Module 2 - Life-Cycle Concepts and Assessment

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KIET
Session 1: Introduction

• Lecture/Discussion:
  – Overview of life cycle thinking
  – Product life cycles – process, material, and energy flows
  – Human well-being and the ecosystem
  – The IPAT equation
  – Some Green Design approaches
Session 2: Life Cycle Concepts

• Lecture/Discussion:
  – Screening LCA Methods
    • Eco-Indicator Methodology
    • Okala Factors
  – Examples

• Activity: Using Eco-Scan Software

• Assignment: Do screening LCA on assigned product
Session 3: Student Presentations

- Planned Activity: Student presentations on their LCA study
- Alternate Activity:
  - Discussion of full-LCA Methodology
  - Example of full-LCA on photocopier
Example Slides

- The following slides are excerpts from session 2
Module 2: Life Cycle Concepts and Assessment

Session 2: Life Cycle Concepts
Life Cycle Thinking

- Every manufacturing process and all the materials and products we use in our lives, at home, at work or in our leisure activities, have an impact on the environment.
- Life Cycle Assessment (LCA) provides a methodology for quantifying a holistic view of the environment's impacts of a product at all stages of its life, ‘Cradle-to-Grave’
Scope of LCA

Cradle
- Ingredients
- Manufacture
- Distribution

Environmental Impacts
- Using renewable materials?
- Choice of technology for extracting raw material?
- Polluting production processes?

Grave
- Use
- Disposal

Environmental Impacts
- How will product get to customers?
- How much energy will the product use?

Environmental Impacts
- What happens when the product is finished with?
- How will it be disposed of?
- Can it be reused/recycled?
Life Cycle Inventory

Raw material and energy consumption

Raw Material | Manufacturing & Distribution | Use | End of Life

Emissions to air, water and land
LCA Methodology

Build Model

Define Scope & Boundary
Model Processes & Activities

Life Cycle Inventory

Inputs:
- Raw Materials
- Energy Carriers
- Water
- Airborne & Waterborne Emissions
- Solid Waste

Life Cycle Impact Assessment

- Global Warming
- Acidification
- Resource Depletion
- Eutrophication
- Etc.
Application of LCA

- Technology Assessment
- Sustainability Review
- Environmental Reporting
- Marketing
- Industry Benchmarking
- GHG Measurement
- Generic Data Sets
- Labelling
- Sales Support
- Performance Improvement
- Product Design

Internal vs. External
- Strategic vs. Tactical
LCA - Light Bulbs

Incandescent vs. fluorescent
Domestic Lighting

- Based on: “Revising the ecolabel criteria for lamps” European Commission DG XI.E.4
- The total domestic lighting consumption in the 15 EU Member States is estimated to be at least 86 TWh, which is 17% of all residential electricity use
- Reducing electricity consumed by lamps has been identified as one policy action for reducing carbon dioxide emissions
# Types of Light Bulbs

<table>
<thead>
<tr>
<th>Type of bulb</th>
<th>Bulb wattage</th>
<th>Efficiency (lm/watt)</th>
<th>Average life (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>15-150</td>
<td>6-16</td>
<td>750-1500</td>
</tr>
<tr>
<td>Low voltage halogen</td>
<td>5-250</td>
<td>12-23</td>
<td>2000-4000</td>
</tr>
<tr>
<td>High voltage halogen</td>
<td>75-2000</td>
<td>13-24</td>
<td>2000</td>
</tr>
<tr>
<td>Double ended fluorescent</td>
<td>5-70</td>
<td>65-100</td>
<td>10000-20000</td>
</tr>
<tr>
<td>Compact fluorescent (CFL)</td>
<td>5-38</td>
<td>42-82*</td>
<td>10000-12000</td>
</tr>
</tbody>
</table>

* - the lower figures represent CFLs with magnetic ballast
# LCA of Lightbulbs

## Life cycle analysis

<table>
<thead>
<tr>
<th>Manufacturing</th>
<th>Use</th>
<th>End of life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass, Plastic, Aluminum, Copper/brass, Steel, Mercury, Phosphors, Packaging</td>
<td>Lamp manufacturing</td>
<td>Energy</td>
</tr>
<tr>
<td>Energy, Dangerous substances</td>
<td>Packaging &amp; Distribution</td>
<td>Lighting (both single ended and double ended)</td>
</tr>
<tr>
<td>Solid waste, Air pollution</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solid waste, Landfill Incineration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dangerous substances</td>
</tr>
</tbody>
</table>
LCA of Lightbulbs

<table>
<thead>
<tr>
<th></th>
<th>Air critical volume</th>
<th>Total acid</th>
<th>Water critical volume</th>
<th>COD</th>
<th>Solid waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard incandescent</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Tungsten Halogen</td>
<td>58</td>
<td>57</td>
<td>53</td>
<td>49</td>
<td>60</td>
</tr>
<tr>
<td>Fluorescent tube</td>
<td>12</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Electronic CFL</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Magnetic CFL</td>
<td>24</td>
<td>25</td>
<td>29</td>
<td>23</td>
<td>24</td>
</tr>
</tbody>
</table>

Is it possible (or even appropriate) to distill these results into a single overall number?
Mercury Emission

- The EU fuel mix for electricity generation is 37% coal, 10% oil, 9% gas, 35% nuclear, and 9% renewables.
- Mercury emission from overall power generation in the EU is about 0.035 mg/KWh.
- The following table shows the energy used, and mercury emitted, in 10,000 hours for three similar lamps in terms of lumen output; a 100 watt incandescent lamp, an 85 watt halogen lamp, and a 20 watt CFL.
Mercury Emission

<table>
<thead>
<tr>
<th></th>
<th>Incandescent lamp</th>
<th>Halogen lamp</th>
<th>Compact Fluorescent lamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wattage</td>
<td>100</td>
<td>85</td>
<td>20</td>
</tr>
<tr>
<td>Hours</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Power used (KWh)</td>
<td>1,000</td>
<td>850</td>
<td>200</td>
</tr>
<tr>
<td>Mercury emitted during power generation (mg)</td>
<td>35</td>
<td>30</td>
<td>7</td>
</tr>
</tbody>
</table>

Plus, what is mercury release during disposal? (What is the likelihood of recycling?)