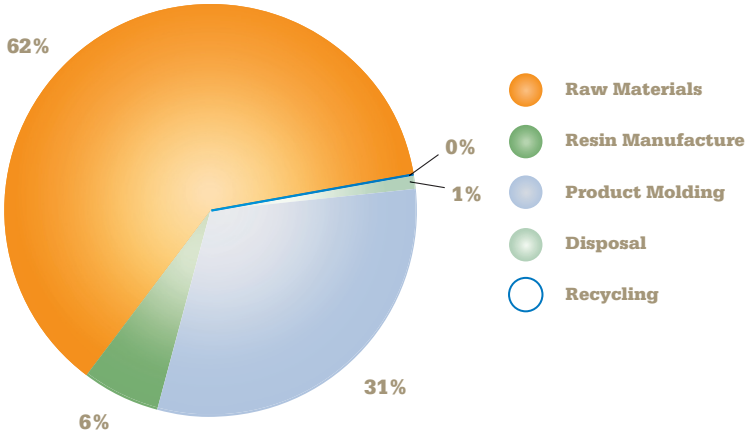
# Expanded Polystyrene Packaging Environmental Profile Analysis

A presentation of quantified environmental life cycle product information for expanded polystyrene (EPS) packaging systems.

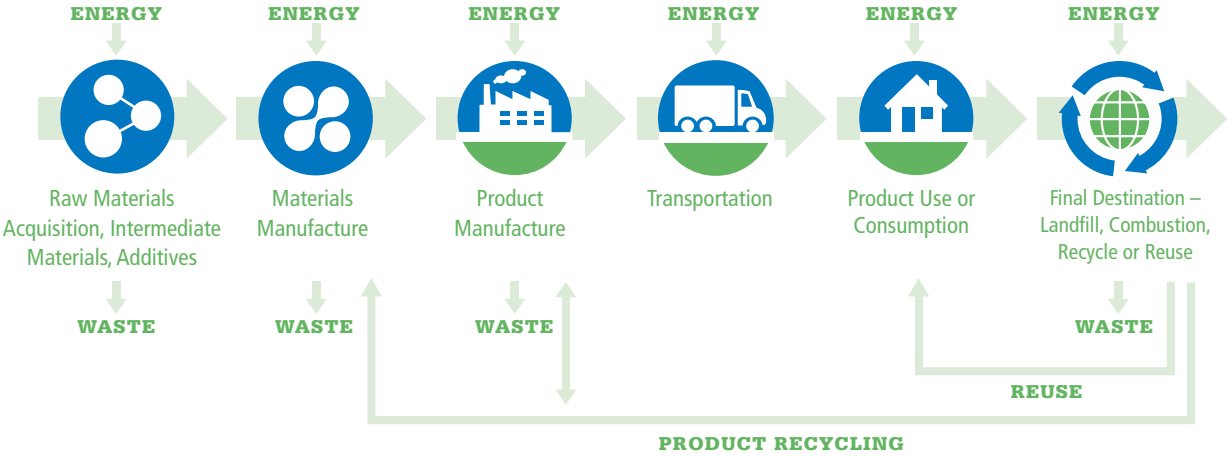
## Energy Requirements by System Component at Current Average of 10% Recycling




## EPS Life Cycle Inventory

The EPS Resource & Environmental Profile Analysis quantifies the resource use, energy use and environmental emissions associated with the product life cycle system. The unique feature of this type of analysis is its focus on the entire life of the product, from raw material acquisition, to processing, transportation and final disposition. An LCI quantifies the energy requirements, solid wastes, atmospheric emissions, and waterborne wastes generated by the production and disposal of products. The EPS life cycle inventory data in this report represents 1,000 units of EPS for vacuum cleaner packaging when used as the inner cushioning material.

### General Materials Flow for "Cradle-to-Grave" Analysis of EPS Packaging




## Expanded Polystyrene

Expanded polystyrene (EPS) is a generic term for polystyrene and styrene copolymers that are expanded into a variety of useful products. The shock absorption properties and other qualities of EPS foam, combined with customized molding capabilities, insulation properties and ease of processing make it a high performance packaging material.

Used in thousands of different ways by individuals and businesses around the world, expanded polystyrene (EPS) is relied upon to provide superior performance in various foam product applications. As a closed-cell, rigid foam plastic, EPS relies on the use of a blowing agent to allow individual beads to be expanded from 2 to 50 times their original size. Whether used as protective packaging for fragile items during shipment, as insulation in building applications, or even as a bicycle helmet, EPS is serving an important role in our everyday lives.

## Material Declaration

EPS feedstock is supplied in the form of an expandable polystyrene pellet impregnated with a blowing agent; typically pentane. The final product is a moisture resistant, closed-cell structure that is comprised of 90 percent air.

EPS is manufactured using a three-step process beginning with pre-expansion. The resin pellet is exposed to pressurized steam that causes the polystyrene to expand to the desired density. Conditioning then allows the bead to achieve increased elasticity and greater expansion capacity. The final stage feeds the pre-expanded beads into a customized mold cavity where steam is again released to achieve the final expansion stage.

