Αστικό ορυχείο: τεχνολογίες και δυνατότητες στην Ευρώπη

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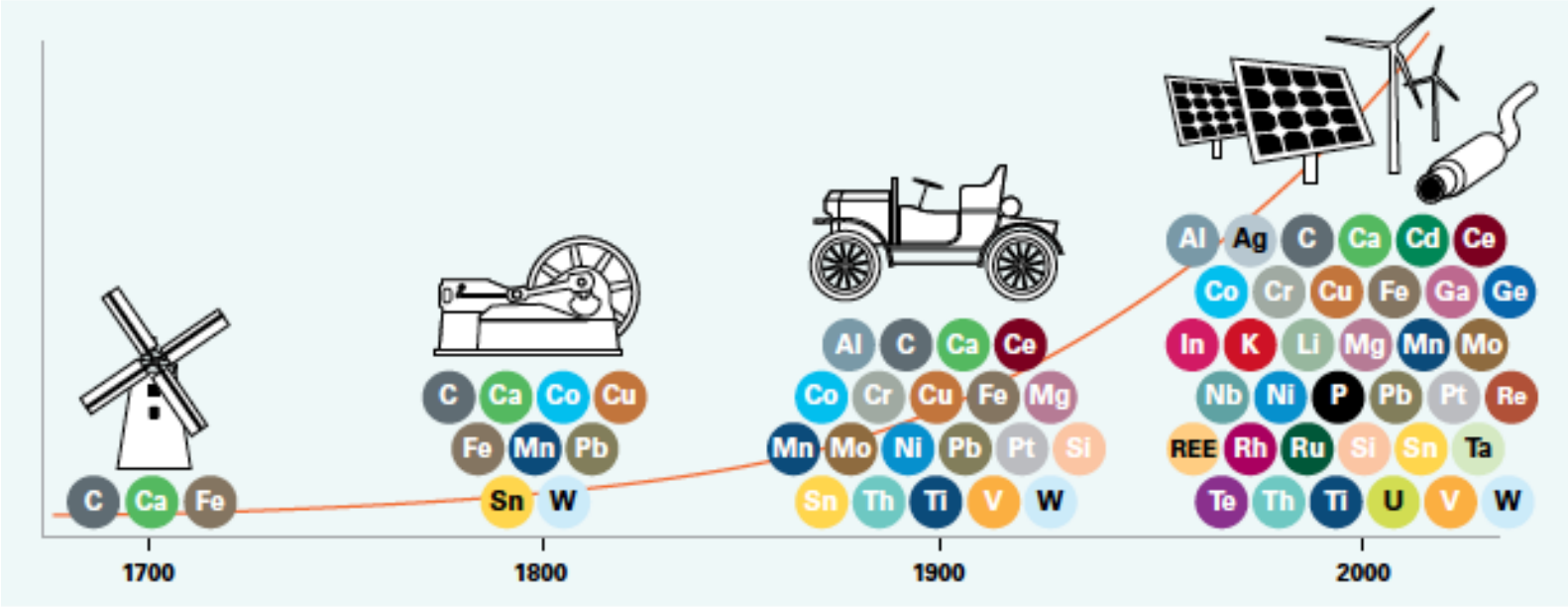
LIFE12 ENV/GR/000427 reclaim Με συγχρηματοδότηση του Προγράμματος LIFE της Ευρωπαϊκής Ένωσης

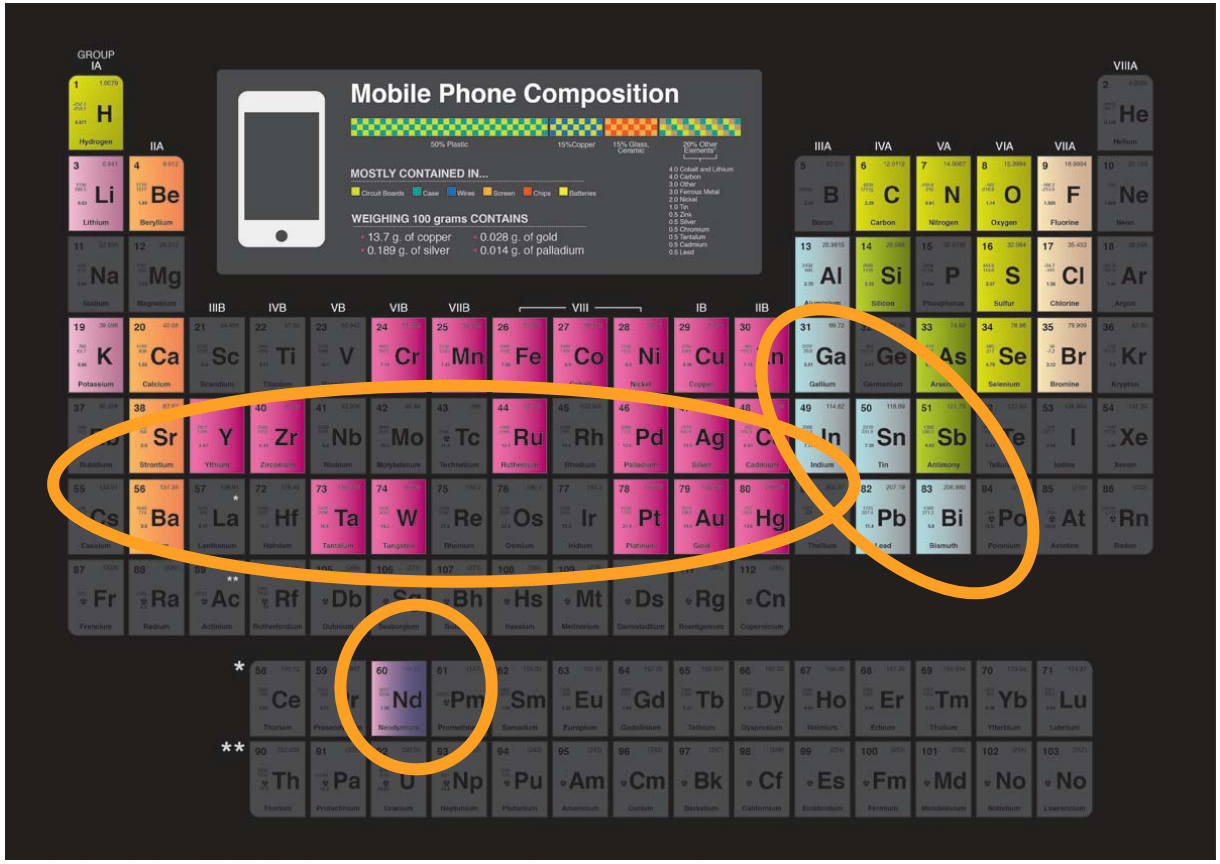
Technology Metals (TM)

- *Technological evolution is historically linked with the materials and especially the metals available to mankind.*



