Arctic Express Pack LCA Report

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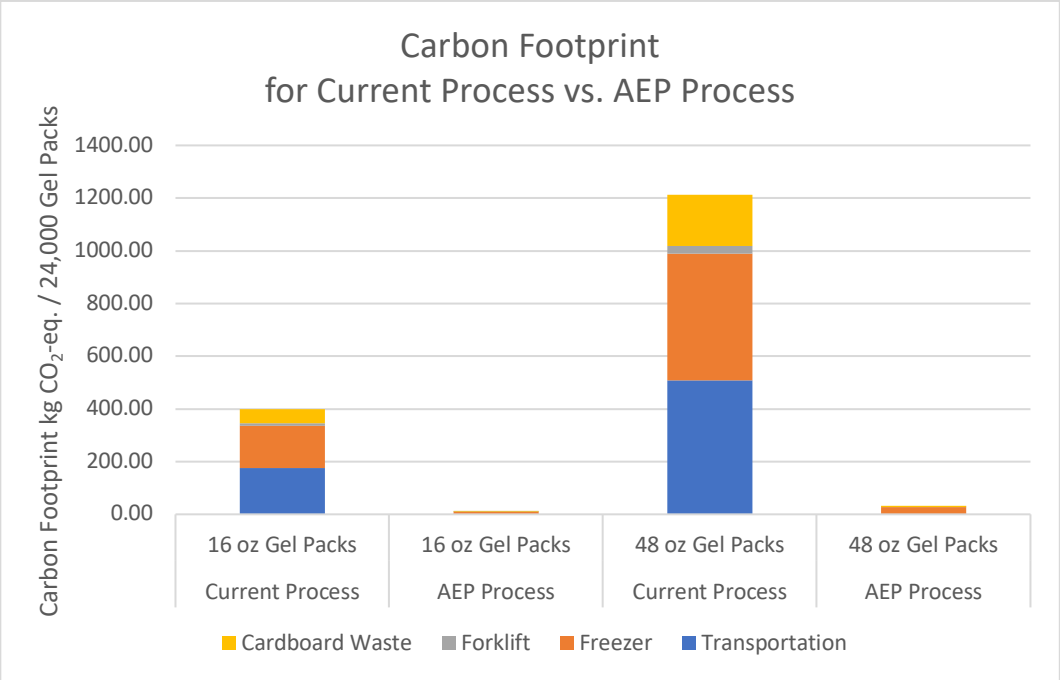
Executive Summary

A life cycle analysis (LCA) was conducted to determine the Carbon Footprint and environmental impacts associated with the logistics for the current process compared to the Arctic Express Pack process from gate-to-gate, including the forklift use, cardboard packaging, freezing, and transportation from manufacturer to end party user.

The following processes were assessed:

- Current Process – 16oz Gel Packs
- Arctic Express Pack Process – 16oz Gel Packs
- Current Process – 48oz Gel Packs
- Arctic Express Pack Process – 48oz Gel Packs



In comparison to the current process, the Arctic Express Pack process would have a Carbon Footprint savings of 96% and 97% for the 16oz and 48oz Gel Packs, respectively. The transportation and freezer phases are the most significant contributors to the Carbon Footprint for the current process, while the freezer phase is the most significant contributor for the Arctic Express Pack process.

The transportation and freezer phases were shown to be the most significant contributors to the Carbon Footprint and environmental impacts. In comparison to the current process, the Arctic Express Pack process would have an environmental impact savings between 94% and 99%, depending on impact category and Gel Pack size.

Filling the Gel Packs at the end party user substantially reduces the weight during transportation and freezing the Gel Packs individually instead of by the pallet substantially reduces the freezing time in comparison to the current process. The reduced transportation weight and freezing time directly relates to the Carbon Footprint and environmental impacts savings for the Arctic Express Pack process.

A sensitivity analysis in relation to transportation distance and freezing time would be recommended to determine the variation in savings between the current process and the Arctic Express Pack process. The distance between Manufacturer and End Party User was assumed and does not represent all applications.

Table of Contents

List of Tables

List of Figures

List of Units

lb – pound

kg – kilogram

km – kilometer

kgkm – kilogram-kilometer

m^3 – cubic meters

kWh – kilowatt hours

MJ – mega joules

kg CO_2 eq. – kilogram carbon dioxide equivalent

kg SO_2 eq. – kilogram sulphur dioxide equivalent

kg PO_4^{3-} eq. – kilogram phosphate equivalent

kg R11 eq. – kilogram trichlorofluoromethane equivalent

Introduction

A life cycle analysis (LCA) was conducted according to ISO 14044:2006 to determine the Carbon Footprint and environmental impacts associated with the logistics for the current process compared to the Arctic Express Pack process from gate-to-gate, including the forklift use, cardboard packaging, freezing, and transportation from manufacturer to end party user. LCA examines the differences between alternatives and the relative benefits or impacts between the two processes can be used for marketing and decision-making purposes.

