Verband der Automobilindustrie

Recommendation

Carbon Accounting of Transport Packaging

VDA 4550

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There are many standards, norms and guidelines for calculating life cycle assessments and carbon footprints. These are often framework guidelines that set out principles without specifying details. This can lead to uncertainties and a lack of comparability. For this reason, the present recommendation aims to fill the gap in the area of transport packaging and recommends a concrete approach where choices exist. The goal is to avoid uncertainties and to achieve harmonisation of carbon accounting. The recommendation takes existing norms into account and complements them where necessary (see section 2). It focuses on the relevant aspects.

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List of abbreviations

Acronym	**Meaning**
ABS	Acrylonitrile-butadiene-styrene copolymer
AL	Aluminium
C	Completeness
CH_4	Methane
CKD	Completely Knocked Down
CO_2	Carbon dioxide
CO_2-eq.	Carbon dioxide equivalents
dLUC	direct Land Use Change
DQR	Data quality ranking
ECG	The Association of European Vehicle Logistics (European Car-Transport Group of Interest)
EF	Environmental Footprint
EFTA	European Free Trade Association
EPP	Expanded polypropylene
ESD	Electrostatic Discharge
CFCs	Chlorofluorocarbons
GEMIS	Global Emissions Model of Integrated Systems
GeR	Geographical Representativeness
GHS	Globally Harmonised System of Classification and Labelling of Chemicals
GLAD	Global LCA Data Access Network
GLO	Global (globally valid data set)
GLT	Large load carriers
GWP	Global Warming Potential
HCFCs	Chlorofluorocarbons
HDPE	High density polyethylene
HFC	Fluorocarbons
HFEs	Fluorinated ethers
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
KLT	Small load carriers
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LDPE	Low density polyethylene
MHKW	Waste-to-energy plant

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N_2O	Nitrous oxide
NF_3	Nitrogen trifluoride
PBAT	Polybutylene adipate terephthalate
PCF	Product Carbon Footprint
PDS	Primary Data Share
PE	Polyethylene
PET	Polyethylene terephthalate
PFCs	Perfluorocarbons
PFPEs	Perfluoropolyether
POM	Polyoxymethylenes
PP	Polypropylen
ProBas	Process-oriented basic data for environmental management instruments
Re	Reliability
RER	Region Europe (dataset valid for Europe)
rLDPE	Recycled LDPE
SF_6	Sulphur hexafluoride
SI	International System of Units
SVHC	Substances of Very High Concern
TeR	Technological Representativeness
GHG	Greenhouse gas
TiR	Time/Temporal Representativeness
TPU	Thermoplastic polyurethane
VCI	Volatile Corrosion Inhibitor
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1 Introduction

1.1 Background and objective

There are many standards, norms and guidelines for calculating life cycle assessments and carbon footprints. These are often framework guidelines that provide principles without specifying details. This can lead to uncertainties and a lack of comparability. For this reason, the present recommendation aims to fill the gap in the area of transport packaging and suggests a concrete approach where options exist. The goal is to avoid uncertainties and to achieve harmonisation of carbon accounting. The recommendation takes existing standards into account and supplements them where necessary (see chapter 2). It focuses on the relevant aspects.

1.2 Target audience

This recommendation is aimed at companies that want to determine climate footprints for transport packaging in automotive supply chains. It is relevant for members of the German Association of the Automotive Industry (VDA) eV as well as for other players along the product life cycle of transport packaging in the automotive industry, such as manufacturers of transport packaging, transport service providers and recycling companies.

1.3 Scope of the recommendation

This recommendation is applicable to transport packaging in the automotive industry.

Definition of transport packaging (according to ISO 21067-1, 2.2.6): “Packaging intended to contain one or more items, packages, or bulk goods for the purposes of transportation, handling and/or distribution.”

The recommendation is applicable to all types of transport packaging, regardless of their design, material composition and whether they are intended for single-use or reuse.

The recommendation is to be applied in its current version (V. 1.0) until a new version is published by the VDA.

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1.4 Structure and terminology of the recommendation

Definitions in boxes clarify fundamental terms, such as "transport packaging”.

Rules to be observed are formatted in italics.

Below the rules, there are explanations. These explanations provide brief clarifications of the rules or offer guidance on how the rules can be implemented in practice. If other sections of the recommendation are relevant, references to them are also provided. Explanations do not contain any additional requirements.

Examples in boxes illustrate the rules to be followed or their implementation.

The terms "must," "has to," etc. and "must not," "may not," etc., in a rule indicate that this rule must be followed to create a carbon footprint in accordance with this recommendation.

The terms "should," "is recommended," etc., in a rule indicate that compliance with this rule is generally recommended.

However, compliance with these "should" rules is not necessary to be in conformity with this recommendation.

The terms "may," "are allowed," etc., indicate that these are suggestions.

Implementing these suggestions may be useful in certain cases but is not required to create a carbon footprint in line with this recommendation.

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2 Existing norms and standards

This recommendation for carbon accounting of transport packaging in the automotive industry is based on various norms and standards that establish the fundamentals for life cycle assessment and include specific requirements for the carbon accounting of transport packaging.

Table 1: Existing standards for carbon accounting

Norm/Standard	Description	Conformity
ISO 14040/ 44	Basic principles of life cycle assessment for products or organisations; sets out the basis for life cycle assessment	Compliant
ISO 14067	Specific standard for carbon accounting of products; includes more detailed requirements for carbon footprints, such as energy consumption guidelines.	Compliant
Product category rules	Concrete rules for life cycle assessment of specific product groups to enhance comparability of results for a particular product group. Includes rules for packaging and end-of-life. Product category rules for packaging and its end of life were taken into account	Aligned
ISO 14083	Specific requirements for the accounting of transport processes, including transport packaging.	Aligned
Pathfinder Framework and Catena-X Product Carbon Footprint Rulebook	Standards from industry consortia that increase the comparability of results and define specific requirements for the carbon accounting of products	Aligned
VDA and ECG Guide to Emissions Calculation for Automotive Supply Chains	Recommendations closely aligned with ISO 14083, setting specific requirements for the accounting of transport processes.	Aligned
EU legislation on packaging and packaging waste	Sustainability-related regulations that do not contain specific requirements for the carbon accounting of transport packaging; synergies possible with carbon accounting, particularly in data collection.	Not relevant

"Compliant" means that the recommendation meets the requirements of the corresponding standard.

"Aligned" means that the recommendations are based on or partially fulfil the corresponding standard.

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3 Scope

3.1 Functional unit

The basic functional unit for transport packaging is a single instance of a transport package.

Example: In a transport system where only small load carriers (without additional packaging components such as inserts, etc.) are used, the basic functional unit for this small load carrier system is a small load carrier.

The basic functional unit for transport bundles consisting of multiple transport packages is a single instance of a transport bundle.

Example: A transport bundle in a transport system consists of corrugated boxes on pallets with strapping bands. The basic functional unit for considering this bundle system is a single instance of such a bundle.

To ensure comparability between different transport packages, published carbon accounting reports must also include various packaging data (see section 7.2).

In addition to the basic functional unit, modellers may choose other types of functional units. Depending on the goal and scope of the carbon accounting, the following functional units may be useful:

- Volume
- Mass
- Volume*kilometres
- Mass*kilometres

If the carbon accounting is intended for publication, results must always be related to the basic functional unit. Additionally, results may also be related to other functional units.

Only in this way can comparability be ensured when different functional units are used alongside the basic functional unit.

Functional units for transport packaging should only include the transport packaging itself, not the freight contained within the transport packaging.

Only a functional unit that refers solely to the transport packaging allows modellers to calculate and optimise the transport packaging as such. This also simplifies avoiding double counting when the freight contained within the transport packaging is already carbon accounted for elsewhere in the company.

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3.2 Definition of the scope

System boundaries

Technology considered

This recommendation must be used for transport packaging as defined by ISO 21067-1.

Other products and their emissions are outside the scope and are not considered in the carbon accounting of the product system. This specifically includes environmental impacts caused by the contents of the packaging (materials, goods, etc.).

The technological scope must include all relevant process steps of the considered transport packaging system.

Section 5 of this recommendation lists the processes that must be accounted for.

Geographical context

The modelling and the data used should reflect the local conditions as accurately as possible.

More precise information on the geographical representativeness of the data can be found in section 4.

Temporal context

The data used should be as current as possible.

Additional information on the temporal representativeness of the data is provided in section 4.

3.3 Cut-off rules

In the carbon accounting of a transport package, at least 95% of the actual greenhouse gas (GHG) emissions must be considered.

Section 5 provides a list of processes that must necessarily be modelled. Practitioners may assume that generally 95% of all emissions are captured if the emission sources listed there are included.

Processes outside the life cycle of a transport package must not be considered.

Examples: Research and development; administration; employee commuting

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3.4 Allocation

Allocation serves to distribute inputs and outputs, as well as their associated emissions, to products when a specific allocation is not possible. In the case of transport packaging, this can occur under the following circumstances:

1. Allocation in multi-output processes
2. Allocation of transport packaging and contained freight
3. Allocation in waste disposal and recycling

Once established, the approach used for a particular process must remain consistent.

The following describes the procedure for addressing the mentioned cases.

3.4.1 Allocation in multi-output processes

If one or more multi-output processes exist within the considered product system, the listed methods should be applied in the following priority:

1. *Subdivision*
2. *Physical allocation*
3. *Economic allocation*

Multi-output allocation describes the allocation of inputs and outputs to several products that result from a single process.

Example: In a single production process, two different small load carriers are produced. The energy and raw material consumption, and associated greenhouse gas emissions, must be allocated to the respective end products appropriately.

