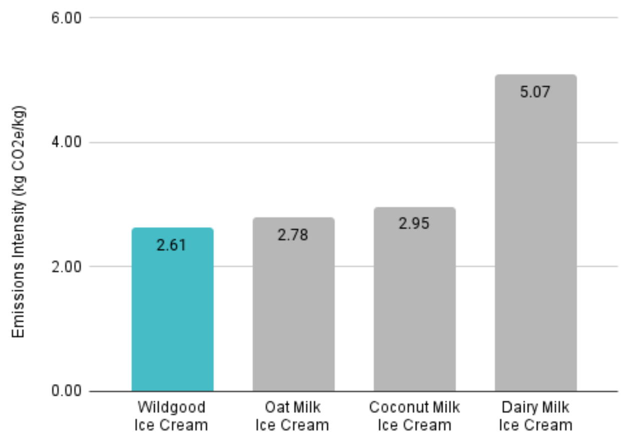
Carbon footprint of four ice cream formulations

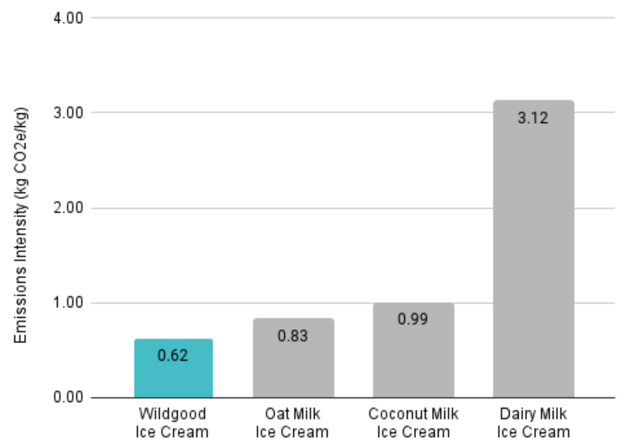
Wildgood commissioned Planet FWD to assess the carbon footprint of their ice cream formulations as well as average dairy and non-dairy ice cream alternatives. The assessment was done on the basis of a **functional unit** of **1 kg of frozen dessert** in packaging. This document provides a summary of the results of four individual LCAs of formulations(Vanilla Bean flavors of Wildgood Ice Cream, Oat Milk Ice Cream, Coconut Milk Ice Cream and Dairy Milk Ice Cream) and compiles key results from these separate analyses. The complete report for the commissioned Wildgood Vanilla Bean Ice Cream and the other formulations are available as an appendix.

Fig. 1: Emissions Intensity of Different Vanilla Ice Creams (Cradle-to-Grave)



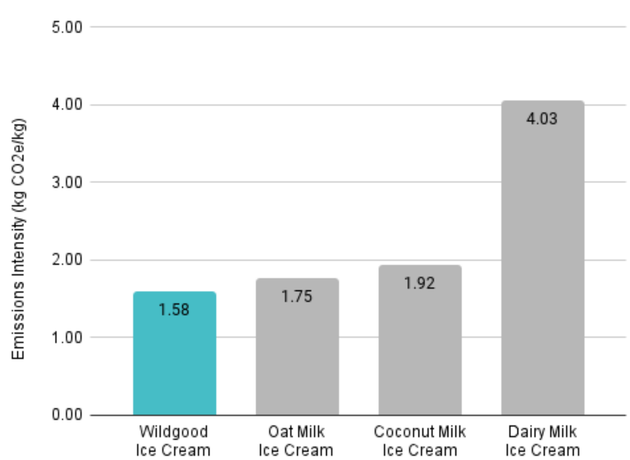
Wildgood's olive oil based cradle-to-grave GHG emissions are up to 6% lower in emissions than ice cream with an Oat Milk base, 11% lower than Coconut Milk base and 48% lower than Dairy Milk base. Life cycle phases included in this cradle-to-grave assessment are ingredients, packaging, processing, distribution, consumer use & end-of-life.

Fig. 2: Emissions Intensity of Different Vanilla Ice Creams (Ingredients only, including upstream transport)



Wildgood ingredient GHG emissions are up to 25% lower in emissions than Oat Milk ice cream, 38% lower than Coconut Milk ice cream and 80% lower than Dairy Milk ice cream. Upstream transport of ingredients from farm gate to processing and then to final production location are included in ingredient emissions. Farm and production locations were estimated based on most common production for each ingredient, where this was unclear, a default transport distance of 2500 km was used. See section B.4. for more information about transportation..

Fig. 3: Emissions Intensity of Different Vanilla Ice Creams (Cradle-to-Gate)



Wildgood cradle-to-gate GHG emissions are up to 10% lower in emissions than Oat Milk ice cream, 18% lower than Coconut Milk ice cream and 61% lower than Dairy Milk ice cream. Life cycle phases included in this cradle-to-gate assessment are ingredients, packaging, & processing. It does not include distribution, consumer-use or end-of-life.

***See page 3 for assumptions.*

Formulation summary

The only difference in the products included in this report are the ingredients used. Packaging, production methods, distribution, consumer use, and end-of-life assumptions were held constant. All assumptions about these sections are detailed in the complete individual reports (results are in Appendices 1-4 and Methodology in Appendix 5)

Ingredient GHG emissions take into account the mass of the ingredient in the recipe, emissions intensity of cultivating and processing that ingredient, and the distance and mode of transport from common source locations to a US-based processing location.
The following ingredients and relative percentages are as follows:

OAT MILK FORMULA		COCONUT MILK FORMULA		DAIRY FORMULA	
INGREDIENT	% OF FINISHED PRODUCT	INGREDIENT	% OF FINISHED PRODUCT	INGREDIENT	% OF FINISHED PRODUCT
Oat Milk (water, oats)	64%	Coconut Milk (water, coconut)	74%	Cream	35%
Coconut Oil	10%	Cane Sugar	16%	Skim Milk	35%
Sugar	9%	Coconut Oil	5%	Liquid Sugar (sugar, water)	21%
Dextrose	7%	Tapioca Syrup	2%	Water	6%
Glucose Syrup	6%	Pea Protein	2%	Egg Yolks	2%
Low Erucic Acid Rapeseed Oil	3%	Carob Bean Gum	1%	Guar Gum	0.3%
Mono & Diglycerides of Fatty Acids	0.3%	Guar Gum	0.3%	Sugar	0.2%
Guar Gum	0.2%	Natural Flavor	0.3%	Vanilla Extract	0.2%
Natural Flavor	0.1%	Vanilla Bean Specks	0.2%	Carrageenan	0.1%
Sea Salt	0.1%			Vanilla Bean Flecks	0.1%
Vanilla Bean Flecks	0.1%				

The following assumption were held constant through the remainder of the cradle-to-grave scope for the study:

STAGE	kg CO2e/kg
Packaging	0.18
Production	0.74
Distribution & Storage	0.98
Consumer Use	0.02
End of Life	0.03

Assumptions include:

- *Packaging: Primary: paperboard, poly-coated cup and lid with a foil seal (laminated film, aluminum foil). Secondary: corrugate tray wrapped in plastic wrap.*
- *Production: Standard ice cream production.*
- *Production waste is split between landfill (4%) and compost (4%).*
- *Cold Chain includes: cold transport in all stages, 45 day warehouse storage, 15 day retail, and 7 day consumer use.*

Reporting Requirements & Methodology

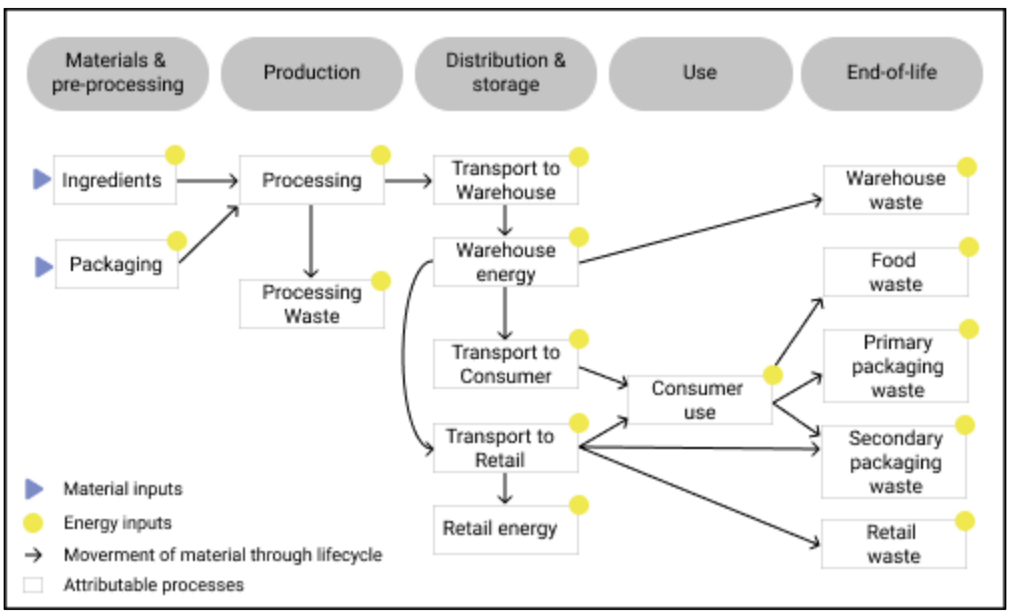
A. Goal, Scope Definition, and Assurance

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 products' published GHG emissions numbers, 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. The **reference flow** is 1 kg. The **system boundary** is 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. Fig. 2 also shows ingredient-only results which has a system boundary of only raw materials and transport. 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 annually 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

This study has undergone critical review through independent internal experts at Planet FWD.

LCA commissioner: Wildgood
LCA practitioner: Radmila Vlastelica
Reviewer: Miranda Gorman
Assurance type: First party (Planet FWD)
Level of Assurance: Reasonable 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.

> "In the opinion of the assurance provider the reporting company's assertion that the inventory product's emissions are fairly stated, in all material respects, and is in conformance with Planet FWD's product LCA methodologies, which are in conformance with the GHG Protocol Product Life Cycle Accounting and Reporting Standard with the exception listed in section 1 (separate reporting of biogenic emissions and carbon contained in the product not released during waste treatment)."

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; PAS 2050; and GHG Protocol Product Standard. The individual product LCIA studies have been conducted according to the requirements of ISO 14040/14044. The LCIA studies follow 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.

All results included in this report use the same functional unit, databases and system boundaries. It should be noted this has not been reviewed by a third party as required by ISO 14044 for comparative assessments and therefore care should be taken in any public disclosures. Individual product LCAs for each 4 products (Vanilla Bean flavors of Wildgood Ice Cream, Oat Milk Ice Cream, Coconut Milk Ice Cream and Dairy Milk Ice Cream) have been completed and are appended below.

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 CO_2, CH_4, N_2O, and HFCs. Global warming potentials for greenhouse gasses are based on the IPCC Fifth Assessment Report (AR5) (Global Warming Potential Values).

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 seadistances.org and is augmented with any road transport using above methods to get from start to end points. Emissions factors are described here and for cold transport, augmented with fuel demand required for refrigeration/freezing with data from Energy Star.

Emissions factors are described here and for cold transport, 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.

Planet FWD carbon assessments allocate resource use and emissions between co-products by using mass-weighted economic value or a biophysical measure (such as mass, energy or nutrition content) as appropriate. 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.

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 such as buildings and equipment used in the product lifecycle is excluded from the LCAs. This is a common practice in product LCAs and compliant with the PAS 2050 standard.

B.7 Non-product outflows
Both solid waste and waste water streams are modeled in detail based on methodologies and parameters adapted from IPCC tier 1/2 for a broad range of industries. 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 CleanMetrics CarbonScopeData life-cycle inventory (LCI) database.
    - Transportation of materials to the production site are calculated using the methodology outlined in section B.4 Transport Methodology.
    - Where indicated, soil carbon change as a result of land-use practices are included in the inventory results following GHG Protocol Agriculture Guidance and IPCC Guidelines (2019 Refinement) Tier 1 calculation methodology.
- 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.
- Data Sources and Methodology
    - The CarbonScopeData LCI 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 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 IEA for international energy demand and USEPA data (available at USLCI) 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 5% 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 and NRDC.
  - 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 described below. See above life cycle stage notes on data quality and methods to improve data quality.