The following processes were assessed:

- Current Process – 16oz Gel Packs
- Arctic Express Pack Process – 16oz Gel Packs
- Current Process – 48oz Gel Packs
- Arctic Express Pack Process – 48oz Gel Packs

The LCA report will outline the process and methodology in addition to the analysis and recommendations for Arctic Express Pack.

Functional Unit and Reference Flow

The functional unit is 24,000 Gel Packs, which represents one Arctic Express Pack pallet.

Primary Function for Gel Packs

The primary function for Gel Packs is to regulate temperature during shipping of perishables for end party users such as medical supplies and food and beverage.

System Boundaries

The system boundaries for the gate-to-gate LCA include the logistics for transporting and freezing gel packs. Included in the system boundaries are the forklift use, cardboard packaging, freezing, and transportation from manufacturer to end party user. The manufacturing, use, and end-of-life stages for the gel packs are outside the system boundaries and are not included in the LCA.

Allocation Procedures

The transportation values provided by Arctic Express Pack are allocated based on number of gel packs per box, pallet and truck shipment. The cardboard and forklift use are also allocated based on gel packs per box, pallet and truck shipment.

LCA Limitations

Parameter uncertainty, scenario uncertainty, and model uncertainty contribute to the limitations in using LCA. Assumptions and secondary data are required when information and primary data are not available. The particular LCA limitations are discussed in the Data Quality discussion.

LCA Software

GaBi is an LCA software used to conduct a life cycle analysis with information gathered from specific industry and regional databases. The system is first visually constructed indicating each life-stage with material and energy flows. The inputs and outputs for the system are defined using arrows to indicate flow direction. Each block is then customized with respect to the particular process. Once the system is complete, the software will then generate values with respect to the environmental metrics such as global warming potential (GWP), acidification, eutrophication, and photochemical oxidation [1].

Environmental Performance and Impact Categories

Environmental performance and impact categories include carbon footprint, use of resources, and potential environmental impacts.

Carbon Footprint

The carbon footprint is expressed in kg CO_2 eq. and includes all greenhouse gases directly and indirectly related to the process [2].

Use of Resources

Primary energy demand expressed in MJ is reported and includes net renewable and non-renewable sources.

Potential Environmental Impacts

The potential environmental impacts are declared per functional unit. The environmental impact categories are global warming potential (GWP, kg CO_2 eq.), acidification potential (AP, kg SO_2 eq.), eutrophication potential (EP, PO_4^{3-} eq), and ozone depletion potential (ODP, kg R11 eq.). Impact category indicators are calculated using the CML-IA characterization methods.

LCIA Methodology

The diagrams below are representations of the processes within the gate-to-gate LCA for the current process and Arctic Express Pack process. The processes include transportation, forklift use, cardboard packaging, and freezing time.

