A SCIENCE-BASED DECISION MAKING: USING LIFE CYCLE ASSESSMENT AND OTHER SCIENTIFIC DATA TO OPTIMISE PACKAGING PERFORMANCE



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- Franklin Associates (Life Cycle Inventory (LCI) Summary for Four Half-Gallon Milk Containers – September 2008)
- Plastics Division of the American Chemistry Council

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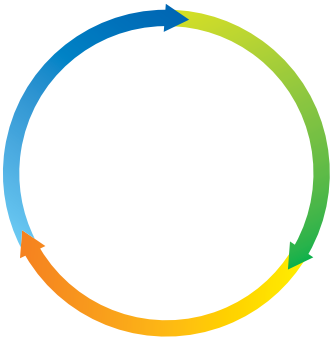


FOREWORD

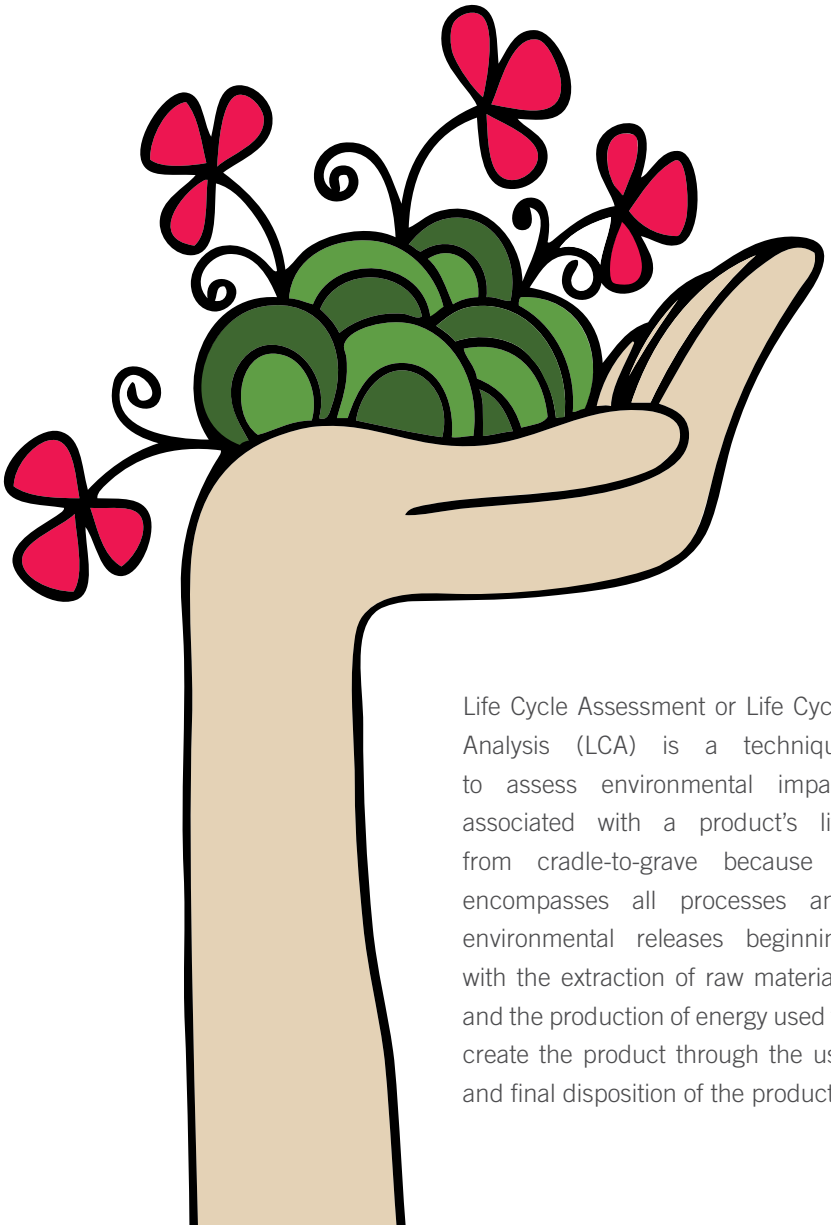
Today, society has become concerned about the issues of natural resource depletion and environmental degradation. As environmental awareness increases, industries and businesses are assessing how their activities affect the environment. Many businesses have responded to this awareness by providing more sustainable products and processes. To achieve this, companies are investigating the environmental performance of products, processes and techniques to minimise effects on the environment. One such tool is Life Cycle Assessment or LCA.

LCA is a structured, comprehensive and internationally standardised method. It quantifies all relevant emission and resources consumed, the related environmental and health impact as well as resource depletion issues that are associated with the entire life cycle of any goods or services (products).

