ME 395: Design for Environment

Strategies for product and process design that will help to protect the earth’s environment

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Negative impact examples

- Accidents:
  - Union Carbide
  - Exxon-Valdez
  - BP/Gulf
  - Others?

Negative Impact Examples

- Unintentional consequences
  - CFC's
  - Lead in gasoline
  - Asbestos
  - Others?

Life Cycle Design

- Minimize emissions and waste
- Evaluate all the ways a product impacts the environment negatively
- Look at ways to increase the useful life of a product

Ways to extend useful life

- Pause

Some ways to extend useful life

- Durability
- Reliability
- Adaptability (eg a modular design)
- Feasibility of repair
- Reuse (additional uses after retirement)
- Recyclability
  - Cost-effective disassembly
  - Recover materials

Life Cycle Assessment (LCA)

- LCA: An accepted and standardized way to assess the environmental impact.
- General framework:
  - Inventory (LCI): quantify the flows of energy and materials to the product in manufacturing and use and disposal (ie its life cycle).
  - Evaluate all potential environmental consequences
  - Develop specific actions for improvement

LCA, continued

- LCA is a developing field
- ECOINDICATORS: An effort to assign quantitative values to various materials for the purpose of comparing environmental impact.
  – European system
  – Carnegi Melon system
  – UWME (Prof. Joyce Cooper; ME 415)

An LCA Example

LIFE CYCLE INVENTORY AND ANALYSIS OF DISPOSABLE HOT BEVERAGE CUP TECHNOLOGIES: COATED PAPER, POLYSTYRENE FOAM, AND EXPANDED RECYCLED PET

performed by Franklyn Associates for MicroGREEN Polymers, Arlington, WA

Full Report at: www.microgreeninc.com

Outline

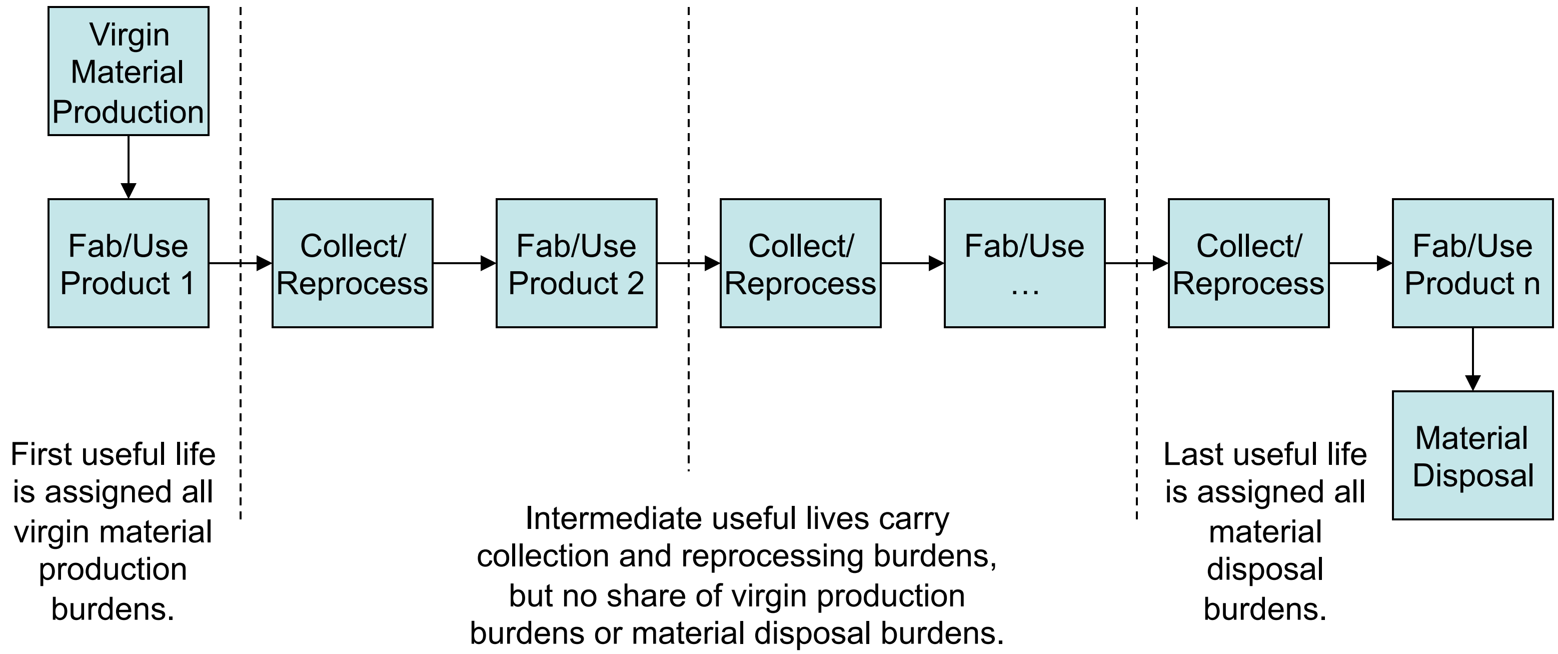
- Introduction
- Methodology
- SMX Process
- Results
- Conclusions

