REVIEW OF LIFECYCLE INVENTORY STUDY FOR HALF-GALLON MILK CONTAINERS

I. OVERVIEW

In December 2006, *The ULS Report* published a review of a study released by Athena Institute International (*Lifecycle Inventory of Five Products Produced from Polylactide (PLA) and Petroleum-Based Resins*, November 2006) that looked at the environmental burdens associated with the production of a number of common packaging items made from both traditional petroleum-based plastics and a corn-based plastic known as polylactide, or PLA. Our report, entitled *Review of Lifecycle Inventory as It Relates to Sustainable Packaging*, concluded that PLA, which is made from a renewable resource, did not appear to produce more sustainable packaging than resins such as high density polyethylene (HDPE), polypropylene (PP), or polyethylene terepthalate (PET), which are made from non-renewable resources. It also stated that, because available post-usage scenarios such as recycling or reuse were not included, further research was needed to support the conclusion.

The Plastics Division of the American Chemistry Council (ACC) read our report, and thought that it potentially cast traditional plastics in a favorable light. They asked Franklin Associates, the research organization which created the original study for the Athena Institute, to develop a Lifecycle Inventory (LCI) of plastic packaging that included the post-usage scenarios that we said were missing from the first study.

The ACC suggested that Franklin study half gallon milk containers, as these packages are both ubiquitous and available in a wide variety of competing material types: glass, HDPE, coated paperboard (described in their study as gable top), and PLA. Once the work was agreed upon, Franklin used milk container weight and material data from our recently published report entitled *A Study of Packaging Efficiency as it Relates to Waste Prevention* (February, 2007). We agreed to review the new milk container LCI analysis upon completion.

For reference, Franklin Associates is an independent provider of lifecycle services. Data used in their study were drawn from published sources wherever possible. Besides its own data, much of 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. Publicly available data on glass and gable top containers were not available, so these were modeled using Franklin Associates private LCI data.

The study examined energy use (process, transport, material resource), solid waste generation, and environmental emissions (atmospheric and waterborne). It also looked at the impacts of recycling and reuse.

We have asked Franklin Associates to review this summary for accuracy, and they have graciously done so. Melissa Huff, Senior Chemical Engineer at Franklin, believes that our conclusions are technically correct and consistent with their findings.

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II. PLEASE NOTE

Differences of 10% or less for energy and post-consumer solid waste, and differences of 25% or less for industrial solid wastes or emissions data, should not be considered meaningful. We are pleased that Franklin included measures of statistical significance, as we previously pointed out that the lack of such a measure in their Athena Institute study hampered our ability to discern truly meaningful differences among both the factors and containers being studied.

The end-of-life scenarios used in the study reflect the current recycling rates of the containers being analyzed. Because no significant recycling or composting of PLA is currently occurring, no resulting credits, offsets, or burdens were applied.

This paper is a review of the full study that was done by Franklin. Their report includes significantly more detail and data, and should be consulted to ensure a full understanding of the methodologies used and any limitations that may be associated with them.

III. DATA OVERVIEW

Table 1 includes the weight of all products in ounces and grams. To make the results equivalent and thus comparable, the weights are converted into what is known as a functional unit – in this case, 10,000 milk container uses. The purpose of creating this equivalency is to recognize and credit the reuse of glass milk bottles. All containers studied were half-gallon containers, providing functional equivalence in quantity of milk delivered per 10,000 container uses.

Table 1

WEIGHTS FOR HALF-GALLON MILK CONTAINER SYSTEMS
(Basis: 10,000 milk container uses)

	Weight per unit		Weight per functional unit	
	(oz)	(g)	(lb)	(kg)
Half-Gallon Milk Container Systems				
PLA Bottle				
Bottle	2.53	71.6	1,578	716
HDPE Cap/seal	0.10	2.9	64	29
Gable Top Carton				
Carton	2.42	68.5	1,510	685
HDPE Cap/spout	0.06	1.8	40	18
Glass Bottle				
Bottle (1)	32.14	911.1	7,801	3,539
LDPE Cap/seal	0.19	5.3	117	53
HDPE Bottle				
Bottle	1.66	47.2	1,041	472
HDPE Cap/seal	0.10	2.9	64	29

(1) The glass bottle is assumed to be reused 8 times before it is either landfilled or recycled. The recovery rate for the reuse of the glass bottle is 70 percent and the breakage rate is 1 percent. This reuse decreases the number of bottles needed for the basis.

