Mining the Technosphere: a Solution for the Industrial Ecosystem?

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EMPA
Materials Science & Technology
SOFIES
solutions for industrial ecosystems

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A few general facts…

- 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

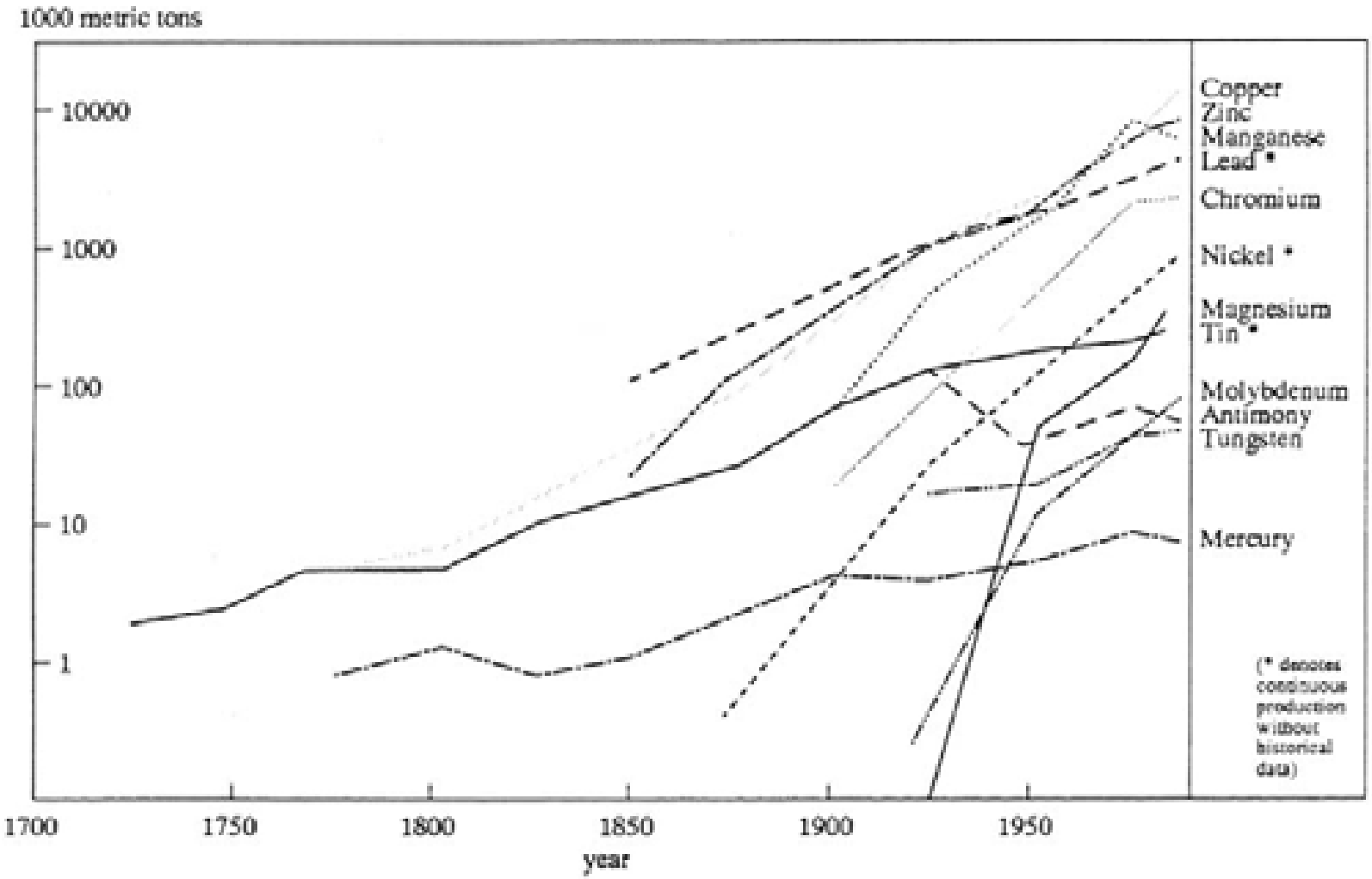


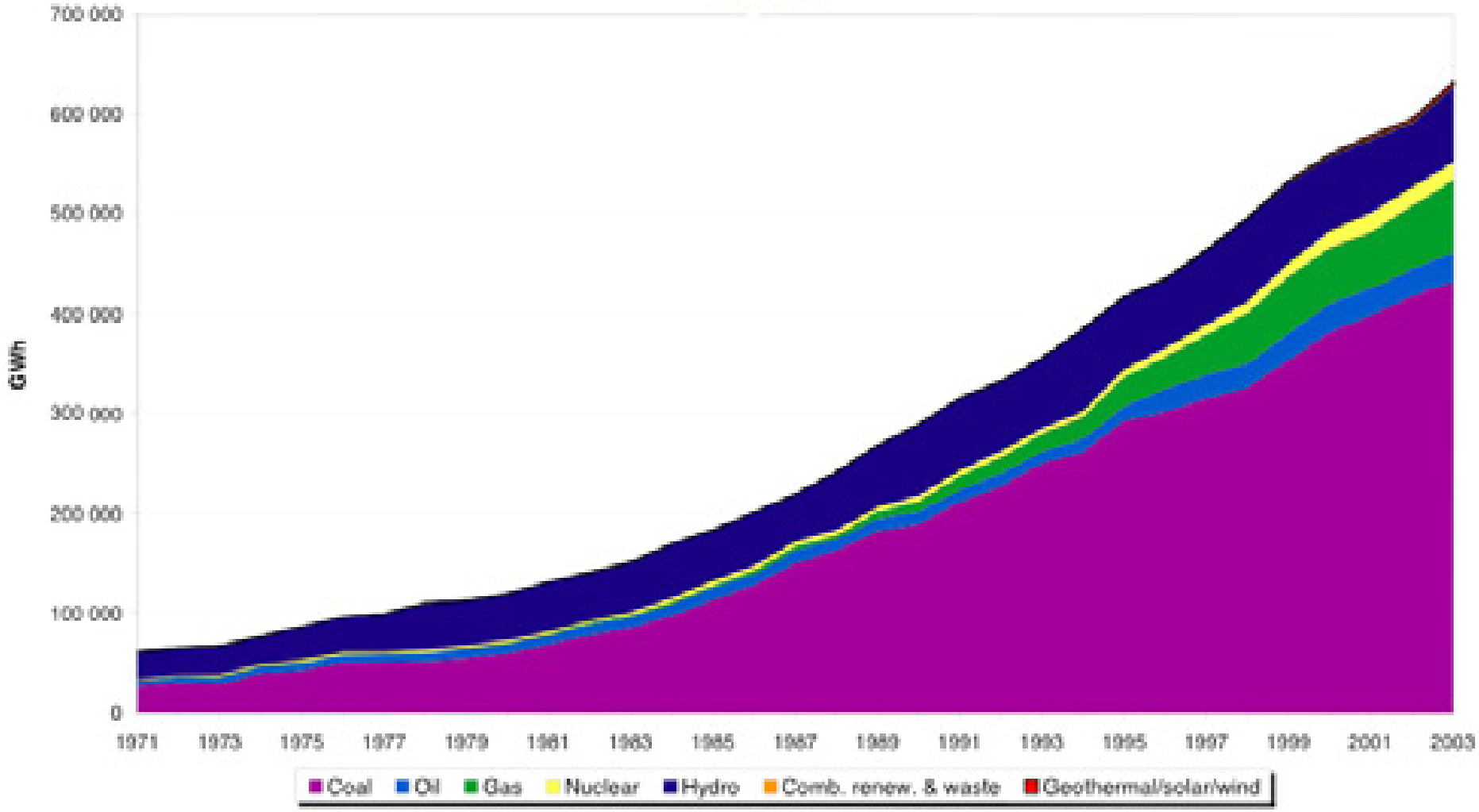
Figure 2: Annual worldwide production of selected metals from 1700 to 1983. Source [Pacyna 1986]

