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Methodology of Barry Callebaut's Corporate Carbon Footprint - Summary

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1 Introduction

The following text summarizes the most important methods and data sources used for calculating Barry Callebaut's corporate and product carbon footprint data. On a corporate level, results are calculated for every fiscal year in tCO_2e (September to August). On a product level, the carbon footprint can be calculated for any given recipe. Calculations on a product level are built on the same methods and data sources as the corporate carbon footprint model, but they aggregate numbers per kg for each specific ingredient needed for a certain product, instead of summing up absolute numbers for a fiscal year.

2 System boundaries

General methodical guidelines applied are the Organisational Environmental Footprint (OEF) and the Product Environmental Footprint (PEF) guidelines of the European Commission[1], as well as the GHG Protocol methodology[2]. Therefore, the system boundaries ("reporting boundaries" according to ISO_14064-1 2019) are "cradle to gate of customer" and include scopes 1, 2, and 3. This means that the corporate carbon footprint covers all processes involved in the life-cycle of the production of all products of Barry Callebaut. In this system, the processes within organisational boundaries (operated/controlled by Barry Callebaut[3] [ISO_14064-1 2019]) can be differentiated from all other upstream and downstream processes (see Figure 1 below):

Within organisational boundaries

- Barry Callebaut's cocoa factories, chocolate factories, and specialty factories
- Intercompany transports of products (cocoa products and industrial chocolate) as well as transports of products to customers, in trucks owned by Barry Callebaut[4]
- Office energy in headquarters in Zurich, Chicago, and Singapore, plus business flights booked by these headquarters

Upstream value chain within reporting boundaries

- Cocoa farming, including impacts of land use change (LUC)
- Production of non-cocoa ingredients (sugar, dairy, oils and fats, nuts and specialties etc.), including impacts of LUC
- Transport of cocoa beans, cocoa products, non-cocoa ingredients, and chocolate products, including transport of products in between Barry Callebaut's factories (organised by Barry Callebaut, but not in vehicles owned by Barry Callebaut)
- Processes to extract, refine, and deliver raw materials, fuels, and electricity
- Production of packaging for cocoa beans, cocoa products, non-cocoa ingredients, and industrial chocolate

Downstream value chain within reporting boundaries

- Transport of products (cocoa products and industrial chocolate) to customers, which are organised by external parties

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013H0179
[2] https://ghgprotocol.org/standards
[3] In FY 22/23, financial and carbon reporting refer to the same scope of factories, except for one new factory, producing 18 t (= 0.0008 % of total production of final products), which is included in financial reporting, but not considered in carbon footprint reporting
[4] Currently only 1 % of total truck shipment is done via Barry Callebaut owned trucks.

- Recovery and disposal of packaging used for cocoa beans, ingredients, cocoa products and industrial chocolate