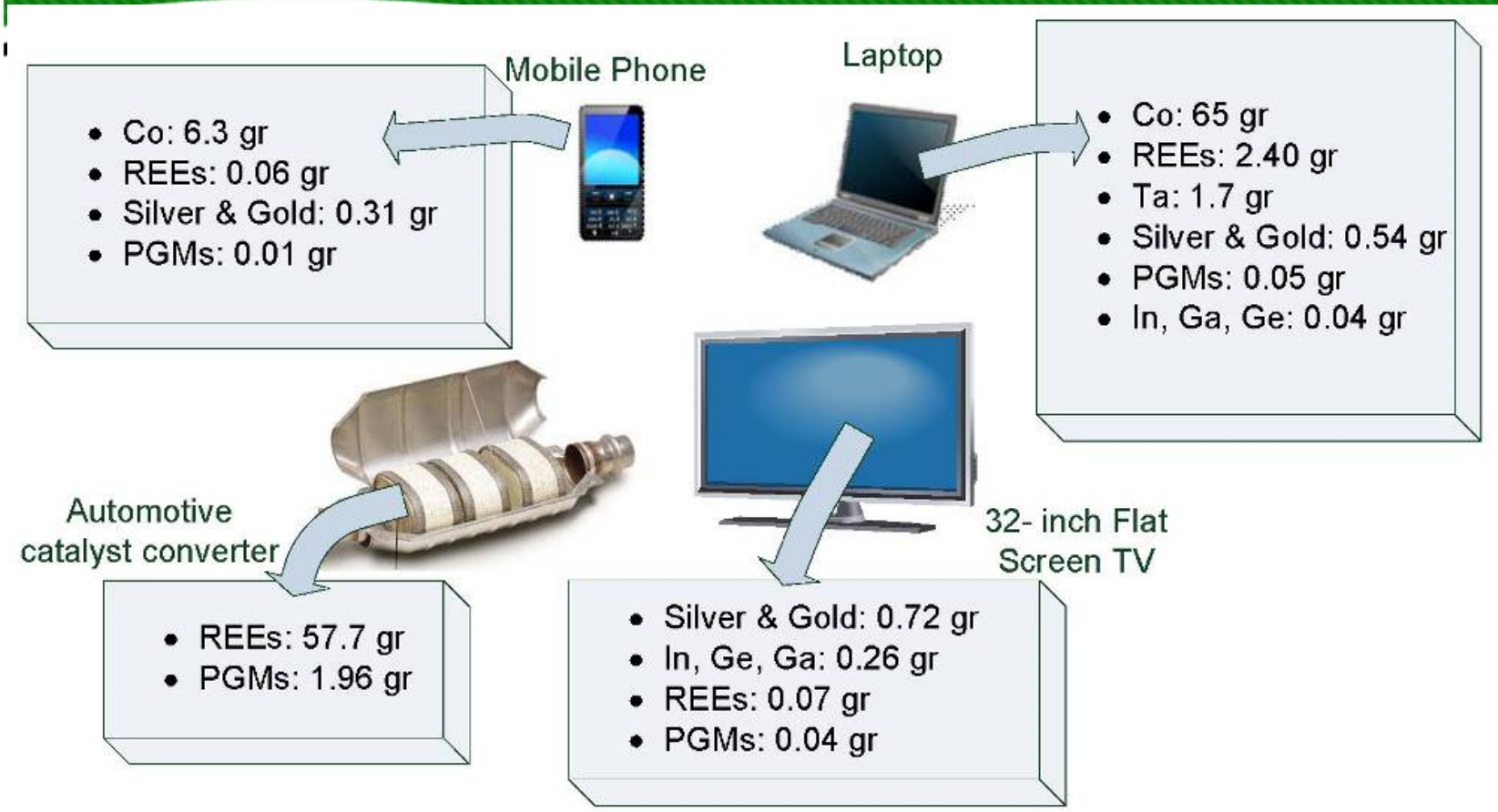
Technology Metals (TM)

In contrast to base metals (Fe, Al, Cu, Zn,…) traditionally used in bulk amounts, today's progress in material science have given rise to a new group of metals, which are used in small or trace amounts to drastically alter the properties of matter. These trace metals are termed here as ***Technology Metals (TM).***



Less than 5% wt

Technology Metals in the household



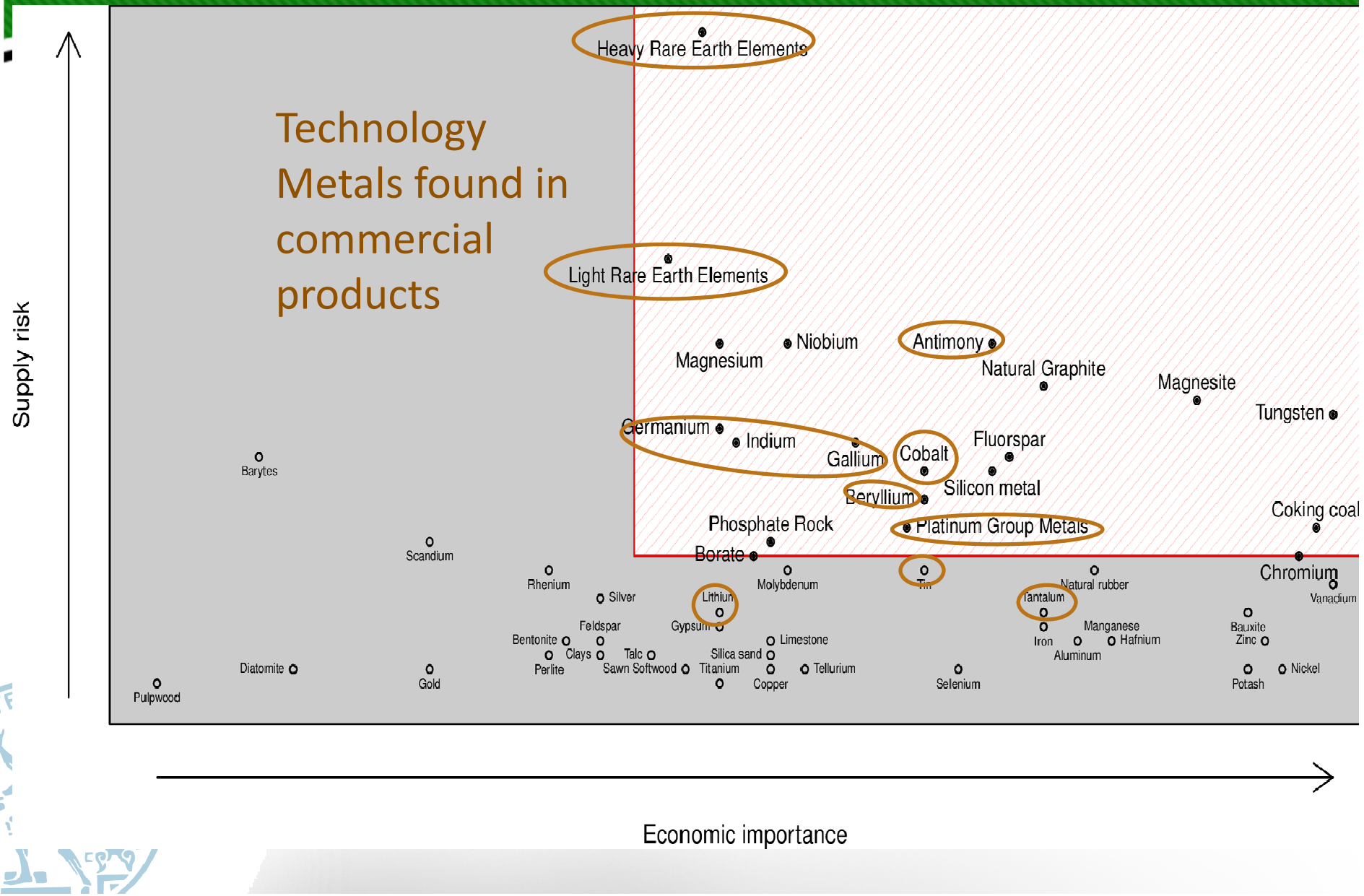
- One ton of electronic scrap from personal computers contains more gold than that recovered from 17 t of gold ore
- One ton of used mobile phones (e.g. 6,000 devices) contains precious metal with combined value of15,000 Euros

