
Transport/ distribution packaging	Packaging 2.1.1 designed to contain one or more articles 2.1.5 or packages 2.1.3, or bulk material, for the purposes of transport, handling and/or distribution.	ISO 21067-1:2016, 2.2.6
Unit process	Smallest element considered in the life cycle inventory analysis 3.1.4.4 for which input and output data are quantified.	ISO 14067: 2018, 3.1.3.6
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 Version 3.0
Use phase	That part of the life cycle of a product that occurs between the transfer of the product to the consumer and the end-of-life of the product.	WBCSD Pathfinder Version 3.0
Validity period	Period in which the PCF can be used (for reporting or calculation).	WBCSD Pathfinder Version 3.0
Value chain	All the upstream and downstream activities associated with the operations of a company.	WBCSD Pathfinder Version 3.0
Waste	Substances or objects that the holder intends or is required to dispose of.	ISO 14067: 2018, 3.1.4.9

Abbreviations

Abbreviation	Definition
CFCs	Chlorofluorocarbons
CH_4	Methane
CO_2	Carbon Dioxide
CO_2eq	Carbon Dioxide equivalent
EoL	End of Life
ESPR	Ecodesign for Sustainable Products Regulation See also information of European Commission
GCD	Great circle distance
GHG	Greenhouse Gas
GLEC	Global Logistics Emissions Council See also Website
GWP	Global Warming Potential GWP100year: 100-year GWP characterization factors
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
HFEs	Hydrofluoroethers
ID	Identification
IPCC	Intergovernmental Panel on Climate Change IPCC AR: IPCC Assessment Report
ISO	International Organization for Standardization
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LUC	Land use change dLUC: direct land use change iLUC: indirect land use change sLUC: statistical land use change
N_2O	Nitrous oxide
NF_3	Nitrogen trifluoride
OEM	Original Equipment Manufacturer
PACT	Partnership for Carbon Transparency See also Website
PCF	Product Carbon Footprint
PCR	Product Category Rules
PFCs	Perfluorocarbons

Abbreviation	Definition
PFPEs	Perfluoropolyethers
SF_6	Sulfur hexafluoride
SFD	Shortest feasible distance
SME	Small and medium enterprise
TFS	Together for Sustainability See also Website
UN CPC	United Nations Central Product Classification See also Website
WBCSD	World Business Council for Sustainable Development See also Website

1 Introduction

1.1 The railway sector

The railway sector is a vital component of sustainable mobility, offering low-emission transport solutions with high public visibility and strategic importance in climate action. As a key enabler of the transition to climate-neutral logistics and passenger transport, the railway industry plays a central role in addressing the global challenge of reducing greenhouse gas (GHG) emissions. To fulfill this role, it is essential for the sector to measure GHG emissions at the product level – both for the current state and for tracking progress in emissions reduction.

However, calculating the product carbon footprint (PCF) for rail vehicles and infrastructure presents significant challenges due to the complexity of the international railway supply chain. Rail systems rely on a wide array of materials, components and technologies. Even standardized parts are often sourced from multiple suppliers across different regions to ensure supply chain resilience and risk mitigation. This diversity and complexity make accurate and transparent emissions accounting a demanding but necessary task for the sector's climate strategy.

1.2 The challenge

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

The operation of rolling stock is shifting towards higher shares of renewable energy in the use of electric units and fossil fueled units are being replaced by alternative electric drives. Automatic train control systems optimize railway networks and further reduce energy consumption. As a result, the upstream and production phases now account for a larger portion of lifecycle emissions of railway systems.

The calculation of product carbon footprints based on secondary data currently does not reward those players within the supply chain, who contribute better than average performance in sourcing, production and distribution. As GHG reduction targets create demand for more sustainable solutions and data transparency, there is a growing need for product-specific, comparable GHG emissions reporting across the industry. Further, regulations such as the Ecodesign for Sustainable Products Regulation (ESPR), the EU Battery Regulation and others –do need stronger integration and harmonization of product related sustainability performance.

Several sector initiatives have emerged to address these needs, with sector-specific PCF accounting rules either published, under development, or planned. However, these initiatives often lack the cross-industry consistency required for reliable and comparable data at the supply chain level.

The railway industry is well-positioned to lead this cross-sector dialogue due to its interconnected supply chains, high material volumes and stringent safety and quality requirements. By exchanging verified, product-level PCFs based on primary GHG emissions data, railway companies can identify and accelerate decarbonization efforts, especially in hard-to-abate sectors, contributing meaningfully to Paris Agreement targets.

In a transitional phase not all value chain companies are able to have primary data available and thus the PCF value calculation is based predominantly on secondary data. In order to provide an incentive a KPI shall be introduced making the efforts towards a higher Primary Data Share (PDS) visible.

Digital ecosystems like Railway-X enable data-driven value chains with full data sovereignty, allowing companies to exchange sensitive information securely. However, the challenge of non-prescriptive standards remains. This means that identical parts and processes may yield different PCF values due to interpretation differences, not factual ones.

As PCFs become a critical KPI in procurement decisions, they must offer a robust basis for comparison. Differences in PCFs should reflect actual emission differences, not methodological inconsistencies. Therefore, a more detailed and harmonized approach to PCF accounting is needed in the railway supply chain to enable the exchange of comparable, verified data.

1.3 The purpose of this document

This PCF rulebook was developed to enable the integration of the PCF values into the **procurement process** and to ensure the **comparability** of the PCF values of different suppliers.

To ensure comparability the Railway-X PCF Rulebook aims to

1. define railway specific requirements for the calculation of cradle-to-gate Product Carbon Footprint values
2. ensure multi-tier industry wide interoperability via alignment with the Manufacturing-X initiative
3. foster a primary-data driven supply chain transparency
4. deliver a guideline for a scalable adoption for a multi-tier supply chain

The PCF rulebook does not disregard existing standards and rules. It formalizes how existing standards relate to each other and includes a hierarchy of conformity defining how it aligns with external methods and standards.

To reduce ambiguity in the interpretation of carbon footprint standards within the railway industry, this Railway Sector Product Carbon Footprint (PCF) Rulebook has been developed with a focus on the consistent exchange of production-related carbon footprint data across the entire value chain. The concept is illustrated through a simplified supply chain model, where each Tier (n) quantifies emissions from its own operations (gate-to-gate) and adds upstream emissions from Tier (n+1) to report the PCF to the next Tier in line (n-1).

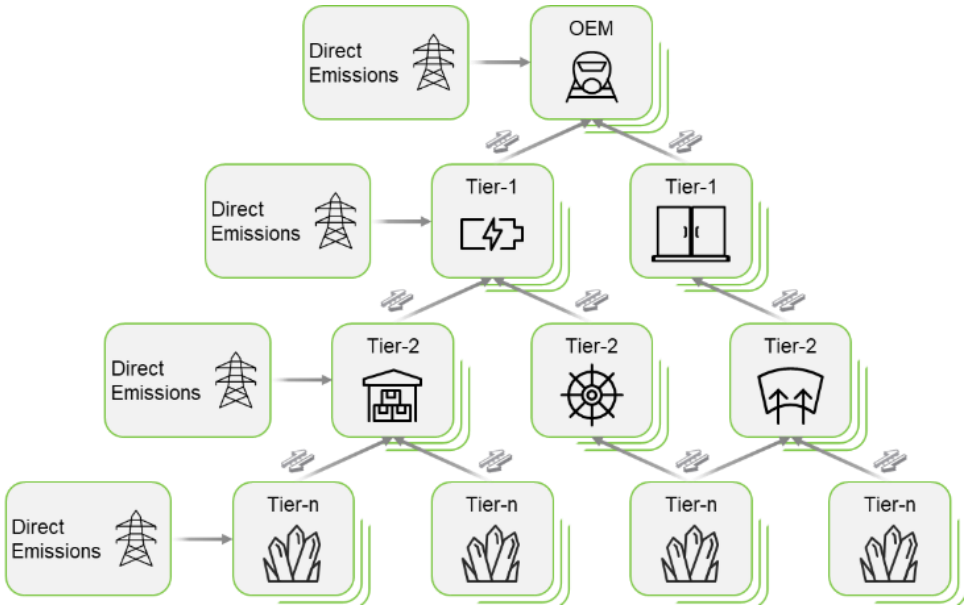


Figure 1 PCF in the value chain

This approach enhances consistency in PCF accounting and ensures comparability of cradle-to-gate PCFs for railway components and systems. It supports informed decision-making in supplier and part selection, particularly for rolling stock and infrastructure systems. In a later version of this Rulebook also guidelines for rail services shall be included. Accordingly, the Rulebook emphasizes the production phase of railway assets and systems.

While large enterprises often have the capacity to implement detailed PCF accounting, small and medium-sized enterprises (SMEs) may face challenges due to limited resources or expertise. Therefore, this Rulebook aims to balance applicability and comparability, ensuring scalability across the diverse and multi-tiered railway supply chain. To support this, certain rules will be introduced after a transition period, allowing companies time to adopt more complex methodologies. Additional guidance materials and collaboration with SME representatives will be prioritized to facilitate adoption.

Given the importance of data sovereignty in the railway sector, full disclosure of all data required for PCF accounting is not always feasible. To address this, the Rulebook defines indicators for data quality and the proportion of primary data used, thereby fostering trust and transparency across the value chain.

This Rulebook is publicly available and open to feedback to ensure broad acceptance of reported PCFs within the railway ecosystem. It is not intended to guarantee conformity with Corporate Scope 3 Accounting under the GHG Protocol.

The railway supply chain is highly complex, involving materials and components from sectors such as steel production, electronics, construction and energy. Therefore, the Rulebook allows for the integration of existing or emerging sectoral guidance and product category rules, provided they are recommended or accepted by the governing body. For sectors critical to railway operations, alignment efforts are underway to accept these methodologies – either fully or with additional requirements – for use in PCF calculation and reporting within the railway ecosystem.

Additional guidance on waste and co-product handling is provided in Annex A 1. Sector methodologies are described in Annex A 3, while Annexes A 4 -A 7 outline the current status of acceptance, additional requirements, and recommendations. Updates to the sector methodologies will be provided if necessary.

Furthermore, alignment with other ecosystems is ongoing to ensure interoperability of PCF data exchange models. This includes collaboration with cross-sector initiatives such as the Pathfinder Initiative by WBCSD.

As regulatory frameworks evolve, such as the EU's delegated regulation on carbon footprint calculation for industry batteries, similar developments in railway-specific regulations will be monitored. Guidance documents will be developed to clarify overlaps and synergies between this Rulebook and emerging regulatory requirements relevant to the railway sector.

1.4 Railway-X PCF use cases framework

Exchanging PCFs based on the Railway-X Product Carbon Footprint Rulebook using the Railway-X data ecosystem requires a predefined use case framework (Product Carbon Footprint ("PCF")) for each participant. They shall agree to this Framework and make their data exchange legally binding by way of separate declarations. To comply with this use case framework: "Data Provider and Data Consumer are responsible for compliance with all legal and regulatory requirements applicable (in particular with regard to (i) antitrust law (including, but not limited to, antitrust-compliant implementation taking into account the "one-up-one-down principle" and "compliance by design"), (ii) tax, trade and export control law, (iii) data protection, (iv) trade secrets, digital regulation) for themselves and any affiliates registered for this use case".

2 Setup of the framework

2.1 Version

This rulebook will be updated and PCFs shall thus be calculated according to the latest available version of this rulebook. The current version of this document can be found on the title page.

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” indicates what is required for a Railway-X-PCF to be compliant with this rulebook.
- The term “should” indicates 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” indicates 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 V).

2.3 Topics out of scope

The Railway-X Rulebook focuses on the products for the railway sector and, thus, PCF accounting spans from cradle-to-(factory outbound) gate for railway signaling products, vehicles and components and all intermediate products.

Railway-X also aims to include maintenance activities. These definitions shall be added in a later version of this Rulebook and thus in the current version service is out of scope.

Therefore, recycling is currently only reflected in the PCF through the use of secondary material considering raw material acquisition and pre-processing. To holistically account for recycling and assess recycling strategies, other methods are required but are currently out of scope.

2.4 Transition period

This document foresees a transition period after the official start of the Railway-X PCF 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 last until end of 2029.

3 Existing methods and standards

3.1 Relationship

Railway-X is part of the larger Manufacturing-X ecosystem and is therefore aligned with the wider industry initiatives. As Catena-X is the pioneer in this context, the Railway-X PCF Rulebook deliberately follows the Catena-X PCF Rulebook closely. Figure 2 shows a list of selected Manufacturing-X initiatives and the interrelation regarding a shared technical foundation.

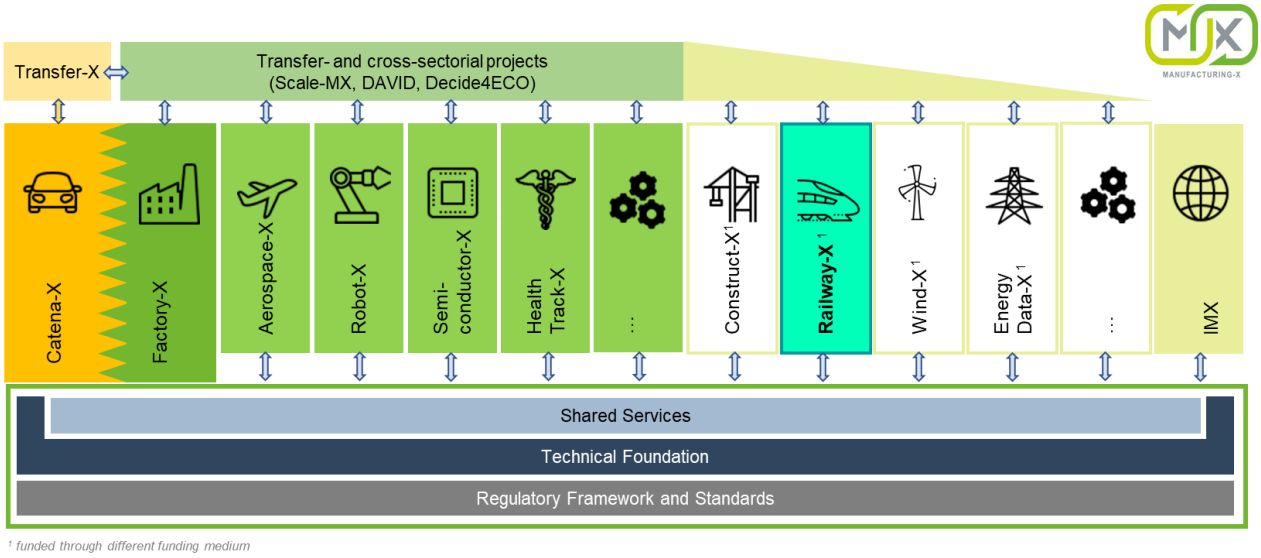


Figure 2 Overview of X-Projects (© BMWE)

The Railway-X Product Carbon Footprint Rulebook is based on the product carbon footprint standard ISO 14067 as well as ISO 14040 and 14044 life cycle assessment standards (Figure 3).

The Railway-X PCF Rulebook further specifies existing standards and, if applicable, refers to sectoral guidance and product category rules for product carbon footprints in the railway sector.

Additional alignment processes for other sectoral guidance are planned.

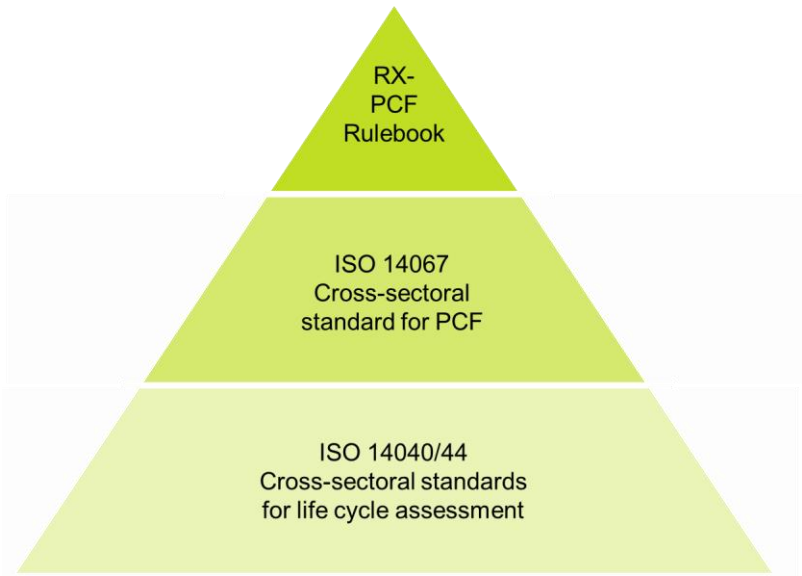


Figure 3 Relationship of standards

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. Railway supply chain-specific requirements shall be applied as defined in this document.
3. Sector-specific, product-specific and component-specific rules should be applied if prescribed within this rulebook.

Eventually, additional sector-specific, product-specific and component-specific rules guidance will be added.

The relationship between the Rolling Stock PCR and this PCF Rulebook is discussed in Annex A 9.

Information on the applied methods or standards shall be shared downstream as part of the PCF Data Model (section Data model) to create greater transparency and enable comparability.

One of the regulations that requires a predefined calculation method for the carbon footprint is EU Regulation 2023/1542, Article 7, Annex II. These methodology guidelines are provided by “Rules for the calculation of the Carbon Footprint of industrial Batteries without external storage (CFB-IND)”.

4 Scope and system boundary

The Railway-X PCF rules are based on the attributional LCA approach and follow the requirements of ISO 14067 in general. 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.

The Railway-X PCF Rulebook shall be applied to the products according to UN CPC 495 and UN CPC 53212 excluding railway roadbeds.

Examples of in-scope products are:

1. Railway vehicles including railway special purpose vehicles
2. Signaling system (onboard and on-track products)
    i. Onboard unit
    ii. Operations control system
    iii. Interlockings
    iv. Signals
    v. Track vacancy detection
    vi. Point Machine
    vii. Level Crossing etc.
3. Power supply system:
    i. Catenary system
    ii. Distribution station
    iii. Power feed cable
    iv. Transformers etc.