IEA Energy Statistics

Statistics on the Web: http://www.iea.org/statist/index.htm

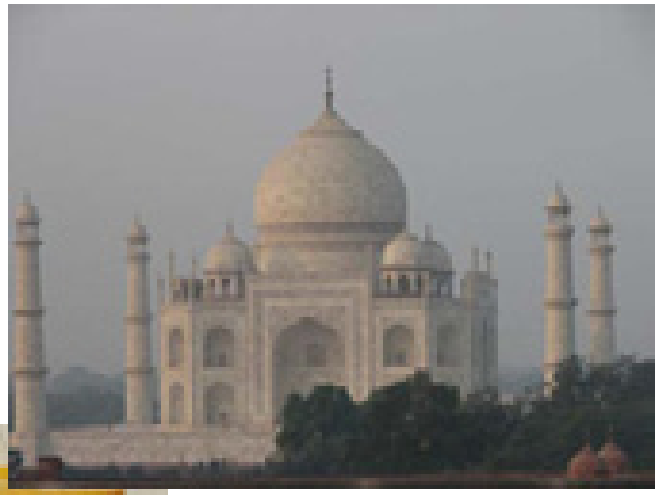
Evolution of Electricity Generation by Fuel from 1971 to 2003

India



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:

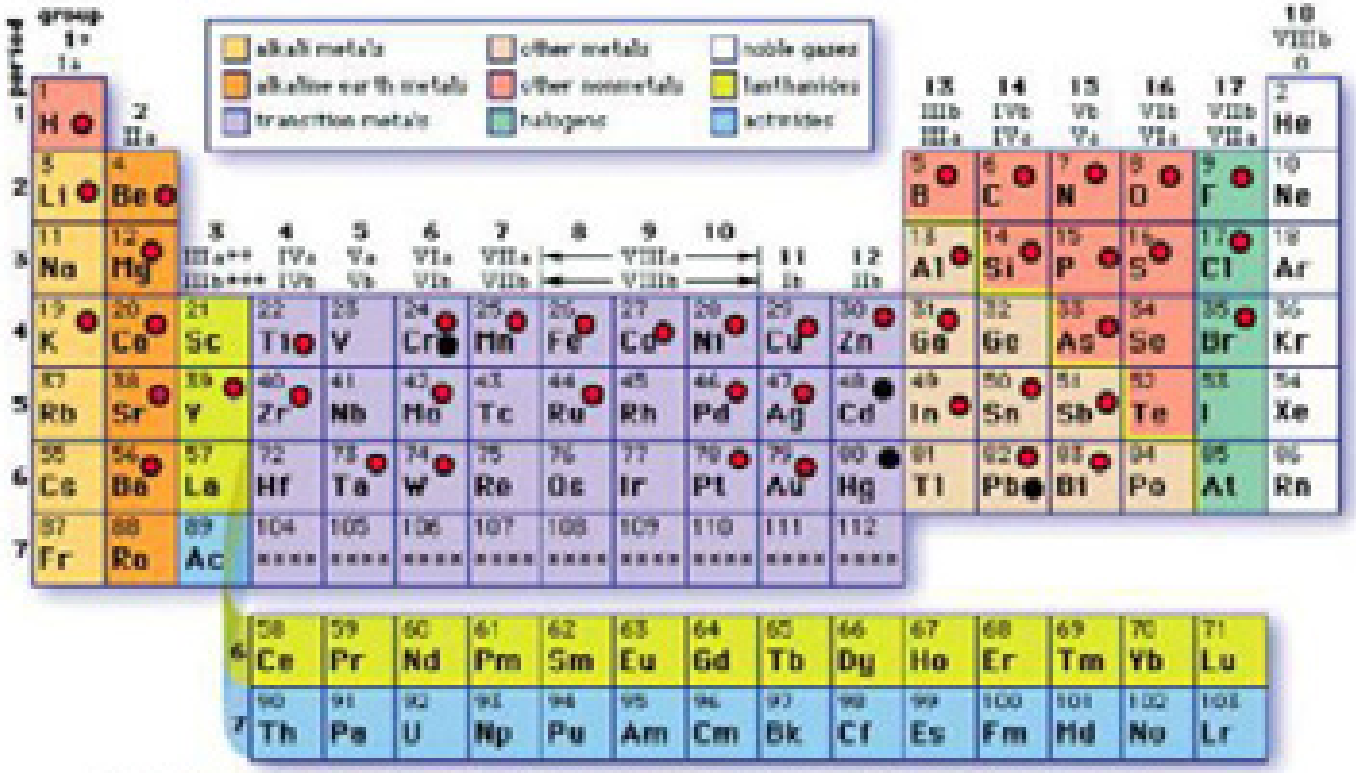
- Environmental impacts
- Natural resource depletion

→ 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?

Material Content of Mobile Phone



* Numbering system recommended by the International Union of Pure and Applied Chemistry (IUPAC)
** Previous IUPAC numbering system
*** Numbering system recommended by the Chemical Abstracts Service
**** For the names of elements 104–112, see Table 27.

