Does WEEE recycling make sense?
An LCA study of the Swiss WEEE recycling system

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Problem setting

Are the (secondary) resources, resulting from a highly mechanical and automated recycling system (like we have in Europe) counter-weighting the caused environmental impacts?
WEEE Recycling in Switzerland
A long, successful story ...

Introduction
Goal & Scope
Results
Conclusion

2005 from 2006
## WEEE Recycling in Switzerland

... with impressive numbers!

### Introduction

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of SENS-licensed businesses</th>
<th>Large electrical appliances</th>
<th>Refrigeration, deep-freeze and air-conditioning appliances</th>
<th>Small electrical appliances</th>
<th>Electronic equipment</th>
<th>Lighting equipment</th>
<th>Fractions from appliances from external sources</th>
<th>Non-ORAREA appliances</th>
<th>Total in tonnes p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>20</td>
<td>9600</td>
<td>6700</td>
<td>Overall 17500</td>
<td>4300</td>
<td>300</td>
<td>38100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>18</td>
<td>5600</td>
<td>6400</td>
<td>Overall 22300</td>
<td></td>
<td>1)</td>
<td>34600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>27</td>
<td>14600</td>
<td>11600</td>
<td>5400</td>
<td>30200</td>
<td>9000</td>
<td>71600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>28</td>
<td>18100</td>
<td>13100</td>
<td>7500</td>
<td>33700</td>
<td>3600</td>
<td>77800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>33</td>
<td>19100</td>
<td>11400</td>
<td>9300</td>
<td>37200</td>
<td>4202)</td>
<td>82500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>34</td>
<td>23400</td>
<td>153003)</td>
<td>10700</td>
<td>41800</td>
<td>1100</td>
<td>100003)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>34</td>
<td>26100</td>
<td>14500</td>
<td>12300</td>
<td>42500</td>
<td>1110</td>
<td>107500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>21</td>
<td>26800</td>
<td>15100</td>
<td>13800</td>
<td>45000</td>
<td>1130</td>
<td>107700</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>21</td>
<td>30700</td>
<td>15300</td>
<td>14600</td>
<td>46100</td>
<td>1120</td>
<td>112700</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>20</td>
<td>30700</td>
<td>15800</td>
<td>15400</td>
<td>50700</td>
<td>1120</td>
<td>120400</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**... more than 17 kg in 2010 per inhabitant!**

(while WEEE is asking 4 kg per inhabitant and year)
Goal & Scope of the study

- Does the WEEE recycling – as it happens in Switzerland – make sense from an environmental perspective?

- Combined Material Flow Analysis (MFA) and Life Cycle Assessment (LCA) study …
  - … using latest material flow statistics from Swiss WEEE systems;
  - … in combination with a stepwise LCA model covering the complete WEEE treatment chain (collection -> secondary resource/final disposal)
  - … using ecoinvent v2 as background LCI database

- Functional unit:
  - Treatment of annual WEEE amount, collected in 2009 in Switzerland
  - … using a «common basket of products»
System Boundaries
Base Case Modelling

Primary production of …
- ferromanganese
- aluminium
- copper
- precious metals
- zinc
- mercury
- steel
- plastics
- other materials

Common basket of products
- ferromanganese
- mercury
- steel
- copper
- heat and electricity
- plastics
- lead, gold, silver
- glass cullets, wood, waste paper

(Additional) Energy Production
- heat production
- electricity production
### Material Flow Data SWICO/SENS

#### Introduction

#### Goal & Scope

#### Results

<table>
<thead>
<tr>
<th>Fractions</th>
<th>2004</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount in t</td>
<td>in %</td>
</tr>
<tr>
<td><strong>Hazardous fractions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batteries</td>
<td>204</td>
<td>0.3</td>
</tr>
<tr>
<td>Capacitors</td>
<td>120</td>
<td>0.2</td>
</tr>
<tr>
<td>Other hazardous fractions 1)</td>
<td>233</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Valuable fractions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td>45'869</td>
<td>61.2</td>
</tr>
<tr>
<td>Metals-plastics mixture</td>
<td>8776</td>
<td>11.7</td>
</tr>
<tr>
<td>Plastics</td>
<td>9133</td>
<td>12.2</td>
</tr>
<tr>
<td>CRT Glass</td>
<td>6862</td>
<td>9.2</td>
</tr>
<tr>
<td>Cables</td>
<td>1105</td>
<td>1.5</td>
</tr>
<tr>
<td>Printed wiring boards (PWB)</td>
<td>1204</td>
<td>1.6</td>
</tr>
<tr>
<td>Other valuable fractions 2)</td>
<td>1450</td>
<td>1.9</td>
</tr>
<tr>
<td><strong>Sum of all fractions</strong></td>
<td>74’957</td>
<td>100</td>
</tr>
</tbody>
</table>