Technology Metals in the household

TM global demand for EEE and lamps (in-chart labels in tons) **and its comparison** as wt% to the corresponding **primary metal production** in 2006

Primary extraction of these metals comes with a very high environmental footprint

Technology Metals and Criticality in EU



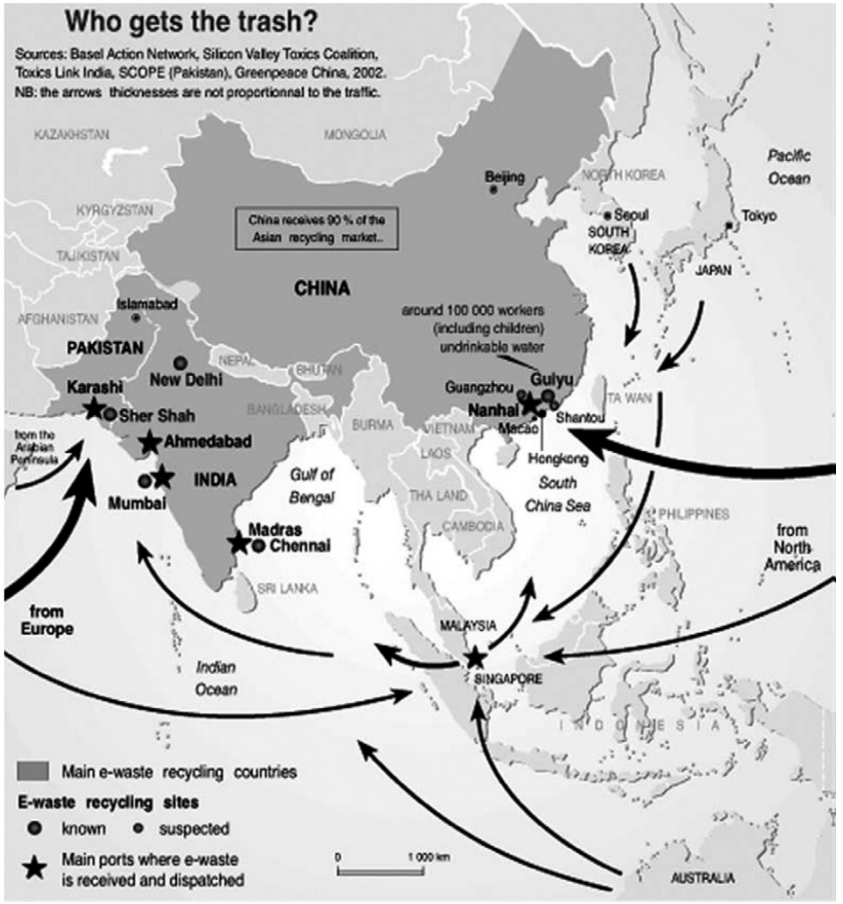
Technology Metals in Europe

	Current Technological Uses	Emerging Technologies	Most common use as	EU Import dependence	Recycling Rate
Sb	Plastics, Semiconductors, LEDs, Glass, Batteries, Alloys	Photovoltaics	Sb_2O_3	**100%**	**11%**
Be	Electric appliances and Electronic equipment, X-Ray scanners, Ceramics	Nuclear fusion	BeO, Metallic	**100%**	**19%**
Co	Li-ion batteries, Alloys, Industrial catalysts	Super alloys, Permanent magnets	WC-Co SmCo $LiCoO_2$	**100%**	**16%**
Ga	Intergraded circuits, Semi-conductors, LEDs, Laser	Photovoltaics	GaAs GaN Al-Ga-S Ga-In-N	**subject to strong fluctuations**	**0%**
Ge	Infrared optics, LEDs, Semi-conductors, Industrial catalysts	Fiber optics	Si-Ge	**100%**	**0%**
In	Flat panel displays, LEDs, Alloys	Thin film solar cells	Ga-In-N In_2O_3	**100%**	**0.30%**
PGM	Automotive catalysts, Electronics and Electrics, Jewelry, Catalysts	Fuel Cells	Metallic	**100%**	**35%**
REE	Electronic and Electrics, HD drives, Motors, Flat panel displays, LEDs, Automotive catalysts, Ceramics, Glass, Alloys, Industrial catalysts	Fuel Cells, Superconductor, Wind turbines, Hybrid Cars,…	Nd (Pr, Dy) $_2Fe_{14}B$, $Y_3Al_5O_{12}$ Y_2O_3-ZrO_2, La_2O_3, $CeMgAl_{11}O_{19}$ $(Y,Gd)BO_3$:Eu Y_2O_3:Eu, $LaPO_4$:Tb	**100%**	**1%**
Ta	Capacitors (electronics), Medicine, Alloys, Glass	Super alloys, Micro-Capacitors	Metallic	**100%**	**4%**

[1] *Tackling The Challenges In Commodity Markets And On Raw Materials*, European Commission COM 25, (**2011**).

What happens (to EEE) at the end-of-life ?

Global Grey Reality…



Illegal trade of WEEE to non-EU countries continues to be identified at EU borders, with prominent destinations China, Ghana, Egypt, and Nigeria

[http://ec.europa.eu/environment/waste/weee/index_en.htm accessed September 2012.]