Out of scope are all buildings, stations, bridges, tunnels, track superstructure, rails and other railway infrastructure.

For later versions of this Rulebook, it is planned to include rules for service activities, which are currently out of scope.

4.1 Quantification of carbon footprint (biogenic and/or fossil)

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

The GHGs that shall be accounted for are 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), hydrofluoroethers (HFEs), perfluoropolyethers (e.g., PFPEs), chlorofluorocarbon (CFCs) and hydrochlorofluorocarbon (HCFCs). To ensure the latest required GHGs, please refer to IPCC Assessment Report (AR).

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 latest IPCC's AR. These factors include the carbon climate response for non-CO_2 gases, i.e., carbon feedback and chemical effects.

Once a new AR has been published, its characterization factors shall be used. If the characterization factors cannot be updated immediately, a transition period of two years after the publication of a new IPCC AR is granted after which the characterization factors shall be updated. If secondary data used are based on outdated characterization factors, this must be clearly stated and alternative datasets that use the latest characterization factors should be prioritized.

Currently applicable during AR6 being the latest AR: The AR 6 characterization factors for the substances that are not listed in case of AR 6 in Table 7.15 of the IPCC AR6[1] shall be extracted from Table 7 SM6 in Section 7 Supplementary Materials of the AR6 Climate Change 2021[2].]

Currently different GHG accounting schemes, i.e., PCF including (ISO 14067) and excluding biogenic CO_2 (PEF and GHG protocol), are applied. The situation is depicted in Figure 4 with the individual contributions (referred to as position A-H) to the total PCF explained in Table 1.

For PCF reporting according to the Railway-X Rulebook, both the total GWP including biogenic CO_2 uptake (T1 in Table 1) and the total GWP excluding biogenic CO_2 uptake (T2 in Table 1) shall be provided. The total GWP including biogenic CO_2 uptake shall be used for the calculation of the primary data share, the data quality rating and the verification share.

The total GWP including biogenic CO_2 uptake includes the sum of the separate emission values T1 = A+C+D+E+F+G+H and the PCF excluding biogenic CO_2 uptake includes the sum of the separate emission values T2 = A+C+E+F+G+H.

In addition to the total PCF, following emission values should be reported separately:

Emission	Conditional	Description
GWP total incl. biogenic CO_2 Uptake	Shall	Position T1 = A+C+D(negative contribution)+E+F+G(negative contribution)+H. Letters refer to individual emission categories below. This also refers to the -1/+1 Approach. "GWP total incl. bio. Uptake" may be set equal to "GWP total excl. bio. Uptake" if the product has no or a neglectable biogenic carbon content. General cut-off criteria apply as criteria for negligibility.
GWP total excl. biogenic uptake	Shall	Position T2 = A+C+E+F+G(negative contribution)+H. Letters refer to individual emission categories below. This also refers to the 0/0 Approach.
GWP fossil	Should	Position A: includes all fossil emissions, including industrial processes, stationary/mobile combustion and fugitive emissions. This position includes the fossil emissions associated to land management (A1: "GWP fossil land management") which cannot be documented as a separate emission category in the Railway-X data set, but is part of PACT and TFS
GWP biogenic emissions other than CO_2	Should	Position C: non-CO_2 biogenic emissions related to agricultural activities. It encompasses emissions as described in PACT v3.0:

[1] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07.pdf
[2] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07_SM.pdf

		CH4 emissions from livestock and manure; CH4 emissions from biomass burning and fires; CH4 emissions from rice production; CH4 emissions from transformation and degradation (e.g., combustion, digestion, composting, landfilling). It must be noted that N_2O from land management activities are not included in this position and are reported in position A and A1 (as a detail).
GWP biogenic CO_2 uptake (biogenic CO_2 contained in the product)	Should	Position D (negative contribution): The CO_2 which was absorbed from the atmosphere during the growth period of the biomass and of which the C is now bound in the product as biogenic carbon content.
GWP land use change (LUC, excluding iLUC)	Should	Position E: Emissions from LUC constitute a release of GHG emissions due to a change in land use from one land use category or subcategory to another, such as primary forest to agricultural land, or peat land (type of wetland) to cropland. This position encompasses dLUC (direct land use change) emissions. If that data is not available, companies should account for LUC using statistical land-use change (sLUC) emissions. iLUC emissions are excluded. Refer to PACT v3.0 for details.
GWP Land Management CO_2 Emissions	Should	Position F: carbon stock losses occurring within the same land use category or subcategory due to agricultural practices such as tillage, field preparations, pruning and harvest. Land Management CO_2 emissions measures biogenic CO_2 emissions from a net loss in carbon stock within one land use category or subcategory. This includes impact on the land-carbon pools, including above- and below-ground biomass, dead organic matter and soil carbon pools. If the carbon stock increases within the same land use category and the conditions to report removals are met, this may be calculated as a Land management CO_2 removal (position G). Refer to PACT v3.0 for details.
GWP Land Management CO_2 Removals	Should	Position G (negative contribution): Land management removals are net CO_2 removals resulting from net increases to carbon stored in land-based carbon pools (biomass, dead organic matter and soil carbon pools) due to ongoing land management practices. This extra net carbon stock is gained over the crop rotation or crop cultivation cycle (e.g., multiple years for perennial crops and multiple years in a rotation that includes annual crops). Refer to PACT v3.0 for details.
GWP Aviation emissions (upstream)	Should	Position H: Aviation emissions which have occurred in distribution stages upstream.

Table 1: Explanation of the factors influencing the biogenic uptake

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 carbon offsets (see Section 7.2.6).

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

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, the CO_2 uptake shall be considered in the separate emission value D (GWP biogenic CO_2-uptake) if documented.

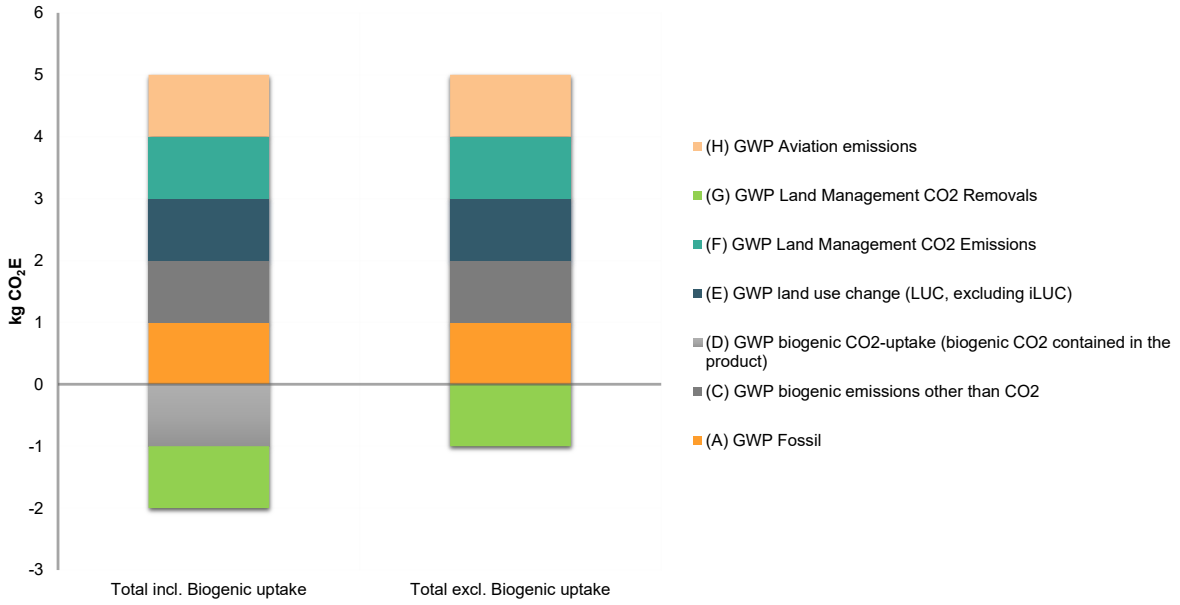


Figure 4: Overview of the specific PCF components (incl. & excl. biogenic uptake)

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 Railway-X 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, selling a product to the end customer (e.g., OEM). Even though the end-of-life (EoL) stage is excluded from the scope of this document the PCF-rules described in this document are applicable to the EoL processes as well and specifically shall be applied to quantify the carbon footprint of secondary material or reuse/remanufacture of components.

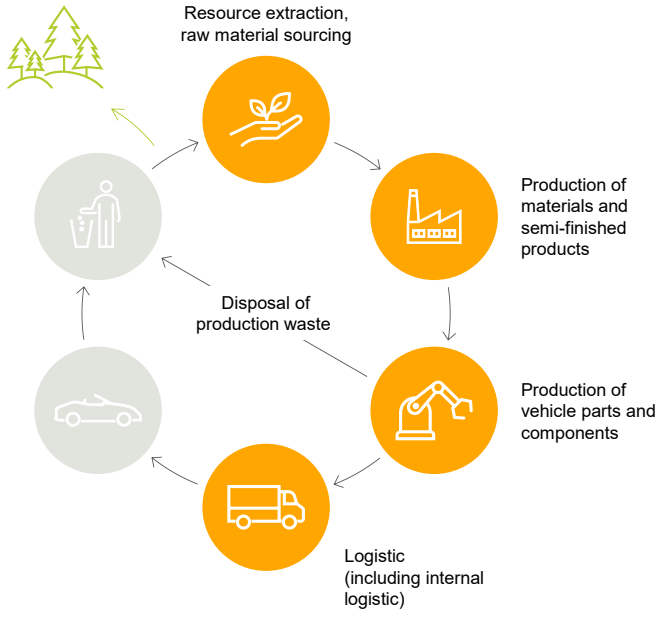


Figure 5: System boundaries for Railway-X PCF

The cradle-to-gate PCF of the Railway-X 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 RX-PCF rules system boundaries are therefore:

- Resource extraction, raw material sourcing
- Production of materials, semi-finished products
- Production of vehicles (+ signaling/infrastructure, power supply) parts and components
- Packaging of vehicle parts and components, including all operations required for performing packaging
- Disposal of production waste (incl. packaging waste)
- Logistics (including internal logistics and transport packaging) (Section 5.2.1)
- Quality control in production
- IT for process and manufacturing control
- Commissioning and testing of vehicle/ onsite test

Despite being included in the system boundaries in principle, insignificant processes may be excluded based on the cut-off rules outlined in section 4.3.

In general, GHG emissions not connected directly to the production system relevant to the product shall be excluded from the system boundaries. These are amongst others:

- Employee commuting and work travel
- Research and development, administration, or sales processes
- Auxiliary inputs not directly related to the production process (such as heating and lighting of associated office rooms, sanitary facilities, canteen services, facility management e.g., plant security and fire safety and general IT)
- Auxiliary inputs to maintain the manufacturing equipment
- Emissions from construction or dismantling of capital goods (such as buildings, manufacturing equipment or any other infrastructure for transport, media or energy distribution and energy generation, within or outside the control of the reporting company)

4.3 Cut-off rules – criteria to exclude certain activities

In general, all processes and flows that are attributable to the analysed system shall be included. If, based on the results of a screening analyses, 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 3% of the total product carbon footprint T1. This 97% coverage shall be achieved and documented in a screening analysis.

Screening Analysis

An initial screening of the Life Cycle Inventory (LCI) of (a) representative product(s) shall be performed by the company calculating PCFs, referred to as the screening step. The screening pursues the goal to point out needs of action in terms of data collection activities or activities to improve data quality. Screening shall include the Life Cycle Impact Assessment (LCIA) for the Impact Category climate change using the characterization factor Global Warming Potential and allow further refinement of the PCF system model of the product(s) in scope in an iterative manner as more information becomes available. Within screening, no exemption is allowed and readily available primary or secondary data may be used, fulfilling the data quality requirements to the extent possible.

To determine the 97% coverage, the PCF data received from suppliers and emission factors shall be considered 100%, as direct insights in the actual coverage of the upstream supply chain are 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 analysis shall be updated at the end of the validity period of the Railway-X PCF (see Section 7.2.1), so that possible changes of significant activities can be considered.

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 Railway-X sectoral guidance acceptance process.

The results of the screening analysis shall be documented.

4.4 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 Railway-X PCF Rulebook.

Possible declared units are piece, kilogram, liter, cubic meter, kilowatt hour, megajoule, ton kilometer, square meter, hour and megabit second or a legally prescribed functional unit exists, it shall be applied, for example for energy-providing batteries, the functional unit is defined (according to Annex II of Regulation (EU) 2023/1542).

For countable products, i.e., a component or part, the declared unit should 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 should be 1 kg of products, regardless of its state (solid, liquid, gas), as its specific density is considered.

The declared unit for service products shall be defined in the upcoming version of the Rulebook including the other definitions regarding the maintenance PCF guidelines.

If packaging is included, the declared unit should be 1 kg or 1 piece of unpackaged product at the factory gate. The PCF however includes the PCF contribution of packaging.

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 4.3).

5.1.1 Calculation

Included in the supplementary Guidance Product Carbon Footprint (PCF) Calculation. (see Annex)

5.1.2 Allocation

Allocation shall be avoided whenever possible. If allocation cannot be avoided, follow the approach in Figure 6. In all cases, double counting shall be avoided by applying consistent allocation approaches.

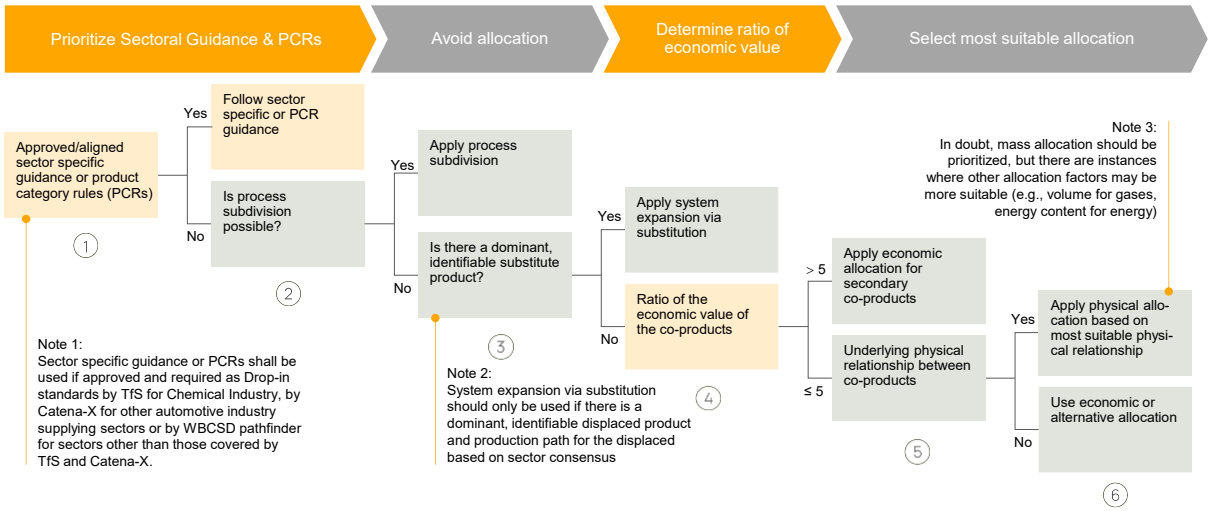


Figure 6: Multi-output allocation decision procedure

1) 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 a governance process or an initiative representing an industry sector and authoring a sector guidance which is accepted by Railway-X as drop-in standard. In absence of a Railway-X governance process, the Catena-X governance process shall be adopted to the railway sector. Any remaining differences or contradictions to the Railway-X Rulebook in an accepted sector guidance or PCR will be handled via the governance process and, if required, additional guidance will be provided.

2) 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.

3) 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 Note 2. in Figure 6:

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. Dominant means that the production process is the main process on the market. If available, positive lists of co-products

and displaced products based on sector consensus shall be used to model the system expansion and the respective substitution credits. For the emissions data, primary data shall be used and secondary data may only be used if primary data is not available. In case of secondary data, the requirements in section 6 shall apply to guarantee that the dataset and source for calculating system expansion credits are compliant. If no sector consensus exists, the following requirements shall always be fulfilled:

- The production of the co-product is an integral part of the production process
- A dedicated, single-output process to produce the co-product exists
- The alternative dataset must be representative of the dominant production route and comply with the requirements of chapter 6.2
- A clear description of the process for selecting the alternative product substituted by the co-product shall be internally documented

No market-mediated effects shall be applied, as the attributional LCA approach shall be used. The customer of the co-product can be provided with a PCF of the co-product. This enables the customer of the co-product to account for the co-product's correct footprint and prevents double counting of credits.

4) 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 coproduct per declared unit. 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, prices as shown in the hierarchy below shall be averaged over the last 3 – 5 years to smooth out fluctuations.

5) 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 masses
- produced pieces
- contained exergy
- contained energy

Combined electricity and heat generation represents a special allocation problem. In this case, allocation shall be based on the amount of exergy generated.

6) 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).

For the determination and use of economic allocation factors, the following hierarchy shall be applied. Only one type of economic allocation factor shall be chosen consistently in the order of priority of the hierarchy. Only if the respective prioritized factor is not available, the next factor in the hierarchy may be chosen. The chosen factor shall always be averaged over 3-5 years to smooth out fluctuations. A systematic approach should be internally documented for materials with high fluctuations of the selected factor of price/cost.

1) Global market price (global market prices are usually only available for commodities)
2) Regional market price
3) Other economic allocation factors (i.e., production costs or sales price)

[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

standards. Further alignment activities with other sectors will be handled via the Catena-X governance process for sector guidance acceptance. The governance process has yet to be established.]

5.2 Additional guidance

5.2.1 Prospective PCF

Fundamental considerations suggest that a distinction should be made between three types of prospective PCF depending on the point in time of the product creation process at which a PCF is quantified.

In very early phases there are only design concepts of the product and accordingly not detailed information on production processes and supply routes has been fixed yet. The uncertainty of a prospective PCF is high due to numerous unknowns. In this case a new product without forerunner shall be applied (a).