Process	Data sources
Energy – Distribution (cold storage)	Emissions & Generation Resource Integrated Database (eGRID) | US Environmental Protection Agency. 2018. https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid. U.S. Life Cycle Inventory Database. NREL.gov. (n.d.). http://www.nrel.gov/lci/ Emission factors for greenhouse gas inventories. (n.d.). https://www.epa.gov/sites/default/files/2015-07/documents/emission-factors_2014.pdf
Electricity - Production	Emissions & Generation Resource Integrated Database (eGRID) | US Environmental Protection Agency. 2018. https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid. U.S. Life Cycle Inventory Database. NREL.gov. (n.d.). http://www.nrel.gov/lci/
Transport - Distribution	Greenhouse Gas Protocol: GHG Emissions from Transport or Mobile Sources. 2005. http://www.ghgprotocol.org/calculation-tools/all-tools. Waldron CD, Harnisch J, Lucon O, et al. 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Chapter 3 Mobile Combustion. 2006. http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf.
Natural Gas - Production	U.S. Life Cycle Inventory Database. NREL.gov. (n.d.). http://www.nrel.gov/lci/ Emission factors for greenhouse gas inventories. (n.d.). https://www.epa.gov/sites/default/files/2015-07/documents/emission-factors_2014.pdf
Tapioca Syrup	Greenhouse Gas Protocol, 2005 (http://www.ghgprotocol.org/calculation-tools/all-tools); IPCC, 2006 (http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf).
Cream	https://doi.org/10.1016/j.idairyj.2012.08.012, https://library.cee1.org/sites/default/files/library/1867/1050.pdf, Soderlund, Robert (1956) PatentUS2849931A. Washington, DC: U.S. Patent and Trademark Office Chandan R. (1997), Dairy-Based Ingredients, Eagen Press, St. Paul, Minn

Coconut Oil	Bawalan et al (2006).; https://doi.org/10.1021/sc5001622; https://doi.org/10.1111/1750-3841.14223; Philippine Coconut Authority. Philippine Coconut and Oil Palm Commodity Prices Monthly Average for (DECEMBER) 2020.; https://pca.gov.ph/images/pdf/commodity/2020-12.pdf Vijaya et al (2008)
Extra Virgin Olive Oil	https://doi.org/10.1002/jsfa.8143; Pienkowski, M., & Beaufoy, G. (2002). The environmental impact of olive oil production in the European Union: practical options for improving the environmental impact.; https://doi.org/10.1016/j.jclepro.2011.10.004
Cane Sugar	https://doi.org/10.1080/09640568.2010.488120; https://doi.org/10.1016/j.jclepro.2020.125170; Zauba. (n.d.). Analysis of Import of: Raw Sugar. ; Zauba. (n.d.). Analysis of Import of: Molasses
Skim Milk	Soderlund, Robert (1956) PatentUS2849931A. Washington, DC: U.S. Patent and Trademark Office, https://doi.org/10.1016/j.idairyj.2012.08.012, Brush, A. (2011). Energy Efficiency Improvement and Cost Saving Opportunities for the Dairy Processing Industry: An ENERGY STAR? Guide for Energy Plant Managers
Oat Milk	ProSoya Inc. (n.d.). Oat Milk Plant. RSS. Retrieved April 5, 2022, from http://www.prosoya.com/oat-milk-plant/ Swedish Institute for Food and Biotechnology. (2013, January). Oatly LCA. https://www.zaailingen.com/wp-content/bestanden/oatly.pdf
Coconut Milk	DOI:10.37833/cord.v16i01.338; Changzhou Combo Machinery Co., Ltd., Coconut Milk and Water Vibrating Filter Coconut Milk Sifter. ; https://pca.gov.ph/index.php/2-uncategorised/196-cocotech ; https://fruitprocessingmachine.com/portfolio-items/coconut-processing-line/ ; DOI:10.1016/j.jfoodeng.2005.01.

Questions? Contact us at:
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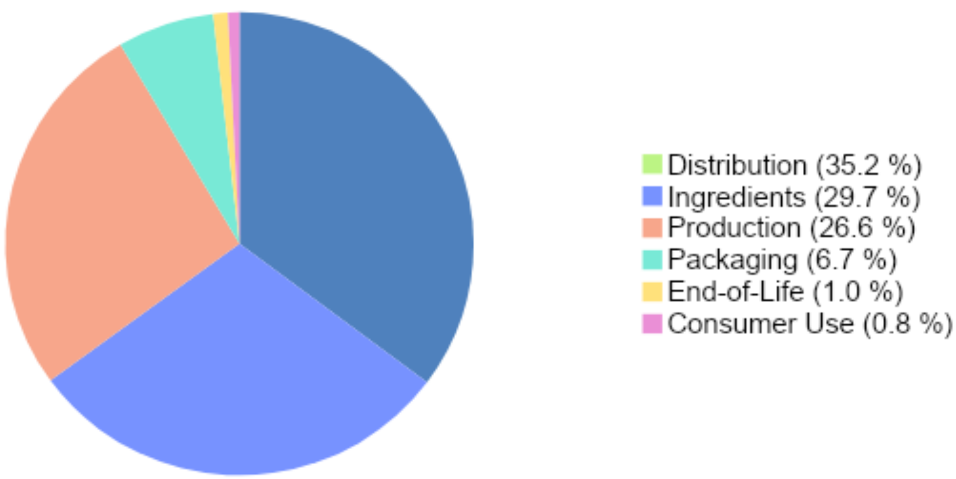
support@planetfwd.com
800.861.3787

Appendices

Appendix 1. Oat Milk Ice Cream Formula LCA

The **cradle-to-grave** (through landfill) GHG emissions total is estimated to be **0.934 kg CO2e** for one unit of product, with a reference flow of 0.336 kg per unit.

What is contributing to this footprint?
The total carbon footprint of this product is 0.934 kg CO2e*. The primary components of the cradle-to-grave product-level carbon footprint are ingredients, packaging, processing, distribution, consumer use & end-of-life. Transport is built into ingredients, packaging and distribution and are outlined in each of the sections below.



Top Emissions Drivers

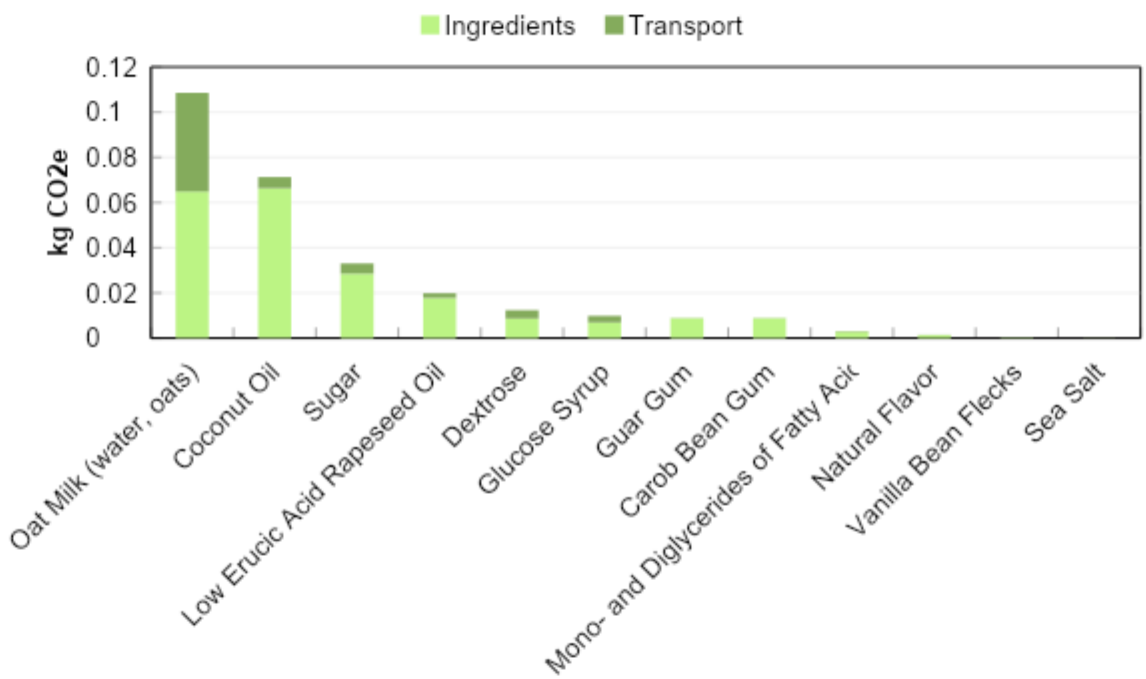
Category	kg CO2e	% of Total
Energy – Distribution (cold storage)	0.254	27.2 %
Electricity - Production	0.167	17.9 %
Oat Milk (water, oats)	0.109	11.6 %
Transport - Distribution	0.075	8.0 %
Natural Gas - Production	0.072	7.8 %
Coconut Oil	0.071	7.6 %

What can I do with this number?
According to the GHG Protocol, these numbers cannot be used for comparison to other companies and/or products. Even for similar products, differences in unit of analysis, use and end-of-life stage profiles, and data quality may produce incomparable results. Reach out to Planet FWD for help in making a qualified comparison!

**This footprint includes emissions from other greenhouse gasses, in addition to carbon emissions. Greenhouse gas emissions measurements are normalized to carbon dioxide equivalents, CO2e, based on global warming potential.*

Ingredients

0.278 kg CO2e

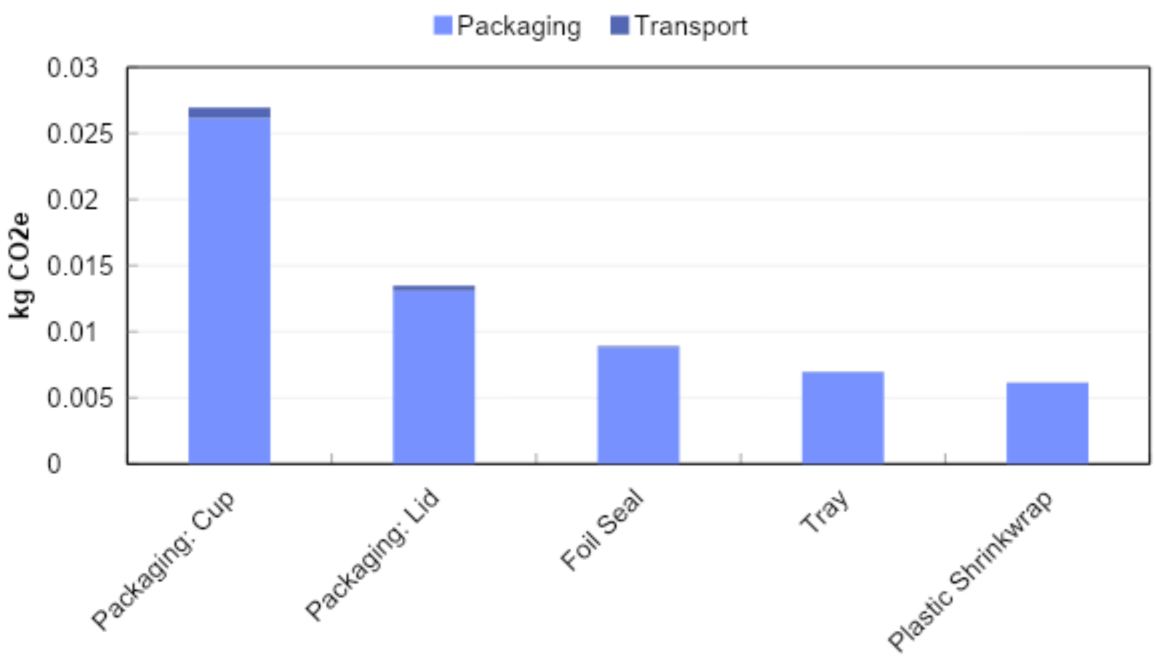


Sourcing as a Sustainability Lever
Ingredient sourcing is one of the most impactful ways to improve the sustainability of your product. As a brand, you can use purchasing power to promote social and environmental sustainability across the supply chain: regenerating ecosystems, providing economic support for a more climate-resilient food system, supporting fair wages and labor conditions, and amplifying BIPOC and women suppliers to advance equity.