Technology Metals in Urban Wastes

TM-Component	Indicative TM content	Recycling method
 **Printed circuit boards (PCBs)**	-Noble Metals: **100 ppm of Pd** in capacitors, along with substantially higher amounts of Ag and Au used in solders and contacts. -**1.7g of Ta** in capacitors - In, Ga, Ge and As are present in semiconductors -Sb in flame – retardants used on plastic components.	• Separated and sent to large metal refineries • ***Complete recovery of Noble metals*** • In large integrated smelters and refineries partial recovery of In and Sb. • Other TMs found in PCBs like Ga, Ge, and Ta are dissipated in the slags or flue dusts.
 **Flat panel displays (FPDs)**	**174 ppm of In** are present in the ITO layer. Smaller amounts of Ge, Ga and REE may be also present	Shredded and recycled with glass fraction; no technical method is available for recovering the ITO layer
 **Fluorescent lamps phosphors**	10%wt REE oxides and phosphates (La, Y, Ce, Gd, Eu, Tb, etc) along with significant amounts of mercury, i.e**. 10 mg of REE** per household fluorescent lamp.	Collected and processed at lamp recycling facilities where lamps are crushed and shredded to recover glass cullet, aluminum/metal materials and remove mercury. In most countries REE containing phosphor powder is not recycled but safely disposed or stored as recycling technologies are either under development.
 **Li-ion and NiMH batteries**	Li-ion rechargeable batteries **14% wt Co** and **3% wt Li .** NiMH rechargeable batteries contain 10% REEs (La,Ce,Pr, Nd) and 4% Co.	Separated in the waste detoxification stage and recycled by pyro- or hydro-metallurgical processing. In Europe, since 2011, **Umicore officially opened a battery recycling plant with an input capacity of 7,000 tons per year**
Permanent magnets (NdFeB and SmCo)	A notebook may contain up to 2.5 g in permanent magnets, used in speakers, microphones, Hard Disk Drives and others. A hybrid car may contain up to 1.2 kg in REE magnetrs	Shredded/Removed during magnetic separation with the ferrous fraction and are dissipated in the secondary steel industry

Recycling WEEE

Collection of WEEE

-Collection of WEEE by Municipal authorities or private sector collectors or “take back” systems

-**Regional process**

Pre-Processing

-Manual Dismantling / sorting and detoxification step in accordance to WEEE directives

- Regional process

End-Procesing

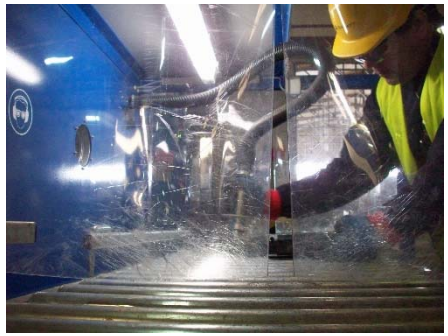
-Metallurgical Recovery of Metals in large end-processing units

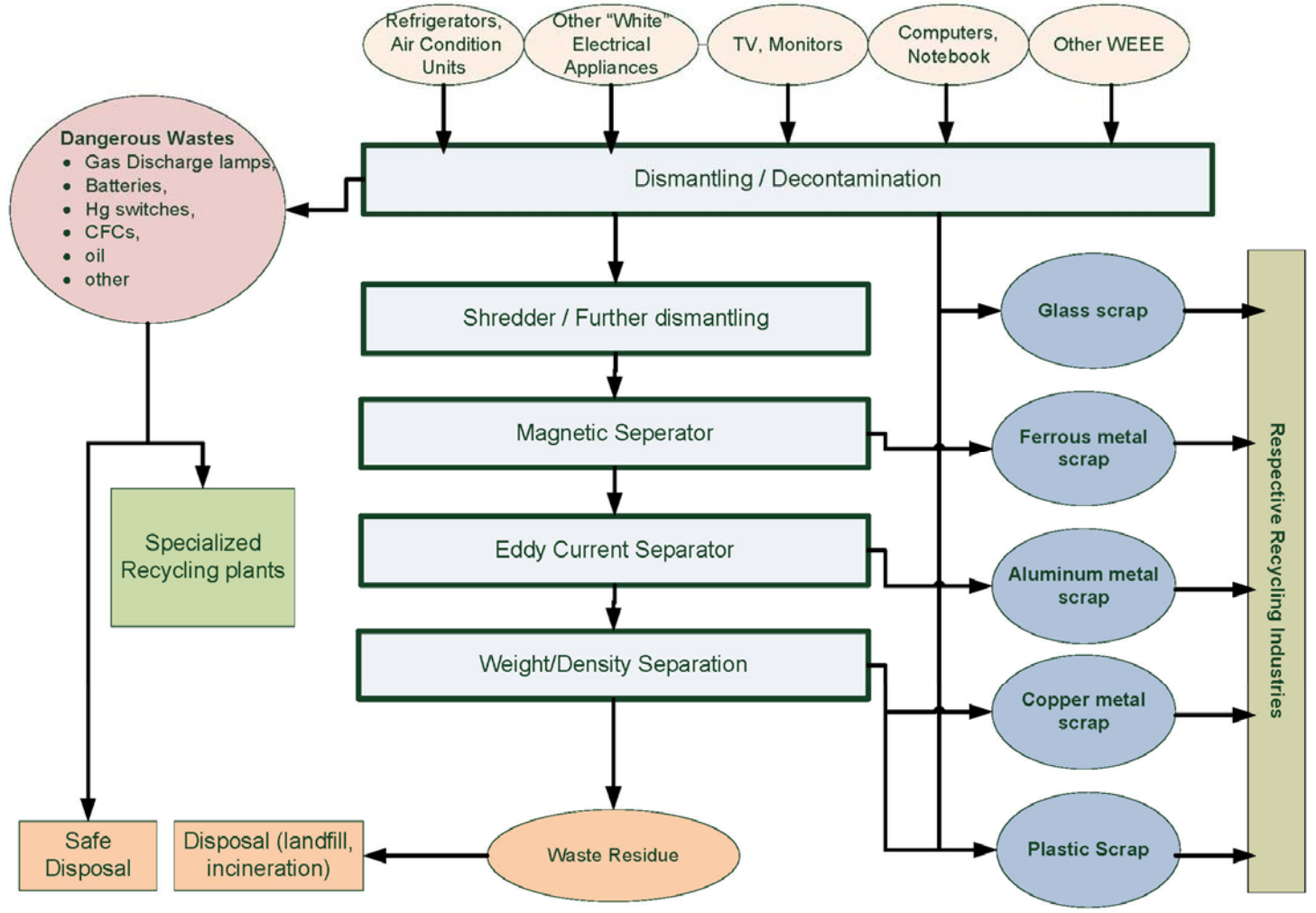
-**Centralized process**

WEEE categories

WEEE classification and relative TM Content			
1. Large household appliances (e.g. refrigerators);	Low	6. Electrical and electronic tools with the exception of large scale stationary industrial tools (e.g. drills and saws);	*Depends*
2 .Small household appliances (e.g. coffee machines);	Low	7. Toys, leisure and sports equipment (e.g. video games);	*Depends*
3. IT and telecommunications equipment (e.g. computers);	**High**	8. Medical devices with the exception of all implanted and infected products (e.g. X-ray equipment);	*Depends*
4. Consumer equipment (e.g. radio and TV sets);	**High**	9. Monitoring and control instruments (e.g. smoke detectors);	Medium
5. Lighting equipment (e.g. fluorescent lamp);	**High**	10. Automatic disperses	Low