The purpose of this Guide is to promote the understanding of LCA so that users (individuals and businesses) can make more informed decisions through a better understanding of the human health and environmental impact of products, processes and activities.



ABOUT LIFE CYCLE ASSESSMENT



Life Cycle Assessment or Life Cycle Analysis (LCA) is a technique to assess environmental impact associated with a product's life from cradle-to-grave because it encompasses all processes and environmental releases beginning with the extraction of raw materials and the production of energy used to create the product through the use and final disposition of the product.

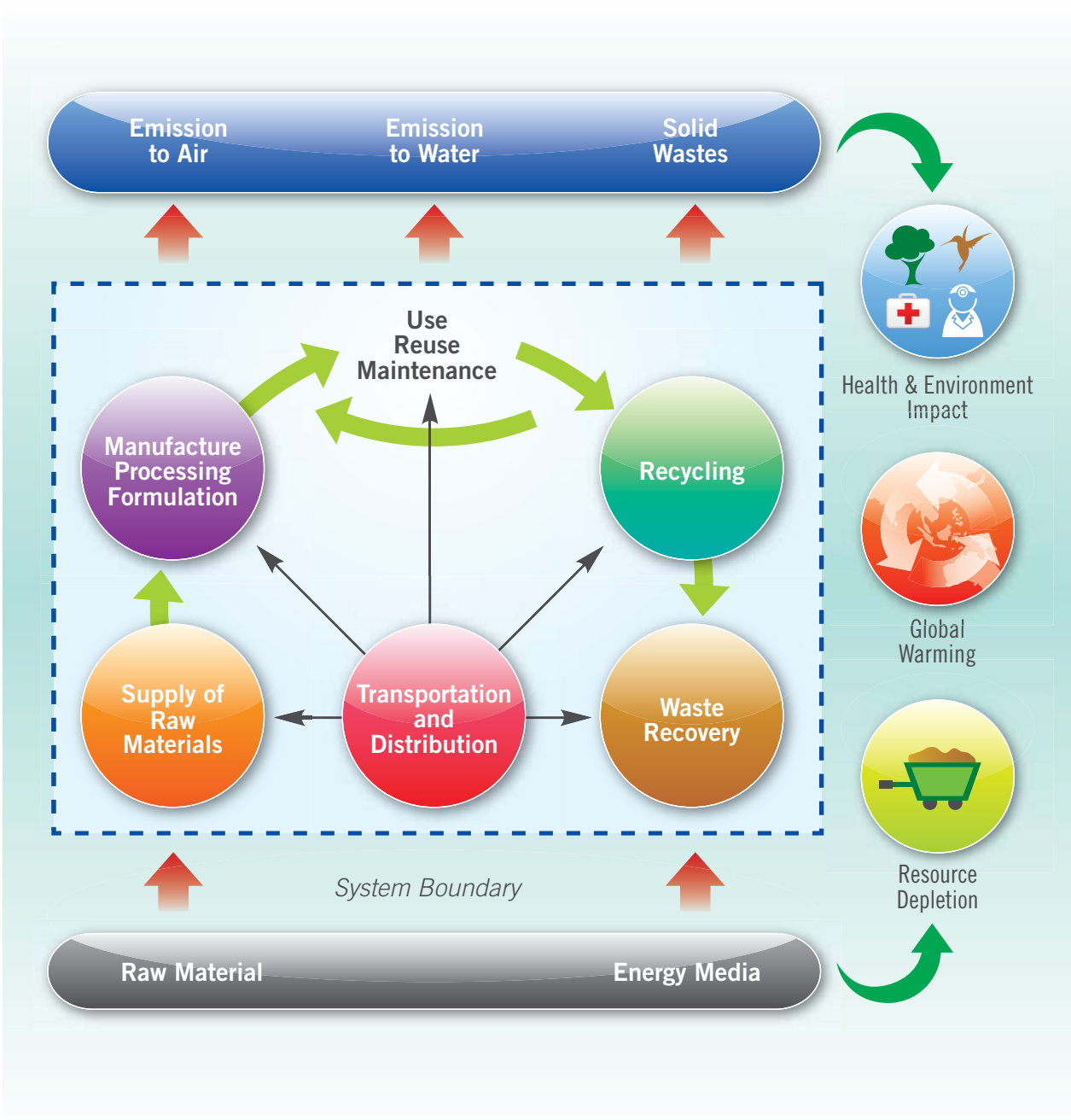
The goal of LCA is to compare the full range of environmental effects assignable to products and services in order to improve processes, support policy and provide a sound basis for informed decisions.

A life cycle usually consists of a number of stages including: materials extraction, processing and manufacturing, product use and product disposal. If the most environmentally harmful of these stages (environmental impact) can be determined, then impact on the environment can be efficiently reduced by focusing on making changes for that particular phase.

