The Association of Plastic Recyclers White Paper:

Greenhouse Gas Generation: Plastics vs. Alternatives for Packaging

May 12, 2020

Executive Summary:

Replacing plastics packaging with function-similar and adequate non-plastic alternatives will increase Greenhouse Gas emissions by a factor of 2.2 with maximum decomposition of degradable alternative materials (57.6 M MT CO_2 equivalents for plastic vs. 125.0 M MT CO_2 equivalents for substitute materials).

For no decomposition of degradables, the factor is 1.7 (57.6 M MT CO_2E for plastics, 97.1 M MT CO_2E for non-degrading substitutes).

The savings in greenhouse gas equivalents from using plastics for packaging is equal to 14 or 8.5 million passenger cars, depending on full degradation or no degradation of cellulosic substitute material such as paper and cardboard.

This was the April 2018 finding by Franklin Associates. The 2018 study was an update of a January 2014 study by Franklin Associates on the same subject. As reported in 2014, replacing plastic packaging with function-adequate non-plastic alternatives would have increased Greenhouse Gas emissions by a factor of 2.5 with maximum decomposition of degradable materials (58.6 M MT CO2E for plastic vs. 148.2 M MT CO2E for substitute materials).

Background:

The American Chemistry Council contracted with Franklin Associates, a division of Eastern Research Group (ERG), to examine the impact of switching from plastic packaging, including rigid bottles and containers, caps, closures, bags, flexibles, and films, to function-similar and adequate metal, glass, and paper/cardboard materials. The first study was conducted in 2014[1]. An expansion and update was conducted in 2018[2]. The update included process improvements for making all materials, changes in the electrical grid fuels makeup, and changes in paper recycling credits. The 2018 substitution analysis used the same market share values as the 2014 study.

Franklin Associates is a well-recognized life cycle study practioner. Franklin Associates has been contracted by the US EPA for many years to conduct municipal solid waste studies. Franklin Associates

[1] **January 2014, IMPACT OF PLASTICS PACKAGING ON LIFE CYCLE ENERGY CONSUMPTION & GREENHOUSE GAS EMISSIONS IN THE UNITED STATES AND CANADA Substitution Analysis** **https://plastics.americanchemistry.com/Education-Resources/Publications/Impact-of-Plastics-Packaging.pdf**

[2] **April 2018, LIFE CYCLE IMPACTS OF PLASTIC PACKAGING COMPARED TO SUBSTITUTES IN THE UNITED STATES AND CANADA Theoretical Substitution Analysis https://plastics.americanchemistry.com/Reports-and-Publications/LCA-of-Plastic-Packaging-Compared-to-Substitutes.pdf**

has conducted life cycle inventories, LCI, since before the discipline of life cycle assessment was formally defined by ISO and SEATAC; Franklin Associates was instrumental in the formalizing of the discipline. Franklin Associates is a regular contributor to and supporter of the United States Life Cycle Inventory Database (USLCI Database) at the National Renewable Energy Laboratory, NREL.

For both the 2014 and 2018 update Franklin Associates followed ISO 14000 standards for life cycle assessments. The methodology and results were peer reviewed by competent reviewers not associated with any packaging material industry (reviewers were members of the Swiss Federal Laboratories for Materials Science and Technology). The functional units were items of equal volume capacity for bottles (including caps and closures), other rigids, bags, pouches, wraps, and films of materials used for those applications other than plastics. All materials were included at the levels of recycled content seen for the years for which the data were obtained. The alternative materials included: “steel; aluminum; glass; paper-based packaging including corrugated board, packaging paper, cardboard (both coated and uncoated), molded fiber, paper-based composites and laminates; fiber-based textiles; and wood. Substitutes for plastic packaging vary depending on the market sector and packaging application.”

The boundaries for the life cycle study began with raw material acquisition and went through packaging manufacture, distribution & retail, and disposal including recycling. Product filling and product refrigeration were not included as such are considered not dependent on the packaging. The plastics examined included polyethylene, polypropylene, PET, PVC, and polystyrene.

Electricity and petroleum data are drawn from public sources including the US LCI Database. Rigid plastic was replaced by rigid non-plastic. The 2014 market share and package weights for plastic and non-plastic items were used for the 2018 update.

A similar study was conducted for Canadian packaging.

The 2018 study finds replacing plastic packaging with other materials means the weight of the replacement is 4.5 times the weight of plastic packaging. This increase in weight of material has profound consequences on all life cycle inventory results. The following table is from the 2018 study and includes all of the life cycle inventory impact categories from which the impact effects are measured. In all cases the sum of plastics packaging was superior to the sum of typical non-plastic packaging materials for the same volume of packaged goods.

