REVIEW OF LIFE CYCLE INVENTORY STUDY AS IT RELATES TO SUSTAINABLE PACKAGING

I. OVERVIEW

The concept of sustainable packaging has recently been grabbing headlines. Influential companies such as Wal-Mart are announcing their desire to streamline packaging in order to ensure that the products they sell are low cost to consumers as well as to the environment.

To gauge and compare the sustainability of various product or packaging alternatives, "life cycle" studies are performed on them. These studies review the environmental effects (known as "burdens") occurring from the "birth" (i.e., raw material extraction) to the ultimate disposal of the items being examined, hence the term "cradle-to-grave" analysis.

A new study just released by Athena Institute International takes a life cycle look at the environmental burdens associated with the production of a number of common packaging items from a corn-based plastic, polylactide (PLA), versus producing them from traditional petroleum-based plastics. The study examines 16 oz. cold drink cups, 16 oz. 2-piece deli containers, envelope window film, foam meat trays, and 12 oz. water bottles. The Life Cycle Inventory (LCI) focuses on the differences in energy consumption, waste generation, and greenhouse gas emissions for these items.

The information provided by the LCI can be used for two purposes. First, companies that produce resins made from renewable resources are claiming that their products are more environmentally sustainable than resins made from non-renewable resources such as petroleum or natural gas. The study was performed to help determine the validity of those claims by examining actual items with which consumers come in contact on a daily basis.

Second, the study itself is analyzed here to determine how best to provide all of the accurate information needed to both make and validate claims related to environmental sustainability, in order to ensure that future studies consider all of the necessary factors needed to develop actionable information.

The study was performed by Franklin Associates, an independent provider of life cycle services. All data used in the study were drawn from published sources. Besides its own data, which are published in the US LCI database, Franklin utilized information from NatureWorks, the leading manufacturer of PLA, and from PlasticsEurope, a plastics manufacturer association that supplied data on general purpose polystyrene (GPPS), high impact polystyrene (HIPS), polypropylene (PP), and polyethylene terepthalate (PET).

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II. STUDY LIMITATIONS

First, by its nature, this LCI does not measure the full cradle-to-grave impact of competitive materials, and thus cannot provide a full assessment of the environmental impacts of the products being reviewed. Although the LCI tracked all environmental burdens from cradle to production of the products studied, the scope of the study did not include end-of-life management of the products, nor did the scope include an impact assessment. Thus, *the data provided should be used to gauge differences in the specific inventories being measured, and cannot be used to make broad, general conclusions about either the plastics or packages being studied*.

Second, because the analysis excludes post-consumer usage scenarios, there is no credit given for recycling. For reference, recycling helps to reduce carbon dioxide creation, and thus can also reduce greenhouse gas emissions. The LCI report explains that post-consumer usage scenarios were not evaluated, because very little data exist on end-of-life recycling and composting of PLA.

Exclusion of post-consumer use scenarios is not a significant issue for drink cups, deli containers, envelope windows or meat trays, as recycling of these items is negligible. However, it could be of consequence when comparing PLA to PET for 12 oz. water bottles. While the former are not recycled nor are they recyclable within existing infrastructures, single-serve PET water bottles can be recycled. It would have been helpful to apply greenhouse gas emission offsets due to recycling, even if the effect proved to be insignificant.

Third, care must be taken to focus on the specific products in question, and not simply the materials from which they were produced. Again using the 12 oz. soda bottle as an example, greenhouse gas emissions for PET are almost 30% higher than for PLA. While this may be true for 12 oz. bottles, it would not be true for larger sizes, where the recycling rate for PET can be in excess of 20%, and up to 80%, depending on the state or locality. Since recycling reduces greenhouse gas production, the gap between PLA and PET would narrow considerably if multiple-serve, rather than single-serve, containers were being analyzed.

III. DATA

The data are provided in two tables. The first, Table ES-1, includes the weight of each product in pounds and kilograms. To make the results equivalent and thus comparable, the weights are converted into what is known as a functional unit – in this case, a functional unit is 10,000 products (cups, deli containers, foam meat trays, water bottles) or, for envelope window film, 1 million square inches of film.