LCI Methodology

- Postconsumer Free (PC Free) Methodology
- Open Loop Methodology

Postconsumer "Free" Recycling Methodology

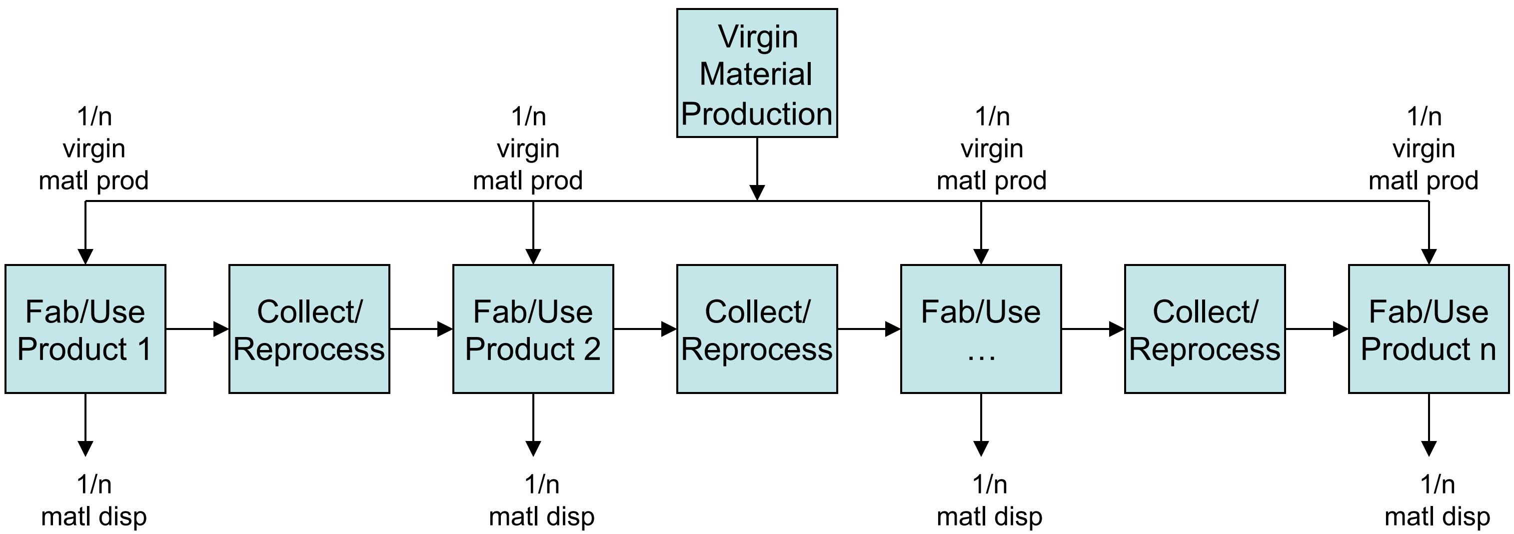
(total useful lives = n)



Each useful life carries its own product fabrication and use burdens.