Subdivision

If possible, processes should be further subdivided.

Subdivision refers to avoiding allocation by breaking down the process unit into subprocesses and separately recording the emission data for these subprocesses.

Example: If a production facility manufactures not only small load carriers but also other plastic products, separate electricity meters should measure the electricity required specifically for producing the small load carriers.

Physical allocation

If subdivision into subprocesses is not possible, physical allocation must be applied.

Physical allocation involves distributing the inputs and outputs of the multi-output process based on physical characteristics such as mass flows (kg, m³, etc.) or energy flows (MJ, kWh, etc.).

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Example: A plastic granulate is used to manufacture both a small load carrier and another product. The total production quantity is 10 tons, with 8 tons corresponding to the small load carrier. Thus, using mass allocation, 80% of the plastic granulate is attributed to the small load carrier.

Economic allocation

If neither subdivision nor physical allocation is possible, economic allocation must be applied.

For economic allocation, average sales prices from the past 5 years should be used.

Economic allocation distributes the input and output data in proportion to the economic value of the products considered (e.g., €/ton, €/m³, €/kWh, etc.). If sales prices are not available or applicable, other economic factors such as costs can be used.

Example: In a mining operation, 250,000 tons of bauxite (50 €/ton) are extracted for later use in aluminium packaging. At the same time, 50,000 tons of iron ore (150 €/ton) are also extracted. The ratio of the extracted quantities and the prices of the two raw materials results in a distribution of 62.5% of the shared inputs/outputs to the bauxite and 37.5% to the iron ore.

3.4.2 Allocation of transport packaging and contained freight

When allocating inputs/outputs between transport packaging and the freight contained within it, the following methods should be applied in the given priority:

1. *Subdivision*
2. *Physical allocation*

Subdivision – Freight and packaging:

Transport packaging and transported goods must be accounted for separately.

Processes that are not relevant to the transport packaging should be identified and excluded from the calculation of the carbon footprint of the transport packaging. Special attention should be given to avoiding double counting, especially if the carbon footprints of goods might already include emissions from transport packaging.

Example: If the transported freight undergoes quality inspections, the effort for these inspections should not be included in the carbon footprint of the packaging.

Physical allocation – Freight and packaging

If subdivision between transport packaging and freight is not possible, physical allocation must be applied.

Inputs and outputs should be allocated in a way that reflects the underlying physical relationships between them.

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Example: A truck transports both transport packaging and freight. The resulting consumption/emissions are allocated proportionally based on the mass of the freight and the transport packaging. Only the consumption or emissions attributable to the transport packaging are considered in the accounting.

3.4.3 Allocation in waste disposal and recycling

For the allocation of GHG emissions at the end of the life cycle, the following approaches are distinguished:

- Energy recovery and disposal
- Material recycling

Energy recovery and disposal

The emissions from the entire disposal pathway are attributed to the transport packaging that generated the waste.

To fully account for a product life cycle in a carbon footprint (cradle-to-grave), it is necessary to model the disposal phase. A list of processes that must be considered in the disposal pathway can be found in section 5.3.1.

Energy recovered from waste incineration is treated as having no environmental impact.

Emissions related to previous life cycles are not considered when secondary energy is used in a subsequent product system. However, the system that generates the energy does not receive credit for the substitution of primary energy.

Example: A small load carrier is incinerated in a waste-to-energy plant. The incineration recovers energy (e.g., electricity/heat), which is used to substitute energy from primary sources (e.g., coal) in the production of another product. The subsequent product system can use the secondary energy from the waste-to-energy plant without emission burden. However, the small load carrier cannot receive credit for avoiding emissions from primary energy sources.

Recycling

If material recycling is applied for the considered product, the allocation method should follow the cut-off approach.

Accordingly, all environmental impacts up to the end-of-life of the product in question are attributed to the first life cycle. The end-of-waste is determined according to DIN EN 15804 (Annex B) and is reached only after the complete preparation of the (recyclable) product. The recycled product can then be included in a subsequent product system without emission burden from the previous chain. However, further emissions occurring after the end-of-waste must be accounted for in the subsequent life cycle.

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Example: Recycled polypropylene is produced from old rain gutters (1st life cycle. This recycled material is used to make a small load carrier. The emissions from the recycling process (collection, transport, cleaning, sorting, shredding, etc.) are allocated to the rain gutters system. Only when the recycled granulate is available (end-of-waste) are the subsequent manufacturing steps allocated to the carbon footprint of the small load carrier (2nd life cycle).

The end-of-waste is determined according to DIN EN 15804 (Annex B) and is reached only after the complete preparation of the (recyclable) product.

According to this standard, processes must be considered until all of the following conditions are met:

- The recovered material is "generally used for specific purposes.”
- There is a "market" for the recovered material (i.e., demand and a positive price).
- The recovered material "meets existing regulations and standards" (applicable to comparable primary materials).
- The recovered material "complies with limits for SVHC" ("SVHC" stands for "Substances of Very High Concern").

If a transport packaging is made from both recycled and primary materials, the respective shares must be considered accordingly.

When manufacturing mixtures of primary and secondary materials, only the portion of the recycled material, according to the cut-off approach, is allocated to the product system without an emission burden. In the case of purchased products, precise manufacturer information regarding material composition should be noted.

Example: A small load carrier is made of 20% recycled polypropylene and 80% primary polypropylene. In the modelling, the share of secondary material (20%) is considered without emission burden according to the cut-off approach, while the primary material (80%) is included with the full emissions from the previous chain processes.

3.5 Electricity

For all relevant process steps within the system boundaries where electricity is required, companies must determine the GHG emissions resulting from this specific electricity usage.

To calculate the share of electricity consumption in the carbon footprint of transport packaging, generation-specific emission factors must be used. The factors used should account for upstream emissions, emissions during electricity generation and downstream emissions.

Different amounts of greenhouse gases are emitted depending on the method of electricity generation. If electricity is used in a process, the way the electricity was generated must be considered. If the electricity comes from multiple sources, these should be accounted for proportionally.

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Example: For the extrusion of packaging film, electricity is used, which is 70% from biomass and 30% from photovoltaic sources. If 100 kWh are needed for the extrusion, the emission factor for biomass electricity generation should be used for 70 kWh and the emission factor for photovoltaic electricity generation should be used for 30 kWh. The emission factors should include, among other things, the cultivation of the biomass or the disposal of the photovoltaic system.

3.5.1 Electricity from directly connected sources

Electricity sourced from directly connected power generation facilities, used for in-house consumption, must be included in the calculation of the CO2 footprint.

If electricity is generated on-site with a direct connection to a power generator, the amount of electricity consumed from this generator (in kWh) and the associated emission factor should be used, provided that the generated electricity has not been sold to third parties. If a specific emission factor is not available, the national residual mix should be used.

Publicly available data sources for national electricity mixes can be found in section 5.4 of this guide.

Example: Directly connected power generators include photovoltaic systems or on-site power plants using fossil fuels.

To prove the use of electricity from own facilities, documentation of the installation of the generation equipment and meter readings is required.

The amount of electricity and the period of the meter reading must align with the required electricity amount and its consumption period.

3.5.2 Electricity from a utility or via contract instruments

When electricity is sourced via a contractual instrument, the following electricity mix should be applied in the hierarchical order below:

1. *A supplier-specific electricity product must be used if*
    - *a tracking system has been established in the country.*
    - *the minimum criteria to ensure the reliability of the contractual instruments are met (see below).*

2. *The supplier-specific total electricity mix should be applied if:*
    - *the minimum criteria to ensure the reliability of the contractual instruments are met (see below).*

If the requirements under 1. and 2. are not met, the country-specific residual grid mix (consumption mix) must be used.

The contractual instrument used to calculate the relevant emission factors (see 1 and 2) must meet the following minimum criteria:

- *It must contain information about the amount of electricity supplied and the type of electricity generation.*

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- *It must be the only contractual instrument that claims the generated electricity.*
- *The claims must be tracked, redeemed, withdrawn, or cancelled by the company or on its behalf (e.g., through contract audits, third-party certification, or automatic mechanisms through other disclosure systems).*
- *The actual electricity consumption must correspond to the same year in which the contractual instrument is applied.*
- *If electricity consumption comes from more than one mix, each mix must be applied according to its share of the total consumed kWh.*
- *If a certificate of origin covers only part of the consumed electricity, the residual mix must be used for the uncovered amount.*

4 Data and data quality

A critical aspect of the quality and validity of a carbon footprint assessment for transport packaging is the data used. The following sections define and explain the collection of data and the general requirements for quality.

For GHG accounting of transport packaging, data is divided into primary and secondary data.

Definition: Primary data (also known as specific data) refers to quantified values of a process obtained through direct measurement or calculation based on direct measurements.

Primary data derived from the processes within the product system being studied are also referred to as site-specific data.

In addition to the company calculating the carbon footprint, primary data can also come from suppliers, service providers, or other organisations involved in the product's lifecycle.

Examples: Primary data includes meter readings; purchase records; utility bills; stoichiometric calculations

Definition: Secondary data (also known as generic data) refers to data that does not come from direct measurements or calculations based on such measurements.

Secondary data can also include default data set for the creation of this guideline. This is not limited to emission factors but can also include standard values for other parameters, such as the number of uses for reusable packaging (see section 5.2.1).

Examples: Secondary data include data from generic databases; published literature, standard emission factors from national inventories; representative data from statistics

4.1 Data collection requirements

For compiling a carbon footprint, the following rules for data collection apply:

Primary data must be used whenever available and should meet the required data quality standards.

