Reuse versus recycling of electrical and electronic appliances: ecological assessment

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Motivation for the study

Is reuse and repair of household appliances a contribution to environmental protection and resource conservation?

Extend use $\Rightarrow$ less production $\Rightarrow$ less resource consumption

Extend use $\Rightarrow$ older products in use $\Rightarrow$ higher energy consumption during use $\Rightarrow$ higher total energy consumption

Resource consumption (Materials, energy)

Extension of life time

$?$
Applied methods: Material Flow Analysis (MFA)  
Cumulative Energy Demand (CED)

Comparison of two scenarios:

Product life cycle of EEE without reuse (normal product life)  
with reuse (extended product life)

Eight household appliances – indicator appliances

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Selected appliances (EEE)

<table>
<thead>
<tr>
<th>EEE</th>
<th>Fraction Mass-%</th>
<th>Collection [kg/(cap.yr)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerators, cooling units</td>
<td>18</td>
<td>0.79</td>
</tr>
<tr>
<td>Washing machines</td>
<td>23</td>
<td>1.00</td>
</tr>
<tr>
<td>Dish washers</td>
<td>6</td>
<td>0.27</td>
</tr>
<tr>
<td>TV-sets</td>
<td>9</td>
<td>0.37</td>
</tr>
<tr>
<td>Monitors (CRT)</td>
<td>9</td>
<td>0.37</td>
</tr>
<tr>
<td>PCs (excl. monitors)</td>
<td>2</td>
<td>0.09</td>
</tr>
<tr>
<td>Video-tape recorders</td>
<td>2</td>
<td>0.07</td>
</tr>
<tr>
<td>Microwaves</td>
<td>2</td>
<td>0.09</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td><strong>70</strong></td>
<td><strong>3.1</strong></td>
</tr>
<tr>
<td><strong>EEE total</strong></td>
<td><strong>100</strong></td>
<td><strong>4.3</strong></td>
</tr>
</tbody>
</table>
## Assumptions for life-time extensions

<table>
<thead>
<tr>
<th>Kind of appliance</th>
<th>Normal product life [years]</th>
<th>Extended product life [years]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 washing machine, dish washer,</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>refrigerator, micro wave, TV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2 monitor, videorecorder (DVD player)</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Group 3 PC (excl. monitor)</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

### Scenario A

![Scenario A Diagram]

**Flow of goods**
- Mining
  - Waste treatment and disposal
  - Fabrication EEE
  - Sorting EEE
  - Use
  - Recycling Possibility
  - Energy supply

**Flow of waste**
- EEE: Electric and electronic equipment
- WE/E/E: Waste of electric and electronic equipment
- WE/E: Waste of electronic equipment
Scenario B

Assumptions

- Reuse of ALL WEEE → Total reuse
- Appliances in use comprise a constant number (no increase by second or third acquisition)
- Chemical material composition of old and new EEE is the same
- Effects on demand of products in the economy is not considered
- Reuse has no effect on Collection, Processing and Recycling processes
- Material and energy consumption of repairing WEEE are negligible
Copper flows over 15 years, use of 1000 W

Source: Truttmann & Rechberger 2006

Use: 10 years

85% Recycl. efficiency

Use: 15 years

85% Recycl. efficiency

Source: Truttmann & Rechberger 2006

Impact of recycling efficiency on the system

Use: 10 years

85% Recycl. efficiency

Use: 15 years

75% Recycl. Efficiency (85%)

Source: Truttmann & Rechberger 2006

ACHEMA 2006, Frankfurt am Main, May 15 – 19 2006
Recycling efficiency versus Reuse

Example:
25 % Reduction of resource consumption either due to
1) Increase of recycling efficiency
   +5 % (without re-use)
   or
2) Extension of product life
   +34 % (85% recycling efficiency)

Cost/benefit examination

Different Recycling-Technologies (1, 2, ...)

Uncertainty ranges
Possible trend of costs for promotion of reuse
Uncertainty range
Energy savings

- Total energy consumption by EEE: 100%
  - + PC's (excl. monitor): 5.4%
  - + Washing machines: 1.6%
  - + Dish washers: 1.3%
  - + Microwaves: 1.2%
  - + TV's: 1.1%
  - + Refrigerators: 0.8%
  - + Monitors: 0.4%
  - + Video/DVD: 0.3%
  
  Ca. 12% reduction

Resource conservation (materials and energy)

- Total material consumption: 100%
  - Production of goods except EEE
    - 1-3% Production of EEE
    - Contribution of Total reuse - 33% → < 1%

- Total energy consumption: 100%
  - Energy consumption except EEE
    - 1.8% Energy consumption by EEE
    - Contribution of Total reuse - 12% → < 0.2%
Conclusions

- Contribution of Total reuse on resource conservation is small < 1 %
- Recycling efficiency is more relevant
- Technological solutions more efficient than change in consumer behaviour
- CBA – Cost Benefit Analysis to decide which strategy to go

Acknowledgement

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