Product GHG Life Cycle Assessment Methodology

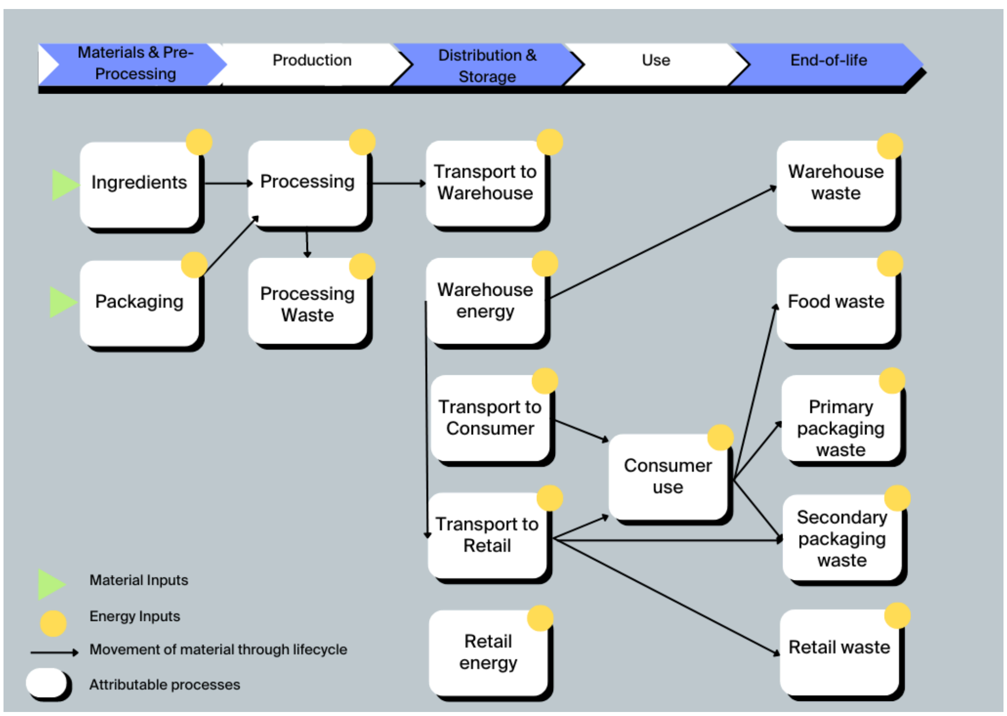
A. Goal, Scope Definition, and Assurance

This life cycle assessment (LCA) is intended to describe the GHG emissions (kg CO2e) of one product to the manufacturing company for the purposes of:

(1) Identifying potential emissions reductions
(2) Communicating GHG emissions impact of a product to customers and the general public
(3) Quantifying product emissions to offset emissions through carbon credits

The results should not be used for comparison with other product's published GHG emissions numbers produced by external parties, due to potential differences in scope and methodology. To be used for comparison purposes, both LCAs must undergo a critical review process to evaluate the comparative assertion.

The functional unit for the LCAs is one unit of packaged product, unless otherwise defined by the commissioning party. The system boundary may be defined as cradle-to-gate, starting from the extraction of raw materials to the end of the production phase or manufacturing gate, or as cradle-to-grave, starting from the extraction of raw materials and ending at the end-of-life for all the inputs required to create a single unit of product. All known emissions sources described in the process map below are included within the assessment. Other potential emissions sources are outside the scope of the assessment.



Product inventories should be reviewed every 3-5 years to determine if any product or process changes may result in significant changes to the estimated product inventory. Product inventories should also be re-evaluated when implementing significant changes to the product or process.

Assurance and Critical Review

Each study has a critical review through independent internal experts at Planet FWD.

Assurance type: First party (Planet FWD)
Level of Assurance: Limited assurance

Summary of Assurance process: All methodology and individual reports go through an internal critical review process by an independent internal expert in accordance with GHG protocol requirements.

Relevant Competencies of Assurance Providers:

- Assurance expertise and experience using assurance frameworks
- Knowledge and experience in life cycle assessment and GHG corporate accounting
- Knowledge of the company's activities and industry sector
- Ability to assess the emission sources and the magnitude of potential errors, omissions and misrepresentations
- Credibility, independence and professional skepticism to challenge data and information

Explanation of how any potential conflicts of interest were avoided: The assurance provider was not included in the project except for the assurance process. There is no disciplinary or economic dependence involved.