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If primary data is not available, secondary data should be used. Secondary data must also meet the same quality standards.

The following sections outline the requirements for data quality.

4.2 General data quality requirements

Data quality refers to the representativeness of both primary and secondary data in relation to the actual life cycle of the transport packaging being assessed. The evaluation of data quality is based on five key indicators:

- **Technological Representativeness** (TeR): The degree to which the data reflects the technology or technologies used in the actual process.
- **Geographical Representativeness** (GeR): The degree to which the data accurately represents the geographic location of the processes within the boundary (e.g., country or site).
- **Time/Temporal Representativeness** (TiR): The extent to which the data reflects the actual time (e.g., year) or age of the process.
- **Completeness** (C): The extent to which the data covers all relevant aspects of the processes.
- **Reliability** (Re): The trustworthiness of the data sources, collection methods and verification procedures used to obtain the data.

Geographical Representativeness (GeR):

Data should be process-specific and site-specific for each process module within the product system being studied.

As a general standard, emissions data should be collected at the level of individual operations. If similar processes occur in multiple locations, averaging across countries or regions may be considered. Even identical transport packaging may show varying carbon footprints depending on the location.

Example 1: Identical transport packaging is produced, used, or disposed of in different locations. Location-specific factors (e.g., disposal method, local electricity mix) must be appropriately taken into account.

Example 2: A transport package is used to deliver a component to multiple countries. If location-based differences in transportation occur (e.g., use of trucks under Euro 3 in country A and Euro 5 in country B), this must be factored in.

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Temporal Representativeness (TiR):

Data should be collected as an average for a full year (reporting or calendar year) to avoid seasonal fluctuations and reflect typical process conditions.

An annual review should be conducted to ensure data remains up-to-date.

Data must be updated if emissions derived from the data increase by 5% or more compared to the previous reporting period.

Shorter time periods may be considered if full-year data is not yet available. Longer reporting periods may also be considered but should not exceed three years. This is to prevent the use of outdated data that no longer accurately reflects current GHG emissions across a product's life cycle.

4.3 Requirements for secondary data

Secondary data must be used in a way that prevents underestimating the carbon footprint.

This conservative approach ensures that a carbon footprint assessment is not underestimated due to reliance on secondary data. By adopting this strategy, the application and communication of the carbon footprint become more reliable, while encouraging the collection and use of primary data.

This conservative principle was also considered when selecting default values (see section 5.2.1).

Example: A database contains generic datasets for both virgin polypropylene and recycled polypropylene. If the analyst is unsure whether recycled material was used in the process being evaluated, they must conservatively choose the dataset for virgin polypropylene.

When using secondary data as emission factors (e.g., fuel consumption emission factors), the following criteria must be met:

- Temporal Representativeness (TiR): The reference year for the secondary data should align with the evaluation period of the activity data. If not, the most representative available year must be used for calculations.
- Geographical Representativeness (GeR): The geographic coverage of the data should match the most geographically relevant activity data for the process.
- Technological Representativeness (TeR): The secondary data source must align with the activity data and be technologically representative of the process.

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4.4 Evaluation of data quality

The underlying data quality for the carbon footprint assessment of transport packaging must be evaluated.

Data quality should be assessed using the Data Quality Rating (DQR) system.

The calculation of the DQR is based on the quality indicators defined in section 4.2. The quality levels are expressed in three categories: 1 "Good", 2 "Acceptable" and 3 "Poor". The following Table 2 is used to determine a semi-quantitative evaluation of data quality:

Table 2: Evaluation of data quality

Indicator	1 - Good	2 - Acceptable	3 - Poor
TeR	Same technology	Similar technology (based on secondary data)	Different or unknown technology
TIR	Data from the reporting year	Data less than 5 years old (date of creation of the data set)	Data older than 5 years (date of creation of the data set)
GeR	Same country or more precise information	Same region or sub-region	Global or unknown
C	All relevant locations for the specified period	<50% of locations for a specific period or >50% of locations for a shorter period	Less than 50% of locations for a shorter period or unknown
R	Measured activity data	Activity data is partly based on assumptions	Estimates

The representativeness (technological, geographical and temporal) indicates how closely the selected data reflects the real-life lifecycle of the transport packaging. The indicators "completeness" and "reliability" further describe the quality of the generated carbon footprint.

The Data Quality Rating (DQR) for activity data or an emission factor is calculated using the arithmetic mean of the five data quality indicators:

$$= (++++) / 5$$

Example: For a manufacturing process dataset, the following indicator values were recorded:

TeR = 1; GeR = 3; TiR = 1; C = 2; R = 1

Using the above formula, the DQR is calculated as:

$$= (1+3+1+2+1) / 5 = 1.6$$

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The overall data quality of the PCF (Product Carbon Footprint), denoted as _{total}, is calculated using a weighted average based on the contribution of each individual data entry () to the total PCF (Σ||):

$_{\text{total}} = \Sigma(\cdot||) \;/\; \Sigma||$

Example: A small load carrier is made of polycarbonate and steel. The dataset for polycarbonate has a DQR of 1 and accounts for 3.6 kg CO_2-eq. For steel, the DQR is 3 with emissions of 5.4 kg CO_2-eq. Using the formula, $_{\text{total}} = (1 \cdot 3.6 + 3 \cdot 5.4) \;/\; (3.6 + 5.4) = 2.2$

the data quality should be at least a $_{total}$ score of 2 or better. Additionally, the TeR indicator should have a value of at least 2.

When considering biogenic or fossil emissions with a characterisation factor of -1 kg CO_2-eq per kg of CO_2, negative PCF contributions may arise (see section 6) This can lead to incorrect calculations in the data quality assessment. Therefore, only absolute values should be used for the DQR and DQ_{total} calculations.

4.5 Primary data share in the PCF

The Primary Data Share (PDS) is a metric used to assess the proportion of a carbon footprint (PCF) that is derived from primary data.

It reflects how much of the total carbon footprint, expressed in kilograms of CO_2-equivalent per functional unit, is based on direct, site-specific measurements or calculations.

$_{\text{PCF}}$ = Share of PCF based on primary data $[\,_2\text{-eq.}] \;/\; \text{total}\, [\,_2\text{-ep.}]$

5 Life cycle inventory

5.1 Manufacturing phase

5.1.1 Description of the production phase

Processes to consider in the manufacturing phase

The carbon footprint of transport packaging must encompass the manufacturing of all materials, components and elements essential for the transportation of goods.

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Example: When multiple layers of goods are protected in a pallet cage by cardboard inserts, both the production of the pallet cage and the inserts must be accounted for.

*In calculating the carbon footprint of the production phase, all relevant processes from raw material extraction to the finalisation of the transport packaging must be considered. To ensure compliance with general cut-off rules, the **following processes** should be **considered**:*

- *Raw material extraction processes:*
    - *Extraction of fossil and mineral primary raw materials*
    - *Cultivation of bio-based raw materials*
    - *Energy generation (e.g., electricity) for raw material extraction.*
- *Raw material processing processes:*
    - *Processing of raw materials*
    - *Energy generation (e.g. electricity) for raw material processing*
- *Intermediate product manufacturing:*
    - *Production of intermediate products*
    - *Energy generation for the production of intermediate products.*
- *Finished transport packaging manufacturing:*
    - *Final product manufacturing.*
    - *Energy generation for the manufacturing of finished transport packaging.*

Examples: Extracting crude oil or cultivating biomass are typical examples. The refining of petroleum or the drying of biomass are examples of raw material processing. One process for manufacturing intermediate products is the melting of plastic granulate to form plastic components of a small load carrier. Finally, the assembly of plastic components into a finished small load carrier is a process of manufacturing finished transport packaging.

***The following processes**, which are not directly related to the manufacturing phase of transport packaging, must **not** be **taken into account** . These are:*

- *Research and development*
- *Administration*
- *Production of machinery, buildings, other capital goods and infrastructure.*
- *Business travel and commuting of staff*

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The following processes *may* ***optionally be considered****:*

- *Transport from raw material extraction to the production of the finished transport packaging*
- *Treatment of waste from raw material extraction to the production of finished transport packaging*

If optional processes are included, it is important in the modelling process to ensure that results can also be calculated without taking these processes into account. This allows for comparability with carbon footprints where these optional processes were not included in the calculations. Including these optional processes may also be necessary to comply with standards other than ISO 14067. If modellers have this objective, they should check the respective standard to determine which processes must be included.

When creating carbon footprints, not all processes in the manufacturing phase need to be modelled individually. Instead, common databases provide datasets that consolidate multiple process steps (see section 5.4). Modellers should check the documentation of these datasets to ensure all relevant process steps are included.

Example: For the carbon footprint of a pallet cage, steel production should be modelled. In addition to datasets for individual processes like mining, pig iron production, etc., common databases also contain datasets for steel that consolidate all these upstream steps in the process chain.

Transport from the manufacturing site to the point of use of a transport packaging should not be accounted for in the manufacturing phase but should be assigned to the use phase.

With this allocation, the processes listed here correspond to a cradle-to-gate accounting of a transport packaging.

Consideration of recyclates and bio-based materials

If materials, intermediate products or finished transport packaging come wholly or partly from recycled or renewable sources, this must be taken into account in the life cycle inventory of the carbon footprint.

If materials, intermediate products or finished transport packaging come wholly or partly from renewable sources, then the cultivation, production and harvesting of the biomass must also be taken into account.

When recycled or bio-based materials are mixed with conventional materials, only the actual proportion of recycled or bio-based materials should be accounted for.

Further details on bio-based materials can be found in the appendix.