Open-loop Allocation Recycling Methodology

(total number of useful lives = n)



This method distributes the virgin production burdens and final disposal burdens over all useful lives of the material.

Each useful life is allocated an equal share (1/n) of virgin material production burdens *and* material disposal burdens. Each useful life carries its own product fabrication and use burdens.The total number of collection/ reprocessing cycles is n-1, so total collection/reprocessing burdens allocated over all useful lives = (n-1)/n allocated to each useful life.

Cup Systems Compared

- MicroGREEN SMX RPET Cups with 100% recycled PET content
  - * disposed after use
  - * recycled after use
- EPS Foamed Cups
- LDPE Coated Paperboard
- Coated Paperboard with Sleeve

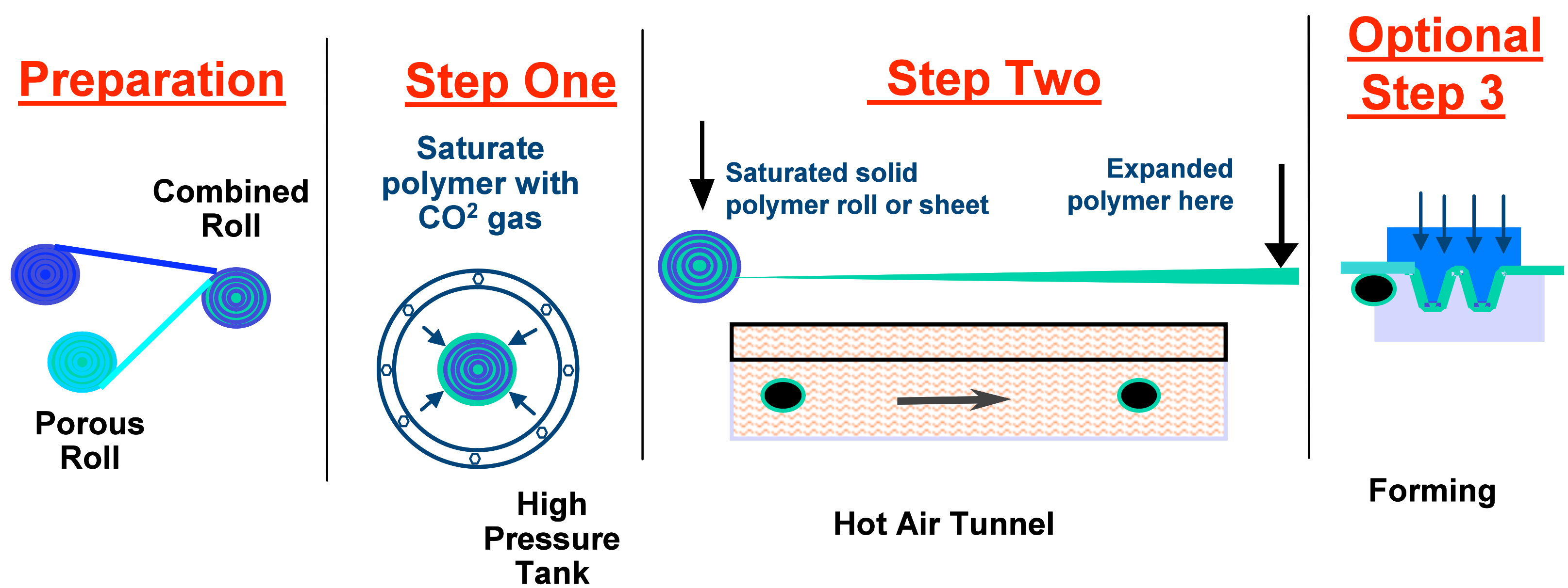
Cup System Weights

TABLE 1. CUP SYSTEM WEIGHTS [1]