B. General Methodology

B.1 Standards
The LCAs are guided by the following international standards: ISO 14040/14044; and GHG Protocol Product Standard. This study has been conducted according to the requirements of ISO 14040/14044. The report follows all methodology and reporting requirements of the GHG Protocol Product Standard with the exception of separate reporting of biogenic emissions and carbon contained in the product that is not released during waste treatment. This information is available upon request, but it is not reported automatically due to limited relevance for the entity's business purposes and the increased burden of reporting.

B.2 GHG Emissions Equivalency and Global Warming Potentials
The greenhouse gas (GHG) emissions calculated in this study are reported as kg CO2e and include the seven greenhouse gasses covered by the Kyoto Protocol – carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF6) and nitrogen trifluoride (NF3) in carbon footprints. Global warming potentials for greenhouse gasses are based on the 100 year global warming potentials from the IPCC Fifth Assessment Report (AR6).

B.3 Data collection and selection
Primary data is used whenever practicable. Primary activity data is required for material inputs. Further specifications for each life cycle stage can be found in section C Lifecycle Stage Methodology.
For inputs that are less than 5% of the mass of a product, data for similar resources may be substituted. For processes with limited data available, assumptions are made based on the best available data. As such, the study favors completeness, in keeping with the goals of this study. More accuracy may be achieved by collecting additional primary data in subsequent reports.

The data sources used are continually being updated based on the latest research and new data availability. Planet FWD evaluates data from many different reliable sources such as peer reviewed publications in renowned journals, government agencies and high quality LCA databases to ensure reliability of our outputs. When multiple high quality data sources are available, an average is used to ensure completeness. If quality data sources are not available, proxy data or modeling methods are used to represent the activity.

B.4 Transport
Transport is calculated using maps.google.com for road transport distances when there is no waterway between start and end points. When a water system is crossed, ocean transport distances are calculated using common shipping routes and augmented with any road transport using the above methods to get from start to end points. If the starting and end location is set as the same country, a default of 453km road transport is assumed (extrapolated from the U.S. Census Bureau Commodity Flow Survey). Additionally, when air freight transport was specified, an ICAO calculator was used to determine jet fuel consumption. Emissions factors are described here.

For cold transport, emissions are augmented with fuel demand required for refrigeration/freezing with data from Energy Star. Additionally, transport emissions are increased due to an increase in fuel use to power refrigeration units, as well as direct leakage of refrigerants. Leakage rates from refrigerated transport are highly variable and poorly documented, because they are largely under the regulated volume, so there is some uncertainty associated with this estimation, though ranges are within the indicated guidance from GHGP (see Table 2). Unless specific details are provided, the refrigerant used in refrigerated transport is assumed to be R404A, and GWP is calculated accordingly.

B.5 Allocation

Planet FWD uses an attributional approach for carbon accounting, as laid out within ISO 14067 and the GHG Protocol. The attributional approach calculates the carbon impact of the individual components of the product, such as individual ingredients and packaging materials, which are then compiled to develop the final emissions value for the overall product.

Allocation of resource use and emissions between co-products is performed by dividing a process into distinct sub-processes, or by using mass-weighted economic allocation. We avoid system expansion because of the inherent difficulties and uncertainties involved in identifying and characterizing appropriate marginal product systems. Mass-weighted economic value has proven to be the most reliable method of allocation in many real-world scenarios, particularly for product systems that produce highly dissimilar co-products. There are some exceptions to this rule, including cases in which underlying data is ingested from external sources that are not compatible with mass-weighted economic allocation (eg. USLCI via LCA Commons), or some specific classes of products such as dairy products, in which we adhere to externally defined standards in this case the International Dairy Federation. These special cases are always noted and explicitly stated in the outcomes of the relevant model. Allocation includes materials, energy and upstream transport emissions of the main product.

Recycled and upcycled materials are modeled using the "recycled content" method which allocates the costs and benefits of recycling to the original production of the material; the system boundaries are drawn such that the system that produces the recyclable waste is responsible up to the point of delivering the waste to a secondary production process or recycling facility, and then any subsequent transport, processing and use of that material is included within other systems that use the material in some form.

B.6 Capital goods

The production of capital goods and infrastructure such as buildings and equipment used in the product lifecycle is excluded from the LCAs. This is a common practice in product LCAs as it has been shown repeatedly to be negligible (European Commission, 2019)

B.7 Non-product outflows

End of Life (EoL) and waste production including solid waste and wastewater streams are modeled in detail based on methodologies and parameters adapted from IPCC (2019) and the EPA's Emission Factors for Greenhouse Gas Inventories. We classify waste materials into specific categories to ensure accurate estimations of their environmental impact. These categories include, but are not limited to: Metals, Plastics, Paper Products, Organic Materials, Electronics, Construction & Demolition, Other. Solid waste modeling includes aerobic/anaerobic landfilling, incineration, composting, and recycling/reuse. Waste water modeling includes aerobic and anaerobic treatments. Methane and energy recovery options are included with waste processing steps. Recycling is modeled as described in section B.5

Other types of outflows that may be useful elsewhere, such as manure from animal systems, are considered to be co-products. The product systems that use the material, such as organic crop systems that use manure as a substitute for fertilizers, are credited for avoiding the resource use and emissions associated with fertilizer manufacture; these systems also incur emissions associated with applying manure and subsequent nitrous oxide emissions from the soil.

