WEEE recycling: key aspects in reducing the carbon footprint and providing access to scarce resources
❖ Umicore Group

❖ Umicore Precious Metals Refining

❖ E-scrap: The recycling chain

❖ Challenges for Latin America

❖ Recommendations

❖ Conclusion
Material technology company with focus on clean technologies

Global presence: 14,400 people in 80 industrial sites worldwide
Key megatrends for Umicore

- Resource scarcity
- More stringent emission control
- Renewable energy
- Electrification of the automobile
Umicore fit with megatrends

**Electrification of the automobile**
We are a leading producer of key materials for rechargeable batteries for laptops, mobile phones as well as electrified vehicles.

**Resource scarcity**
We are the largest recycler of precious metals; we are able to recycle more than 20 different metals.

**More stringent emission control**
We provide catalysts for 1 out of 3 cars in the world as well as for trucks & non-road vehicles.

**Renewable energy**
We supply key innovative materials for high-efficiency solar cells and other photovoltaic applications.
Umicore’s structure
Umicore and sustainability

- On January 23rd 2013, Umicore has been ranked as the most sustainable company in the “Global 100 Most Sustainable Corporations in the World” index.

- The index, based on many variables, is published annually since 2005 by Corporate Knights, an independent media and investment research company based in Toronto, Canada.
Exploring Umicore Precious Metals Refining

Excellence in recycling
UPMR: the leading precious metals recycler

- unique & innovative technology
- excellent services to an international customer basis
- wide range of complex precious metals bearing materials
- efficient recovery of 17 different metals
- applying world class environmental standards
Our core business

- Raw materials supply
- Sampling & Assaying
- Smelting & Refining
- Metals sales
Raw Materials Supply

Each year UPMR processes around 350,000 tonnes of more than 200 different types of raw materials containing lead / copper / nickel & precious metals.
Types of raw materials

By-products
- By-products from non-ferrous industry
  - e.g. drosses from lead smelters, slimes from copper industry, ...

Recyclable products
- Spent Industrial Catalysts
- Electronic Scrap
- Spent Automotive Catalysts
  - Industrial catalysts from oil refining & petrochemical industry
  - e.g. printed circuit boards
  - end-of-life car catalysts

Others
- Precious metal bearing raw materials
  - e.g. fuel cells, photographic residues
E-scrap:
The Recycling Chain
E-waste, what are we talking about?
E-waste: something to ‘deal’ with

Printed circuit boards  Steel scrap  Cable scrap  Plastic scrap  ALU scrap  CRT, LCD  Others
E-waste: something to ‘deal’ with

- Printed circuit boards, cell phones
- Steel scrap
- Cable scrap
- Plastic scrap
- ALU scrap
- CRT, LCD
- Others

**LARGE DIVERSITY OF FRACTIONS**

... THAT EACH REQUIRE TREATMENT BY SPECIALIZED COMPANIES

→ IT E-WASTE IS THE MOST HUNTED FOR
Booming product sales & increasing functionality drive demand for (technology) metals

Annual global sales of mobile phones

Source: after Gartner statistics (www.gartner.com)

Million units

Accumulated global sales until 2010
~ 10 Billion units

1º Brazil → 262 million
2º México → 101 million
3º Argentina → 59 million
4º Colombia → 49 million
5º Venezuela → 29 million

www.teleco.com.br
Recent boom in demand for most technology metals

REE = Rare Earth Elements
Low loadings per unit, but volume counts
Example: Metal use in electronics

Global sales, 2011

<table>
<thead>
<tr>
<th>a) Mobile phones</th>
<th>1800 million units/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>X 125 mg Ag ≈ 225 t Ag</td>
<td></td>
</tr>
<tr>
<td>X 25 mg Au ≈ 45 t Au</td>
<td></td>
</tr>
<tr>
<td>X 4 mg Pd ≈ 7 t Pd</td>
<td></td>
</tr>
<tr>
<td>X 9 g Cu ≈ 16,000 t Cu</td>
<td></td>
</tr>
</tbody>
</table>

1800 million Li-ion batteries
X 3.8 g Co ≈ 6800 t Co

<table>
<thead>
<tr>
<th>b) PCs &amp; laptops</th>
<th>365 Million units/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>X 1000 mg Ag ≈ 365 t Ag</td>
<td></td>
</tr>
<tr>
<td>X 200 mg Au ≈ 73 t Au</td>
<td></td>
</tr>
<tr>
<td>X 80 mg Pd ≈ 29 t Pd</td>
<td></td>
</tr>
<tr>
<td>X~ 500 g Cu ≈ 183,000 t Cu</td>
<td></td>
</tr>
</tbody>
</table>

