PCF Calculation Method Supply Chain

Edition 2021

Content

Glossary

Activity data
Activity data is used as a term for process information needed for LCA/PCF calculation. Examples of activity data include quantity of kilowatt-hours of electricity used, quantity of fuel used, output of a process (e.g. waste), number of hours equipment is operated, etc.

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" (ISO 14040:2006, section 3.17)

Carbon Dioxide Equivalent (CO_2e)
Carbon dioxide equivalent, or CO_2e, is a metric measure representing all greenhouse gases by converting them to the equivalent amount of CO_2

Consumption mix
This approach focuses on the domestic production and the imports taking place hence differing from the production mix which does not account for imports. These mixes can be dynamic for certain commodities (e.g., electricity) in the specific country/region

Cradle-to-gate
An assessment that includes parts of the product's life cycle, including material acquisition through the production of the studied product and excluding the use or end-of-life stages

Cradle-to-grave
An assessment that includes the entire life cycle of a product, from the time natural resources are extracted from the ground and processed through each subsequent stage of manufacturing, transportation, product use, recycling, and ultimately, disposal. (Athena Institute & National Renewable Energy Laboratory draft 2010)

Bill of material
A bill of material (BOM) contains the relevant parts/components of a product including technical information on materials and weights

Emission factor
An emission factor is a quantity that indicates how much of a substance or mixture of substances is emitted in relation to a suitable reference quantity, e.g. 2,5 kg CO_2e/kg steel

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 14067:2019, section 3.1.2.1)

Guarantee of Origin (GO)
Guarantees of Origin (GOs) are tracking and labelling instruments for electricity from renewable sources defined in article 15 of the European Directive 2009/28/EC

GWP
The impact category "global warming potential" considers the potential contributions of different air emissions to global climate change. It is measured in kg carbon dioxide equivalent (CO_2e)

Life Cycle
A view of a product system as "consecutive and interlinked stages from raw material acquisition or generation from natural resources to final disposal" (ISO 14040:2006, section 3.1). This includes all material and energy inputs as well as emissions to air, land and water

Life Cycle Assessment (LCA)
"Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (ISO 14040:2006, section 3.2)

Life Cycle Inventory (LCI)
"Phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle" (ISO 14040:2006, section 3.3)

1. Introduction

Today, sustainability is an integral part of the ZF's strategy. With "Next Generation Mobility," ZF is pursuing an agile and integrated approach to shaping the fundamentally changing mobility needs of tomorrow. This is why ZF has drawn up a climate strategy – ZF aims to be climate neutral by 2040 for all three scopes of the Greenhouse Gas Protocol.

To achieve this target, the transparency of product related emissions is key and therefore also the product related emissions of purchased parts (Scope 3 upstream).

The purpose of this document is to set a methodological framework for the calculation of product carbon footprints (PCF) of the products of ZF's suppliers. The document follows the structure of a product life cycle assessment (LCA) according to the relevant standards ISO 14040/14044.

It is mainly based on the ISO14067 being the most widely used PCF standard. The ISO14067 however is a sector-overarching standard which leaves some room for interpretation. This document specifies the ISO14067 for ZF requirements and needs to ensure consistent PCF calculation within ZF's supplier base. The specifications given here are hence in line with the ISO requirements. Any guidance given and assumptions made will be regularly reviewed and cross-checked. This document will be adapted as necessary to take into account relevant developments within the industry.

2. Goal and Scope

The ISO 14040/14044 standard states that there is a strong link between the goal and scope of a LCA study and the subsequent steps of the study. The goal of a study (e.g. understanding the entire lifecycle or comparing processes) directly defines the scope of the study (e.g. cradle-to-gate, etc.). It defines the processes that should be included in the product system, (system boundaries) and how accurate and representative the collected data needs to be to fulfil the defined goal. The goal and scope of each study should therefore clearly be stated. A PCF-study is essentially an LCA study with focus on the climate change impacts of a product's life cycle only, such studies need to follow the guidelines of the ISO standards, in particular the specific PCF standard ISO 14067.

