Environmental Overview

Complete Life Cycle Assessment of North American Container Glass

Cradle-to-Cradle: The Complete Life Cycle Assessment of North American Container Glass

Glass is the only food and beverage packaging material that is endlessly recyclable back to its original use. Made from all-natural resources—sand, soda ash, limestone, and recycled glass—and with a 400-year history in the American marketplace, glass has been and continues to be a safe container. While it is an established industry, glass container manufacturers have never rested in their efforts to enhance sustainable practices by finding new ways to reduce energy, waste and water usage in production and distribution practices. Now the North American glass industry is taking a pioneering step in producing the first complete and thorough cradle-to-cradle life cycle assessment (LCA) ever conducted by any food and beverage packaging industry.

While policymakers, industry and the public are all hungry for credible data, a good deal of confusion and skepticism has been injected into the sustainability debate. This is particularly true regarding the life cycle assessment methods used today. Such assessments vary greatly in their scope and approach, making it difficult to accurately and objectively compare one packaging material with that of another.

That is why, to address current LCA shortcomings, the glass container industry reached out to the leading global consulting firm and software provider specializing in sustainability — *PE Americas*. Not only were all established scientific protocols adhered to by *PE Americas*, but a top independent scientific panel was recurred to observe methodologies and peer reviewed the findings. In addition, unlike many food and beverage packaging LCAs, **this report examines the impact of every stage in the life cycle of glass containers**, from raw material extraction to end-use.

The industry took the position that since the Earth is a closed-loop environment only a closed looped or cradle-to-cradle LCA can accurately reveal the whole picture and measure the carbon footprint of any industry. These findings provide key new insights into glass packaging's environmental profile. The cradle-to-cradle LCA is one very important element to be fully considered by policy makers, industry and the public as they pursue greater understanding of sustainable packaging. However, even this LCA is not the end of the glass story. There are many areas that an LCA is not designed to study and where glass excels for both the consumer and the environment, such as not leaching toxins into our food and beverages, maintaining the flavor and shelf-life of food and beverages longer than any other commercial container; and the intrinsic "image" and "trust" glass holds with consumers.

Today, by establishing a high standard of environmental accountability, this cradle-to-cradle LCA represents an unprecedented step forward in the packaging industry. We hope other consumer packaging industries will join us in our commitment to clarity and completeness.

Joseph J. Cattaneo
President
Glass Packaging Institute (GPI)

The Glass Packaging Institute (GPI) complete life cycle assessment (LCA) represents the most comprehensive collection of data and analysis ever conducted on the environmental impact of the glass container industry in North America. The research collected data from 105 furnaces representing 75 percent of North American glass container production. The North American glass container industry creates glass containers for wines, beers, foods, jams, condiments, spirits, non-alcoholic beverages, and cosmetics.