Example: Steel for a pallet cage is 70% recycled scrap. Therefore, the carbon footprint calculation should account for a steel recycled content of 70%.

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5.1.2 Data collection and origin in the manufacturing phase

Primary data of the manufacturing phase

If the packaging manufacturing processes occur within the company that is also preparing the carbon footprint, primary data should be collected and used in the carbon footprint for these processes.

If a company preparing the carbon footprint of transport packaging has direct operational control over another company where the packaging manufacturing processes take place, primary data should also be collected and used.

If a company preparing the carbon footprint for transport packaging sources packaging directly from a manufacturer and the manufacturer can provide relevant primary data, these primary data should be included in the carbon footprint of the packaging.

If additional primary data from the (indirect) supply chain of the packaging production are available, they should also be used for calculating the carbon footprints.

Primary data on the production of transport packaging can be available in two forms: First, process data can be collected, meaning data on material and energy flows in the production of raw materials, intermediates and packaging. Second, emission data can be available, meaning measurements of greenhouse gas emissions during the production phase. Both types of information can be used to create a carbon footprint.

Example: A supplier of plastics provides information on the amount of electrical energy required to produce the polypropylene granulate used in a later small load carrier. This data can be combined with an appropriate dataset for emissions from electricity generation in the modelling.

Example: A logistics provider has collected data on the greenhouse gas emissions generated during the transport of raw materials for a subsequent pallet cage. This data can be directly included in the carbon footprint.

Recycled content or shares of renewable raw materials in materials, intermediates and transport packaging must be supported by certified proof of origin. Otherwise, it must be assumed in the lifecycle assessment that the materials, intermediates and transport packaging do not contain recycled content.

There are now many types of certifications that companies can request from their suppliers for different materials. Modellers should consult with their procurement department to see if a certification is recognised.

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Carbon footprints from suppliers

If third-party carbon footprints are available, the results should only be used if these carbon footprints have been critically reviewed.

In addition to process data and emissions data, existing carbon footprints may also be available and can be used as a basis for the company's own modelling of a carbon footprint. Carbon footprints for the production of raw materials, intermediates, or finished transport packaging may already exist if third parties in the packaging supply chain have calculated their own carbon footprints.

Information on the critical review of carbon footprints can be found in section 7.4.

For carbon footprints from suppliers, particular attention should be paid to whether

- *Renewable electricity is included,*
- *Materials from renewable sources are accounted for,*
- *Materials from recycling sources are included.*

In these three cases, it should be checked whether the requirements for recognising renewable electricity sources, renewable raw materials, or recycled content are met. If these requirements are not met, the results of the carbon footprints should not be used without appropriate adjustments.

Information on the recognition of renewable electricity sources can be found in section 3.5. If the requirements in carbon footprints from suppliers are not met, the corresponding data should be replaced with more conservative figures, if possible.

Example: A manufacturer of a plastic component provides a carbon footprint for it up to its factory gate (cradle-to-gate). The manufacturer states that only recycled granulate was used for extrusion, but this claim is not substantiated. The emissions associated with the granulate are also provided. A modeller can then use the data for the remaining emissions caused by the plastic processing at the supplier's site. However, the data for the production of the recycled plastic granulate is ignored. Instead, it is replaced with a generic dataset for primary plastic granulate.

When supplier carbon footprints are available, it must be checked whether their upstream supply chain has been fully accounted for (cradle-to-gate) or whether only specific segments of the upstream supply chain (gate-to-gate) have been considered.

If only certain segments of the upstream supply chain have been considered, the remaining sections must be supplemented in the company's own carbon footprint modelling.

Example: A steel manufacturer provides a carbon footprint that includes emissions from processing pig iron into finished steel. However, the emissions from the mine to the delivery of the pig iron are not included in the carbon footprint. Therefore, additional data must be added for this part, potentially from generic lifecycle inventory databases.

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Generic data for the manufacturing phase

If no primary data is available for relevant processes in the manufacturing phase, data from generic databases may also be used.

The generic data used should reflect the processes in the supply chain as accurately as possible.

If no information is available about a process for producing a raw material, a material or an intermediate product, data sets based on average data may also be used.

Section 5.4 provides information on lifecycle inventory databases that provide such generic data. As described in section 4.5, modellers must specify what proportion of the carbon footprint is based on generic data.

> Example: A manufacturer of a pallet cage knows how much steel he needs to produce it; ; however, the pallet cage manufacturer does not know where in the world the steel was produced or which manufacturing process was used. Then an average data set may be used that reflects the average world production of steel (with the shares of countries of origin, production processes, etc.).

5.2 Usage phase

5.2.1 Description of the usage phase

Processes and parameters to be considered in the usage phase

In the carbon footprint calculation of the usage phase of transport packaging, all relevant processes of its use must be considered. To ensure that the general cut-off rules are met, the ***following processes must be included:***

- *Transport from the production of the finished transport packaging to the place of first use*
- *Transport processes from the place of first use:*
    - *Vehicle operation processes*
    - *Processes for supplying energy to vehicles*
    - *Journeys with filled transport packaging*
    - *Trips with empty (reusable) transport packaging for refilling, processing or repair of transport packaging*
- *Processes for maintenance, repair and reprocessing of reusable packaging:*
    - *Packaging cleaning processes*
    - *Manufacture of spare parts*
    - *Electricity generation and other energy generation*

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When describing transport processes from the point of first use, at least ***the following parameters must be taken into account****:*

- *Distances*
- *Vehicle types*
- *Drive types*
- *Vehicle weights*
- *Capacity utilisation*
- *Share of empty journeys*

Carbon footprints of reusable packaging must also take the following parameters into account:

- *Either: cycle counts*
- *Or: their entire lifespan*
- *Or: their total transport distance across all reuses*

Capacity utilisation and empty run rates should be calculated as described in ISO 14083 (sections 7-9). Maybe the effort is too high?

The following processes*, which are not directly related to the usage phase of a transport packaging, must* ***not be taken into account****, including:*

- *Manufacture, maintenance, repair and disposal of vehicles*
- *Construction, operation, maintenance, repair and dismantling of transport infrastructure*
- *Trips that are not directly related to a transport order, including:*
  - *Trips to the petrol station, trips to charging stations*
  - *Trips to maintenance, repair of motor vehicles, vehicle inspections*
- *Production and supply of refrigerants*
- *Administrative processes of the companies involved in transport*
- *Commuting of staff*

The following processes *may* ***optionally be considered****:*

- *Transport processes from the place of first use:*
  - *Processes of operating equipment in logistics hubs*
  - *Processes for supplying energy to equipment in logistics hubs*
  - *Shunting*
  - *Starting and idling of vehicles*
  - *Starting and idling equipment in logistics hubs*
  - *Possible fuel leaks in vehicles or logistics hubs*

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    - *Possible leaks of refrigerants in vehicles or in logistics hubs*
- *Processes for maintenance, repair and reprocessing of reusable packaging:*
    - *Transport of spare parts to the reprocessing site*
    - *Waste treatment*
- *Transport processes at logistics hubs that precede, link or follow the above-mentioned types of transport:*
    - *Transport with forklifts*
    - *Transport with pallet truck*
    - *Further transports to logistics hubs*

If optional processes are included, it is important in the modelling process to ensure that results can also be calculated without taking these processes into account. This allows for comparability with carbon footprints where these optional processes were not included in the calculations. Including these optional processes may also be necessary to comply with standards other than ISO 14067. If modellers have this objective, they should check the respective standard to determine which processes must be included.

All types of transport for which the transport packaging in question is used must be accounted for:

- *Road transport*
- *Rail transport*
- *Air transport*
- *Shipping on inland waterways and seas*
- *Cable car transport*

5.2.2 Data collection and origin for the usage phase

Primary data for the usage phase

When available, primary data should be used for calculating the carbon footprint of packaging transport.

Relevant primary data for transport include:

- Distances covered (with filled transport packaging, with empty transport packaging)
- Consumption data for fuel or electricity
- Weights (of vehicles, transport packaging and the goods contained therein)
- Volume (of transport packaging)

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Generic data of the usage phase

If primary data for transport processes are not available, generic data may be used to account for transport emissions.

Recommendations for generic life cycle inventory databases can be found in section 5.4. There you will also find sources for literature values such as capacity utilisation, proportions of empty runs, etc.

Data for reusable packaging

Cycle counts, transport distances, or lifespan data for the entire usage phase of reusable packaging should be based on primary data.

If primary data are not available, assumptions based on literature values or other generic data can be used.

If neither primary nor generic data are available, the default values provided by the VDA may be used.

Table 3: Default values for the usage phase of reusable packaging

Type of packaging	Total useful life	Comments
KLT (plastic)	7 years	
GLT (plastic)	7 years	
GLT (steel)	14 years	
GLT (wood)	14 years	
Special load carriers (steel, PP, EPP)	5-10 years	At least one vehicle project run (retrofit approach / modular basic concept)

The default values were developed based on a survey among the industrial partners involved and are based on empirical values.

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5.3 End-of-life phase

5.3.1 Description of the end-of-life phase

End-of-life processes to be considered

When accounting for the end-of-life phase of a transport packaging, all relevant processes that follow the last use of the packaging must be considered.

If reusable packaging is repaired or refurbished between uses, these processes are part of the usage phase. Therefore, modellers should attribute them to the usage phase.