- RoHS substance
- Mobile phone substance

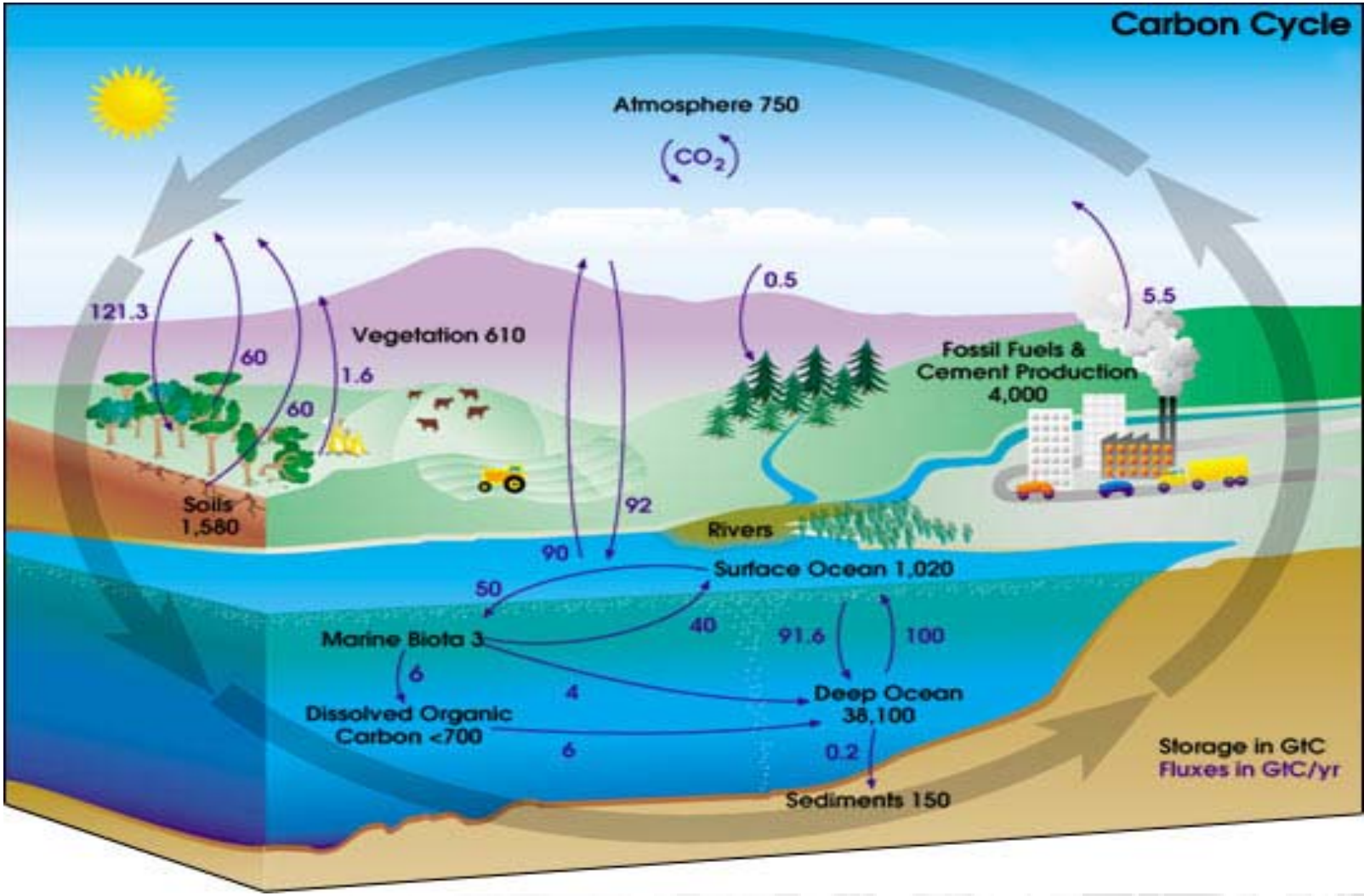
Industrial Ecology Concept

«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 Amercian, november 1989

Industrial Ecology Concept

La biosphère comme source d'inspiration pour l'économie



Industrial Ecology Concept

Urban mining: e-waste

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Urban mining: e-waste

Loi introduisant l'écologie industrielle

Agenda 21 du Canton de Genève (2001)

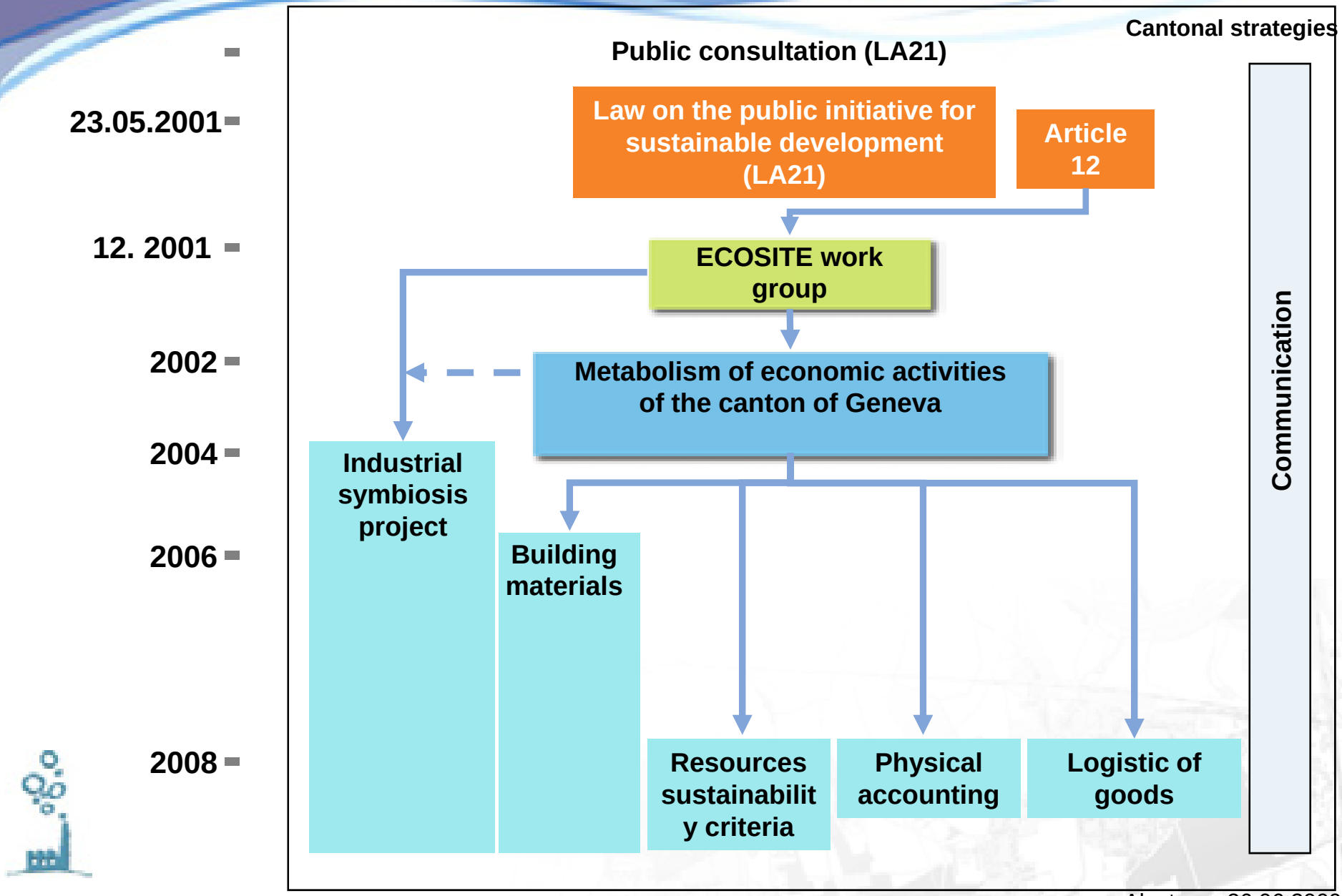
Base légale:

Loi sur l'action publique en vue d'un développement durable (Agenda 21)

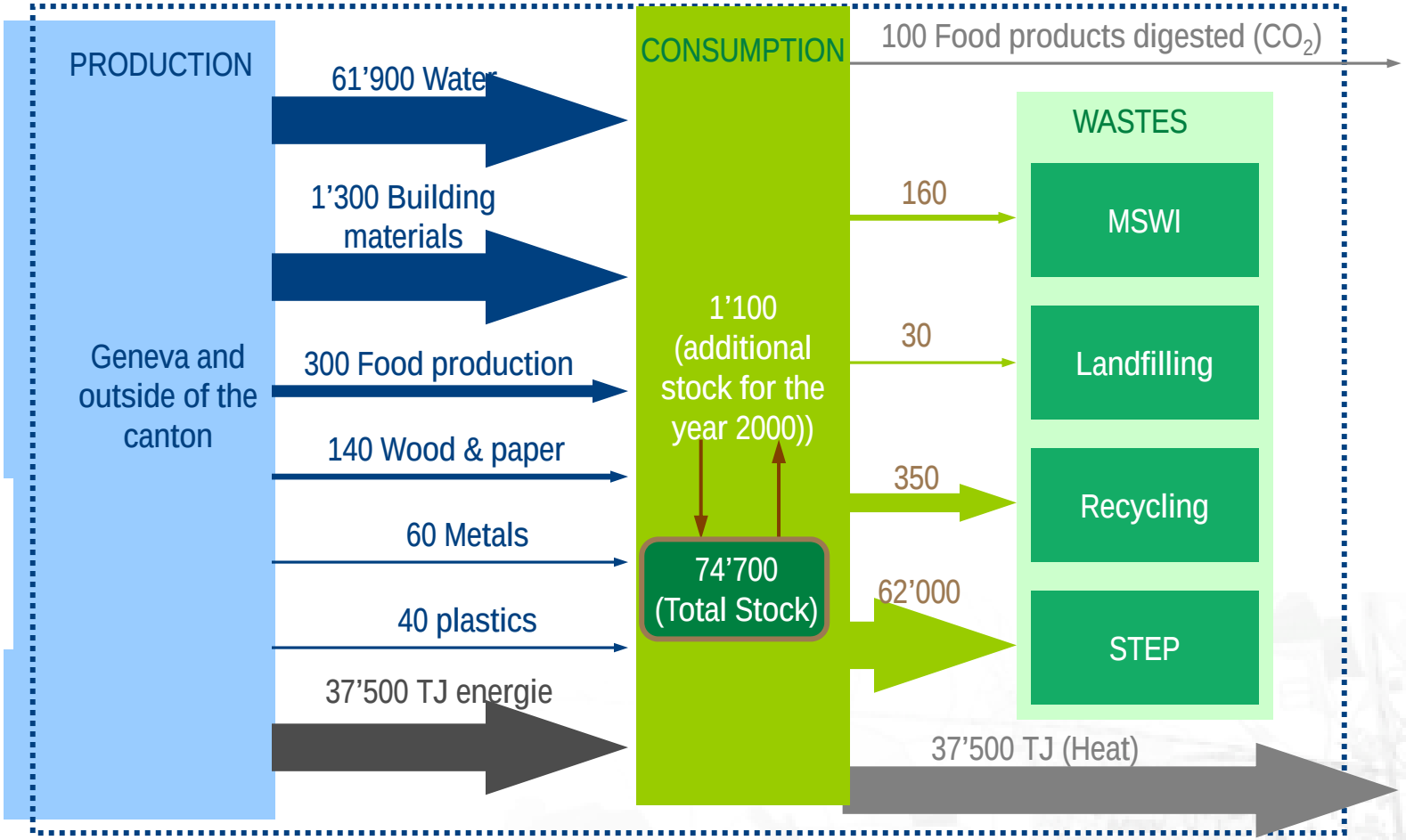
Article 12 (Ecosite):

