LEVERAGING LCA'S FOR PACKAGING OPTIMIZATION

A CASE STUDY

TRAYAK
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THE PACKAGING PROBLEM

Our current packaging system has created one of the most persistent and perilous forms of pollution of our time. The single-use packaging we rely on in our daily lives is incredibly resource-intensive to produce, extremely hard to get rid of, and toxic to both people and the planet. Our oceans, landfills, streets, and waterways have become overwhelmed with waste, forcing us to reimagine our relationship with and reliance on packaging.

As society continues to reckon with our packaging crisis it has become clear that we need a solution to the linear 'take, make, waste' model we have all become accustomed to. Businesses are prompting a paradigm shift as they reevaluate the ways that they design, produce, and package the products we use in our daily lives, embracing principles of regeneration and circularity at each step of a package's lifecycle. However, making this transition is complex, nuanced, and technical. Using tools like materiality assessments combined with LCAs allows brands to harness the power of data to make informed decisions and ultimately guide their path towards greater package sustainability.

USING LCA'S TO MAKE DATA INFORMED DECISIONS

Life Cycle Assessments (LCAs) are powerful tools that can be used to make holistic decisions about products, services, and policies by evaluating the environmental impacts associated with a package throughout its entire life cycle. LCAs can be utilized to identify hotspots, visualize tradeoffs, substantiate environmental claims, and more. These analyses are conducted by gathering science-based data about the environmental impacts of a product throughout its life cycle; however, it's important to note results depend on assumptions and system boundaries of the LCA model.

THE LCA PROCESS

For these case studies, Trayak utilized their streamlined LCA tool, EcoImpact-COMPASS to measure the environmental impacts associated with a packaging transition. EcoImpact-COMPASS is a screening LCA solution which offers users an easy-to-use, cost effective, and reliable way of performing LCAs. The case studies represent a cradle-to-grave LCA that examines the environmental impact of the packaging across four phases of its life cycle (raw material extraction, manufacturing, transportation, and disposal). Each case study features an "apples to apples", or functionally equivalent packaging system, comparison.

The packaging systems were modeled using unique package-specific information (materials, masses, conversion processes, transportation, etc.) provided by each company. This process allows practitioners to identify hotspots and key areas for environmental footprint reductions.

This COMPASS tool uses life cycle inventory (LCI) data that represents an industry average for materials, manufacturing processes, and end-of-life impacts. The Life Cycle Analysis (LCA) in this report can be used for directional guidance in internal decision making and understanding trade-offs. COMPASS follows the guidelines of ISO 14040 in determining and documenting the scope, assumptions, consistent boundary conditions, and data sources.

Note: The material phase measures the environmental footprint of extracting and processing materials. The manufacturing phase calculates the impact of the manufacturing or conversion processes that companies use to add value and create the package or product. Use phase includes the environmental impact during the useful life of the package/product. Typically, the use phase impact is due to the consumption of resources like electricity, fuel, or other consumables. For the transportation phase, the impact is calculated based on the mode of transportation (road, rail, air, sea) as well as the distances traveled. The end of life impact calculation incorporates the most likely fate of the package and its components based on typical curbside municipal waste management. Typical percentage rates for region based recycling, incineration, and landfill are used to calculate the impacts.

Launched in 2016 as a Certified B Corp, Grove Collaborative is transforming consumer products into a positive force for human and environmental good. Grove creates and curates high-performing, planet-first products across household cleaning, personal care, laundry, clean beauty, and pet, serving millions of households across the U.S. With a flexible delivery model and access to knowledgeable Grove Guides, Grove makes it easy for people to build sustainable routines.

Recently, Grove Collaborative made a commitment to become a completely plastic free platform by 2025. As a strategic first step towards becoming a zero-plastic platform, Grove is looking to rapidly convert the items that they produce and package in single-use plastic. To aid in developing the roadmap for creating a zero-plastic platform, Grove Collaborative, partnered with Trayak, to conduct an LCA study to understand and help establish a baseline when transitioning away from a single-use plastic pouch made from 25% PCR LDPE to a refillable durable aluminum canister consisting of a lid, canister, and paper refill pouch.