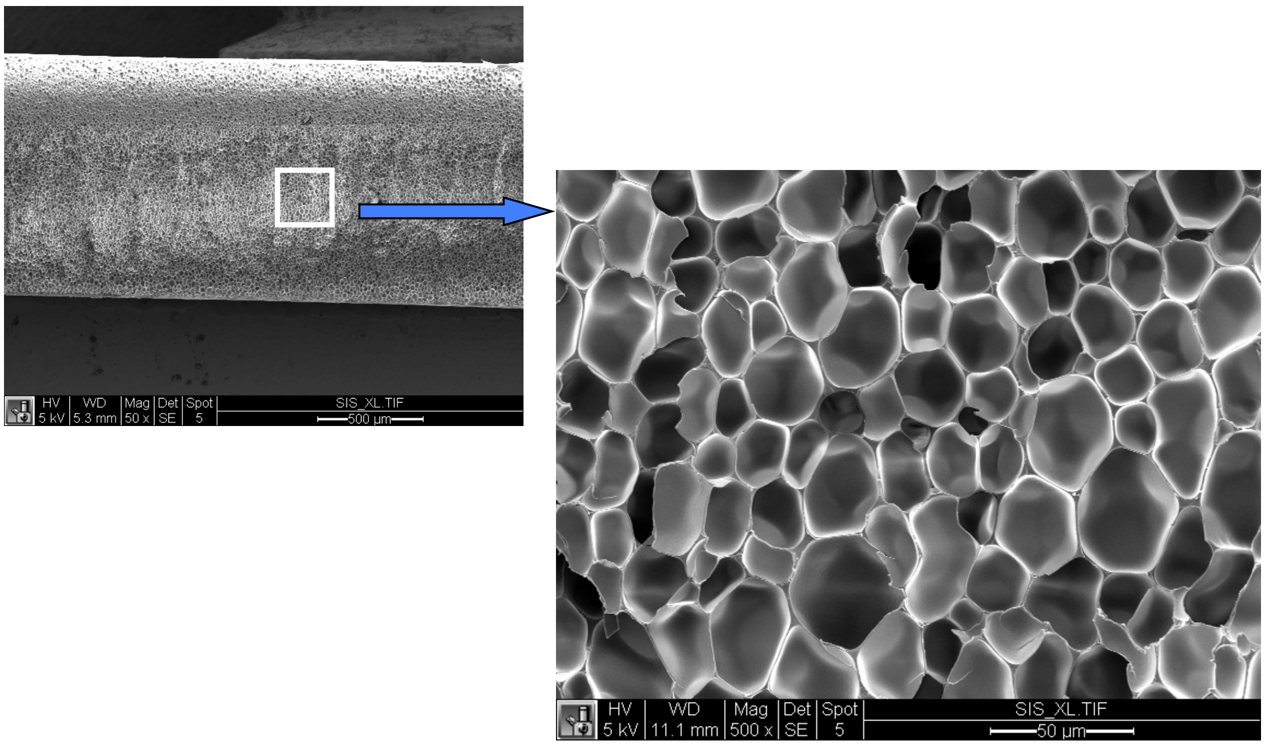
	Grams per Cup	Pounds per Case of 1,000 Cups	Pounds per 10,000 Cups
RPET SMX Cup	6.3	13.88	138.8
Film Sleeves		0.28	2.8
Corrugated Box		2.50	25.0
EPS Foam Cup	4.7	10.35	103.5
Film Sleeves		0.47	4.7
Corrugated Box		3.20	32.0
LDPE-Coated Paperboard Cup	13.3	29.33	293.3
Film Sleeves		0.25	2.5
Corrugated Box		2.20	22.0
Corrugated Cup Sleeve	5.8	12.69	126.9
Corrugated Box		0.54	5.4

Weights of the SMX cup and case packaging components for all cup systems were provided by MicroGREEN.
Weights of EPS cups, coated paperboard cups, and cup sleeves are average weights from the PSPC LCI study.
Case packaging weight for corrugated cup sleeves was calculated from the shipping weight for a full case minus the weight of sleeves in the box.

