PRODUCT CARBON FOOTPRINT ANALYSIS

A note to readers of this report,

Product Carbon Footprint (PCF) and Life Cycle Analysis (LCA) are valuable tools for understanding the carbon impacts of products and materials. Their efficacy, however, is highly dependent on the quality of the data used to generate the charts and graphs that fill reports like this one.

In 2011, Eco-Products set a new standard for the industry by making custom carbon footprint reporting available to all our customers, and we offered the service for over a decade until it became clear that our models needed updating. We spent over two years studying the inputs, databases, calculations and outputs of most of the models in use today, and have identified substantial data gaps up and down the value chain for compostable products and materials. As a result, some of the charts and graphs generated by the tool we worked so hard to build are at odds with things we know to be true about our products and the materials they are made from.

Examples of Data Gaps Identified in Our Process

Raw Material	Life Cycle Phase	Potential Change to kg CO2e Impact
Molded Fiber	Manufacturing	75% Reduction in Manufacturing Phase Impact
PLA	Raw Material	64% Reduction in Raw Material Phase Impact
PLA	EOL - Typical	97% Reduction in EOL Typical Phase
PLA	EOL - Compost	Not yet resolved – working on update
All Materials	EOL - Compost	Not yet resolved – working on update

For a more detailed visual of these updates, please review the graphs on page 4 of this report.

The chart above details the five most significant data gaps we've identified in our work so far. The first two have been addressed by using primary data from our supply chain rather than the proxy data relied on by the databases, and our modeling partner made an update to their inputs that helped address the third. It is critical to note that these updates have only been applied to the Eco-Products model, and other tools drawing on the proxy data will produce different information than what we are reporting. We have not been able to resolve the remaining data gaps as of yet, and are reporting the information as it stands today knowing updates are required.

The only way to make the models better is to improve the data they rely on, either by identifying existing studies that have yet to be included, or by commissioning new research. And we can't forget that compostable products and materials are very much an emerging technology; even the most accurate data by today's standards will become outdated quickly as scale and efficiencies increase.

Eco-Products is committed to addressing the data gaps that exist up and down the value chain for compostable products and materials. We will be updating our models regularly as new information becomes available.

We have made the decision to share this imperfect information publicly in an effort to bring awareness to the danger of using it as a standalone decision-making tool. Every consultant, researcher, and impact professional we know has their own way of expressing the "grain of salt" factor that should be applied to reports like these. "It's a compass, not a map", is a phrase we've grown to like. Tools like ours provide directional information, but can't get you home the same way a map can.

So, thanks for engaging with us on this important topic, and enjoy your journey through the data as it exists today. While we don't have the whole map either, we've got a lot more to share and would love to hear about your travels thus far.

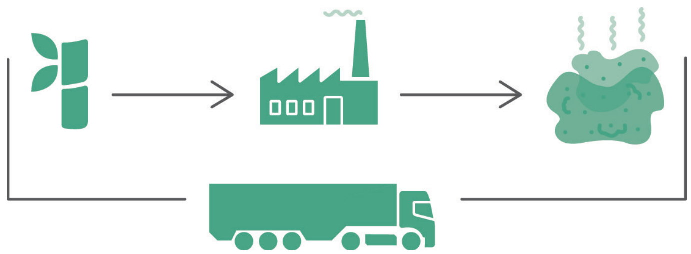
Best Regards,
Megan Jorgensen
Sustainability Maven
Eco-Products

What is a Product Carbon Footprint Analysis?

A Product Carbon Footprint (PCF) measures the carbon impacts of a product. To determine the greenhouse gas (GHG) emissions associated with our product impacts, carbon dioxide equivalent (CO2e) values are measured through the evaluation of the inputs, outputs, and potential environmental impacts of a product throughout its entire life cycle.