In a very late phase of the product creation process, the product may already be in serial production and the prospective PCF refers to the future performance of the existing production. Manufacturing processes can be assessed and information from the supply chain can be gathered. The uncertainty of a prospective PCF in this case is low due to the limited number of unknowns. In this case a further developed product with forerunner shall be applied (c).

Type “b” of a prospective PCF is introduced here, as it represents an intermediate case in terms of uncertainty. This applies when a product undergoes further development compared to a predecessor model. For the predecessor all information on manufacturing processes and supply chain are available and only the revised portions of the product introduce new and higher uncertainties.

These three types of prospective PCF will be differentiated in this document:

a) new product without forerunner,

b) further developed product with forerunner,

c) current product for future production date

5.2.1.1 Upstream GHG emissions for a prospective PCF

In case a prospective PCF is provided for a **new product** without forerunner, LCA models that use secondary data may be applied to quantify the upstream production emissions. The applied process models shall represent those intended for series production.

In case the prospective PCF refers to a **new generation or further development of an existing product**, the upstream production emissions for the modified product portions may be quantified with LCA models that use secondary data. Also, in this case the modelled processes shall represent those intended for series production. For portions of the product that remain unchanged upstream production emissions shall be quantified based on the supply chain of the forerunner product. Reductions to these upstream emissions are only permitted if commitment from the reporting supplier can be presented at time of declaration.

In case the prospective PCF refers to an **existing product**, reductions to the upstream production emissions are only permitted if commitment from the reporting supplier can be presented.

Commitment means in this context that a written statement of the reporting supplier on the emission reduction was obtained. Proof of commitment is not required from all upstream suppliers. The commitment can also be demonstrated by a prospective PCF report from the supplier.

5.2.1.2 GHG emissions for a prospective PCF from own operations

In case a prospective PCF is provided for a **new product** without forerunner LCA models secondary data may be applied to quantify the production emissions. The applied process models shall represent those intended for series production.

In case the prospective PCF refers to a **new generation or further development of an existing product**, the production emissions for the modified product portions may be quantified with LCA models that use secondary data. Also, in this case the modelled processes shall represent those intended for series production. For portions of the product that remain unchanged production emissions shall be quantified based on the production of the forerunner product. Reductions to these emissions are only permitted if changes to established production processes can be demonstrated, or emission intensity of used energy can be justified and proven.

In case the prospective PCF refers to an **existing product**, reductions to production emissions from own operations are only permitted if improvements to the production emissions can be justified by reduced emission intensity of used energy. To justify a reduction in emission intensity of energy used, the energy supplier's commitment, respective purchase agreements or official corporate statements on the reduction of scope 1 and 2 emissions is required.

5.2.2 Homogeneous parts

While many parts 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 homogeneous 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 homogeneous 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 homogeneous 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 $R^2 > 90\%$. 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.

Prospective PCF

The interpolation for homogeneous parts may be used in case the product in question is a future new member to a homogeneous product family. In case the interpolation of the whole product family is projected into the future, the interpolation parameters shall be recalculated based on the prospective PCF for the minimum and maximum PCF-variant of the family. The procedure is illustrated in Figure 7.

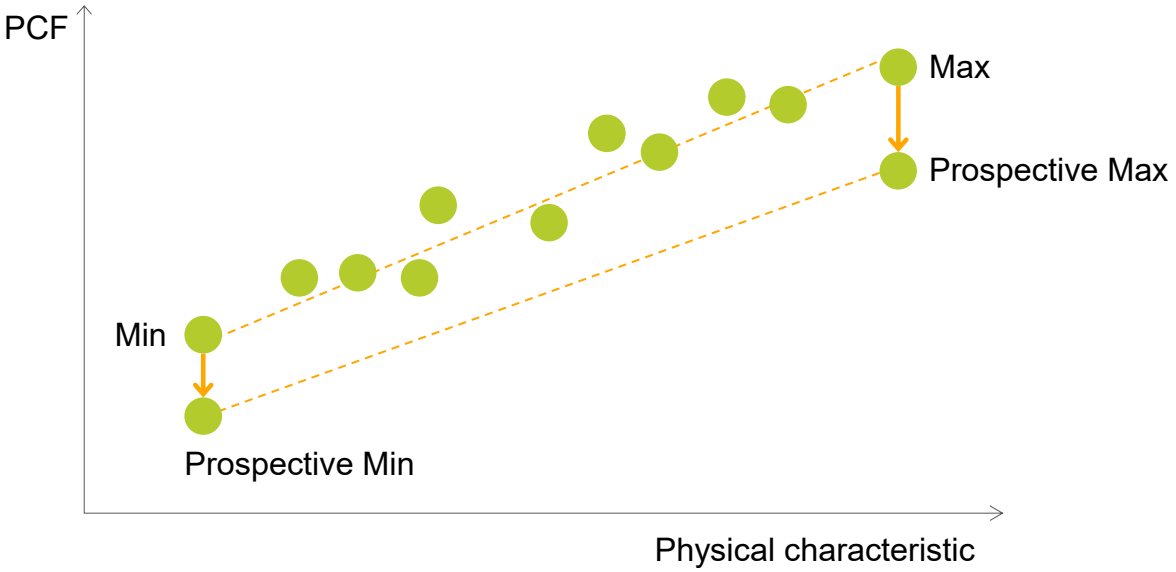


Figure 7: Interpolation line for prospective PCF of homogeneous part

5.2.3 Emissions from transportation

In addition to emissions from production and manufacturing, there are also emissions from transportation and transshipment of products. All upstream transportation and transshipment 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 4.3 Cut-off-Rules). This section deals with transportation from a supplier to its customer.

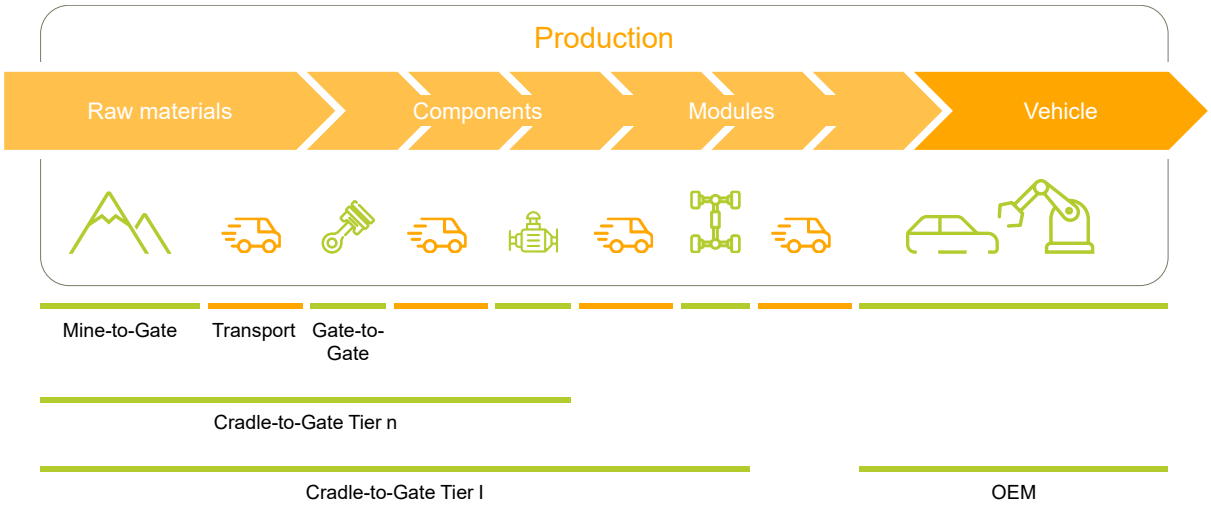


Figure 8: Definition of scopes

As for the product carbon footprint, the cradle-to-gate boundaries end at the suppliers' outbound 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 2). Otherwise, the customer shall account for transportation between the supplier's and its own shipping site (factory gate or distribution center, see Figure 9 and Figure 10).

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

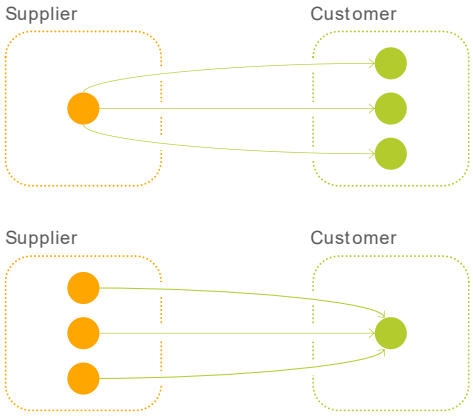
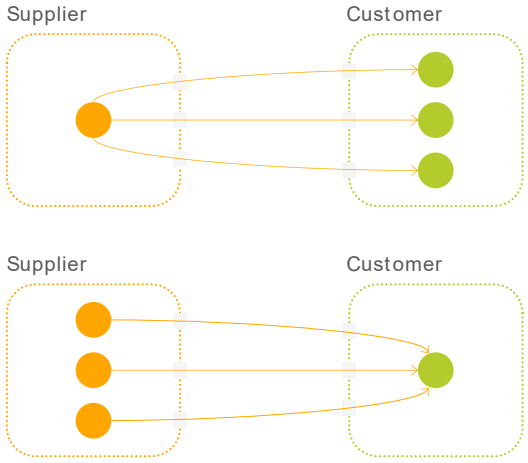
Case	Description	Economic/operative responsibility for transportation from supplier to customer	Accounting for transportation emissions
1	Multiple shipping sites and/or multiple unloading sites 	Inbound transportation contracted or operated by customer	Customer responsible for quantification of transportation emissions. As for multiple transportation relations, emissions shall be attributed by mass between the respective products
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 attributed by mass between the respective products

Table 2: 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.

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.

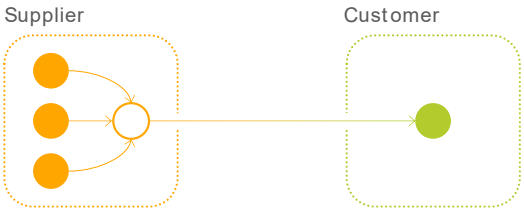


Figure 9: Distribution center on supplier side

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.

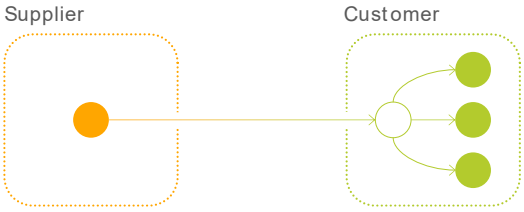


Figure 10: Distribution center on customer side

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

5.2.3.1 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.

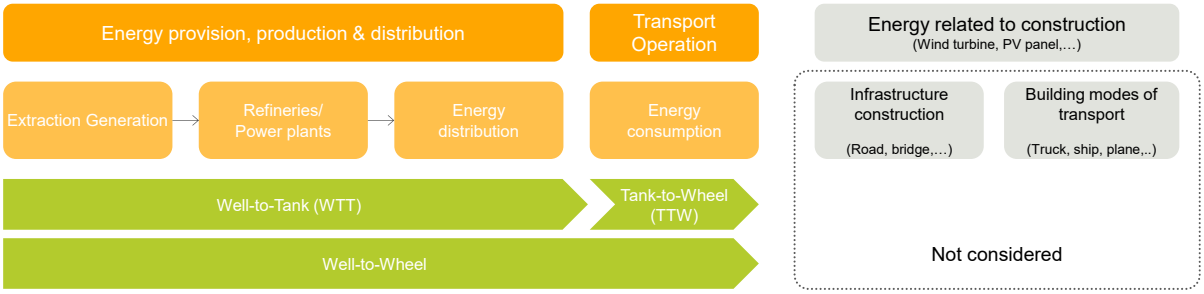


Figure 11: System boundaries for transportation

In case of transport chains (transport of a product by more than one transport mode) the chain links shall be individually quantified and subsequently summed up.

Consistent with the Railway-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. In case of collective transport operations the primary data-based transport emissions require allocation to the individual product. Such allocations do not change the classification of emission data as being primary data.

Direct measurement of fuel/energy consumption of a transport operation may however not always be possible and modelling transport emissions is required. Calculation of transport emissions shall follow the recommendation set out in the latest GLEC Framework. The GLEC framework allows for three

approaches to establish transport distances: Shortest feasible distance (SFD), great circle distance (GCD) and actual distance. These approaches shall be used according to the following hierarchy:

- Actual distance
- SFD
- GCD

To perform the calculation, tools verified according to the GLEC framework may be used, for example, but not limited to

- CarbonCare CO_2-Emissionsrechner
- EcoTransIT Emission Calculator

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.

Prospective PCF

In case transport emissions for an existing product need to be quantified, any changes to the current transport emissions need to be justified by commitments of the logistic companies.

The same applies to unaltered portions of a product with a forerunner product. Only modified portions can be subject to modelling the transport emissions.

In case of a product without any forerunner product transport emissions require modelling.

For the not yet determined shipping points/route of a transported good an assumption concerning the predominant origin of this product in the company's own supply chain shall be set. The most common mode of transport/transport chain shall be assumed for the defined shipping route. Subsequently, the transport distance shall be established according to the GLEC framework. To perform the calculation, tools certified according to the GLEC framework may be used.

5.2.4 Accounting for waste treatment

Waste is any material or process output which is not deliberately produced as an integral part of a multioutput production process. No further use of the material or process output is certain. Additionally, the holder discards or intends to discard or is legally required to discard the residue based on national waste legislation.

Waste materials with certain further use but requiring further treatment other than normal industrial practice before use (i.e., waste recovered by recycling) shall follow the requirements laid down in section 5.2.5 on material recycling.

"Normal industrial practice" can include all steps which a producer would take for a product, such as the material being filtered, washed, or dried; or adding materials necessary for further use; or carrying out quality control. However, treatments usually considered as a recovery operation cannot, in principle, be considered as normal industrial practice in this sense. Some of such processing tasks considered as normal industrial practice can be carried out on the production site of the manufacturer, some on the site of the next user and some by intermediaries, as long as they also meet the criterion of being 'produced as an integral part of a production process' (adopted from the EU's Guidance on the interpretation of key provisions of Directive 2008/98/EC on waste).

A **co-product** in contrast is produced as an integral part of a multi-output process where its further use is certain. Typically, co-products directly replace a raw material or fuel without requiring further

processing other than normal industry practice. For co-product allocation, multi-output allocation applies (please refer to section 5.1.2). The following hierarchy shall be applied (please refer to Annex 1.A 1 for definitions of the respective criteria):

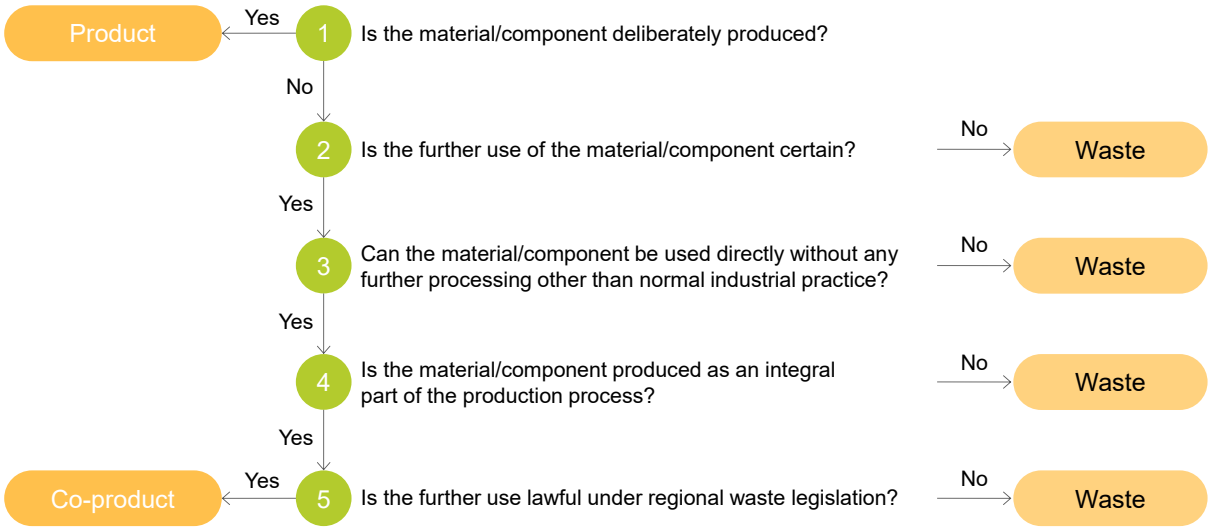


Figure 12: Waste vs. co-product classification hierarchy based on EU Waste Framework Directive

Residues classified as waste following the hierarchy can also be transformed into recycled feedstock. However, this transformation would require further processing other than normal industry practice (see point 3 in Figure 12), such that the residue would be classified as waste in the first instance.

Pre-consumer scrap that is not reintroduced into the same process shall be defined as waste unless legal evidence (following legislation of the region where scrap is generated, e.g., legal judgement or legal report from regional waste legislation) exists that classifies the pre-consumer scrap material as co-product.

Any GHG emissions arising from the treatment of production waste shall be included in the total PCF. Since this document's system boundaries span from cradle-to-gate, this production waste treatment refers to the production life cycle stage only.