THE STUDY

In order to determine the overall impact of transitioning from flexible pouches to refillable aluminum canisters, Trayak analyzed eight select indicators including fossil fuel usage, GHG emissions, water usage, freshwater eutrophication, mineral resource usage, human impact, GHG emissions (with carbon uptake) and freshwater ecotoxicity. Together, these indicators paint a holistic picture of the overarching impact of each material and provide a robust basis for comparison. Trayak's findings detail the total impact for each of the selected indicators studied in the Life Cycle Analysis. The impact of each indicator is analyzed by breaking down the percentage of impact across the material extraction, manufacturing, transportation, end-of-life, and use phases, allowing Grove to determine which phases of the material's life cycle has the greatest impact on which areas of human and planetary health.

For this study, Grove Collaborative wanted to understand the breakeven environmental point of their single use flexible pouch compared to a refillable aluminum canister with paper pouch refills. When comparing single-use versus refillable options, it is important to calculate the environmental breakeven point to understand if the refillable option can be utilized enough by the average consumer to offset its usually higher material impact in comparison to single-use. This LCA compared 100 flexible pouches against 1 refillable aluminum canister with 99 paper refill pouches.

THE DATA

Fossil Fuel Usage

Fossil fuel usage examines the total quantity of fossil fuel consumed throughout the life cycle reported in megajoules (MJ) equivalents deprived.

Material	**Flexible Pouch (reference)**	Refill Canister
MJ Deprived	138.99	106.66
% Increase (+) or Reduction (-) from reference		**-23.26%**

A transition from a flexible pouch to an aluminum canister refill decreases overall fossil fuel usage across the material and manufacturing stages of the product's life cycle with an increase in usage during transportation and end-of-life, with an overall fossil fuel use reduction of 23.26%. This reduction is equivalent to 0.005285 less barrels of oil or 0.00086376 less average homes powered yearly.

GHG Emissions

The total quantity of greenhouse gasses (GHG) emitted throughout the lifecycle of the packaging materials under study are reported in kilograms of CO2equivalents. This calculation follows the latest IPCC 2013 method and considers climate feedback loops.

Material	**Flexible Pouch (reference)**	Refill Canister
kg CO_2 Equivalents	6.97	11.41
% Increase (+) or Reduction (-) from reference		**+63.7%**

Using this method, the study revealed that the transition would see a 63.7% increase in GHG emissions - which is equivalent to an increase of 10.87 miles driven by passenger vehicles yearly or 1.89 liters of gasoline consumed.

Water Usage

This metric accounts for water scarcity and the data represents the relative value in comparison with the average liters consumed in the world. Essentially, the total water consumed to make the package is multiplied by the region's scarcity factor which will either increase or decrease the water usage value based on the scarcity or excess availability of water in a specific region, respectively.

Material	**Flexible Pouch (reference)**	Refill Canister
m^3	3.28	3.08
% Increase (+) or Reduction (-) from reference		**-6.1%**

The model for transitioning to an aluminum can refill shows that the transition would result in a 6.1% overall reduction in water usage which is equivalent to 51.1 gallons of water or 2.97 average showers saved!

Freshwater Eutrophication

E*utrophication is the abnormal increase in chemical nutrients that results in excessive plant/algal growth and decay resulting in an anoxic condition in fresh water systems. (The major consequences are often harmful algal blooms.) Typically, emissions of phosphorus compounds are released during the production of materials. This indicator is reported in phosphate (PO4) equivalents and is calculated with Impact World+ characterization factors.*

Material	**Flexible Pouch (reference)**	Refill Canister
PO_4 Equivalents	0.005336	0.01098
% Increase (+) or Reduction (-) from reference		**+105.77**

When comparing eutrophication as a result of the flexible pouch's life cycle versus the life cycle of a canister, we see a 105.77% increase when looking at the canister's freshwater eutrophication impact. The material phase is particularly impactful for an aluminum canister, making up 85.4% of the canister's overarching impact on freshwater systems.

Mineral Resource Use

This indicator uses the material competition scarcity index from de Bruille (2014) as a midpoint indicator. The factor represents the fraction of material needed by future users that are not able to find a reliable substitute for the mineral. It is expressed in units of kilograms of deprived resource per kilogram of resource dissipated. It considers mineral scarcity and viable substitutes.