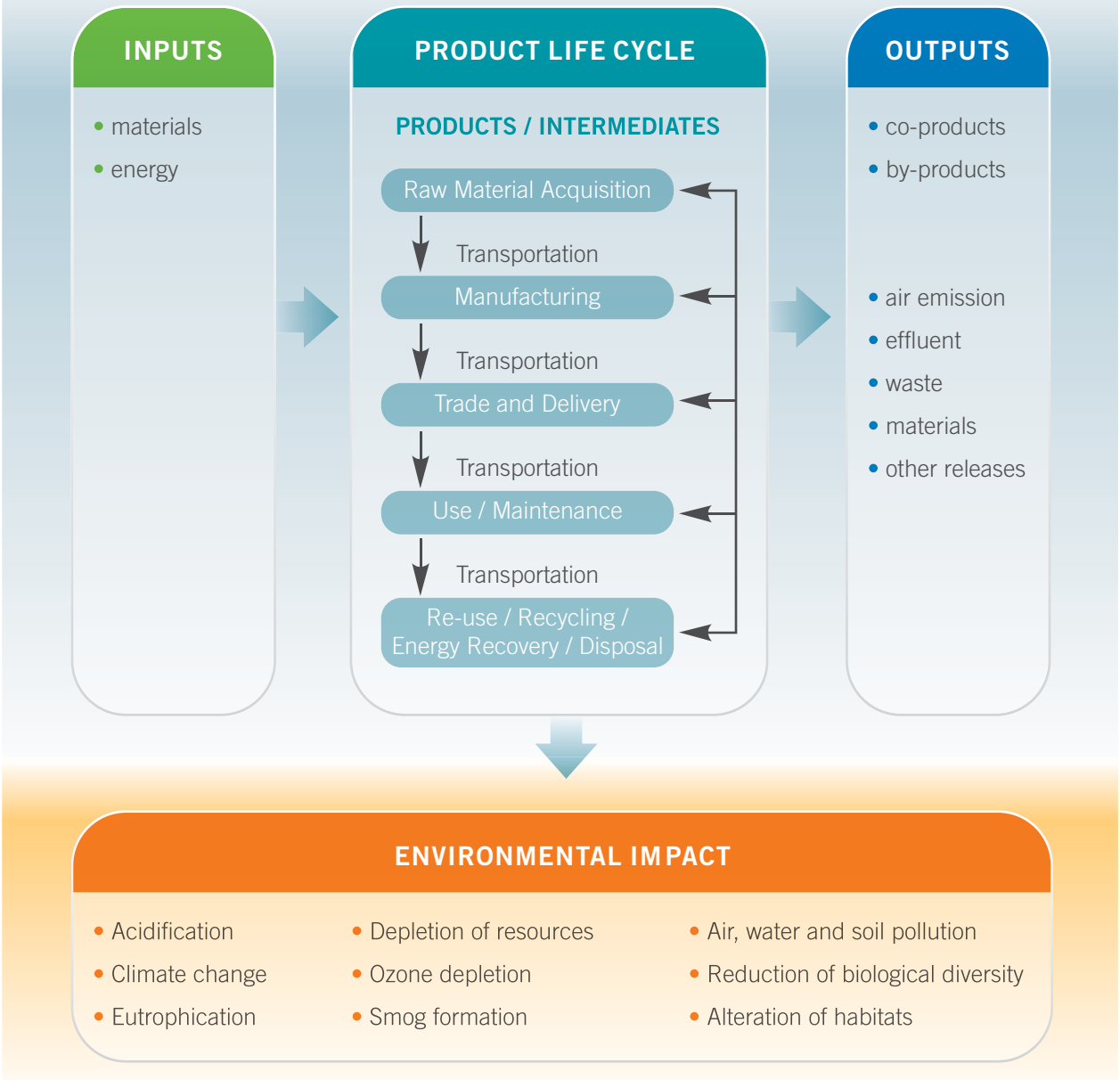
Examples of environmental impact include acidification, human toxicity, water impact, eutrophication, ecotoxicity, amongst others.

LCA data compiled from these impacts are then characterised according to their impact category, such as global warming, acidification and carcinogens.

Life Cycle Assessment



Environmental Impact Associated with a Product's Life Cycle



Source: ISO 14062

CARBON FOOTPRINT AND GREENHOUSE GASES

A carbon footprint analysis is part of a full LCA. It evaluates the total amount of greenhouse gases (GHG) produced to directly and indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO_2).

GHGs are essential for regulating our climate because they absorb and hold heat from the sun in the atmosphere around the earth.

Every stage of a product's life cycle impact climate change. In addition, each stage requires the use of natural resources and the consumption of energy - human activities that result in the release of GHGs that has an impact on the earth's atmospheric balance.