Table ES-1

WEIGHTS FOR VARIOUS PRODUCT APPLICATIONS FOR PLA AND PETROLEUM-BASED PLASTIC PRODUCTS

Products	Weight per unit		Weight per functional unit	
	(oz)	(g)	(lb)	(kg)
16-ounce cold drink cup (Basis: 10,000 cups)				
PLA	0.52	14.8	326	148
HIPS	0.43	12.3	271	123
PET	0.56	15.8	348	158
PP	0.37	10.5	231	105
Clear 16-ounce 2-piece deli container (Basis: 10,000 2-piece containers) (1)				
Light-Weight (2)				
PLA	0.63	18.0	396	180
GPPS	0.52	14.9	328	149
Heavy-Duty (2)				
PLA	0.71	20.0	441	200
PET	0.90	25.6	564	256
Envelope window film (Basis: 1,000,000 sq. inches)				
PLA			51.9	23.6
GPPS			43.5	19.7
Foam meat tray (Basis: 10,000 trays) (3)				
PLA Foam	0.19	5.5	121	54.8
GPPS Foam	0.18	5.2	115	52.2
12-ounce water bottle (Basis: 10,000 bottles)				
PLA	0.74	21.0	463	210
PET	0.72	20.3	448	203

(1) This weight includes both the container and a flat lid. Samples of lids and containers were weighed and averaged separately, then the averages were summed.
(2) Light weight deli containers are packed by hand, while heavy duty deli containers are filled using automated packing. The PET resin is commonly used for the automated packing, while the GPPS is commonly used for hand packing.
(3) This foam meat tray is commonly used for 1 pound packs of ground beef.

Source: Franklin Associates, a Division of ERG

All of the available energy and emissions data is then applied to the functional units. The final results are available on the next page, in Table ES-2.

Table ES-2

TOTAL ENERGY, POSTCONSUMER SOLID WASTE, AND GREENHOUSE GASES
FOR PLA AND PETROLEUM-BASED PLASTIC PRODUCTS

Products	Total Energy (GJ)	Postconsumer Solid Waste (kg)	Greenhouse Gases (kg of CO2 equivalents)
16-ounce cold drink cup (Basis: 10,000 cups)			
PLA 2005	14.5	118	510
HIPS	13.3	98.4	576
PP	9.82	84.0	345
PET	16.1	126	719
16-ounce 2-piece deli container (Basis: 10,000 2-piece containers)			
Light-Weight			
PLA 2005	17.2	144	589
GPPS	15.7	119	684
Heavy-Weight			
PLA 2005	19.3	160	669
PET	26.2	205	1,170
Envelope window film (Basis: 1,000,000 sq. inches)			
PLA 2005	2.03	18.8	62.6
GPPS	1.87	15.8	76.1
Foam meat tray (Basis: 10,000 trays)			
PLA Foam 2005	5.59	43.8	192
GPPS Foam	5.77	41.8	231
12-ounce water bottle (Basis: 10,000 bottles)			
PLA 2005	19.8	168	744
PET	21.4	162	961

Source: Franklin Associates, a Division of ERG

IV. FINDINGS

A. Overall

Based on the life cycle data for the packaging products evaluated, neither corn-based nor petroleum-based products can be considered more environmentally sustainable than the other. As shown in Table ES-2, there is no clear-cut "winner" when looking at the three inventory factors, or at the specific products being examined. In fact, there are instances in which each of the resins examined can claim lower environmental burdens than the others.

B. By Specific Resin and Application

Before discussing the details, it must be noted that NatureWorks provided two sets of data – one set for 2005 and one for 2006. However, only 2005 data is being considered for this review, because differences between the two sets are due to the purchase of wind energy vouchers in 2006, and the application of credits based upon that purchase. Any resin manufacturer could buy these same credits, so there is no inherent or competitive value that can be assigned to them.

Applying these types of offsets is also problematical because it creates additional opportunities for confusion. For example, if instead of purchasing a competing supply of wind energy vouchers, the petroleum-based plastics manufacturers decided to buy solar energy vouchers or greenhouse gas emission credits, how would one compare the potential value of one type of voucher or credit against that of another type?

1. Energy
In general, it takes at least as much energy to produce products from PLA as it does to produce them from petroleum-based plastics. Even though corn is a renewable resource, it takes a great deal of energy to grow it, and to process it into plastic pellets in manufacturing facilities that look and operate very similarly to petroleum-based plastics facilities.

2. Post-Consumer Solid Waste
In general, PLA creates at least as much solid waste as packages made from more traditional materials like polystyrene, polypropylene, and PET. The reason is fairly straightforward. Other than PET, which has a similar density to PLA, the weight of the petroleum-based plastic needed to produce a particular package is significantly less than the weight of the PLA needed to produce the corresponding package.

3. Greenhouse Gases
In general, the use of PLA produces fewer greenhouse gas emissions than the use of petroleum-based plastics in the reviewed packaging applications.