«L'Etat 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



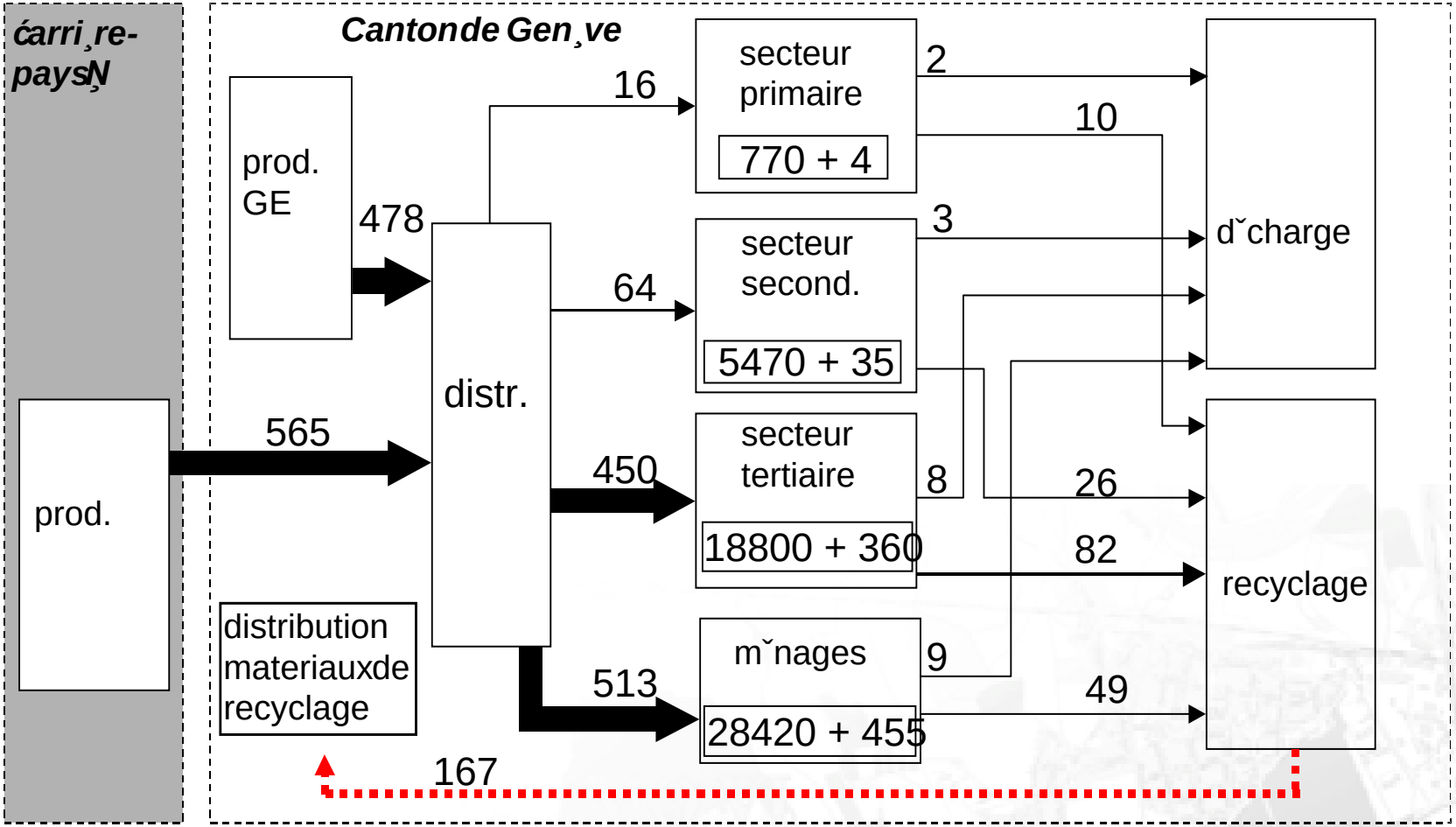
IE in Geneva: Metabolism of Economic Activities



In thousand tons

Source : (Faist et *al.*, 2003)

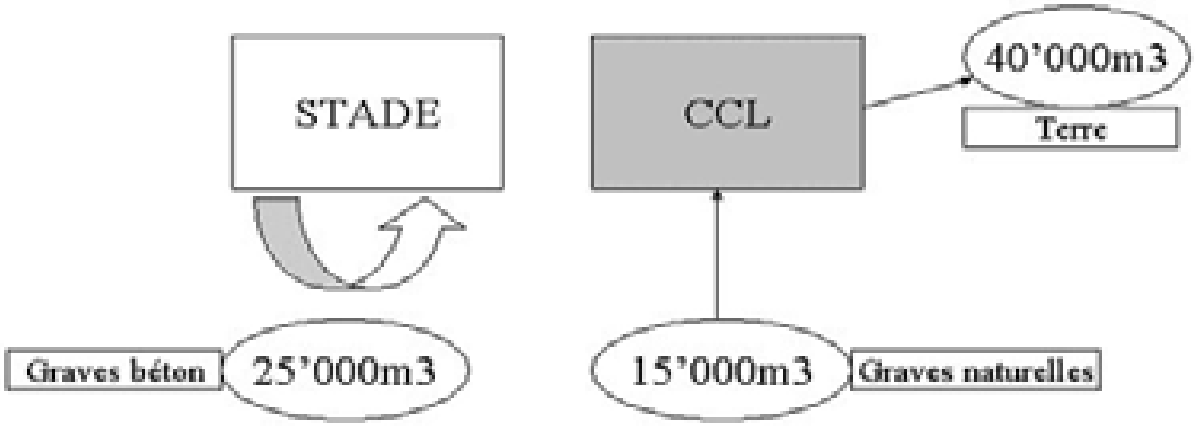
Flux et stocks de béton et briques
(milliers de tonnes)