These functional unit weights are the basis for the data generated by Franklin, and the comparisons upon which our findings and conclusions are based.

IV. FINDINGS

A. TOPLINE

Based on the lifecycle data for the milk packages evaluated, HDPE bottles consume less energy, produce less post-consumer solid waste, and generate lower greenhouse gas emissions than either glass or PLA bottles. Specific details for each category will be discussed in findings B-D below.

Table 2

TOTAL ENERGY, POSTCONSUMER SOLID WASTE, AND GREENHOUSE GASES FOR THE USE OF 10,000 HALF-GALLON MILK CONTAINERS

	Total Energy	Postconsumer Solid Waste		Greenhouse Gases
	(MM Btu)	(lb)	(cu ft)	(lb of CO2 equivalents)
Half-gallon milk container systems				
PLA Bottle (1)	66.0	1,061	80.7	5,450
Gable Top Carton (1)	42.5	1,248	46.5	4,341
Glass Bottle (2)	48.5	6,718	71.0	8,509
HDPE Bottle (3)	39.8	763	58.0	3,260

(1) End-of-life for this system is modeled with 80% going to a landfill and 20% combusted with energy recovery.
(2) End-of-life for this system is modeled with 15% recovered for recycling, 68% going to a landfill, and 17% combusted with energy recovery. However, the energy recovery is only available for the cap/seal.
(3) End-of-life for this system is modeled with 29% recovered for recycling, 57% going to a landfill, and 14% combusted with energy recovery.

B. ENERGY REQUIREMENTS

Based upon current end-of-lifecycle scenarios, the HDPE bottle and paperboard cartons had the lowest energy requirements, with the PLA container requiring the most lifecycle energy. For reference, if credit is given for the ability to combust waste to generate energy, the HDPE container requires the least net energy (see Table 3, on the next page).

For most readers, this finding will be highly counterintuitive, as HDPE is petroleum based. As shown in Table 3 on the next page, 56% of the total energy for the HDPE bottle system comes from the energy content of the raw material used to create the container. (In fact, as the full report details, 95% of the energy for the HDPE system is fossil fuel energy.) Yet, on a system-wide basis, the HDPE container is the smallest net user of energy.

The reason for this seeming disparity is the fact that the HDPE bottle system is by far the least intensive in terms of production efficiency. Thus, a lifecycle approach produces a radically different finding than what would be expected when looking solely at the material used to produce the container.

Table 3

Energy by Category for Half-Gallon Milk Containers
(MM Btu per 10,000 half-gallon milk container uses)

	Energy Category					
	Process	Transport	Energy of Material Resource	Total	Combustion Energy Credit (4)	Net Energy
Half-gallon milk container systems						
PLA Bottle System (1)	45.4	2.03	18.5	66.0	2.83	63.1
Gable Top Carton System (1)	36.0	1.86	4.66	42.5	2.25	40.3
Glass Bottle System (2)	35.9	9.84	2.79	48.5	0.47	48.1
HDPE Bottle System (3)	15.8	1.54	22.4	39.8	3.81	36.0

	Energy Category (percent)				
	Process	Transport	Energy of Material Resource	Total	Combustion Energy Credit (4)
Half-gallon milk container systems					
PLA Bottle System (1)	69%	3%	28%	100%	4%
Gable Top Carton System (1)	85%	4%	11%	100%	5%
Glass Bottle System (2)	74%	20%	6%	100%	1%
HDPE Bottle System (3)	40%	4%	56%	100%	10%

(1) End-of-life for this system is modeled with 80% going to a landfill and 20% combusted with energy recovery.
(2) End-of-life for this system is modeled with 15% recovered for recycling, 68% going to a landfill, and 17% combusted with energy recovery.
(3) End-of-life for this system is modeled with 29% recovered for recycling, 57% going to a landfill, and 14% combusted with energy recovery.
(4) The combustion energy credit includes a credit for the recovered energy from combustion of the final product at an incinerator. Any recovered energy from the material production processes are subtracted out of the total.