The Eco-Products Approach to Product Carbon Footprint Analysis

Eco-Products conducts its Product Carbon Footprint analysis through a **Cradle-to-Grave** approach, meaning we consider the entire life cycle of the product. This includes inputs from Raw Materials --> Manufacturing Process --> Product Secondary Packaging --> End-of-Life Scenarios. We map out this process to include transportation impacts during and between each phase as well. If we plan to share data in a different boundary, we will always be transparent on the boundary of PCF data shared.



Eco-Products partnered with a third-party consultant to build our Product Carbon Footprint database, which is supported by the EcoImpact-COMPASS platform. A mix of primary and secondary data were used to feed the database, and CO2e values were mostly determined through secondary data available in the ecoinvent database. Considering our global supply chain, some assumptions were made for select product families that are manufactured in multiple locations.

PCF data in this report are presented in Global Warming Potential (GWP) with Carbon Uptake.

How do our products stack up against others?

Product Carbon Footprint data provided by companies like Eco-Products should typically not be directly compared to data provided by other companies who manufacture similar products. This caution is rooted in the varying PCF approaches taken by companies in defining:

- Goal, Scope or System Boundary
- Process for determining data inputs, which can vary in detail and between the use of primary and secondary data

Eco-Products refrains from providing direct comparisons between our products and that of another company for these reasons.

You may be more familiar with the term "LCA" which stands for Life Cycle Analysis. An LCA has the capability to review several impacts of a product such as freshwater eutrophication, global warming potential, and mineral resource use. Since we are highlighting the indicator of ***Global Warming Potential (GWP)*** *in this analysis, we use the term* ***Product Carbon Footprint (PCF)*** *as a more technically accurate term for the data presented in this analysis.*

Product Carbon Footprint calculations contain data that may evolve over time. The information presented in this report is a snapshot of data available to Eco-Products at the time this report was published. Updated information may be available in the future.

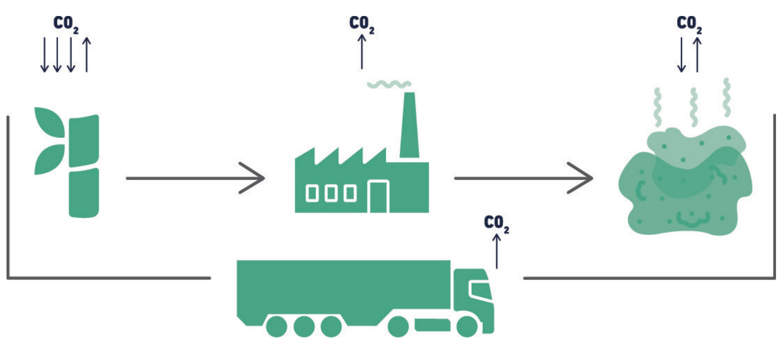
PCF data is just one factor to help make decisions about impacts of products. There are other externalities associated with products that may be factors in determining the environmental impact of products.

What is GWP with CO2 Uptake?

Global Warming Potential (GWP) is a measurement that provides the carbon equivalent (CO2e) impact of a product throughout its life cycle. It can be measured both with carbon uptake included, or without carbon uptake included. Carbon uptake is essentially carbon sequestration, which is *the capturing, removal and storage of CO2 from the earth's atmosphere*. Depending on the raw material and how it is grown or harvested, it may provide climate benefits by sequestering carbon from the atmosphere while still in its plant form.

We mainly provide PCF data measured by GWP with Carbon Uptake, but make comparisons to how different the CO2e value would be if measured by GWP without Carbon Uptake, which does not include carbon sequestration or biogenic carbon emissions in its calculation.