MIcroGreen SMX Process



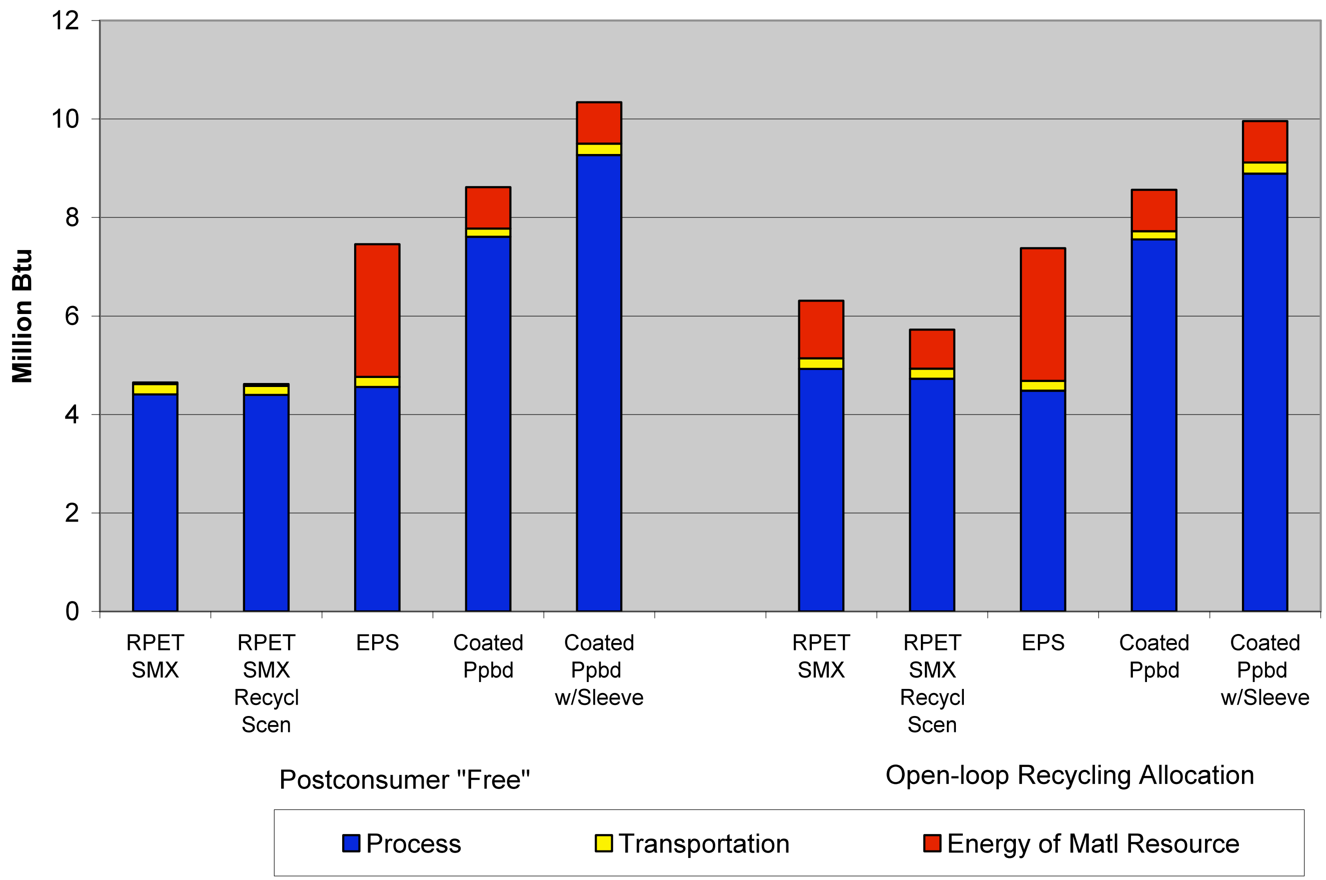
Microstructures of Expanded RPET