Waste can be generated during different stages of a product's life cycle (cradle-to-gate), including (see Figure 13):

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

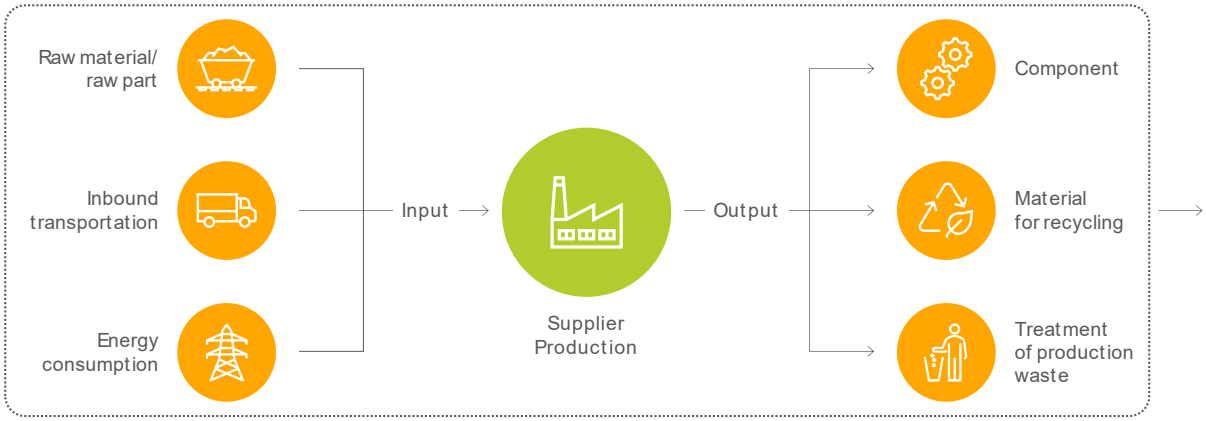


Figure 13: Waste generation during different stages of a product's life cycle

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 4.3 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.

For incineration, credits are not considered, only incineration process impacts shall be taken into account. 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 5.2.5. Accounting for recycling (within the transition period).

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 secondary databases can be employed (section 6.2).

If companies do not have access to primary data from third-party waste treatment facilities, they should 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).

5.2.5 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.

Railway-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 multioutput 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 Railway-X network
- Avoidance of double counting
- Higher comparability of PCFs across Railway-X

The product system generating material for recycling follows a cut-off approach in a cradle-to-gate scope. Preparatory steps for recycling shall generally be allocated to the waste receiving system (i.e., the product system using the (to be) recycled material). This deviation from the polluter pays principle (as required for waste-to-energy, incineration, or disposal emissions) is a pragmatic exemption as following the polluter pays principle in this context would require defining material- and component-specific system boundaries. Other than the emissions from the respective preparatory steps and the recycling treatment emissions, to be recycled, to be re-used, or to be re-manufactured materials enter the product system using burden-free recycled materials.

For pre-consumer scrap, preparatory steps owned by the company generating the waste shall be accounted for by the producer of the waste (they might be insignificant; cut-off rules apply).

5.2.5.1 Accounting for recycling (after the transition period)

Railway-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 sector-specific guidelines may serve as the basis for deciding if other allocation methods are prescribed.

For PCF reporting according to Railway-X the cut-off applies.

5.2.6 Accounting for GHG emissions from electricity

For each process step within the System boundaries that require 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. Contrary to the general definition of the system boundaries, which exclude emissions from construction and decommissioning of infrastructure (in the following referred to as infrastructure emission), these are included for the electricity infrastructure. The transition to renewable and non-dispatchable energy generators results in additional emissions that should be reflected in a PCF.

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) including losses during transmission and distribution and downstream emissions (e.g., the treatment of waste arising from the electricity plants). The inclusion of infrastructure emissions shall be handled specifically according to the way a consumer is connected to electricity generators and the consumers demand profile. Connecting to the electricity grid generally allows a consumer to receive electricity on demand. The electricity system has to ensure that power demand and power generation is in balance at any instance. This system feature requires considerable additional efforts on the infrastructure side beyond installing the nominal renewable energy generation capacity. Energy storage, conversion, back-up generation and additional transmission capacities are required as even higher shares of non-dispatchable energy generators (e.g. wind turbines and solar panels) enter into the electricity system. The electricity **system** infrastructure emissions therefore need to be quantified.

5.2.6.1 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 from this power generator and the related emission factor shall be used if no contractual instruments have been sold to a third party. Otherwise, the electricity shall be considered as provided from the grid.

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.

The infrastructure emissions shall be reported for the specific generator type (e.g. onshore wind turbine, solar panel, etc.) reflecting the specific emissions from the construction and decommissioning of the generator as well as the respective local capacity factor and lifetime definitions.

5.2.6.2 Electricity from the grid (by a power supplier or) via contractual instruments

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

1. 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.

2. 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 is met to ensure the contractual instruments are reliable.

Otherwise, the country-specific residual grid mix (consumption mix) shall be used (such as AIB4[3] for Europe). Country-specific means the country in which the activity occurs.
If residual grid mixes are not available, grid-specific fossil mixes shall be used.
In case secondary data are used that include country specific grid mixes and with reasonable effort it is not possible to replace those by residual fossil grid mixes, these data sets are admissible.

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

Contractual instruments

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.

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. Electricity from PPAs can only be considered eligible linked with EACs.

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 an interconnection can be proven).

If minimum criteria are not met the fossil grid mix shall be used.

If in a region no contractual instruments concerning the carbon intensity of electricity are available, the location-based reporting with the country specific grid mix shall be used.

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 electricity consumed, the residual grid mix shall be used for the uncovered amount.

Since Energy Attribute Certificates (EACs) typically do not contain explicit emission factors, but rather indicate the generator type and geographical location, it is acceptable to use emission factors from secondary databases that correspond to the technology type and region.

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)
- Infrastructure emissions:
  - If contractual instruments define the generator form (e.g. wind or solar power) from which the energy is purchased ´as produced´, the infrastructure emissions, as defined for a direct connection (see 5.2.6.1), are to be included, along with the infrastructure emissions for the transmission network. The latter are currently not quantified and omission is therefore accepted for the time being.
  - If contractual instruments do not define a specific generation profile the system infrastructure emissions shall be added. As this is currently not quantified in a systematic and regular manner, the infrastructure emission shall be determined from the annual non-dispatchable renewable energy, the split of installed generator capacity the specific emissions from the construction and decommissioning of the generator and the respective life-time definition.
  - If in absence of contractual instruments, the residual or fossil grid mix is applied, dispatchable generators shall be assumed for which infrastructure emissions are typically negligible and shall be stated as such.

Prospective PCF

For prospective PCF: If a commitment is made to use a certain generator/power supplier (e.g. wind power) by the company, it shall be eligible to use the emission factor for the committed type of power generation. If there is no commitment the electricity for the company's own operations shall be accounted by using the residual grid mix for the region or country of the foreseen manufacturing site. In case upstream production emissions are estimated via LCA models from secondary sources the future location-based consumption mix according to the Stated Policies Scenario (STEPS) of the IEA World Energy Outlook may be used.

A commitment may be evidenced by a contracted green energy procurement for the PCF's reference period with corresponding EACs or a written obligation to enter into such green energy procurement. Alternatively, a corporate commitment e.g. documented in the company's sustainability report shall suffice as evidence. On-site energy production and dedicated connections follow the same guidelines as a retrospective PCF.

5.2.7 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, five possible chains of custody models, illustrated in Figure 14. 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.

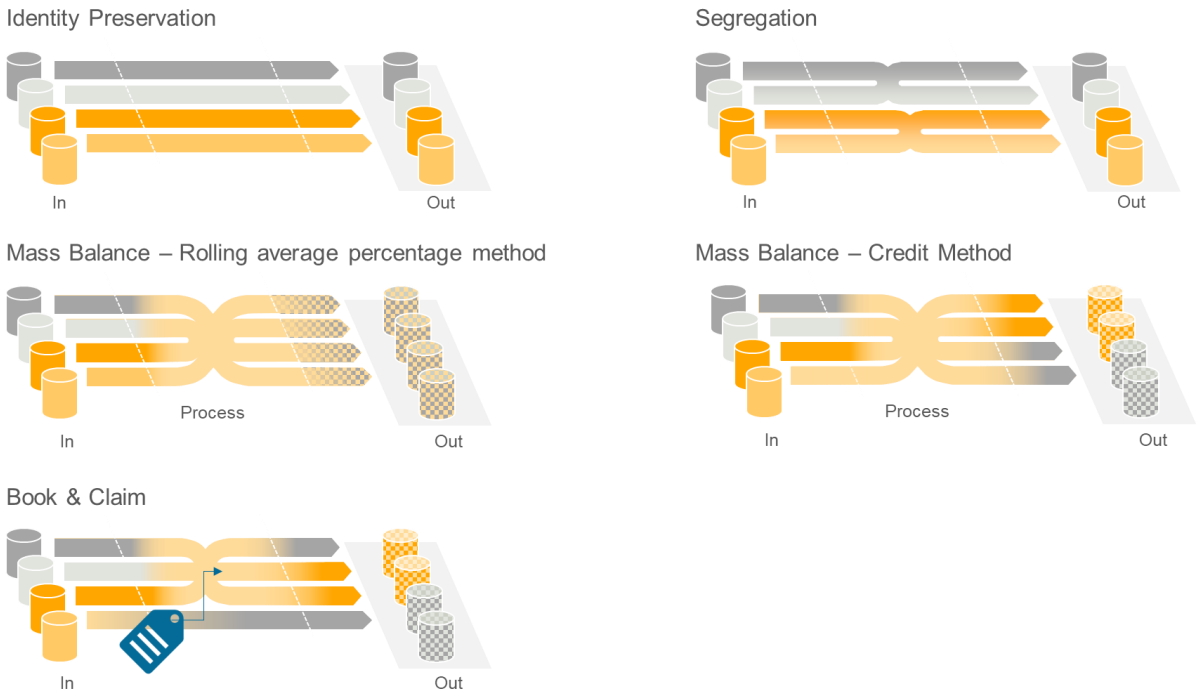


Figure 14: Overview of chain of custody models

The following table provides high-level explanations and differentiations for the chain of custody models:

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 steel from a single certified producer.
Segregation	Consists of the aggregation of volumes of products of identical origin or produced according to the same standards in one stock item.	Buying steel from a trader that exclusively handles identically certified supplies
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 steel production, use of recycled, or green steel
Mass balance - Rolling average percentage method	The rolling average percentage method is based on the use of a fluctuating proportion of input bearing specified characteristics entering the organization over a defined claim period, allowing a claim of an average percentage to be made for the output over the claim period. This means the attributes are allocated as a time-averaged value across a process chain or production sites.	Proposal: the example of electricity with fluctuating amounts of on-site produced and grid electricity used (depending on e.g. weather conditions, an average can be assumed over a certain period of time)

Model	Explanation	Example
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.

Table 3: Explanation chain of custody models

[adapted from the EMF Whitepaper: "Enabling a circular economy for chemicals with the mass balance approach" Table 1, page 11]

The rolling average percentage method and the credit method are special cases of mass balance and were added subsequently.
The mass balance approach is intended to enable the transition from fossil raw materials to more sustainable alternative materials (e.g., scrap or bio-based materials).
Only clearly product-related Chain of Custody Models may be used. That means that the book and claim method is, by default, not an applicable method to use. This rule does not apply to energy carriers such as electricity, fuels and biomethane. For these purposes the book and claim method can be applied.

5.2.7.1 Guiding principles

In implementing chain-of-custody methods, including mass balancing, the 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 lower GHG emissions production in complex value chains.
2. The choice and implementation of chain-of-custody approaches and models shall be transparent, clear, credible and verifiable. Established certificate systems like REDCert II and ISCC Plus can be used if they follow the specifications for mass balancing in this chapter. Proof must be submitted by the organization using the certificate, i.e. the company producing the product that was verified according to the scheme.

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.

If the "specified characteristic" content in products cannot be measured and verified, labels and claims shall mention this. This often applies to mass balancing, e.g. chemically recycled content in plastics.

3. No double counting: A reliable accounting system shall be installed at each operating site to ensure that the claimed volume on the output side exactly matches the actual volume on the input side within the declared time and regional scope.
4. For each material or product, claim periods shall be defined, which shall correspond to the claimed relation of the input to the output. These input and output claim periods shall not exceed the defined time period of reporting (max. 1 year)

5. The operating sites in the spatial boundaries for mass balancing are under the operational control of the same company/ corporate group/ joint venture.

Additional requirements for a mass balance credit method.

6. It shall be technically possible according to standard industry practice to produce a mass-balanced product from an alternative feedstock. The share of the balanced input shall not exceed the maximum technically possible share for this process route (e.g. Blast furnace route vs. Electric arc furnace route for steel).
7. Only additional measures relative to the PCF of the residual product shall be considered. The residual product is the product without reduction measures used in mass balance within the respective reporting year.
8. Physical traceability of the material in the supply chain: By default, it shall be possible for portions of the material to be physically present in the product.
9. Technical equivalence: The product must possess the same technical properties as the equivalent product without applied measures.

Continuous production processes in downstream vehicle (component) production can entail challenges in the attribution of sustainable characteristics to products within single sites. A multi-site mass balance (i.e. multi-site credit transfer) may be applied within integrated economic areas (e.g., European Economic Area (EEA), USA, China) in cases where a site-specific mass balance leads to an unintended increase in GHG emissions compared to a multi-site mass balance.

The multi-site mass balance must be certified or verified externally (e.g. by an accredited certifier or verifier). The requirements for a site-specific mass balance shall equally be applied for multi-site regional mass balances. It shall be made transparent if multi-site transfer is applied.

5.2.8 Accounting for commissioning and testing

In the railway sector, products such as rolling stock, components and related equipment undergo extensive testing before they are placed into service. These tests serve different purposes and occur at different stages of the product lifecycle. To ensure consistency in carbon footprint reporting, it is essential to define which emissions should be included in the Product Carbon Footprint (PCF) and which should be excluded, as well as to clarify who bears responsibility for calculating these emissions.

Type tests, which are performed once during a project to obtain regulatory approval, represent a unique category. These tests, together with theoretical analyses and documentation, are necessary for type certification and are typically carried out by the manufacturer. However, because they are one-off activities that do not relate to individual units, the emissions associated with type tests should not be included in the PCF of any product. This approach aligns with ISO 14064 principles, which emphasize relevance and appropriate boundary setting and avoids distorting per-unit comparisons.

In contrast, **series tests and commissioning activities** are integral to the production process. These tests are performed on every unit – whether a rail vehicle or a component – to verify functionality and safety before delivery. Commissioning includes final integration and operational checks that ensure the product is ready for service. Emissions arising from these activities must be included in the PCF because they are directly attributable to the individual product. This includes energy consumption during functional tests, fuel use during dynamic commissioning and any auxiliary processes required for these checks. The testing activities and resulting emissions should be attributed to the product that is being tested as long as it is not further installed, in which case the emissions would be attributed to the subsequent product. Where engines or exhaust systems are involved, ISO 8178 provides guidance on test cycles, fuel specifications and measurement methods, which should be applied to quantify emissions accurately.

Responsibility for calculating and reporting these emissions follows the principle of economic responsibility. The party that bears the cost and operational control of the tests must include the associated emissions in the PCF of the product it delivers. For example, if a manufacturer performs functional tests on each HVAC unit before shipment, those emissions belong in the component's PCF. Conversely, if a railway operator conducts network compatibility tests after delivery, these emissions fall outside the manufacturer's cradle-to-gate boundary and shall not be included in the vehicle's PCF.

6 Data sources and hierarchy

6.1 Primary data

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

Efforts shall be taken to increase the share of primary data as well as achieve high data quality for both secondary and primary data, for data quality rating see section 7.2.5.

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_2eq per unit (Table 4Table 5). Consequently, the measured materials consumptions incl. using a secondary GHG emission factor is not considered primary (see Table 4 and section 7.2). 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.

Measurements used in combination with stoichiometric relations — such as calculating GHG emissions from measured fuel consumption — are also judged as primary data. For the combustion of standard fuels qualities (as e.g. Diesel B7 or Gasoline E10), their respective emission factors shall be considered as primary data; upstream shall be considered separately.

In addition, emission factors derived from Energy Attribute Certificates (EACs), when matched to the generator type and location using recognized secondary databases as described in section 5.2.6, may also be considered primary data.

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 secondary data bases representing GHG emission intensity (CO_2eq per kWh).

Approach	**Direct emission measurement**			
Primary data, if	Source of emission is within company boundaries and is measured			
Approach	**Activity data source**		**Emission factor source**	
	Energy	**Material**	**Energy**	**Material**
Primary data, if	Consumption measured (primary)		For on-site production Emission measured (primary) For supplier-specific electricity: Primary with guarantee of origin	Measured and reported as a share by supplier
Secondary data, if	Consumption/production measured (primary)		Secondary databases, data proxy	

Table 4: Possible variances of primary and secondary data

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 Allocation). Mathematical modelling 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 shall be used, which might incorporate more than production-related emissions, e.g. emissions related to research and development.

6.2 Secondary data

Railway-X pursues the goal of calculating PCF based on primary data. This, however, will not be feasible from the onset of Railway-X as primary data will not be widely available in the short term. 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.

Even if the use of secondary data is required, any competitive distortion shall be avoided (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 ecosystem partners, regardless of size, economic power or experience in life cycle assessment.

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

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

Combinations of the approaches are also feasible.

Regarding the above-mentioned requirements, the first option is clearly the superior approach to achieve comparability. 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 practitioner has access to the same data. A fully harmonized prescribed set of data provided by Railway-X would also eliminate the need to define and do any data quality rating.

The 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 must keep in mind however, without a RX-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 prescriptive data, but the need to provide this effort upfront and centrally from the Catena-X, Manufacturing-X or Railway-X side. A pragmatic solution with the support of various associations seems to be the most viable way forward.

Defining a hierarchical list of secondary data sources starting with association data already follows the logic of a RX 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 association's data. This already indicates that avoiding arbitrary evasion of universal databases will require a set of rules/criteria regarding which approximations are permissible and RX-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 RX 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 RX is the superior approach. As of now, this harmonized data does not yet exist and RX will thus require hierarchical use of secondary data sources in the following sequence:

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

If secondary data is not available within the references listed, 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 7.2.5 Data quality rating).

The particular value of association data is the higher certainty that the CO_2eq intensities represent an industry/sector average and, in some cases, even indicate the dispersion of CO_2eq intensities around the average value. RX 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 RX 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 RX-PCF Rulebook. A report on the full technical specification will be included in a separate document.

Prospective PCF

Three types of prospective PCF (see 5.2.1) shall be indicated in the data model:

1. new product without forerunner,
2. further developed product with forerunner,
3. current product for future production date

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.