LIFE CYCLE STAGES PROVIDE NUMEROUS OPPORTUNITIES TO REDUCE GHG EMISSION

Because GHGs are released during each stage of a product's life cycle, there are numerous opportunities for a company to decrease a product's contribution to climate change. Companies can reduce emission associated with resource extraction, manufacturing, distribution, product use, combustion or landfilling. Waste prevention and recycling can also play a significant role in reducing GHG emission.

LCA Case Study: Life Cycle Inventory Study for Half-Gallon Milk Containers

A Life Cycle Inventory (LCI) is an environmental profile that expresses environmental burdens from the perspective of energy consumption, solid waste generation, atmospheric emissions, and waterborne emissions. The LCI study undertaken by Franklin Associates for the American Chemistry Council in 2007 involved the study of half gallon milk containers, as these packages are both ubiquitous and available in a wide variety of competing material types: glass, high density polyethylene (HDPE) and coated paperboard (described in their study as gable top). The following is an overview of the findings with respect to energy consumption, postconsumer solid waste generation and greenhouse gas emission.

A. Summary

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 emission.

Total Energy, Post-consumer 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 CO_2 equivalent)
Half-gallon Milk Container Systems				
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.

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

	Energy Category					
Half-gallon Milk Container Systems	**Process**	**Transport**	**Energy of Material Resource**	**Total**	**Combustion Energy Credit (4)**	**Net Energy**
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)				
Half-gallon Milk Container Systems	**Process**	**Transport**	**Energy of Material Resource**	**Total**	**Combustion Energy Credit (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

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.

Post-consumer Solid Waste for Half-gallon Milk Containers

(lb. per 10,000 half-gallon milk container uses)

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

D. Greenhouse Gas Emission

The HDPE container system produces significantly less greenhouse gas emission than the other container systems.

Greenhouse Gas Summary for Half-gallon Milk Containers

(lb carbon dioxide equivalent per 10,000 half-gallon milk container uses)

	Gable Top Carton System	Glass Bottle System	HDPE Bottle System
Fossil Carbon Dioxide (CO_2)	3,953	7,956	2,755
Nitrous Oxide (N_2O)	124	50.1	17.9
CFC/HCFC/HFC not Specific Elsewhere	0.28	0.20	0.11
Methane (CH_4)	263	502	487
Methylene Chloride (CH_2Cl_2)	0.044	0.0026	0.0012
Total	**4,341**	**8,509**	**3,260**

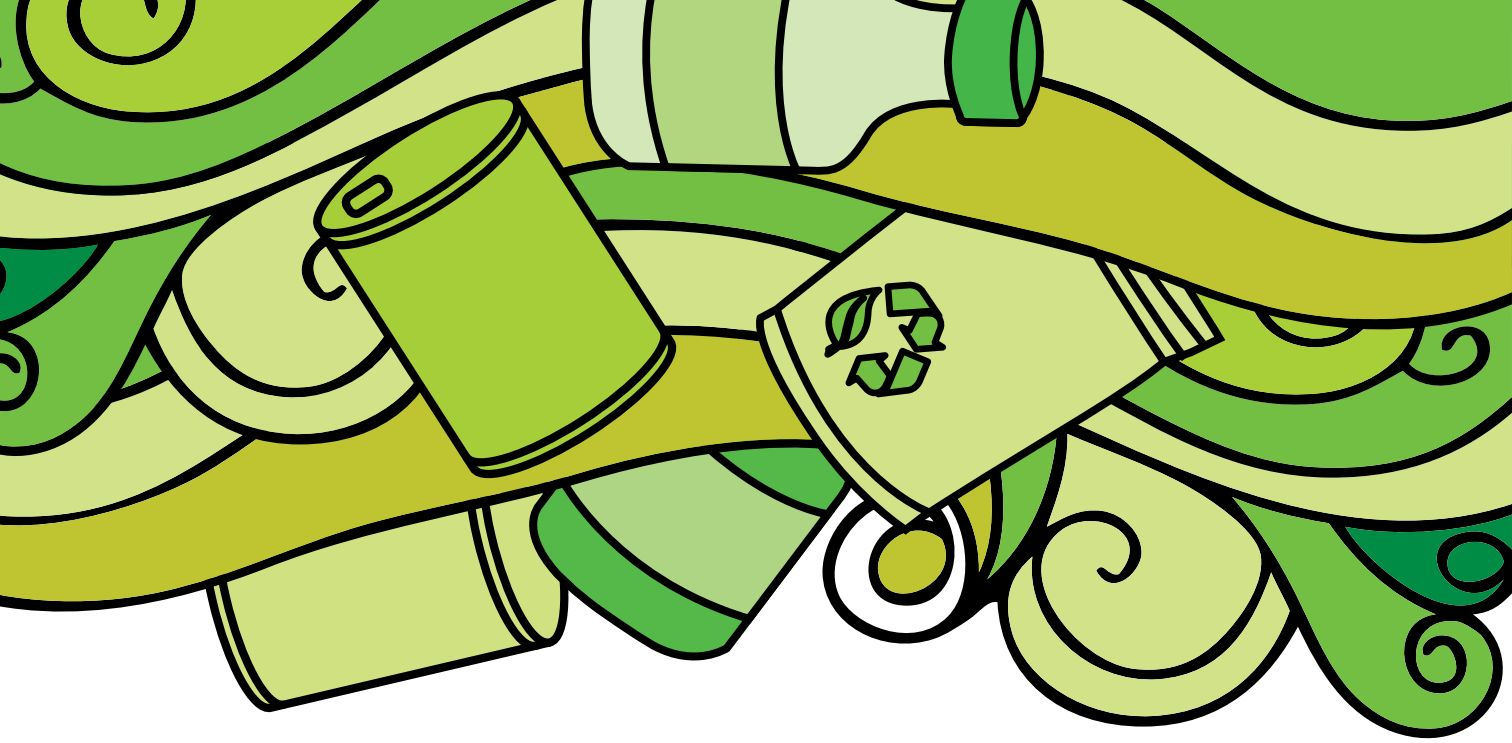
Note : The 100 year global warming potential used in this table are as follows: fossil carbon dioxide--1, nitrous oxide--296, CFC/HCFC/HFC--1700, methane chloride--10.