Current Process Life Cycle Flow Diagram

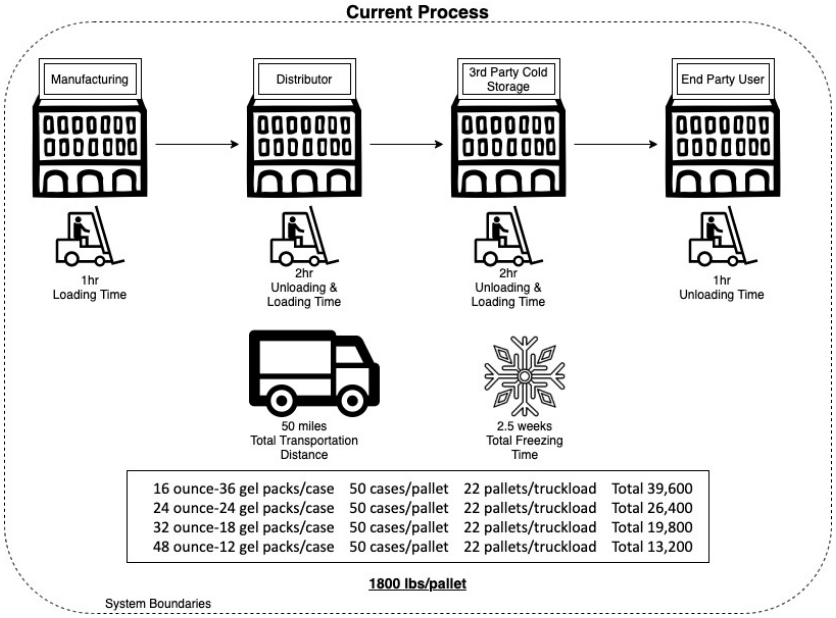


Figure 1 Current Process Life Cycle Flow Diagram

Arctic Express Pack Process Life Cycle Flow Diagram

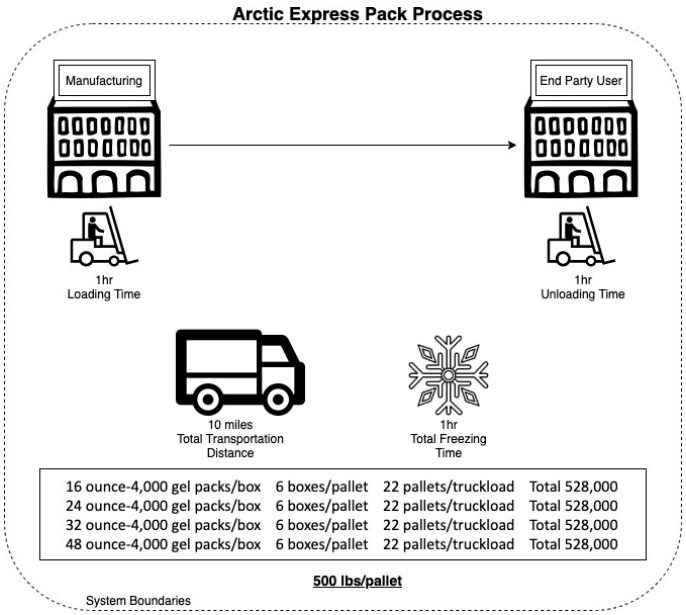


Figure 2 Arctic Express Pack Process Life Cycle Flow Diagram

Assumptions and Interpretation

Transportation

The total transportation distance is determined from Gel Pack Manufacturer to End Party User. Assume 50 miles total transportation distance for the current process from Manufacturer, to Distributor, to 3rd Party Cold Storage, and to End-Party User. Assume 10 miles total transportation distance for the Arctic Express Pack process from Manufacturer directly to End-Party User. The converted units depend on total transportation distance and weight for 24,000 Gel Packs.

Freezer

The freezer phase is associated with the energy and time required to continuously freeze Gel Packs for use. The current process takes 2.5 weeks to freeze Gel Packs on pallets before use, while the Arctic Express Pack process takes 1hr to freeze Gel Packs individually before use. Assume 1 day freezing time for the Arctic Express Pack process to take into account the number of Gel Packs required per day. Freezer requirements determined by weight for 24,000 gel packs (filled and ready to be frozen) and freezing time.

Forklift

The total forklift use required is determined from Gel Pack Manufacturer to End Party User. Assume electric forklift for drive-in freezer warehouse is used, requiring 4kWh per hour of use plus 25% for recharge [3][4]. Assume the current process unloads and loads gel packs at the Distributor and 3rd Party Storage, requiring 2hrs at each location in addition to 1hr loading and unloading time at Manufacturer and End Party User, respectively.

Cardboard Waste

Assume different sized boxes are required for the current process and the Arctic Express Pack process. The dimensions are determined based on number of boxes per pallet in calculation. Assume pallet dimensions are 48" by 48" by 6" high [5]. Assume load height must not exceed 60" total [6]. Assume standard box composition for both processes, including flutes, thickness and density [7].

Study Data and Converted Data

Table 1 Study Data and Converted Data for Arctic Express Pack

LCI System Inputs and Outputs		Original Data Provided by Arctic Express Pack					Converted Data to Functional Units					Notes	Calculations
		Current Process	AEP Process	Current Process	AEP Process	Units	Current Process	AEP Process	Current Process	AEP Process	Functional Units (/24,000 gel packs)		
		16 oz Gel Packs	16 oz Gel Packs	48 oz Gel Packs	48 oz Gel Packs		16 oz Gel Packs	16 oz Gel Packs	48 oz Gel Packs	48 oz Gel Packs			
Transportation	Distance	50	10	50	10	miles	875980.50	3649.92	2627941.50	3649.92	kgkm	Total transportation from Gel Pack Manufacturer to End Party User. Converted units depend on distance and weight for 24,000 gel packs.	(distance miles)*(1.609 km/mile)*(Pallet weight lbs per pallet)*(24,000 gel packs/(number of gel packs per pallet))*(0.454 kg/lb)
	Pallet Weight	1800	500	1800	500	lb							
	Gel Packs per Pallet	1800	24000	600	24000	Gel Packs/pallet							
Freezer	Freezing Time	17.5	1	17.5	1	days	190680	10896	572040	32688	kgdays	Energy and time determined to continuously freeze gel packs for use. Current process takes 2.5 weeks to freeze gel packs on pallets before use, while AEP process takes 1hr to freeze gel packs individually before use.	(freezing time days)*(weight lbs per gel pack)*(24000 gel packs)*(0.454 kg/lb)
	Weight per Frozen Gel Pack	1	1	3	3	lb							
Forklift	Truck Loading and Unloading Time	6	2	6	2	hrs/truck	18.18	0.45	54.55	0.45	kWh	Total forklift use from Gel Pack Manufacturer to End Party User. 4kWh per hour of use and 25% for recharge.	(hours per truck)*(4 kWh)*(1.25)*(24000 Gel Packs/(Gel Packs per Truck))
	Gel Packs per Truck	39600	528000	13200	528000	Gel Packs/truck							
Cardboard Waste	Gel Packs per Box	36	4000	12	4000	Gel Packs/box	225.73	16.14	817.30	16.14	kg	Different sizes boxes - dimensions determined based on number of boxes per pallet in calculation. Pallet dimensions are 48" by 48" by 6" high. Load height must not exceed 60" total.	Current Process: ((2*(length in)*(width in)*(1/8 in))+(2*(length in)*(height in)*(1/8 in))+(2*(width in)*(height in)*(1/8 in)))*(0.000016387 m3/in3)*(228 kg/m3)*(24000/gel packs per box) New Process: ((2*(length in)*(width in)*(1/8 in))+(2*(length in)*(height in)*(1/8 in))+(2*(width in)*(height in)*(1/8 in))+(2*(length in)*(height in)*(1/16))))*(0.000016387 m3/in3)*(228 kg/m3)*(24000/gel packs per box)
	Boxes per Pallet	50	6	50	6	boxes/pallet							
	Length	15	48	15	48	inches/box							
	Width	8.5	24	8.5	24	inches/box							
	Height	10	18	10	18	inches/box							