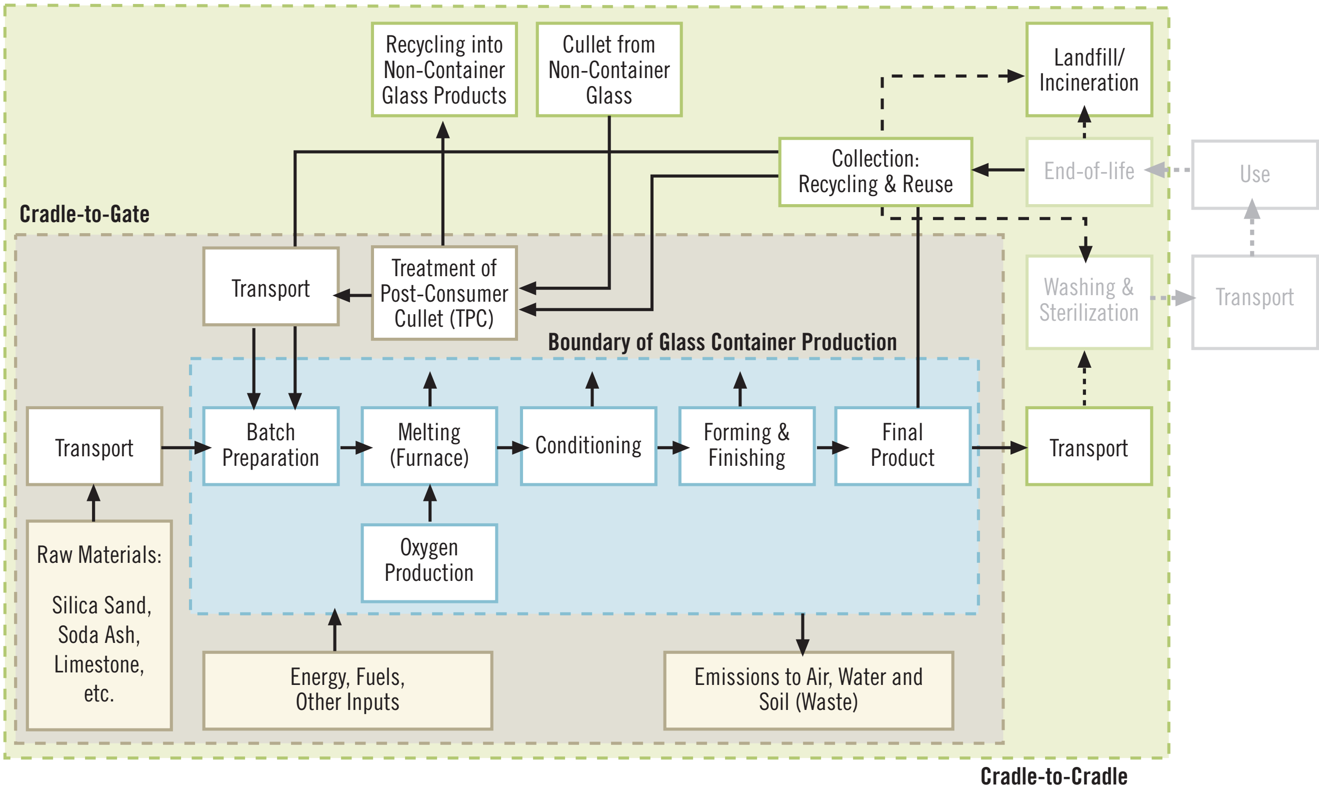
GPI container manufacturers provided current life cycle inventory data on container glass production for this study. The study was conducted in parallel with a study for the European Container Glass Federation (FEVE) and its member companies. This approach generated an internationally comprehensive set of data on the production of container glass. The methods employed in developing the life cycle impacts are comparable between the two studies, and **life cycle assessment** and glass experts conducted both studies according to strict ISO 14040/44 guidelines; both studies also underwent a rigorous critical independent peer review.

Life Cycle Assessments allow for analysis at various stages of a product's life cycle:

1) **Gate-to-gate** — focusing on one particular plant or operation
2) **Cradle-to-gate** — gate-to-gate findings with the addition of up-stream providers (mining of raw materials, processing and transportation); and
3) **Cradle-to-grave** —encompassing the entire linear life cycle of the product from extraction through disposal.
4) **Cradle-to-cradle** —that includes the entire cradle-to-grave life cycle of the product with the addition of **recycling the product back to its original purpose.**

To obtain a clear and accurate picture of the entire life cycle of container glass, the **Glass Packaging Institute (GPI)** chose to look at the results of the surveyed glass furnaces in North America from a full cradle-to-cradle assessment.

Life Cycle Flow Diagram for Systems Analyzed Cradle-to-Cradle



The Whole Picture

Measuring the Complete Life Cycle

Objectives of the Studies

GPI initiated the **life cycle assessment** process to establish a clear understanding of the environmental impact of container glass at all stages of the life cycle, and to develop realistic and tangible targets for improvement. Other objectives included:

- Participating in and contributing to LCA discussions with customers, distributors, retailers, industry, regulators and other stakeholders
- Engendering complete life cycle thinking in the packaging industry
- Measuring the importance of recycling of glass in **life cycle analysis**

This methodology transcends common LCAs that focus on one or two stages of the full life cycle, such as gate-to-gate or cradle-to-gate. As depicted in the diagrams at right, the cradle-to-cradle approach used in the glass industry assessments addressed all steps of manufacture and end-of-life management.

Specifically, the GPI study included the impact of raw material extraction and processing, as well as closed-loop recycling. Closed-loop refers to the reuse of glass in its original state or as recycled cullet in production to make new containers, resulting in a reduction of energy needed for production.