[1] The general principles of this methodology however can also be applied for other use cases, e.g. prototypes.

For the supplier base of ZF, two major use cases for PCF calculation can be distinguished which will differ in goal and scope:

Before Start of Production (SOP):

- Sourcing: PCF calculation of supplied parts, inclusion of supplier PCFs into ZF product

After Start of Production:

- PCF calculation of series products: Tracking decarbonisation efforts and provide proof to ZF

The focus of this methodology is the PCF calculation of serial production1.

3. Methodological Framework Following ISO14067

The following sections describe the general methodological aspects of PCF calculation for ZF suppliers. This includes, but is not limited to, the identification of specific product systems to be assessed, the product function(s), functional unit and reference flows, the system boundary, allocation procedures, and cut-off criteria of the PCF. Every PCF calculation should be documented to ensure transparency and reproducibility. All assumptions made (e.g. exclusion of process steps) should be justified and well documented.

3.1 Product System

The product system shall be specified to enable a clear understanding of the product being investigated. The supplier product system shall be cradle-to-gate as shown in Figure 1. The cradle-to-gate product system is the sum of greenhouse gas (GHG) emissions, from the extraction of the raw materials up to production of the final sales product at the supplier plant. All product related GHG emissions shall be included from Scopes 1, 2 and 3 upstream.

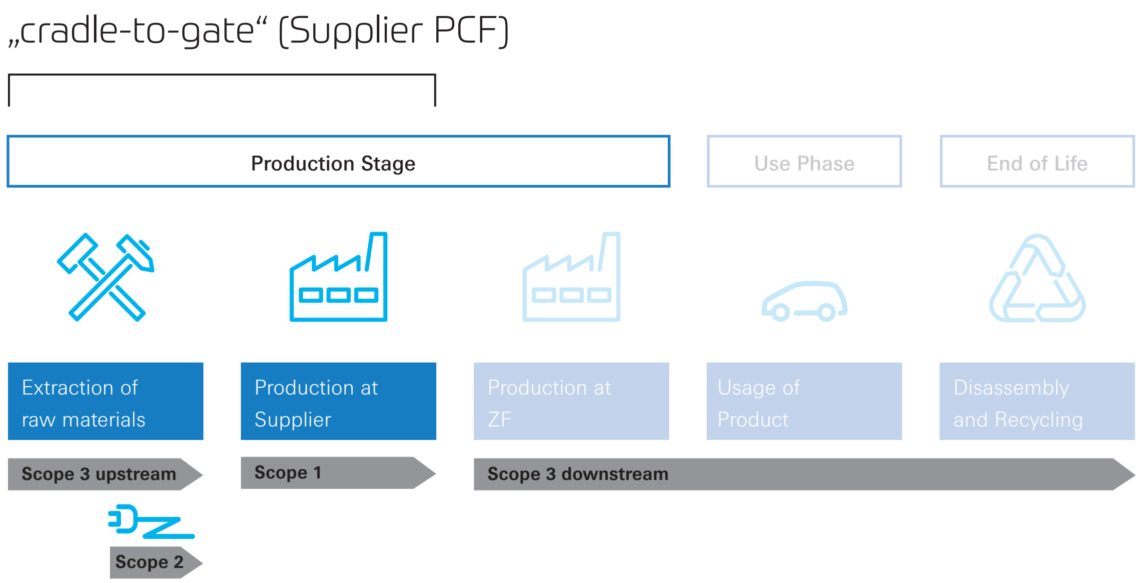


Figure 1: Description of the different life cycle stages

3.2 System Boundary

The supplier PCF (cradle-to-gate, see also section 3.1) shall include the raw material extraction and production as well as further processing, transport and production at the supplier up until the product leaves the supplier gate.