Data Sources

The following table provides information relating to the data sources used within GaBi.

Table 2 Data Sources in GaBi

Packaging Materials				
Cardboard Box	Corrugated Board	Corrugated Board 2015, average composition	GaBi Professional Database	2015
Freezer				
Frozen Cold Storage	Cold Storage	Chilled & Frozen Cold Storage	GaBi Professional Database	2012
Warehousing	Cold Storage	Warehousing, refrigerated	GaBi Professional Database	2013
Transportation				
Truck	Diesel	Transport, Single Unit Truck, Diesel Powered	US LCI Database	2001
Forklift	Electricity	US Electricity Grid Mix	GaBi Professional Database	2016

Data Quality Discussion

Table 3 Data Quality Discussion

Data Quality Parameter	**Data Quality Discussion**
Geographical Coverage: **Geographical area from which data for unit processes is collected to satisfy the goal of the study**	The data used in GaBi is from the United States and European datasets.
Technology Coverage: **Specific technology or technology mix**	US technology mix is used throughout.
Precision: **Measure of the variability of the data values for each data expressed**	Transportation distance is approximated for the current and AEP process based on typical distances travelled.
Representativeness: **Qualitative assessment of the degree to which the data set reflects the true population of interest**	Plastic shrink wrap is not included in the analysis. Transportation distance and freezing time are assumed and may not represent each particular logistical situation.
Consistency: **Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis**	The methodology is applied uniformly for each process under consideration.
Sources of the Data: **Description of all primary and secondary data sources**	Data is provided by databases within GaBi for the materials and logistical processes. Packaging dimensions are based on engineering estimates.
Limitations: **Description of data limitations**	Packaging dimensions, freezing time, and transportation time may vary and are not specific to all applications.
Uncertainty of the Information: **Uncertainty related to data, models, and assumptions**	There is moderate uncertainty due to the data limitations and representativeness. The LCA results depict general trends for decision making purposes.

Results and Discussion

Carbon Footprint

Table 4 Current Process vs. AEP Process Carbon Footprint Results

		Current Process 16 oz Gel Packs	AEP Process 16 oz Gel Packs	Current Process 48 oz Gel Packs	AEP Process 48 oz Gel Packs	Units (/24,000 gel packs)
Carbon Footprint	Transportation	175.60	0.73	509.50	0.73	kg CO_2-eq.
	Freezer	160.00	9.28	480.00	27.40	kg CO_2-eq.
	Forklift	10.00	0.25	30.00	0.25	kg CO_2-eq.
	Cardboard Waste	53.10	3.80	192.40	3.80	kg CO_2-eq.
	Total	**398.70**	**14.06**	**1211.90**	**32.18**	kg CO_2-eq.