Prospective PCF

For a prospective PCF, a defined period of one year shall be taken into account. For example, the Start-of-Production (SoP) year using planning values and reference consumption from existing facilities. Reference consumption from existing facilities shall reflect annual average values to balance out seasonal fluctuations.

For simplification the reference values shall refer to a steady-state production situation neglecting any volume ramp-up effects.

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. To perform the annual check, the initial screening analysis should be updated based on data for the most recent year. An update of data is mandatory if the reported emission increases by 10% or more based on the screening analysis compared to the previous reporting period. Additionally, an update of data is mandatory in the following situations (adapted from GHG protocol):

- Structural changes in operation to the product system under study, including significant process change in operation, technology advancement, raw material or energy changes.
- Changes in calculation methodology or improvements in the accuracy of emission factors or activity data or inclusion of new types of sources that result in a significant impact on the emissions data. Discovery of significant errors, or a number of cumulative errors that are collectively significant.

Prospective PCF

For a prospective PCF no annual checks are mandatory. An update shall only be provided on demand

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. The Primary Data Share (PDS) is defined as the proportion (percentage) of a PCF that is derived from primary data (as defined in section 6.1).

To ensure that a consistent PDS can be reported no matter if reporting is done stepwise or collectively for multiple steps, the percentage of the primary data shall relate to the absolute sum of all positive or negative PCF contributions (PCF_{as}). Otherwise, negative emissions would lead to wrong weighting of contributions to the aggregated PDS.

For the PCF excluding biogenic CO_2, the absolute value is identical to the Total PCF excluding biogenic, because no negative values occur.

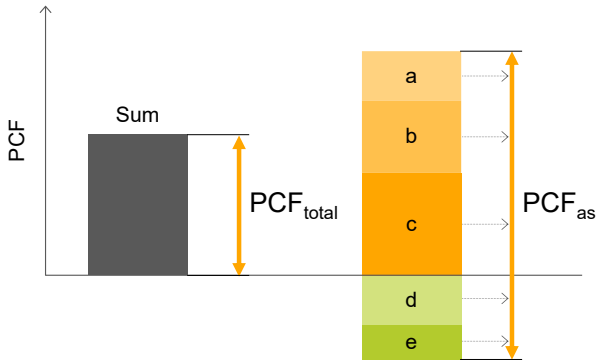
> **Introduction of the PDS for PCF including biogenic CO_2 uptake**
>
> *Biogenic emissions have a negative PCF value when using the -1/+1 approach. Therefore, the net value (total PCF including biogenic CO_2) has a lower value than the sum of all its absolute contributions.*
>
> *-1+1 = 0 vs absolute value |-1| + |1| = 2*
>
> *For the PDS including biogenic CO_2 an absolute value PCF has to be used to consider that positive and negative emissions have an influence on the PDS. Otherwise, the above described wrong weighting would occur and could even lead to a negative primary data share or a primary data share above 100 percent.*

The primary data share is calculated based on all contributions to the PCF caused by the company itself and in the upstream activities and emissions.

If a system expansion or an allocation is necessary, these have no influence on the value of the primary data share itself. All main and co-products from one unit process therefore have the same PDS.

Figure 15 illustrates the definition of PCF_{as} (a-e represent contributions to the PCF, of which d & e are biogenic CO_2).

$$PCF_{as} = \sum_i |PCF_i|$$



Contribution	PCF_i	$PCF_{total,i}$	$PCF_{as,i}$
a	1.00	1.00	1.00
b	1.50	1.50	1.50
c	2.00	2.00	2.00
d	-1.00	-1.00	1.00
e	-0.75	-0.75	0.75
Results		2.75	6.25

Figure 15: Definition of PCFas

Having introduced PCF_{as} the primary data share can now be defined:

$$PDS_{PCF} = \frac{|Amount\ of\ emissions\ based\ on\ primary\ data\ |}{PCF_{as}}$$

The aggregated primary data share for multiple PCF contributions reported with individual PDS (PDS_i)

$$PDS_{aggregated} = \frac{\sum_i \left(PCF_{as,i} \cdot PDS_i\right)}{\sum_i PCF_{as,i}}$$

All PCF values have the unit $kgCO_2eq$.

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 (shown in orange color) and contribution to the absolute value total PCF of the part of Company D (cf. Figure 16). According to the formula above, the primary data share of Company D's part (shown in green color) is calculated from the primary data share and contributions to the absolute value total PCF (see Figure 16).

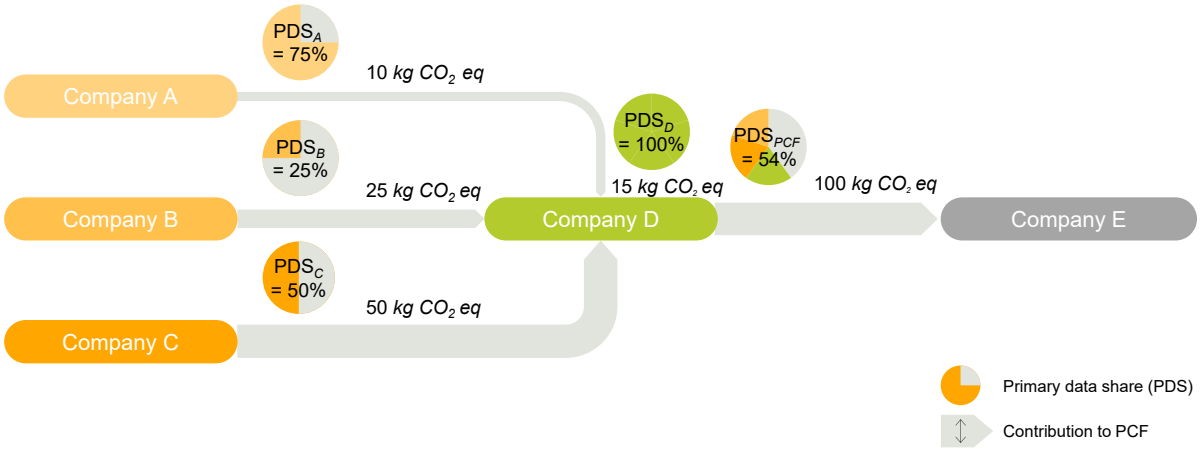


Figure 16: PCF cascade of primary data for an exemplary supply chain

	PDS_i	$PCF_{as,i}$	$PCF_{as,i} \cdot PDS_i$
Company A	75%	10 $kg\ CO_2\ eq$	7,5 $kgCO_2\ eq$
Company B	25%	25 $kg\ CO_2\ eq$	6,3 $kg\ CO_2\ eq$
Company C	50%	50 $kg\ CO_2\ eq$	25 $kg\ CO_2\ eq$
Company D	100%	15 $kg\ CO_2\ eq$	15 $kg\ CO_2\ eq$
Total	54%	100 $\boldsymbol{kg\ CO_2\ eq}$	≈ 54 $\boldsymbol{kg\ CO_2\ e}$, (7,5 + 6,3 + 25 + 15) $kg\ CO_2\ eq$

Table 5: Primary data share of the example as in Figure 16

When calculating the primary data share, a contribution to the primary data share shall only be attributed, if both the activity data (e.g. amount in kWh) and the GHG emission factor (expressed in $kgCO_2eq$ per unit) information is derived from primary (Table 5). Supplier data shall only be considered as primary data if declared as such in percentage of primary data share.

Only product- or company-specific data may contribute to the primary data share.

Prospective PCF

A Primary Data Share shall only be provided for retrospective PCFs.

Transition period

The Primary Data Share will be mandatory after the transition period. In between it is highly recommended to report the Primary Data Share.

7.2.5 Data quality rating

In Railway-X, companies calculate the product carbon footprint from (compare chapter 6):

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.

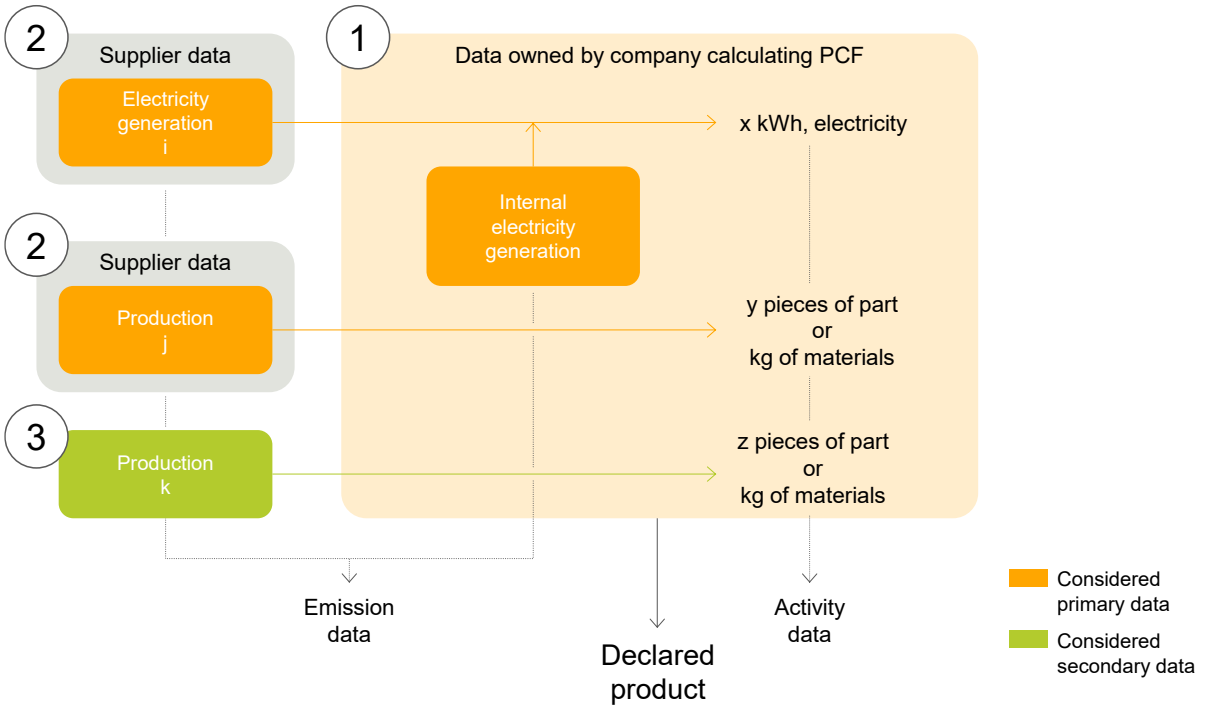


Figure 17: Data sources for PCF calculation

7.2.5.1 Data quality assessment (only valid after transition period)

The latest PCF data model supports the here prescribed approach. Previous versions of DQR reporting are discontinued. The use of data quality ratings is recommended to increase transparency and data reliability; however, their application is not mandatory at this stage.

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

Today companies can calculate their Product Carbon footprints (PCFs) with the scope cradle-to-gate using several data types. The quality of data can be significantly different. Therefore, data quality assessments of data used to calculate a PCF provide data users with a better understanding of the overall integrity of the data and the resulting PCF.

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

- **Technological representativeness:** the degree to which the data reflects the actual technology 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.

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 three data quality criteria where TeR is the technological representativeness, TiR is the time/temporal representativeness, GeR is the geographical representativeness, Table 6 shall be used to determine a semi-quantitative data quality rating.

The quality levels are expressed in five categories from 1 (best) to 5 (worst). The representativeness (technological, geographical and time-related) characterizes the degree to which the processes and products selected depict the system analyzed.

Technological Representativeness (TeR)

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

Temporal Representativeness (TiR)

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

Geographical Representativeness (GeR)
1. The dataset has been created based on data reflecting the country subdivision in which the product has been manufactured. **Example for country subdivision:** Provinces in China, States in the US, applicable for bigger countries.
2. The data set has been created based on data pertaining to the country in which the product has been manufactured. The area where the dataset is generated is valid for the geographical area where the site is located. **Example:** The site is in California and the dataset is a US average
3. The data set has been created based on data pertaining to the geographical region (e.g. Europe, Asia, N. America), in which the product has been manufactured. The area where the dataset is generated is valid for the geographical area where the site is located. **Example:** The site is in Spain and the dataset is a European average
4. The dataset has been created based on global averages **Example:** The site is in Japan and the dataset is a global average
5. The dataset has been created based on data with a geographical scope which is either unknown or pertaining a country, or region not including the site in which the product has been manufactured. **Example 1:** In absence of a global average, the dataset geographical applicability is unknown. **Example 2:** The site is in Mexico, but the dataset is a US average, or a Finnish average or an Asian average or a European average.

Table 6: Sample scoring criteria for performing a qualitative data quality assessment

The data quality shall be propagated through the supply chain in the same manner as the primary data share (PDS). If no DQR is reported, the values representing the lowest data quality as per the sample scoring criteria in Table 6 will be propagated as a default. Therefore, the lowest rating has either the meaning of the lowest data quality or that no data quality rating has been reported.

Prospective PCF

A DQR shall only be provided for retrospective PCFs.

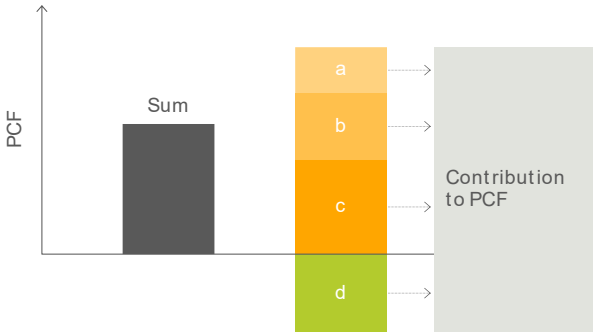
7.2.5.2 Aggregated Data Quality Rating

Each data quality indicator of the PCF (technical, temporal and geographical) shall be calculated as a weighted mean with the absolute total product carbon footprint excl. bio contribution as weight:

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 18). When calculating an aggregated DQR, negative contributions would lead to erroneous calculation of the data quality rating.

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

$$DQR_{aggregated} = \frac{\sum_i (|PCF_i| \cdot DQR_i)}{\sum_i PCF_{as,i}}$$



Contribution	PCF	DQR	PDS
a	1.00	1.00	0.90
b	1.50	2.00	0.70
c	2.00	2.00	0.80
d	-1.75	2.70	0.30
Results	w/o correction w/ correction	1.20 2.00	1.10 0.65

Figure 18: Calculation of an aggregated DQR

7.2.6 Reporting carbon offsets

Sharing PCF data across the Railway-X network requires the full PCF (cradle-to-gate) to be shared. Any GHG offsets (such as defined in the glossary) 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 carbon offsets have been purchased, they shall transparently mention the origin of reported carbon offsets and refer to the original certificate.

For rules on taking a renewable electricity certificate into account, refer to section 5.2.6.

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

Annex

A 1. Additional guidance on classifying waste vs co-product

‘Deliberately produced’ means that the manufacturing process directly seeks to produce the material/ component, i.e. is the result of a technical choice.

‘Further use is certain’ means that it is not a mere possibility but a certainty; in other words, it is guaranteed that the material will be used. This criterion may be indicated through, for example:

- Existence of contracts between the material producer and subsequent user
- A financial gain for the material producer
- A solid market (sound supply and demand) existing for this further use
- Evidence that the material fulfils the same specifications as other products on the market

‘Used directly without any further processing other than normal industrial practice’ means that if a production residue has to be treated before it can be used, this may indicate a waste treatment operation. Those treatment techniques that address typical waste-related characteristics of the production residue, such as its contamination with components which are hazardous or not useful, would prevent classification as non-waste. On the other hand, a treatment which is normal industrial practice, e.g. modification of size or shape by mechanical treatment, does not prevent the production residue from being regarded as a by-product.

‘Normal industrial practice’ can include all steps which a producer would take for a product, such as the material being filtered, washed, or dried; or adding materials necessary for further use; or carrying out quality control. However, treatments usually considered as a recovery operation cannot, in principle, be considered as normal industrial practice in this sense. Recovery operations are divided into three sub-categories: preparing for re-use, recycling and other recovery.

‘Produced as an integral part of a production process’ means that the process where the co-product is generated has to be an integral part of a production process. Therefore, a material, which is made ready for further use through an integral part of a production process, can be regarded as a co-product. If a material leaves the site or factory where it is produced in order to undergo further processing, this may be evidence that such tasks are no longer part of the same production process, thus disqualifying it as a co-product.

‘Further use is lawful‘ means that the further use of the material must be lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements at the national level for the specific use and will not lead to overall adverse environmental or human health impacts.

Source for Annex: European Commission (2012): Guidance on the interpretation of key provisions of Directive 2008/98/EC on waste.[4]

A 2. Additional guidance on PCF Calculation from Catena-X

See document: https://catena-x.academy/index.php?gf-download=2024%2F11%2F2024-07-29_PCF-Calculation_V89428.pdf&form-id=1&field-id=5&hash=d235dd71bb2c49b8786bd13a5679be3b5017913726c541f1d0dc5904290d738a

[4] https://ens.dk/sites/ens.dk/files/Affald/guidance_on_the_interpretation_of_key_provisions_on_waste.pdf

A 3. Sectoral guidance acceptance

This document provides additional rules for the calculation of product carbon footprints (PCFs) using accepted sectoral guidelines while ensuring compliance with the methodological principles set out in this document.

Currently, the below listed sectoral guidelines have been accepted by Railway-X and may be used to calculate PCFs for Railway-X reporting purposes. These sectoral guidelines may only be used for reporting in the Railway-X ecosystem when fulfilling the additional requirements stated in this document with further recommendations that should be complied with. Fulfilling these additional requirements will ensure compliance with the rules in RX-PCF by resolving the divergences between RX-PCF and the accepted sectoral guidelines.

If particular production steps in the value chain are not covered by the currently accepted sectoral guidelines, the RX-PCF rules shall be applied. As shown in Figure 19 this is currently the case for, e.g., certain component producers.