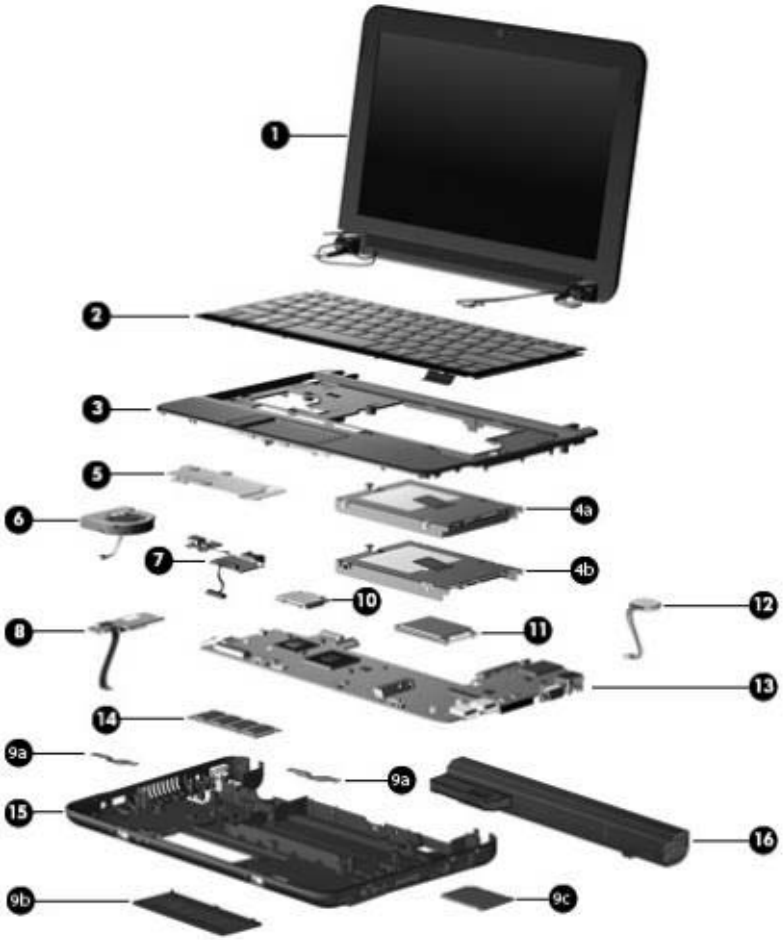
Pre-processing WEEE





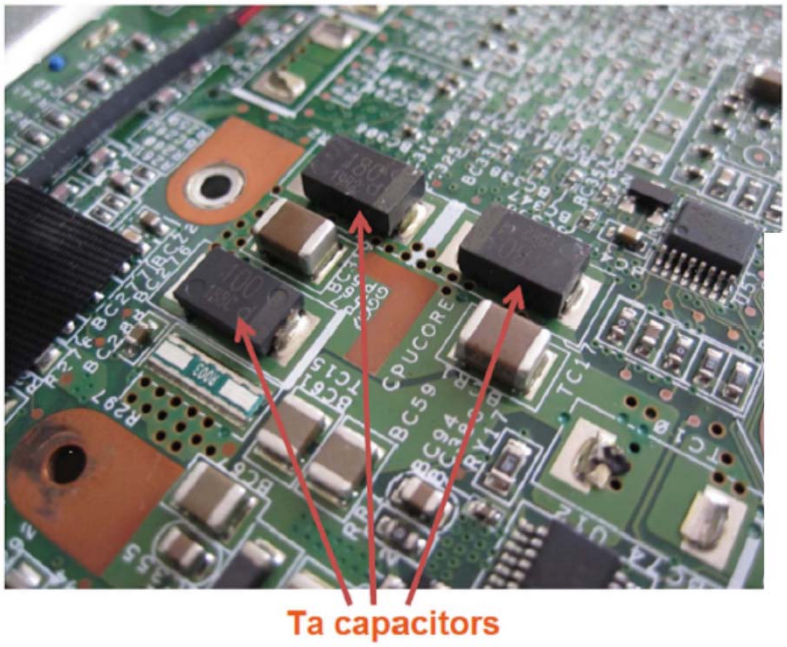
Devices are getting smaller and smaller

Manual dismantling needed…

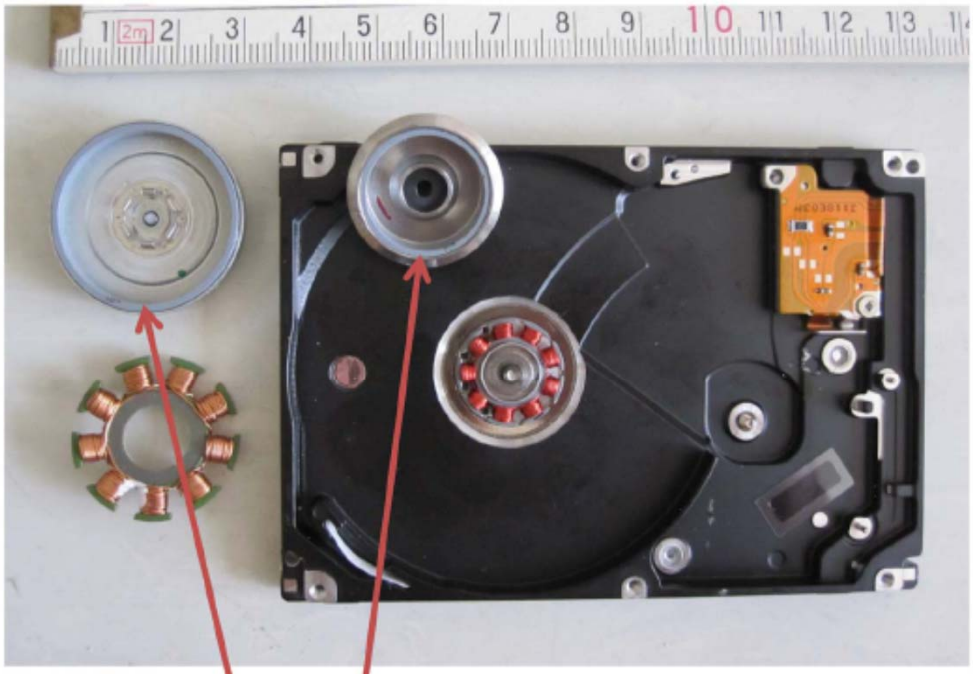


Technology Metals in Urban Wastes

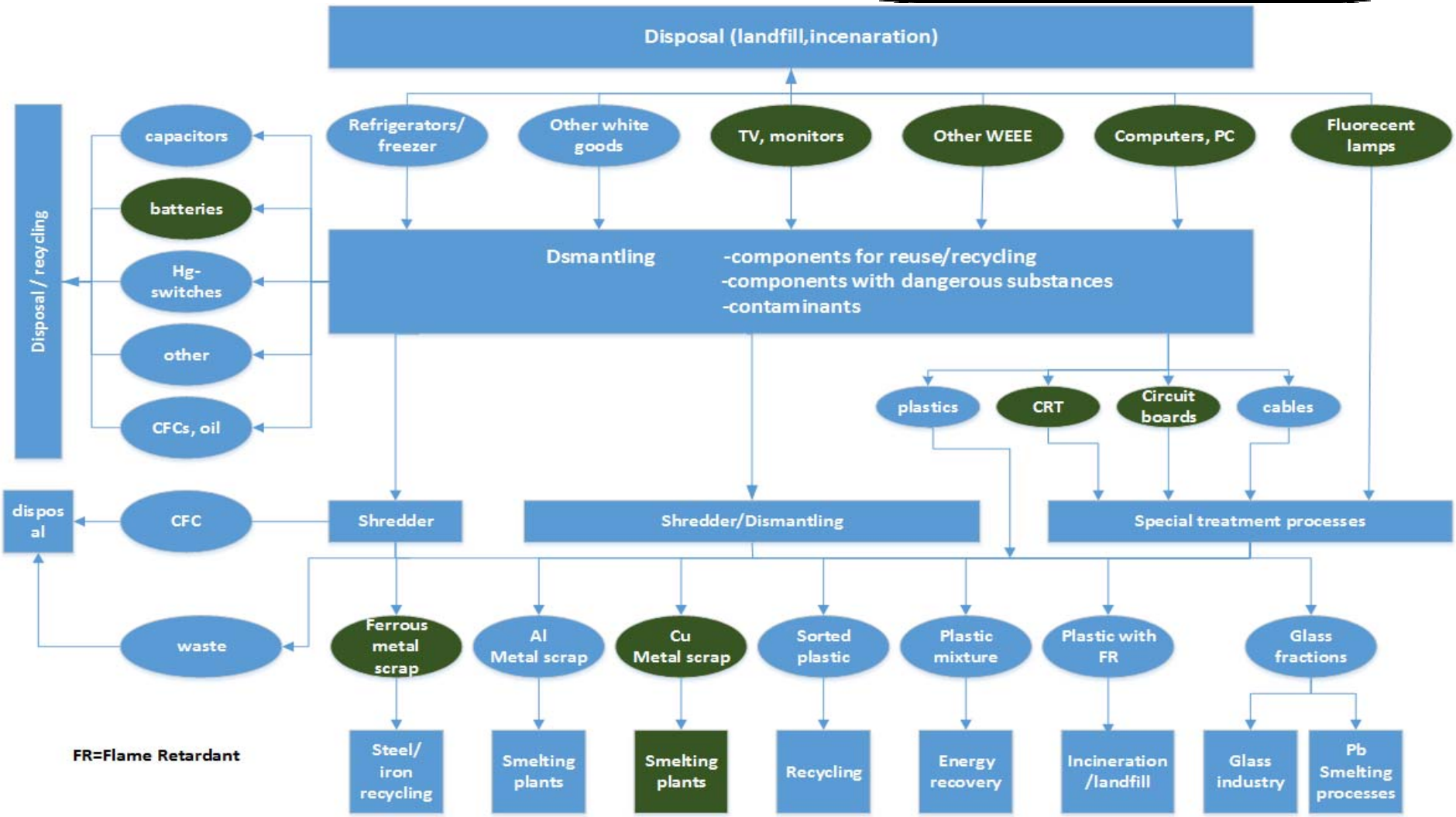
Figure 10: Tantalum capacitors on the motherboard of a notebook (photo Oeko-Institut)