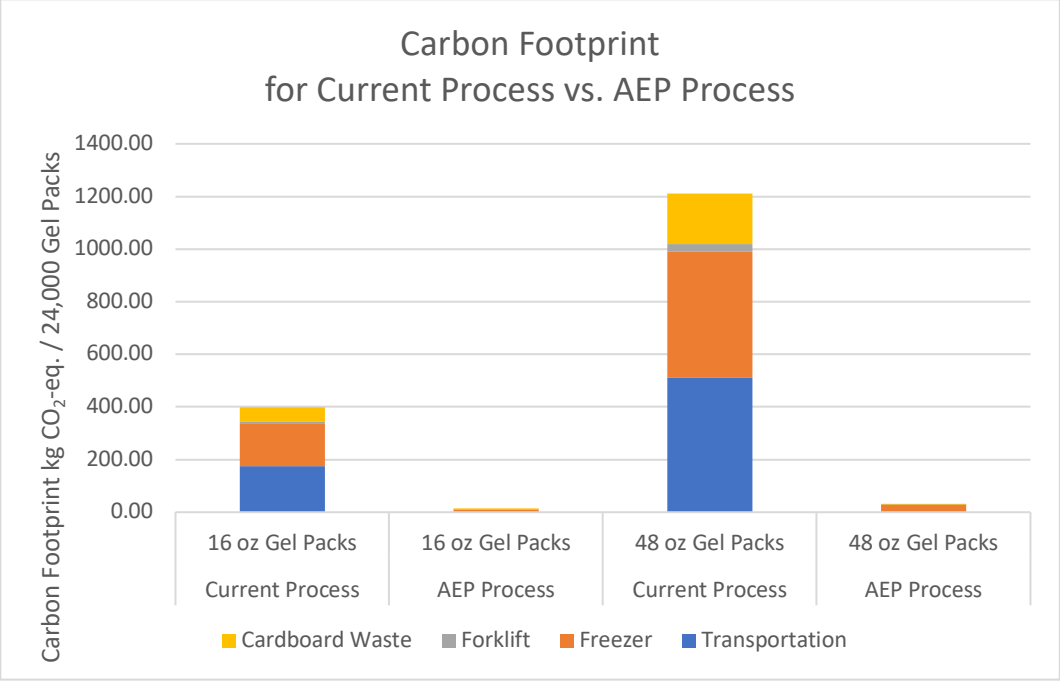


Figure 3 Carbon Footprint for Current Process vs. AEP Process

In comparison to the current process, the Arctic Express Pack process would have a Carbon Footprint savings of 96% and 97% for the 16oz and 48oz Gel Packs, respectively. The transportation and freezer phases are the most significant contributors to the carbon footprint for the current process, while the freezer phase is the most significant contributor for Arctic Express Pack process.

Life Cycle Impact Assessment

Impact category indicators are calculated using the CML-IA characterization methods. CML-IA impact category indicators include global warming potential (100 years), acidification potential, eutrophication potential, and ozone depletion potential. Resource use for net primary energy demand includes renewable and non-renewable sources.

Table 5 Current Process vs. AEP Process Environmental Metrics Results

		Current Process	AEP Process	Current Process	AEP Process	Units (/24,000 gel packs)
		16 oz Gel Packs	16 oz Gel Packs	48 oz Gel Packs	48 oz Gel Packs	
Global Warming Potential (GWP, 100 years)	Transportation	175.60	0.73	509.50	0.73	kg CO2-eq.
	Freezer	160.00	9.28	480.00	27.40	kg CO2-eq.
	Forklift	10.00	0.25	30.00	0.25	kg CO2-eq.
	Cardboard Waste	29.50	2.11	107.00	2.11	kg CO2-eq.
	Total	**375.10**	**12.37**	**1126.50**	**30.49**	**kg CO2-eq.**
Primary Energy Demand	Transportation	2310.00	9.64	6940.00	9.64	MJ
	Freezer	3560.00	207.00	10700.00	1180.00	MJ
	Forklift	192.00	4.74	575.00	4.74	MJ
	Cardboard Waste	869.00	62.10	3150.00	62.10	MJ
	Total	**6931.00**	**283.48**	**21365.00**	**1256.48**	**MJ**
Acidification Potential (AP)	Transportation	0.64	2.67E-03	1.92	2.67E-03	kg SO2-eq.
	Freezer	0.37	2.12E-02	1.09	6.26E-02	kg SO2-eq.
	Forklift	1.46E-02	3.62E-04	4.39E-02	3.62E-04	kg SO2-eq.
	Cardboard Waste	0.13	8.91E-03	0.45	8.91E-03	kg SO2-eq.
	Total	**1.15**	**3.31E-02**	**3.51**	**7.45E-02**	**kg SO2-eq.**
Eutrophication Potential (EP)	Transportation	0.17	7.18E-04	0.52	7.18E-04	kg PO_4^{3-}-eq.
	Freezer	4.54E-02	2.63E-03	0.14	7.78E-03	kg PO_4^{3-}-eq.
	Forklift	1.54E-03	3.81E-05	4.62E-03	3.81E-05	kg PO_4^{3-}-eq.
	Cardboard Waste	3.68E-02	2.63E-03	0.13	2.63E-03	kg PO_4^{3-}-eq.
	Total	**0.26**	**6.02E-03**	**0.79**	**1.12E-02**	**kg PO_4^{3-}-eq.**

		Current Process	AEP Process	Current Process	AEP Process	Units (/24,000 gel packs)
		16 oz Gel Packs	16 oz Gel Packs	48 oz Gel Packs	48 oz Gel Packs	
Ozone Depletion Potential (ODP, steady state)	Transportation	2.00E-14	8.35E-17	6.01E-14	8.35E-17	kg R11-eq.
	Freezer	1.29E-08	7.49E-10	3.87E-08	2.21E-09	kg R11-eq.
	Forklift	4.79E-14	1.19E-15	1.44E-13	1.19E-15	kg R11-eq.
	Cardboard Waste	1.85E-11	1.32E-12	6.71E-11	1.32E-12	kg R11-eq.
	Total	**1.29E-08**	**7.50E-10**	**3.88E-08**	**2.21E-09**	**kg R11-eq.**