Let's break it down!
Your ingredient emissions total is estimated to be 0.278 kg CO2e. GHG emissions for ingredients are driven by the mass of the ingredient in the recipe, emissions intensity of cultivating & processing that ingredient, and the distance and mode of transport. The highest emissions ingredient(s) in this recipe are Oat Milk (water, oats) and Coconut Oil, making up about 19.2 % of the total emissions.

Packaging

0.062 kg CO2e

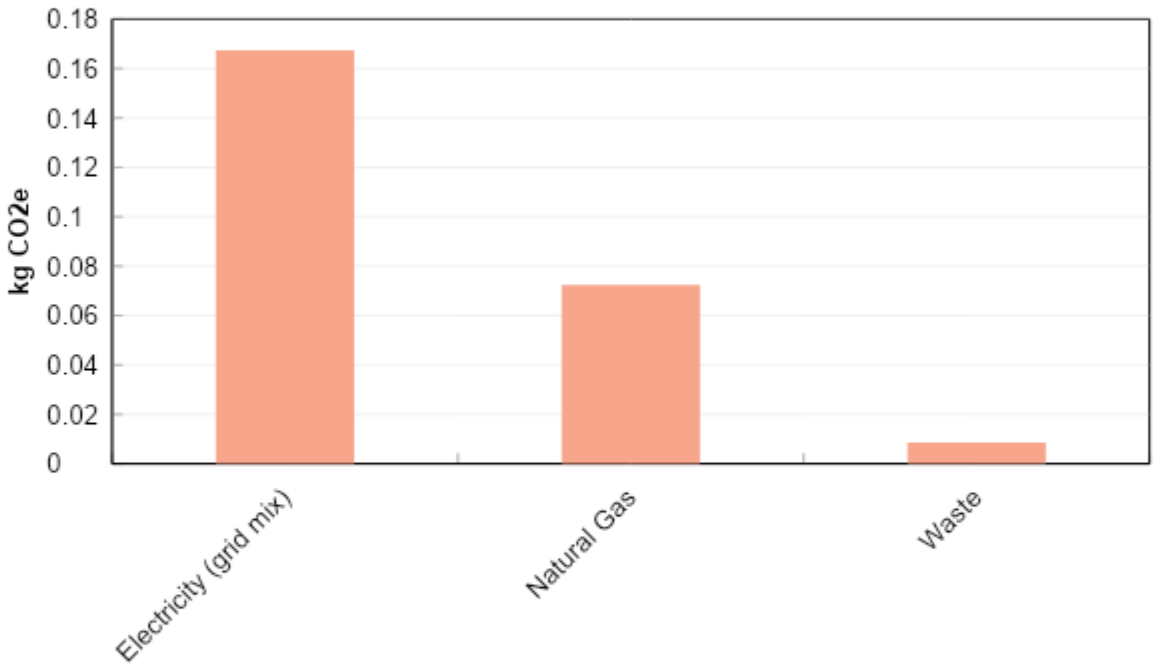


Packaging as a Sustainability Lever

Packaging is another key element of product sustainability, and oftentimes one of the most important to consumers as the negative impacts of packaging are highly visible. Consumers want packaging materials that reflect a brand's environmental commitment whether that comes from sustainability, reuse, recycling, or innovative materials.

Production

0.248 kg CO2e



Production as a Sustainability Lever
Cooking processes also contribute to the sustainability of a product through the energy usage of different methods. It is encouraged to work with processors that include renewable energy in its processing facilities. Even in facilities powered by renewable energy, natural gas is often used for cooking processes. Switching from natural gas to electric from renewables could help address this part of the footprint.

Distribution & Storage

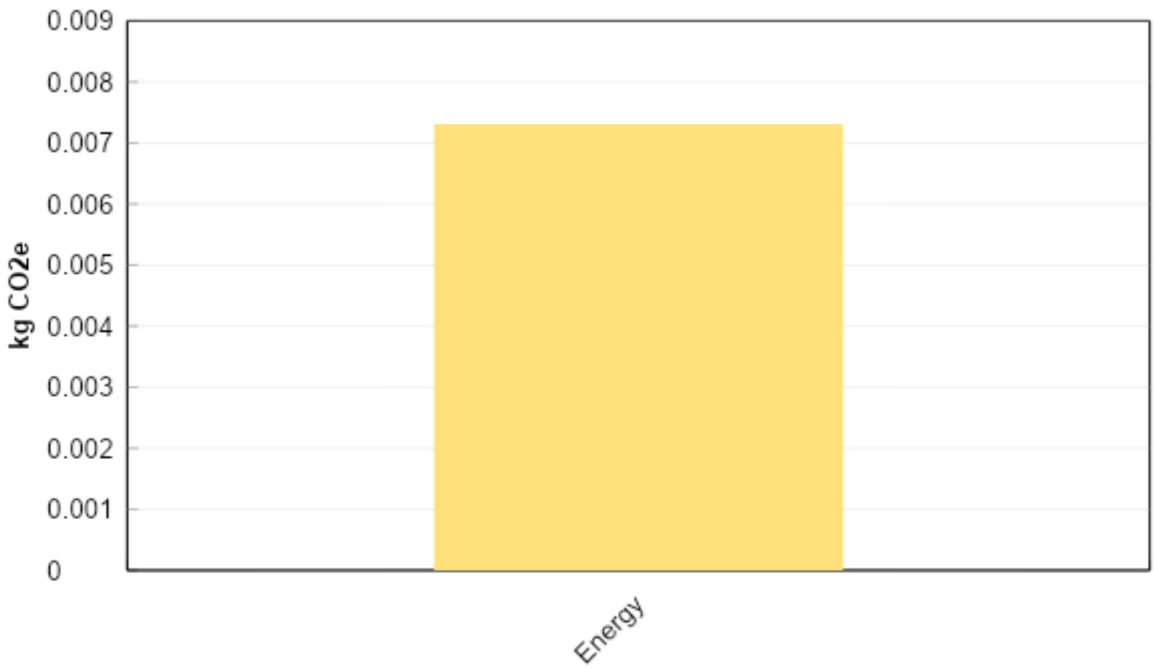
0.329 kg CO2e

Distribution & Storage as a Sustainability Lever
Emissions from distribution are mainly driven by the transportation of goods, however the energy consumed at the warehouse or retail locations is also an important factor, especially when refrigeration is involved. Refrigeration at retail has significantly higher emissions than refrigeration at warehouse due to the types of refrigerants used, the distance between refrigeration units and cooling systems, and the high temperature differential and constant exposure to warm air.

Ways to lower the emissions from distribution include reducing the weight of your product, either from ingredients or packaging, or decreasing the miles of air transport required to move product (FACT: air transport has almost 10x the impact as road transport!).

Consumer Use

0.007 kg CO2e

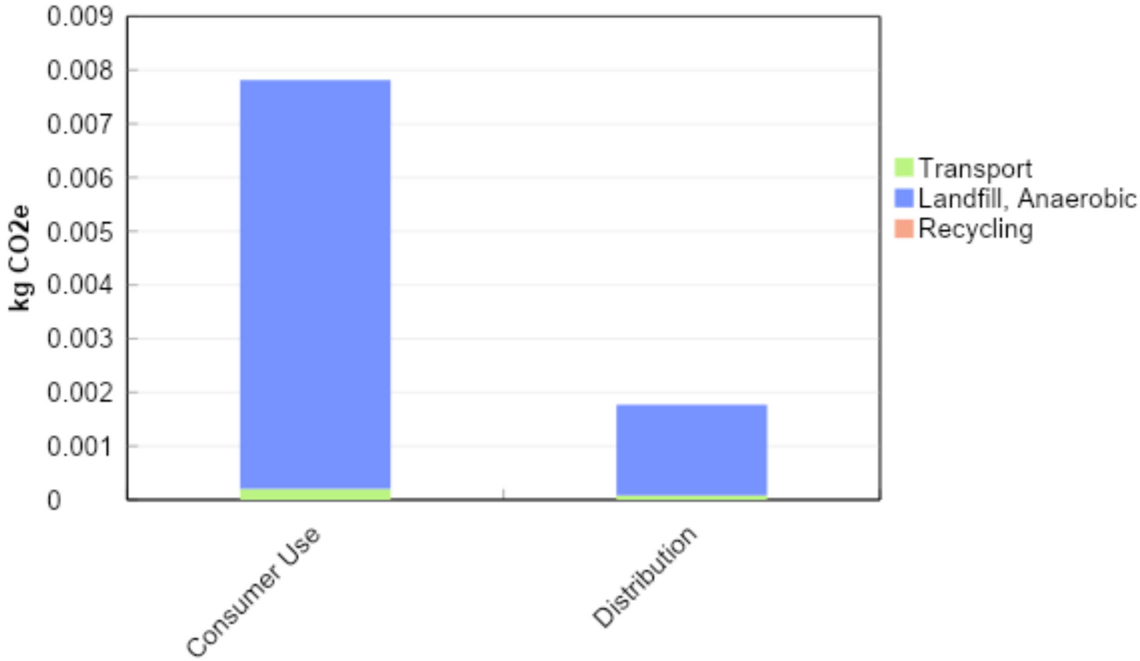


Consumer Use as a Sustainability Lever

A product's carbon footprint doesn't end with the manufacturer. How the consumer is expected to realize product utility can impact the carbon footprint.

End-of-Life

0.010 kg CO2e

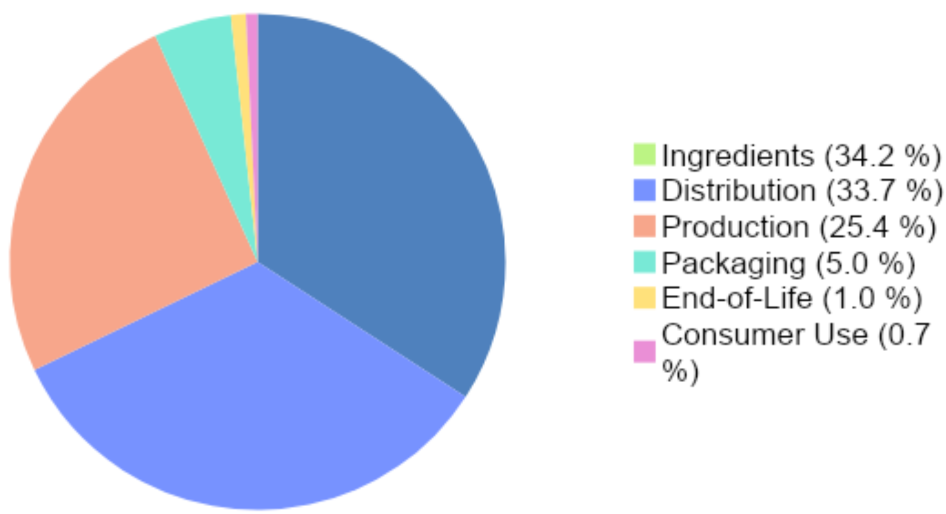


End-of-life as a Sustainability Lever
In most places, we estimate that a portion of recyclable products go to landfill and a portion goes to recycling. Emissions from transportation of recycled materials to the recycling facility are included here, but emissions from recycling are not included in the boundary of this LCA (they would be included as part of the material input emissions of products using the recycled materials). Recycling rates differ by material and by geographic location, as do composting rates, which are generally very low in the US (see our methodology for more details).