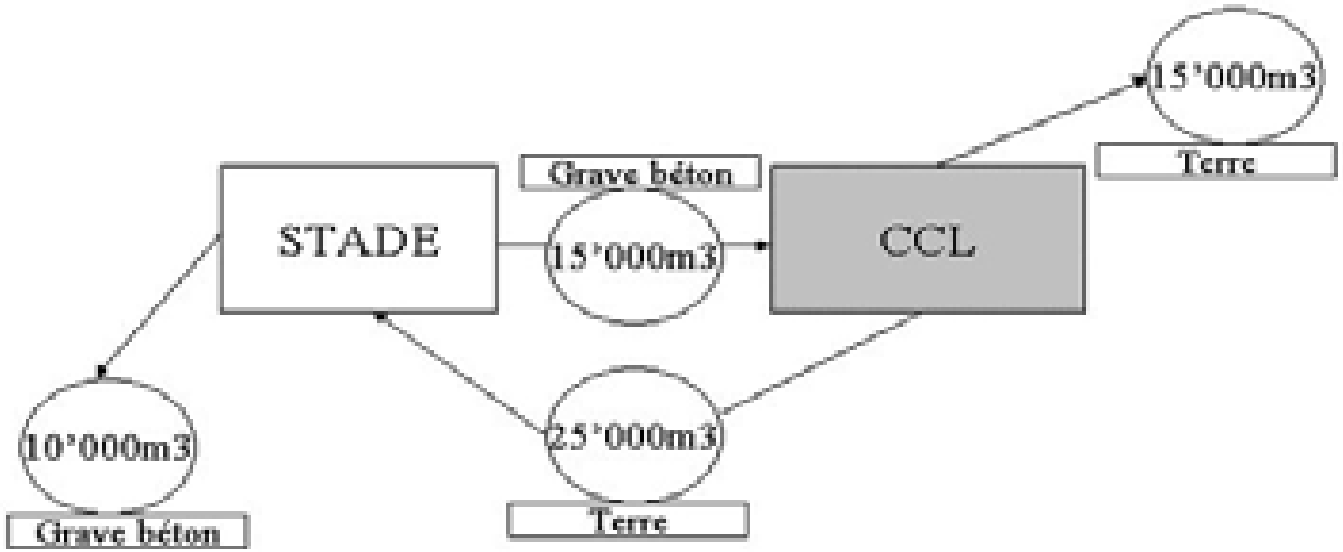


Source: M. Faist & al., 2003

Construction du nouveau stade de Genève (mai 2002):

Stade de la Praille: 25’000 m^3 de gravats

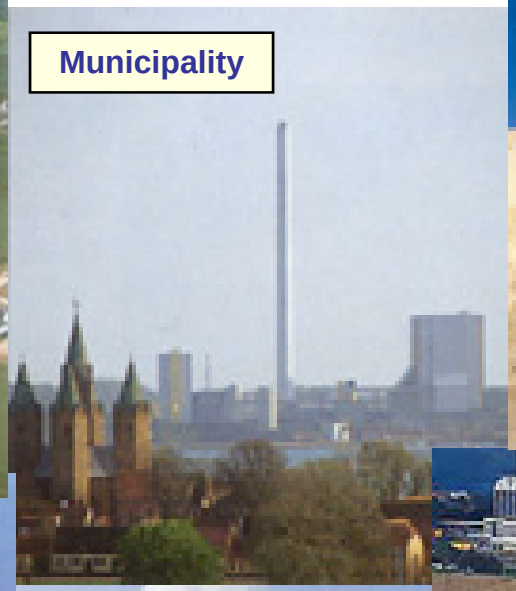

STADE
CCL
40'000m3
Terre
Graves béton
25'000m3
15'000m3
Graves naturelles

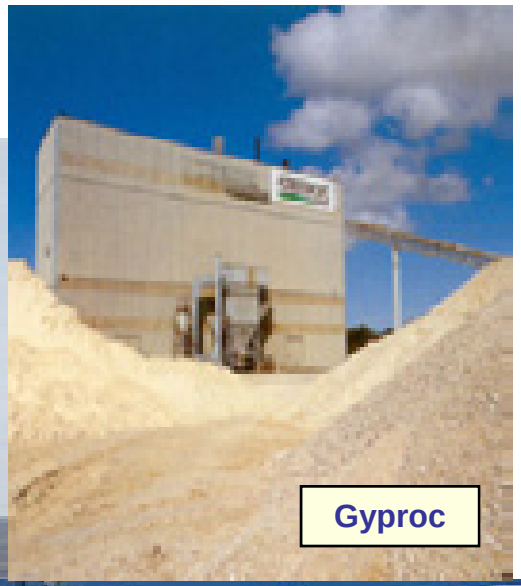

15'000m3
Terre
Grave béton
STADE
15'000m3
CCL
10'000m3
Grave béton
25'000m3
Terre