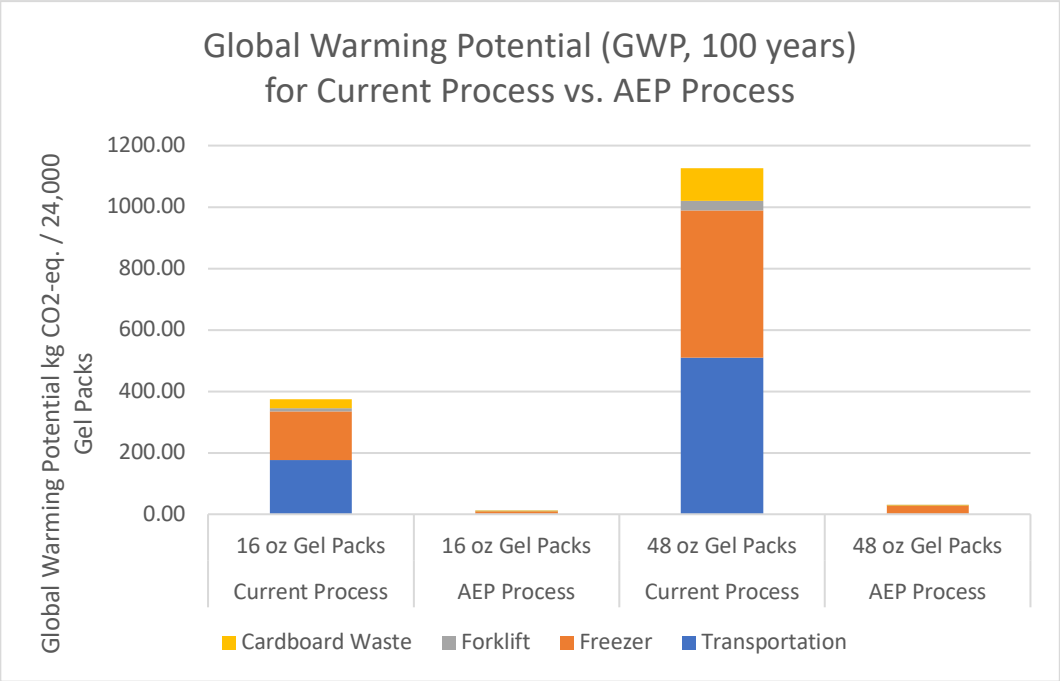


Figure 4 Global Warming Potential (GWP, 100 years) for Current Process vs. AEP Process

In comparison to the current process, the Arctic Express Pack process would have a Global Warming Potential savings of 97% for both the 16oz and 48oz Gel Packs. Similar to Carbon Footprint, the transportation and freezer phases are the most significant contributors to the Global Warming Potential for the current process, while the freezer phase is the most significant contributor for the Arctic Express Pack process.

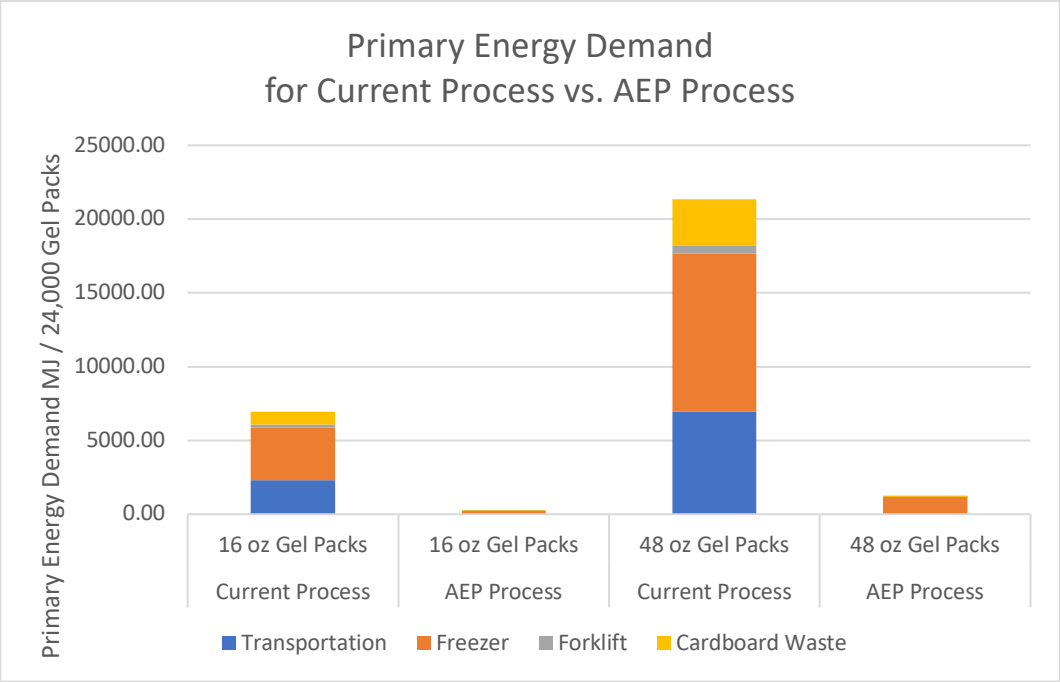


Figure 5 Primary Energy Demand for Current Process vs. AEP Process

In comparison to the current process, the Arctic Express Pack process would have a Primary Energy Demand savings of 96% and 94% for the 16oz and 48oz Gel Packs, respectively. The 48oz Gel Packs weigh more when filled and contributes to a higher freezer phase Primary Energy Demand relative to the 16oz Gel Packs for the Arctic Express Pack process, which results in a lower Primary Energy Demand savings. The freezer phase is the most significant contributor to Primary Energy Demand for the current process and the Arctic Express Pack process.