Example of GWP with CO2 Uptake:



[2] https://drawdown.org/solutions/composting#:~:text=For%20every%20million%20metric%20tons,by%20more%20than%2050%20percent.)
[3] Elisabeth C. Van Roijen, Sabbie A. Miller, A review of bioplastics at end-of-life: Linking experimental biodegradation studies and life cycle impact assessments, Resources, Conservation and Recycling, Volume 181, 2022, 106236, ISSN 0921-3449,
https://doi.org/10.1016/j.resconrec.2022.106236
(https://www.sciencedirect.com/science/article/pii/S0921344922000842)
[4] https://www.compostingcouncil.org/page/CompostBenefits

Why GWP WITH CO2 Uptake Should Not be the Only Environmental Consideration – Especially for Compost EOL

Global Warming Potential (GWP) with Carbon Uptake is a valuable LCA indicator used to understand carbon impacts of different products and processes. However, additional considerations should be applied if attempting to use this indicator as a decision-making tool across a variety of raw materials, especially as related to compost as an end-of-life scenario for plant-based raw materials.

Why? Plant-based raw materials sequester CO2 from the atmosphere during their growth phase, typically resulting in a reduced raw material phase value when measured through the indicator of GWP with CO2 Uptake. Naturally, most of this carbon is then released back into the atmosphere and soil when it is composted, resulting in CO2 emissions during the end-of-life phase.

What environmental impacts does GWP with CO2 Uptake *not* include?

- GHG emissions reduced due to the food scraps that are often sent to compost facilities along with compostable foodservice products. **Food that is sent to compost facilities instead of landfills reduces GHG emissions associated with the disposal of food waste by more than 50%[2].**
- Climate benefits of producing compost from food and compostable products, ultimately **harnessing embedded resources to create compost rather than 'wasting' them in a landfill[3]**. Benefits include[4]:
  - » Improved soil health
  - » Water retention, assisting in stormwater management
  - » Increased crop yields if compost is used in farming applications
  - » Reduced need for chemical fertilizer production and application
  - » Carbon sequestration, when finished compost is applied to land. An additional carbon reduction associated with composting that should be considered.

Since many LCA studies do not include externalities outside of typical LCA indicators, **it is critical to consider a variety of additional impacts associated with different raw materials and their end-of-life scenarios used for foodservice packaging.**

LEARN: PRODUCT CARBON FOOTPRINT ANALYSIS

Evolving PCF Data

Product Carbon Footprint data collection and modeling for molded fiber and bioplastics is in its infancy, and the models in use today are constantly evolving as new data become available and scale improves.

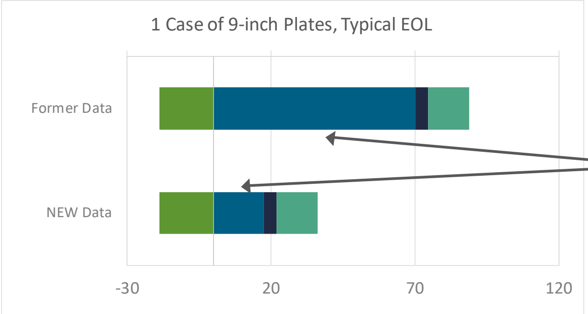
End-of-life data for composting is a particular challenge. In a recent scientific review of 49 studies analyzed to understand accuracy of end-of-life modeling in LCA studies, the most represented waste treatment option included was waste incineration, following by mechanical recycling and landfilling, with only 15 studies including industrial composting. Due to differences in scope and method, emissions associated with different end-of-life scenarios sometimes differed by up to 500%.[1]

Examples of Identified Data Gaps

And, how drastically data can change with more relevant information.

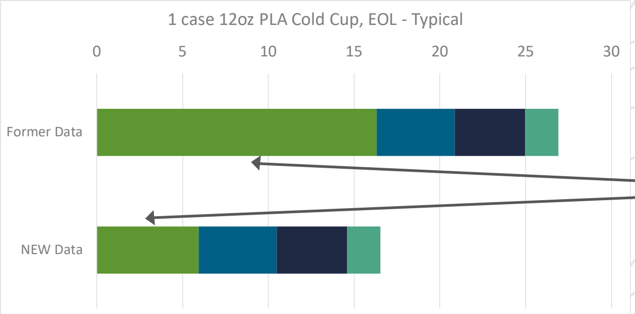
KEY **All data is showing Global Warming Potential (GWP) with CO2 Uptake in kg CO2e.**
Material | Manufacturing | Transportation | End of Life

