ENVIRONMENTAL IMPACTS OF TRANSITIONING 100 MILLION POLYSTYRENE AND POLYPROPYLENE COFFEE PODS TO COMPOSTABLE PURPODS

Corresponding Author: Dr. Calvin Lakhan

Secondary Author(s):

- **Elizabeth Cho Macmillan**

Prepared by: Waste Wiki@FES

Faculty of Environmental Studies, York University

Contents

Defining Model Boundaries

For the purposes of this report, model boundaries include:

- Virgin Material Extraction (Petroleum Extraction, corn starch/sugar cane cultivation)
- Material Processing (Petroleum to Ethylene pellets, PLA production)
- Manufacturing (Ethylene pellets/PLA into final product)
- Virgin Transport (Source to Processing) – distance between where virgin material is being extracted and the processor
- Transport (Processing to Manufacturer) – distance from processor to manufacturing plant
- Transport to End Market – Distance from manufacturing plant to end market

Calculation Steps

To accurately model the emissions impacts associated with the manufacturing and transport of Club Coffee and Plastic pod manufacturers products, the following steps were taken:

Data Preparation

- Using product compositions provided by Club Coffee and the EcoInvent entry for plastic coffee pods (both PP #5, and PS #6) , calculate total quantities of plastics, paper, aluminum and PLA being used to manufacture each product – this includes both construction of the product itself, and the corresponding packaging.

- Calculate the transport distances from source extraction, to manufacturing facility, to distribution center. For the purposes of these calculations, we use EcoInvent's default data assumptions surrounding transport distance of coffee pods for the Canadian market.

Identify and calculate the emissions coefficients associated with each of the stages highlighted in the model boundaries (virgin material extraction etc.)

Emissions coefficients are taken from the EcoInvent database, which is the world's largest open source repository for life cycle data. Given that this is a high level LCA, we have used data surrogates to approximate for the manufacturing processes used by Club Coffee and plastic pod manufacturers (i.e. extruding plastic pellets into PP uses an assumed process taken from Eco Invent, and may not reflect the actual process used by manufacturers).

Generally speaking, there is limited variability with respect to the energy intensiveness and LCA impacts associated with various processes. Carbon coefficients are most sensitive to the energy grid mix being used as the inputs for production (which have been accounted for).

Calculate Process Energy Coefficients

Using EcoInvent, model the processing energy coefficient (which includes all process energy associated with material extraction, material processing and manufacturing into end product).

- Processing energy coefficients will be unique to the material type used in manufacturing Club Coffee/plastic pod products, i.e. Polystyrene/Polypropylene Shell, PLA, Polyethylene wrapper, HDPE etc.

Of note, emissions coefficients used in this study assumes that exclusively virgin resin is used in the manufacturing of both PurPods and plastic pods.

Transportation Energy (Source to Processor) will be unique for each material used in the manufacturing of Club Coffee/plastic pod products, as it is assumed virgin material is sourced from different areas.

Calculating Transport Energy (Process to End Markets)

Based on the transport distance provided by EcoInvent, (from origin plant location, to shipping port, to receiving port), and the EcoInvent emissions per truck km (Diesel) and emissions per ship km (Diesel), calculate transport energy (process to end market).

*Equation: (Distance traveled by truck * Emissions per truck km) + (Distance traveled by ship * Emissions per ship km)*

Transportation Energy (Processor to End Market) will be the same for each material used in manufacturing (as the finished product is being transported) from one manufacturing location, to a destination port.

Calculate Overall Emissions Impacts

To calculate the overall emissions impacts of various Club Coffee and plastic pod products in each market area, we use the following formula:

*Equation: [(Material Tonnes * Process Energy Coefficient) + (Material Tonnes * Transport Energy (Source to Processor)) + (Material Tonnes * Transport Energy (Processor to End Market)]*

Summary of Results

Note: All results shown are modeled assuming 100 million coffee pods (for both Club Coffee PurPods and #6 PS and #5 PP coffee pods). Please refer to Appendix for a 1 billion coffee pod scenario

Tables 1 and Figure 1 summarize the differences in total carbon footprint attributable to the manufacturing of 100 million PurPods vs 100 Million #6 (PS) and #5 (PP) platic pods. These results are communicated using environmental KPIs that attempt to quantify environmental impacts into "easy to understand" metrics that can be readily communicated to both consumers and policy makers.