Material	**Flexible Pouch (reference)**	Refill Canister
kg Deprived	0.06576	0.0825
% Increase (+) or Reduction (-) from reference		**+25.4%**

A transition to a refillable canister would result in a 25.4% increase in overall mineral resources used throughout the canister's lifecycle when compared to usage from the lifecycle of an LDPE flexible pouch.

Human Impact

The Human Impact indicator measures the quantity of environmental emissions resulting in particulate, cancer & toxic non-cancer impacts to humans released throughout the packaging material's lifecycle. The metric reports these three measurements in Disability Adjusted Life Years (DALY) and is calculated using Impact World+ and considers severity factors of any adverse effects.

Material	**Flexible Pouch (reference)**	Refill Canister
Disability Adjusted Life Years (DALY)	0.0000041326	0.000012055
% Increase (+) or Reduction (-) from reference		**+191.7%**

Freshwater Ecotoxicity

The quantity of environmental emissions resulting in aquatic toxic impacts released throughout the lifecycle reported in Comparative Toxic Unit ecosystem (CTUe). CTUe corresponds to a fraction of disappeared species over a cubic meter of freshwater (or marine water) during one year. This is a measure of the ecotoxicity impact of chemical releases to air, water, and land using aquatic toxicity factors and is calculated using characterization factors from USEtox 2.0.

Material	**Flexible Pouch (reference)**	Refill Canister
CTUe	205.3	116.43
% Increase (+) or Reduction (-) from reference		**-43.33%**

A transition to an aluminum canister would yield a 43.33% reduction in aquatic toxicity, a significant reduction in toxic chemical release into surrounding water.

THE OUTCOME

As Grove looks to deliver their Beyond Plastic commitment by 2025, LCA's will be an important tool to help identify the effects of transitioning away from plastic. The objective of this study was to understand the impact of moving away from a linear model to a circular model and to help establish a baseline for future package development. Grove recognized going into this study that making improvements on a plastic pouch LCA profile would be unlikely, however, the company wanted to understand if the end-of-life phase would be a significant factor in determining a breakeven point for the circular packaging model: Durable Aluminum + Paper Refill.

For this evaluation, a single use plastic pouch vs. a durable aluminum canister + paper pouch refill, the breakeven environmental point is never reached for every indicator because with this refill scenario, the consumer still must purchase a paper pouch containing the product to refill the aluminum canister. Because the paper pouch is not significantly lighter or more concentrated than the original flexible pouch, and this scenario now utilizes a durable aluminum canister, the breakeven point is not obtainable.

Running this LCA allowed Grove to answer their initial question of "Is there a breakeven point?" as well as generate data to optimize this packaging system for future development. As Grove develops additional packaging solutions for this refill scenario, decision-making can be guided by utilizing the data collected from future LCA's.