Appendix 2. Coconut Milk Ice Cream Formula LCA

The **cradle-to-grave** (through landfill) GHG emissions total is estimated to be **0.990 kg CO2e** for one unit of product, with a reference flow of 0.336 kg per unit.

What is contributing to this footprint?
The total carbon footprint of this product is 0.977 kg CO2e*. The primary components of the cradle-to-grave product-level carbon footprint are ingredients, packaging, processing, distribution, consumer use & end-of-life. Transport is built into ingredients, packaging and distribution and are outlined in each of the sections below.



Top Emissions Drivers

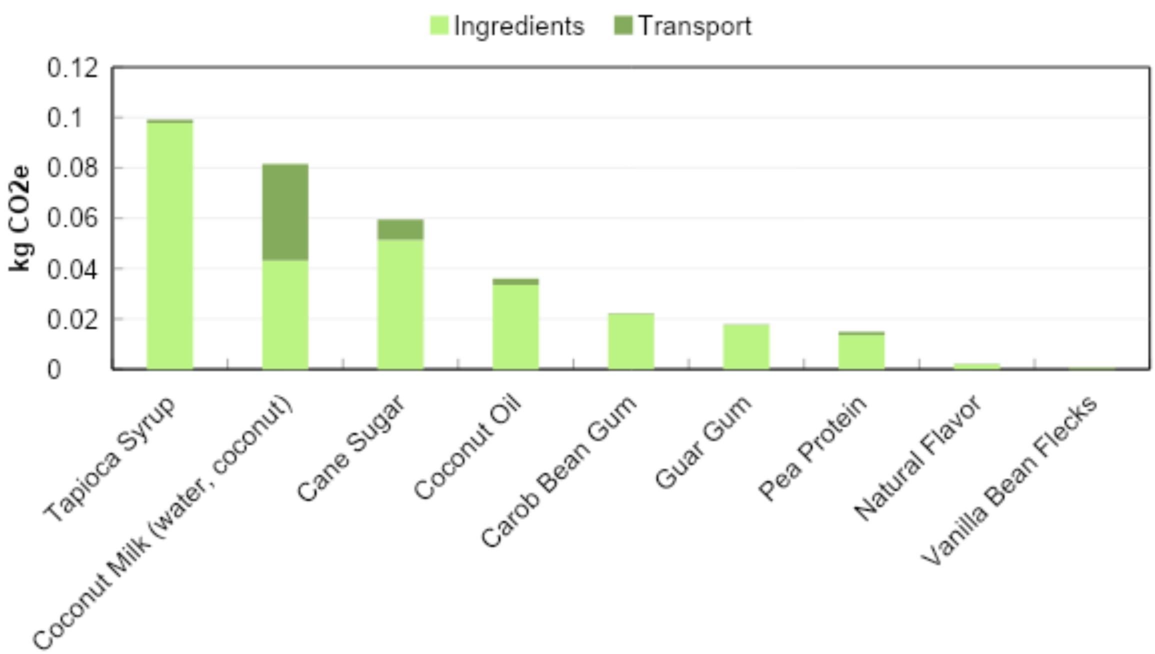
Category	kg CO2e	% of Total
Energy – Distribution (cold storage)	0.254	26.0 %
Electricity - Production	0.167	17.1 %
Tapioca Syrup	0.099	10.1 %
Coconut Milk (water, coconut)	0.082	8.3 %
Transport - Distribution	0.075	7.6 %
Natural Gas – Production	0.072	7.4 %
Cane Sugar	0.060	6.1 %

What can I do with this number?
According to the GHG Protocol, these numbers cannot be used for comparison to other companies and/or products. Even for similar products, differences in unit of analysis, use and end-of-life stage profiles, and data quality may produce incomparable results. Reach out to Planet FWD for help in making a qualified comparison!

**This footprint includes emissions from other greenhouse gasses, in addition to carbon emissions. Greenhouse gas emissions measurements are normalized to carbon dioxide equivalents, CO2e, based on global warming potential.*

Ingredients

0.334 kg CO2e



Sourcing as a Sustainability Lever
Ingredient sourcing is one of the most impactful ways to improve the sustainability of your product. As a brand, you can use purchasing power to promote social and environmental sustainability across the supply chain: regenerating ecosystems, providing economic support for a more climate-resilient food system, supporting fair wages and labor conditions, and amplifying BIPOC and women suppliers to advance equity.

Let's break it down!
Your ingredient emissions total is estimated to be 0.334 kg CO2e. GHG emissions for ingredients are driven by the mass of the ingredient in the recipe, emissions intensity of cultivating & processing that ingredient, and the distance and mode of transport. The highest emissions ingredient(s) in this recipe are Tapioca Syrup and Coconut Milk (water, coconut), making up about 18.5 % of the total emissions.

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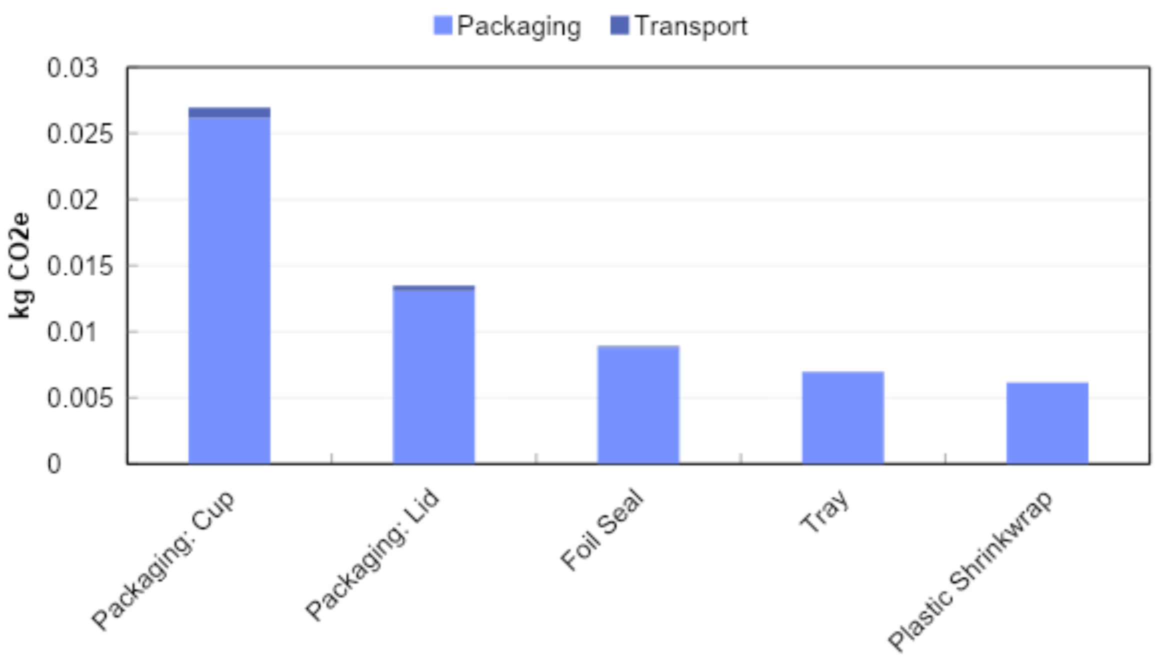
Packaging

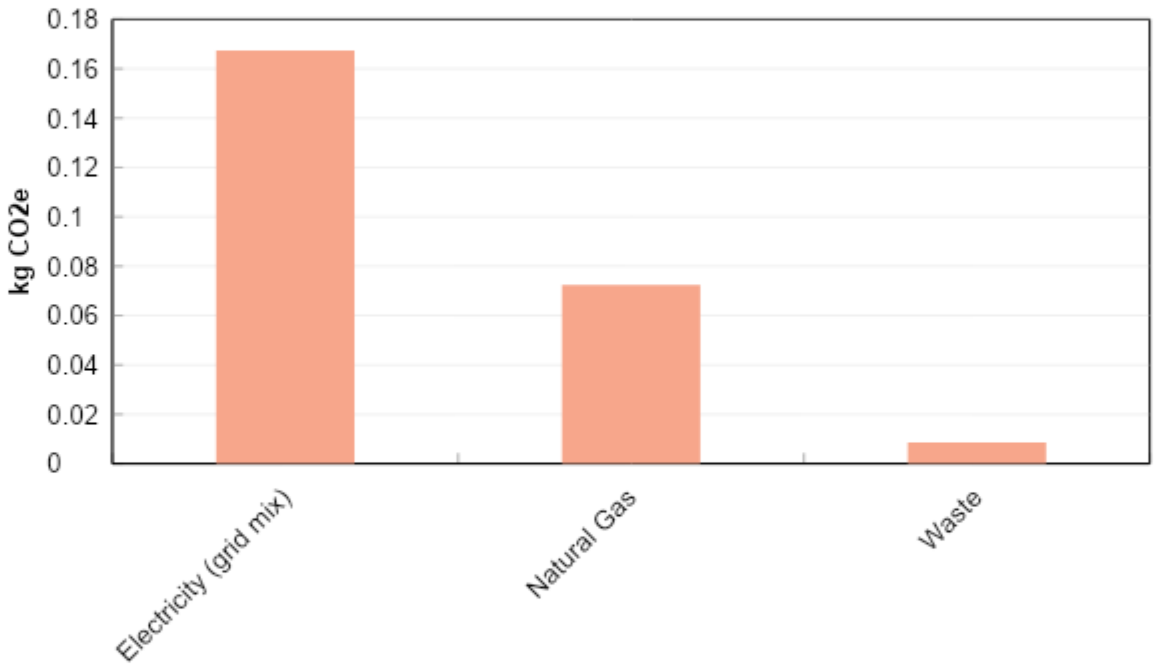
0.062 kg CO2e



Packaging as a Sustainability Lever
Packaging is another key element of product sustainability, and oftentimes one of the most important to consumers as the negative impacts of packaging are highly visible. Consumers want packaging materials that reflect a brand's environmental commitment whether that comes from sustainability, reuse, recycling, or innovative materials.

Production

0.248 kg CO2e



Production as a Sustainability Lever
Cooking processes also contribute to the sustainability of a product through the energy usage of different methods. It is encouraged to work with processors that include renewable energy in its processing facilities. Even in facilities powered by renewable energy, natural gas is often used for cooking processes. Switching from natural gas to electric from renewables could help address this part of the footprint.

Distribution & Storage

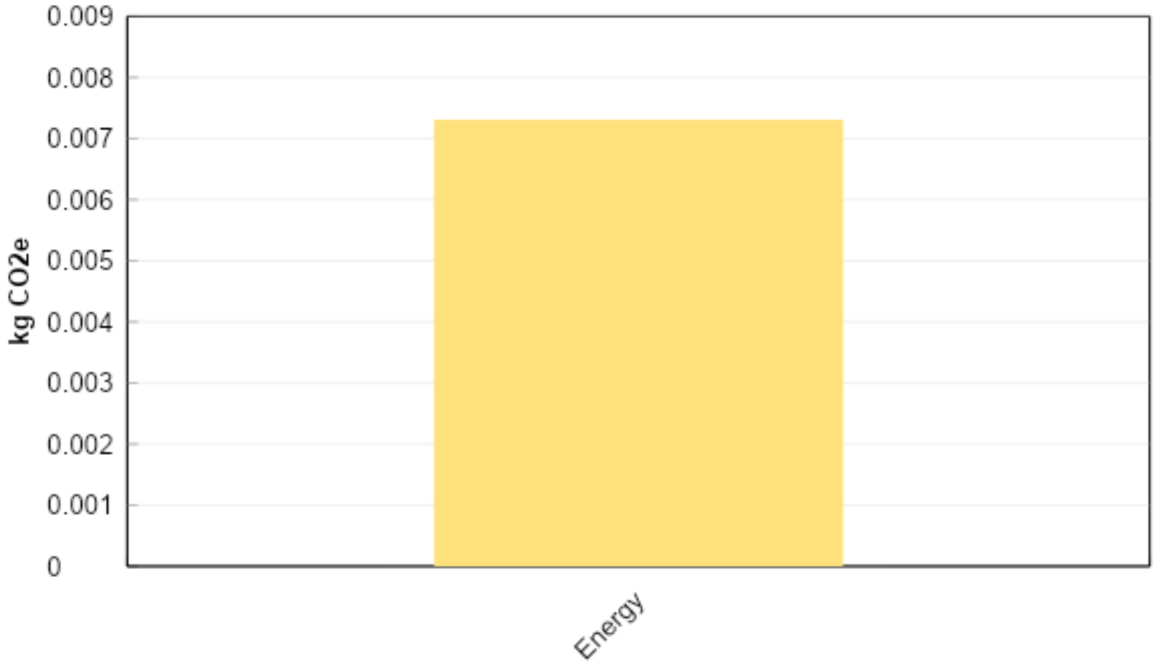
0.329 kg CO2e

Distribution & Storage as a Sustainability Lever
Emissions from distribution are mainly driven by the transportation of goods, however the energy consumed at the warehouse or retail locations is also an important factor, especially when refrigeration is involved. Refrigeration at retail has significantly higher emissions than refrigeration at warehouse due to the types of refrigerants used, the distance between refrigeration units and cooling systems, and the high temperature differential and constant exposure to warm air.