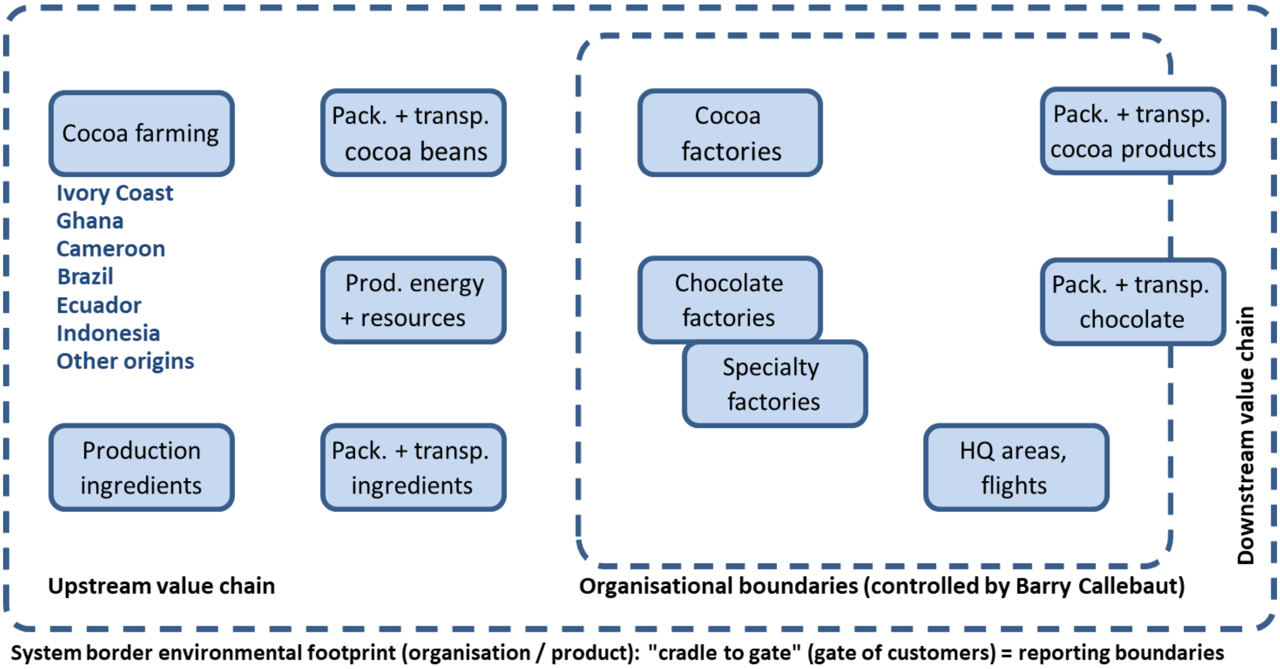

Figure 1: Investigated system showing included processes of the cocoa and chocolate value chain. Abbreviations: Packaging and transport (Pack. + transp.), Production (Prod.), headquarters (HQ). Transports of cocoa and chocolate products to customers are partly organised by external parties; these are therefore part of the downstream value chain.

Differentiation between emissions in scope 1, 2, and 3; coverage within scopes

Since fiscal year 22/23 the corporate carbon footprint (CCF) reporting has been split into emissions generated in scopes 1, 2, and 3, as defined in the GHG protocol. In fiscal year 22/23, 1.3 % of total CCF emissions were generated in Scope 1, 1.9 % in Scope 2 (market-based approach), and 96.8 % in scope 3.

In the current version of the CCF, the majority of quantified scope 1 and 2 emissions relate to energy consumption from Barry Callebaut factories, with the very small addition via energy consumption in three headquarter offices[5]. Where not attached to a factory or head office, energy relating to chocolate academies, beverage academies, innovation centres and all other sales and distribution centres are excluded.

Scope 1 emissions

- Factories: Fossil fuels consumed in factories, natural gas and a small amount of fuel oil
- Office Footprint: Office heating in the headquarters in Zurich, Chicago, and Singapore

Note that approximately 1% of total truck shipment is done via Barry Callebaut owned trucks; this small portion is currently not separated from the scope 3 category "upstream transport", and therefore excluded from scope 1. Further, fugitive emissions from refrigerants are currently considered non-significant in the scope 1 emissions, and therefore excluded from our scope 1 reporting.

[5] In FY 22/23 a conservative estimation of the carbon footprint of office areas resulted in 0.01 % of the total CCF, or 0.3 % of total scope 1+2 emissions.

Scope 2 emissions

- Factories: Consumption of purchased electricity and imported steam consumed in factories
- Office Footprint: Consumption of purchased electricity in the headquarters in Zurich, Chicago, and Singapore

Scope 2 emissions are calculated under both the location-based method and also the market-based method. Further detail on the emission factors applied is set out in section 4 of this document.

Scope 3 emissions

- Purchased goods & services (Category 3.1 in the GHG protocol): Cocoa Farming, Packaging Cocoa Beans, Packaging Cocoa Products, Packaging Non-Cocoa Ingredients, Packaging Chocolate, Purchased Cocoa Products, Purchased Non-Cocoa Ingredients (Sugar, Milk, Other Dairy, Oils & Fats and Other Non-Cocoa Ingredients), Cocoa Farming LUC, Purchased Cocoa LUC, Non-Cocoa LUC; Factory Water Consumption)
- Fuel and energy-related activities not included in scope 1 or scope 2 (Category 3.3): Factory Energy Consumption
- Upstream transportation and distribution (Category 3.4): Transportation of Cocoa Beans, Transportation of Chocolate, Transportation of Cocoa Products, Transportation of Non-Cocoa Ingredients
- Waste generated in operations (Category 3.5): Cocoa Bean Shells; Packaging Cocoa Products, Packaging Non-Cocoa Ingredients
- Business Travel (Category 3.6): Business air travel booked by those in the headquarters of Zurich, Chicago, and Singapore
- End-of-life treatment of sold products (Category 3.12): Packaging of Chocolate Products

Scope 3 emissions are by far the most relevant contribution for the overall CCF (approx. 97 % in FY 22/23). Within quantified scope 3 emissions, purchased goods contribute 91 % of the overall figure, and upstream transport and distribution 8 %. Further, minor contributions within scope 3 emissions include fuels and energy related activities (not included in scope 1 or scope 2), end-of life treatment of sold products, business air-travel and waste generated in operations.