Source : Franklin Associates, a division of ERG calculates using original data from LCI/LCA by Nature Works, LLC, the Franklin Associates database and the US LCI Database.

Conclusions

The study performed by Franklin Associates on milk containers indicates that the 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, while the HDPE system inherently contains fossil fuels because it is produced from them, its lifecycle uses less energy and produces fewer greenhouse gas emission than the other systems.

Policymakers, journalists and other public communicators should use life cycle thinking when making decisions or informing the public about the impact that their decisions might actually have on the environment.



In many cases it is too costly or time consuming to complete a full LCA. In these instances it is still important to make decisions using relevant scientific information. It may be helpful to complete a streamlined LCA, where a smaller set of data are gathered for analysis and decision-making. In other cases, basic technical information on key metrics such as energy consumption, greenhouse gas emission and waste generation can be used to scientifically base decisions. Some examples of how scientific information can be used for decision making are shown in the following examples from the Flexible Packaging Association.

FLEXIBLE PACKAGING

For the purpose of this Guide, case studies of flexible and alternative packaging systems will be featured. The studies identify trends in packaging weight, product-to-package ratio, landfill discards, energy consumption and GHG emission. The case studies were undertaken by the US Flexible Packaging Association in 2009.

FLEXIBLE PACKAGING REDUCES ENVIRONMENTAL IMPACT

Flexible packaging offers significant value and sustainability benefits to product manufacturers, retailers and consumers. Flexible packaging reduces waste, energy use and GHG emission. Additionally, flexible packaging provides many consumers convenience including extended shelf life, easy storage, microwave ability and reseal ability.

Beverage Packaging



Beverages have typically been packaged in aluminum cans, glass or plastic bottles. Stand-up flexible pouches are making in-roads in packaged juices and fruit drinks.

- The flexible beverage pouch consumes 1/2 the amount of energy compared to the closest alternative.
- The flexible beverage pouch generates 75% less emission than the closest alternative.
- Stand-up flexible pouches significantly reduce greenhouse gases released and energy consumed during the transport of unfilled packaging from packaging converter to filling operation.

Beverage Packaging	Product Weight	Packaging Weight	Product-to-Packaging Ratio	Packaging Weight per 100 g Product	*MSW Landfill per 100 g Product*	Energy Consumed MJ/8 oz	Emission kg CO_2 e/8 oz
Glass Bottle & Metal Cap	8 ounces (236 g)	198.4 g	1:1	83.9 g	54.5 g	3.36	0.29
Plastics PET Bottle & Cap	8 ounces (236 g)	22.7 g	10:1	9.6 g	6.0 g	3.0	0.18
Aluminum Can	8 ounces (236 g)	11.3 g	21:1	4.7 g	2.4 g	0.99	0.08
Stand-up Flexible Pouch	6.75 ounces (199 g)	5.7 g	35:1	2.8 g	2.8 g	0.45	0.02

Cradle-to-grave life cycle energy consumption and CO_2 emission data developed for the US FPA by Battelle Memorial Institute.
Source: US Flexible Packaging Association

Product assumed to be water.
**Recycling rates factored: US EPA 2007 MSW Report.*
Packaging weight, product weight and product-to-packaging ratio calculated by Packaging & Technology Integrated Solutions, LLC (PTIS).