Results

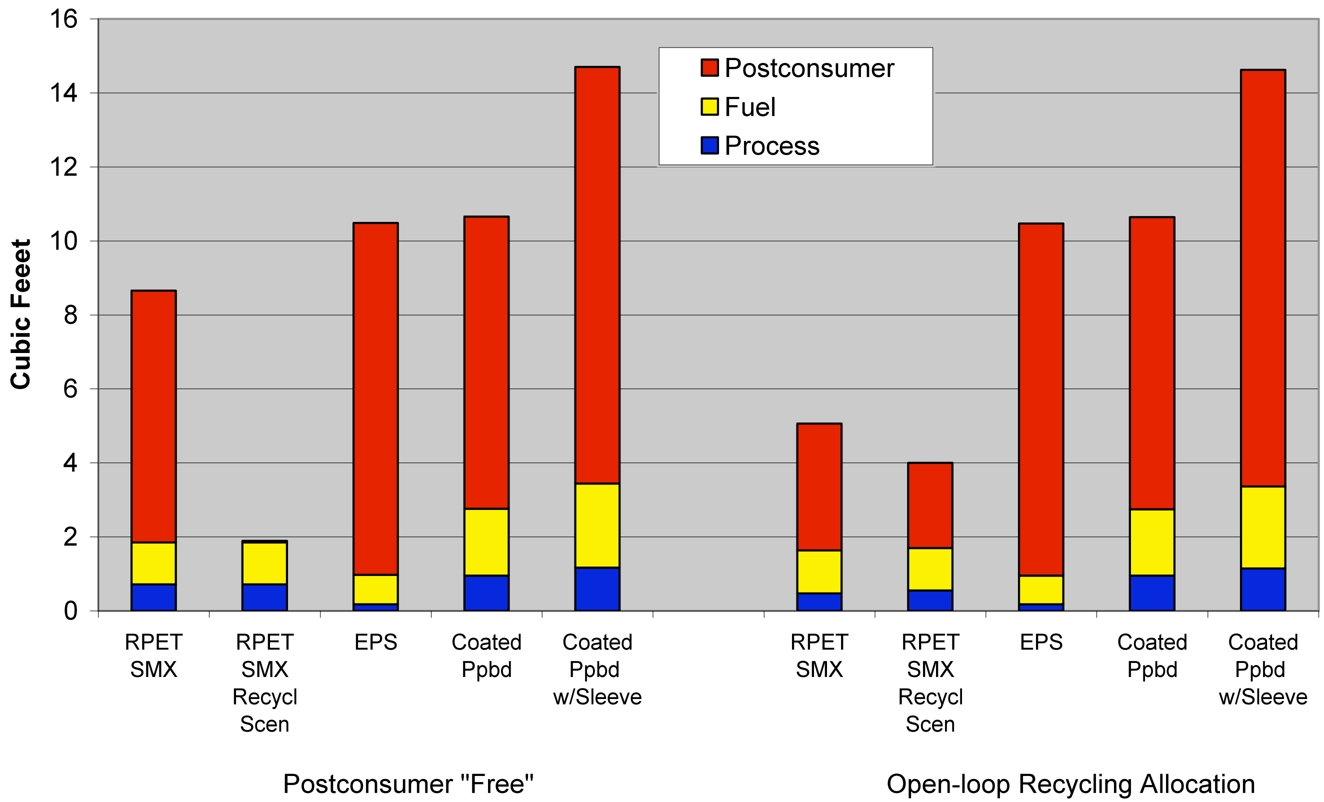
Total Energy

Figure ES-1. Total Energy by Category