GUIDANCE

PRODUCT CARBON FOOTPRINT (PCF) CALCULATION

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Catena-X
Your Automotive Network

PCF CALCULATION

A Product Carbon Footprint (PCF) measures the environmental impact of a product by quantifying the total greenhouse gas emissions generated throughout its life cycle. Calculating the PCF is essential for manufacturers aiming to reduce their environmental footprint and make informed decisions.

This guide explains the process of calculating a PCF using the example of an output shaft. It covers the necessary steps, challenges, and data collection methods required for an accurate and comprehensive assessment.

Description

Challenges of calculation a PCF:

The process of calculating the PCF is a complex task that requires meticulous attention to detail and a comprehensive understanding of the product's lifecycle. This complexity arises from a multitude of factors, each presenting its own unique set of challenges. In the following list, we delve into these challenges in greater detail:

1 Data Collection Complexity:
Gathering accurate and comprehensive data from multiple sources, including production planning, controlling, and suppliers, is time-consuming and often incomplete.

2 Data Accuracy:
Ensuring the accuracy of primary data, such as material weights, energy consumption, and emissions, is critical but difficult, especially when dealing with secondary data sources.

3 Supplier Coordination:
Engaging with suppliers to obtain upstream emissions data requires significant coordination and collaboration, which can be challenging without a standardized approach.

4 Emission Factors Variability:
The variability in emission factors, particularly for energy sources like electricity, adds complexity to the calculation process.

5 Waste Management:
Accurately accounting for waste and scrap generated during production stages is often overlooked, yet can be relevant for a precise PCF.