*All relevant end-of-life processes must be accounted for until the transport packaging is fully disposed of, or until, in the case of recycling, the "end of waste" status is achieved (see below). To ensure that general cut-off rules are met, the **following processes** must be **included** in the life cycle inventory:*

- *Processes of transport from the place of final use to waste treatment:*
  - *Direct transport from the final place of use to the place of waste treatment*
  - *if necessary, transport via collection points*
- *Waste pretreatment processes:*
  - *Reduction in packaging size if necessary*
  - *If necessary, cutting, shredding, other separation processes of individual packaging components*
  - *If necessary, sorting of different waste streams*
  - *If necessary, removal of impurities, floating*
  - *If necessary, further preliminary processes of waste treatment*
- *Waste treatment processes:*
  - *Complete treatment of emissions from waste treatment (gases, waste water, sludge, ash, leachate, etc.)*

*Processes that are not directly related to the end-of-life phase of a transport packaging must not be included in the life cycle inventory. The **following processes**, among others, should **not be considered**:*

- *Manufacture of waste disposal, recovery and recycling facilities, buildings, other capital goods and other infrastructure*
- *Administration*
- *Research and development*
- *Business travel and commuting of staff*

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***The following processes** may **optionally be considered**:*

- *Processes of transport from the place of final use to waste treatment:*
  - *Cleaning of vehicles if necessary*
- *Waste pretreatment processes:*
  - *If necessary, transport from the pre-treatment site to the waste treatment site*
- *Final disposal processes:*
  - *If necessary, transport from waste treatment to final disposal*

If optional processes are included, it is important in the modelling process to ensure that results can also be calculated without taking these processes into account. This allows for comparability with carbon footprints where these optional processes were not included in the calculations. These optional processes are sometimes necessary to ensure compliance with standards other than ISO 14067 (see section 2). If modellers have this objective, they should check the respective standard to determine which processes must be included.

Consideration of biodegradable materials

If materials are fundamentally biodegradable, it must be ensured that they are actually biodegraded in the current disposal process. If this is not the case, thermal recycling must be assumed.

Further information on biodegradable materials can be found in the appendix.

5.3.2 Data collection and origin in the end-of-life phase

Primary data for waste treatment

Whenever available, primary data should be used for the carbon footprint calculation of a packaging's end-of-life phase.

Primary data regarding the end-of-life stage of transport packaging can take various forms. On the one hand, life cycle inventory data may be available, i.e. data on processes, material and energy flows in waste treatment. This life cycle inventory data can then be used for modelling the carbon footprint.

Example: A waste management company provides information on the distance between the packaging's last point of use and the recycling facility.

Primary data may also consist of emission data from waste treatment companies.

Example: A thermal treatment plant operator provides measurements of emissions generated from burning a specific type of plastic.

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If electricity consumption data is available, it is essential to verify whether the electricity from renewable sources can be recognised as such.

Refer to chapter 3.5 for guidelines on the recognition of renewable energy sources.

Carbon footprints from waste management companies

If waste management companies have already provided carbon footprints for waste treatment or disposal, these results should only be used if they have undergone critical review.

For example, companies that handle packaging waste might have their own carbon footprint calculations for the treatment of transport packaging.

For details on critical review processes, refer to section 7.4.

Particular attention should be given to whether renewable electricity is accounted for in the waste management company's carbon footprint. If the criteria for recognising renewable energy are not met, then the carbon footprint results should not be used without necessary adjustments. If these requirements are not met, the results of the carbon footprints should not be used without appropriate adjustments.

Example: A waste management company provides a carbon footprint for the thermal treatment of a specific plastic used in transport packaging. The company claims to use only renewable electricity, but this is not substantiated. The amount of electricity required for the recycling processes is specified in the carbon footprint. A modeller can then use data on the other emissions caused by plastic recycling. The emissions from electricity consumption are deducted from the carbon footprint. Emissions from electricity consumption from non-renewable sources, which are obtained from a database, are added.

When carbon footprints from waste disposal processes are available, care must be taken to ensure that these calculations only include emissions up to the end of the waste status.

This prevents double-counting emissions from recycling. Criteria for determining when waste status ends are explained in section 3.4.3.

Data on waste treatment methods

If primary data is unavailable for waste treatment processes, collaboration with waste treatment providers is necessary to determine how packaging components are treated. Then a distinction should be made as to whether packaging components or materials

- *are recycled*
- *are thermally recycled*
- *are disposed of without material recycling or thermal recovery*

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If the proportions of each packaging component treated in different ways are known, generic data can be used for material recycling and thermal recovery processes up to the end of the waste status. Generic data for final disposal without recycling or thermal recovery can also be applied, which covers the processes leading up to landfilling.

Mixed approaches can also be considered when packaging components are treated differently at the end of their life.

Example: Identical cardboard inserts are sent to two locations: 30% to a facility in Wolfsburg and 70% to a plant in Stuttgart. There, the inserts are sent for waste treatment. In Wolfsburg, the inserts are fully recycled, while in Stuttgart, 50% are recycled and 50% are thermally treated. Accordingly, modellers could associate 65% of the waste with a generic dataset for recycling and 35% with a generic dataset for thermal treatment.

Fully generic scenarios

If no primary data is available for waste treatment processes and waste handlers cannot provide information on the proportions of materials recycled, thermally treated, or disposed of, fully generic scenarios must be used for modelling the packaging's end-of-life phase.

Scenarios for the end-of-life of transport packaging must describe assumptions as to what proportion of each component of packaging will be disposed of, utilised for energy recovery or recycled.

End-of-life scenarios should reflect the current market situation and be representative of the most likely alternatives. More than one scenario (including future ones) can also be assessed.

All assumptions must

- *be based on the best available information*
- *reflect current technologies*
- *be economically viable*
- *be legally permissible*

Modellers can base scenarios on official statistics, such as recycling and recovery rates for a material in the country where waste treatment occurs.

Example: In 2021, 35% of all plastics in Germany were recycled and 64% were recovered for energy. A modeller assessing a polypropylene small load carrier disposed of in Germany could assume that 35% is recycled and 64% is thermally treated.

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Digression: Synergies in data collection for the EU Packaging Directive

All three data collection methods mentioned above are permissible for carbon footprint calculations at the end of the packaging life cycle. Regardless of carbon footprint data collection, companies will also need to gather primary data to comply with reporting requirements under the upcoming EU Packaging Directive. For this, it will be necessary to track whether and in what proportions packaging is materially recycled, thermally recovered, or disposed of.

5.4 Generic life cycle inventory databases

Various databases are available to users for creating a Product Carbon Footprint (PCF), covered by different software providers. These databases offer comprehensive sources of environmental information on various products and services, enabling users to understand and assess the environmental impacts of their activities.

- **Data quality**: Depending on the database, over 20,000 datasets from various sources are included, covering a wide range of sectors on both global and regional levels. These datasets are regularly updated, sometimes annually.

- **Geographical coverage**: The databases typically provide global and country-specific average values for major products and services.

- **Life Cycle Assessment (LCA)**: Each dataset usually contains LCA results for multiple internationally recognised assessment methods (e.g., "IPCC 2021," "EF v3.1," or "ReCiPe") and corresponding impact categories (e.g., "Climate Change," "Human Toxicity," "Water Consumption," or "Land Use"). Depending on the provider, the database enables users to trace and understand the impacts of their products throughout the supply chain, with datasets broken down to their deepest level. However, with some providers, datasets are only shown at the highest aggregated level, limiting detailed insights into the upstream supply chain.

- **Access and support:** Access to the databases and the level of support from providers vary significantly. Typically, purchasing a license is required for database access. Depending on the provider, the data can be retrieved via specialised third-party LCA software or through the provider's specific online portal. Some providers also offer the ability to combine multiple databases within a single software (for a fee). In some cases, technical documentation, training and direct support are also offered to the users of the database.

In addition to paid providers, LCA practitioners have access to other databases that are sometimes available free of charge. However, such databases often have significantly less coverage and are updated less frequently, including fewer environmental impact categories. Additionally, smaller, industry-specific databases are often integrated into other larger databases. Alternatively, datasets from other databases can be used, provided they meet the data quality requirements.

When using multiple databases, users must ensure that the modelling approaches are consistent across datasets. In general, it is recommended to use as few databases as

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possible. Data from upstream processes that do not follow the principles of this guide must be clearly identified and justified.

Application examples

For packaging production, the materials used, as well as the manufacturing and processing processes, need to be modelled. These include:

- Plastics and plastics processing
- Wood, cardboard and paper, manufactured using processes from the forestry and paper industries; whose processing is carried out by punching, screwing or gluing
- Metals; manufactured in the metal industry; and whose further processing is carried out by welding and screwing

If no datasets are available for a precursor product, it must be modelled through its raw materials and production processes.

The electricity required for further material processing can be accounted for using generic data from the energy carriers used. These data must be reflected in the International Energy Agency (IEA) statistics.

Transport

The transport is calculated based on the recommendation VDA-ECG (2023): "Emissions calculation and reporting guideline for automotive supply chains". Reference is made to the data sources contained therein.

Selected transport packaging, materials and manufacturing processes

The following examples list relevant materials and processes, though they are not exhaustive, nor do they replace the need for assessing data quality.