Scope 3 emissions, which are currently not quantified (assumed to be non-significant in comparison with the huge amount of resources and products flowing through the investigated system, or not quantified because of lacking data for downstream activities) are: capital goods (category 3.2), business travel beside air-travel (category 3.6), employee commuting (category 3.7), upstream leased assets (category 3.8), downstream transportation and distribution (category 3.9), processing of sold products (category 3.10), use of sold products (category 3.11), downstream leased assets (category 3.13), franchises (category 3.14), and investments (category 3.15).

Relevance of activities/processes in the value chain

In Table 1 the investigated activities (here called processes) in the cocoa and chocolate value chain are grouped according to their relevance for Barry Callebaut's corporate carbon footprint.

Relevance of processes in the value chain for Barry Callebaut's corporate carbon footprint (sorted by relative contribution of each process to total corporate carbon footprint)		
High contribution	**> 25 %**	**Cocoa farming LUC, Dairy production**
Medium contribution	**5 – 25 %**	Non-cocoa ingredients production beside dairy, transports, cocoa farming, production of purchased cocoa products
Low contribution	**0.5 – 5 %**	Non-cocoa ingredients LUC, processing in factories of Barry Callebaut, packaging production
Negligible	**< 0.5 %**	Offices (office energy & business flights)

Table 1: Relevance of processes in the value chain for Barry Callebaut's corporate carbon footprint, sorted by relative contribution to total corporate carbon footprint.

3 Primary data inputs from Barry Callebaut

Basic data inputs to calculate the corporate carbon footprint are provided by Barry Callebaut annually for the respective fiscal year (FY): Volumes processed and produced (cocoa beans by sourcing countries, purchased cocoa products, non-cocoa ingredients split into dozens of sub-categories), data on energy and water consumption in all factories of Barry Callebaut (including data on supplier-specific electricity mixes), data on recovery routes for cocoa bean shells, and data on transport. Due to their minor relevance in the total corporate carbon footprint, the data on packaging, office energy, and air travel are only updated every five years or when the basic activity data increases or decreases by more than 50 %.

Based on these inputs, a detailed input-output mass balance is established. Volumes and energy data of new factories are included in the corporate carbon footprint if data on sold products of these factories are included as well. The input-output mass balance is the basis of all further corporate carbon footprint calculations, while specific recipes are the basis for product carbon footprint calculations. Further detail on the data sources used for all aforementioned inputs can be found in Section 4 below.

4 Carbon footprint methodology and databases/references

Scope 1

4.1 Factories, Scope 1

Data on energy consumption in Barry Callebaut's factories (gas, fuel oil, cocoa bean shells, wood chips) are converted to GHG emissions by using CO_2e factors covering scope 1. Reference databases are Ecoinvent version 3.4 and IEA 2016 (International Energy Agency). Emission factors for natural gas used in Europe and for natural gas used in "rest of world" are applied.

4.2 Office Footprint

Office heating GWP in the headquarters in Zurich, Chicago, and Singapore is calculated from office areas and typical heating energy per m^2, here modelled as heat from gas, based on Ecoinvent 3.4 emission factors.

Scope 2

4.3 Factories, Scope 2

Data on energy consumption in Barry Callebaut's factories (electricity and externally produced steam) are converted to GHG emissions by using CO_2e factors covering scope 2. Reference databases are Ecoinvent version 3.4 and IEA 2016 (International Energy Agency).

For factories in a liberalised electricity market, specific residual energy mixes are used to calculate site-specific CO_2e factors for electricity (market-based approach). For the location-based approach, country specific electricity mix datasets are used to calculate scope 2 emissions.

4.4 Office Footprint

Office electricity GWP in the headquarters in Zurich, Chicago, and Singapore is calculated from office areas and typical electricity consumption per m^2 of office area, based on Ecoinvent 3.4 emission factors.