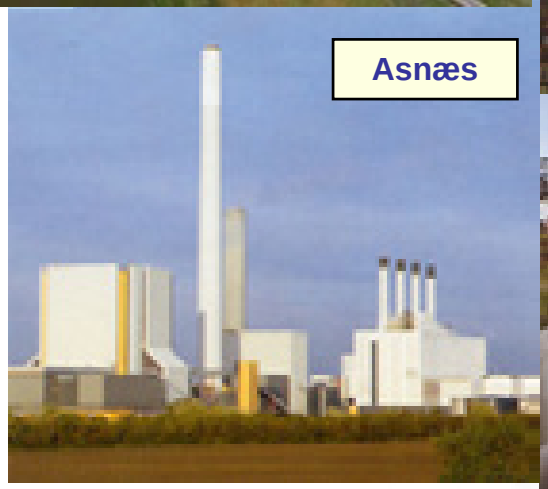
Implementing IE: Industrial Symbiosis

Kalundborg

Photos: Symbiosis Institute, Novo Nordisk, Statoil



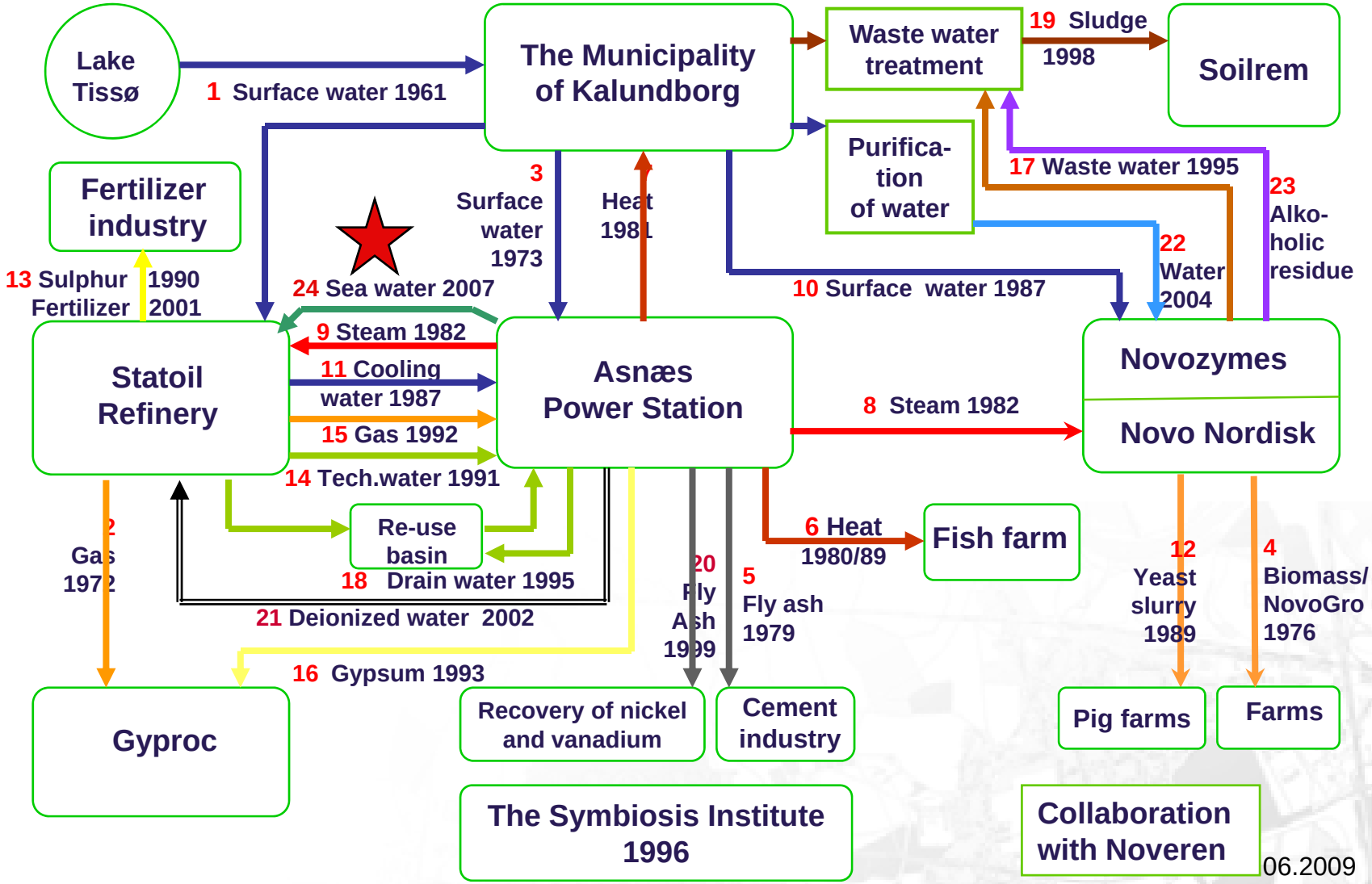




Implementing IE: Industrial Symbiosis

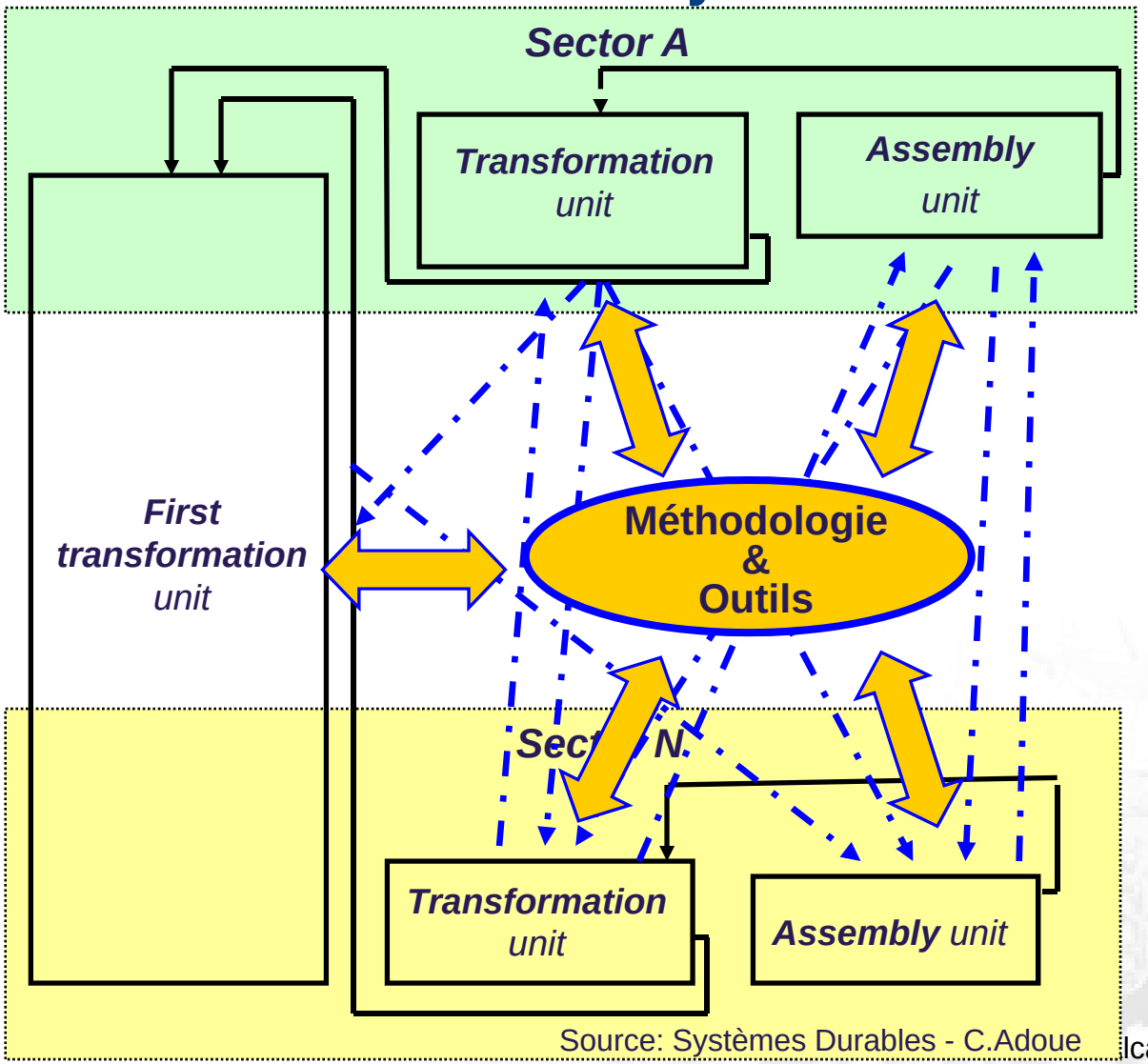
La Symbiose industrielle de Kalundborg - Etat en 2006

[Source: Christensen, 2006]



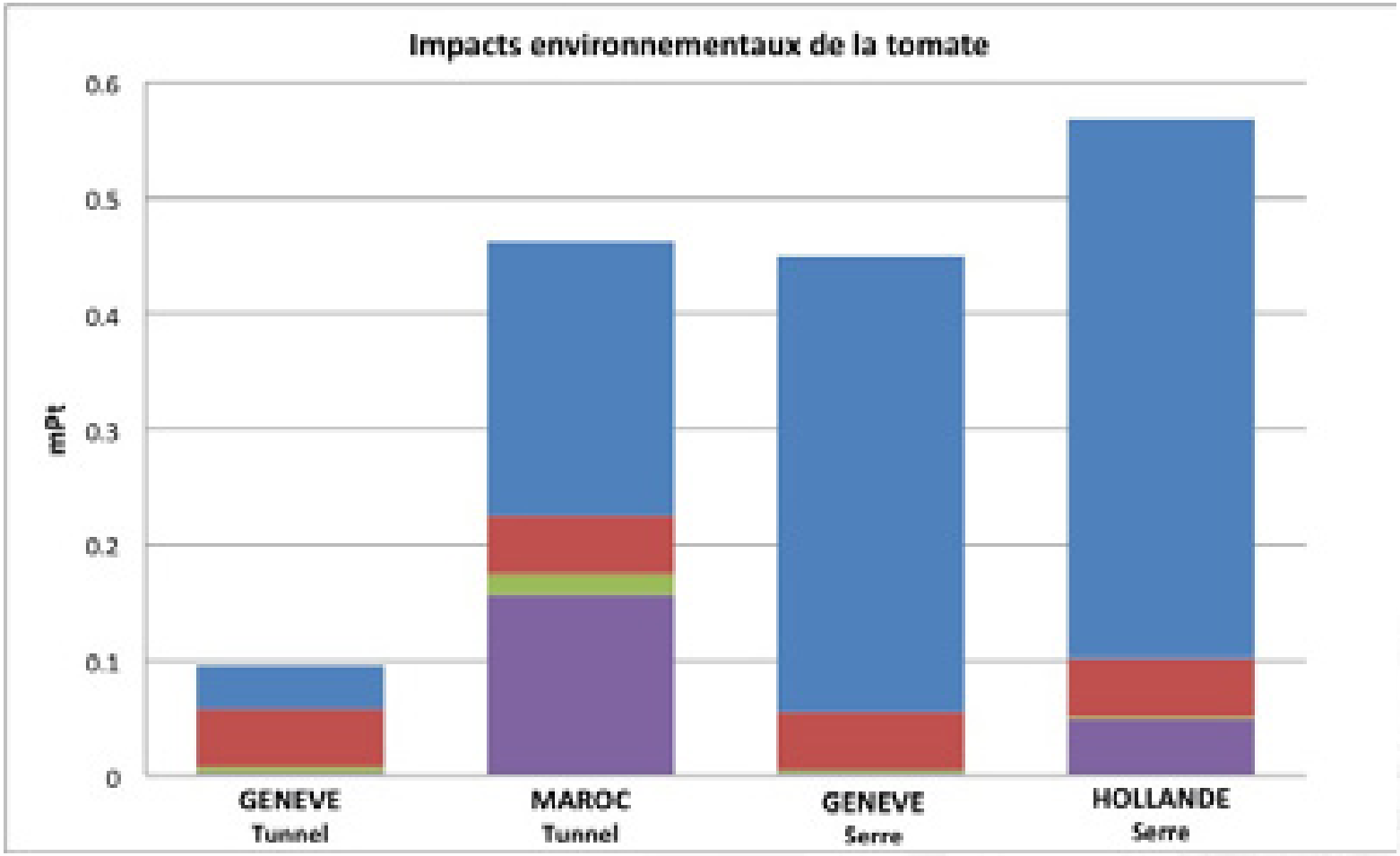
Implementing IE: how to make it systematic?