~190 million Li-ion batteries
X 65 g Co ≈ 12,350 t Co

<table>
<thead>
<tr>
<th>a+b) Urban mine</th>
<th>Mine production / share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag: 23,500 t/a ▶ 3%</td>
<td></td>
</tr>
<tr>
<td>Au: 2,800 t/a ▶ 4%</td>
<td></td>
</tr>
<tr>
<td>Pd: 230 t/a ▶ 16%</td>
<td></td>
</tr>
<tr>
<td>Cu: 16 Mt/a ▶ 1%</td>
<td></td>
</tr>
<tr>
<td>Co: 98,000 t/a ▶ 20%</td>
<td></td>
</tr>
</tbody>
</table>

Tiny metal content per piece → Significant total demand
Other electronic devices add even more to these figures
and considering the CO₂ impact of primary metal production is huge ...

CO₂ impact of secondary metal production is much lower for majority of metals => incentive to stimulate recycling

Example: 70,000 tons of metals produced by Umicore Hoboken in 2007 = 1 million tons of CO₂ savings vs primary metal production

source: ecoinvent 2.0, EMPA/ETH-Zürich, 2007
UPMR $\rightarrow$ maximizing metal extraction from Urban mines

**Primary mining**
- ~ 5 g/t Au or PGM’s in ore
- Low grade, high volume, fixed location

**Urban mining**
- 200 g/t Au, 80 g/t Pd & Cu, Sn, Sb, … in PC boards
- 2,000 g/t PGM in automotive catalysts
- High grade, million of units, globally spread
Reducing CO\textsubscript{2} emission significantly

Example:

**Umicore Precious Metals Refining**, Hoboken/Belgium (UPMR):

- recovered metals 2007*: 70,000 t
- total CO\textsubscript{2} impact of UPMR in 2007*: 0.27 Mt
- total CO\textsubscript{2} impact primary production**: 1.3 Mt

\textgreater CO\textsubscript{2} saving potential recycling*: 1.0 Mt

*from treatment of 300,000 t of recyclables & smelter by-products.

Output: 1000 t Ag, 30 t Au, 37 t PGM, 65 000 t Cu/Pb/Ni, 3500 t Sn/Se/Te/In/Sb/Bi/As

**if these metals would have come from primary production, calculated with ecoinvent 2.0:

the unavoidable “black box approach” of the UPMR calculation mixes the CO\textsubscript{2} impacts of very low grade materials (e.g. slags, flue dusts) with richer ones from recycling of consumer goods (e.g. circuit boards, catalysts)

\textgreater for recycling of electronics the CO\textsubscript{2} benefit compared to mining is even higher!
Modern electronics make use of ~ 50% of elements from periodic table => a big consumer of natural resources

- Precious & special metals → „technology metals“, crucial for functionality
- Key components: circuit boards, batteries, LCD screens
E-waste: structure of recycling chain

Collection

Entire EOL-devices

Sorting/dismantling/component picking

Stripped equipment & components

Mechanical preprocessing

Circuit boards & highly complex materials

Complex metals refining

- Large scale metallurgical & chemical technologies

Magnitude of losses in materials and value

Some 1,000 (local)

Some 100 (local)

Some 10 (partly international)

≈ 5 globally (3 in Europe)

Mainly locally

Mainly globally

Typical numbers of participants (for industrial countries)

Not collected

Landfill, incineration or other losses

Lost in sidestreams and wrong fractions (e.g., Au in Al-fraction)

Transfer in slags or other sidestreams
Recycling chain

Example: \[10\% \times 90\% \times 80\% \times 95\% = 7\%\]

*effective recovery rate for e.g. Au, Cu etc. from EOL-streams

Total efficiency is determined by the weakest step. Consider the entire chain & its interdependencies.
How does the recycling chain often look like in reality in some countries?