Use Case

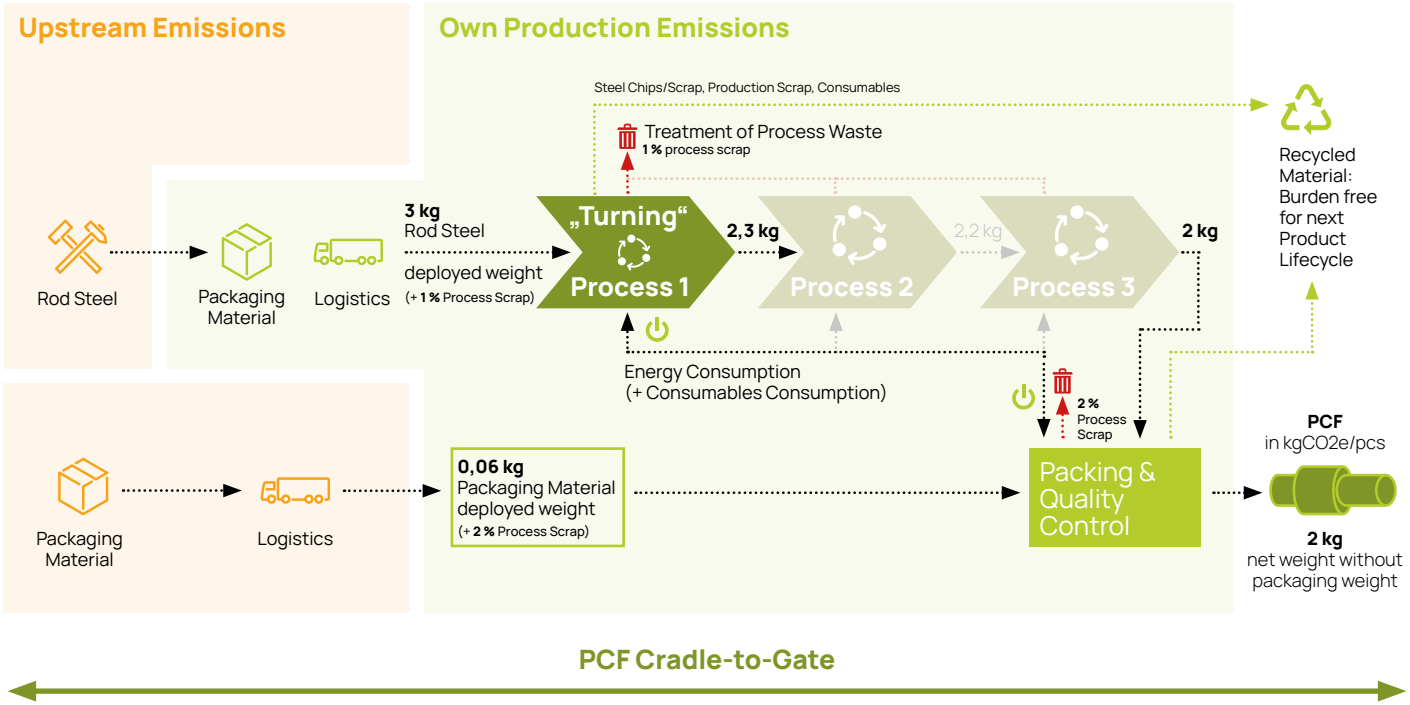
Example: Output Shaft

To illustrate the calculation of a PCF, we use the example of an Output Shaft. **Figure 1** shows an illustration of relevant processes to produce the Output Shaft. The declared unit of this PCF is 1 piece Output Shaft with a net weight of 2 kg.

NOTE:

Please note, that the GHG Emissions of the packaging are included but the declared unit refers to the mass of the unpackaged product.

Process Illustration for an Output Shaft



Step-by-Step

PCF Calculation of Output Shaft

Step 1: Screening Analysis

To begin with the PCF calculation, we conduct a **Screening Analysis** by collecting all relevant data for the production of this shaft. Start with the list of materials needed to produce, e.g. by filling the VDA LCA data collection form for each step of the process.

In our example, we focus on the first process step, Process 1 „Turning“.

NOTE:

The screening analysis is used to determine which processes are relevant and which may fall under the cut-off criterion. If no data is available for processes, a conservative estimate must be made.

A screening analysis update is used to estimate annually whether a recalculation of the PCF is necessary. It is required if there is a change in the PCF result of more than 5 % compared to the previous year's value.

Step 2: Data Collection for Process 1 „Turning“
For each process step, collect the data as accurately as possible:

- **Material Weight:** Information can be obtained from production planning.
- **Consumption of Energy, Utilities, and Auxiliaries:** Information can be derived from machine hourly rate calculations, typically handled by the controlling department.
- **Direct Emissions:** Coming from your production's own processes. These should be measured or stoichiometrically calculated.
- **Waste and Scrap Amount:** Record the amount of waste and scrap generated during the production process.
- **Transport Emissions:** Account for emissions from plant logistics (internal and external), if applicable.

Inputs	quanity	unit [9]	range [10]	data quality and comments [11]
energy sources including energy efficiency [12]				
electricity	0,80	kWh		measured; contract with energy supplier
material input [13]				
rod steel	3,0	kg		calculated; purchased from supplier A in a transport box of 0,5kg/pcs
utilities & auxiliaries [14]				
grease	6,7E-05	kg		estimated; delivered by supplier B
Process 1 - Turning				
process description [1]	Turning the rod steel for a first intermediate state			
process operator [2]				
location [3]	Germany			
reference value and refernce unit [4]	1 piece output shaft			
Outputs				
product(s) [15]				
intermediate state shaft	2,30	kg		1 piece
emissions to air [16]				
-				
emissions to water [17]				
-				
wastes/waste treatment [18]				
steel chips/scrap	0,70	kg		measured; recyclable
grease	6,7E-07	kg		estimated; waste

Transports [19]			
material inputs, utilities & auxiliaries and waste (delivered to and by the plant) [20]	distance (km) [21]	means of transportation [22]	utilisation (%) [23]
rod steel to plant	145	lorry	90
steel chips to recycler	80	lorry	70

Figure 2: Inventory for Process 1 „Turning“ (data collection sheet)

Figure 2 shows a completed inventory with inputs and outputs for the Process 1 „Turning“.

To complete a screening fill out such an inventory form for each necessary process step.