Ways to lower the emissions from distribution include reducing the weight of your product, either from ingredients or packaging, or decreasing the miles of air transport required to move product (FACT: air transport has almost 10x the impact as road transport!).

Consumer Use

0.007 kg CO2e

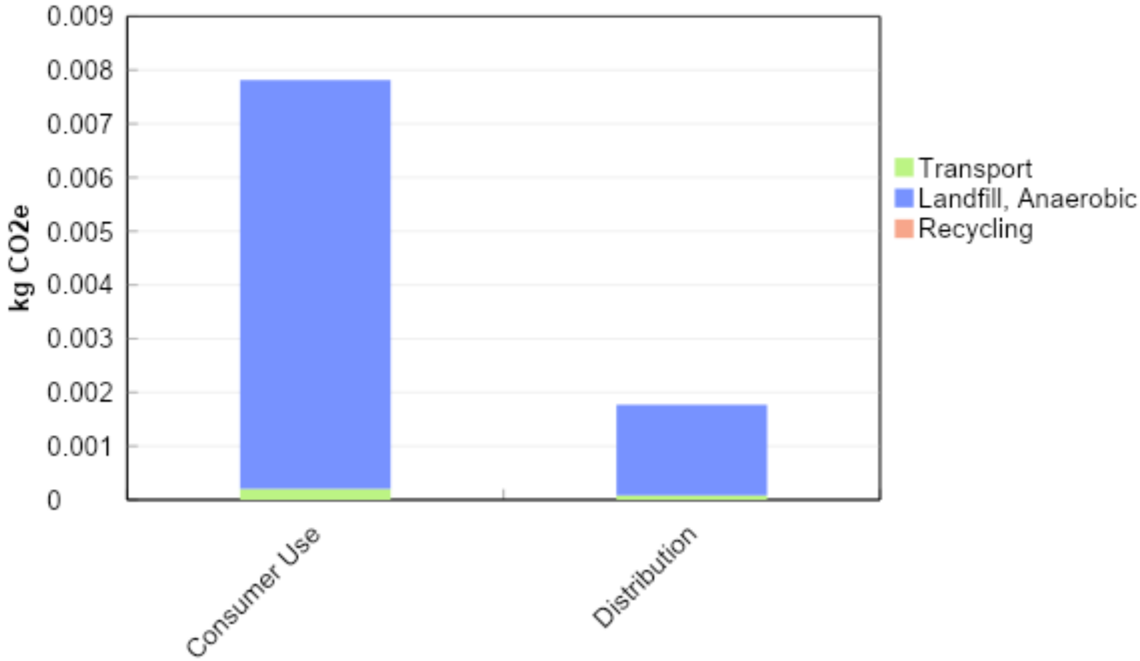


Consumer Use as a Sustainability Lever

A product's carbon footprint doesn't end with the manufacturer. How the consumer is expected to realize product utility can impact the carbon footprint.

End-of-Life

0.010 kg CO2e



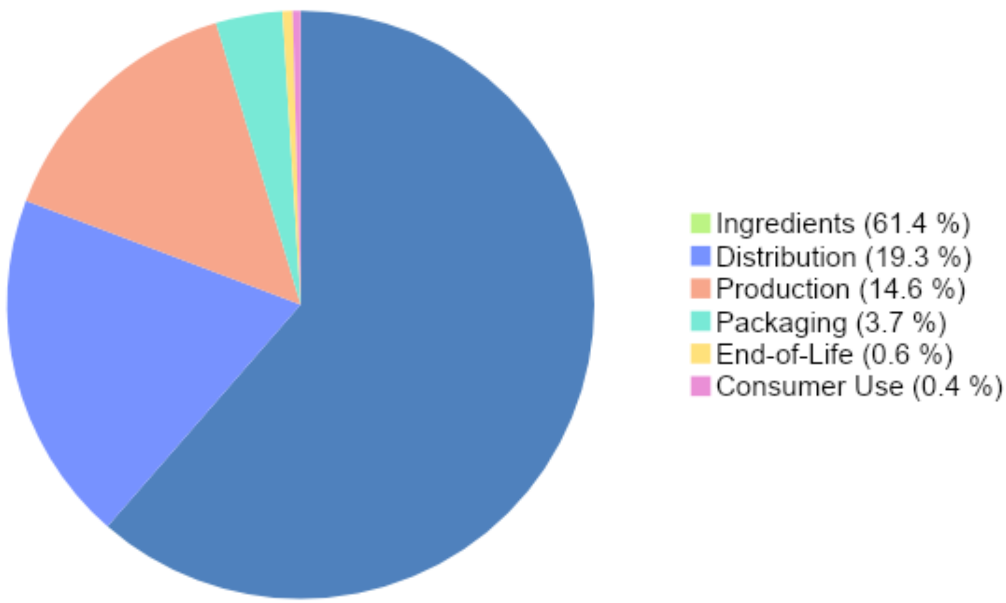
End-of-life as a Sustainability Lever

In most places, we estimate that a portion of recyclable products go to landfill and a portion goes to recycling. Emissions from transportation of recycled materials to the recycling facility are included here, but emissions from recycling are not included in the boundary of this LCA (they would be included as part of the material input emissions of products using the recycled materials). Recycling rates differ by material and by geographic location, as do composting rates, which are generally very low in the US (see our methodology for more details).

Appendix 3. Dairy Milk Ice Cream Formula LCA

The **cradle-to-grave** (through landfill) GHG emissions total is estimated to be **1.702 kg CO2e** for one unit of product, with a reference flow of 0.336 kg per unit.

What is contributing to this footprint?
The total carbon footprint of this product is 1.702 kg CO2e*. The primary components of the cradle-to-grave product-level carbon footprint are ingredients, packaging, processing, distribution, consumer use & end-of-life. Transport is built into ingredients, packaging and distribution and are outlined in each of the sections below.



Top Emissions Drivers

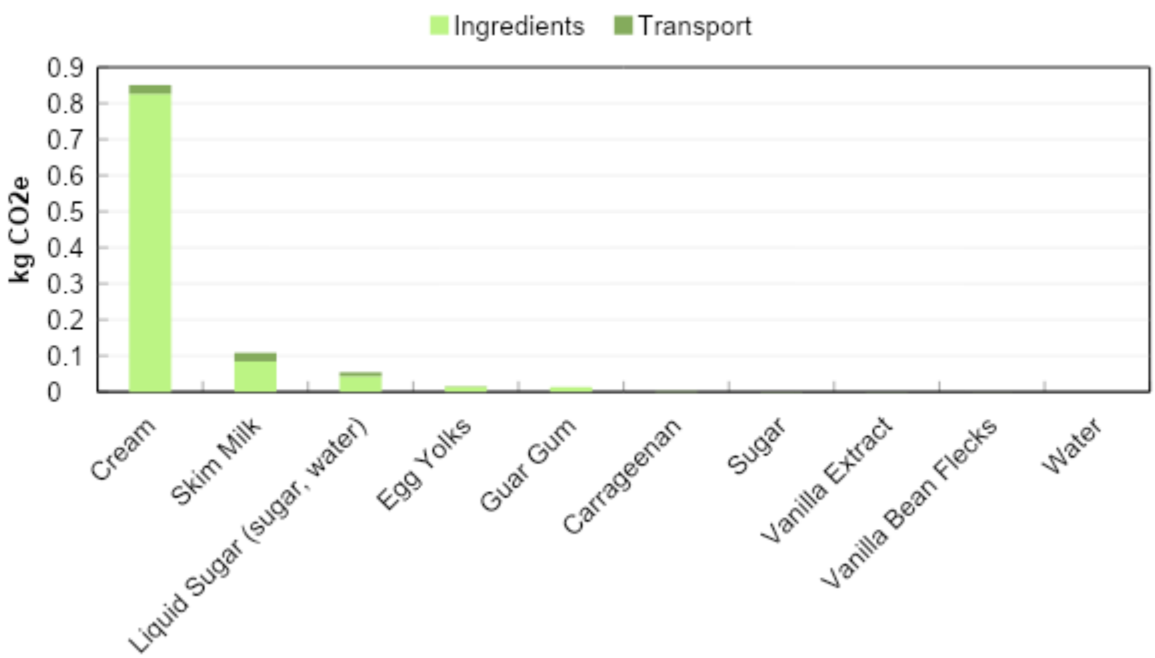
Category	kg CO2e	% of Total
Cream	0.851	50.0 %
Energy – Distribution (cold storage)	0.254	14.9 %
Electricity - Production	0.167	9.8 %
Skim Milk	0.108	6.4 %

What can I do with this number?
According to the GHG Protocol, these numbers cannot be used for comparison to other companies and/or products. Even for similar products, differences in unit of analysis, use and end-of-life stage profiles, and data quality may produce incomparable results. Reach out to Planet FWD for help in making a qualified comparison!

**This footprint includes emissions from other greenhouse gasses, in addition to carbon emissions. Greenhouse gas emissions measurements are normalized to carbon dioxide equivalents, CO2e, based on global warming potential.*

Ingredients

1.045 kg CO2e

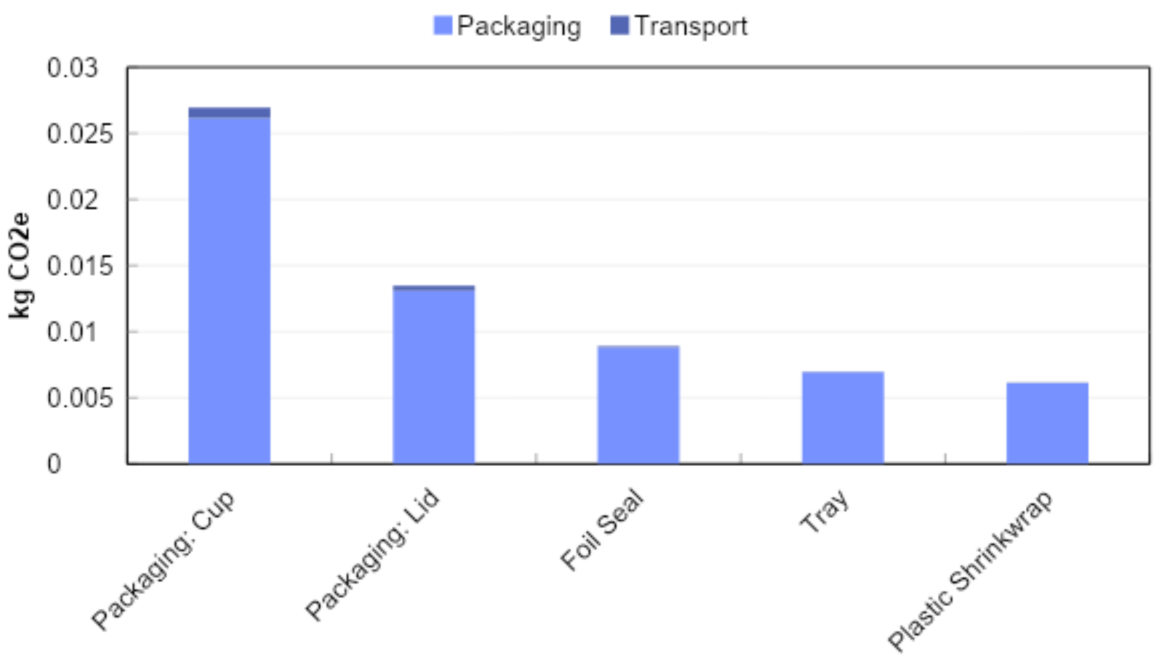


Sourcing as a Sustainability Lever
Ingredient sourcing is one of the most impactful ways to improve the sustainability of your product. As a brand, you can use purchasing power to promote social and environmental sustainability across the supply chain: regenerating ecosystems, providing economic support for a more climate-resilient food system, supporting fair wages and labor conditions, and amplifying BIPOC and women suppliers to advance equity.