Molded Fiber Manufacturing Phase Update



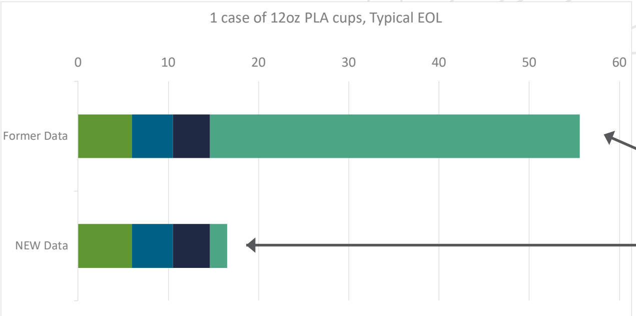
Primary data from Eco-Products manufacturing partners provides **a 75% reduction** in the manufacturing phase for wet molded fiber.

PLA Raw Material Phase Update



Primary data from Eco-Products PLA raw material suppliers provides **a 64% reduction** in the raw material phase for PLA.

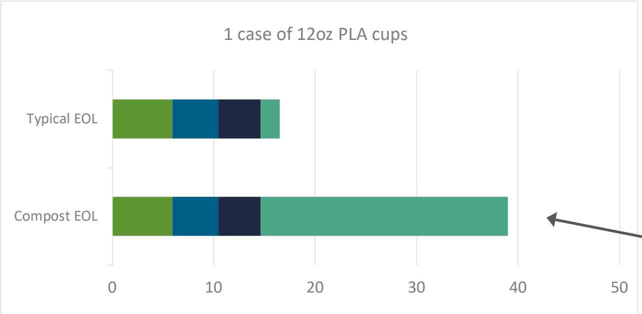
PLA EOL - Typical Phase Update



Trayak updated its input information for EOL – Typical phase for PLA, providing **a 97% reduction** in EOL – Typical phase impact.

PLA EOL – Compost Phase - Unresolved

Not yet resolved and updates will be forthcoming. The current model has a logical inconsistency which shows the carbon emitted from PLA in the EOL - Compost phase to be larger than the amount of carbon sequestered during the raw material phase.



We believe updates are required for Compost EOL across all compostable products, especially PLA. We assume updates will reduce this value.

[1] Felicitas Pellengahr, Ali Ghannadzadeh, Yvonne van der Meer, How accurate is plastic end-of-life modeling in LCA? Investigating the main assumptions and deviations for the end-of-life management of plastic packaging,Sustainable Production and Consumption, Volume 42, 2023, Pages 170-182, ISSN 2352-5509, https://doi.org/10.1016/j.spc.2023.09.014
(https://www.sciencedirect.com/science/article/pii/S235255092300221X)