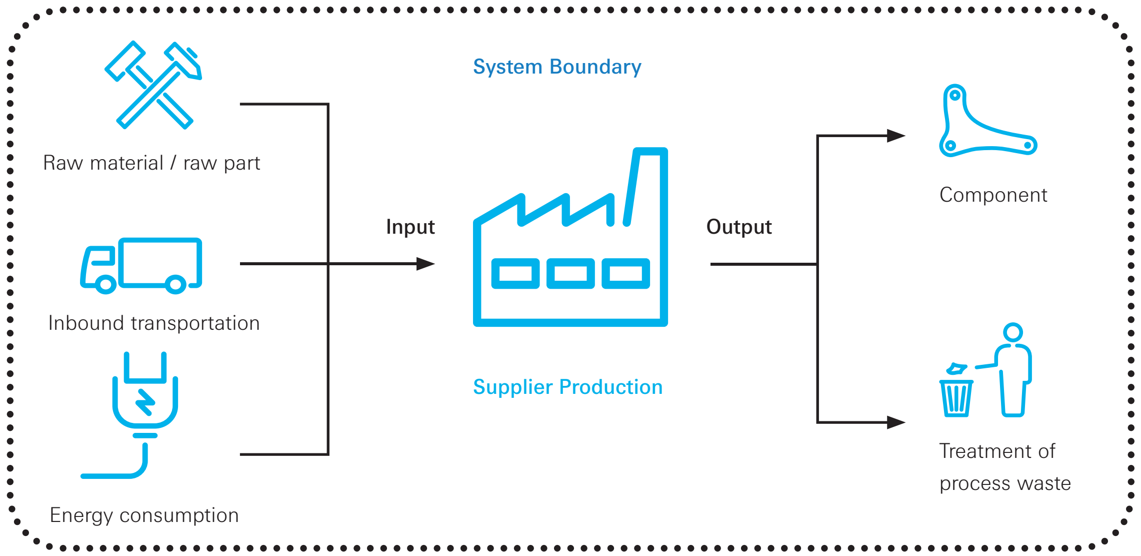


Figure 2: System boundary for cradle-to-gate analysis

Table 1 gives more detailed guidance on the data to be included respectively excluded in the system boundary.

Table 1: System boundary for cradle-to-gate analysis

Included	Excluded
✔ Raw materials (steel, aluminium, polymers etc.)	✘ General tooling [2]
✔ Energy consumption	✘ Packaging
✔ Consumables (machine oil, cleaning agent, cooling agent etc.)	✘ Capital goods / infrastructure
✔ Manufacturing (production and assembly in the respective plants)	✘ Non-production-related products
✔ Inbound transportation	✘ Employee commuting
✔ Internal site-to-site transportation	✘ Business travel
✔ Treatment of process waste (from production and assembly in the respective plants)	✘ Processing of product at customer
	✘ Outbound transport (exception dap based shipments, see also section 3.6.5)
	✘ Use phase (included for cradle-to-grave)

[2] In general, toolings like CNC toolings should be excluded. However, toolings that are suspect to frequent overhaul or replacement (e.g. primary forming tools) or small-scale production, should be assessed and stated separately in the PCF calculation. They may be omitted if the mass and impact is below the cut-off threshold described in section 3.4)
[3] In case of the situation that specific production conditions are required (e.g. steady temperature or clean room conditions) this effort expressed in energy needs to be allocated to the product.
[4] Non-production-related products are used to enable operation and consist of products and services, that are no integral part of the company's products. This may include capital goods such as office equipment, computers and furniture. These products are not part of the final product under investigation.

3.2.1 Time Coverage

Before Start of Production (SOP):
Most reasonable values (e.g. experience values, forecast values) should be used for the PCF forecast calculation.

After Start of Production (SOP):
The most current and up-to-date information should be used for the PCF calculation. If e.g. activity data from a plant is used, it should reflect a representative timeframe and seasonal fluctuations (both positive and negative) should be normalized wherever possible. It is recommended to use activity data averaged over one calendar year.

3.2.2 Technology Coverage

The technology coverage states the intended technology reference that shall be assessed to complete the study. PCF calculation should be based on current technology (concerning manufacturing equipment) and the most up-to-date bill of material.