for 10,000 Cups and Packaging

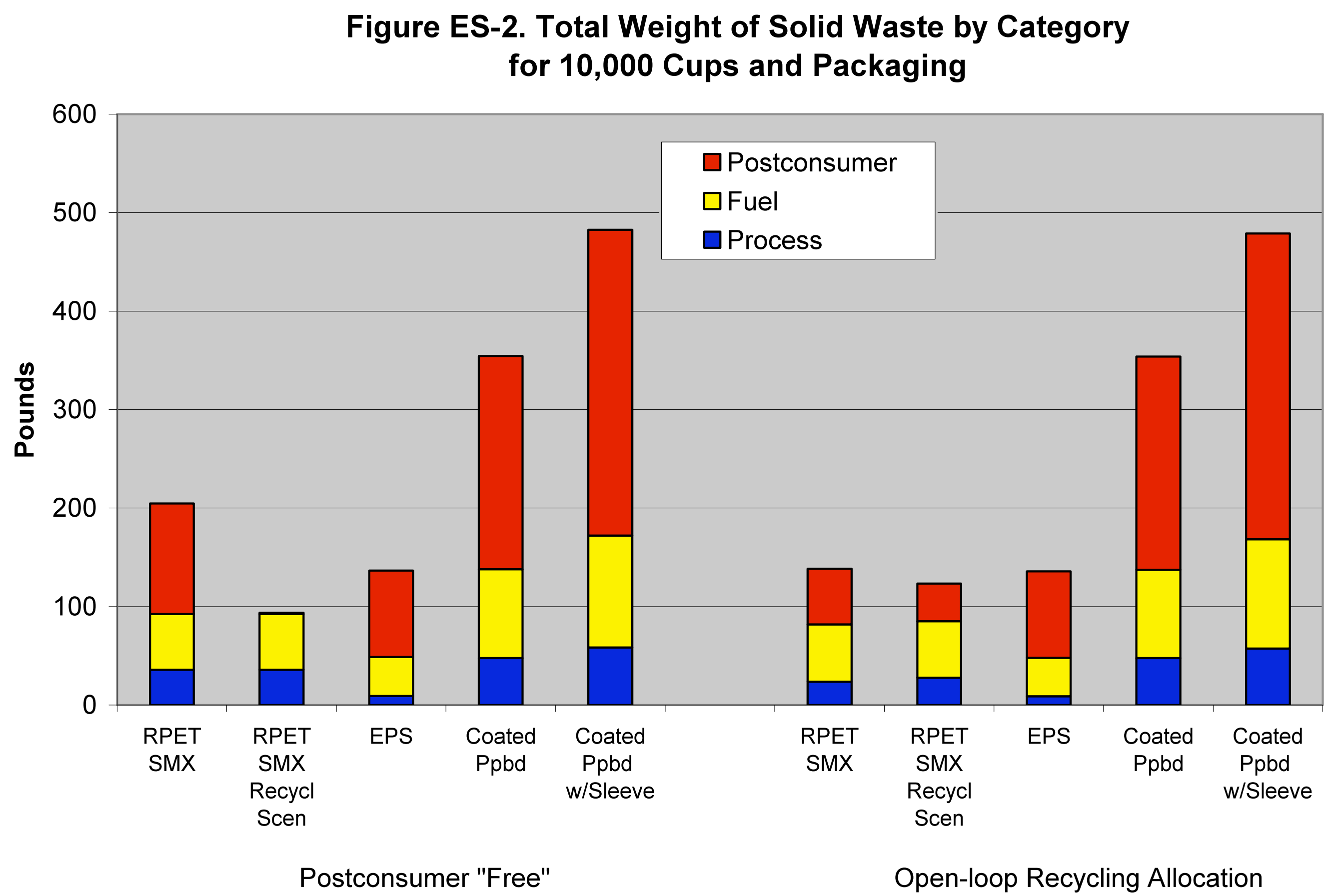


Solid Waste (by Volume)