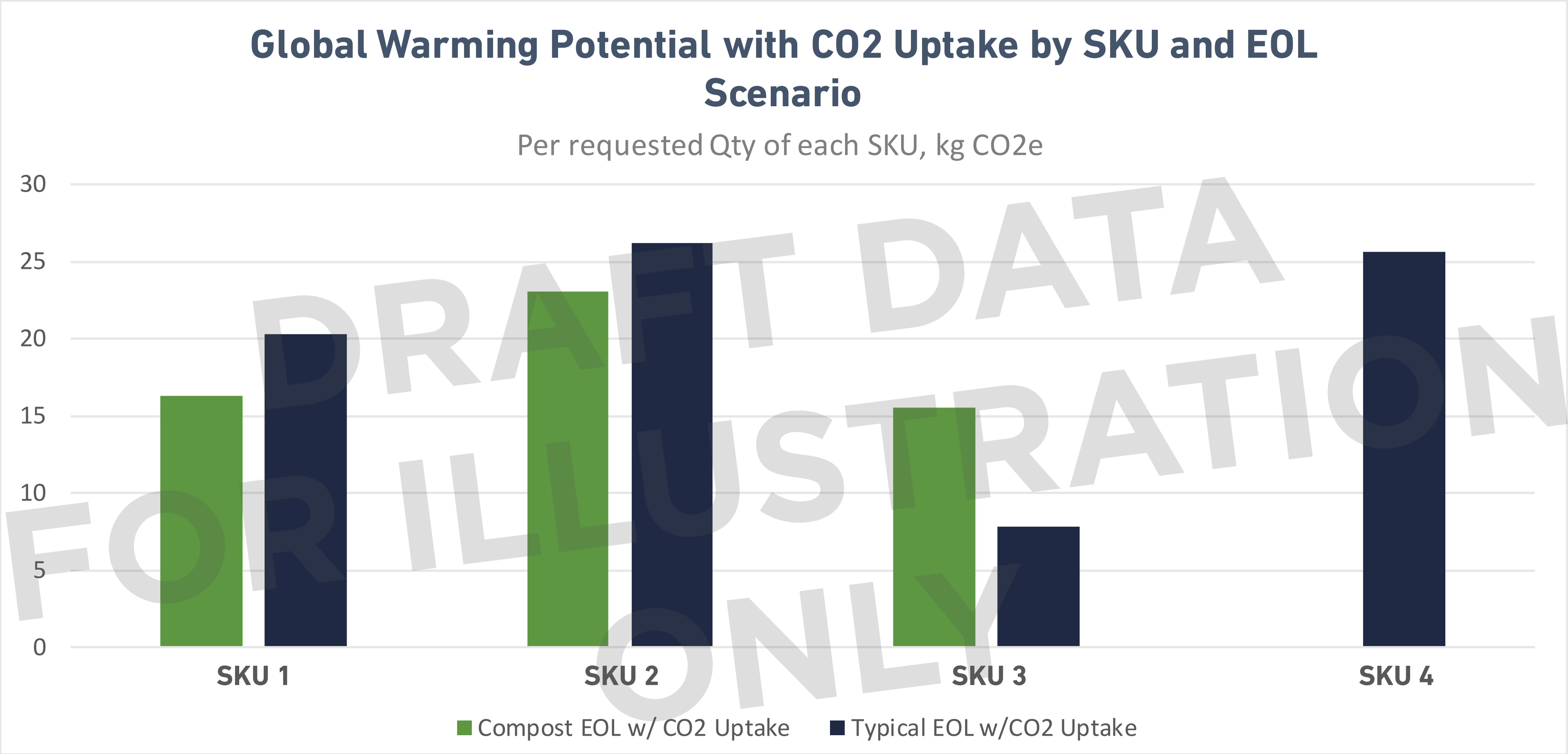
GWP *with* CO2 Uptake

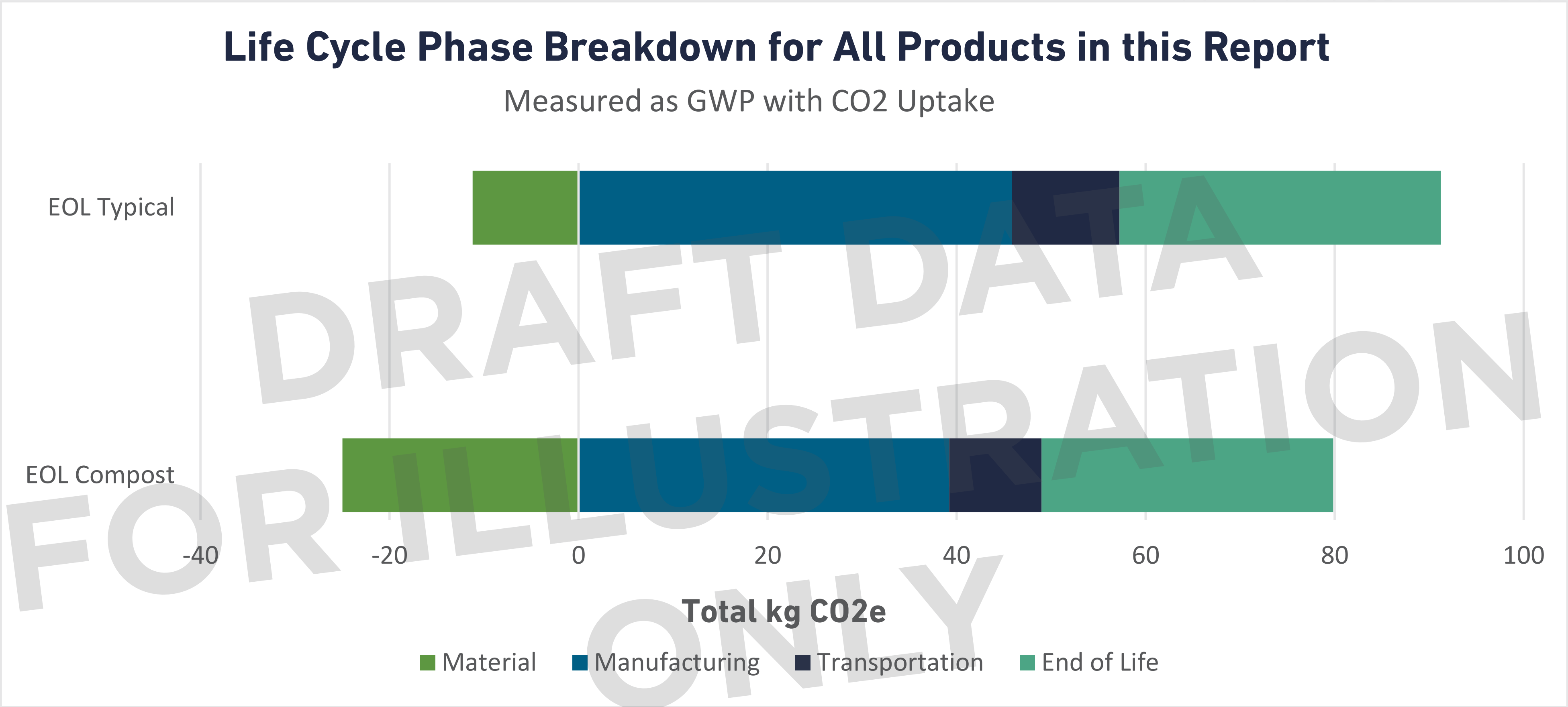
Global Warming Potential (GWP) with Carbon Uptake considers the total quantity of greenhouse gases (GHG) emitted throughout the life cycle reported in kilograms of CO2 equivalents. This calculation follows the IPCC Sixth Assessment Report (AR6) 2021 100a w/ CO2 Uptake method. It considers global warming potential for a 100-year timeframe. **This indicator also accounts for carbon sequestration and biogenic carbon emissions.**