3.3 Allocation

Allocation is defined as the "partitioning of the input or output flows of a process or a product system between the product system under study and one or more other product systems". The allocation rules applied here generally follow the requirements and hierarchy described in ISO 14044, section 4.3.4[5]. Two different types of allocation can be distinguished:

1. Multi-output allocation is relevant for operations data (e.g. energy data on a plant level need to be allocated to the products produced in the plant). Guidance on how to address this topic can be found in section 3.6.3.

2. End-of-Life allocation addresses the question of how to account for recycled material that is used in future product system and might replace virgin material and its related impacts. This is the case for both the EoL of the product as well as the scrap/waste occurring in the production.

Within End-of-Life allocation two main approaches are commonly used in LCA/PCF studies. The substitution approach (also known as 0:100, closed-loop approximation, recyclability substitution or end of life approach) and the cut-off approach (also known as 100:0 or recycled content approach).

The cut-off approach is currently widely used in the automotive industry and shall be used for the PCF calculation.

This means that burdens or credits associated with material from previous or subsequent life cycles are not considered i.e., are "cut-off". Therefore, scrap input to the production process is considered to be free of burdens but, equally, no credit is received for scrap available for recycling at end of life[6]. This approach rewards the use of recycled content but does not reward end of life recycling. Treatment of process wastes occurring within the plants however always needs to be considered (internal and external waste treatment).

3.4 Cut-Off Criteria

Cut-off criteria specify the amount of material, energy flow or the level of environmental significance associated with single processes or the product system that are excluded from the PCF study. To define the cut-off criteria, three main options are available according to ISO14044 section 4.2.3.3.3.:

a) Mass
b) Energy
c) Environmental significance

PCF calculation shall aim for completeness hence trying to completely avoid the need for cut-offs. If cut-offs cannot be avoided, e.g. where no data are available or where the level of effort required to close data gaps (mass and energy balance) and to achieve a complete result becomes exorbitant, the following rules apply: Each flow (material or energy) being cut-off must not exceed 1% of mass, energy or environmental significance (kgCO_2e related to the product investigated).

The sum of all excluded flows in the product system must not exceed 5% of mass, energy or environmental significance. If such individual material or energy flows are found to be below this threshold and hence can be cut off, they may be excluded and shall be reported as data exclusions. In this case a sensitivity analyses using proxy data should be done (stating the flow name and quantity as well as the expected impact on the overall result).

3.5 Selection of LCIA Methodology and Impact Category

The PCF describes the potential impact of the product on global warming.

The PCF should be calculated by assessing the global warming potential based on the latest IPCC characterisation factors for a 100-year timeframe (GWP100). The total impact is described in CO_2 equivalents (CO_2e). The PCF is calculated considering all six Kyoto gases (Carbon dioxide "CO_2", Methane "CH_4", Nitrous oxide "N_2O", Hydrofluorocarbons "HFCs", Perfluorocarbons "PFCs", Sulphur hexafluoride "SF_6"), plus NF_3, measured by mass and converted into CO_2e.

The appropriate method for characterization is available in the LCA-Tool GaBi Professional under the nomenclature "IPCC AR5 GWP100, incl biogenic carbon, incl Land Use Change, no norm/weight [kg CO_2 eq.]".

In other LCA/PCF tools the name can differ from that but shall contain the same characterisation factors.

3.6 Data Requirements

The following section defines the approach to collect data for the PCF study. It serves as a general guideline on how to assess the relevant data for the different steps of the lifecycle, how to treat data gaps, and which background data to use.

3.6.1 General

It is a general principle that for processes that are in direct control of the company performing the PCF, primary data should be used. The data needs matrix indicates for which processes company-specific data or secondary data shall or may be used (see Table 2). This statement is in accordance with the ISO14067 that "secondary data shall only be used for inputs and outputs where the collection of primary data is not practicable, or for processes of minor importance."

Secondary data can include activity data (close linkage to the closing of data gaps, see section 3.6.6) but is mainly associated to the emission factors respectively LCI-data taken from LCI databases. Where secondary LCI-data is needed, the logic of choosing the fitting dataset should always follow the data quality needs.