TM are found in very small parts



Pre-processing WEEE – fate of TM



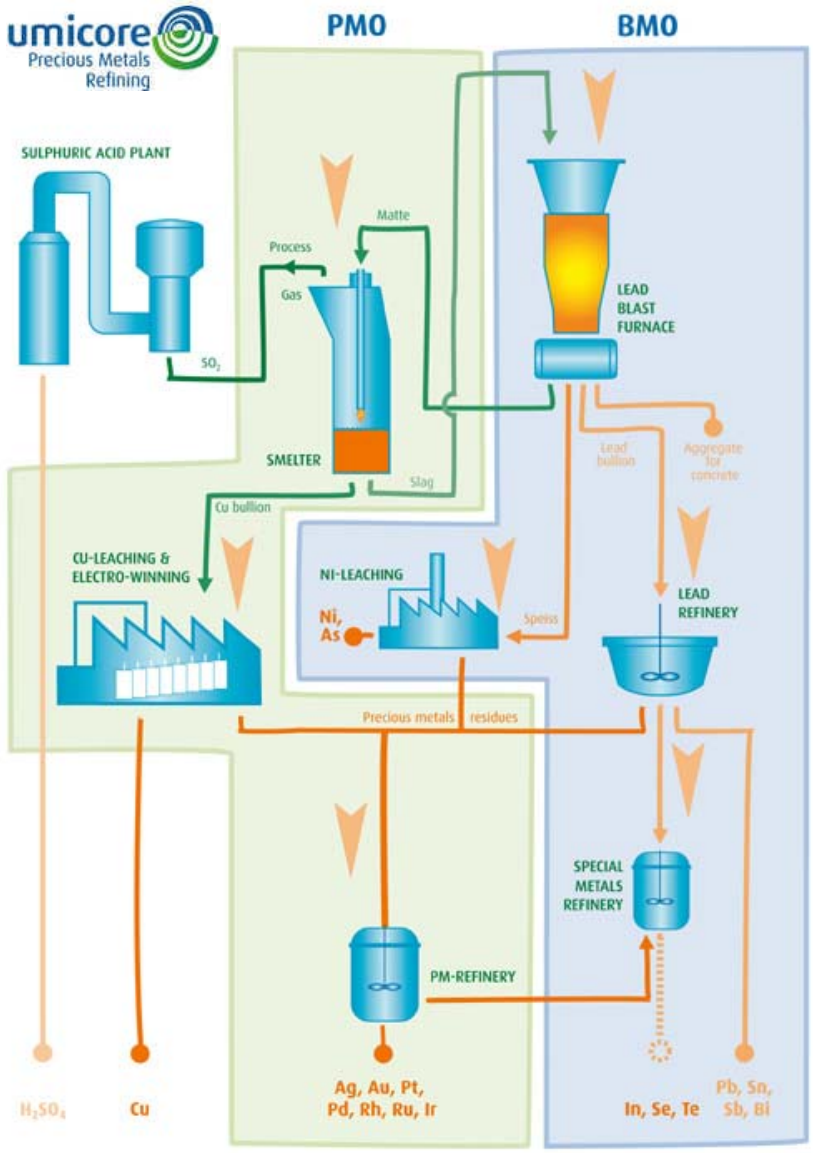
End-Processing WEEE

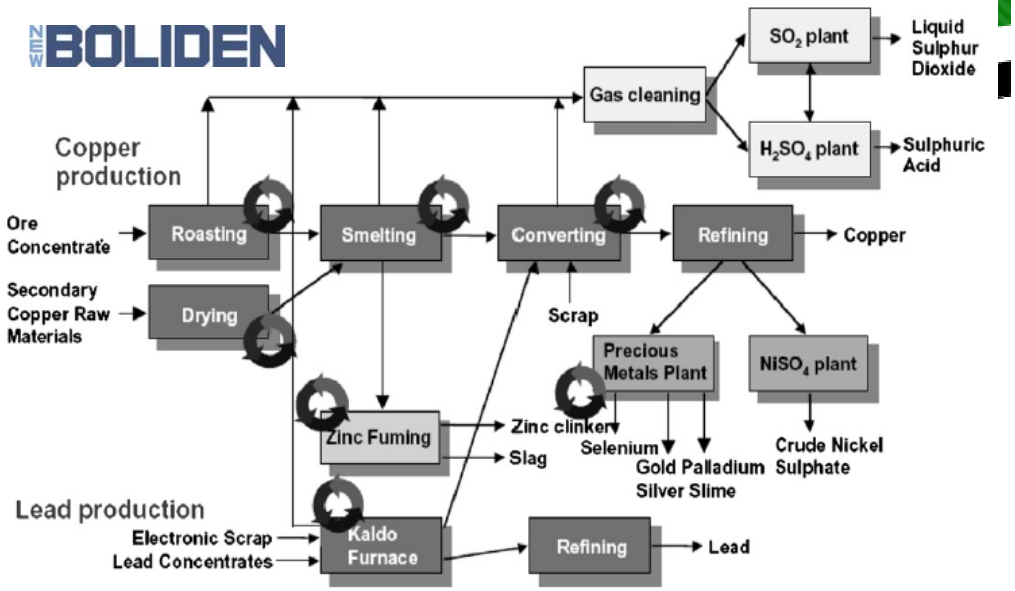
End-Processing takes place in large (global scale) metallurgical units such as:

- Horne Smelter at Rouyn-Noranda, Canada (XSTRA),
- Rönnskär smelter in Sweden (Boliden)
- Hoboken plant in Belgium (Umicore)

umicore
Precious Metals
Refining

End-Processing WEEE





- Such global scale smelters, recycle about 100,000 tonnes of WEEE per year, which however represent only 10-14% of their total throughput
- The “WEEE ore” composes of elemental combinations not found in nature - as a result ***traditional metallurgical plant can not process them***.

Recycling WEEE

Collection of WEEE

On average **only 35% of all European WEEE are collected and treated by the formal sector**, the remaining 65% is split between “grey-recycling” and landfill disposal

Pre-Processing

- Pre-processing is currently oriented towards **base metal bulk recovery**
- **Automation results to TM dissipation**