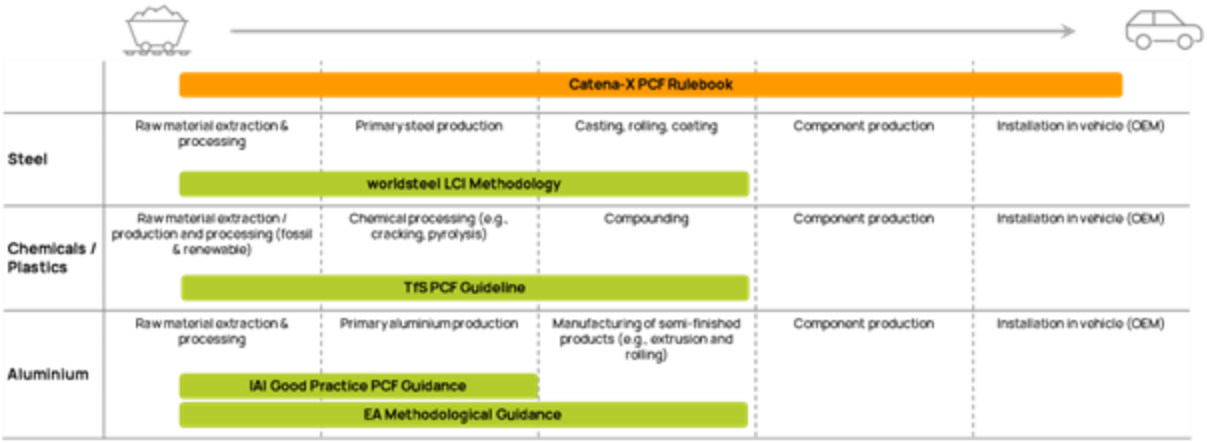


Figure 19: Coverage of accepted sectoral guidelines mapped to the automotive supply chain

Accepting sectoral guidelines requires a detailed mapping of the respective sectoral guideline to RX-PCF rules to identify and classify methodological differences as well as an extensive alignment process with sectoral stakeholders to derive resolutions for all methodological divergences.

Steel

- **World Steel Association (worldsteel) (2017)**: Life cycle inventory methodology report for steel products (2017 update). URL.

Aluminum

- **International Aluminium Institute (IAI) (2021)**: Good Practice Guideline for Calculation of Primary Aluminium and Precursor Product Carbon Footprints (v2.0). URL.
- **European Aluminium (EA) (2023)**: Methodological Guideline for the Environmental Assessment of Aluminium Intermediate and Semi-Finished Products (Rev. 8). URL.

Chemicals

- **Together for Sustainability (TFS) (2022)**: The Product Carbon Footprint Guideline for the Chemical Industry - Specification for product Carbon Footprint and Corporate Scope 3.1 Emission Accounting and Reporting (Version 3.0). URLs.

Railway-X acknowledges that further sector- or material-specific PCF methodologies and standards exist. Railway-X prioritized the worldsteel, IAI, EA and TFS methodologies as accepted sectoral

guidelines due to their high relevance in the railway value chain in terms of PCF contribution and broad adoption in practice. Going forward, further sectoral guidelines will be considered for acceptance by Railway-X. Only the above-specified versions of the guidelines have been accepted. Acceptance of any updates to the specified versions of the guidelines generally requires a re-assessment by Railway-X.

For each accepted sectoral guideline, Annexes A 4 to A 7 provide tables that describe the divergences between RX-PCF rules and the respective accepted sectoral guideline, as well as additional requirements that shall or should be applied to ensure compliance with RX-PCF rules (i.e., additional requirements (“shall”) or recommendations (“should”) when using the respective sectoral guideline). Where no additional requirement or recommendation is provided in this chapter, following the sector methodology can be considered as being compliant with RX-PCF rules. During the creation of Version 4 of the RX-PCF rulebook, also a new version of the TFS PCF guideline was in preparation and a majority of discovered discrepancies has been resolved in a joint effort. Annex A 5 only shows remaining divergences between RX-PCF and the TFS guideline.

Railway-X strives to minimize the need for additional requirements and closely engages with sector representatives throughout the sectoral guideline acceptance process and beyond.

A 4. Additional requirements for user of the worldsteel LCI methodology (2017)

Table 7 provides additional requirements for the worldsteel LCI methodology that shall be applied as accepted sectoral guideline for Railway-X compliance. It describes the divergences and additional requirements. The additional requirements presented in Table 7 shall be followed by companies reporting until further notice and independent of the transition period that RX-PCF defines (except if explicitly mentioned otherwise).

Table 8 provides information on methodological differences that are classified as additional recommendations that should be followed.

The additional requirements in Table 7, as well as the recommendations in Table 8 are based on the version of the worldsteel methodology that is specified in Annex A 3 of this document. Both tables may be updated as required.

Table 7: Additional requirements for worldsteel LCI method, shall be applied for RX compliance

PCF topic	Chapter in worldsteel	Chapter in RX-PCF	Methodological divergence	Additional requirement for Railway-X reporting
Allocation of multi-functionality	3.6.1 Co-products	5.1.2 Allocation	worldsteel does not prescribe the ISO 14067 allocation hierarchy that shall be followed by RX-PCF and instead applies system expansion as the default methodology to all co-products. No further requirements for applying system expansion are prescribed by worldsteel.	Since subdivision is not possible for typical co-products in the steel industry, applying system expansion is compatible with the RX-PCF hierarchy. However, the requirements for applying system expansion set out by RX-PCF in section 5.1.2 Allocation shall be fulfilled. The customer of the co-product can be provided a PCF of the co-product. This enables the customer of the co-product to account for the co-product's correct footprint and prevents double counting of credits. Companies shall refer to the worldsteel Life cycle inventory (LCI) study 2020 data release table "Appendix 8: System expansion assumptions" for choosing dominant, identifiable displaced product and production paths for applying system expansion.

PCF topic	Chapter in worldsteel	Chapter in RX-PCF	Methodological divergence	Additional requirement for Railway-X reporting
Accounting for waste treatment	3.5.5 Waste for disposal	5.2.4 Accounting for waste treatment	worldsteel classifies “materials exported from the site for external applications” as co-products, while RX-PCF prescribes a classification hierarchy that shall be followed and classifies pre-consumer scrap by default as waste.	The requirements in RX-PCF chapter 5.2.4 shall be followed: waste shall be classified following the RX-PCF waste versus co-product classification hierarchy. Pre-consumer scrap (excluding runaround scrap) shall be classified as waste and thereby cut-off allocation shall be applied unless legal evidence exists for classifying pre-consumer scrap as co-product.
Accounting for waste treatment	N/A	5.2.4 Accounting for waste treatment	While RX-PCF requires the polluter pays approach for energy recovery, worldsteel does not provide specific guidance on waste-to-energy allocation.	The RX-PCF requirements on waste-to-energy modelling shall be applied (i.e., polluter pays principle) (chapter 5.2.4). The general practice in the industry is following the polluter pays principle, i.e., allocating waste treatment emissions to the product system generating the waste. Hence, recovered energy from waste is emission-free in the product system using it.
Recycling approach (material)	3.6.2 Steel Scrap	5.2.5 Accounting for recycling (within the transition period)	For cradle-to-gate LCI datasets, there is compliance between RX-PCF’s and worldsteel’s cradle-to-gate approaches as no substitution credits are involved and preparatory steps are included. However, worldsteel does not explicitly prescribe the cut-off allocation for users of the guideline. Still in worldsteel’s cradle-to-gate scope, applying the cut-off approach is common practice in worldsteel.	The cut-off approach shall be applied (refer to material recycling section 5.2.5 in RX-PCF).
Electricity and energy modelling	3.3.2 Geographic coverage; 3.5.2	5.2.6 Accounting for GHG emissions from electricity	While RX-PCF requires a market-based approach in regions where residual grid mixes are available, worldsteel prescribes the	For electricity modelling, the RX-PCF market-based modelling requirements in chapter 5.2.6 shall be followed. The market-based

PCF topic	Chapter in worldsteel	Chapter in RX-PCF	Methodological divergence	Additional requirement for Railway-X reporting
	Fuels and energy – upstream data		location-based approach for electricity modelling.	modelling approach shall be applied where residual grid mixes are available and issuing bodies oversee the issuance of electricity instruments (e.g. AIB). Only in regions where contractual instruments and residual grid mixes are not available, grid-specific consumption mixes shall be used while contractual instruments are not allowed (i.e., a location-based approach).
Scope and system boundaries	3.3 System boundaries	4.2 System boundaries	worldsteel allows both a “cradle-to-gate” and a “cradle-to-gate with recycling” scope, while RX-PCF only allows the cradle-to-gate scope.	worldsteel users shall follow the “cradle-to-gate” scope (not “cradle-to-gate with recycling”).
Cut-off criteria and threshold	3.5.8 Cut-off criteria	4.3 Cut-off rules	RX-PCF prescribes a cut-off threshold of 3% based on the total carbon footprint of the reporting company’s system boundary identified in a screening study. worldsteel prescribes a cut-off threshold of 3% based on mass, energy, or environmental relevance for each unit process and the sum of excluded material flows must not exceed 5%.	Cut-off rules may diverge (e.g., based on mass or energy rather than PCF) if achieving a high coverage (i.e. 97%) of the total PCF based on a screening analysis. To determine the 97% coverage, the PCF data received from suppliers and emission factors shall be considered as 100% for practicality reasons. The underlying screening analysis shall be compliant with RX-PCF section 4.3. worldsteel may publish representative studies which may be used by companies instead of individual screening analyses. Until these are available, a company-specific screening analysis shall be provided.
Characterization factors	n/a	4.1 Quantification of carbon footprint	While the latest IPCC characterization factors are currently used in worldsteel’s modelling, the LCI methodology does not include explicit specifications for reporting companies.	The 100-year GWP characterization factors (GWP100y) according to the latest Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR) shall be

PCF topic	Chapter in worldsteel	Chapter in RX-PCF	Methodological divergence	Additional requirement for Railway-X reporting
				used (currently AR6; see RX-PCF chapter 4.1)
Separate reporting in line with ISO 14067	n/a	4.1 Quantification of carbon footprint	worldsteel does not explicitly mention accounting and reporting of biogenic emissions and removals, while RX-PCF requires separate reporting of biogenic emissions following a specified accounting approach (-1/+1 approach).	The RX-PCF requirements for accounting and reporting of biogenic emissions in chapter 4.1 shall be followed.
Chain of custody principles	n/a	5.2.7 Accounting for Chain of Custody models	The worldsteel LCI methodology does not include provisions on using chain of custody models for product carbon footprint accounting.	The set of principles prescribed by RX-PCF in 5.2.7 shall be followed if chain of custody models are applied for PCF accounting.
Data requirements	3.3.3 Time coverage; 3.5.7 Data quality requirements	7.2.2 Temporal validity	While RX-PCF prescribes an annual data check, worldsteel prescribes a validity period of five years for primary and ten years for secondary data.	Reporting companies are encouraged to submit data with high temporal validity and required to perform data updates if the PCF increases by 10% or more based on the screening analysis compared to the previous reporting period as defined in section 7.2.2 of RX-PCF.

Table 8: Further guidance that should be followed (recommendations)

PCF topic	Chapter in worldsteel	Chapter in RX-PCF	Methodological divergence	Recommendation for Railway-X reporting
Accounting for waste treatment	3.5.5 Waste for disposal	5.2.4 Accounting for waste treatment	While RX-PCF prescribes the use of primary data for waste modelling, worldsteel models waste as an input into a generic conservative waste landfill process.	In line with RX-PCF chapter 5.2.4, waste treatment emissions should 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 6.2).
Scope and system boundaries	1.3.2 Applicable products	4.2 System boundaries	worldsteel does not explicitly mention the inclusion of packaging emissions.	In general, packaging emissions may only be excluded under RX-PCF cut-off rules (i.e., packaging might be cut-off if its impact is below prescribed threshold based on a screening analysis). RX-PCF cut-off rules (chapter 4.3) should be followed for packaging emissions.
Separate reporting in line with ISO 14067	N/A	4.1 Quantification of carbon footprint	IAI does not specify separate reporting requirements for carbon footprints of aluminum products in line with ISO 14067.	The separate reporting requirements in line with ISO 14067 as per RX-PCF section 4.1 should be applied in compliance with the CX data model.
Separate reporting in line with ISO 14067	n/a	4.1 Quantification of carbon footprint; 7.2.6 Reporting offsets	Reporting of carbon offsets is not explicitly mentioned in worldsteel. RX-PCF requires excluding carbon offsets from the calculation of the reported PCF. Further, carbon offsets shall be reported separately (if applicable).	The RX-PCF requirements for reporting carbon offsets in chapters 4.1 and 7.2.6 should be applied.
Transport emissions modelling	3.5.1 Transport	5.2.3.1 Accounting for transportation emissions	RX-PCF prescribes a hierarchical approach for transportation modelling, from measuring fuel and energy use as first priority to calculating emissions based on estimated	No divergence as RX-PCF hierarchy allows transport modelling prescribed by worldsteel. However, RX recommends to follow the RX-PCF transport hierarchy for more accurate modelling of

PCF topic	Chapter in worldsteel	Chapter in RX-PCF	Methodological divergence	Recommendation for Railway-X reporting
			values (e.g., using EcoTransIT). worldsteel only requires information on distance travelled and type of transportation.	transport emissions if possible and relevant (chapter 5.2.3).
Transport emissions reporting	3.5.1 Transport	5.2.3 Emissions from transportation	RX-PCF requires that the customer quantifies the transport emissions if the customer contracts or operates inbound transportation. If the supplier contracts or operates outbound transportation to the customer, the supplier shall report transport emissions separately (such that the customer can account for the emissions). worldsteel does not require a similar "one down" approach.	For reporting transportation emissions between supplier and customer, RX-PCF section 5.2.3 should be followed.
Data requirements	3.5.7 Data quality requirements	6. Data sources and hierarchy	RX-PCF generally follows a "primary data first" principle, while worldsteel prescribes primary data for gate-to-gate processes ("Primary data is to be used for gate-to-gate production processes") and recommends primary data for up- and downstream processes ("primary data should be utilized for upstream and downstream processes if possible").	Companies are encouraged to collect upstream primary data (i.e. supplier-specific PCF values). The Primary Data Share (PDS) and Data Quality Rating (DQR) will reflect potential data shortcomings.
Primary Data Share (PDS)	n/a	7.2.4 Primary data share	worldsteel does not explicitly require the calculation and reporting of a PDS while RX-PCF does.	The PDS as set out in RX-PCF chapter 7.2.4 should be calculated and reported taking into consideration the primary data definition and additional guidance as provided in RX-PCF chapter 6 and additional guidance documents. Note that the PDS will be set to zero (i.e., the most conservative value) if no PDS is submitted. The PDS data field in the Catena-X data model will become mandatory only after the RX-PCF

PCF topic	Chapter in worldsteel	Chapter in RX-PCF	Methodological divergence	Recommendation for Railway-X reporting
				transition period. Hence, this might become a “shall” requirement in the future.
Data Quality Rating (DQR)	n/a	7.2.5 Data quality rating	While similar data categories shall be taken into consideration in LCI data collection, worldsteel does not explicitly require assessing a data quality rating (DQR).	The DQR as set out in RX-PCF chapter 7.2.5 should be calculated and reported. Note that the DQR will be set to the most conservative value if no DQR is being submitted. The DQR data field in the Catena-X data model will become mandatory only after the RX-PCF transition period. Hence, this might become a “shall” requirement in the future.

A 5. Additional requirements for users of the Together for Sustainability PCF Guideline (2024)

Table 9 provides additional requirements for the Together for Sustainability (TFS) PCF Guideline for the Chemical Industry that shall be applied as accepted sectoral guideline for Catena-X compliance. It describes the divergences and additional requirements. The additional requirements presented in Table 9 shall be followed by companies reporting in an RX ecosystem until further notice and independent of the transition period that RX-PCF defines (except if explicitly mentioned otherwise).

Table 9: Additional requirements for TFS PCF Guideline that shall be applied for RX compliance

PCF topic	Chapter in TFS	Chapter in RX-PCF	Methodological divergence	Additional requirement for Railway-X reporting
Allocation of multi-functionality	5.2.9.3 Allocation rules	5.1.2 Allocation	TFS recommends calculating the factor "based on stable market prices, as a yearly average or over multiple years in case of high fluctuation (e.g. >100%) of prices to average out high fluctuations of prices" rather than requiring averaging of at least 3 years as in RX-PCF.	The chosen economic allocation factor (prices) shall always be averaged at least over the last 3 years to smooth out fluctuations.
Accounting for waste treatment	5.2.8.4 Waste treatment and recycling	5.2.4 Accounting for waste treatment	TFS allows cut-off, reverse cut-off and substitution approaches for modelling waste-to-energy processes. RX-PCF prescribes the "polluter pays principle", which corresponds to the reverse cut-off approach in TFS.	In order to comply with RX's polluter pays principle, TFS users shall follow the reverse cut-off approach for waste-to-energy allocation. The general practice in the automotive industry is following the polluter pays principle, i.e., allocating waste treatment emissions to the product system generating the waste. Hence, recovered energy from automotive waste is emission-free in the product system using it. Catena-X is aware, that this approach is not recommended by GHG protocol.
Recycling approach (material)	5.2.8.4 Waste treatment and recycling	5.2.5 Accounting for recycling (within the transition period)	TFS prescribes the cut-off approach by default and allows Upstream System Expansion (USE) to be used instead of cut-off for exceptional cases (chemical recycling) if certain requirements are fulfilled. RX prescribes the	The cut-off approach shall be applied for recycling for the calculation of the final PCF value in line with RX-PCF chapter 5.2.5.