Table 1:

	PurPod vs PS #6	PurPod vs PP #5
Reduction in Overall Plastic (Pod Only)	88.86% less plastic	90.00% less plastic
Reduction in Overall Emissions (Pod Only)	94.38% fewer cabon emissions	92.48% fewer cabon emissions
Total Difference in Carbon Footprint (per 100m)	1,092.70 T/CO2e	1,218.08 T/CO2e
Carbon savings is the equivalent of planting (mature trees)	6,829.12 mature trees	7,613.00 mature trees
Carbon savings is the equivalent of removing (cars from road)	237.53 cars removed from road	264.80 cars removed from road

Figure 1:

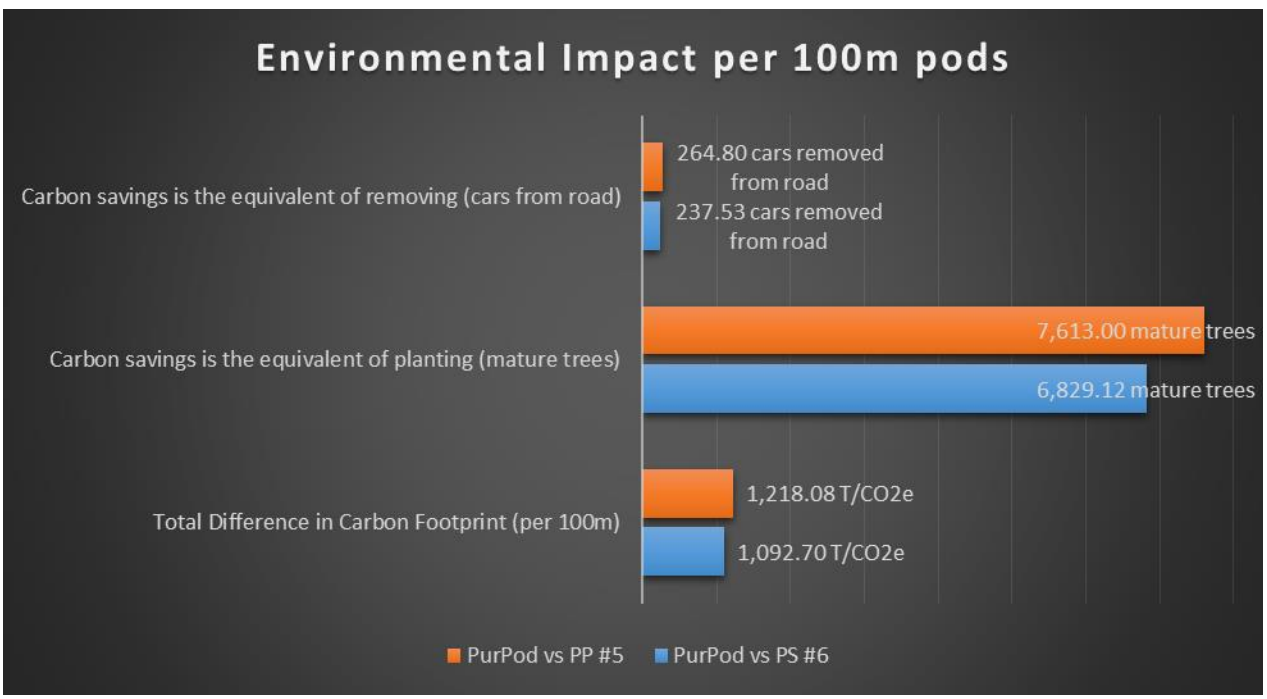

Table 2 summarizes total plastics reduction using metrics that help readers conceptualize what that looks like in practical terms. As an example, total plastics reduction from switching 100 million plastic coffee pods into 100 million PurPods results in a plastics reduction of approximately 314.5 tonnes (when compared against #6 PS Pods) and 318.15 tonnes (when compared against #5 PP Pods). Expressed alternatively, eliminating 100m plastic pods (of either #5PP or #6 PS pods when stacked) is the equivalent of:

Table 2:

# of CN Towers	5,424.95 CN Towers
# of Empire State Buildings	7,874.02 Empire State Building
Distance from Toronto to Ottawa	9.15 Trips
Distance from New York to Washington	9.62 Trips
Distance around earth	0.09 trips around earth
Plastic Savings per Canadian Household (Cad Sales)	0.74 kg/hh
Plastic Savings per US Household (US Sales)	0.61 kg/hh

*Note: Measures of height assumes 100 million coffee pods stacked vertically. Measures of distance assumes 100 million coffee pods stacked side by side. Assumed dimensions of coffee pod are H(33m),W(37mm).

Of note, kg plastic savings per household (US and Canada) are based on converting all plastic pods sold into the Canadian/US market, divided by total # of households.

While the figures above are not conventional ways of communicating environmental performance, they are useful measures in providing readers with a reference point.

The above results show the significant environmental benefit of using compostable coffee pods in lieu of conventional polypropylene and polystyrene based pods.

Detailed Emissions Coefficients by Material Type and by Process

As shown in Figures 2 through 4 below, the emissions impacts associated with virgin ethylene production and processing are significantly higher than those found in PLA manufacturing, resulting in plastic pods (both #5 PP and #6 PS) having a carbon impact that is more than 15x greater than compostable pods.