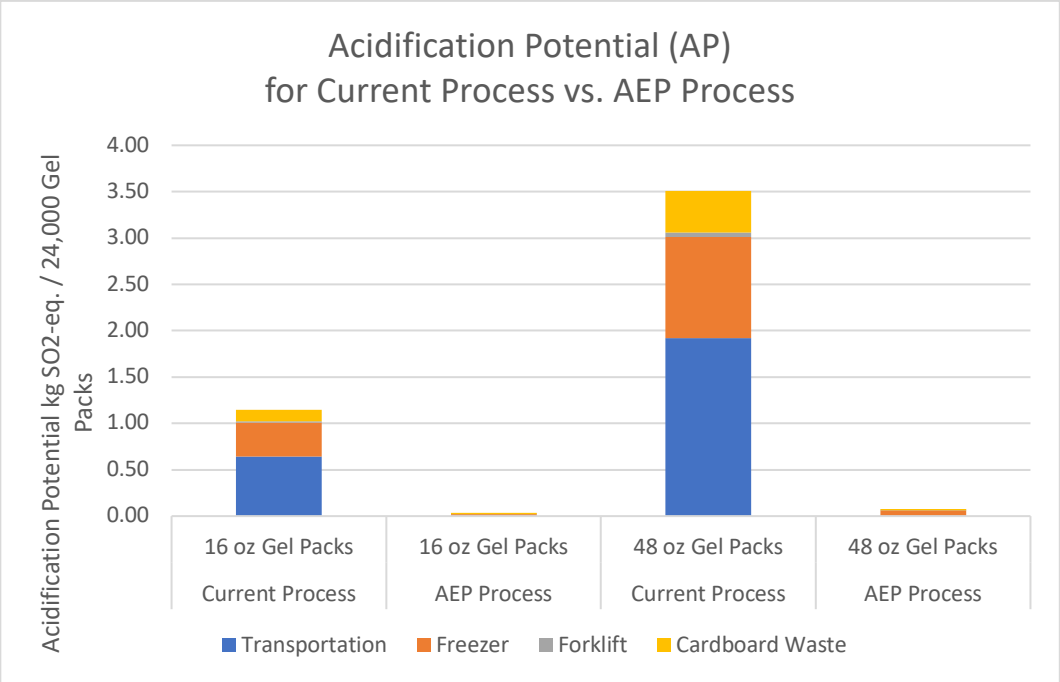


Figure 6 Acidification Potential (AP) for Current Process vs. AEP Process

In comparison to the current process, the Arctic Express Pack process would have an Acidification Potential savings of 97% and 98% for the 16oz and 48oz Gel Packs, respectively. The transportation and freezer phases are the most significant Acidification Potential contributors for the current process, while the freezer phase is the most significant contributor for the Arctic Express Pack process.