NOTE:

- **Direct Emissions:** No emissions to air or water are created during production, so there are no direct emissions.
- **Grease Usage:** Within the process „Turning 1“ a grease is needed for the machine, but it is difficult to measure or calculate the amount needed to produce one piece „intermediate state shaft“. For the screening the amount shall be estimated conservatively, so that a PCF for the grease can be calculated to evaluate its relevance/significance.
- **Scrap Management:** The scrap generated in the respective production steps must be considered in the calculation. For the „Turning“ process, steel chips and 1% process scrap occur and are later recycled. So, the emissions for transporting the scrap to the recycler must be included. Refer to the Catena-X PCF Rulebook (section 5.2.3) for details on handling these flows. Additionally, process scrap from grease and final packaging must be treated as waste and considered until final disposal (section 5.2.2).
- **Energy Emissions:** To calculate the emissions of energy used, both the amount of energy and the emission factor of the energy carrier are needed. This is especially crucial for electricity. The electricity supplier should provide information about the origin of the electricity (e.g., wind, coal, or gas) and the corresponding emission factor. This emission factor should include all relevant emissions for cradle-to-gate accounting, such as coal mining, losses, and waste treatment, see Catena-X PCF Rulebook section 5.2.4. If the electricity supplier's cradle-to-gate PCF is not available, but only the sources mix, it can be combined with secondary data for the cradle-to-gate electricity supply. If no specific contractual information is available, the residual mix should be used, as required by the Catena-X PCF Rulebook.

Step 3: Upstream Data Collection
For processes not under your control, the upstream emissions, request appropriate data from suppliers. In this example it would be the preparation of the rod steel, the grease as well as the packaging material.

In this example, we assume that you are responsible for the steel transport from your steel supplier to your factory gate. So you have to take into account the associated emissions for that. For grease and packaging material this amount should already be integrated in the PCF you receive from your respective suppliers.

Step 4: Secondary Data Usage
For processes where you don't have access to primary data you will need secondary data. The share of secondary data should be as low as possible.

Once all data is collected, you can proceed with the PCF calculation within the defined system boundaries.

PCF Calculation

Formulas

The **PCF Cradle-to-Gate** results from the sum the **Own Production PCF** and the **Upstream PCF.**

PCF Cradle-to-Gate = **PCF Own Production** + **PCF Upstream**

NOTE:
The outbound transport of the Shaft is under the control of the costumer receiving it. Therefore, it is not included in the cradle-to-gate PCF.

NOTE:
This PCF calculation example refers to the Calculation of a total PCF excluding biogenic, as required for PCFs shared via Catena-X until end of 2025.

➔ The following formulas are an example of how to apply the rules.

PCF Own Production Formulas

PCF Own Production = Steel Transport + „Turning" Electricity + „Turning" Grease + Steel Chips Transport + „Turning" Grease Waste Treatment + Quality Control & Packing Electricity + Packaging Material Waste Treatment

In this example, the entire formula for calculating the PCF of our Own Production consists of a total of seven values, which in turn must be calculated using separate formulas. **Let's go through it step by step.**

Steel Transport

$$PCF\ steel\ transport = 145\ km * (3{,}0\ kg + 0{,}5\ kg) * \left(6{,}0E^{-}05\ {}^{kgCO2e}/_{kgkm}\right) = 0{,}03\ {}^{kgCO2e}/_{pcs}$$

Distance | Weight Rod Steel + Transport Box | PCF Well-to-Wheel lorry

NOTE: PCF Well-To-Wheel lorry data can be requested from the transport operator or taken from secondary database, refer to Catena-X PCF Rulebook section 5.2.1.1.

„Turning" Electricity

$$PCF\ turning = 0{,}8\ kWh * 0{,}246\ {}^{kgCO2e}/_{kWh} * \left(\frac{1}{(1-1\%)}\right) = 0{,}199\ {}^{kgCO2e}/_{pcs}$$

Amount of Electricity | PCF Electricity | Scrap Factor

NOTE: In the Process 1 „Turning" 1 % process scrap is generated, see Figure 1.

The formulas for calculating the values highlighted in gray can be found on page seven.

„Turning“ Grease

$$PCF\ grease = 6{,}7E^{-}05kg * 1{,}2\ {}^{kgCO2e}/_{kg} * \left(\frac{1}{(1-1\%)}\right) = 8{,}1E^{-}05\ {}^{kgCO2e}/_{pcs}$$

Weight of Grease | PCF Grease Material | Scrap Factor

NOTE: Weight of grease per piece.
PCF grease material is coming from secondary database.

