Green Manufacturing: Resource Recovery

Paper or Plastic? A Life Cycle Inventory Comparing Unbleached Paper Grocery Sacks and Polyethylene Grocery Sacks

- Consumers make choices about which grocery sacks to use based on (in part) their perception of the relative environmental impacts of these two products.

- What are the environmental impacts?
  1. Compare energy used
  2. Compare wastes generated in the production, use and disposal of these products.

Use life cycle analysis as a consistent framework for comparison to keep track of flows of material, energy and waste.

Life Cycle Analysis

Life Cycle Inventory: collect data on material, energy and waste flows over life of product.
Stages of Life Cycle for Paper and Plastic

Paper sacks

Polyethylene sacks

Assumptions

1. All recycled grocery sacks are to the material manufacture stage
   - No product reuse
   - No product remanufacture

2. Consider only air emissions (solid wastes and waste water are not considered).
## Data

Analysis has resulted in the following data: (1990)

<table>
<thead>
<tr>
<th>Life Cycle Stage</th>
<th>Air emissions (oz/sack)</th>
<th>Energy (btu/sack)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials Manufacture</td>
<td>Paper 0.0516</td>
<td>Paper 905</td>
</tr>
<tr>
<td></td>
<td>PE 0.0146</td>
<td>PE 464</td>
</tr>
<tr>
<td>Product Manufacture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raw Materials</td>
<td>0.0560</td>
<td>724</td>
</tr>
<tr>
<td>Acquisition</td>
<td>0.0045</td>
<td>185</td>
</tr>
<tr>
<td>Product Disposal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notice the units: Per sack

## Determine Comparison Basis

In order to compare the two types, need to compare them on a constant basis.
Specific Questions

1. a) Determine the amount of energy required and the quantity of air pollutants released per 1000 lb of production of PE sacks.

   b) Same as a, but for paper sacks carrying the same volume of groceries as 1000 lb of PE sacks.

Function of recycle rate
   i. 0%
   ii. 50% (half of the sacks are disposed of, other half recycled after product use stage)
   iii. 100%
       1 PE sack = 0.2632 oz.
       1 paper sack = 2.144 oz.

2. Plot and compare.

Determine Number of Sacks
### Sample Calculation

### Results

<table>
<thead>
<tr>
<th></th>
<th>0%</th>
<th>50%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PE</td>
<td>Paper</td>
<td>PE</td>
</tr>
<tr>
<td>Energy, MM $\text{btu}$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atmospheric pollutants, $\text{lbs}$</td>
<td></td>
<td></td>
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</tbody>
</table>
Graphical Results

Discussion
3. Discuss the relative environmental impacts of the two products.
   a) Do they allow for comprehensive comparison?
   b) What are qualitative characteristics of emissions?

4. Material and energy requirements of PE sacks are primarily satisfied using petroleum, a non-renewable resource

   Paper relies on petroleum to a small extent – to generate a small fraction of the manufacturing requirements. Most are met by burning wood waste.

   Compare the amount of petroleum necessary to provide 10% of energy required in one paper sack at 0% recycle, knowing that 1.2 lb of petroleum is required to manufacture 1 lb of PE. HHV of petroleum is 20,000 btu/lb.
Results

Additional Points to Consider

a) Is 100% recycle feasible?
Additional Questions to Consider

b. What are the alternatives?