Mining the Technosphere: a Solution for the Industrial Ecosystem?

ASPO summit - Alcatraz

27.06.2009

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Our problem: living exponentially in a finite world…

Satisfying our exponential needs starts with the use of resources

Using resources starts with mining them from the lithosphere

Mining = transferring mass stocks from the lithosphere to the technosphere… and to the biosphere
Figure 2: Annual worldwide production of selected metals from 1700 to 1983.
Source [Pacyna 1986]
Evolution of Electricity Generation by Fuel from 1971 to 2003

India

GWh

For more detailed data, please consult our on-line data service at http://data.iea.org.
The economic purpose of mining
Consequences…

Transferring large stocks of mass from the lithosphere to other compartments results in:

- Environmental impacts
- Natural resource depletion

→ First natural sources for some rare metals will expire very soon (e.g. Indium)
→ Most natural sources for base metals (Cu, Al, Fe, etc.), hydrocarbons, etc. will peak / expire in a few years / decades.

Million dollar questions: Where did they go? In which concentration? Are they useable? Do we know how?
The traditional model of industrial activity should be transformed in a more integrated model: an industrial ecosystem …

R. Frosch & N. Gallopoulos, General Motors Laboratories, Scientific American, November 1989
La biosphère comme source d’inspiration pour l’économie
Industrial Ecology Concept
Urban mining: e-waste
Urban mining: e-waste
Urban mining: e-waste
Loi introduisant l’écologie industrielle

Agenda 21 du Canton de Genève (2001)
Base légale:
Loi sur l’action publique en vue d’un développement durable (Agenda 21)

Article 12 (Ecosite):
«L’État favorise la prise en compte des synergies possibles entre activités économiques en vue de minimiser leur impact sur l’environnement.»
IE in Geneva: the Roadmap

Public consultation (LA21)

Law on the public initiative for sustainable development (LA21)

Article 12

ECOSITE work group

Metabolism of economic activities of the canton of Geneva

Industrial symbiosis project

Building materials

Resources sustainability criteria

Physical accounting

Logistic of goods
IE in Geneva: Metabolism of Economic Activities

PRODUCTION
- 61'900 Water
- 1'300 Building materials
- 300 Food production
- 140 Wood & paper
- 60 Metals
- 40 plastics
- 37'500 TJ energie

Geneva and outside of the canton

CONSUMPTION
- 1'100 (additional stock for the year 2000)
- 74'700 (Total Stock)

WASTES
- MSW
- Landfilling
- Recycling
- STEP

In thousand tons

Source: (Faist et al., 2003)
Flux et stocks de béton et briques (milliers de tonnes)

Pays

Canton de Genève

IE in Geneva: Metabolism of Construction Material

Source: M. Faist & al., 2003
Construction du nouveau stade de Genève (mai 2002):
Stade de la Praille: 25’000 m³ de gravats
Implementing IE: Industrial Symbiosis

Kalundborg

Photos: Symbiosis Institute, Novo Nordisk, Statoil
Implementing IE: Industrial Symbiosis

La Symbiose industrielle de Kalundborg - Etat en 2006
[Source: Christensen, 2006]
Implementing IE: how to make it systematic?

Flux d’information dans le système industriel

Source: Systèmes Durables - C. Adoue
Finding the right material flow
Do we have the know how?
Precious metal recovery from PWBs
Mass Flow Analysis – Wet Chemical Process

- 1000 kg PWB
- 200 kg Gold
- 580 kg Nude PWB
- 116 g Nude PWB
- 50 kg Dust
- 10 g Dust
- 370 kg Connectors
- 74 g Connectors
- Gold Extraction
- 367 kg Scrap Metal
- 11 g Scrap Metal
- Gas & Liquid Emissions
- 3 kg Gas & Liquid Emissions
- 12 g Gas & Liquid Emissions
- Disposal
- 1000 kg Chemicals & Energy
- 1000 kg Gold

Further processing and disposal steps are involved in the flowchart.
Alternative scenario: precious metal smelting and refining
Smelting / Refining Scenario

- **PWBs**: 1000 kg, 200 g gold
- **Treated PWB**: 950 kg, 190 g
- **Fuel**: 60 kg
- **Transport**
  - **Emissions to air**: 380 kg, 9.5 g
- **Smelting / Refining**
  - **Slag (Mg, Al, Ca, Si, Fe)**: 266 kg
  - **Energy**
  - **Metals**: 285 kg (base, precious and special metals), 190.5 g gold
- **Undesired fraction**: Dust 50 kg 10 g
- **Further processing**

**Alcatraz - 26.06.2009**
Flux de matières: Que trouve-t-on dans un téléphone portable?

- Recovered as metal
- Chemical use as process additive
- Transfer into an inert slag (product)
- Neutralised in effluents
- Isolation and safe deposit
Fast growing consumption of e-products = fast growing e-waste

- Global, 2004: 180 Mio. PCs sold, 100 Mio. PCs disposed (estimation)
- Global 2008: approx. 80% increase
- Switzerland, 2007: WEEE recycled approx. 14kg/ cap yr (equals other waste per week )

E-waste consists of a multitude of substances: valuable 1) and toxic 2)

1) Au, Ag, Pd, Cu, Fe, Al, Glass, Plastics
2) Heavy metals, flame retardants, PCB, etc.
How big is the urban mine: e-waste?

<table>
<thead>
<tr>
<th>Global Sales 2006 (estimates)</th>
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<tbody>
<tr>
<td><strong>Mobilphones:</strong></td>
</tr>
<tr>
<td>1 billion pieces</td>
</tr>
<tr>
<td>x 250 mg Ag ≈ 250 t Ag</td>
</tr>
<tr>
<td>x 24 mg Au ≈ 24 t Au</td>
</tr>
<tr>
<td>x 9 mg Pd ≈ 9 t Pd</td>
</tr>
<tr>
<td>x 9 g Cu ≈ 9000 t Cu</td>
</tr>
<tr>
<td>1000 M x 20 g/Battery*</td>
</tr>
<tr>
<td>x 3.8 g Co ≈ 3800 t Co</td>
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<tr>
<td><strong>PCs &amp; laptops:</strong></td>
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<tr>
<td>0.230 billion pieces</td>
</tr>
<tr>
<td>x 1000 mg Ag ≈ 285 t Ag</td>
</tr>
<tr>
<td>x 200 mg Au ≈ 46 t Au</td>
</tr>
<tr>
<td>x 80 mg Pd ≈ 18 t Pd</td>
</tr>
<tr>
<td>x ≈ 500 g Cu ≈ 115,000 t Cu</td>
</tr>
<tr>
<td>= 60 M laptop Batteries*</td>
</tr>
<tr>
<td>x 75 g Co ≈ 4500 t Co</td>
</tr>
</tbody>
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**production:**
- global annual
  - Ag: 20'000 t/a = 3%
  - Au: 2'500 t/a = 3%
  - Pd: 215 t/a = 12%
  - Cu: 15 Mt/a = 1%
  - Co: 58'000 t/a = 15%

*Li-Ion Type
**Li-Ion Type: > 90% in new laptops

- despite minimal content total quantities have become important!
- key question: how much can be recycled?
CONCLUSIONS

• gain knowledge about the urban mine:
  - How much? Where? When?
  - new tools and methodologies

• develop urban mining technologies

• decision making criteria:
  - which materials do you bleed out of the material cycles?
  - which material must remain in the cycles?
Thanks for your attention!

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