A hierarchy for chosing secondary LCI-data for the upstream processes shall be applied as follows:

1. Choose a regional or country-specific production mix in case the production origin (region or country) of the supplied raw material is known.

2. Choose a regional or country-specific consumption mix based on the location of your tier-1 supplier in case the production origin in not known.

3. Choose the same raw material or fuel from another country or region which is the most appropriate in case no regional or country-specific data is available.

4. Choose an appropriate proxy in case no data of the specific raw material or fuel is available.

[5] ISO14044 requires to avoid allocation where possible through separation of the process into subprocesses or through system expansion. If allocation becomes necessary, physical allocation should be preferred over other allocation schemes (e.g. economic).
[6] Recycling activities at the End-of-Life are not considered as it is cut-off before the recycling step (also refer to Table 1).

Considering this, the below hierarchy for raw materials, utilities and fuels sourced from secondary databases shall be applied:

1. Most recent association data (e.g. Worldsteel, International Aluminium Institute (IAI), Plastics Europe etc.) where feasible[7]

2. Sphera/GaBi[8]

3. Other LCI-Databases (e.g. Ecoinvent)

Situation 1 refers to processes that are under operational control of the supplier which should be represented by primary data collected in the respective plants (see section 3.6.3).
Situation 2 and 3 refer to the supply chain of the supplier reflecting different options of data availability:

- Situation 2, option 1: the subsupplier is able to provide a company-specific primary dataset in an aggregated form (e.g. kg CO_2e per product supplied to the supplier).

- Situation 2, option 2: the sub-supplier is providing activity data (e.g. energy demand, materials, wastes, etc.) for its own production (gate-to-gate, see also Figure 1) which is supplemented by respective secondary datasets (e.g. energy, material inputs) to create a company-specific dataset.

- Situation 3, option 1: the sub-supplier is not able to provide any information hence secondary data must be used.

Table 2:
Data need matrix (following PEF (Zampori & Pant, 2019))

Data requirement		
Situation 1: process run by supplier (operational control)	Option 1	Provide supplier-specific primary data (activity data, direct emissions etc.) and create a supplier-specific dataset.
Situation 2: process not run by supplier but with access to company-specific information	Option 1	Provide company-specific primary dataset (e.g. PCF from sub-suppliers). The quality of the sub-supplier-specific PCF has to be evaluated and checked for appropriateness according to the GHG Protocol Standard or ISO 14067.
	Option 2	Use secondary datasets for materials, and link company-specific activity data (gate-to-gate) with supply-chain specific datasets (e.g energy mix).
Situation 3: process not run by supplier and without access to company-specific information	Option 1	Use a secondary data set in aggregated form.

[7] The dataset should reflect the respective material or energy flow as good as possible. The focus should be on fulfilling the criteria of technological representativeness. The time and geography criteria can be fulfilled by choosing the most up-to-date datasets for the specific geographical region of the product under study.
[8] Most accepted and used secondary database in automotive industry.

3.6.2 Material

The information needed for the raw materials and processing of the raw materials are typically being reflected in a bill of material. The entire bill of material needs to be considered and used for a PCF calculation. As described in section 3.6.1 primary data should be used to calculate the proportion of material in the PCF (Table 2, situation 2).