Or a gold recycling efficiency of: $95\% \times 50\% \times 25\% = 12\%$

* Illustrative figures

backyard recycling ➤ “low tech”

- High losses, few metals recovered only dramatic environment & health impacts
- Typical for most Asian - African countries – LATIN AMERICAN COUNTRIES?
Another examples

Low collection

⇒ lack of legislation in some Latin American countries & new business models are required

“Deviation” of collected goods
⇒ dubious exports ⇒ low quality ”recycling”

⇒ “Tracing & Tracking“, controls & enforcement, stakeholder responsibility, transparency
Still have some opportunities

<table>
<thead>
<tr>
<th>Number of cell phones</th>
<th>Quantity for the next 2 years</th>
<th>10% decided to ‘recycle’ the device</th>
<th>Estimated quantity of Au to be recycled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Million units</td>
<td>Million users</td>
<td>Estimated quantity of Au to be recycled</td>
<td></td>
</tr>
<tr>
<td>262.000.000</td>
<td>17.500 tons</td>
<td>1.750 tons</td>
<td>437 kg</td>
</tr>
<tr>
<td>Million users</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49.000.000</td>
<td>3.300 tons</td>
<td>330 tons</td>
<td>82,5 kg</td>
</tr>
<tr>
<td>Million users</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

15.000 cell phones = 1 ton of cell phones ≈ 250 grams of Au - Illustrative figures

Very important source of materials / metals (Au, Ag, Cu, Pd and others) Pulverized in the market and challenge to collect, sort and recycle.
How should/could the recycling chain look like in some countries?

Or a gold recycling efficiency of: 95 % x 90 % x 95 % = 81 %*

What is needed to achieve this result?

• Maximum & organized collection, with adequate presorting of various types of WEEE
• Focused dismantling (=> training is needed !)
• Best available end-processing technology (=> best environmental performance often goes hand in hand with best recycling performance)
• Tracing & tracking, transparency, controls.

→ SYNERGIE CAN BE ACHIEVED BY RIGHT INTERNATIONAL PARTNERSHIP

* Illustrative figures
Umicore’s e-scrap: complex & precious metals

UPMR is specialized in treating complex fractions with precious metals

Typically
- printed circuit boards
- cell phone handsets
- IT components (chips, CPU, processors)
- metallic pins
- IT connectors
Challenges for Emerging Regions

Informal sector: a useful network

- collection experience: existing broad network with door-to-door service, but sometimes informal

- recycling experience: out of livelihood, broad experience in sorting, dismantling & repair

- Good work environment requires moderate investment (training, infrastructure, fair wage.....)
Challenges for Emerging Regions

Informal sector: a useful network

Weaknesses

- Back-yard ‘refining’ = artisanal burning & leaching:
- fast access to metals,
- low yield recovery (Au < 20% recovery)
- no EHS measurements, no awareness

- Absence of proper ‘transparent’ end-refining technology (?)
Implementing recycling technologies

Collection / manual sorting & dismantling

- HIGH PRIORITY
- Low investment cost
- Use the strength of available workforce
  - Involve informal sector & create skilled labour

Mechanical pre-processing (shredding/seperation)

- Useful for high volumes of e-waste without or with low precious metal content (small domestic appliances, white goods, engines, ...)
- Moderate investment cost

Smelting/refining (resource recovery)

- Only useful if formal collection is organized
- High investment cost
- Big scale operations required to achieve high recovery yield & to make use of economy of scale
Recommendations

- Assure **organized collection first** before thinking of high tech refining technology

- Proper collection by **actively involving the existing unofficial sector** instead of excluding them. Make use of the available strengths among the informal recyclers

- Create/implement **legislative framework** that **promotes/facilitates formal collection & recycling** and that discourages/hinders informal recycling (and not the other way around)

- If no collection → no recycling
Recommendations

- **Maximize** the use of manual dismantling and minimize mechanical pre-processing as far as the *precious metals bearing e-waste* is concerned

- The more complex/interlinked the material, the less selective are mechanical separation processes and the higher are **losses of precious metals** by co-segregation
Recommendations

- **End-processing** (physical materials recovery) is crucial for final value generation & toxic control.

- Recycling trace elements from complex products needs “high-tech”, large scale processes which cannot be replicated in any country.

- Use **synergy** of locally available workforce for dismantling/pre-processing and internationally available technology for materials recovery: **economy of scale & international division of labour**
Conclusions

- Legislation extremely important;
- Motivate collection/define targets;
- More environmental awareness;
- More transparency/control of flows;
- Sector Informal to FORMAL;
- Reuse as part of the process;
- Ensure quality recycling (complex materials);
- Recycling needs a chain, not a single process;
- **If no collection → no recycling**
Thanks for your attention