***Figure 1**. A side by side comparison of the packaging materials analyzed in the study.*

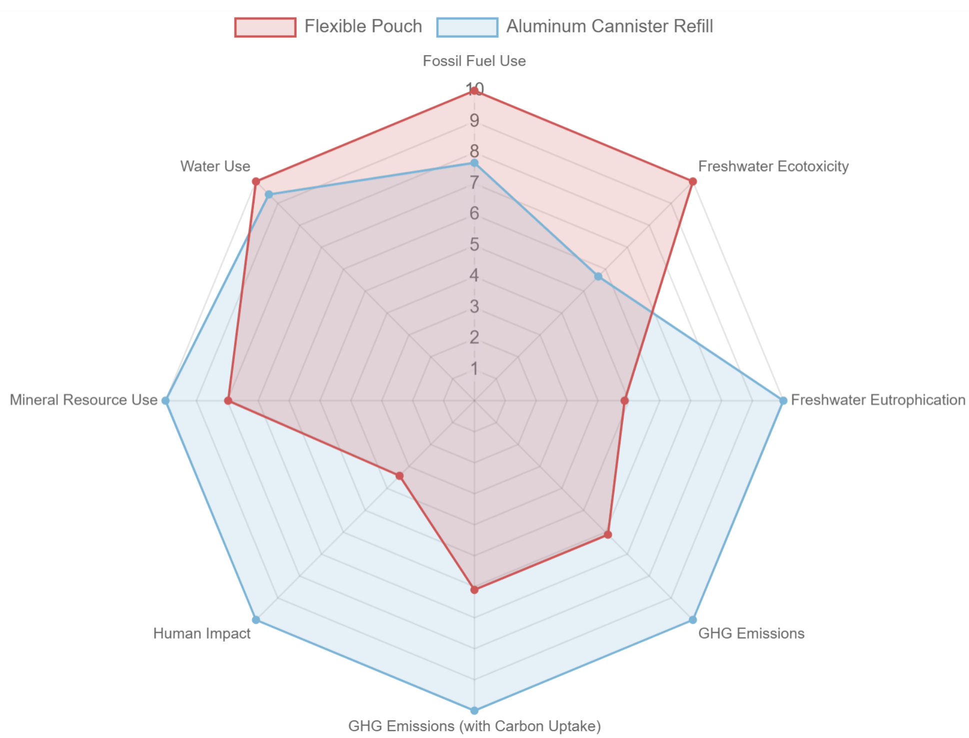

***Figure 2.** The overview is shown as a spider chart which includes the selected indicators for the environmental impact assessment. It serves as a representation of how the packages compare to each other; a smaller shaded area represents less of an environmental impact.*

Dr. Bronner's is not only known for their castile soaps, but also for being an industry leader committed to sustainability and social justice. Many of Dr. Bronner's customers buy their soap not only for the quality, but also to know that they are supporting ethical and sustainable business practices. It is no surprise then that customer inquiries around plastic use and packaging are becoming a daily occurrence. Dr. Bronner's consumers are beginning to hold the brand accountable and want to see an alternative to the rPET plastic bottles currently being used.

Dr. Bronner's is dedicated to finding the best material solution that can suit both their product and consumer needs. This prompted Dr. Bronner's to partake in an LCA study with Trayak in order to evaluate the impacts of four different packaging materials; their current PET design made with PCR content, a paper bottle, an aluminum bottle made with PCR content, and a paper gable top bottle. While embracing a plastic-free value chain is the ultimate goal, Dr. Bronner's first wants to make sure that they are evaluating packaging solutions through a holistic lens, understanding that material source is just one part of the picture.

This case study allowed the company to get a more whole picture of how different packaging formats and material choices– all with unique sustainability wins – impact the environment. Using multiple metrics like GHG emissions and water use to quantify the entire supply chain of each packaging design, the company was able to use real data to choose a package that is fit for the current systems and infrastructure available to most Americans.

THE STUDY

In order to determine the overall impact of transitioning from a PET bottle made with recycled content to any of the three proposed alternatives (a paper bottle, an aluminum bottle made with PCR content, and a paper gable top bottle), Trayak analyzed eight select indicators including fossil fuel usage, GHG emissions, water usage, freshwater eutrophication, mineral resource usage, human impact, GHG emissions (with carbon uptake), and freshwater ecotoxicity. Together, these indicators paint a holistic picture of the overarching impact of each material and provide a robust basis for comparison. Trayak's findings detail the total impact for each of the selected indicators studied in the Life Cycle Analysis.

Each indicator is analyzed by breaking down the percentage of impact across the material extraction, manufacturing, transportation, and end-of life-phases, allowing the company to determine which phases of the packages's life cycle has the greatest impact.

For this study, Dr. Bronner's looked at the environmental impact of their top selling product (32oz castile soap) which sold approximately 10,000,000 units in 2021. This study uses an annual quantity of 10,000,000 containers to calculate the overall impact of 32oz castile soap packaging. Since the paper bottle data was only available in a 16oz option, a quantity of 20,000,000 was used for this package alternative.

THE DATA

Fossil Fuel Use

Material	**PET (reference)**	Paper Bottle	Aluminum Bottle	Paper Carton
GJ Deprived	36,191.83	34,698.55	32,516.88	9,252.53
% Increase (+) or Reduction (-) from reference		**-4.13%**	**-10.15%**	**-74.43%**

The non-recyclable paper gable top bottle was associated with the largest fossil fuel use reduction at 74.43%. This reduction is equivalent to 4,403.39 barrels of oil and 719.61 average homes powered yearly for 10,000,000 gable top cartons used!