Raisin Packaging



- Stand-up flexible pouches are 37% less by weight compared to bag-in-a-box packaging.
- Per 100 g of product, bag-in-a-box packaging produces approximately three times more MSW than stand-up pouches.
- A flexible pouch consumes about 54% less energy over its life cycle than the next most efficient package.
- Energy consumption during transportation is significantly less for flexible packaging than alternatives.

Raisin Packaging	Product Weight	Packaging Weight	Product-to-Packaging Ratio	Packaging Weight per 100 g Product	MSW Landfill per 100 g Product*	Energy Consumption MJ/24 oz	Emission Kg CO_2 e/24 oz
Round Paperboard Canister with Plastics Lid	24 ounces (680 g)	39.69 g	17:1	5.83 g	5.83 g	2.16	0.13
Folding Carton with Inner Poly Bag	12 ounces (340 g)	22.68 g	15:1	6.67 g	4.87 g	1.95	0.16
Stand-up Flexible Pouch	24 ounces (680 g)	11.34 g	60:1	1.66 g	1.66 g	1.06	0.05

Cradle-to-grave life cycle energy consumption and CO_2 emission data developed for the 2007 MSW Report. US FPA by Battelle Memorial Institute.
Source: US Flexible Packaging Association

**Recycling rates factored: US EPA 2007 MSW Report.*
Packaging weight, product weight and product-to-packaging ratio calculated by Packaging & Technology Integrated Solutions, LLC (PTIS).

Rotisserie Chicken Packaging



Ready-to-eat rotisserie chickens have traditionally been packaged in rigid dome containers. Innovative technology now allows a flexible package to perform in a deli hot case for freshly prepared foods while reducing environmental impacts.

- 88% less fossil fuel is used and 85% fewer CO_2 emission are generated during the manufacturing of flexible pouches.[1]
- The fossil fuel equivalent of changing a year's worth of rigid dome rotisserie chicken packaging to flexible pouches would save enough gas to drive around the world 1,475 times.[2]
- The flexible pouch uses 91% less space by case in shipping. More than 12 truckloads of rigid containers are needed to ship the same amount of Hot N Handy® pouches contained in one 53'-long truckload.[3]
- The flexible pouch offers a 2/3 reduction of solid waste by weight introduced in landfills versus rigid dome packaging.[1]
- The flexible pouch offers value-added features such as a built-in handle, a resealable zipper, being microwaveable and hot case ready.

Rotisserie Chicken Packaging	Product Weight	Packaging Weight	Product-to-Packaging Ratio	Packaging Weight per 100 g Product	Energy Consumption MJ/40 oz	Emission Kg CO_2 e/40 oz
Rigid Dome Container (Tray + Lid)	40 ounces (1,134 g)	64 g	18:1	5.6 g	5.49	0.20
Hot N Handy® Flexible Pouch	40 ounces (1,134 g)	15 g	76:1	1.3 g	1.35	0.03

Source: Robbie Manufacturing, Inc. Cradle-to-gate energy consumption data based on European ecoprofiles (www.PlasticsEurope.org).

Product weight assumption: Average weight of cooked whole rotisserie chicken.

[1]Data based on 2007 LCA testing by Robbie Manufacturing, Inc, conducted using SimaPro 7.1 LCA Software.

[2]Compared to rigid packaging based on annual rotisserie sales of 550 M units.

Fuel estimate: 1,809,623 gallons; total miles: 36,729,786.25 @ 20.3 MPG. Calculations generated using US Energy Information Administration and US EPA's Greenhouse Gas Equivalencies Calculator.

[3]Based on industry average packaging/shipping dimensions of rigid packaged rotisserie chicken.

Source: US Flexible Packaging Association

Multi-unit Packaging



Flexible collation shrink wrap packaging reduces product shift in transit, decreasing breakage and/or product waste.

- The flexible shrink wrap consumes 35% less energy than the alternative.
- Compared to paperboard folding containers (such as in this study), flexible shrink wrap provides an 81% reduction in packaging weight.
- Flexible shrink wrap packaging (in this comparison) offers five times more product-to-packaging ratio.

Multi-unit Packaging	Product Weight	Packaging Weight	Product-to-Packaging Ratio	Packaging Weight per 100 g Product	Energy Consumption MJ/120 oz	Emission Kg CO_2 e/120 oz
Paperboard	120 ounces (3,402 g)	66.2 g	51:1	1.9 g	2.13	0.05
Flexible Collation Shrink Wrap	120 ounces (3,402 g)	12.6 g	270:1	0.4 g	1.36	0.05

Cradle-to-grave life cycle energy consumption and CO_2 emission data developed for the US FPA by PE Americas based on readily available data. The results are not critically reviewed per ISO 14040 standards and represent the magnitude of the comparative environmental profiles.