Scope

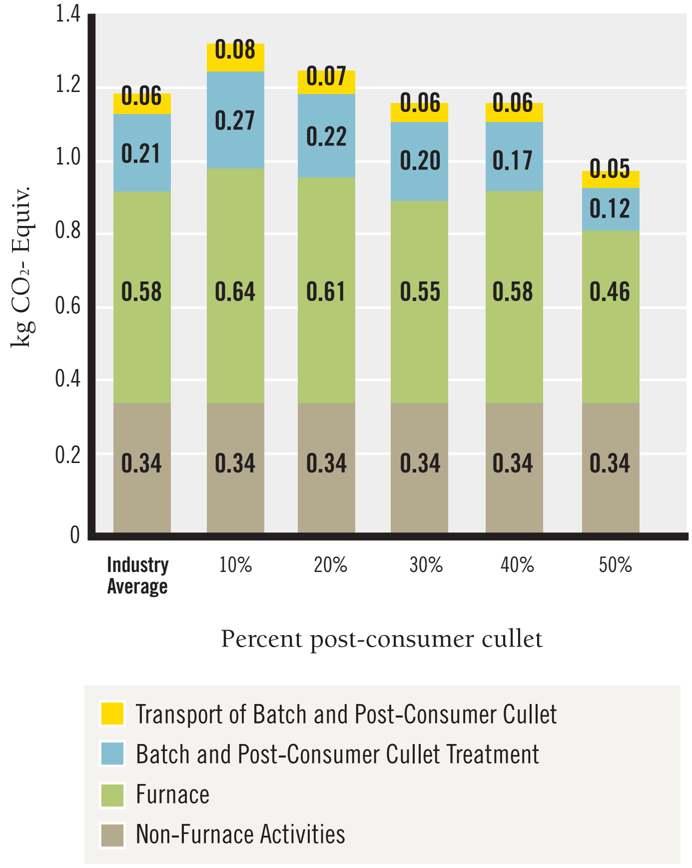
The internationally conducted LCA surveyed 105 North American furnaces, collecting primary data for 8.17 million metric tons of container glass produced in 2007.

The cradle-to-cradle LCA inventory of container glass addresses all inputs and outputs for the production and end-of-life management of 1 kg of container glass including:

- Extraction and processing of raw materials and cullet
- Transportation of raw materials and cullet
- The production and combustion of fuels and energy for the melting and formation of glass (including all non-melting activities at the facility)
- The impacts of post-consumer cullet treatment
- Transportation of the finished container to the end user

The Glass Packaging Institute (GPI) is the trade association representing the North American glass container industry. Through GPI, glass container manufacturers speak with one voice to advocate industry standards, promote sound environmental policies and educate packaging professionals. www.gpi.org

Cradle-to-Cradle LCA Results per 1kg Formed and Finished Glass



- Collection and different end-of-life management options:
  For glass packaging the following end-of-life management scenarios are considered:
  1. Closed-loop of glass packaging back to new packaging
  2. Recycling of glass packaging into non-packaging products or fiberglass
  3. Losses via aggressive landfill cover, incineration

The cradle-to-cradle analysis addressed the environmental impacts of container glass recycling with the goal of quantifying the effects.

Key Finding

The key environmental impacts and indicators studied in the life cycle impact assessment were selected by GPI to address these key issue areas head-on with completeness and integrity. The indicators below reflect this commitment.

- *Primary energy demand* (PED) – the total fossil energy consumed
- *Global warming potential* (GWP) – climate change

Overall, the increase of recovery and recycling results in a decrease of the *primary energy demand* (PED) and an even greater decrease of *global warming potential* (GWP). The greater benefit for GWP is related to the fact that, in addition to lower energy numbers, the CO_2 emissions also decrease from the reduction of batch materials.

Through the use of cullet, the glass container industry is already contributing to the savings of energy consumption and the reduction of greenhouse gases (GHG) in manufacturing.

The environmental impact of recycling in this cradle-to-cradle scenario can have a demonstrable impact on greenhouse gases. In base year 2007, the industry in North America produces 8.17 million metric tons of formed and finished glass, incorporating an average post-consumer recycle input rate of 23 percent (baseline year 2007). This recycling effort saves 894-thousand metric tons of CO_2e (“e” equivalent number) from being emitted, compared to using strictly virgin materials.

The key environmental impacts and indicator results:

The impact in the manufacturing of glass containers comes from the melting of glass in the furnace, followed by non-melting activities such as heating and cooling of plants, compressors and finishing steps of the glass containers. This is followed by virgin material extraction and finally transportation of these materials. Melting contributes the largest percentage to each impact category considered, but the exact contribution varies by impact category.