- Efficiency in some TM recovery app 70%

End-Procesing

- Only Co, Cu and PGMs are effectively being recovered currently
- **Non dedicated metallurgical processing**

Overall Efficiency of the recycling process is the product of the efficiency of each step

Recycling WEEE – case study phones

Recycling of Critical Resources
V. S. Rotter, P. Chancerel

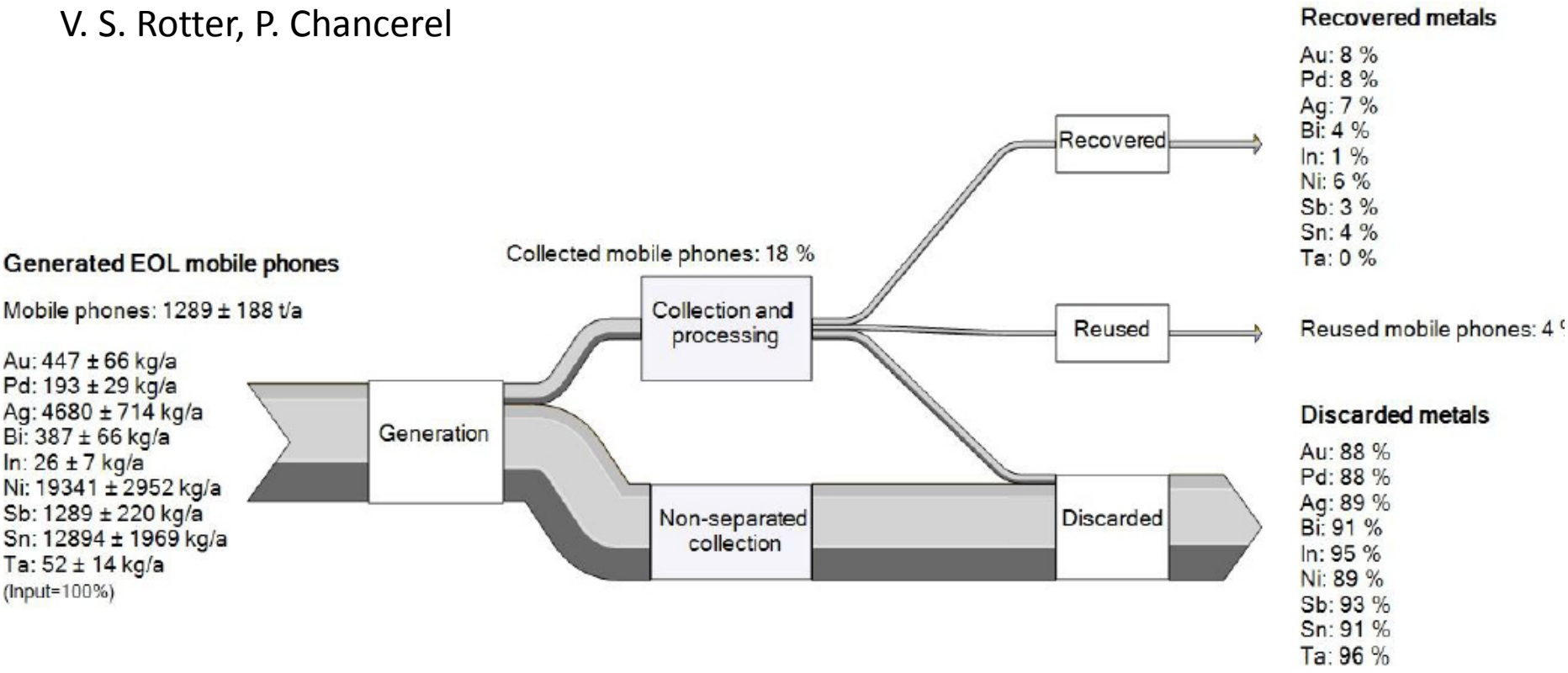


Figure 2: Flows of trace metals associated with end-of-life mobile phones

Recycling WEEE – case study laptops

In 2010 approximately 14 million laptop devices were sold in Europe.
Their average service-life in EU is estimated at 5.6 years – i.e. to be recycled in 2016

TM	TM in laptops sold in EU 2010 (tones)	TM End-Processing efficiency for TM recovery	TM Pre-processing efficiency	Collection efficiency	Overall TM recycling rate
Co	910.0	95%	100%	35%	33%
Sn	130.0	55%	70%	35%	13%
REE	34.0	0%	(?)	35%	0%
Ta	23.8	0%	100% (?)	35%	0%
Ag	6.2	98%	70%	35%	24%
Au	1.4	98%	70%	35%	24%
PGMs	0.6	98%	70%	35%	24%
In	0.6	15%	70%	35%	24%

Is WEEE Recycling really important?