Flux d'information dans le système industriel



Source: Systèmes Durables - C.Adoue

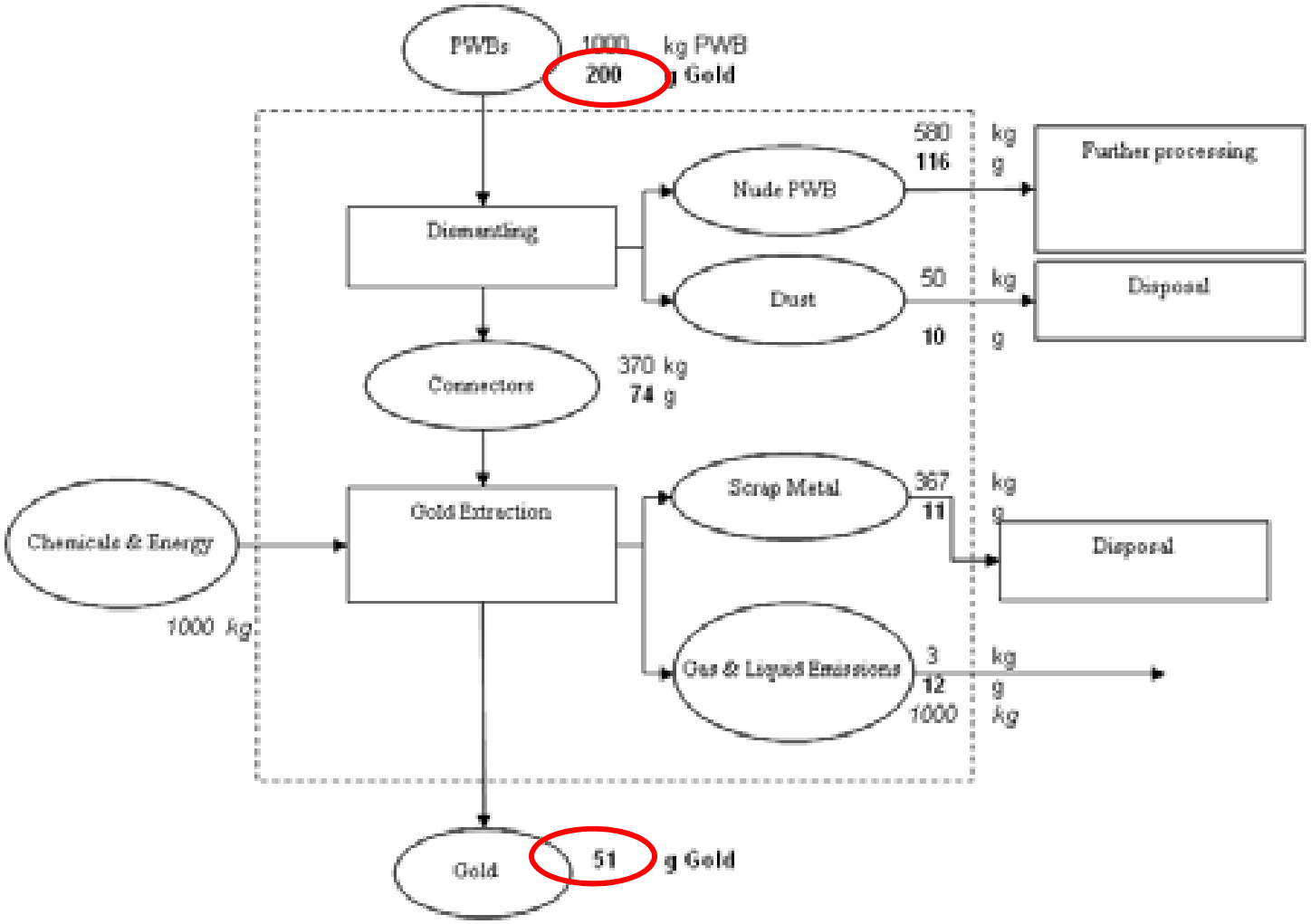
Finding the right material flow



Do we have the know how?