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Table 4: Transport packaging, its materials and manufacturing processes

Sample packaging	Materials	Processes
4500 Small load carriers	Co-polymeric polypro- pylene	Thermoforming Injection moulding
4503 Standardised load carrier	HD polyethylene	Thermoforming Injection moulding
4520 Large load carrier	POM	Thermoforming Injection moulding
4525 Standardised single-use packag- ing for sea containers application	Corrugated cardboard	Corrugated paper produc- tion Punching
4530 Single-use small load carriers	Corrugated cardboard	Corrugated paper produc- tion Punching
4540 Specification of corrugated fibre- board packaging	Corrugated cardboard	Corrugated paper produc- tion Punching
Pallet cages	Galvanised steel	Welded Screwed Milling
Wooden boxes	Wooden boards	Nailed
Tray (pallet and cover)	ABS, ABSr, ABS/TPU	Thermoforming Injection moulding
Inlay	EPP	EPP foamed Waterjet cut Milled
Steel sheets	Galvanised steel	Welded Screwed
Bags, foils	LDPE with VCI agent□ LDPE with ESD pro- tection	(Blown) film extrusion
Tray, single-use	PET; PP	Thermoforming Injection moulding
Aluminium composite	Aluminium	Film extrusion
Hollow chamber panels	PP	Extruded Punched
Wooden box	Wood	Sawn Screwed
Edge protection made of solid card- board	Corrugated cardboard	Corrugated paper produc- tion
Strapping bands	PE, PET, LPDE, rLDPE	Extrusion
Aluminium composite	AL/LDPE Desiccant	Film extrusion

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In the following figure, the defined processes illustrate which processes are recommended for using database data. After collecting primary data, these can be supplemented or represented by secondary data from datasets.

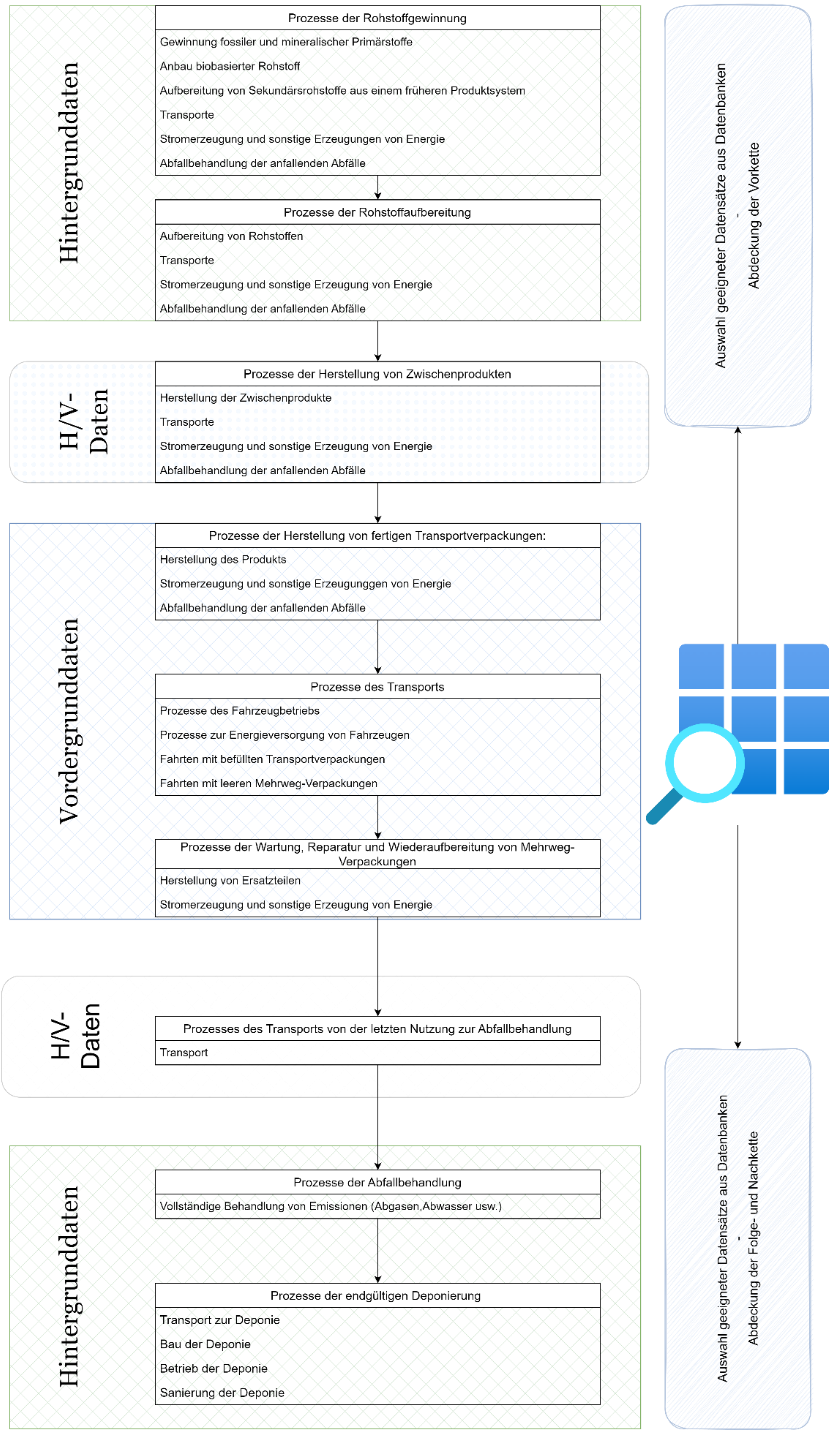

Figure 1: Processes in the life cycle of transport packaging

6 Impact assessment

In the previous step, the life cycle inventory analysis (see section 5), all relevant mass and energy flows in the product life cycle of a transport packaging were determined. In the impact assessment, emission factors are now assigned to these flows to determine their climate impact.

6.1 Impact assessment of greenhouse gas accounting

Fundamentals

Calculations of the carbon footprints must be carried out using the static approach.

All greenhouse gas (GHG) amounts for the entire product lifecycle must be calculated as if they were released or sequestered simultaneously at the beginning of the assessment period. This static approach is typically used in carbon accounting software in practice. Other "dynamic" approaches are still under research and are not yet sufficiently developed; therefore, they should not be used.

Example: A pallet cage is recycled 14 years after its production. However, the calculation assumes that emissions from production and recycling occur at the same time.

Carbon footprints for transport packaging must be determined using the attributional approach.

In the attributional approach, greenhouse gases are assigned directly to a product. This is standard practice. Other "consequential" approaches, which assess the future impacts of decisions, are not yet widespread in practice and should not be used.

Example: A carbon accounting database offers data sets to calculate the extrusion of a packaging film either "consequentially" or "attributively." In this case, the data set following the attributional approach should be chosen.

In addition to the total value of greenhouse gas emissions along the lifecycle of a logistics packaging, the following GHG values must also be calculated separately:

- *The absolute and relative contributions of each lifecycle stage (production, use and end-of-life);*
- *The GHG emissions from aviation.*

All values must be calculated relative to the functional unit.

A categorisation of which contributions each of the three life cycle stages comprises can be found in section 5 of this recommendation. Once the lifecycle of a transport packaging is fully modelled and the carbon footprint is calculated, further (partial) results can also be determined using standard software applications without additional modelling work.

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Example: For a reusable pallet, a complete life cycle has been modelled and the overall carbon footprint result is available. It is then also possible to determine what portion of the total emissions is attributable to air transport. Re-modelling is not necessary.

Characterisation factors

GWP100 characterisation factors should be derived from the most recent assessment report of the Intergovernmental Panel on Climate Change (IPCC).

When greenhouse gases are released into the atmosphere, the Global Warming Potential (GWP) serves as a conversion factor to indicate how much the released gas contributes to climate change compared to the same amount of CO_2. These conversion factors are also referred to as “characterisation factors.” The IPCC provides practitioners with generally accepted values that are already included in carbon footprint software. As of Winter 2023, the characterisation factors from the 6th Assessment Report (IPCC 2021) should be used. The IPCC characterisation factors are usually also found in impact assessment methods developed by third parties, such as EF3.1 or ReCiPe.

The greenhouse gases that must be considered include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorinated compounds, sulphur hexafluoride (SF_6), nitrogen trifluoride (NF_3), perfluorocarbons (PFCs), hydrofluorolethers (HFEs), perfluoropolyethers (PFPEs), chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs).

The literature source for the characterisation factors must be clearly indicated and used consistently.

In practice, modellers can select in all common software solutions that the impact assessment should follow IPCC 2021 All mentioned greenhouse gases will then be included. The IPCC 2021 can also be cited as the literature source.

Impact assessment for biogenic carbon, land use change

Greenhouse gas amounts emitted and sequestered from biogenic materials must be included in the carbon footprint and reported separately.

The sequestration of CO_2 through incorporation into biomass should be characterised in the assessment as −1 kg CO_2-eq./kg CO_2 in the calculation

Emissions of biogenic CO must be characterised as +1 kg CO_2 -eq./kg CO_2 of biogenic carbon in the calculation.

Known information on the biogenic carbon content in raw materials, materials and transport packaging must be provided.

Biogenic carbon is always found when transport packaging is bio-based, i.e. materials made from renewable raw materials are used. Throughout the life cycle, the contained biogenic

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carbon is CO_2-neutral − unlike carbon from fossil-based sources. At the same time, it is not always apparent whether a material is derived from renewable or fossil resources. Therefore, it is important that bio-based carbon is always calculated and reported as such – especially when others might use the results for further calculations.

Example: The polypropylene of a small load carrier was made from corn starch; it is visually indistinguishable from a KLT made from fossil-based polypropylene. It contains cardboard inserts. To account for the fact that the polypropylene contains CO_2-neutral carbon, its origin must be known. Even for clearly bio-based materials, such as cardboard, it must be known how much CO_2-neutral carbon they contain for a carbon footprint.

The emitted and sequestered greenhouse gas amounts resulting from direct land use changes (dLUC) must be calculated and included in the carbon footprint in accordance with internationally recognised procedures, such as the guidelines from the IPCC on national inventory reports.