PCF topic	Chapter in TFS	Chapter in RX-PCF	Methodological divergence	Additional requirement for Railway-X reporting
			cut-off approach as the default allocation approach.	Other approaches may be prescribed or allowed after the transition period, as stated in chapter 5.2.5.
Allocation of multi-functionality	5.2.9.1 Substitution	5.1.2 Allocation	The requirements for applying system expansion and substitution in RX-PCF and TFS are broadly aligned, but RX-PCF provides explicit data requirements and recommends a PCF statement for co-products that are sold, if system expansion substitution is applied.	The requirements for applying system expansion set out by RX-PCF in chapter 5.1.2 shall be fulfilled. The customer of the co-product can be provided a PCF of the co-product. This enables the customer of the co-product to account for the co-product's correct footprint and prevents double counting of credits.
Chain of custody principles	4.6.7 Mass-balance chain-of-custody	5.2.7 Accounting for chain of custody models	In principle, the Chain of Custody requirements are aligned with TfS. However, the specific criteria for applying mass balance diverge in some specifications (e.g. additionality).	The set of principles prescribed by RX-PCF in 5.2.7 shall be followed if chain of custody models are applied for PCF accounting.
Data requirements	5.2.2 Temporal Scope	7.2.2 Temporal validity	RX-PCF requires an update of the reported PCF if the reported PCF increases by 10% or more based on an annually checked screening study, while TfS allows up to 20% and requires an update of the PCF after three years.	Reporting companies are encouraged to submit data with high temporal validity and required to perform data updates if the PCF increases by 10% or more based on the screening analysis compared to the previous reporting period as defined in section 7.2.2 of RX-PCF.

A 6. Additional requirements for users of the methodology published by European Aluminum (2023)

Table 10 provides additional requirements for the European Aluminum (EA) methodology that shall be applied as accepted sectoral guideline for Railway-X compliance. It describes the divergences and additional requirements. The additional requirements presented in Table 10 shall be followed by companies reporting in RX until further notice and independent of the transition period that RX-PCF defines (except if explicitly mentioned otherwise).

Table 11 provides information on methodological differences that are classified as additional recommendations that should be followed.

Note that the additional requirements in Table 10 as well as the recommendations in Table 11 are based on the version of the EA methodology that is specified in Annex A 3. Both tables may be updated as required.

Table 10: Additional requirements for the EA methodology, shall be applied for RX compliance

PCF topic	Chapter in EA	Chapter in RX-PCF	Methodological divergence	Additional requirement for RX reporting
Allocation of multi-functionality	11.1. Allocation in the alumina production process	5.1.2 Allocation	EA prescribes physical allocation based on mass for the alumina refining process step. However, no allocation is needed as smelter- and non-smelter-grade alumina are not co-products of the same process but produced separately.	In line with the RX-PCF allocation hierarchy (chapter 5.1.2), process sub-division shall be applied in the alumina refining process step.
Allocation of multi-functionality	11.5. Allocation at salt slag/SPL recycling	5.1.2 Allocation	Salt slag recycling: EA prescribes closed-loop modelling in case of in-house recycling. If salt slag is exported for recycling, it is usually treated as waste and cut-off is applied at the aluminum producer. At the recycler, economic allocation is recommended by EA.	If salt slag is recycled externally, companies shall apply the cut-off allocation for salt slag at the secondary aluminum producer (as waste recovered by recycling) and economic allocation at the recycler of salt slag, provided that the price differential is in line with RX requirements outlined in chapter 5.1.2.
Accounting for waste treatment	2. Glossary	5.2.4 Accounting for waste treatment	EA uses a scrap typology coupled with the process stage where scrap originates from to classify waste vs. co-product, while RX-PCF classifies pre-consumer scrap by default as waste (based on the EU Waste Framework Directive interpretation).	Pre-consumer scrap (excluding runaround scrap) shall be classified as waste and thereby cut-off allocation shall be applied unless legal evidence exists for classifying pre-consumer scrap as co-product. The requirements in RX-PCF chapter 5.2.4 shall be followed.
Recycling approach (material)	11. Allocation rules	5.2.5 Accounting for recycling	For post-consumer scrap, EA prescribes the cut-off approach. However, EA allows different allocation approaches for modelling pre-consumer scrap, while RX-PCF prescribes cut-off approach (since pre-consumer scrap is classified as waste	The requirements in RX-PCF chapter 5.2.5 shall be followed: waste shall be classified following the RX-PCF waste versus co-product classification hierarchy Pre-consumer scrap (excluding runaround scrap) shall be modelled using the cut-off approach if recovered by

PCF topic	Chapter in EA	Chapter in RX-PCF	Methodological divergence	Additional requirement for RX reporting
			unless legal evidence exists for co-product classification).	recycling following chapter 5.2.5 unless legal evidence exists for classifying pre-consumer scrap as co-product. In the latter case, RX-PCF allocation rules outlined in chapter 5.1.2 shall apply.
Electricity and energy modelling	12.6.1 Location-based approach for electricity modelling	5.2.6 Accounting for GHG emissions from electricity	While RX prescribes a market-based approach where residual grid mixes are available, EA allows both the location-based and the market-based approach for electricity modelling (with the market-based modelling being broadly aligned).	For electricity modelling, the RX-PCF market-based modelling requirements in chapter 5.2.6 shall be followed. The market-based modelling approach shall be applied where residual grid mixes are available and issuing bodies oversee the issuance of electricity instruments (e.g. AIB). Only in regions where contractual instruments and residual grid mixes are not available, grid-specific consumption mixes shall be used while contractual instruments are not allowed (i.e., a location-based approach).
Cut-off criteria and threshold	10. Cut-off rules	4.3 Cut-off rules	While RX prescribes a cut-off threshold of 3% based on the total carbon footprint of the reporting company's system boundary, EA prescribes a cut-off threshold of 3% based on mass and energy per unit process and the sum of excluded material flows must not exceed 3%.	Cut-off rules may diverge (e.g., based on mass or energy rather than PCF) if achieving a high coverage (i.e. 97%) of the total PCF based on a screening analysis. To determine the 97% coverage, the PCF data received from suppliers and emission factors shall be considered as 100% for practicality reasons. The underlying screening analysis shall be compliant with RX-PCF section 4.3. EA may publish representative studies which may be used by companies instead of individual screening analyses. Until these are available, a company-specific screening analysis shall be provided.

PCF topic	Chapter in EA	Chapter in RX-PCF	Methodological divergence	Additional requirement for RX reporting
Characterization factors	13. Impact categories and resource indicators	4.1 Quantification of carbon footprint	RX-PCF currently requires the use of the latest 100-year GWP characterization factors (GWP100y) according to the latest Intergovernmental Panel on Climate Change (IPCC) Assessment Report 6 (AR6). EA refers to characterization factors from IPCC 2013 (AR5).	The 100-year GWP characterization factors (GWP100y) according to the latest Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR) shall be used (currently AR6; see RX-PCF chapter 4.1)
Chain of custody principles	n/a	5.2.7 Accounting for Chain of Custody models	The EA methodology does not include provisions on using chain of custody models for product carbon footprint accounting.	The set of principles prescribed by RX-PCF in 5.2.7 shall be followed if chain of custody models are applied for PCF accounting.
Data requirements	9. Data collection & data requirements	7.2.2 Temporal validity	RX prescribes an annual data check, EA recommends it.	Reporting companies are encouraged to submit data with high temporal validity and required to perform data updates if the PCF increases by 10% or more based on the screening analysis compared to the previous reporting period as defined in section 7.2.2 of RX-PCF.

Table 11: Further guidance that should be followed (recommendations)

PCF topic	Chapter in EA	Chapter in RX-PCF	Methodological divergence	Recommendation for RX reporting
Allocation of multi-functionality	11. Allocation rules	5.1.2 Allocation	RX-PCF prescribes an allocation hierarchy for co-product allocation based on ISO 14067, while EA prescribes process-specific allocation procedures.	In multi-output allocation cases that are not covered by EA and where room for interpretation remains, the RX-PCF allocation hierarchy based on ISO 14067 should be followed.

PCF topic	Chapter in EA	Chapter in RX-PCF	Methodological divergence	Recommendation for RX reporting
Accounting for waste treatment	11. Allocation rules	5.2.4 Accounting for waste treatment	EA implements energetic closed-loop modelling for waste-to-energy processes, while RX-PCF prescribes the polluter pays principle.	Due to low relevance in the aluminum sector, Catena-X recommends (rather than requires) to use the polluter pays principle for waste-to-energy allocation according to RX-PCF chapter 5.2.4.
Scope and system boundaries	8. Life cycle stages	4.2 System boundaries	EA prescribes the inclusion of distribution packaging emissions only if their contribution to the overall PCF is deemed relevant and requires excluding packaging of raw materials used.	Packaging emissions may only be excluded under RX-PCF cut-off rules (i.e., packaging might be cut-off if its impact is below prescribed threshold based on a screening analysis). RX-PCF cut-off rules (chapter 4.3) should be followed for packaging emissions.
Transport emissions modelling	12.5. How to model transport of raw materials and semi-finished products	5.2.3 Accounting for transportation emissions	RX-PCF prescribes a hierarchical approach for transportation modelling, from measuring fuel and energy use as first priority to calculating emissions based on estimated values (e.g., using EcoTransIT). EA also prescribes a hierarchical approach, which prioritizes primary data, followed by default scenarios.	RX-PCF hierarchy allows transport modelling prescribed by EA. However, RX recommends to follow the RX-PCF transport hierarchy for more accurate modelling of transport emissions if possible and relevant (chapter 5.2.3).
Transport emissions reporting	12.5. How to model transport of raw materials and semi-finished products	5.2.3 Emissions from transportation	RX-PCF requires that the customer quantifies the transport emissions if the customer contracts or operates inbound transportation. If the supplier contracts or operates outbound transportation to the customer, the supplier shall report transport emissions separately (such that the customer can account for the emissions). EA does not require a similar “one down” approach.	For reporting transportation emissions between supplier and customer, RX-PCF section 5.2.3 should be followed.

PCF topic	Chapter in EA	Chapter in RX-PCF	Methodological divergence	Recommendation for RX reporting
Separate reporting in line with ISO 14067	n/a	4.1 Quantification of carbon footprint	EA does not specify separate reporting requirements for carbon footprints of aluminum products in line with ISO 14067.	The separate reporting requirements in line with ISO 14067 as per RX-PCF section 4.1 should be applied in compliance with the RX data model.
Separate reporting in line with ISO 14067	N/A	4.1 Quantification of carbon footprint; 7.2.6 Reporting carbon offsets	RX-PCF requires excluding offsets as well as avoided emissions from the reported PCF. Further, offsets shall be reported separately (if applicable) and avoided emissions shall not be reported. EA does not include requirements on separate reporting of avoided emissions and offsets.	It is recommended to follow RX-PCF requirements for reporting offsets and avoided emissions in chapter 4.1 and chapter 7.2.6.
Data requirements	9. Data collection & data requirements	6. Data sources and hierarchy	RX-PCF generally follows a “primary data first” principle, while EA defines processes that shall use primary data in Section 8 and recommends using primary data for other processes.	Companies are encouraged to collect upstream primary data (i.e. supplier-specific PCF values). The Primary Data Share (PDS) and Data Quality Rating (DQR) will reflect potential data shortcomings.
Primary Data Share (PDS)	N/A	7.2.4 Primary data share	EA does not explicitly require the calculation and reporting of a PDS while RX-PCF does.	The PDS as set out in RX-PCF chapter 7.2.4 should be calculated and reported taking into consideration the primary data definition and additional guidance as provided in RX-PCF chapter 6 and additional guidance documents. Note that the PDS will be set to zero (i.e., the most conservative value) if no PDS is submitted. The PDS data field in the Catena-X data will become mandatory only after the RX-PCF transition period. Hence, this might become a “shall” requirement in the future.
Data Quality Rating (DQR)	N/A	7.2.5 Data quality rating	EA does not explicitly require the calculation and reporting of a DQR while RX-PCF does.	The DQR as set out in RX-PCF chapter 7.2.5 should be calculated and reported. Note that the DQR will be set to the most conservative value if no DQR is being submitted.

PCF topic	Chapter in EA	Chapter in RX-PCF	Methodological divergence	Recommendation for RX reporting
				The DQR data field in the Catena-X data model will become mandatory only after the RX-PCF transition period. Hence, this might become a “shall” requirement in the future.

A 7. Additional requirements for users of the methodology published by International Aluminum Institute (2021)

Table 12 provides additional requirements for the International Aluminum Institute (IAI) methodology that shall be applied as accepted sectoral guideline for Railway-X compliance. It describes the divergences and additional requirements. The additional requirements presented in Table 12 shall be followed by companies reporting in AN RX ECOSYSTEM until further notice and independent of the transition period that RX-PCF defines (except if explicitly mentioned otherwise).

Table 13 provides information on methodological differences that are classified as additional recommendations that should be followed.

Note that the additional requirements in Table 12 as well as the recommendations in Table 13 are based on the version of the IAI methodology that is specified in the introduction of this document. Both tables may be updated as required.

Table 12: Additional requirements for the IAI methodology, shall be applied for RX compliance

PCF topic	Chapter in IAI	Chapter in RX-PCF	Methodological divergence	Additional requirement for RX reporting
Allocation of multi-functionality	11.1. Allocation in the alumina production process	5.1.2 Allocation	IAI prescribes physical allocation based on mass for the alumina refining process step. However, no allocation is needed as smelter- and non-smelter-grade alumina are not co-products of the same process but produced separately.	In line with the RX-PCF allocation hierarchy (chapter 5.1.2), process sub-division shall be applied in the alumina refining process step.
Accounting for waste treatment	7.2.3 Primary cast-house products; IAI reference document on scrap flows: Sections 4 – 6	5.2.4 Accounting for waste treatment	IAI classifies waste vs. co-product based on the process stage where scrap originates from, while RX-PCF classifies pre-consumer scrap by default as waste (based on the EU Waste Framework Directive interpretation).	Pre-consumer scrap (excluding runaround scrap) shall be classified as waste and thereby cut-off allocation shall be applied unless legal evidence exists for classifying pre-consumer scrap as co-product. The requirements in RX-PCF chapter 5.2.4 shall be followed.
Accounting for waste treatment	N/A	5.2.4 Accounting for waste treatment	IAI does not provide guidance on waste modelling. Also the IAI Reference document for scrap flow accounting does not prescribe an approach.	IAI users shall follow European Aluminum (EA) methodology on accounting for waste treatment, including the guidance presented in EA tables 10 and 11 of this document.

PCF topic	Chapter in IAI	Chapter in RX-PCF	Methodological divergence	Additional requirement for RX reporting
Recycling approach (material)	IAI reference document on scrap flows: Section 8.2	5.2.5 Accounting for recycling	For post-consumer scrap, IAI prescribes the cut-off approach. However, IAI allows different allocation approaches for modelling pre-consumer scrap, while RX-PCF prescribes cut-off approach (since pre-consumer scrap is classified as waste unless legal evidence exists for co-product classification).	Pre-consumer scrap (excluding runaround scrap) shall be modelled using the cut-off approach if recovered by recycling following chapter 5.2.5 unless legal evidence exists for classifying pre-consumer scrap as co-product. In the latter case, RX-PCF allocation rules outlined in chapter 5.1.2 shall apply.
Electricity and energy modelling	6.4.1 Selection of Emission Factors	5.2.6 Accounting for GHG emissions from electricity	While RX prescribes a market-based approach where residual grid mixes are available, IAI prescribes the location-based approach for electricity modelling.	For electricity modelling, the RX-PCF market-based modelling requirements in chapter 5.2.6 shall be followed. The market-based modelling approach shall be applied where residual grid mixes are available and issuing bodies oversee the issuance of electricity instruments (e.g. AIB). Only in regions where contractual instruments and residual grid mixes are not available, grid-specific consumption mixes shall be used while contractual instruments are not allowed (i.e., a location-based approach).
Cut-off criteria and threshold	N/A	4.3 Cut-off rules	While RX prescribes a cut-off threshold of 3% based on the total carbon footprint of the reporting company's system boundary identified in a screening study, IAI does not specify a specific cut-off rule in its guideline. However, according to the IAI (2019) LCI Data and Environmental Metrics, a 1% cut-off threshold per unit process is applied.	Cut-off rules may diverge (e.g., based on mass or energy rather than PCF) if achieving a high coverage (i.e. 97%) of the total PCF based on a screening analysis. To determine the 97% coverage, the PCF data received from suppliers and emission factors shall be considered as 100% does practicality reasons. The underlying screening analysis shall be compliant with RX-PCF section 4.3. IAI may publish representative studies which may be used by companies instead of individual screening analyses. Until these are available, a

PCF topic	Chapter in IAI	Chapter in RX-PCF	Methodological divergence	Additional requirement for RX reporting
				company-specific screening analysis shall be provided.
Characterization factors	6.1 Climate change impact category characterization factor	4.1 Quantification of carbon footprint	RX-PCF currently requires the use of the latest 100-year GWP characterization factors (GWP100y) according to the latest Intergovernmental Panel on Climate Change (IPCC) Assessment Report 6 (AR6). IAI refers to characterization factors from IPCC 2007 (AR4) in its methodology ("at the time of writing"). Note, though, that IAI applies latest AR6 characterization factors in their modelling.	The 100-year GWP characterization factors (GWP100y) according to the latest Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR) shall be used (currently AR6; see RX-PCF chapter 4.1).
Chain of custody principles	N/A	5.2.7 Accounting for chain of custody models	The IAI methodology does not include provisions on using chain of custody models for product carbon footprint accounting.	The set of principles prescribed by RX-PCF in 5.2.7 shall be followed if chain of custody models are applied for PCF accounting.
Data requirements	6.2 Applicable time series	7.2.2 Temporal validity	RX prescribes an annual data check, IAI requires data updates "whenever a significant change occurs" or "every 5 years".	Reporting companies are encouraged to submit data with high temporal validity and required to perform data updates if the PCF increases by 10% or more based on the screening analysis compared to the previous reporting period as defined in section 7.2.2 of RX-PCF.