B.8 Parameter and Model Uncertainty

In addition to the descriptions specified, parameter uncertainty exists where emissions factors are based on averages from industry samples, and model uncertainty exists in agricultural models (following GHG Protocol Agriculture Guidance). Planet FWD addresses these uncertainties by conducting sensitivity analysis and reviewing areas of high uncertainty.

C. Life-cycle Stage Methodology

C.1 Ingredients and Packaging - Material Acquisition and Pre-processing

- Definition: Materials acquisition and pre-processing are the embodied emissions of raw materials and inputs to production and packaging, including secondary packaging for distribution where applicable. It also encompasses inbound transportation of raw materials, however it may not include emissions from packaging of raw materials (this information is estimated to be insignificant and is often unavailable).
- Data Sources and Methodology
    - Primary activity data (materials, material mass, origin location, and other characteristics) are provided by product producers (the company)
    - Emissions factors are sourced from the Planet FWD Database.
    - Our models use standard assumptions for transport distances and modes, when distance is not provided. These assumptions are averaged values specific to product groups (rather than products themselves) based on SCTG commodity codes. These average values are derived from the U.S. Census Bureau Commodity Flow Survey.
    - Carbon removals are included in a products carbon footprint when the requirements set by the GHG Protocol's Land Sectors and Removals Guidance are met. These requirements include: ongoing storage monitoring, traceability, primary data, uncertainty, and reversals accounting.
- Data Quality: For ingredients we use the closest match to our database based on agricultural category and ingredient form. For packaging, we use the closest material in our database. For inputs that are more than 5% of the mass of a product, if a required match is not available in our database, we create that entry based on LCI standards & methodology. Geographical variation is taken into account as an average when peer-reviewed published data is available for multiple geographies. For any pre-processing steps location-based grid information is used at the level of granularity accessible. Data quality can be improved by collected supplier-specific data for significant materials.

C.2 Production

- Definition: Emissions from energy usage are the direct emissions from outputs of manufacturing processes and emissions from waste generated during the manufacturing process. It does not include embodied emissions of manufacturing equipment (see B.6 Capital Goods).
- Data Sources and Methodology
    - The Planet FWD Database provides a number of unit processes to model commonly used food processing and cooking methods and are composed of the average energy demand of the machinery/equipment required to perform each process. Production methods in the LCAs are modeled using one or more of these unit processes as building blocks in conjunction with the appropriate fuels and electric grid for the processing location.
    - Energy sources used in these production methods include electricity from the local grid (assumed to be the US average grid) and other fuels. The emissions factors for these energy sources are based on data from Ember Climate for international energy demand and USEPA data for domestic grid emissions footprints. An emissions factor of zero is assumed for the portion of energy that is attributable to renewable energy sources.
    - Non-product material outflows are described in section B.7. When non-product material outflow (waste) data is not available from the user a default of 2% is used, which is an average value for pre-consumer food loss as found by NRDC .
- Data Quality: If primary data is provided by the customer on any processing energy use, that is used over secondary data from the methods described above. For unit processes, we use the closest match to our database and if an entry is not available in our database, we create that entry based on LCI standards & methodology.