Source: The Dow Chemical Company, internal calculations based on data derived per Environmental Defense (www.papercalculator.org); Boustead Model V5; The ULS Report, February 2007; and a raw material cradle-to-gate, plus recycle system boundary.

Packaging weight, product weight and product-to-packaging ratio calculated by Packaging & Technology Integrated Solutions, LLC (PTIS).

Source: US Flexible Packaging Association

Coffee Packaging



Coffee packaging includes metal cans, rigid plastic containers and the flexible "brick pack."

- The flexible brick pack consumes 1/4 of the energy used by alternate packaging.
- The flexible brick pack generates 75% less emission than the closest alternative.
- The energy savings equivalent of changing all steel coffee cans to flexible brick packs is more than 17,200,000 gallons of gasoline per year.
- The flexible brick pack contains 88% less packaging by weight when compared to metal cans.[1]
- The flexible brick pack reduces the weight of waste to landfill by 72% versus metal cans (taking recycling rates of cans into account).[2]
- Flexible brick packs use 20% less space in shipping than cans,[2] reducing transportation emission.

Coffee Packaging	Product Weight	Packaging Weight	Product-to-Packaging Ratio	Packaging Weight per 100 g Product	Energy Consumption MJ/11.5 oz	Emission Kg CO_2 e/11.5 oz
Metal Can with Plastics Lid	11.5 ounces (326 g)	96.38 g	3:1	29.56 g	4.21	0.33
Plastics Container & Lid	11.5 ounces (326 g)	59.53 g	5:1	18.26 g	5.18	0.17
Flexible Brick Pack	11.5 ounces (326 g)	11.33 g	29:1	3.47 g	1.14	0.04

Cradle-to-grave life cycle energy consumption and CO_2 emission data developed for the US FPA by PE Americas based on readily available data. The results are not critically reviewed per ISO 14040 standards and represent the magnitude of the comparative environmental profiles.

Source: US Flexible Packaging Association

[1]Calculations compare 422.38 g total weight metal can with plastics lid (326 g of contents) versus 337.33 g total weight brick pack (326 g of contents).

[2]The ULS Report, February 2007, "Coffee Conundrum" Case Study.

Packaging weight, product weight and product-to-packaging ratio calculated by Packaging & Technology Integrated Solutions, LLC (PTIS).

Foodservice #10 Packaging



Flexible pouch packaging is an alternative to metal cans for a wide range of foodservice applications. The flexible foodservice pouch eliminates sharp edges and offers dispensing fitments and product visibility.

- The flexible foodservice pouch consumes 75% less energy than the metal can.
- The flexible foodservice pouch generates 1/10 the CO_2 emission of the metal can.
- The flexible pouch is less than 1/10 the packaging weight of the metal can.
- Each case of #10 flexible pouches with finished product utilises 30% less volume than a case of #10 cans.

Foodservice Packaging	Product Weight	Packaging Weight	Product-to-Packaging Ratio	Packaging Weight per 100 g Product	Energy Consumption MJ/108 oz	Emission Kg CO_2 e/108 oz
#10 Metal Can	108 ounces (3,064 g)	312.4 g	10:1	10.2	12.59	1.07
#10 Flexible Pouch	108 ounces (3,064 g)	28.4 g	108:1	0.9 g	2.87	0.11

Cradle-to-grave life cycle energy consumption and CO_2 emission data developed for the US FPA by PE Americas based on readily available data. The results are not critically reviewed per ISO 14040 standards and represent the magnitude of the comparative environmental profiles.

Source: Sealed Air Corporation, www.sealedair.com
Source: US Flexible Packaging Association

Parcel Mailer



There are two forms of mailers commonly used: recycled paperboard and HDPE flexible pouches.

- The flexible pouch consumes approximately 1/3 the energy of the alternative to produce, ship and use.
- The flexible pouch generates approximately 1/2 the CO_2 emission of the alternative.
- Recycled paperboard mailers produce seven times more landfill waste by weight per 100 g of product than HDPE flexible pouch mailers (taking into consideration a 27.3% recovery rate of paperboard).
- The flexible pouch mailer uses 1/8 the amount of packaging per 100 g of product versus the paperboard mailer.

Parcel Mailer	Product Weight	Mailer Weight	Product-to-Mailer Ratio	Mailer Weight per 100 g Product	Energy Consumption MJ/Mailer	Emission Kg CO_2 e/Mailer
Recycled Paperboard Mailer (100% recycled paperboard, 35% post consumer recycled material)	13.28 ounces (376 g)	96.38 g	4:1	25.63 g	4.80	0.23
HDPE Flexible Pouch Mailer	13.28 ounces (376 g)	11.33 g	33:1	3.01 g	3.37	0.11

Cradle-to-grave life cycle energy consumption and CO_2 emission data developed for the US FPA by Battelle Memorial Institute.
Source: US Flexible Packaging Association

Product weight assumption: 100 sheets of 24 lb 8.5" x 11" copy paper. US EPA 2007 MSW Report.
Mailer weight, product weight and product-to-mailer ratio calculated by Packaging & Technology Integrated Solutions, LLC (PTIS).