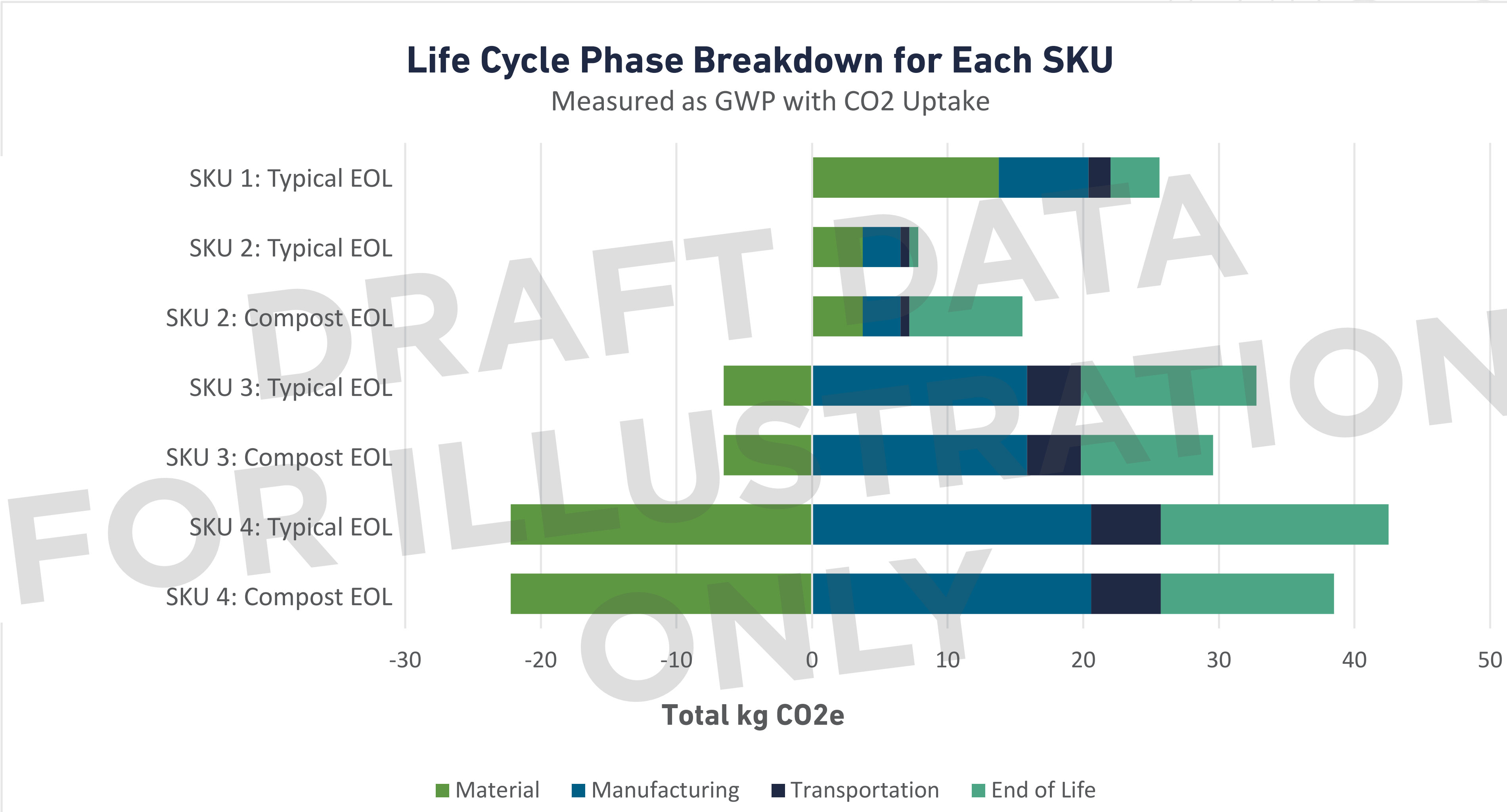
GWP WITH CO2 UPTAKE				EOL COMPOST*		EOL TYPICAL**	
ITEM #		UNITS PER CASE	# OF CASES	kg CO2e PER 1 CASE	kg CO2e PER # OF CASES	kg CO2e PER 1 CASE	kg CO2e PER # OF CASES
SKU 1		400	1	16.27	16.27	20.29	20.29
SKU 2		400	1	23.05	23.05	26.25	26.25
SKU 3		200	1	15.51	15.51	7.84	7.84
SKU 4		400	1	N/A	N/A	25.62	25.62
	TOTAL	**1400**	**4**	**54.83**	**54.83**	**80**	**80**

***EOL Compost (End-of-Life Compost):** The entire case impact includes the secondary packaging of the corrugated cardboard and polyethylene sleeves used for food contact safety. This end-of-life scenario includes all materials in the cases included in this volume report, and assumes that the following end-of-life scenarios occur for the entire case contents: 92% compost, 6.6% recycling, .28% Waste to Energy and 1.12% Landfill.