Let's break it down!
Your ingredient emissions total is estimated to be 1.045 kg CO2e. GHG emissions for ingredients are driven by the mass of the ingredient in the recipe, emissions intensity of cultivating & processing that ingredient, and the distance and mode of transport. The highest emissions ingredient(s) in this recipe is Cream, making up about 50.0 % of the total emissions.

Packaging

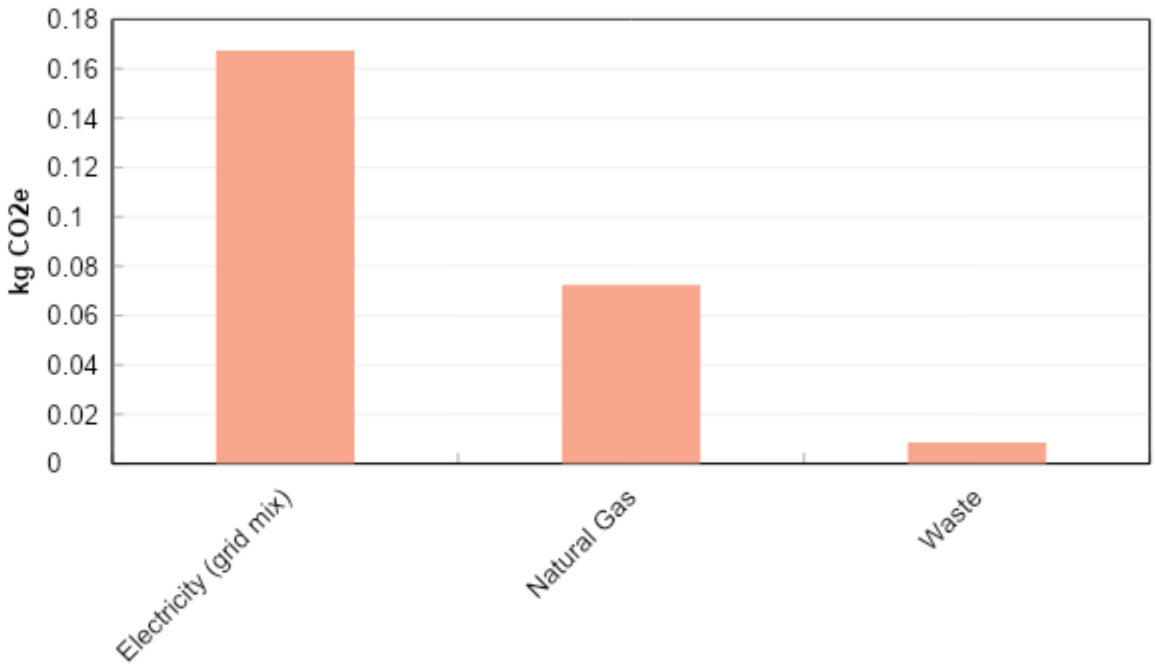
0.062 kg CO2e



Packaging as a Sustainability Lever
Packaging is another key element of product sustainability, and oftentimes one of the most important to consumers as the negative impacts of packaging are highly visible. Consumers want packaging materials that reflect a brand’s environmental commitment whether that comes from sustainability, reuse, recycling, or innovative materials.

Production

0.248 kg CO2e



Production as a Sustainability Lever
Cooking processes also contribute to the sustainability of a product through the energy usage of different methods. It is encouraged to work with processors that include renewable energy in its processing facilities. Even in facilities powered by renewable energy, natural gas is often used for cooking processes. Switching from natural gas to electric from renewables could help address this part of the footprint.

Distribution & Storage

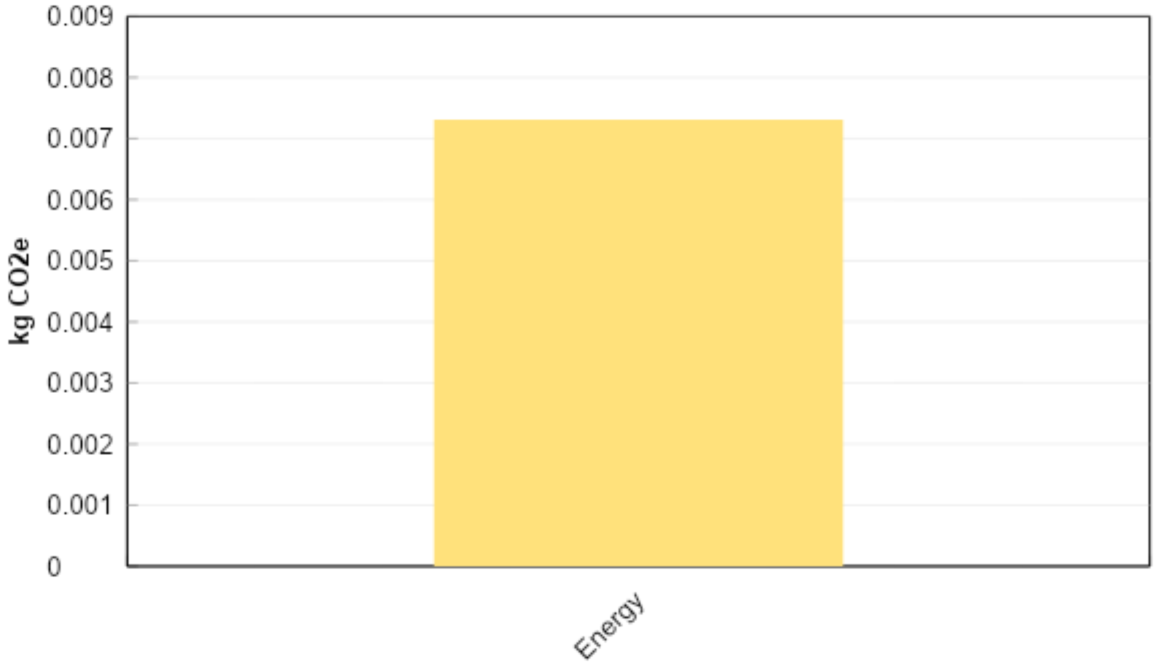
0.329 kg CO2e

Distribution & Storage as a Sustainability Lever
Emissions from distribution are mainly driven by the transportation of goods, however the energy consumed at the warehouse or retail locations is also an important factor, especially when refrigeration is involved. Refrigeration at retail has significantly higher emissions than refrigeration at warehouse due to the types of refrigerants used, the distance between refrigeration units and cooling systems, and the high temperature differential and constant exposure to warm air.

Ways to lower the emissions from distribution include reducing the weight of your product, either from ingredients or packaging, or decreasing the miles of air transport required to move product (FACT: air transport has almost 10x the impact as road transport!).

Consumer Use

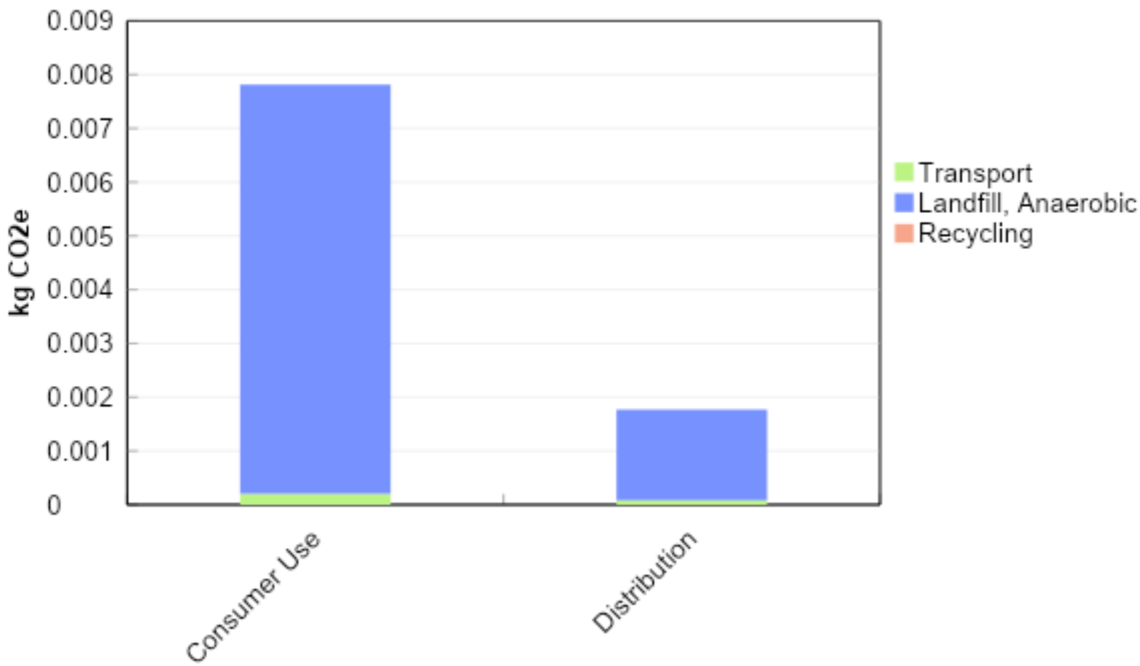
0.007 kg CO2e



Consumer Use as a Sustainability Lever
A product's carbon footprint doesn't end with the manufacturer. How the consumer is expected to realize product utility can impact the carbon footprint.

End-of-Life

0.010 kg CO2e



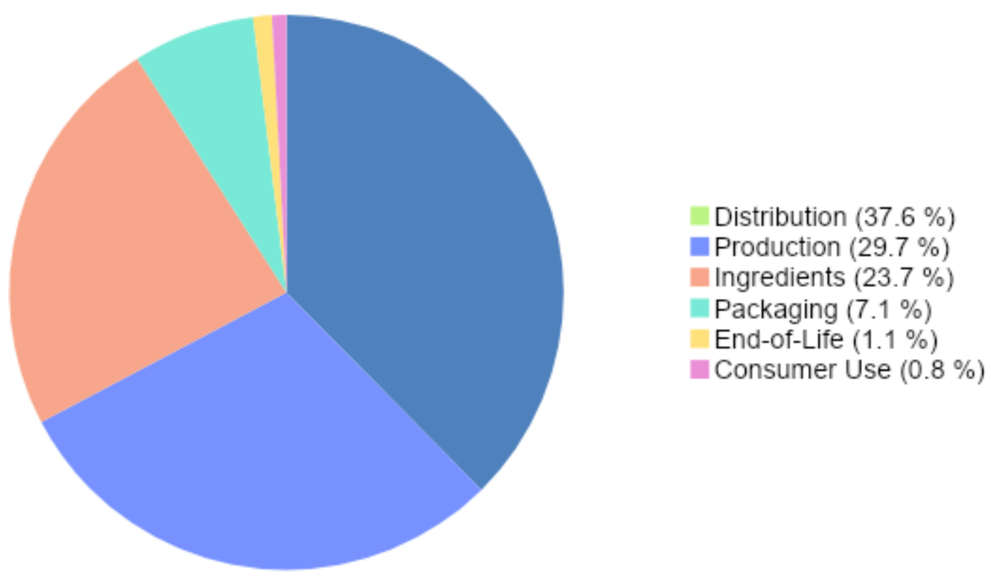
End-of-life as a Sustainability Lever

In most places, we estimate that a portion of recyclable products go to landfill and a portion goes to recycling. Emissions from transportation of recycled materials to the recycling facility are included here, but emissions from recycling are not included in the boundary of this LCA (they would be included as part of the material input emissions of products using the recycled materials). Recycling rates differ by material and by geographic location, as do composting rates, which are generally very low in the US (see our methodology for more details).