Scope 3

4.5 Land use change (LUC) related to processed cocoa beans and purchased cocoa products

Currently LUC (i.e., impacts of deforestation[6]) related to cocoa farming is – together with impacts of dairy – the most relevant share within the total corporate carbon footprint of Barry Callebaut. LUC impacts are calculated for the main six cocoa sourcing countries (Côte d'Ivoire, Ghana, Cameroon, Indonesia, Ecuador, and Brazil), covering 88 % (fiscal year 22/23) of sourced cocoa beans. LUC impacts for remaining sourcing countries are extrapolated, based on the weighted average of these main sourcing origins.

Direct LUC (dLUC) impact is quantified for directly sourced volumes from Côte d'Ivoire, Ghana, Cameroon, and Indonesia, covering approx. 40 % of total sourcing. Net carbon losses due to cocoa farming are quantified based on an overlay of satellite data (Global Forest Watch) and GIS data of more than 450,000 mapped cocoa farms. The script running the overlay assessment checks for the set of all active and mapped farms, if and when tree cover loss appeared in the past (since the reference year of 2000) on any pixels which overlap with farm polygons. The number of pixels showing tree cover losses, grouped into classes of original tree cover (e.g. 90 – 100 %; 80 – 90 %; etc.) are then further processed in the dLUC calculation as described below. This overlay assessment is updated annually. In general, the dLUC impact assessment follows a cocoa specific version of the "Natural Climate Solutions (NCS) Guidance" methodology (Quantis 2019)[7].

Calculations of the dLUC impact of cocoa beans consider:

- a time horizon of 20 years
- all carbon pools (above ground biomass AGB, below ground biomass BGB, soil organic carbon SOC, dead organic matter DOM) in forests and cocoa farms
- data for different typical systems of cocoa farming, called "cocoa farming archetypes"[8]; for each of the six most relevant sourcing countries, three different cocoa farming archetypes are considered; data relevant for LUC calculations are yields and farm gate prices[9] for cocoa and non-cocoa crops in

[6] Deforestation is the most relevant LUC impact for cocoa farming. Degradation of wetlands, and changes from grassland or annual cropland to perennial cropland are rare.

[7] Quantis (2019): Natural Climate Solutions (NCS) Guidance. https://quantis-intl.com/metrics/initiatives/accounting-for-natural-climate-solutions/

[8] Cocoa farming archetypes represent typical systems of cocoa farming, described by data for yields and farmer prices for cocoa and non-cocoa crops in between cocoa trees, data for fertiliser and pesticide use, water for irrigation, etc.

[9] Farm gate prices are needed for the economic allocation of LUC impacts between different products from the same land.

between cocoa trees; these values were updated in 2018 by leading agronomists of Barry Callebaut and Mars

- conservative[10] estimations of wood utilisation in case of deforestation, split into logging and fuelwood; farm gate prices of logs and fuelwood
- economic allocation of the total dLUC impact to cocoa, wood use, and non-cocoa crops
- linear depreciation of the total impact allocated to cocoa over the 16 years of cocoa production within the relevant 20 years since farm establishment (no cocoa yield in years 1 – 4).

For indirectly sourced volumes from Côte d'Ivoire, Ghana, Cameroon, and Indonesia, safety factors are added to dLUC values for direct sourcing, to consider an estimated share of plots with higher original carbon stocks, for example in protected areas. The respective LUC factors for indirect sourcing were originally proposed in a study of Quantis for Barry Callebaut in 2019 and were not changed since then.

For approximately 10 – 15 % of cocoa beans (Brazil[11], Ecuador), carbon stock losses are based on average deforestation intensities (loss of above ground biomass AGB per hectare) as given by Global Forest Watch for relevant cocoa growing regions, and conservatively estimated shares of tree cover loss in the total cocoa farm area. This approach is called a "regional statistical LUC (sLUC)" assessment. For Brazil and Ecuador, currently no differentiation is made for volumes sourced directly or indirectly. For the remaining cocoa beans (all other countries), a weighted average of the LUC impact for the 6 most relevant sourcing countries is used.

Purchased cocoa products

Purchased cocoa products, not produced in factories of Barry Callebaut, are associated with the same weighted average cradle to gate carbon footprint as cocoa products produced by Barry Callebaut.