### Energy Requirements by Category - Percentage of Total

| | Process Energy | Transportation Energy | Material Resource |
|---|---|---|---|
| VIRGIN | 56.0 | 3.5 | 40.5 |
| 10% OPEN-LOOP RECYCLING (AVG) | 56.6 | 3.5 | 39.8 |
| 10% CLOSED-LOOP RECYCLING CONTENT | 57.4 | 3.5 | 39.1 |
| 20% CLOSED-LOOP RECYCLING CONTENT | 59.0 | 3.5 | 37.5 |

# Manufacturing Emissions

**Solid Wastes** – Industrial solid wastes include wastewater treatment sludge, solids collected in air pollution control devices, trim or waste materials from manufacturing operations that are not recycled, fuel combustion residues such as the ash generated by burning coal or wood, and mineral extraction wastes. Post-consumer solid waste refers to products discarded by consumers and sent to landfills or to combustion facilities after fulfilling their intended use.

**Airborne Emissions** – Air emissions include carbon dioxide as well as all substances classified as pollutants such as particulates, nitrogen oxides, hydrocarbons, sulfur oxides, and carbon monoxide.

**Waterborne Emissions** – This category includes substances classified as pollutants, such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, dissolved solids, iron, chromium, acid, and ammonia.

***As recycling increases, atmospheric and waterborne emissions in all categories decrease or remain the same.***

## Environmental Emissions - Total Pollutants*

| Category | Parameter | Inventory Value (Per 1,000 Units) | Primary Source (Fuel or Process-Related) | % Reduction 10% Open-Loop Recycling | % Reduction 10% Closed–Loop Recycling | % Reduction 20% Closed–Loop Recycling |
|---|---|---|---|---|---|---|
| GLOBAL WARMING | | | | | | |
| | CO2 (Carbon Dioxide) | 1867 | 99% Fuel–Related | 2% | 4% | 9% |
| | N2O (Nitrous Oxide) | N/A | N/A | N/A | N/A | N/A |
| | CH4 (Methane) | 0.029 | 100% Fuel–Related | 0% | 3% | 6% |
| ACIDIFICATION | | | | | | |
| | SOx (Sulphur Oxides) | 7.33 | 83% Fuel–Related | 2% | 4% | 8% |
| | NOx (Nitrogen Oxides) | 5.85 | 90% Fuel–Related | 2% | 6% | 9% |
| | NH3 (Ammonia) | 0.02 | 99% Process–Related | 5% | 10% | 20% |
| EUTROPHICATION | | | | | | |
| | NOx (Nitrogen Oxides) | 5.85 | 90% Fuel–Related | 2% | 6% | 9% |
| | N2O (Nitrous Oxide) | N/A | N/A | N/A | N/A | N/A |
| | NH3 (Ammonia) | 0.02 | 99% Process–Related | 5% | 10% | 20% |
| PHOTOCHEMICAL | | | | | | |
| | C5H12 (Pentane) | 15.7 | 100% Process–Related | 0% | 0% | 0% |
| | CO (Carbon Monoxide) | 2.5 | 98% Fuel–Related | 2% | 4% | 8% |
| | Other Organics | 0.53 | 100% Fuel–Related | 2% | 4% | 8% |
| | CH4 (Methane) | 0.029 | 100% Fuel–Related | 0% | 3% | 6% |
| | HC's (Hydrocarbons) | 19.7 | 65% Fuel–Related | 4% | 7% | 14% |

**Does not reflect all impact categories in Resource & Environmental Profile Analysis of EPS Packaging Products report.*

## Open-Loop Recycling

### A Material Has Two Assumed Lives

The recovered material is used to manufacture another product, which is assumed to be disposed after use.

For the purpose of this study, the assumed recovery rate of post-consumer EPS packaging is 10%.

In an open-loop system, the material has two useful lives. The recovered EPS may be reprocessed mechanically or chemically into reprocessed resin and be used for a variety of durable applications.

## Closed-Loop Recycling

### A Material Has Many Useful Lives

Recovered material is used to produce a product, which in turn is assumed to be recycled into another product which is again recycled, and so on.

For the purpose of this study, the average recycled content rate for EPS packaging is 10%.

In a closed-loop system, the post-consumer EPS is mechanically ground, mixed with virgin EPS, and molded into new EPS packaging, which in turn may be recovered for recycling.

### Solid Wastes Per 1,000 Items by Landfill Volume

| Product | Industrial | Postconsumer Wastes | | Total Recycling | |
|---|---|---|---|---|---|
| | % Increase | (cu ft) | % Decrease | (cu ft) | % Decrease |
| VIRGIN | — | 67.6 | — | 69.2 | — |
| 10% OPEN-LOOP RECYCLING (AVG) | 1% | 64.1 | 5% | 65.7 | 5% |
| 10% CLOSED-LOOP RECYCLED CONTENT | 3% | 60.4 | 11% | 62.1 | 10% |
| 20% CLOSED-LOOP RECYCLED CONTENT | 6% | 53.3 | 21% | 55.0 | 21% |

## LCI Methodology & Assumptions

The primary information source referenced is *Resource and Environmental Profile Analysis of EPS Packaging Products* conducted by Franklin Associates, Ltd., 1997. The complete report assesses the life cycle energy requirements and waste emissions for various EPS packaging systems using methodologies consistent with the U.S. Environmental Protection Agency (EPA) and Society of Environmental Toxicology and Chemistry (SETAC) guidelines.

The data shown for the EPS vacuum cleaner packaging uses a material density of 1.35 pounds per cubic foot (pcf). Given 0.37 pounds per unit, 1,000 units of EPS vacuum cleaner packaging represents 371 pounds of EPS. This standardized amount was used to generate all of the data in this report. The corrugated outer box is not included, nor is a small piece of corrugated used in the inner packaging.

The vacuum cleaner packaging life cycle inventory data presented is representative only. As expanded polystyrene packaging is customized for each application, results will vary depending on the specific amount of EPS used in each packaging application.



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