Appendix 4. Wildgood Vanilla Bean Ice Cream Product LCA

The **cradle-to-grave** (through landfill) GHG emissions total is estimated to be **0.875 kg CO2e** for one unit of product.

What is contributing to my footprint?
The total carbon footprint of this product is 0.875 kg CO2e*. The primary components of the cradle-to-grave product-level carbon footprint are ingredients, packaging, processing, distribution, consumer use & end-of-life. Transport is built into ingredients, packaging and distribution and are outlined in each of the sections below.



Top Emissions Drivers

Category	kg CO2e	% of Total
Cold Storage - Distribution	0.254	29.1 %
Electricity - Production	0.167	19.1 %
Beet Fructose Powder	0.106	12.1 %
Transport - Distribution	0.074	8.5 %
Natural Gas - Production	0.072	8.3 %

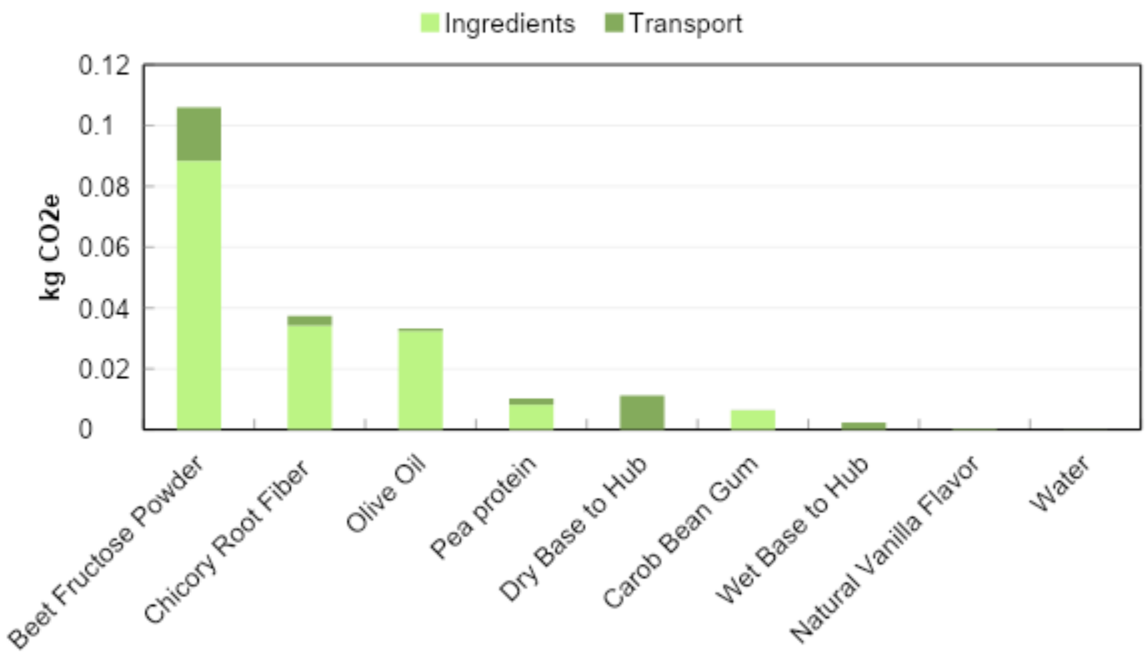
What can I do with this number?
Use it to inform targeted sustainability improvements, share your footprint with consumers to promote transparency, or consider creating a climate action plan & offsetting unavoidable emissions to make this product carbon neutral.

According to the GHG Protocol, these numbers cannot be used for comparison to other companies and/or products. Even for similar products, differences in unit of analysis, use and end-of-life stage profiles, and data quality may produce incomparable results. Reach out to Planet FWD for help in making a qualified comparison!

**This footprint includes emissions from other greenhouse gasses, in addition to carbon emissions. Greenhouse gas emissions measurements are normalized to carbon dioxide equivalents, CO2e, based on global warming potential.*

Ingredients

0.207 kg CO2e

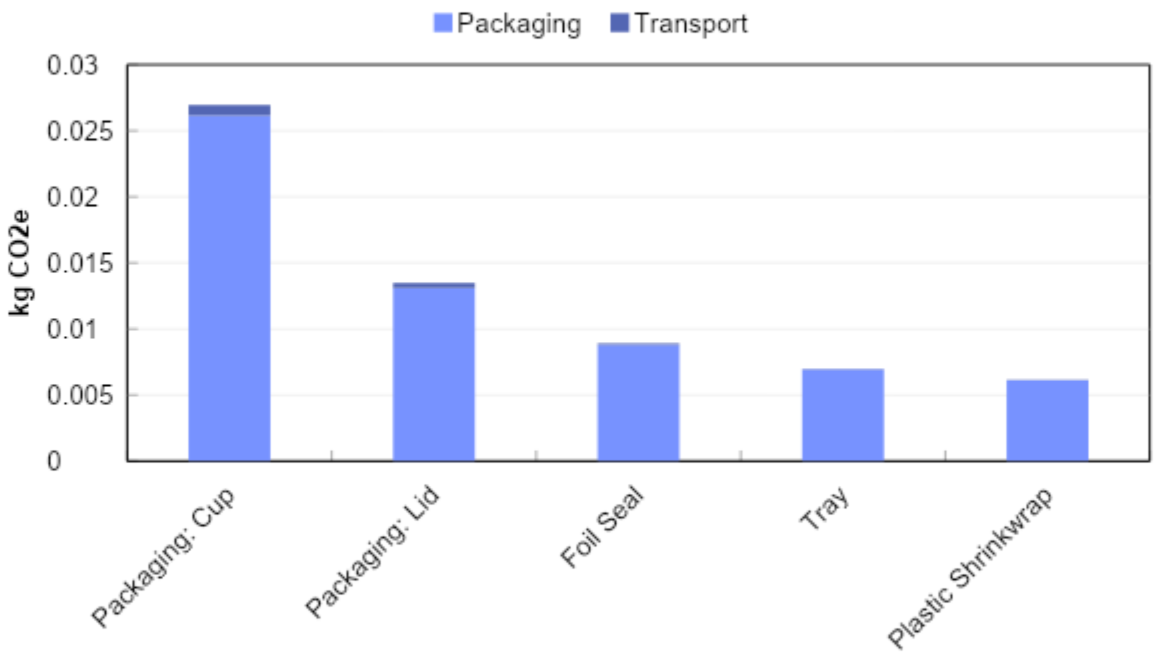


Sourcing as a Sustainability Lever
Ingredient sourcing is one of the most impactful ways to improve the sustainability of your product. As a brand, you can use purchasing power to promote social and environmental sustainability across the supply chain: regenerating ecosystems, providing economic support for a more climate-resilient food system, supporting fair wages and labor conditions, and amplifying BIPOC and women suppliers to advance equity.

Let's break it down!
Your ingredient emissions total is estimated to be 0.207 kg CO2e. GHG emissions for ingredients are driven by the mass of the ingredient in the recipe, emissions intensity of cultivating & processing that ingredient, and the distance and mode of transport. The highest emissions ingredient in this recipe is Beet Fructose Powder, making up about 51.2 % of the total ingredients emissions.

Packaging

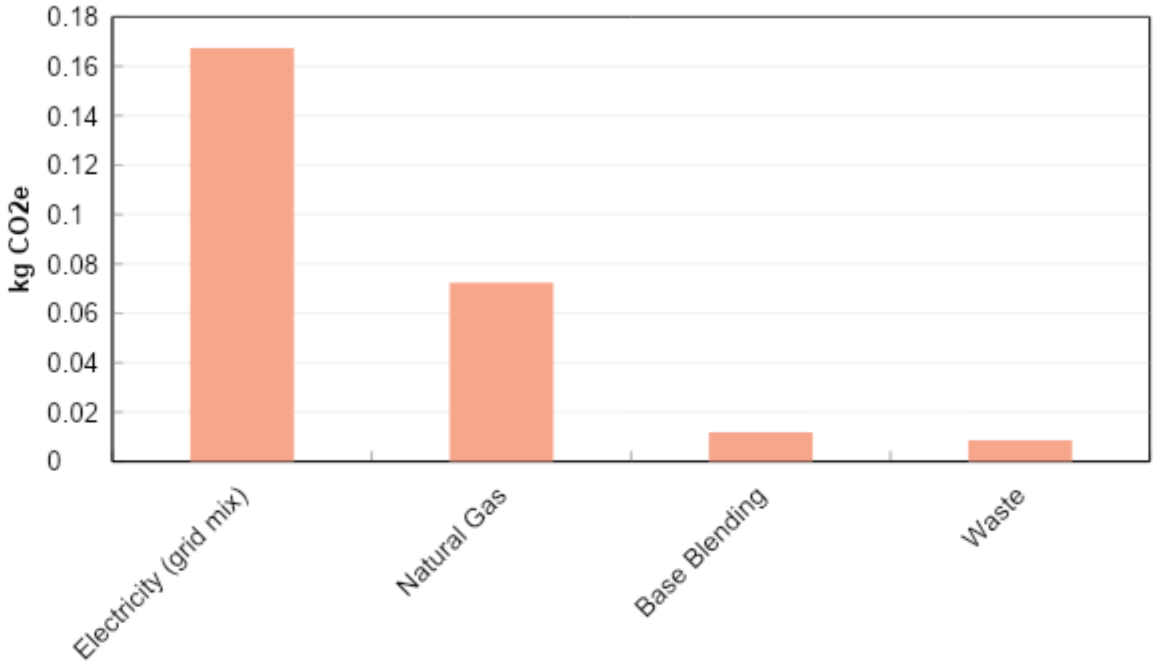
0.062 kg CO2e



Packaging as a Sustainability Lever
Packaging is another key element of product sustainability, and oftentimes one of the most important to consumers as the negative impacts of packaging are highly visible. Consumers want packaging materials that reflect a brand's environmental commitment whether that comes from sustainability, reuse, recycling, or innovative materials.