4.6 Land use change (LUC) related to non-cocoa ingredients

Currently LUC related to non-cocoa ingredients is not among the three most important contributors to the total corporate carbon footprint of Barry Callebaut. LUC impacts are considered for the following non-cocoa ingredients: dairy products (LUC is mostly related to soy in feed for cows), cane sugar, palm (kernel) oil, soy lecithin, coconut oil, and sunflower oil. The respective values are taken from the World Food LCA database, version 3.4 (2019), and from Schmidt & De Rosa (2019)[12] for (certified) palm oil. Reduced LUC impacts are also considered for products certified under Bonsucro and ProTerra (data published by respective certification organisation).

4.7 Dairy and other non-cocoa ingredients

GHG emissions related to dairy products (milk powder, whey powder, butter oil, other dairy) are – together with impacts of cocoa LUC – currently the most important contribution to the total corporate carbon footprint of Barry Callebaut. The carbon footprint of all other non-cocoa ingredients is significantly lower. Dairy, sugar, and oils together are responsible for 95 % of the total carbon footprint of all non-cocoa ingredients, which means that data quality is most relevant for these three groups of ingredients.

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[10] Estimations of utilised wood volumes are rather low. As a result, LUC impacts of cocoa are rather overestimated than underestimated.

[11] For Brazil, the cocoa volumes sourced from different regions (with considerably different LUC intensity) are updated annually since Sept. 2022.

[12] Schmidt J and De Rosa M (2019). Comparative LCA of RSPO-certified and non-certified palm oil. 2.-0 LCA consultants: https://lca-net.com/clubs/palm-oil/

Where no validated supplier specific or certification specific emission factors are available, an alternative approach is taken. The CO_2e emission factors for non-cocoa ingredients are taken from the World Food LCA database, version 3.4 (2019) for raw milk, beet and cane sugar, soy lecithin, coconut oil, sunflower oil, and vanilla; and from Schmidt & De Rosa (2019) for palm oil. CO_2e emission factors for some smaller volumes of other non-cocoa ingredients (nuts, sweeteners, additives, specialties) are taken from Ecoinvent database, version 3.3 and from specific LCA studies[13].

For raw milk, specific carbon footprint factors can be considered for 37 different sourcing countries. For the other most relevant non-cocoa ingredients, the number of country specific datasets varies between 3 and 7. In addition to these generic CO_2e factors, also **supplier specific CO_2e emission factors** are used for approximately 20 % of all non-cocoa ingredients (mostly for dairy; also for beet sugar), as well as reduced CO_2e emission factors for certified (RSPO, Bonsucro, ProTerra, RTRS) or organic ingredients (organic cane sugar, organic dairy). Respective background methodologies are checked regarding sufficient consistency, before being used for Barry Callebaut's CCF.[14]

The carbon footprint of dairy products is calculated by allocation of carbon footprint data for raw milk to different subsequent products (cream, skimmed milk, whey, skimmed milk powder, full cream milk powder, etc.) based on the dry mass content of the products. This allocation approach is consistent with the methodologies of the International Dairy Federation (IDF)[15] and the PEFCR for dairy products[16]. Data for respective mass flows and energy consumption in dairy factories, as well as carbon footprint for transports to dairy factories were extracted from a study by IFEU[17].

4.8 Cocoa farming

Effects considered for calculating the carbon footprint of cocoa farming, and respective source of data:

- Fertiliser production and use: Only small impact in West Africa, higher impact for "high input farms" in Brazil, Ecuador and Indonesia. Emission factors taken from WFLDB version 3.4.
- Impacts from degradation of cocoa pod husks in piles (CH_4 and N_2O emissions): Emission factors are based on WFLDB version 3.5 and on specific amendments for Barry Callebaut's context made by Denkstatt in 2019. Impacts are partly compensated by carbon sequestration via pod husk composting; respective assumptions are chosen in a very conservative way.
- Indirect N_2O emissions from leaching of SOC and associated nitrogen: Calculations are based on the "2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories".
- Seedlings and orchard: taken from WFLDB version 3.4.