Emitted and sequestered greenhouse gas net amounts associated with direct land use changes must be reported separately.

Indirect land use changes do not need to be reported.

Increased land management can be responsible for greenhouse gases being released from the soil into the atmosphere, particularly through agriculture. Since these emissions can be very high, they must be reported separately. If the life cycle of a transport packaging is fully modelled in common software and the carbon footprint is calculated, this information can also be reported. without additional modelling work.

GHG offsets

Certificates for GHG offsets for products (product carbon offsets) should not be considered in the calculation of carbon footprints for transport packaging.

This must be considered in the calculation of one’s own carbon footprints. If one’s calculations are based on the carbon footprints of others, it is important to check if their results include GHG offsets. This is particularly relevant for so-called “CO_2-neutral” or “climate-neutral” materials that were not derived from renewable resources.

Example: An OEM wants to determine the carbon footprint of its pallet cages. According to the manufacturer, the steel used in these boxes is “completely CO_2 neutral.” Currently, this is only possible through offsets. For the steel, it should be inquired what its carbon footprint would be without offsetting.

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6.2 Additional types of impact assessment

In addition to assessing carbon footprints, other environmental impact categories may also be calculated and reported.

The focus of this recommendation is on carbon footprint accounting. At the same time, users of this recommendation are free to supplement their calculations and models with impact assessments of additional environmental categories, such as water usage. Many carbon footprint software solutions also provide the capability to calculate other environmental impacts without additional effort.

Practitioners should verify if other environmental impact categories need to be considered when a transport packaging contains materials from renewable resources.

It may be advisable not to focus solely on climate impact. When optimising transport packaging for greater sustainability, care should be taken to avoid "burden shifting," where improving the carbon footprint of transport packaging results in other environmental problems. In the context of logistics packaging, burden shifting is especially relevant when using bio-based materials (see Appendix).

Example: Bio-based polypropylene often has lower carbon footprints compared to fossil-based polypropylene. However, bio-based plastics frequently come with higher environmental impacts in terms of water usage, biodiversity loss, eutrophication and other environmental categories.

If additional impact assessments beyond climate change are conducted, their calculation should be based on internationally recognised standards or, at a minimum, on methods that are transparent and developed according to scientific criteria. The methods used should always be clearly and transparently reported.

Typically, impact assessment methods available in carbon footprint calculation software adhere to these standards. However, modellers should ensure that outdated impact assessment methods, which may still be included in software, are not used.

When considering additional environmental impact categories alongside climate impact, it should always be specified whether and how the different categories are related.

For example, modellers should indicate if multiple results for a transport packaging represent different aspects of water usage.

In addition to impact categories related to carbon footprints and life cycle assessments, other environmental indicators that do not fall under the narrower definition of impact categories can also be determined. It should be clear that these are not impact assessments in the sense of a life cycle assessment.

Information necessary for creating a carbon footprint can also be relevant independently of the carbon footprint itself. Practitioners can then leverage synergy effects.

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Example: To determine the carbon footprint of a packaging film, it must be known whether it is made entirely or partially from recycled plastic. Information about the recycling content can also be relevant for reporting obligations under the EU Packaging Regulation.

7 Presentation and communication of results

7.1 Basics of presentation and communication

The presentation and communication of results must be verifiable, accurate, relevant and non-misleading. Therefore, it must adhere to the principles and requirements of ISO 14020.

Further provisions can be found in the ISO 14020:2022-12 standard.

The results of carbon footprints for transport packaging must be expressed in CO_2 equivalents.

These results should be presented relative to the functional unit.

In carbon footprint software solutions, this is usually done automatically. More details about the functional unit can be found in section 3.1 of this recommendation.

In addition to the total carbon footprint result, results for the individual stages of the life cycle should also be provided. These stages are distinguished as production, use and end-of-life. Results for individual processes within these life cycle stages may also be reported.

A precise delineation of which processes belong to these three phases can be found in section 5.

In addition to presenting results in CO_2 equivalents, results may also be displayed in other formats to illustrate and contextualize them.

Alternative presentation forms can help to interpret information more clearly without distorting the data. This is especially useful when only the absolute value of a carbon footprint is known, without direct comparison to other carbon footprints.

Example: The carbon footprint of a transport packaging can be compared to the annual carbon footprint of an average person, known as "per capita values." For instance, a person living in Germany in 2021 had an average emission of 11.2 tons of CO_2-equivalent. If all KLTs (small load carriers) used in a supply chain for a component together emit 28 tons of CO_2-equivalent, this corresponds to 2.5 per capita values.

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7.2 Report template

If reports on the carbon footprint of transport packaging are published, they must include the following:

- *Title page*
- *Result of the carbon footprint*
- *Basic packaging information*
- *Information on determining the carbon footprint*
- *Literature and data sources*

If relevant, the following information must also be included:

- *Differences from previous report versions*

Additionally, the following information may be included:

- *Environmental information in addition to the carbon footprint*

What exactly the above report sections contain is shown below:

Title page

The title page must contain:

- *Clear designation of the transport packaging*
- *Picture(s) of the transport packaging*
- *If it is a transport packaging that complies with a VDA recommendation for transport packaging: VDA recommendation with which the packaging conforms*
- *Date of creation of the carbon footprint*
- *Critical reviewer, date of critical review*
- *Address and contact information for the publisher of the carbon footprint*
- *If applicable, revision date, report version*

Result of the carbon footprint

Information on the outcome of the packaging's carbon footprint must include:

- *Overall carbon footprint result*

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- *If the carbon footprint assessment also included processes that did not necessarily have to be included: Overall result of the carbon footprint without taking into account optional processes*
- *If GHG emissions originate from aviation: the quantities of GHG emitted from aviation*
- *If GHG quantities were removed or emitted from biogenic sources: the GHG quantities removed and emitted from biogenic sources*
- *If land use change has occurred: the amounts of GHG emitted and removed that have occurred as a result of direct land use change (dLUC)*
- *Absolute and relative results of the carbon footprint for the individual stages along the life cycle:*
    - *For cradle-to-grave carbon footprints: Results for the life cycle phases production, use and end of life*
    - *For cradle-to-grave carbon footprints: Results for the manufacturing life cycle phase*

Information on the outcome of the packaging's carbon footprint may additionally include:

- *Results of the carbon footprint for individual processes along the life cycle*

Section 5 defined which processes along the life cycle of a transport packaging must necessarily be included in the carbon footprint. If modellers have included additional processes, it is important to also report the result without their emissions to ensure comparability.

For information on GHG emissions from aviation; on biogenic GHG emissions; on GHG emissions from land use change, see section 6 of this recommendation. For a definition of which emissions are to be allocated to which life cycle stages, see section 5.

Basic packaging information

Packaging information must include:

- *Identification by name, by VDA standards or other standards or classifications*
- *Description of the transport packaging, its application, intended use and technical functions, including:*
    - *External dimensions [mm]*
    - *Internal volume [l], internal dimensions of the transport packaging (mm)*
    - *Tare weight (without load) [kg]*
    - *Maximum load per transport packaging*
    - *Foldable*
    - *Internal volume of the transport packaging (l),*

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  - *Packing density [kg/l]*
  - *Stacking values (e.g. results of the stacking test according to ISO 12048)*
  - *Typical application area in the automotive sector (e.g. series production; aftersales; CKD; development)*
- *For reusable packaging: Lifespan in years, or information on the number of cycles, or the total transport distance travelled until final disposal*
- *Information on materials used must include:*
  - *List of materials and chemical substances used in the packaging, including information on their environmental and hazardous properties*
  - *If applicable, information on the biogenic carbon content in the transport packaging*
  - *If applicable, information on recycled materials in the packaging*

Information on the hazardous properties of materials and chemical substances should comply with the requirements of the latest revision of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS).

Information on determining the carbon footprint

Information for determining the carbon footprint must include:

- *Geographical scope, i.e. for which locations the production, use and end of life of the transport packaging were accounted for*
- *Functional unit*
- *System diagram of the processes included in the life cycle assessment, divided into the life cycle phases of production phase, use phase and end of life phase*
- *Indication of whether the system boundary is cradle-to-gate or cradle-to-grave*
- *If applicable, information about which life stages are not taken into account, with a reason for their omission*
- *If the end of life of the transport packaging was also calculated when creating the carbon footprint, the following information should be provided:*
  - *Materials for recycling (in kg per functional unit)*
  - *Components for reuse (in kg per functional unit)*
  - *Materials for energy recovery (in kg per functional unit)*
  - *Non-hazardous waste disposed of (in kg per functional unit)*
  - *Hazardous substances disposed of (in kg per functional unit)*

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  - *Information on recycling, including appropriate procedures for recycling the whole product or selected parts*
  - *Information on an appropriate method for reusing the product (or parts of the product) and procedures for disposal as waste*
- *Indication of the year or years covered by the data used for the calculation*
- *Indication of the "Data Quality Rating"*
- *Specifying the "Primary Data Share"*
- *Information on the critical review including review statement*
- *For basic assumptions and specifications for calculating the carbon footprint (on allocation, cut-off rules, etc.): Reference to this recommendation*
- *if applicable, address and contact information of the organisation that calculated the carbon footprint – if this calculating organisation is not the same as the publisher*

Information on the geographical scope, the functional unit and the system boundaries can be found in chapter 3 of this recommendation; information on data quality is provided in section 4.2; notes on critical review can be found in section 7.4.