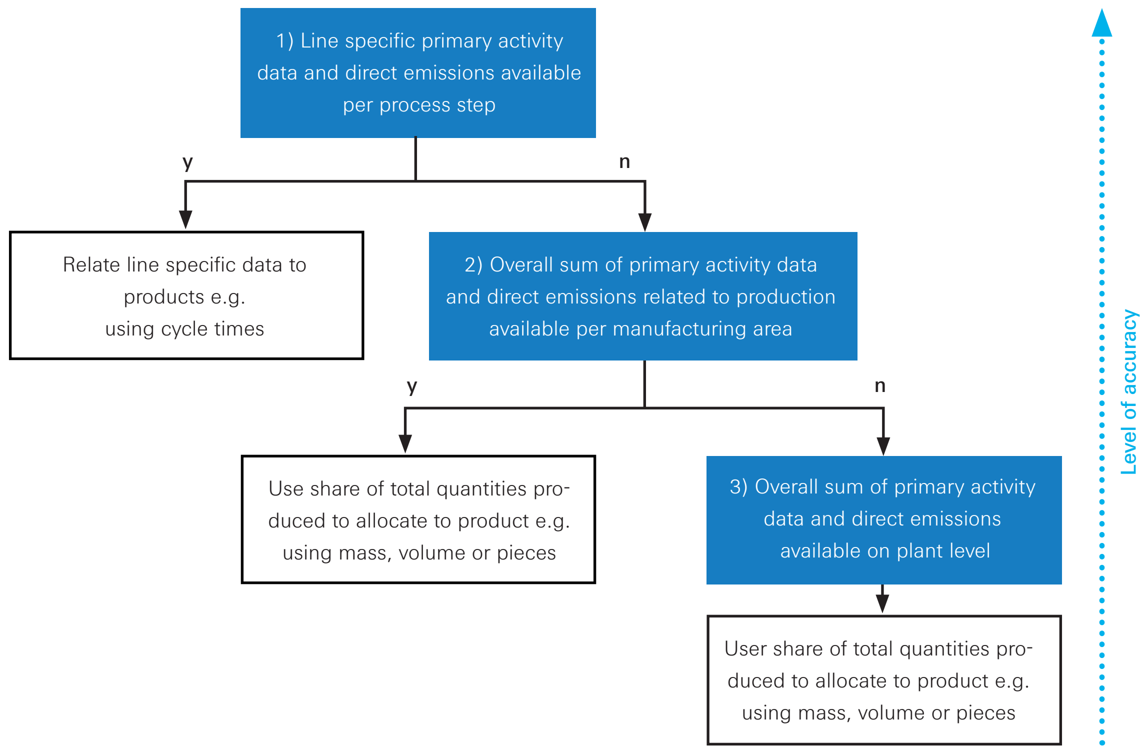
3.6.3 Manufacturing

Processes within the supplier plant usually refer to situation 1, option 1 in Table 2. Inhouse manufacturing data should hence always be based on primary data. This primary data includes activity data (e.g. energy demand, consumables, wastes, etc.) as well as direct emissions arising from the processes. The data should cover everything which is related to the production of the product[9].

Depending on the specific situation in the respective supplier plant with respect to the availability of electricity meters etc., the data can be available on different levels ranging from process/line-specific (high granularity and accuracy) over manufacturing area specific to plant-specific (e.g. no separate meter for different manufacturing areas or production lines). All data nonetheless needs to be allocated to the respective product the PCF is calculated for. Allocation can be based on production quantities (site or manufacturing area) or other technical categorizations like weight or cycle times. In general, a technically reasonable allocation procedure should be chosen and clearly documented. Figure 3 gives guidance on how data should be collected and possible allocation schemes.

Data should be based on measured data. If this is not possible, calculated information or data from planning can be used.

