Cost-benefit analysis of WEEE Recycling in Germany – Case study of mobile phones and smartphones

MBA Nicoleta Gurita
(1) Precious and critical metal stocks and value of critical and precious metals in selected electronic equipment sold in Germany

(2) Value of metal stocks not put to any use as a result of inefficiencies in the WEEE management system

(3) Cost-benefit analysis of WEEE recycling

(4) Major issues and challenges of exploiting these stocks

E-waste is a term used to cover all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of re-use.

WEEE = Waste Electrical and Electronic Equipment
Quantity WEEE generated in year 2014 worldwide

The European countries with the highest e-waste generation:
- **Germany** (1.8 Mt),
- the United Kingdom (1.5Mt),
- France (1.4 Mt)
- Russia (1.2 Mt).

Electronics may contain up to 60 elements – a complex mix of valuables & hazards

Materials in a mobile phone (UNEP, 2009).

- Demand (and prices) of special & precious metals have increased significantly (specific metal properties are needed for more functionality)
- Their primary production requires significant amounts of energy and resources
- „Concentration“ in specific components like circuit boards
- New material combinations compared to their natural occurrence & dissipation in final product (e.g. computers, mobile phones, cars, etc.) make recycling challenging
**EU Critical Metals**

Critical metals: **Cobalt, Gallium, Indium, Chromium, Magnesium, Antimony, Beryllium**

Precious metals: **Gold, Silver, Palladium**

Rear Earth: **Praseodymium and Neodymium.**

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<table>
<thead>
<tr>
<th>Critical Metals</th>
<th>Precious Metals</th>
<th>Rear Earth</th>
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<tbody>
<tr>
<td>Antimony</td>
<td>Cobalt</td>
<td></td>
</tr>
<tr>
<td>Gallium</td>
<td>Magnesium</td>
<td></td>
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<tr>
<td>PGMs</td>
<td>Silicon Metal</td>
<td></td>
</tr>
<tr>
<td>Beryllium</td>
<td>Coking Coal</td>
<td></td>
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<tr>
<td>Germanium</td>
<td>Natural Graphite</td>
<td></td>
</tr>
<tr>
<td>Phosphate Rock</td>
<td>Tungsten</td>
<td></td>
</tr>
<tr>
<td>REEs (heavy)</td>
<td>Niobium</td>
<td></td>
</tr>
<tr>
<td>REEs (light)</td>
<td>Fluorspar</td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>Magnesite</td>
<td></td>
</tr>
<tr>
<td>Borates</td>
<td>Indium</td>
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</tbody>
</table>

Source: European Commission, 2014
Booming product sales & increasing functionality boosts demand for (technology) metals

Accumulated global mobile phone sales until 2011 > 10 billion units containing in total:

2500 t Ag, 240 t Au, 90 t Pd, 38,000 t Co, 90,000 t Cu, …

Germany – Metal Stock

Metals stock in mobile phones and smartphones in Germany, 2004 -2014

- **Primary mining**: 5g Gold/tonne ore
- **5g Gold** in just 125 mobile phones
- **or 167 smartphones**

> 5600 tonnes

Source: self-prepared
Collection rate = 5%
Reuse Rate = 5%
UNEP Recycling Rates

Precious and critical metals content in units sold
5.6 thousand tonnes

Precious and critical metals content in units available for recycling
2.1 thousand tonnes

Recycled precious and critical metals content
931 tonnes

Excl. REE for sixty metals. The periodic table of global average EoL (post-consumer) functional recycling (EoL-RR) for sixty metals. Functional recycling is recycling in which the physical and chemical properties that made the material desirable in the first place are retained for subsequent use. Unfilled boxes indicate that no data or estimates are available, or that the element was not addressed as part of this study. These evaluations do not consider metal emissions from coal power plants.
Value of metals stock not put to any use