Steel Chips Transport

$$PCF\ steel\ chips\ transport = 80\ km * (0{,}7\ kg + 0{,}25\ kg) * \left(7{,}0E^{-}05\ {}^{kgCO2e}/_{kgkm}\right) = 0{,}0053\ {}^{kgCO2e}/_{pcs}$$

Distance | Weight Steel Chips + Transport Box | PCF Well-to-Wheel lorry

NOTE: PCF Well-To-Wheel lorry data can be requested from the transport operator or taken from secondary database, refer to Catena-X PCF Rulebook section 5.2.1.1.
Transport box weight is for this case 0,25kg.

„Turning“ Grease Waste Treatment

$$PCF\ grease\ waste = 6{,}7E^{-}07kg * (0{,}01\ {}^{kgCO2e}/_{kg} + 1{,}09\ {}^{kgCO2e}/_{kg}) = 7{,}3E^{-}07\ {}^{kgCO2e}/_{pcs}$$

Weight of Grease Waste | PCF Logistic | PCF incineration

NOTE: PCF Logistic calculation analogue to PCF Steel Chips Transport.
PCF incineration data is coming from secondary database.

Quality Control & Packing Electricity

$$PCF\ packing = 0{,}06\ kWh * 0{,}246\ {}^{kgCO2e}/_{kWh} * \left(\frac{1}{(1-2\%)}\right) = 0{,}015\ {}^{kgCO2e}/_{pcs}$$

Amount of Electricity | PCF Electricity | Scrap Factor

NOTE: In this example is a 2 % process scrap generated at packing process. The finished output shaft is subjected to a quality check in this process step and packaged in plastic film.

Packaging Material Waste Treatment

$$PCF\ packaging\ waste = 0{,}01\ kg * (0{,}013\ {}^{kgCO2e}/_{kg} + 1{,}087\ {}^{kgCO2e}/_{kg}) = 0{,}011\ {}^{kgCO2e}/_{pcs}$$

Weight of Foil Waste | PCF Logistic | PCF Incineration

NOTE: PCF Logistic calculation analogue to PCF Steel Chips Transport.
PCF incineration data is coming from secondary database.

The formulas for calculating the values highlighted in gray can be found on page seven.

Required Formulas

In the following, we come to four formulas for calculating values that are required for the formulas of the PCF calculation of your Own Production:

PCF Electricity | „Turning“ Electricity per piece | „Turning“ Grease per piece | Electricity Packing

PCF Electricity

$$PCF\ electricity = 0{,}6 * 0{,}4\ ^{kgCO2e}/_{kWh} + 0{,}3 * 0{,}01\ ^{kgCO2e}/_{kWh} + 0{,}1 * 0{,}03\ ^{kgCO2e}/_{kWh} = 0{,}246\ ^{kgCO2e}/_{kWh}$$

60 % natural Gas | PCF Electricity from natural Gas, incl. losses | 30 % Wind | PCF Electricity from Wind, incl. losses | 10 % PV | PCF Electricity from PV, incl. losses

NOTE: Required Data: Mix of energy carriers and emission factors of the individual energy sources.

„Turning“ Electricity per piece

$$Electricity\ per\ piece = 120\ kWh * 0{,}8 * \frac{30\ ^{sec}/_{pcs}}{3600\ sec} = 0{,}80\ ^{kWh}/_{pcs}$$

Elec-tricity/ hour | Facility Capacity Utilization (80 %) | Cycle time

NOTE: Required Data: Electricity/hour, capacity and cycle time of the Process 1 „Turning“ machine.

„Turning“ Grease per piece

$$Grease\ per\ piece = 0{,}01\ kg * 0{,}8 * \frac{30\ ^{sec}/_{pcs}}{3600\ sec} = 6{,}7E\text{-}05\ ^{kg}/_{pcs}$$

Usage Grease per hour | Facility Capacity Utilization (80 %) | Cycle time

NOTE: Required Data: Usage Grease per hour, capacity and cycle time of the Process 1 „Turning“ machine.

Electricity Packing

$$Electricity\ packing = 12\ kWh * 0{,}9 * \frac{20\ ^{sec}/_{pcs}}{3600\ sec} = 0{,}06\ ^{kWh}/_{pcs}$$

Elec-tricity/ hour | Facility Capacity Utilization (90 %) | Cycle time

NOTE: Required Data: Electricity/hour, capacity and cycle time of the packing machine.