GHG Emissions

Material	**PET (reference)**	Paper Bottle	Aluminum Bottle	Paper Carton
kg CO_2 Equivalents	2,538.56	2,628.26	2,582.46	760.29
% Increase (+) or Reduction (-) from reference		**+3.53%**	**+1.73%**	**-70.05%**

A transition to a gable top carton would yield the greatest reduction in overall emissions, a significant reduction equivalent to 1,778.27 kg of CO2 equivalents, 380.79 passenger vehicles driven yearly, 757,453.4 liters of gasoline consumed or 4,358,509.65 miles driven by passenger vehicles yearly. This reduction increases by an additional ~8% (to 78.43%) when the carbon uptake of the paper materials used is factored in. This is because there is carbon sequestered during the growth phase of the materials used for the gable top carton.

Water Use

Material	**PET (reference)**	Paper Bottle	Aluminum Bottle	Paper Carton
m^3	1,392,010.42	666,631.12	969,106.6	327,847.59
% Increase (+) or Reduction (-) from reference		**-52.11%**	**-30.38%**	**-76.45%**

A transition to the gable top carton would yield the highest water savings (76.45%), equivalent to a reduction of 16,346,587.29 average showers, 44,785.17 less people showering daily for a year, or 425.67 olympic sized swimming pools saved per 10,000,000 gable top cartons!

Freshwater Eutrophication

Material	**PET (reference)**	Paper Bottle	Aluminum Bottle	Paper Carton
Ton PO_4 Equivalent	4.36	2.89	4.59	1.72
% Increase (+) or Reduction (-) from reference		**-33.72**	**+5.28**	**-60.55%**

When comparing the PET design to the three proposed alternatives, a transition to a paper bottle would reduce freshwater eutrophication associated with the packaging's lifecycle by 33.72% and the gable top carton by 60.55%. A transition to an aluminum alternative would see an increase in freshwater eutrophication by 5.28%.

Mineral Resource Use

Material	PET (reference)	Paper Bottle	Aluminum Bottle	Paper Carton
Ton Deprived	23.05	19.67	65.05	8.29
% Increase (+) or Reduction (-) from reference		-14.66%	+182.21	-64.03%

Human Impact

Material	PET (reference)	Paper Bottle	Aluminum Bottle	Paper Carton
Disability Adjusted Life Years (DALY)	2.1	1.45	3.98	0.8613
% Increase (+) or Reduction (-) from reference		-30.95%	+89.52%	-58.99%

The aluminum bottle would have the most significant impact on human life, increasing the emissions related to health issues by 89.52%. Both the paper bottle and gable top carton would decrease the impact on human life by 30.95% and 58.99% respectively.

Freshwater Ecotoxicity

Material	PET (reference)	Paper Bottle	Aluminum Bottle	Paper Carton
CTUe	59,632,655.82	57,965,444.03	4,893,500,483.57	14,710,129.9
% Increase (+) or Reduction (-) from reference		-2.8%	+8,106.08%	-75.33%

When comparing the PET design to the three proposed alternatives, a transition to a paper bottle would reduce freshwater eutrophication associated with the packaging's lifecycle by 33.72% and the gable top carton by 60.55%. A transition to an aluminum alternative would see an increase in freshwater eutrophication by 5.28%.

THE OUTCOME

The resulting data from the LCA study provided valuable insights to the Dr. Bronner's team, along with some surprises. All four options compared have unique sustainability advantages and are often promoted as 'eco-friendly' packaging options. The team came into this study with many questions, many revolving around the trade-offs that must be considered when selecting a packaging option. Is it better to use recycled material or to prioritize the recyclability of the package? Is it better to be completely plastic-free or to use a lighter package? Through this exercise, it has become clear that there is no "one-size fits all" approach when it comes to sustainable packaging.

The LCA study allowed the team to find a solution that best fits the specific application of packaging a 32oz liquid product in a single-use format. When looking at the overall environmental impact of the packaging options compared in the study, the gable top paper carton came out as a clear favorite for this application. While the end goal is to get out of single-use packaging all together, the LCA shows that the paper carton provides a more sustainable alternative to plastic while the company continues to work towards a refill model. In the few months since the team was presented with these findings, they have already seen a big impact in the way this data has shaped internal discussions and decision making.

***Figure 3**. A side by side comparison of the packaging materials analyzed in the study.*

***Figure 4.** The overview is shown as a spider chart which includes the selected indicators for the environmental impact assessment. It serves as a representation of how the packages compare to each other; a smaller shaded area represents less of an environmental impact.*