4. Package-to-Package Differences
There are two specific instances in which packages made from PLA had lower environmental burdens than packages produced from petroleum-based resins. However, for reasons described below, these results can only be considered preliminary:

a. **Heavy Weight 16 oz. 2-Piece Deli Containers** – The PLA version consumed less energy, created less solid waste, and produced fewer greenhouse gas emissions than did the PET container. However, since the data for these items came from one company that produced both products, the only conclusion that can be drawn with certainty is that these differences exist for items produced *by that company*. These results may not be typical for that application across multiple producers.

b. **Foam Meat Trays** – To show how the weight of the meat tray affects the results, consider that the tray made from polystyrene foam performed similarly to the PLA foam tray, and that the two weigh about the same. Thus, differences relate to the amount of PLA or polypropylene used in the product, as well as to the resins' environmental burdens per pound.

The importance of weight, as well as resin type, cuts across other resins as well. For example, for cold drink cups, where the polypropylene version is 30% lighter than the PLA version, the former performs about 30% better than PLA across the three dimensions of energy use, post-consumer solid waste, and greenhouse gas emissions. (*For reference, the environmental burdens for a product are calculated as [environmental burdens per pound of material) x (pounds of material used in the product]. Thus, differences in the weight of alternative products can often overcome differences in the environmental burdens per pound for the materials used.)*

C. Intra-Study Limitations

Besides those mentioned in the discussions above, there are two other rather significant limitations that exist within the study. These must be addressed before accurate assessments and conclusions can be made:

1. <u>In most cases, a specific product, NatureWorks PLA, is compared against a general industry average for petroleum-based plastics</u>. Comparisons such as this must be carefully examined, as they can lead to faulty conclusions from which informed decisions cannot be made. In this case, the problem is that products made from one specific resin, PLA, are compared against products in which the resin examined is a database composite of petroleum-based resins produced by multiple manufacturers.

   While using averages for the petroleum-based resins simplifies the analysis, it does not provide a methodology by which actual decisions can be made. It would have been more accurate to review the range of results for the petroleum-based resins, so that it could be determined if there were meaningful differences with which to draw conclusions or even make purchasing decisions. However, published data are not available on the range of environmental burdens for petroleum-based resins produced by individual companies.

   To provide an easy-to-understand analogy, consider a scenario in which a Chinese car manufacturer enters the U.S. market with a sub-compact that delivers 35 miles per gallon. The company claims that its vehicle gets better gas mileage than all other available sub-compacts, which average 34 miles per gallon. At first glance, it appears that the Chinese car is the one to buy if fuel economy is a key purchasing factor.

   The problem is that a car buyer looking for good fuel economy cannot buy an average car, but must look at the various cars from which that average is derived. The real question is how well the Chinese car fared against **each** of the similar models from other car companies, not how it compared against **all** of them. In order for the existing car average to be 34 miles per gallon, some cars must have performed below this level, and some must have performed above it. The buyer's job is to find those that may have performed significantly better than the average.

2. <u>There is no available metric by which to understand the significance of the differences being studied for energy, post-consumer solid waste, and greenhouse gas emissions</u>. Going back to the example above, it might appear that, at 35 mpg, the new car did better than the older car average of 34 mpg. The problem is that from a statistical perspective, there may in fact be little, if any, real difference to either the environment or the owner's wallet.

V. CONCLUSIONS/SUMMARY

The available data does not support claims that plastic resins made from renewable resources such as corn are more sustainable than resins produced from petroleum or natural gas. In some cases, life cycle data contradicts these claims, while in other cases, there is a lack of available data to support them.

An interesting observation from this study is that the environmental comparisons tracked closely with the weights of the products, indicating that packaging weight per unit of delivered product may be an acceptable "top line" metric for examining environmental sustainability, at least when the products being compared are made from similar types of materials, in this case, plastic resins. For example, although there are differences in the environmental burdens per pound for corn-based and petroleum-based resins, products made from higher density materials like PLA tend to be heavier than products made from the petroleum-based resins. As a result, the PLA products often showed higher overall environmental burdens compared to corresponding products made from petroleum-based resins.

Finally, before any firm conclusions can be drawn or claims validated, two issues must be addressed:

1. Research is needed to determine post-usage scenarios and impacts for these different packages and material types. For example, inclusion of recycling and composting data could significantly impact environmental burden levels and thus the conclusions that should be drawn between packages and materials.

2. Although this life cycle inventory underwent internal review by Franklin Associates and by Athena International, it is also advisable to conduct independent peer review at all stages – from methodology and design through data gathering, analysis and results reporting. Finally, all interested parties must agree, and adhere to, the levels at which differences are considered to be statistically meaningful and significant.

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Note: The Athena Institute Summary Report and Franklin Associates Technical Report are available on-line:

Athena Institute Summary Report:
http://www.athenasmi.ca/projects/docs/Plastic_Products_LCA_Summary_Rpt.pdf

Franklin Institute Technical Report:
http://www.athenasmi.ca/projects/docs/Plastic_Products_LCA_Technical_Rpt.pdf