Cradle-to-Cradle Results Per kg Formed and Finished Glass

Carbon Footprint Measurements	North America
Primary Energy Demand (MJ/kg glass)	16.6
Global Warming Potential (kg CO_2/kg glass)	1.25

Average for glass bottles produced in North America

These figures provide the first food and beverage packaging industry carbon footprint developed with a Cradle-to-Cradle LCA methodology, encompassing every stage of the packaging life cycle. LCA studies conducted using different system boundaries cannot be compared. All LCAs should use the ISO 14040/44 methodology (which allows for cradle-to-gate, cradle-to-grave, etc). The true environmental impact represented by these numbers can be best understood in the full context of the life cycle stages and the benefits of glass packaging that are discussed later in this brochure.

Key Environmental Concerns about Glass

One of the primary findings of the LCA is the relatively small energy impact resulting from transportation of glass packaging within the full scope of the environmental life cycle of glass. Transportation of raw materials and cullet used in glass production represents less than 10 percent of the total energy used in the production of container glass. Even at current industry recycled content rates, it is clear that the transportation emissions are offset by the energy savings gained from the use of recycled glass in the manufacturing process.

The CO_2 savings from glass recycling are as large, or larger, than the transportation emissions.

LCA was Conducted by:

PE Americas is an independent consultancy with extensive experience in conducting life cycle assessment (LCA) studies and facilitating critical stakeholder review processes. It is a market leader in strategic consultancy and software solutions - www.gabi-software.com GaBi for product sustainability and www.sofii-software.com SoFi for corporate sustainability.

Why Recycling is Good for Industry and the Environment:

Glass containers are endlessly recyclable, made from all-natural ingredients (sand, soda ash, limestone, and recycled glass), and is the only packaging material accepted by the U.S. FDA as "GRAS" or "**generally recognized as safe**" for food and beverage contact. Glass is nonporous and impermeable, so there are no interactions between the glass packaging and the contained products that could affect the flavor of foods and beverages.

Recycling glass containers provides for unmatched production efficiencies and significant environmental benefits: decreases the amount of raw materials used, lessens the demand for energy, cuts CO_2 emissions, extends furnace life without any processing by-products and saves on overall manufacturing costs.

Much of glass container recycling is in a closed loop, which means that a glass container becomes the same product again and again. Though some glass containers are recycled into non-container products, the endless recycling of glass back to its original use without loss of quality or purity is the true definition of a recyclable material.

The glass container industry, its companies, and thousands of employees, recognize the growing importance of protecting the environment and conserving valuable energy resources. In recognition of the environmental value of post-consumer cullet, or recycled glass, the U.S. glass container industry has set a goal of using at least 50 percent recycled glass in the manufacture of new glass bottles and jars by 2013. Part of the ongoing effort to reach the industry goals can be seen in the on-premise bar, restaurant, and hotel recycling initiatives. More than 18 percent of beverages packaged in glass are sold in restaurants and other away-from-home venues. Glass container manufacturers also support innovative curbside collection practices and will continue to work with policymakers to improve and expand state beverage deposit programs.

In addition, many recovered glass processing facilities that supply cullet are located near glass container manufacturing plants. These facilities use impact crushing, air classification, screening, metal separation, vacuum extraction, and dust control to remove contaminants such as paper, plastic and metal, and then crush the glass. Optical sorting and ceramic detection equipment are also used to beneficiate the recovered cullet.

Making Glass

The glass container industry is very diverse and covers a variety of different types of technology to produce glass bottles and jars.

Container glass begins with melting together several largely naturally occurring minerals. The most common raw materials used to produce glass are:

- Cullet (recycled glass)
- Silica sand
- Soda ash (brings down melting temperatures)
- Limestone (enhances durability)
- Materials can be added to produce different colors

Container glass furnaces are generally designed to melt large quantities of glass over a continuous period of more than 20 years and range in output from 150 tons of glass per day to over 600 tons of glass per day.

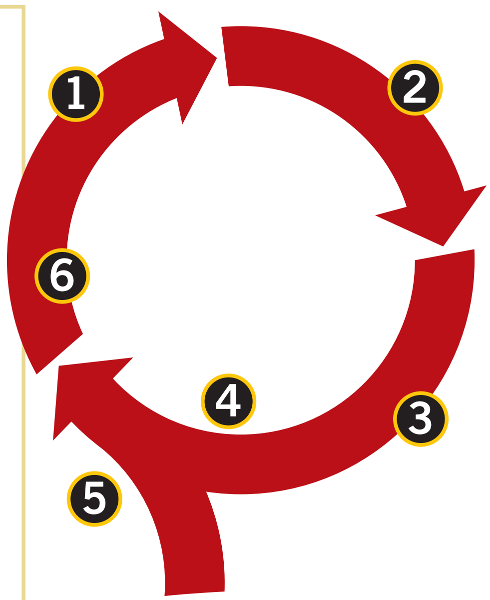
Materials are heated to 2350 ˚F at a constant temperature and the glass gob cools slowly to a working temperature around 2150 ˚F. Then the glass goes through a two-stage molding process by using either the press-and-blow or the blow-and-blow techniques.