Figure 2:

Poly # 6 Pod		Primary Production (Raw material extraction)	Secondary Production (Product Manufacturing)	Recycling	Composting
Shell	Polystrene, expandable	-3.13 TCO2e	-1.92 TCO2e	1.8 TCO2e	0.00 TCO2e
	Polyethylene, LDPE	-3.07 TCO2e	-1.88 TCO2e	1.39 TCO2e	0.00 TCO2e
	Ethylene vinyl acetate copolymer	-3.00 TCO2e	-1.94 TCO2e	0.00 TCO2e	0.00 TCO2e
	Aluminum	-11.32 TCO2e	-5.59 TCO2e	10.01 TCO2e	0.00 TCO2e
Lid	Polytehylene, terephtalate,granulate	-3.11 TCO2e	-1.91 TCO2e	1.69 TCO2e	0.00 TCO2e
	Polyethylene, LDPE, granulate	-3.07 TCO2e	-1.88 TCO2e	1.39 TCO2e	0.00 TCO2e
	Printing Color (Masterbatch)	1.79 T/CO2E	0.70 T/CO2E	0.00 T/CO2E	0.00 T/CO2E
Filter	Kraft paper, bleached	-5.52 TCO2e	-1.44 TCO2e	2.82 TCO2e	1.71 TCO2e
	Polyethylene, LDPE, granulate	-3.07 TCO2e	-1.88 TCO2e	1.39 TCO2e	0.00 TCO2e

Figure 3:

	Material Type (TCO2E)	Weighted Average Primary Production Emissions (TCO2E)	Weighted Average Processing Production (T/CO2e)	Weighted Average Landfilling Emissions (T/CO2e)	Weighted Average Emissions Savings Recycling (T/CO2e)	Weighted Average Emissions Savings Composting (T/CO2e)
#5 PP K Cup	Abaca Filter - Abaca Fiber	-4.11 TCO2e	0.00 TCO2e	0.06 TCO2e	0.00 TCO2e	0.06 TCO2e
	Abaca Filter - Softwood	-4.17 TCO2e	0.00 TCO2e	0.15 TCO2e	0.00 TCO2e	0.15 TCO2e
	Abaca Filter - PET	-3.11 TCO2e	-1.91 TCO2e	0.00 TCO2e	1.78 TCO2e	0.00 TCO2e
	Shell - PE	-2.99 TCO2e	-1.84 TCO2e	0.00 TCO2e	1.69 TCO2e	0.00 TCO2e
	Shell - EVOH	-3.00 TCO2e	-1.94 TCO2e	0.00 TCO2e	0.00 TCO2e	0.00 TCO2e
	Shell - PP	-3.13 TCO2e	-1.99 TCO2e	0.00 TCO2e	1.49 TCO2e	0.00 TCO2e
	Aluminum Lid - PE	-2.99 TCO2e	-1.84 TCO2e	0.00 TCO2e	1.69 TCO2e	0.00 TCO2e
	Aluminum Lid - PET	-3.11 TCO2e	-1.91 TCO2e	0.00 TCO2e	1.78 TCO2e	0.00 TCO2e
	Aluminun Lid - ALU Foil	-11.32 TCO2e	-5.59 TCO2e	0.00 TCO2e	10.01 TCO2e	0.00 TCO2e

Figure 4:

PRODUCT TYPE	MATERIALS	Primary Production (Raw material extraction)	Secondary Production (Product Manufacturing)	Recycling	Composting	Landfill
Compostable Pod, with compostable film	Paper Lid - Kraft Paper	-5.52 TCO2e	-1.44 TCO2e	2.82 TCO2e	1.71 TCO2e	-0.21 TCO2e
	Paper Lid - PLA	-0.71 TCO2e	-1.75 TCO2e	0.00 TCO2e	2.65 TCO2e	-0.13 TCO2e
	Mesh - PLA	-0.71 TCO2e	-1.75 TCO2e	0.00 TCO2e	2.65 TCO2e	-0.13 TCO2e
	PLA - Wrapping Bag	-0.71 TCO2e	-1.75 TCO2e	0.00 TCO2e	2.65 TCO2e	-0.13 TCO2e
	Brown Wring - Chaf	-1.16 TCO2e	-0.84 TCO2e	0.00 TCO2e	1.69 TCO2e	-0.08 TCO2e
	Brown Wring - PLA	-0.71 TCO2e	-1.75 TCO2e	0.00 TCO2e	2.65 TCO2e	-0.13 TCO2e

While what happens at end of life for both plastic and PLA pods is heavily debated, the most salient finding is that even in a situation where every single PurPod is landfilled, and every plastic pod is recycled (a highly unlikely, if not impossible scenario given existing recycling infrastructure cannot readily recycle either polystyrene or polypropylene pods), the environmental footprint of the PurPod would still be smaller.