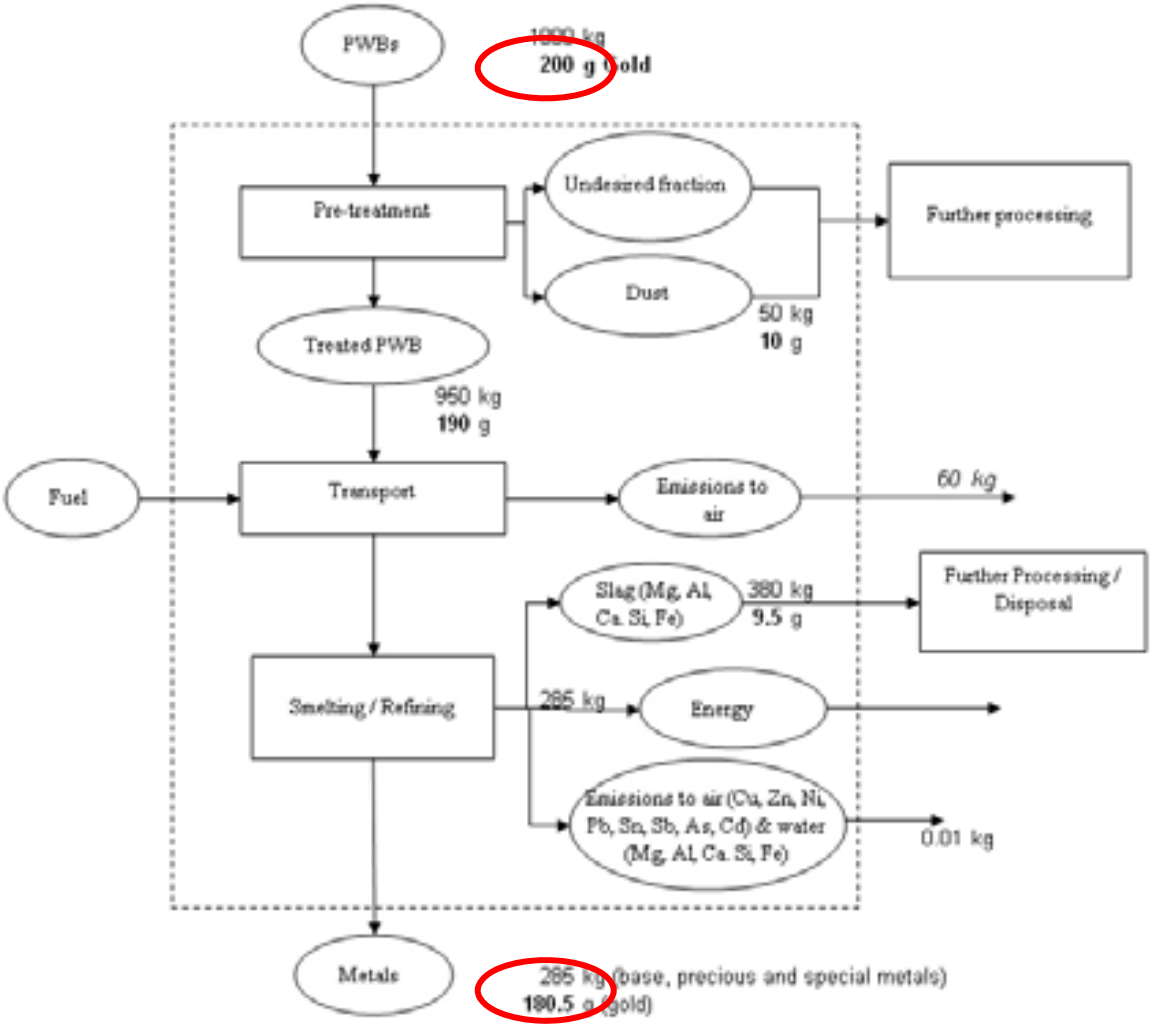
Precious metal recovery from PWBs

Mass Flow Analysis – Wet Chemical Process

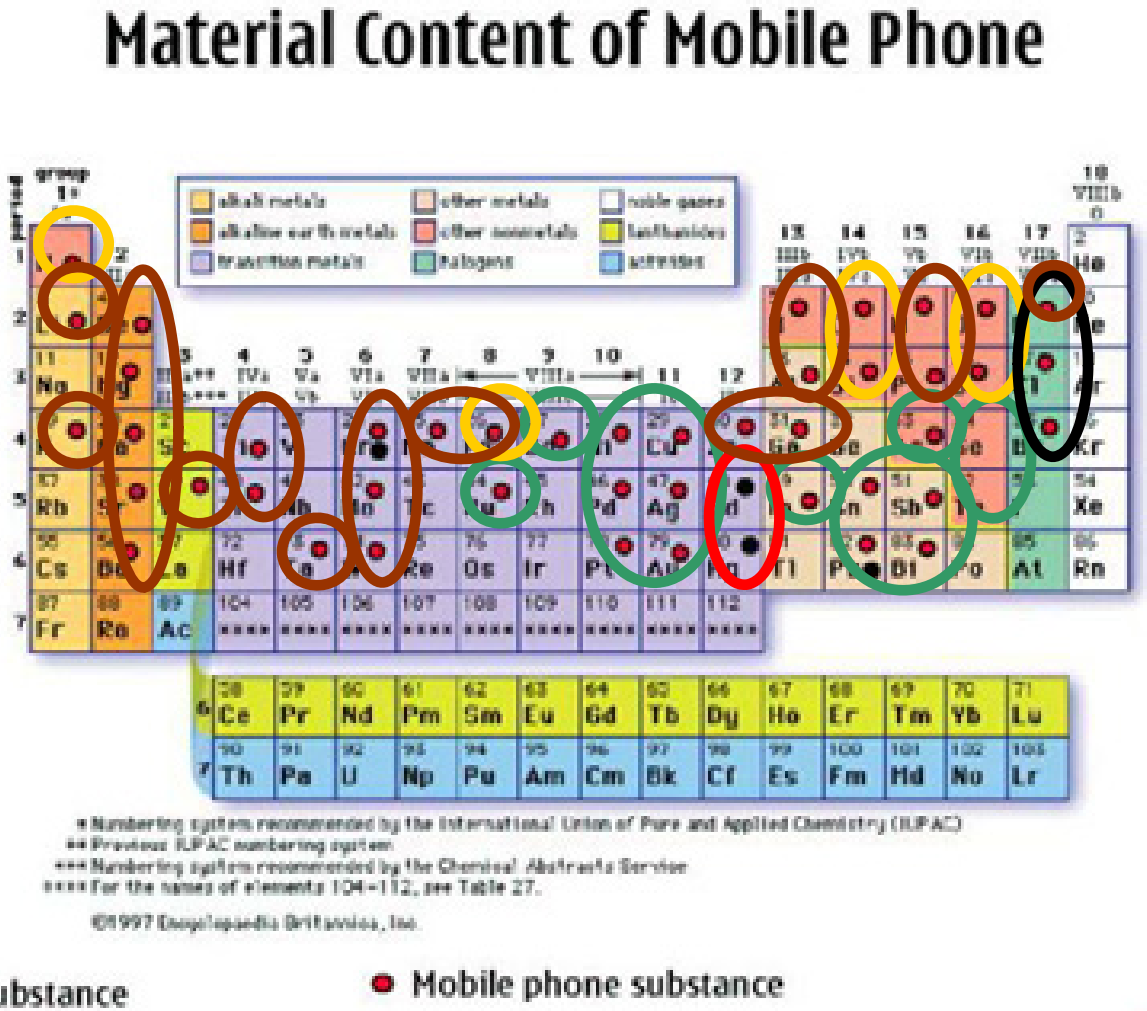


Alternative scenario: precious metal smelting and refining

Smelting / Refining Scenario

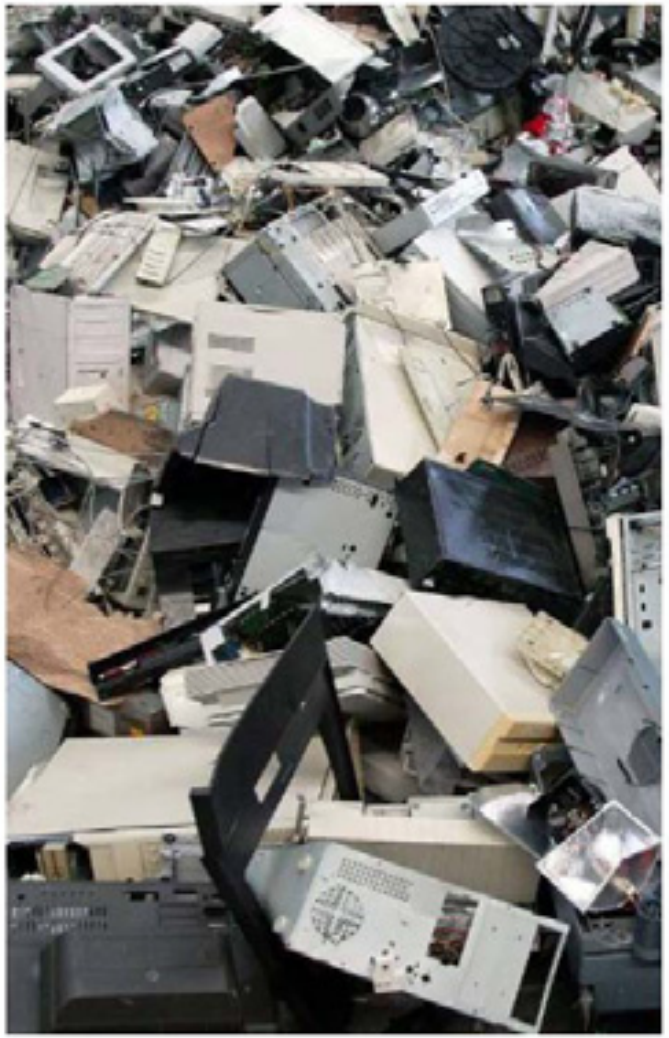


Flux de matières: Que trouve-t-on dans un téléphone portable?



- 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?

Global Sales 2006 (estimates)

Mobilphones:

1 billion pieces

x 250 mg Ag ≈ 250 t Ag

x 24 mg Au ≈ 24 t Au

x 9 mg Pd ≈ 9 t Pd

x 9 g Cu ≈ 9000 t Cu

1000 M x 20 g/Battery*

x 3.8 g Co ≈ 3800 t Co

* Li-Ion Type

PCs & laptops:

0.230 billion pieces

x 1000 mg Ag ≈ 285 t Ag

x 200 mg Au ≈ 46 t Au

x 80 mg Pd ≈ 18 t Pd

x ≈ 500 g Cu ≈ 115,000 t Cu

≈ 60 M laptop Batteries*

x 75 g Co ≈ 4500 t Co

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

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%

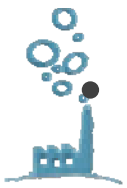
Co: 58'000 t/a ≈ 15%

Source: Umicore / Empa

- 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?
  -



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Thanks for your attention !

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