Figure 3: Decision tree for collection of inhouse manufacturing data



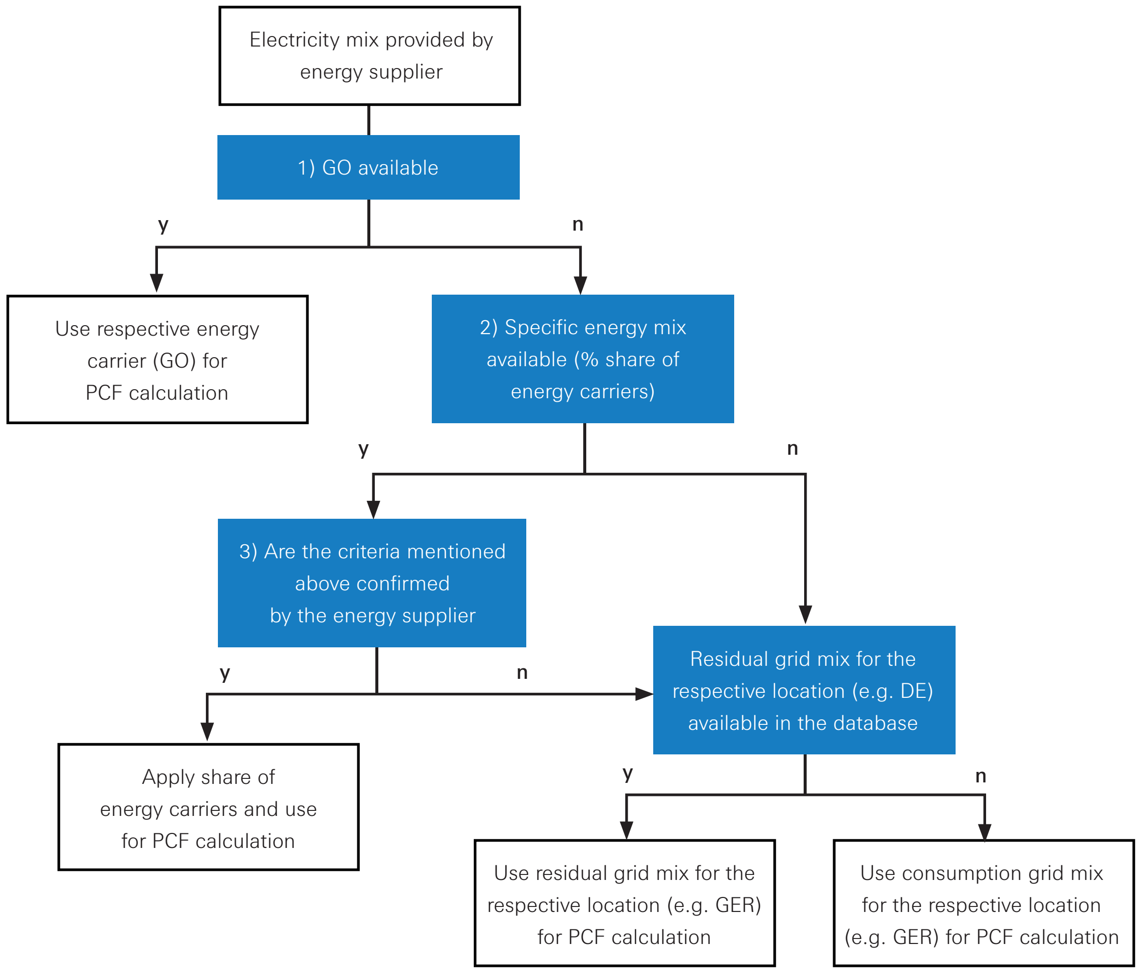
[9] Non-production related energy or consumable demand can include e.g. electricity for offices, heating etc. As long as these processes are not needed for the production as such (e.g. are not required to create a special environment needed for the production of electronics), they can be excluded. However, in practice there are not always meters for the different aspects available. For simplification reasons and following a conservative approach, the activity data can include the respective overheads even if they are not production-related. This should then be reported.

3.6.4 Electricity

Scope 2 emissions should be energy supplier-specific (also referred to as market-based emission factors) from energy suppliers for the reference period. The Scope 3 upstream emissions for the fuels that go into the energy production shall be added as well as grid losses that occur when transporting the electricity to the plants, in order to consider the full PCF of the purchased energy. For electricity data needed for the modelling of the PCF, the same general principals shall apply as stated above. Furthermore, it should be modelled based on the principles described in ISO14067 section 6.4.9.4.

Contractual instrument needs to be in place that fulfils these principles. The decision tree shown in Figure 4 gives guidance on the actual grid mix to be used for PCF calculation. If the energy supplier can provide a Guarantee of Origin (GO), the respective energy carrier stated there should be chosen. The energy supplier should proof that it is assured with a unique claim and a clear evidence of the origin of the electricity should be given. If no evidence is given, the residual grid mix (respectively consumption grid mix) should be chosen for the respective region (if available).