The stages for this are:

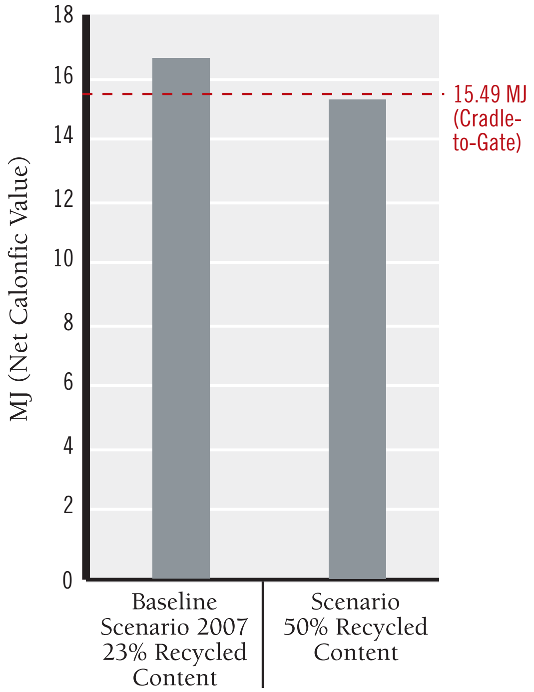
1. Obtain a gob of molten glass at the correct weight and temperature
2. Form the primary shape in a first or blank mold by pressure from compressed air or metal plunger
3. Transfer the primary shape into the final mold
4. Complete the shaping process by blowing the container with compressed air to the shape of the final mold
5. Remove the finished product from the post forming process

Glass: The Perfect Cycle

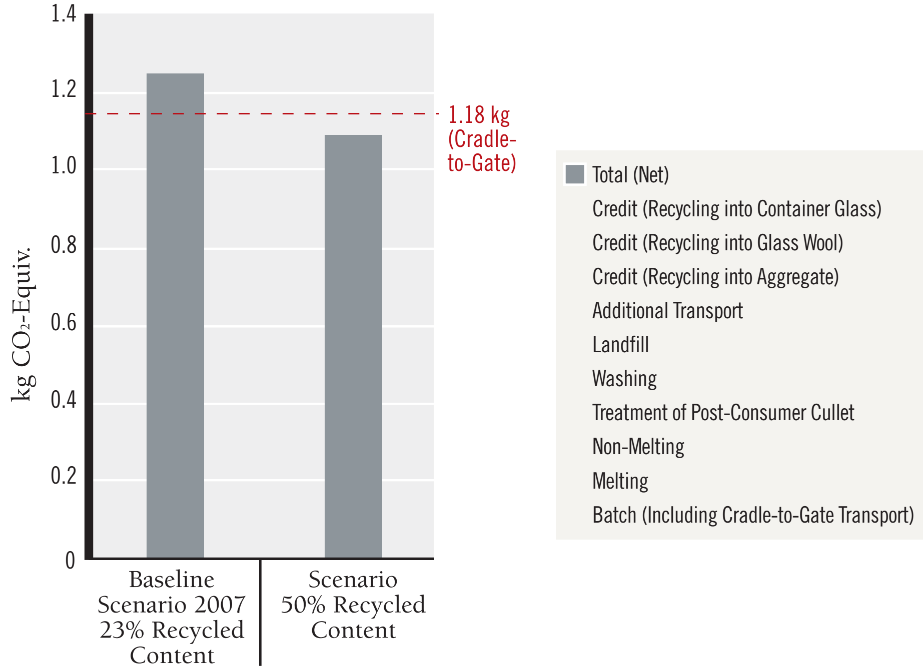
1. The new glass packaging is filled with product and distributed through retail outlets.
2. The product is purchased by consumers and consumed.
3. Containers are collected through curbside, drop-off centers, and commercial on-premises locations.
4. Recovered glass packaging is crushed into cullet and used as raw material to make new glass packaging.
5. Virgin raw materials are added as needed to the mix for new packaging.
6. The raw material is formed into new glass packaging.