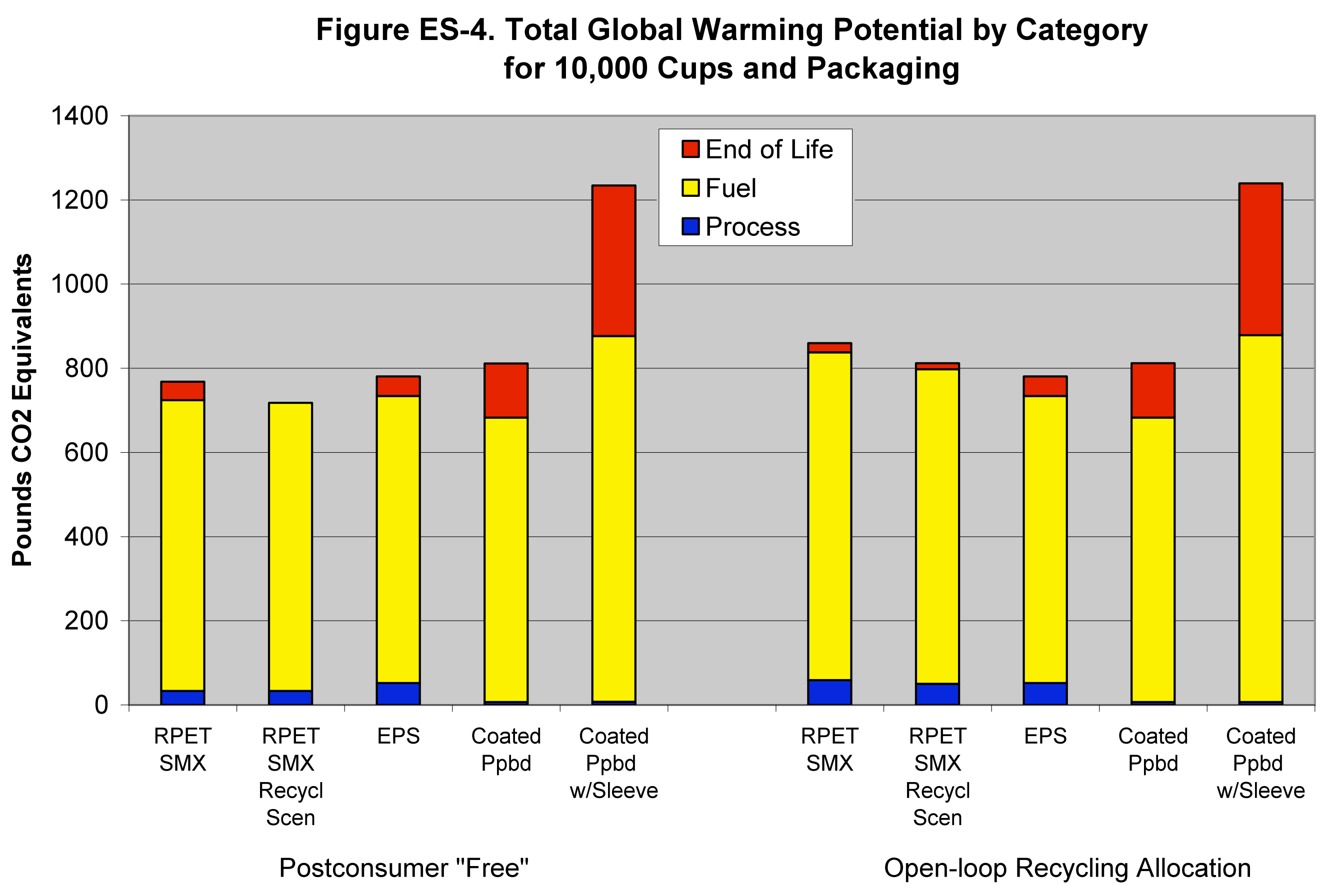
Figure ES-3. Total Solid Waste Volume by Category for 10,000 Cups and Packaging



Solid Waste (by Weight)



Global Warming Potential



Conclusions: Energy

- **Energy.**

  Regardless of the recycling methodology used to allocate burdens for the recycled content, the ***RPET SMX cup has lower total energy*** requirements than the other cup systems.

Conclusions: Solid Waste

- **Weight of Solid Waste.**

  The weight of solid waste for the ***RPET SMX cup system is significantly lower*** than the paperboard cup system and the paperboard cup with sleeve.

- **Volume of solid Waste.** For 'PC Free' scenario, ***no significant difference*** in the three systems.

  For open-loop scenario, the total solid waste volume for ***RPET SMX cup is significantly lower*** than all others.

Conclusions: Global Warming Potential

- **Global Warming Potential.** There is ***no significant difference*** in GWP for the three cup technologies compared.

- **End-of-Life Global Warming Potential.** For a 50 percent decomposition scenario with national average management of landfill gas, there was ***no significant difference*** in total life cycle GWP for the three cup systems.

Conclusions: Cup Recycling After Use

- **SMX RPET Cups can be recycled after use.**

Postconsumer recycling of SMX RPET cups would further reduce their environmental profile compared to the environmental profile for cups that are disposed after use.

Sustainable Development

Seeking a world where

………the rate of resource consumption will be balanced by the rate of resource creation……..