4.9 Transportation of Cocoa, Cocoa Products, Non-Cocoa and Chocolate

GHG emissions from transporting cocoa beans and non-cocoa ingredients are estimated by modelling typical transport routes via truck and ship for each product group. The respective distances are combined with relevant volumes and with emission factors from Ecoinvent version 3.4. For truck transport of cocoa beans, an average of all four truck classes is used (3.5 – 7.5 t, 7.5 – 16 t, 16 t – 32 t, > 32 t); for non-cocoa ingredients only the biggest truck type is used due to the large volumes delivered.

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[13] Sabzevari et al. (2015) for Hazelnuts; Kendall et al. (2015) beside WFLDB for Almonds; Vercalsteren et al. (2012) for liquid glucose

[14] Internal guidance documents describe basic principles to be followed for sufficient consistency.

[15] https://www.fil-idf.org/idf-standing-committee-environment/life-cycle-assessment/carbon-footprint/

[16] https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR-DairyProducts_2018-04-25_V1.pdf

[17] IFEU (2014): Umweltbilanz von Milcherzeugnissen – Status quo und Ableitung von Optimierungspotentialen.

For calculating the carbon footprint of cocoa and chocolate transports, Barry Callebaut internally developed a refined tool in 2018. It combines specific data on distances, transported volumes, transport modes (ship, truck type, liquid / solid standard / solid cooled), and payload utilisation of trucks, with GHG emission factors specific to each transport situation. The GHG emission factors (sub-tool developed by Denkstatt) consider truck size, actual payload utilisation, and share of empty trips. Data sources are actual fuel consumptions provided by transport companies, fuel consumptions listed in CLECAT/DSLV (2012)[18], and emission factors from Ecoinvent version 3.4.

4.10 Factories, Scope 3

Data on energy consumption in Barry Callebaut's factories are converted to GHG emissions by using CO_2e factors covering scope 3. Reference databases are Ecoinvent version 3.4 and IEA 2016 (International Energy Agency). Data on water consumption Barry Callebaut's factories are converted to GHG emissions by using CO_2e factors from Ecoinvent version 3.4 on water supply.

4.11 External Recovery and Disposal of Cocoa Bean Shells

Benefits of external bean shell recovery options (only calculated in the framework of the OEF/PEF[19] methodology) are estimated based on the following assumptions: utilisation of bean shells for soil improvement material considers only carbon sequestration of composting (no substitution effect); utilisation of bean shells for feed production assumes substitution of maize with a substitution factor of 0.5 (i.e. 50 % less value of feed, compared to maize). For all external recovery routes, only 50 % of the total benefit is allocated to Barry Callebaut as credit ("open loop" recycling and recovery[20]), and therefore netted off the total scope 3 emissions figure.

Effects of landfilling bean shells (carbon sequestration and CH_4 emissions) are based on models for degradation of organic waste in landfills.

4.12 Packaging of Cocoa Beans, Cocoa Products, Non-Cocoa Ingredients and Chocolate

Packaging materials are considered for cocoa beans, cocoa products, non-cocoa ingredients, and chocolate produced. Carbon footprint calculations consider production and waste management of packaging materials. Respective CO_2e data are based on Ecoinvent versions 3.6 and 3.8. Net-credits of open loop packaging recycling are only calculated in the framework of the OEF/PEF[21] methodology.

4.13 Business Travel

Flights booked by Zurich, Chicago, and Singapore headquarters contribute only marginally to the total corporate carbon footprint of Barry Callebaut, but are taken into account. Air travel carbon footprint data was first calculated with 2016 data, based on distances and CO_2e factors from Ecoinvent version 3.4. Due to marginal relevance (0.03 % of total CCF), the original calculation was not updated so far.

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[18] CLECAT/DSLV (2012): Calculating GHG emissions for freight forwarding and logistics services in accordance with EN 16258

[19] Organisational Environmental Footprint (OEF), Product Environmental Footprint (PEF)

[20] In LCA methodologies (like the PEF and OEF methodologies) recycling and energy recovery of waste is linked to credits due to substituted primary production or substituted fossil fuels. For the corporate and product carbon footprint data of Barry Callebaut these credits are calculated based on the "circular footprint formula" of the EU (see reference for PEF methodology above and https://ec.europa.eu/environment/eussd/pdf/Webinar%20CFF%20Circular%20Footprint%20Formula_final-shown_8Oct2019.pdf). For CDP reporting such credits are excluded.

[21] Organisational Environmental Footprint (OEF), Product Environmental Footprint (PEF)