Cradle-to-Cradle Primary Energy Demand – (1 kg Formed & Finished Glass)



Cradle-to-Cradle Global Warming Potential – (1 kg Formed & Finished Glass)



The results of these cradle-to-cradle scenarios are related to 1kg of container glass production on the market. The graphs show a reduction in the environmental burden of container glass production with an increase in recycling and re-purposing of container glass.

Overall, the increase of recovery and recycling result in a decrease of the primary energy demand and an even greater decrease of the global warming potential (GWP). The greater benefit for GWP is generated by the lower energy numbers, the cut in CO_2 emissions and from reduction of batch materials.

The 50 percent scenario shows nearly a 10 percent decrease in GWP in the cradle-to-cradle over the cradle-to-gate scenario. This highlights the importance of a full cradle-to-cradle study when considering the usefulness of any LCA.

For GWP, the baseline is 1.26 kg CO_2 per 1 kg of container glass production on the market and the 50 percent scenario results in a decrease to 1.11 kg CO_2 equivalents. In other words, the 50 percent recycle rate would remove 2.2 million metric tons of CO_2 from the environment, the equivalent of removing the CO_2 emissions of nearly 400,000 cars every year. While each glass container has its own environmental profile, on average the 50 percent rate offsets the typical CO_2 transportation burden when shipping foods and beverages in glass containers throughout the continental U.S.

Glass container manufacturers continue to look for ways to strengthen glass, through new surface treatments and better designs, without sacrificing the improvements in material reduction. Improvements in coating technologies have helped to make glass more durable and versatile for consumer use.

Lightweighting has become one of the single most important innovations in the industry. Improved technology has led to **lighter weight glass containers** that are remarkably **strong and safe**. Lightweighting has multiple environmental benefits, since lower container weight means fewer emissions from both container production and shipping. As lightweighting continues within the industry, the CO_2 savings will increase. (See Lightweighting)

Lightweighting

The glass packaging industry continues to look for ways to strengthen glass through new surface treatments and better designs, without sacrificing improvements in material reduction. The industry term is lightweighting. Improvements in coating technologies have helped to make glass more durable and versatile for consumer use.

Sample Weight Reductions Since 1985

- 7 oz. Beer – **30%**
- 12 oz. Long Neck Beer – **24%**
- 1 L Liquor – **23%**
- 16 oz. Juice – **22%**
- 32 oz. Vinegar – **32%**
- 19 oz. BBQ – **33%**
- 14 oz. Catsup – **32%**
- 375 mL Flask – **27%**

The Many Benefits from Lightweighting

- By reducing the weight, companies are able to save on raw materials and melting costs.
- Production lines can run at a much faster pace because there is less glass per container and less energy needed for cooling. As a result of lightweighting, glass containers can be more economical and competitively priced with lower environmental impact.
- The introduction of the Narrow Neck Press and Blow (NNPB) forming process is widely credited with helping to reduce the overall manufacturing weight and thickness of glass containers, thereby increasing productivity (on production and filling lines).
- Since 1985, the glass packaging industry has reduced the weight of glass containers and improved productivity by as much as 15 to 25 percent.
- In the manufacturing process, the bottle is pressed into its initial shape while still in the blank mold.
- Manufacturers are able to exert greater control over the desired thickness of a glass container.
- Excess glass from the neck and other parts of the bottle where thickness is not critical is shifted into areas where it is needed most.
- The result is a reduction in the amount of glass required in a given container and more uniform glass distribution throughout the container.

To ensure the highest integrity and objectivity of the data, the LCA was conducted by PE Americas. The study used comparable methods in evaluating life cycle impacts, and was performed in accordance to ISO 14040/44 guidelines. This LCA differs from those of other packaging industries in that it includes detailed end-of-life management results, which take into account the **impact of recycling of glass packaging**.

The analysis was based on a state-of-the-art modeling methodology developed by:

Roland Geyer, Ph.D., Donald Bren School of Environmental Science & Management, University of California at Santa Barbara, U.S., developed ISO methodology on end of life.

The assessment underwent an extensive critical peer-review by a panel of four independent experts, including:

- **Prof. Dr. Ir. Ruud Beerkens**, TNO Science & Industry, Eindhoven, The Netherlands
- **Dr. Arpad Horvath**, Berkeley, California
- **Prof. Matthias Finkbeiner**, Institute of Environmental Technology, Technical University of Berlin, Germany
- **C. Philip Ross**, President, Glass Industry Consulting International, Laguna Niguel, California

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