The key take away from this modeling exercise is to demonstrate the superior environmental benefits of compostable pods, using data that is both publically accessible (EcoInvent) and methodologically replicable.

APPENDIX: 1 Billion Pod Scenario

The following tables and figures summarize the results from substituting 1 billion #5PP and #6PS Plastic Pods with 1 billion compostable PurPods.

This modeling assumes that there is a direct 1 to 1 substitution between ethylene pods and compostable pods, and that no additional resources or infrastructure are required to make this transition (i.e. additional packaging, labor, equipment purchases etc.). Given that the composition and dimensions of the pod are fixed, and the only being changed is quantity, then we should observe a direct linear relationship that scales environmental impacts and plastic reduction with the number of pods, i.e. doubling the number of pods would also double plastic reduction, carbon reduction etc.

Table 3:

	PurPod vs PS #6	PurPod vs PP #5
Reduction in Overall Plastic (Pod Only)	88.86% less plastic	90.00% less plastic
Reduction in Overall Emissions (Pod Only)	94.38% fewer cabon emissions	92.48% fewer cabon emissions

Figure 5:

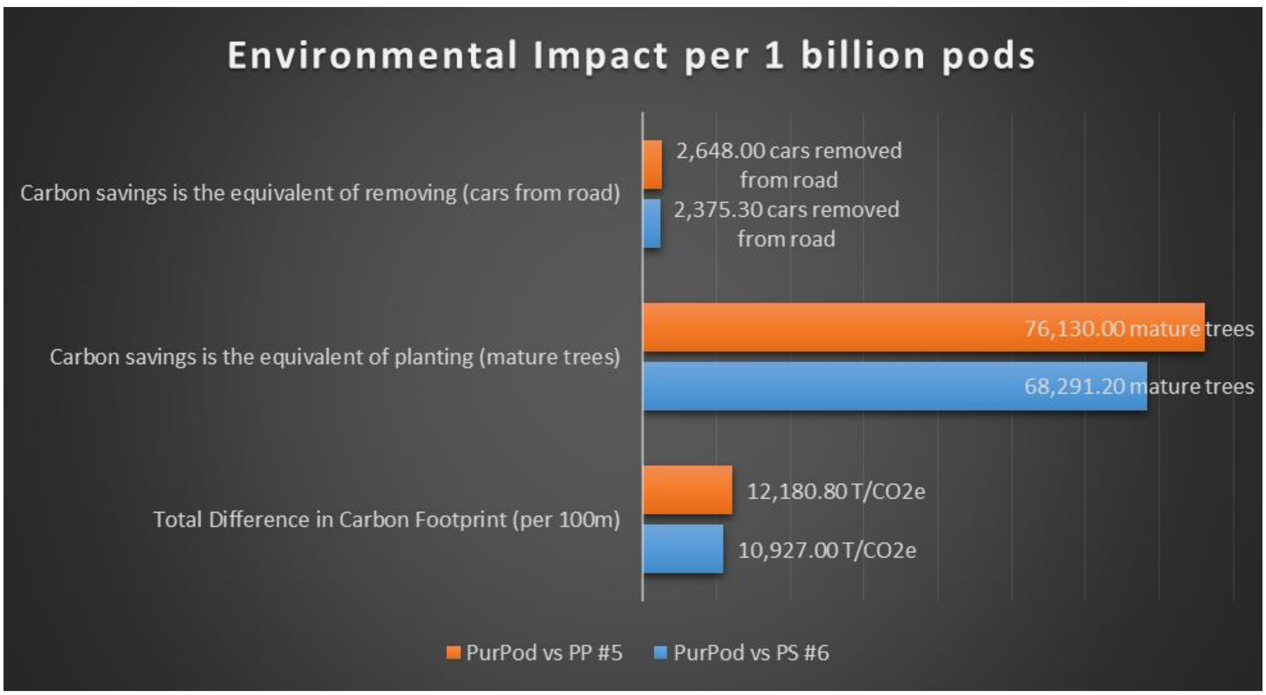

Table 4 summarizes total plastics reduction using alternative KPIs that were used in the body of the report (to provide the reader with context). Total plastics reduction from switching 1 billion Plastic Pods into 1 billion PurPods results in a plastics reduction of approximately 3145 tonnes (when compared against #6 PS pods) and 3181.5 tonnes (when compared against #5 PP pods). This is the equivalent of[1]:

Table 4:

[1] *Note: Measures of height assumes 1 billion coffee pods stacked vertically. Measures of distance assumes 1 billion coffee pods stacked side by side. Assumed dimensions of coffee pod are H(33m),W(37mm).

# of CN Towers	54,249.55 CN Towers
Distance from Toronto to Ottawa	91.52 Trips
Distance around earth	0.92 trips around earth
Plastic Savings per Household	0.25 kg plastic per HH