C.3 Distribution and Storage

- Definition: Distribution and storage consist of transportation of finished product to warehouse and retail outlets, emissions from energy usage, emissions from refrigeration and refrigerants used in product storage and transportation, and emissions from waste generated during distribution and storage.
- Data Sources and Methodology
    - Transportation of materials to distribution & storage locations are calculated using the methodology outlined in section B.4 with primary data on locations when available. If multiple locations exist, a weighted average based on production distribution is used to account for the variability in distances. If primary data does not exist, reasonable approximations based on country size and expected distribution radius are used.
    - For non-refrigerated shelf stable products, the energy use at the warehouse & retail locations is considered negligible & omitted from the analysis.
    - If there is refrigeration or freezing, the volume of the product as well as the average time it is in storage at the warehouse/distribution center is required to calculate the carbon footprint of the product warehousing phase. For warehouses, given the low probability of HFCs and other high GWP refrigerants (Burek & Nutter, 2019) emissions are calculated based only on energy consumption.
        - For warehouses and distribution centers, natural refrigerants, primarily ammonia, are the most predominantly used (Burek & Nutter, 2019); because ammonia has a GWP of 0, any leakage is not considered, and emissions are calculated based only on energy consumption.
        - For retail locations, most refrigerants use HFCs and therefore leakage is included in emissions calculations in addition to emissions from energy consumption. The leakage rate is estimated based on the profile of an average U.S. supermarket (USEPA). The average emission of refrigerant is calculated based on kg of refrigerant per kWh of electricity, and is estimated based on data from U.S. EIA, 2012. A leakage rate of 25% is assumed, fitting into the range from GHGP and IPCC (Table 2). Electricity consumption is calculated based on ENERGY STAR data. For display cabinets specifically it is assumed 50% of the volume is not occupied.
        - If the product is fresh, we seek primary data from the warehouse management team; however if that data is unavailable, food loss can be estimated by USDA data or UN SDG Indicator 12.3.1. Secondary packaging that would be disposed of at retail locations are allocated to landfill or recycling with EPA values as defaults.
- Data Quality: When primary data is available for transportation distances, energy consumption and waste, that data is used. For times when secondary data is used, the methodology described above is followed. Geographical variability is expected to be at the country level and captured by using UN SDG Indicator data.

C.4 Use

- Definition: The use phase consists of emissions from product use by the end user and emissions from waste generated during product use. This includes energy use of appliances and other equipment needed to provide utility of the goods and excludes emissions from the manufacturing of these appliances and equipment.
- Data Sources and Methodology
    - Energy usage of sold products over their expected lifetime are modeled based on *product use instructions, energy demand of appliances, US household appliance distribution, and energy usage emissions factors*
    - *Product use instructions* (e.g. cooking time, water volumes, refrigeration space) are provided by the product producers (the company) Primary data for product use instructions are highly

recommended. When primary data is not available, a reasonable approximation can be made on use instructions.

    - *Energy demand of appliances:* Appliances include ovens for baking/roasting, smaller convection ovens or toaster ovens, multiple methods for boiling water, microwaving, refrigeration, and more. The appliance type must match the stated use instructions and if that does not exist, a new appliance is added to our database. Data are collected from various sources, including Energy Star, the US EPA, and peer-reviewed journal articles (e.g. Oberasher et al., 2011; Hager & Morawicki, 2012).
    - *US appliance distribution:* Data from the EIA Residential Energy Consumption Survey to determine on average what proportion of the required appliance runs on what type of fuel: electricity, natural gas, propane, or other).
    - *Energy usage emissions factors:* The emissions factors for these energy sources are based on US EPA data (USLCI) for domestic grid emissions footprints and IEA for international energy usage. An emissions factor of zero is assumed for the portion of energy that is attributable to renewable energy sources.
- Data Quality: Data has good technological, temporal, and geographical representativeness, good completeness and fair reliability. Data quality is limited by lack of knowledge for specific appliance types, energy usage, and grid emissions for the subset of the population that uses the company's products, but is representative of overall US usage.

C.5 End-of-Life

- Definition: Emissions from product and/or packaging disposal at end of life.
- Data Sources and Methodology:
    - End-of-life assumptions for primary packaging materials are based on documented consumer behavior in the relevant region.
    - Landfill, recycling, and composting rates of typical materials in the US are based on US EPA Sustainable Materials Management Data. International data are based on the World Bank What a Waste 2.0 study. Specific materials may be pulled from additional studies. Emissions factors for various end-of-life forms are from IPCC and EPA.
    - Food waste assumptions are from USDA ERS, NRDC, and ReFED Inisights Engine.
    - Secondary packaging materials discarded during processing, distribution, and retail facilities are assumed to have landfill diversion rates of 80% at retail, in keeping with reporting from Walmart, Costco, Kroger, and Target. Recyclable materials (paper and board, metals) are recycled at this rate, and any non-recyclable materials (soiled papers, etc.) are assumed to be sent to landfill.
- Data Quality: Data has good temporal, good geographical, and poor technological representativeness. In aggregate, the data has good completeness and reliability. Data quality is limited by lack of knowledge of behaviors and end-of-life processing for the subset of the population that uses the company's product, but is representative of overall US usage and would be difficult to improve. Data quality could be improved by surveying the company's consumers about their specific end-of-life behaviors.

C.6 Data for Significant Processes

Data for processes that contribute more than 5% of the total emissions are available upon request. See above life cycle stage notes on data quality and methods to improve data quality.

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