FLEXIBLE PACKAGING OFFERS A LESSER ENVIRONMENTAL FOOTPRINT

Flexible Packaging

Manufacturing, distribution and use:

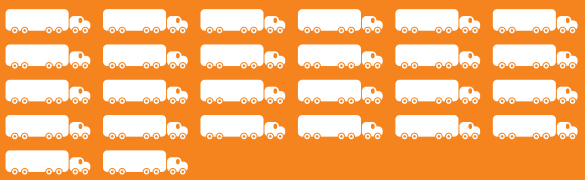
- Consumes less energy and fewer natural resources.
- Generates less CO_2 emission.
- Results in higher product to package ratio.
- Requires fewer trucks for transportation using less fuel and creating less emission.
- Provides many consumer conveniences:
  - Extended shelf life
  - Easy storage
  - Microwaveability
  - Recloseability

Flexible Packaging
Creates Less Footprint

Energy consumption and environmental impact during transportation is greatly reduced.

Truckloads needed to transport packaging for equal amounts of product.

26 truckloads of unfilled glass jars



1 truckloads of unfilled flexible pouches



Reference Sources:

(1) FPA, "Flexible Packaging: Less Resources. Less Footprint. More Value." Case Study Brochure

(2) DuPont Packaging Awards for Innovation

(3) The Dow Chemical Company, Dow Presentation (equation data): American Chemistry Council, US Energy Information Administration

(4) US EPA, "Municipal Solid Waste in the US: 2007 Facts and Figures"

(5) FPA/Battelle Memorial Institute Report on the Sustainability of Flexible Packaging

Flexible Packaging
Uses Less Resources

Examples of packaging needed to package 60 pounds of beverage:

50 pounds of glass

6 pounds of rigid PET

3 pounds of aluminum

1.5 pounds of flexible plastics



In summary, flexible packaging thus offers exceptional environmental benefits to converters, manufacturers, retailers and consumers. Over its life cycle, flexible packaging generally uses less energy and fewer resources, produces less CO_2 emission, significantly improves product to package ratio, requires fewer trucks on the road for transport and provides numerous safety and consumer convenience features. Flexible packaging is an excellent sustainable choice; creating more value and less footprint.



Malaysian Plastics Forum

The Malaysian Plastics Forum (MPF) was established in May 2005 and is a joint collaboration between three industry organisations, namely, the Malaysian Petrochemicals Association (MPA), the Plastic Resins Producers Group (PRPG) and the Malaysian Plastics Manufacturers Association (MPMA).

Prior to the formation of MPF, the three industry groups had collaborated on waste management projects with the view that a more effective approach to promote environmental values would require all three groups to be established as a single entity to work together with the Government, the public as well as other interest groups with a common concern for the environment.

MPF's objectives are to create awareness and education on plastics, disseminate factual information on safety and trends on the use of plastics as well as to drive the 3Rs concept for plastics which is to Reduce, Reuse and Recycle.

Malaysian Plastics Manufacturers Association

The Malaysian Plastics Manufacturers Association (MPMA), established in 1967, is a progressive trade association providing leadership and quality service to its members and the plastics industry. MPMA is the official voice of the Malaysian plastics industry, representing its members and the industry in Government interaction, spearheading the plastics industry's growth and providing the platform to assist members to be globally competitive, taking into cognisance its social responsibility towards the environment and community.

MPMA currently has about 800-odd members comprising Ordinary members, which represent about 60 percent of plastics manufacturers in the country and account for 80 percent of the country's total production of plastic products.

Dow

Dow (NYSE: DOW) combines the power of science and technology to passionately innovate what is essential to human progress. The Company connects chemistry and innovation with the principles of sustainability to help address many of the world's most challenging problems such as the need for clean water, renewable energy generation and conservation and increasing agricultural productivity. Dow's diversified industry-leading portfolio of specialty chemical, advanced materials, agrosciences and plastics businesses delivers a broad range of technology-based products and solutions to customers in approximately 160 countries and in high growth sectors such as electronics, water, energy, coatings and agriculture. In 2011, Dow had annual sales of US$60 billion and employed approximately 52,000 people worldwide. The Company's more than 5,000 products are manufactured at 197 sites in 36 countries across the globe.

References to "Dow" or the "Company" mean The Dow Chemical Company and its consolidated subsidiaries unless otherwise expressly noted. More information about Dow can be found at www.dow.com.

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