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Life Cycle Inventory Comparisons: Plastics Packaging vs. Non-Plastic Packaging[1]

	Units	Plastic	Non-Plastics, No Degrading	Ratio, Non-Plastics/ Plastics
Total energy	B MJ	1,309	2,544	1.9
Expended energy	B MJ	693	2,127	3.1
Global Warming Potential	M MT CO_2E	57.6	97.1	1.7
Water Consumption	K M^3	232,845	1,353,815	5.8
Solid Waste, weight	K MT	13,563	66,725	4.9
Solid Waste, volume	M M^3	39.9	95.3	2.4
Acidification Potential	K MT SO_2E	225	766	3.4
Eutrophication Potential	K MT NE	6.47	347	53.6
Smog Formation Potential	K MT O_3E	3,068	9,750	3.2
Ozone Depletion Potential	MT CFC-11E	0.41	1.56	3.8

[1] LIFE CYCLE IMPACTS OF PLASTIC PACKAGING COMPARED TO SUBSTITUTES IN THE UNITED STATES AND CANADA Theoretical Substitution Analysis, https://plastics.americanchemistry.com/Reports-and-Publications/LCA-of-Plastic-Packaging-Compared-to-Substitutes.pdf

The comparison is for plastics packaging compared to non-plastics packaging with no degradation of the paper-based products, which is the most favorable case for the non-plastics. Total energy is the sum of inherent energy and expended energy.

1. "B MJ" is billion megajoules. In life cycle assessment conventions plastics have an inherent or embedded energy which is counted. We see that as fuel value. Paper and wood fuel value is not counted, by convention. Metals and glass have not fuel value. Examination of expended energy for alternatives is a comparison on a constant basis.
2. "Global Warming Potential" is the proper term for greenhouse gas (GHG) profile.
3. "M MT CO_2E" is millions of metric tons of carbon dioxide equivalents, a means of combining all global warming potential emissions under one characteristic.
4. "K M^3" is thousands of cubic meters.
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6. "K MT" is thousands of metric tons.

7. “K MT SO_2E” is thousands of metric tons of sulfur dioxide equivalents, a means of combining all the emissions that cause acidification.
8. “K MT NE” is thousands of metric tons of nitrogen equivalents, a means of combining emissions to water that cause excessive algae growth and the oxygen depletion of eutrophication.
9. “K MT O_3E” is thousands of metric tons of ground level ozone equivalents that cause smog.
10. “MT CFC-11E” is metric tons of the Freon CFC-11 equivalents that destroy upper atmosphere ozone and allow for high levels of ultra-violet radiation to strike the earth.
11. The “Ratio” is the non-plastics materials life cycle environmental burden total divided by the plastics materials environmental burden doing the same function. Any value greater than 1 means the environmental burden from the non-plastic packaging is greater than that from plastics packaging.

Franklin Associates has estimated that a 10% difference at least is needed for statistical significance. Therefore, a “Ratio” of over 1.1 is needed for statistical significance. For all Ratio values for all of the environmental burden categories, plastic packaging as a whole performs better than non-plastic substitutes as a whole.

Additional Input

Another study by Franklin Associates was published in 2009, comparing the life cycle inventory for different carbonated soft drink containers, PET and glass and aluminum, for a given constant amount of beverage[3]. The containers examined were common sizes: 12 fluid ounces for aluminum cans, 8 fluid ounces for glass, and 20 fluid ounces for PET. The scope was raw material acquisition and synthesis, packaging manufacture, delivery, and disposal and included closures and labels. The materials contained the recycled content for the data time, 2006, which had no recycled content for PET and substantial recycled content for glass and aluminum.

Greenhouse Gas Emissions for Soft Drink Containers
(per 100,000 fluid ounces), 2006 data, published 2009

	Recycled Content	CO_2 Equivalents	Ratio
Aluminum can, 12 fluid ounce	41%	2,766 pounds	2.5
Glass bottle, 8 fluid ounce	30%	4,848 pounds	4.3
PET bottle, 20 fluid ounce	0%	1,125 pounds	1

The PET bottle with no recycled content generated only 41%, (1125/2766), as much greenhouse gas as did the aluminum can for the same number of fluid ounces of beverage delivered. The PET bottle generated only 23% as much greenhouse gas as did the common glass bottle for soft drinks. On the basis of carbonated soft drink packaging and greenhouse gas emissions, the PET bottle was superior to either glass bottles or aluminum cans. If one included current 2020 recycled content levels, the PET bottle would perform even better in environmental impact. In 2020 to 2021 there will be a revisit to the subject of PET bottles vs. aluminum cans vs. glass bottles.

[3] **August 2009, LIFE CYCLE INVENTORY OF THREE SINGLE-SERVING SOFT DRINK CONTAINERS http://petresin.org/pdf/FranklinLCISodaContainers2009.pdf**