Literature and data sources

Information on literature sources or data sources must include the following:

- *List of sources used*
- *Reference to the life cycle inventory database(s) for generic data and LCA software used, if relevant*
- *Source of the characterisation factors of CO_2 emissions*

Recommendations for the use of life cycle inventory databases are given in section 5.4. For sources of characterisation factors, see section 6 of the recommendation.

Differences from previous report versions

Updated carbon footprints must also include the following information:

- *Description of differences from previous versions*
- *If the update affects the specified results (see above):*
  - *Description of the percentage change in results*
  - *Reason for the update*

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Environmental information in addition to the carbon footprint

In addition to the carbon footprint results, the following environmental information may be included:

- *Life cycle assessment results for other environmental impact categories besides contribution to climate change*
- *Other environmental indicators*

Information on what needs to be considered for other environmental impact categories can be found in section 6.2.

7.3 Language and units

Language

Packaging carbon footprint results reports should be written in German or English. If reports are written in other languages, a summary should be available in German or English.

Units

For units and quantities, the following requirements should be met for harmonisation:

- *In principle, the International System of Units (SI units) must be used. The following exceptions apply:*
    - *Energy use should be expressed in kilowatt hours (kWh) or megajoules (MJ)*
    - *Water consumption should be expressed in cubic metres (m^3)*
    - *Temperature should be expressed in degrees Celsius (°C)*
    - *Time should be expressed in the most practical units (seconds, minutes, hours, days or years)*
- *The decimal point must be in SI style (French version, decimal comma)*
- *The dates and times specified should be in the format specified in ISO 8601*
- *The following should be taken into account when looking at results and result tables:*
    - *Use “0” only for parameters calculated as zero*
    - *If a value was not calculated, it is marked with “na” (“not available”)*
    - *No blank cells, hyphens, less than or greater than signs, or letters (except “na”).*
- *Footnotes should be used to explain any limitations on the result value.*

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SI units include kilograms (kg), joules (J) and meters (m). To improve readability, meaningful multiples of SI units can be chosen, for example megajoules (MJ).

For dates, the prescribed format according to ISO 8601:2019 is YYYY-MM-DD, e.g. 2023-12-06 for 6 December 2023.

7.4 Review process

Fundamentals

Carbon footprints intended for external reporting must undergo a critical review. Carbon footprints created solely for internal purposes should also be critically reviewed. A critical review according to ISO/TS 14071 is sufficient for this purpose. Verification and validation under ISO 14064-3 are not required.

The critical review is intended to ensure that:

- *The procedures used in conducting the carbon footprint assessment comply with the ISO 14067 standard.*
- *The methods used are scientifically sound and technically valid.*
- *The data used are sufficient and appropriate for the study's objective.*
- *The evaluations take the objectives of the carbon footprint assessment into account.*
- *The result report is transparent and internally consistent.*

Reviewing compliance with ISO 14067 is typically an iterative process. If reviewers cannot immediately confirm compliance with ISO 14067, the modellers should consult with them. Reviewers can then provide insight into how much additional effort is required to achieve compliance or whether it is realistic to expect compliance under the given circumstances.

Should the critical review also ensure compliance with other standards and norms, the requirements of these standards must also be considered.

An overview of relevant standards is provided in chapter 2. Many of these standards also contain more detailed instructions on how the review should be conducted.

The critical review should address all aspects of a packaging carbon footprint, including the adequacy and appropriateness of the data, calculation procedures, inventory, impact assessment methodologies, characterisation factors, the calculated inventory and the inventory results as well as the interpretation.

A critical review should also include an evaluation of data quality and individual datasets.

A procedure for determining data quality is described in section 4.4.

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A critical review can be conducted by one or more internal or external independent reviewers or by a committee of reviewers according to ISO 14044:2006, sections 6.2 and 6.3. If it is a comparative carbon footprint intended for publication, the critical review must be conducted by a committee of reviewers.

Neither external nor internal reviewers may be involved in the creation of the carbon footprint under review.

The critical review may be conducted alongside the creation of a carbon footprint or at the end.

If the critical review is conducted concurrently, particular attention should be paid to ensuring that the reviewers are solely tasked with the review, not with creation or advisory roles.

Requirements for reviewers

Reviewers must be familiar with the requirements of life cycle assessments according to ISO 14040 and ISO 14044 and possess suitable scientific or technical expertise. Reviewers must be familiar with the requirements for creating carbon footprints according to ISO 14067. If reviewers are tasked with verifying compliance with additional standards and norms, they must also be familiar with these accordingly.

The accounting standards in addition to ISO 14040/14044 and ISO 14067 (see chapter 2) may contain additional requirements for reviewers. Information about these can be found in the respective standards.

Reviewers must have knowledge and expertise in the following areas:

- *Methodology and current practice of carbon accounting, particularly in the context of a life cycle inventory (including dataset creation and dataset review)*
- *The practice of critical review*
- *The scientific disciplines relevant to the environmental impact categories of the study*
- *Environmental, technical and other relevant performance aspects of the investigated product system(s)*
- *The language used in the study*

In the case of carbon accounting for transport packaging, reviewers should not only be knowledgeable about carbon accounting but also about transport packaging. Modellers should ensure, before awarding the review contract, that this is the case.

Reviewers should not subcontract or delegate their work.

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Carbon footprint modellers should ensure that their contact person performs the review themselves. Creators of carbon footprints should have this assured when awarding the review contract.

Verification statement

A successful review must be confirmed by a verification statement.

A verification statement must include:

- *The title of the carbon accounting*
- *The client of the carbon footprint*
- *The creator of the carbon footprint*
- *The reviewer or, in the case of a review by a committee, the committee members, including identification of the committee chairperson*
- *A description of the review process, including information on:*
    - *Whether the review was conducted by individual external reviewers or by a committee of reviewers*
    - *Whether the review was conducted concurrently with or at the end of the study*
    - *Whether the review included an analysis of individual datasets*
- *A description of how comments were provided, discussed and implemented*
- *A statement on the outcome of the critical review, i.e., whether the study was found to be in compliance with the reviewed standards (ISO 14067, others)*

The verification statement must be attached to the results of the carbon accounting.

Reviewers must sign the verification statement.

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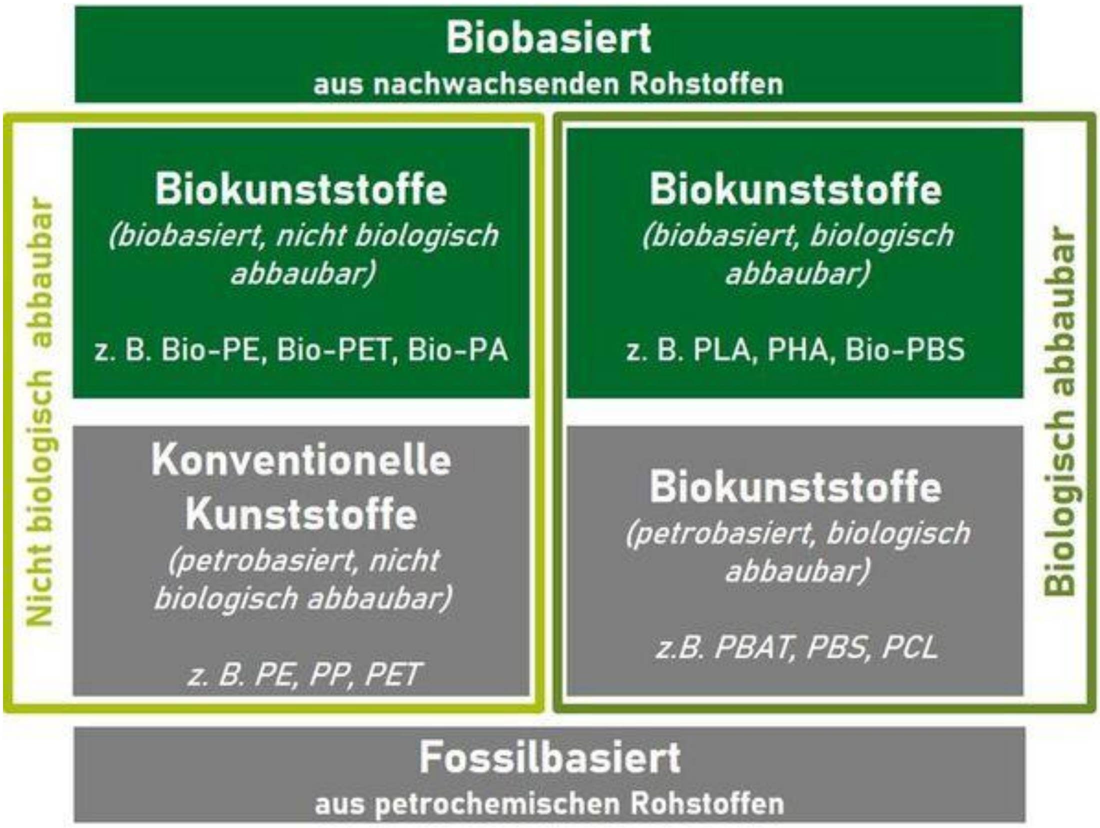
Appendix

Bio-based and biodegradable materials

Definition: Bio-based materials are materials derived from renewable resources.

Definition: Biodegradable materials are those that can be broken down by microorganism.

For bio-based materials, their production is crucial, whereas for biodegradable materials, their end-of-life is important. Bio-based materials do not necessarily have to be biodegradable, for example, bio-polyethylene made from corn starch. Conversely, biodegradable materials do not necessarily have to be made from bio-based materials, for example, biodegradable PBAT, a plastic made from fossil resources.



(Source: IfBB Institute for Bioplastics and Biocomposites, Hannover University of Applied Sciences)

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