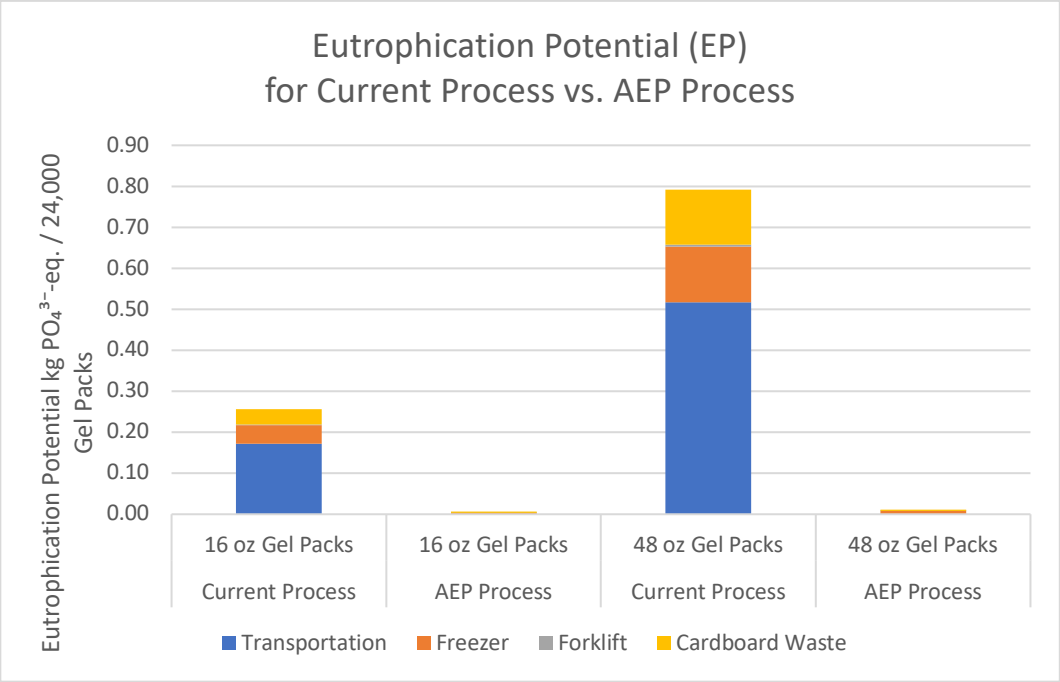


Figure 7 Eutrophication Potential (EP) for Current Process vs. AEP Process

In comparison to the current process, the Arctic Express Pack process would have a Eutrophication Potential savings of 98% and 99% for the 16oz and 48oz Gel Packs, respectively. The transportation phase is the most significant contributor to the Eutrophication Potential for the current process. For the Arctic Express Pack process, the same number of Gel Packs are shipped per pallet for the 16oz and 48oz Gel Packs, and the transportation phase contribution would remain the same.

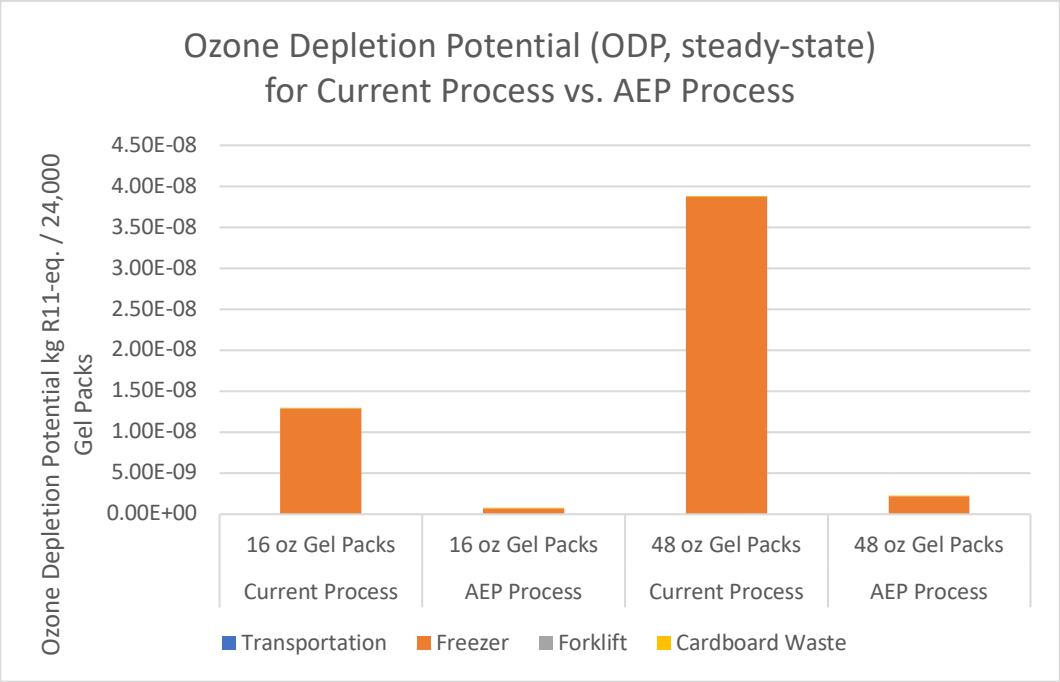


Figure 8 Ozone Depletion Potential (ODP, steady-state) for Current Process vs. AEP Process

In comparison to the current process, the Arctic Express Pack process would have an Ozone Depletion Potential savings of 94% for both the 16oz and 48oz Gel Packs. The freezer phase is the most significant contributor to the Ozone Depletion Potential for the current process and the Arctic Express Pack process, although the overall Ozone Depletion Potential for either process is negligible at <5 E-08 kg R11-eq. / 24,000 Gel Packs.

Conclusions

The LCA report outlined the process and methodology to determine the Carbon Footprint and environmental impacts associated with the logistics of the current process and the Arctic Express Pack process from gate-to-gate for marketing and decision-making purposes. The transportation and freezer phases were shown to be the most significant contributors to the carbon footprint and environmental impacts. In comparison to the current process, the Arctic Express Pack process would have an environmental impact savings between 94% and 99%, depending on impact category and Gel Pack size.

Filling the Gel Packs at the End Party User substantially reduces the weight during transportation and freezing the Gel Packs individually instead of by the pallet substantially reduces the freezing time in comparison to the current process. The reduced transportation weight and freezing time directly relates to the Carbon Footprint and environmental impacts savings for the Arctic Express Pack process.

Recommendations

A sensitivity analysis in relation to transportation distance and freezing time would be recommended to determine the variation in savings between the current process and the Arctic Express Pack process. The distance between Manufacturer and End Party User was assumed and does not represent all applications.

References

[1] Life Cycle Assessment Software. (2020). Retrieved April 8, 2020, from http://www.gabi-software.com/canada/index/

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