Production

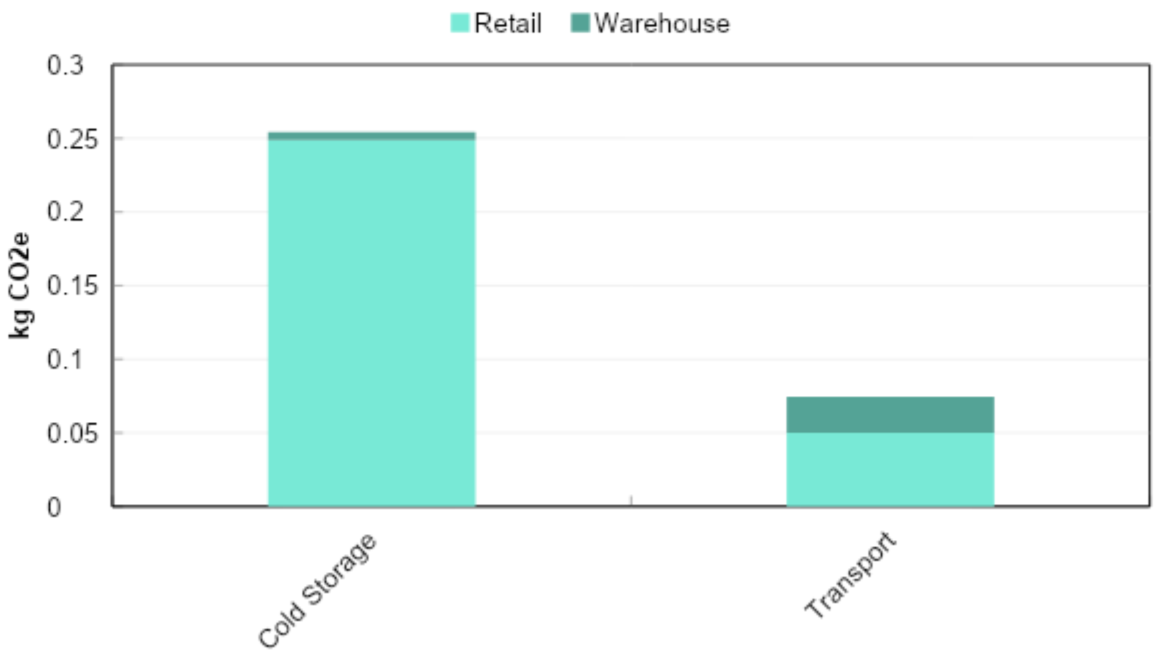
0.260 kg CO2e



Production as a Sustainability Lever
Cooking processes also contribute to the sustainability of a product through the energy usage of different methods. It is encouraged to work with processors that include renewable energy in its processing facilities. Even in facilities powered by renewable energy, natural gas is often used for cooking processes. Switching from natural gas to electric from renewables could help address this part of the footprint.

Distribution & Storage

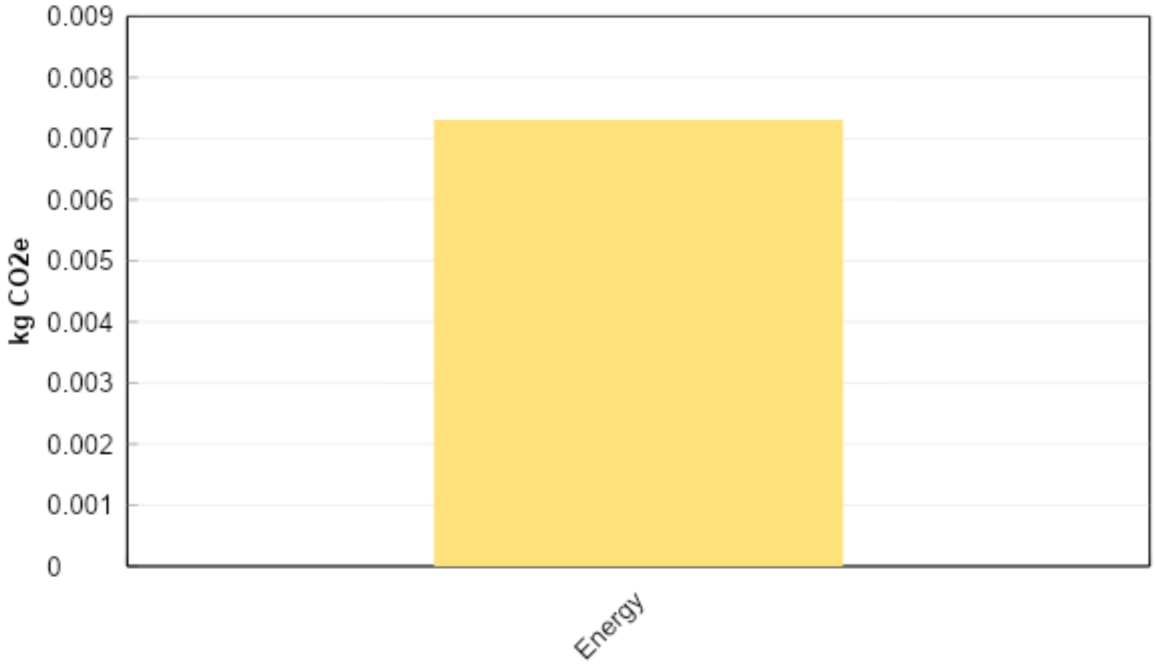
0.329 kg CO2e



Distribution & Storage as a Sustainability Lever
Emissions from distribution are mainly driven by the transportation of goods, however the energy consumed at the warehouse or retail locations is also an important factor, especially when refrigeration is involved. Ways to lower the emissions from distribution include reducing the weight of your product, either from ingredients or packaging, or decreasing the miles of air transport required to move product (FUN FACT: air transport has almost 10x the impact as road transport!!).

Consumer Use

0.007 kg CO2e

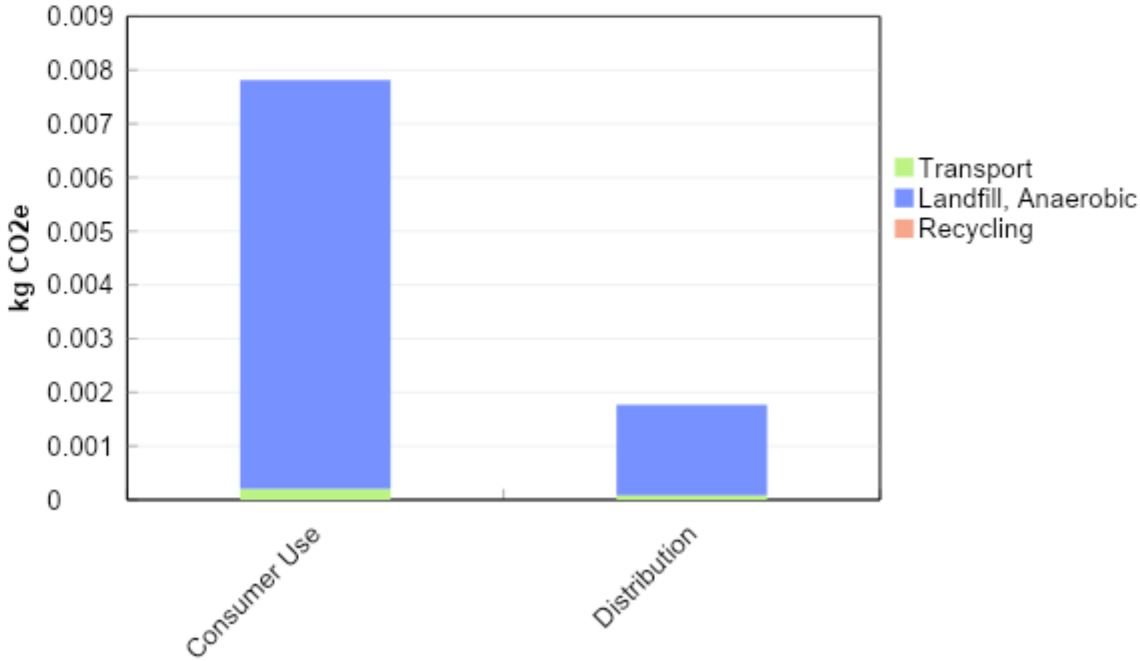


Consumer Use as a Sustainability Lever

A product's carbon footprint doesn't end with the manufacturer. How the consumer is expected to realize product utility can impact the carbon footprint.

End-of-Life

0.010 kg CO2e



End-of-life as a Sustainability Lever
In most places, we estimate that a portion of recyclable products go to landfill and a portion goes to recycling. Recycling rates differ by material and by geographic location, as do composting rates, which are generally very low in the US (see our methodology for more details).

Appendix 5. Reporting Requirements & Methodology for Product LCAs

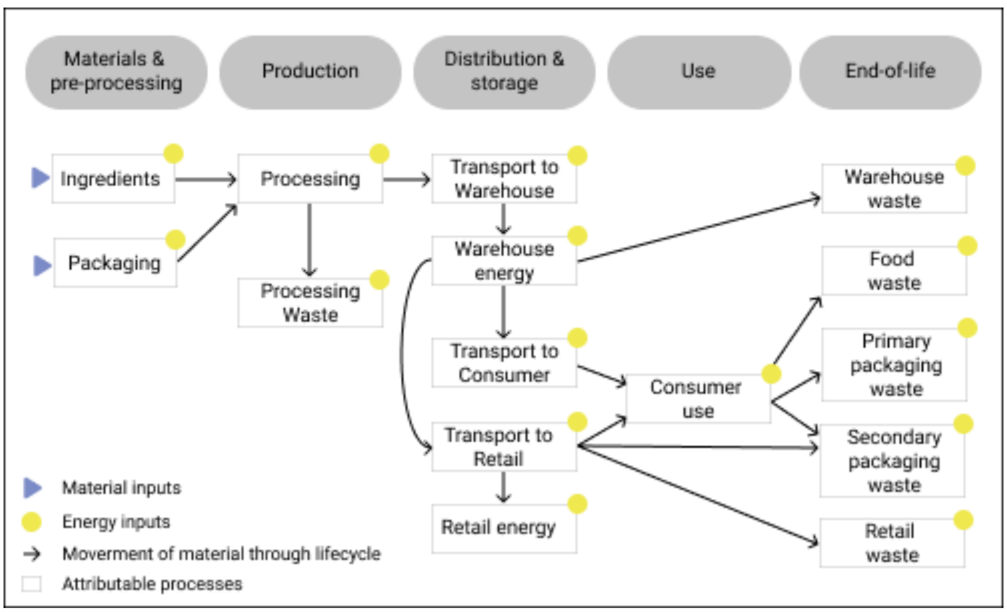
A. Goal, Scope Definition, and Assurance

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, 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 (Oat Milk Ice Cream: Appendix 1, Coconut Milk Ice Cream: Appendix 2, Dairy Milk Ice Cream: Appendix 3, and Wildgood Ice Cream: Appendix 4). The **reference flow** is 0.336 kg in all four cases. The **system boundary** is 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 annually 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

This study has undergone critical review through independent internal experts at Planet FWD.

LCA commissioner: Wildgood
LCA practitioner: Radmila Vlastelica
Reviewer: Miranda Gorman
Assurance type: First party (Planet FWD)
Level of Assurance: Reasonable 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.

> "In the opinion of the assurance provider the reporting company's assertion that the inventory product's emissions are fairly stated, in all material respects, and is in conformance with Planet FWD's product LCA methodologies, which are in conformance with the GHG Protocol Product Life Cycle Accounting and Reporting Standard with the exception listed in section 1 (separate reporting of biogenic emissions and carbon contained in the product not released during waste treatment)."

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; PAS 2050; 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 CO_2, CH_4, N_2O, and HFCs. Global warming potentials for greenhouse gasses are based on the IPCC Fifth Assessment Report (AR5) (Global Warming Potential Values).

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 seadistances.org and is augmented with any road transport using above methods to get from start to end points. Emissions factors are described here and for cold transport, augmented with fuel demand required for refrigeration/freezing with data from Energy Star.

Emissions factors are described here and for cold transport, 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.

Planet FWD carbon assessments allocate resource use and emissions between co-products by using mass-weighted economic value or a biophysical measure (such as mass, energy or nutrition content) as appropriate. 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.

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 such as buildings and equipment used in the product lifecycle is excluded from the LCAs. This is a common practice in product LCAs and compliant with the PAS 2050 standard.

B.7 Non-product outflows
Both solid waste and waste water streams are modeled in detail based on methodologies and parameters adapted from IPCC tier 1/2 for a broad range of industries. 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 CleanMetrics CarbonScopeData life-cycle inventory (LCI) database.
    - Transportation of materials to the production site are calculated using the methodology outlined in section B.4 Transport Methodology.
    - Where indicated, soil carbon change as a result of land-use practices are included in the inventory results following GHG Protocol Agriculture Guidance and IPCC Guidelines (2019 Refinement) Tier 1 calculation methodology.

- 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.
- Data Sources and Methodology
  - The CarbonScopeData LCI 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 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 IEA for international energy demand and USEPA data (available at USLCI) 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 5% 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 and NRDC.
    - 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 described on page 11. See above life cycle stage notes on data quality and methods to improve data quality.

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