> € 558 million material value

> € 488 million worth of materials is not being used

Source: self-prepared
### Costs of mobile phones and smartphones recycling

<table>
<thead>
<tr>
<th>Activity</th>
<th>Guarantee</th>
<th>Collection</th>
<th>Transportation</th>
<th>Pre-processing</th>
<th>Treatment</th>
</tr>
</thead>
</table>
| Costs    | Financial Guarantee (in EUR)  
= Registration amount (in tons)  
x Expected return rate (as a percentage, as specified by EAR)  
x Estimated disposal costs (in EUR / tonne, as specified by EAR) | 0.01 €/unit | 13 €/t         | 85 €/t         | 135 €/t   |

*Source: Self-prepared based on Das Elektrogesetz (2015), HP (2006), Walther et al. (2010), Walther & Spengler (2005).*
Cost-benefit analysis

- Guarantee: 30.57%
- Collection: 20.26%
- Transportation: 0.02%
- Pre-processing: 0.02%
- Treatment: 3.10%

Guarantee (€/t) | Collection (€/t) | Transportation (€/t) | Pre-processing (€/t) | Treatment (€/t)

Total costs of recycling | Revenues from recycling
WEEE Management

- Increasing standards of living
- Increasing urban population
- Technology development

Generation of WEEE

- GHG emissions
- CFCs
- Heavy metals
- Certain Flame retardants
- Trapped resources

EU WEEE Directive
Directive 2012/19/EU

Extended Producer Responsibility -> Mass based recovery rates

- Climate Change
- Destruction of the ozone layer
- Leakage from landfills into water and soil
- Possible formation of new hazardous substances during incineration

WEEE Management

- Collection
- Treatment
- Recycling

Consumer take-back
Large informal market

Source: self-prepared
Today more than 50% of the WEEE generated in Europe follows unofficial collection routes, sometimes leading to export and improper treatment.

Further important players are the **retailers** and the **consumers**, even though the (ElektroG) does not assign them specific responsibilities.

Source: Otmar Deubzer, 2011
Disincentives for Individual Producer Responsibility (IPR)

1. Producers pay at the moment according to their pre-calculated market shares and not for their own products.

   "In practice each producer shares the average cost of collectively recycling mixed categories of types of waste products" (Mayers et al., 2013).

3. For IPR, producers must organize their own collection and treatment systems outside of the centralized system, which would be too costly.
Lack of Incentives for Eco-Design

1. Initial assumption -> IPR will incentivize producers to pay more attention to eco-design

2. Germany -> competition -> lower treatment costs for producers -> little incentive to focus or even consider the concept of ecodesign

<table>
<thead>
<tr>
<th>Country</th>
<th>Laptop</th>
<th>Desktop</th>
<th>Digital Camera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>0.07 €</td>
<td>0.38 €</td>
<td>0.01 €</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>1.08 €</td>
<td>2.70 €</td>
<td>0.07 €</td>
</tr>
</tbody>
</table>

*Cost in Euros of collecting and recycling of specific IT&TE products per unit in 2006 (Okopol et al. 2007:237)*
5. Recycling Step-backs

Metal specific recovery rates at the pre-processing level

WEEE -> potential source of secondary raw materials

High recovery rates for major elements, low recovery rates for trace metals
Closing the loop

Reduce metal losses and boost recycling along all steps of the lifecycle

- Securing access to scarce resources
- Reducing impact on energy/climate, biosphere & water resources
- Inducing innovation & creating jobs

• Better collection
• Tracing & tracking of material flows
• Prevention of dubious exports
• Creating transparency
• Economic incentives

Take back systems

End users → Producers → Service providers → Storage and sorting facilities → Reuse, Spare parts, Recycling facility

Success factors are product design & technical-organisational set-up of the recycling chain

Source: self-prepared
Investigation of incentive-based approaches to sustainable and resource-efficient delivery of electronic products -> business models to close the loop

Effective recycling can play a key role to:

- Conserve metal resources & enable a regionally more balanced access (supply security)
- Mitigate metal price increase/volatility
- Contribute significantly to a reduction of energy use and emissions
- Stimulate fair international cooperation along the value added chains
Thank you for your attention!

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