C. Post-Consumer Solid Waste

<u>The HDPE container produces the least amount of post-consumer solid waste on a weight basis, and is second to the paperboard carton on a volume basis</u>. As shown below and detailed in the full Franklin report, the post-consumer weight of HDPE container waste is significantly less than the other systems. Volume-wise, HDPE outperforms PLA because the former is recycled at a 29% rate, while the latter is not currently being recycled to any measurable degree.

Post-Consumer Solid Waste for Half-Gallon Milk Containers
(Lb. per 10,000 Half-Gallon Milk Container Uses)

	PLA	Gable Top	Glass Bottle	HDPE Bottle
By Weight	1,061	1,248	6,718	763
By Volume	80.7	46.5	71.0	58.0

D. GREENHOUSE GAS EMISSIONS

The HDPE container system produces significantly less greenhouse gas emissions than the other three container systems. This finding is also highly counterintuitive, again because of the fact that 95% of the HDPE system's total energy comes from fossil fuels. There are two reasons for this seeming disparity. First, as seen previously, production efficiency for HDPE significantly reduces energy consumption, and thus greenhouse gas creation, versus the other systems. Second, because the fuels used in the material production of HDPE are not combusted, they do not produce any carbon dioxide equivalents (See Table 6 on the next page). This carbon is sequestered within the HDPE container and is released if the container is incinerated.

As in the energy discussion, this finding also points out the value of taking a lifecycle, rather than simply a materials-based, approach. Accuracy requires that a more system-based analysis be undertaken, especially since the differences in results can obviously be very significant.

Table 6

Greenhouse Gas Summary for Half-Gallon Milk Containers
(lb carbon dioxide equivalents per 10,000 half-gallon milk container uses)

	PLA Bottle System	Gable Top Carton System	Glass Bottle System	HDPE Bottle System
Fossil carbon dioxide (CO_2)	4,587	3,953	7,956	2,755
Nitrous oxide (N_2O)	173	124	50.1	17.9
CFC/HCFC/HFC not specified elsewhere	1.2E-04	0.28	0.20	0.11
Methane (CH_4)	690	263	502	487
Methylene chloride (CH_2Cl_2)	1.1E-04	0.044	0.0026	0.0012
Total	5,450	4,341	8,509	3,260

Note: The 100 year global warming potentials used in this table are as follows: fossil carbon dioxide--1, nitrous oxide--296, CFC/HCFC/HFC--1700, methane--23, methylene chloride--10.

Source: Franklin Associates, a Division of ERG calculations using original data from LCI/LCA by NatureWorks, LLC, the Franklin Associates database, and the U.S. LCI Database.

V. CONCLUSIONS

1. The study performed by Franklin Associates on milk containers indicates that three popular notions regarding traditional plastics and the environment are not correct for this application, and potentially not for many applications. First, among the four systems studied, the HDPE-based container system generally produced the least environmental impact in terms of total energy consumption, post-consumer solid waste and greenhouse gas generation. Second, the HDPE system, which is produced from a non-renewable resource (petroleum), significantly outperformed the PLA system, a plastic produced from a renewable resource (corn). Third, while the HDPE system inherently contains fossil fuels because it is produced from them, its lifecycle uses less energy and produces fewer greenhouse gas emissions than the other systems.

While this conclusion will be news to most people, it reinforces the value of *The ULS Report*'s main message regarding the very positive environmental (and economic) impact of source reduction, or waste prevention. Much of the reduced environmental burden associated with HPDE containers comes from their being lighter than containers made from other materials, giving them the ability to deliver the same amount of product while using less material.

2. This study should be validated for accuracy and scope by performing similar studies across other packaging systems and materials. Doing so will ensure that the conclusions reached here can be generalized beyond milk containers.

3. Policymakers, journalists and other public communicators should use lifecycle thinking when making decisions or informing the public about the impact that their decisions might actually have on the environment. This doesn't mean that legislators or editors need to become lifecycle experts, merely that they need to understand the value of lifecycle thinking, and should request to see these types of studies prior to making decisions.

Robert Lilienfeld, Editor