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1) consisting of cooling substances, fluorescent layer from cathode ray tube (CRT) screens, mercury, selenium drums

2) consisting of glass, liquid crystal displays (LCDs), paper/board, toner modules, wood.
Results

Overall Impact of the various Models
Results
Overall Impact of the various Models
Results

Overall Impact of the various Models
Results

The WEEE treatment model – step by step

- Collection & pre-processing
- Battery treatment
- Metal treatment
- CRT devices treatment
- PWB treatment
- Cable treatment
- Plastic treatment
- Treatment other waste & OHW
Results
Primary vs secondary production processes

Introduction
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Results
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Does WEEE recycling make sense from an environmental perspective?
The environmental impacts of the Swiss take-back and recycling systems for waste electrical and electronic equipment (WEEE)

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Abstract

The production of electrical and electronic equipment (EEE) is one of the fastest growing markets in the world. At the same time this also means that the amount of waste electrical and electronic equipment (WEEE) will continue to increase in the coming decades. As it is crucial to obtain reliable data on the environmental consequences of the different WEEE treatment systems, a study has been carried out to analyse the environmental consequences of the different WEEE treatment systems. The study was based on a detailed review of the literature and the classification of the most relevant factors. The study was concluded with a summary of the results and conclusions. The study was published in the journal "Science of the Total Environment" in 2005.

What is the influence on the result …

(a) from development of LCI data (ecoinvent v1 -> v2)
(b) From the developments of the Swiss WEEE system (2004 -> 2009)
Results
Development in LCI data (ecoinvent v1 -> v2)
New Modelling of CRT treatment

Results

Modelling with ecoinvent v1.1

- CRT Screens
  - CRT glass recycling
  - milling
  - Grinding, washing
  - Disposal Getter/Coatings
  - Electric Arc furnace
  - Lead smelter

Legend
- own dataset(s)
- empty dataset
- dataset(s) from ecoinvent

Modelling with ecoinvent v2.2

- CRT Screens
  - (i) Glass recycling
  - (ii) Black Copper

- Disposal Getter/Coatings
  - Electric Arc furnace
  - secondary copper production

- CRT glass pre-treatment
- secondary CRT glass production

- Electric Arc furnace
- secondary copper production

- Cu, Pb, Zn
- Sand

EIP per t of treated CRT-Screens
# Results

## New Modelling of CRT treatment

<table>
<thead>
<tr>
<th>EIP part of Printed Wiring Boards</th>
<th>Modelling with ecoinvent v1.1</th>
<th>Modelling with ecoinvent v2.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary Cu production</td>
<td>Printed Wiring Boards</td>
<td>PWB</td>
</tr>
<tr>
<td>Secondary Cu pre-treatment</td>
<td>PWB</td>
<td>secondary Cu pre-treatment</td>
</tr>
<tr>
<td>Secondary Cu conversion</td>
<td>secondary Cu conversion</td>
<td>secondary Cu conversion &amp;</td>
</tr>
<tr>
<td>Precious Metals refining</td>
<td>Precious Metals refining</td>
<td></td>
</tr>
<tr>
<td>Lead, Copper, Zinc, Tin, Oxide</td>
<td>Printed Wiring Boards</td>
<td>Precious Metals refining</td>
</tr>
<tr>
<td>Lead, Copper, Zinc, Tin, Oxide</td>
<td>secondary Cu conversion</td>
<td>secondary Cu conversion &amp;</td>
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<tr>
<td>Lead, Copper, Zinc, Tin, Oxide</td>
<td>Precious Metals refining</td>
<td>Precious Metals refining</td>
</tr>
</tbody>
</table>

**Legend**
- Orange: Secondary Cu production
- Blue: PWB pre-treatment
- Red: Secondary Cu conversion
- Yellow: Precious Metals refining
- Copper: Lead
- Yellow: Zinc
- Red: Tin

**Own dataset(s) from ecoinvent**

**Results**

**New Modelling of CRT treatment**
Results
Development 2004 - 2009 (in WEEE treatment / in LCI data)
Conclusion(s)

- A WEEE recycling & recovery system results in clearly lower environmental impacts than the baseline models (incineration / landfilling)
  - Collection and pre-processing contribute only marginally to environmental impacts;
  - main contribution comes from metals treatment, CRT devices treatment and plastics treatment;
  - greatest savings in can be achieved with secondary production from battery, metals, cables, and PWB treatment;

- Utilisation of non-adequate LCI data could influence in details the results considerably (in both directions) – but only minor influence on the overall picture
More Information:

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