Figure 4: Decision tree for choosing the respective electricity mix for PCF calculation

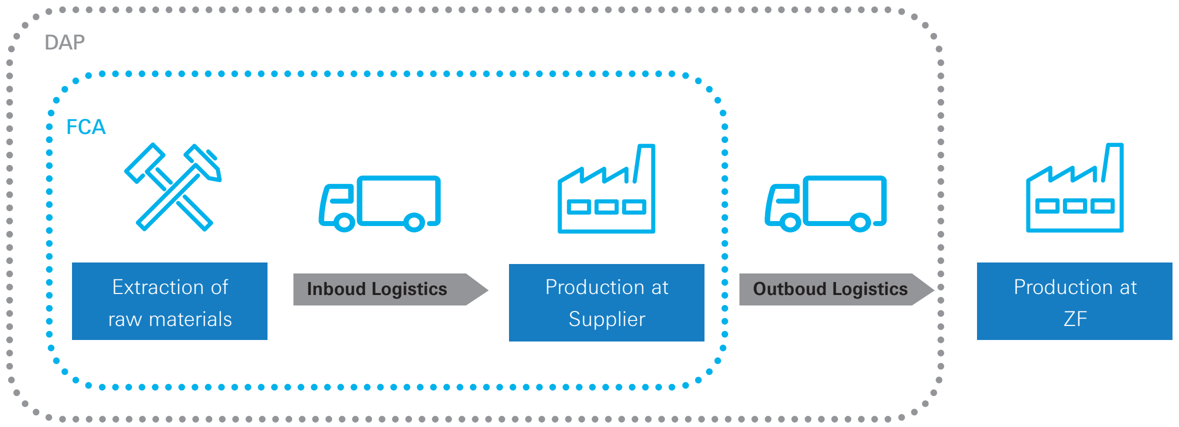


3.6.5 Logistics

Inbound logistics:
Logistics data must be collected using the purchased parts bill of material. In general, primary data from the logistics provider should be used as described in section 3.6.1. If no primary data is available, the shipping weight [kg], transport mode (e.g. truck and ship) as well as transport distances [km] need to be collected for every purchased part. The resulting ton-kilometers [weight*distance] can be used to calculate the emissions with secondary data.

Outbound logistics:
Outbound logistics only have to be included in the PCF calculation for dap (incoterm "delivered at place") based shipments, also shown in Table 1, the calculation approach is the same as for inbound logistics.

Figure 5: Inbound and outbound logistics



3.6.6 Treating Data Gaps

The data needs to be checked for completeness, accuracy, and plausibility against both internal and external product benchmarking. Data gaps could occur as a result of an incomplete bill of material or lacking activity data in a newly setup process in a plant. If such data gaps, outliers, or other inconsistencies occur and no primary data is available, proxy data should be used based on predecessor or similar products or processes. Remaining data gaps and inconsistencies should be clearly documented and explained. The influence of these proxy data on the results of the assessment should be carefully analysed.

3.6.7 Data Quality

For all primary data being collected for the PCF calculation, the criteria in Table 3 apply and should be carefully checked when assessing the data. Deviations should be documented and reported.the assessment should be carefully analysed.

Table 3: Data quality criteria for PCF calculation

Data Quality Criteria	Requirement
Geographical representativeness	Data from all sites relevant for the product under investigation
Technological representativenes	Data from existing technologies from the production sites
Temporal representativeness	Refers to the most recent annual administration period; not older than 3 years
Consistency	Data consistency has to be ensured by checking for 15% deviation from the previous year's primary data
Completeness	See data demand as described in section 3.6.1 to 3.6.6.
Reliability	Actual and site-specific production data
Precision	Checked by internal or external reviewer (measured/calculated and internally verified)

ZF Friedrichshafen AG
Löwentaler Straße 20
88046 Friedrichshafen
Germany
Phone: +49 7541 77-0
Fax: +49 7541 77-908000

www.zf.com