Table 13: Further guidance that should be followed (recommendations)

PCF topic	Chapter in IAI	Chapter in RX-PCF	Methodological divergence	Recommendation for RX reporting
Allocation of multi-functionality	7.2 Allocation procedure	5.1.2 Allocation	RX-PCF prescribes an allocation hierarchy for co-product allocation based on ISO 14067, while IAI is prescribing process-specific allocation procedures.	In multi-output allocation cases that are not covered by IAI and where room for interpretation remains, the RX-PCF allocation hierarchy based on ISO 14067 should be followed.
Allocation of multi-functionality	N/A	5.1.2 Allocation	IAI does not provide guidance on the allocation procedure for anode butts, spent pot lining (SPL), coal tar pitch, and petroleum coke.	If allocation for anode butts, spent pot lining (SPL), coal tar pitch, and petroleum coke is applicable for IAI users, European Aluminum (EA) methodology for allocating these processes should be followed, including the requirements and guidance presented in tables 4.1 and 4.2.
Accounting for waste treatment	N/A	5.2.4 Accounting for waste treatment	IAI does not provide guidance on the allocation procedure for waste-to-energy processes, while RX-PCF prescribes the polluter pays principle.	Due to low relevance in the aluminum sector, Catena-X recommends (rather than requires) to use the polluter pays principle for waste-to-energy allocation according to RX-PCF chapter 5.2.4.
Scope and system boundaries	N/A	4.2 System boundaries	IAI does not mention the inclusion of packaging emissions, while RX-PCF generally includes packaging emissions in the system boundary.	Packaging emissions may only be excluded under RX-PCF cut-off rules (i.e., packaging might be cut-off if its impact is below prescribed threshold based on a screening analysis). RX-PCF cut-off rules (chapter 4.3) should be followed for packaging emissions.
Scope and system boundaries	Annex C	4.2 System boundaries	In Annex C, IAI includes capital goods, employee commuting, and upstream leased assets. RX excludes such non-product related emissions.	RX-PCF rules on excluding non-product related emissions should be followed as presented in chapter 4.2.
Transport emissions modelling	4.3 System boundary	5.2.3 Accounting for transportation emissions	RX-PCF prescribes a hierarchical approach for transportation modelling, from measuring fuel and energy use as first	RX-PCF hierarchy allows transport modelling prescribed by IAI. However, RX recommends to follow the RX-PCF transport hierarchy for more

PCF topic	Chapter in IAI	Chapter in RX-PCF	Methodological divergence	Recommendation for RX reporting
			priority to calculating emissions based on estimated values (e.g., using EcoTransIT). IAI does not prescribe a hierarchical approach and requests the following data from companies to calculate their transport emissions: Transport type, vehicle type, distance, loading rate, number of empty returns.	accurate modelling of transport emissions if possible and relevant (RX-PCF chapter 5.2.3).
Transport emissions reporting	N/A	5.2.3 Emissions from transportation	RX-PCF requires that the customer quantifies the transport emissions if the customer contracts or operates inbound transportation. If the supplier contracts or operates outbound transportation to the customer, the supplier shall report transport emissions separately (such that the customer can account for the emissions). IAI does not require a similar “one down” approach.	For reporting transportation emissions between supplier and customer, RX-PCF chapter 5.2.3 should be followed.
Separate reporting in line with ISO 14067	N/A	4.1 Quantification of carbon footprint	IAI does not specify separate reporting requirements for carbon footprints of aluminum products in line with ISO 14067.	The separate reporting requirements in line with ISO 14067 as per RX-PCF section 4.1 should be applied in compliance with the CX data model.
Separate reporting in line with ISO 14067	N/A	4.1 Quantification of carbon footprint; 7.2.6 Reporting offsets	RX-PCF requires excluding offsets as well as avoided emissions from the reported PCF. Further, offsets shall be reported separately (if applicable) and avoided emissions shall not be reported. IAI does not include requirements on separate reporting of avoided emissions and offsets.	It is recommended to follow RX-PCF requirements for reporting offsets and avoided emissions in chapter 4.1 and chapter 7.2.6.

PCF topic	Chapter in IAI	Chapter in RX-PCF	Methodological divergence	Recommendation for RX reporting
Data requirements	8.2 Data Quality	6. Data sources and hierarchy	RX-PCF generally follows a “primary data first” principle, while IAI recommends using primary data.	Companies are encouraged to collect upstream primary data (i.e. supplier-specific PCF values). The Primary Data Share (PDS) and Data Quality Rating (DQR) will reflect potential data shortcomings.
Primary Data Share (PDS)	N/A	7.2.4 Primary data share	IAI does not explicitly require the calculation and reporting of a PDS while RX-PCF does.	The PDS as set out in RX-PCF chapter 7.2.4 should be calculated and reported taking into consideration the primary data definition and additional guidance as provided in RX-PCF chapter 6 and additional guidance documents. Note that the PDS will be set to zero (i.e., the most conservative value) if no PDS is submitted. The PDS data field in the Catena-X data model will become mandatory only after the RX-PCF transition period. Hence, this might become a “shall” requirement in the future.
Data Quality Rating (DQR)	N/A	7.2.5 Data quality rating	IAI does not explicitly require the calculation and reporting of a DQR while RX-PCF does.	The DQR as set out in RX-PCF chapter 7.2.5 should be calculated and reported. Note that the DQR will be set to the most conservative value if no DQR is being submitted. The DQR data field in the Catena-X data model will become mandatory only after the RX-PCF transition period. Hence, this might become a “shall” requirement in the future.

A 8. Rulebook comparison between Railway-X v1.0 versus Catena-X v4

Chapter	Heading	Level of differences	Differences	Railway-X rulebook v1.0 focus	Catena-X rulebook v4.0 focus
1.1	**The railway/ automotive industry**	Significant differences	The Railway chapter focuses on the rail sector's essential role in achieving climate-neutral transport, while the Catena chapter emphasizes the automotive industry's visibility in driving low-emission mobility.	Highlights the critical role of the railway industry in sustainable mobility and the intricacies involved in measuring GHG emissions due to its complex supply chain	Discusses the automotive industry's visibility and contribution to climate action, along with the challenges of measuring GHG emissions arising from a multifaceted supply chain
1.2	**The Challenge**	Largely similar	Both chapters emphasize the use of established methods for calculating Product Carbon Footprint (PCF) in their respective industries but highlight differing lifecycle emissions profiles and the need for consistent standards	Discusses established PCF calculation methods, lifecycle emissions shifts due to renewable energy, and the necessity for harmonized and comparable GHG emissions reporting within the railway sector.	Highlights established PCF calculation methods and the emissions shift from the use to production stages for vehicle technologies, stressing the need for consistent industry-wide GHG emissions reporting
1.3	**The purpose of this document**	Largely similar	Both the Railway and Catena chapters outline the development of a PCF Rulebook aimed at enhancing comparability, scalability, and interoperability in their respective industries, with a focus on supplier transparency and the integration of existing standards.	Details the Railway-X PCF Rulebook's objectives to integrate PCF values in procurement processes, enhance industry-wide interoperability, and support SMEs in contributing to transparent emissions reporting within the railway supply chain.	Describes the Catena-X PCF Rulebook's aim to facilitate the exchange of PCFs across supply tiers, ensuring scalability, supporting SMEs, and maintaining data sovereignty while addressing regulatory developments relevant to the automotive sector.
1.4	**PCF use cases framework**	No significant differences			
2.1	**Version**	No significant differences			

2.2	**Terminology: Shall, should, may, can**	No significant differences			
2.3	**Topics out of scope**	Largely similar	Both the Railway and Catena chapters emphasize cradle-to-gate PCF accounting for their respective sectors, highlighting the current focus on secondary materials for recycling and stating that holistic recycling strategies are out of scope.	Focuses on PCF accounting for railway products and components, indicating that maintenance and recycling strategies will be addressed in future versions while currently relying on secondary material for accounting.	Centers on PCF accounting for vehicle production, noting that recycling is considered through secondary materials, with holistic recycling strategies similarly deemed out of scope at present.
2.4	**Transition period**	No significant differences			
3.1	**Relationship**	Largely similar	Both chapters detail the foundations of their respective PCF Rulebooks in accordance with ISO standards, highlighting alignment with broader manufacturing initiatives, though the Railway-X emphasizes its connection to the Manufacturing-X ecosystem while Catena-X mentions specific industry collaborations.	Highlights Railway-X's position within the Manufacturing-X ecosystem, its close adherence to the Catena-X Rulebook, and alignment with ISO standards while specifying plans for additional sectoral guidance.	Describes the Catena-X Rulebook's basis in ISO standards and its alignments with various sector initiatives including the WBCSD Pathfinder Framework, aiming for comprehensive integration within automotive supply chains.
3.2	**Hierarchy of conformity**	Largely similar	Both chapters outline a hierarchy for applying existing rules for calculating product carbon footprints based on ISO standards, but the Railway section specifically mentions regulations related to industrial batteries while the Catena section focuses on automotive supply chain requirements.	Defines a hierarchical structure for PCF calculation, basing it on ISO standards, emphasizing railway-specific requirements, and mentioning compliance with EU Regulation 2023/1542 regarding industrial battery carbon footprints.	Establishes a similar hierarchy for PCF calculation based on ISO standards, emphasizing automotive supply chain requirements, and highlights the sharing of methodologies and standards for enhanced transparency and comparability.

4.	**Scope and system boundary**	Significant differences	The Railway section specifies the application of its PCF rules to specific railway products and whether certain infrastructure is included or excluded, while the Catena section does not define product scope or exclusions.	Details the application of the Railway-X PCF rules based on an attributional LCA approach, specifying in-scope products including vehicles and signaling systems, and planning to include service activities in future revisions.	Summarizes the attributional LCA approach for assessing environmental impacts and global warming potential, without detailing specific products, exclusions, or future developments related to the rulebook.
4.1	**Quantification of carbon footprint (biogenic and/ or fossil)**	No significant differences			
4.2	**System boundaries**	Largely similar	Both chapters outline the life cycle stages and system boundaries for carbon footprint accounting, but the Railway section specifically mentions the inclusion of signaling/infrastructure and power supply components, while the Catena section does not.	Describes the Railway-X PCF framework, detailing the life cycle stages and system boundaries specific to railway products, including upstream emissions and exclusions while clarifying applicability to end-of-life processes.	Summarizes the CX-PCF framework, outlining life cycle stages and system boundaries relevant to automotive products, focusing on upstream emissions but omitting specific references to components like signaling/infrastructure or power supply.
4.3	**Cut-off rules - criteria to exclude certain activities**	No significant differences			
4.4	**Declared unit**	Largely similar	Both chapters outline criteria for assessing the product carbon footprint based on declared units, but the Railway section includes specific mentions of energy-providing batteries and a future definition for service products, which the Catena section does not address.	Provides criteria for declaring units in product carbon footprint assessments, detailing specific units for different product types, including future guidelines for services while explicitly mentioning energy-providing batteries.	Describes the framework for declaring units in carbon footprint assessments, focusing on various product types but omitting references to energy-providing batteries and future definitions regarding service product guidelines.

5.	**Guidance for product carbon footprinting**	No significant differences
5.1	**Accounting for product carbon footprint**	No significant differences
5.1.1	**Calculation**	No significant differences
5.1.2	**Allocation**	No significant differences
5.2	**Additional guidance**	-
5.2.1	**Prospective PCF**	No significant differences
5.2.1.1	**Upstream GHG emissions for a prospective PCF**	No significant differences
5.2.1.2	**GHG emissions for a prospective PCF from own operations**	No significant differences
5.2.2	**Homogenious parts**	No significant differences
5.2.3	**Emissions from transportation**	No significant differences
5.2.3.1	**Accounting for transportation emissions**	No significant differences
5.2.4	**Accounting for waste treatment**	No significant differences
5.2.5	**Accounting for recycling (within**	No significant differences

	the transition period)				
5.2.5.1	**Accounting for recycling (after the transition period)**	No significant differences			
5.2.6	**Accounting for GHG emissions from electricity**	No significant differences			
5.2.6.1	**Electricity from a directly and dedicated connected generator**	No significant differences			
5.2.6.2	**Electricity from the grid (by a power supplier or) via contractural instruments**	No significant differences			
5.2.7	**Accounting for chain of custody models**	Largely similar	Both documents detail chain of custody models, but Railway focuses on specific examples related primarily to materials in industry, while Catena references examples from food and renewable materials.	Focus: Describes chain of custody models emphasizing sustainable material tracking and accounting within industrial supply chains, including detailed examples of traditional materials	Similar structure outlining chain of custody, featuring examples from food production and broader renewable contexts, with a focus on sustainable materials across various industries.
5.2.7.1	**Guiding principles**	No significant differences			
5.2.8	**Accounting for commissioning and testing**	Significant differences	The Railway chapter provides detailed guidelines on emissions testing for products, whereas the Catena chapter does not exist	The Railway chapter focuses on emissions testing, reporting responsibility, and product lifecycle impact associated with rolling stock and components	-
6.	**Data sources and hierarchy**	No significant differences			

6.1	**Primary data**	No significant differences			
6.2	**Secondary data**	No significant differences			
7.	**Required elements for PCF data exchange**	No significant differences			
7.1	**Data model**	No significant differences			
7.2	**Details on the required data elements**	Largely similar	Both chapters outline procedures for annual emission reporting and updating, with slight variations in phrasing and the addition of commentary regarding supply chain data updates in the Catena section	States requirements for annual reporting, checks for data accuracy, and conditions necessitating updates to emission data, mainly focusing on the Railway context	Aligns with Railway's focus on emission reporting and updates but emphasizes changes in supply chain data and documents the requirement for previous year activity data from operations
7.2.1	**Time period**	No significant differences			
7.2.2	**Temporal validity**	No significant differences			
7.2.3	**Geography**	No significant differences			
7.2.4	**Primary data share**	No significant differences			
7.2.5	**Data quality rating**	No significant differences			
7.2.5.1	**Data quality assessment (only valid after transition period)**	Largely similar	The Railway document states that Data Quality Assessment will not be mandatory.		
7.2.5.2	**Aggregated Data Quality Rating**	No significant differences			
7.2.6	**Reporting carbon offsets**	No significant differences			

A 9. Relationship between the Rolling Stock PCR and the Railway-X PCF Rulebook

Purpose and Rationale of Maintaining Two Documents

The Rolling Stock PCR (Product Category Rules) was developed within the framework of the International EPD System to ensure the consistent creation of LCAs and Environmental Product Declarations (EPDs) for rolling stock and rolling stock components. Its primary objective is the transparent, verifiable and comparable communication of a product's overall environmental performance throughout its life cycle, including multiple environmental impact categories beyond climate change.

The Railway-X PCF Rulebook, in contrast, was developed to enable the exchange of Product Carbon Footprint (PCF) data within the railway supply chain and to ensure that PCF values can be used as a reliable decision-making criterion in procurement and supplier selection. Its primary objective is therefore the creation of comparable, interoperable and digitally exchangeable carbon footprint data that can be exchanged across multiple supply chain tiers and integrated into digital ecosystems such as Railway-X and Manufacturing-X.

As a result, both documents address different business needs:

Document	Primary objective
Rolling Stock PCR	Creation of LCAs and EPDs for external environmental communication and environmental performance reporting
Railway-X PCF Rulebook	Creation of comparable PCF data for supply-chain transparency, digital data exchange and procurement decisions

The two documents should therefore be regarded as complementary rather than competing methodologies.

Key Differences between the Documents

The Rolling Stock PCR follows a full LCA approach and requires the assessment of environmental impacts across the entire life cycle and multiple environmental impact categories according to the EPD framework.

The Railway-X PCF Rulebook focuses exclusively on greenhouse gas emissions expressed as CO_2-equivalents and therefore addresses only one environmental impact category: climate change.

The Rolling Stock PCR primarily supports cradle-to-grave assessments including: upstream processes, manufacturing processes, transport to customer, use phase, maintenance, end-of-life treatment and disposal.

The Railway-X PCF Rulebook focuses on cradle-to-gate product carbon footprints exchanged within supply chains and therefore concentrates on emissions up to the supplier's outbound gate.

The PCR defines functional units for rolling stock such as: transport of one passenger over one kilometre, or transport of one tonne of freight over one kilometer.

The Railway-X PCF Rulebook uses declared units suitable for product-level carbon data exchange between suppliers and customers and therefore allows reporting at component, subsystem and material level.

The PCR is designed to support: LCAs, EPD development, environmental communication, sustainability reporting, customer information.

The Railway-X PCF Rulebook is designed to support: procurement decisions, supplier comparison, decarbonization programs, PCF data exchange, Digital Product Passport requirements, Manufacturing-X interoperability.

The PCR provides methodological requirements for EPD generation but does not define a digital supply-chain exchange framework.

The Railway-X PCF Rulebook explicitly includes requirements for data exchange, interoperability, primary data share, data quality ratings and alignment with digital ecosystems such as Railway-X, Catena-X and Manufacturing-X.

The PCR was developed to support environmental assessments and EPD declarations. While it improves consistency within a product category, it was not specifically designed for procurement-based supplier comparison using a single climate KPI.

The Railway-X PCF Rulebook was explicitly developed to ensure that differences in PCF values reflect actual emissions differences rather than methodological interpretation differences, thereby enabling supplier comparison and procurement decisions based on PCF values.

Which Document Should Be Used for Which Application?

Application	**Rolling Stock PCR**	**Railway-X PCF Rulebook**
Environmental Product Declaration (EPD)	Mandatory	Not intended
Full Life Cycle Assessment	Primary reference	Supplementary only
Product environmental communication	Primary reference	Supplementary only
Procurement based on CO_2 performance	Can provide input	Primary reference

Supplier PCF comparison	Limited suitability	Primary reference
Multi-tier supply chain PCF exchange	Not intended	Primary reference
Digital Product Passport preparation	Supporting input	Primary reference for PCF data
Manufacturing-X / Railway-X interoperability	Not intended	Primary reference
Decarbonization programmes in supply chains	Supporting input	Primary reference

If the objective is the environmental assessment of a rolling stock product throughout its complete life cycle and the publication of an EPD, the Rolling Stock PCR shall be used.

If the objective is the generation, exchange or comparison of Product Carbon Footprint data within the railway supply chain, the Railway-X PCF Rulebook shall be used.

Where a Product Carbon Footprint originates from an LCA performed according to the Rolling Stock PCR, the Railway-X PCF Rulebook should be applied as an additional layer of requirements whenever the PCF is exchanged or used for procurement purposes.