****EOL Typical (End-of-Life for Typical "Trash" disposal):** The entire case impact includes the secondary packaging of the corrugated cardboard and polyethylene sleeves used for food contact safety. This end-of-life scenario includes all materials in the cases included in this volume report. A "typical" disposal of this product is calculated through national averages, and without compost as an option, and is assumed as: 6.8% recycling, 18.84% waste to energy, and 74.55% landfill.


Global Warming Potential with CO2 Uptake by SKU and EOL Scenario
Per requested Qty of each SKU, kg CO2e
30
25
20
15
10
5
0
SKU 1
SKU 2
SKU 3
SKU 4
Compost EOL w/ CO2 Uptake
Typical EOL w/CO2 Uptake
DRAFT DATA FOR ILLUSTRATION ONLY


Life Cycle Phase Breakdown for All Products in this Report
Measured as GWP with CO2 Uptake
EOL Typical
EOL Compost
-40
-20
0
20
40
60
80
100
Total kg CO2e
Material
Manufacturing
Transportation
End of Life
DRAFT DATA FOR ILLUSTRATION ONLY


Life Cycle Phase Breakdown for Each SKU
Measured as GWP with CO2 Uptake
SKU 1: Typical EOL
SKU 2: Typical EOL
SKU 2: Compost EOL
SKU 3: Typical EOL
SKU 3: Compost EOL
SKU 4: Typical EOL
SKU 4: Compost EOL
-30
-20
-10
0
10
20
30
40
50
Total kg CO2e
Material
Manufacturing
Transportation
End of Life

Comparison between GWP with Carbon Uptake and GWP without Carbon Uptake

Data values for all SKUs and case counts requested in this report	EOL Compost kg CO_2e per # of Cases	EOL Typical kg CO_2e per # of Cases
GWP WITH CO_2 Uptake	54.83	80
GWP WITHOUT CO_2 Uptake	93.27	131.33
Difference	-38.44	-51.33

Carbon Comparisons Between Our Products and Other Emitters of GHG

When these products have a typical EOL (as explained on pg. 2 of this report), their total GWP with Carbon Uptake = **80kg CO_2e**.

80kg CO_2e is equivalent to the GHG emissions associated with:

205 miles driven by an average gasoline-powered passenger vehicle

The electricity required to charge 5.281 smartphones

0.01 of the average homes' electricity use for one year

*These GHG equivalencies are calculated using the EPA GHG Equivalencies Calculator

Raw Materials

MOLDED FIBER
Our molded fiber products are made from a blend of sugarcane and bamboo.

Sugarcane is a renewable, plant-based resource that is grown primarily for cane juice extraction. Once the juice is extracted, the remaining sugarcane fiber, known as bagasse, is commonly incinerated or discarded.

Bamboo is the fastest growing plant in the world and is considered a rapidly renewable resource with many climate benefits.

POST-CONSUMER RPS (POST-CONSUMER RECYCLED POLYSTYRENE)
Polystyrene (PS) is a common petroleum-based plastic that can be identified using resin code #6. Just as with rPET, we use the highest amount of rPS that we possibly can in the different products we make from this material.

PLA (POLYLACTIC ACID)
PLA is derived from plants like corn, sugarcane or cassava. These plant-based starches are processed into a biopolymer that looks, acts, and performs like a traditional petroleum-based plastic.

WOOD
We use birch wood for wooden cutlery and stir sticks. Wood is a plant-based renewable resource that is compostable at end of life.

PAPERBOARD
Paper is a plant-based, renewable resource produced from trees. It is compostable at end of life, and occasionally recyclable depending on food residue and acceptance in local programs.

To learn more about how we think about our products, how we approach environmental impacts of our products and services, and how to use this information please visit ecoproducts.com/productcarbonfootprint