$0{,}26\ ^{kgCO2e}/_{pcs}$ = Steel Transport + „Turning“ Electricity + „Turning“ Grease + Steel Chips Transport + „Turning“ Grease Waste Treatment + Quality Control & Packing Electricity + Packing Waste Treatment

PCF Upstream Formulas

For the calculation of the Upstream PCF following key points to keen in mind:

- Request data from suppliers for upstream processes.
- Include emissions from the transport of materials to your factory gate if responsible

PCF Upstream = Steel + Packaging Material

Steel

$$Upstream\ PCF\ steel = 3{,}0\ kg * \left(2{,}7\ {}^{kgCO2e}/_{kg}\right) * \left(\frac{1}{(1-1\%)}\right) = 8{,}182\ {}^{kgCO2e}/_{pcs}$$

Deployed Weight | PCF Steel | Scrap Factor

NOTE: The PCF for Steel is coming from the supplier.

Packaging Material

$$Upstream\ PCF\ packaging = 0{,}06\ kg * \left(0{,}6\ {}^{kgCO2e}/_{kg} + 0{,}02\ {}^{kgCO2e}/_{kg}\right) * \left(\frac{1}{(1-2\%)}\right) = 0{,}038\ {}^{kgCO2e}/_{pcs}$$

Deployed Weight | PCF Packaging Material | PCF Logistic + PCF Packing | Scrap Factor

NOTE: The PCF for Packaging Material and Logistic & Packing is coming from the supplier.

8,22 $^{kgCO2e}/_{pcs}$ = Steel + Packaging Material

PCF Cradle-to-Gate of the finished Output Shaft

The PCF of the finished Output Shaft is calculated from the sum of the previous Upstream PCF and Own Production PCF. In our example, we have only considered Process 1 „Turning“ in detail. However, the production process of the output shaft also includes other processes that must also be taken into account in the overall calculation of the PCF (see Figure 1). The outbound transport of the Shaft to the customer is not included in the Cradle-to-Gate PCF.

PCF Cradle-to-Gate = PCF Upstream + PCF Own Production + PCF Process 2 + PCF Process 3

8,48 $^{kgCO2e}/_{pcs}$ = **8,22 $^{kgCO2e}/_{pcs}$** + **0,26 $^{kgCO2e}/_{pcs}$** (8,48 + Z = 8,22 + 0,26 + X + Y)

PCF Contribution of estimated Grease

As previously mentioned, the amount of grease was estimated, because it cannot be measured easily. According to the screening analysis the grease PCF share is 0,001 %, so that you are allowed to leave it out from the final assessment (cut-off approach, see section 4.2.1 in the CAtena-X PCF Rulebook).

Relevance of estimated Grease

$$PCF\ contribution\ of\ grease = \frac{\overbrace{8{,}1E{-}05^{kgCO2e/pcs}}^{\text{PCF Grease}}}{\underbrace{8{,}48^{kgCO2e/pcs}}_{\text{PCF Cradle-to-Gate}}} = 0{,}001\%$$

Final PCF Cradle-to-Gate without Grease

0,26 $^{kgCO2e}/_{pcs}$ = Steel Transport + „Turning" Electricity + ~~„Turning" Grease~~ + Steel Chips Transport + ~~„Turning" Grease Waste Treatment~~ + Quality Control & Packing Electricity + Packing Waste Treatment

8,48 $^{kgCO2e}/_{pcs}$ = **8,22** $^{kgCO2e}/_{pcs}$ + **0,26** $^{kgCO2e}/_{pcs}$

NOTE:

In our example, the values of the Grease are so low that nothing changes in the overall result.
In principle, this calculation can be used as a basis for further PCF calculations.

PCF Calculation

Results and Findings

The PCF calculation, in this case for an output shaft, involves meticulous data collection and collaboration with suppliers. Using Catena-X can streamline this process by providing a standardized framework for data exchange and collaboration.

Links

Catena-X PCF Rulebook	Catena-X Standard Library	Catena-X Campus	VDA LCA Inventory

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