Potential TM import supply reduction				
TM	2010 EU Total External Imports (tones)	Approximation of TM in all EEE and lamps sold annually EU (tones)	% of raw material Imports which could be avoided through TM recycling	
			100% recycling efficiency	Current Recycling Scheme
Ag*	9,543	1,500	16%	5%
Au*	2,855	75	3%	1%
PGMs	206	18	9%	3%
Sn	41,500	22,500	54%	9%
Co	9,149	2,750	30%	9%
In	129	95	74%	3%
REEs	12,700	8,100	64%	0%
*(Ag and Au imports are largely related to economic activities)				

What is needed ?

Collection of WEEE

- Separate “electronic and TM device” collection system
- **Consumer awareness**

Pre-Processing

- Redesign pre-processing towards ***TM-component separation***
- **Design-to-recycle**

End-Processing

- New dedicated metallurgical technologies
- **Regional processing**

A re-structuring of the recycling value chain through new technologies will ultimate enhance overall recycling efficiency

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Definition ELFM

- Enhanced Landfill Mining =
- "the safe conditioning, excavation and integrated valorization of (historic and/or future) landfilled waste streams as both materials (Waste-to-Material) and energy (Waste-to-Energy), using innovative transformation technologies and respecting the most stringent social and ecological criteria." (http://dx.doi.org/10.1016/j.jclepro.2012.05.021)

Establishment of EURELCO - March 11, 2014

44 Members, 12 EU Member States,

Vision and mission EURELCO

Mission : To be a an open, quadruple helix network that supports the required technological, legal, social, economic, environmental and organisational innovation with respect to Enhanced Landfill Mining within the context of **a *transition to a circular, low carbon economy.***

Vision: By 2020 Enhanced Landfill Mining is implemented EU wide as a key component of a resource efficient, circular and low carbon economy. **The EU's 150.000 to 500.000 landfills provide for a substantial part of the EU's material, energy and land needs**. ELFM has paved the way for breakthrough exploration, separation, transformation and upcycling technologies that are also used for recycling/urban mining of newly produced waste and residues.

Enhanced Landfill Mining – transdisciplinary science

Quadruple Helix Innovation

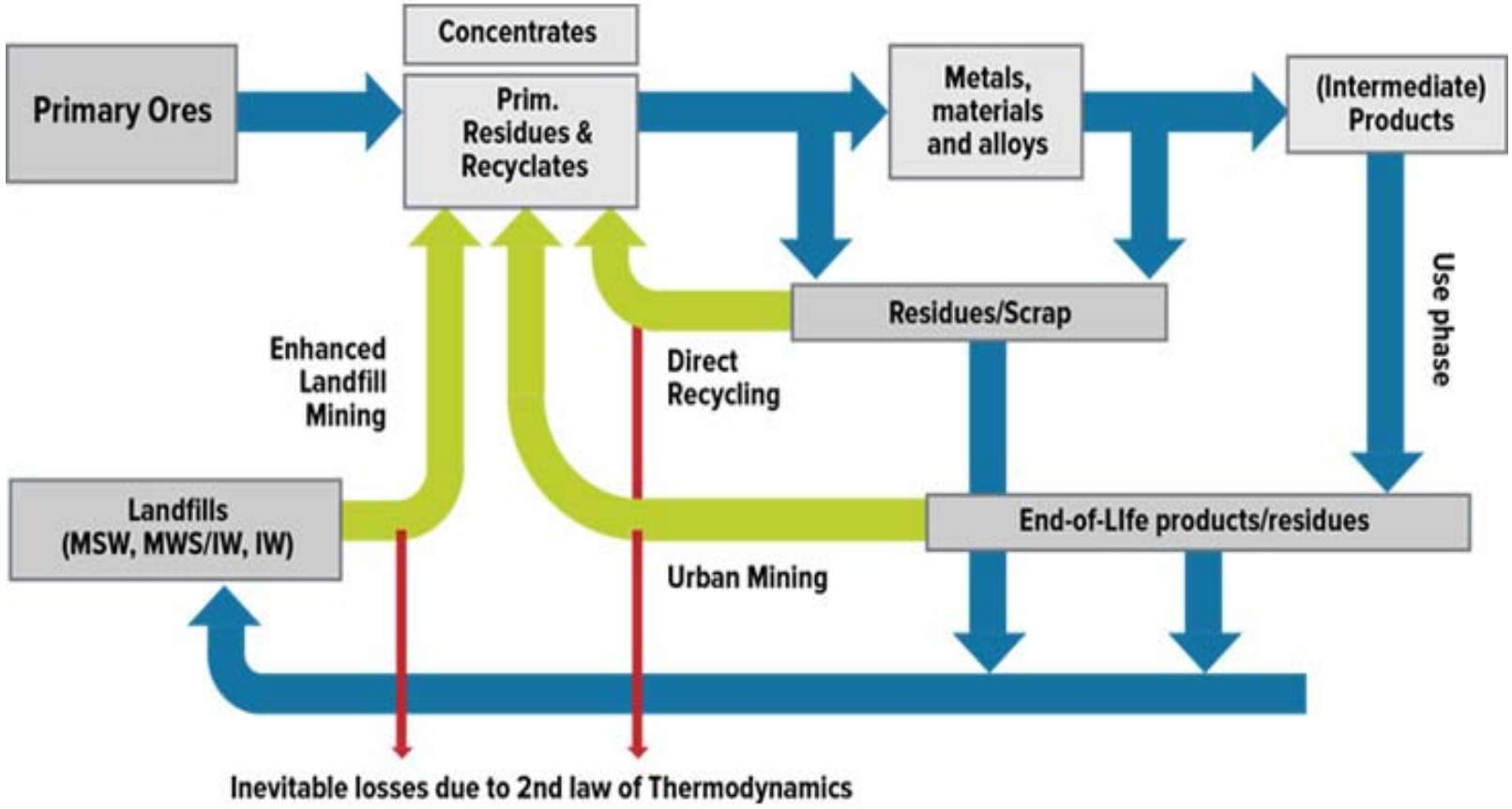
Government, Academia, Industry and Citizens collaborating together to drive structural changes far beyond the scope of any one organization could achieve on it's own

Involve all stakeholders in quadruple helix to innovate and experiment in real world settings, in creating frictionless ecosystems

Tasks: EURELCO is a network that

- maps and shares information on Enhanced Landfill Mining projects and programmes in the EU's Member States;
- further elaborates Enhanced Landfill Mining;
- integrates ELFM with both traditional recycling/urban mining and other landfill mining concepts (…);
- keeps track and stimulates the innovation in science and technology for exploration, excavation, separation/recovery, transformation/upcycling (…);
- analyses national and EU Landfill and Waste/Materials Management legislation;
- develops policy guidelines for improved legislation frameworks (revised EU Waste Hierarchy) and economic incentives in line with the expected public benefits of ELFM;
- develops and applies scientifically based methods for evaluating ELFM in terms of social, environmental and economic impacts, from a local, regional to global perspective;
- develops and executes ELFM research, demonstration and coordination projects;
- disseminates the technological and non-technological features of ELFM (..)

(Enhanced) Landfill Mining within a broader Recycling strategy



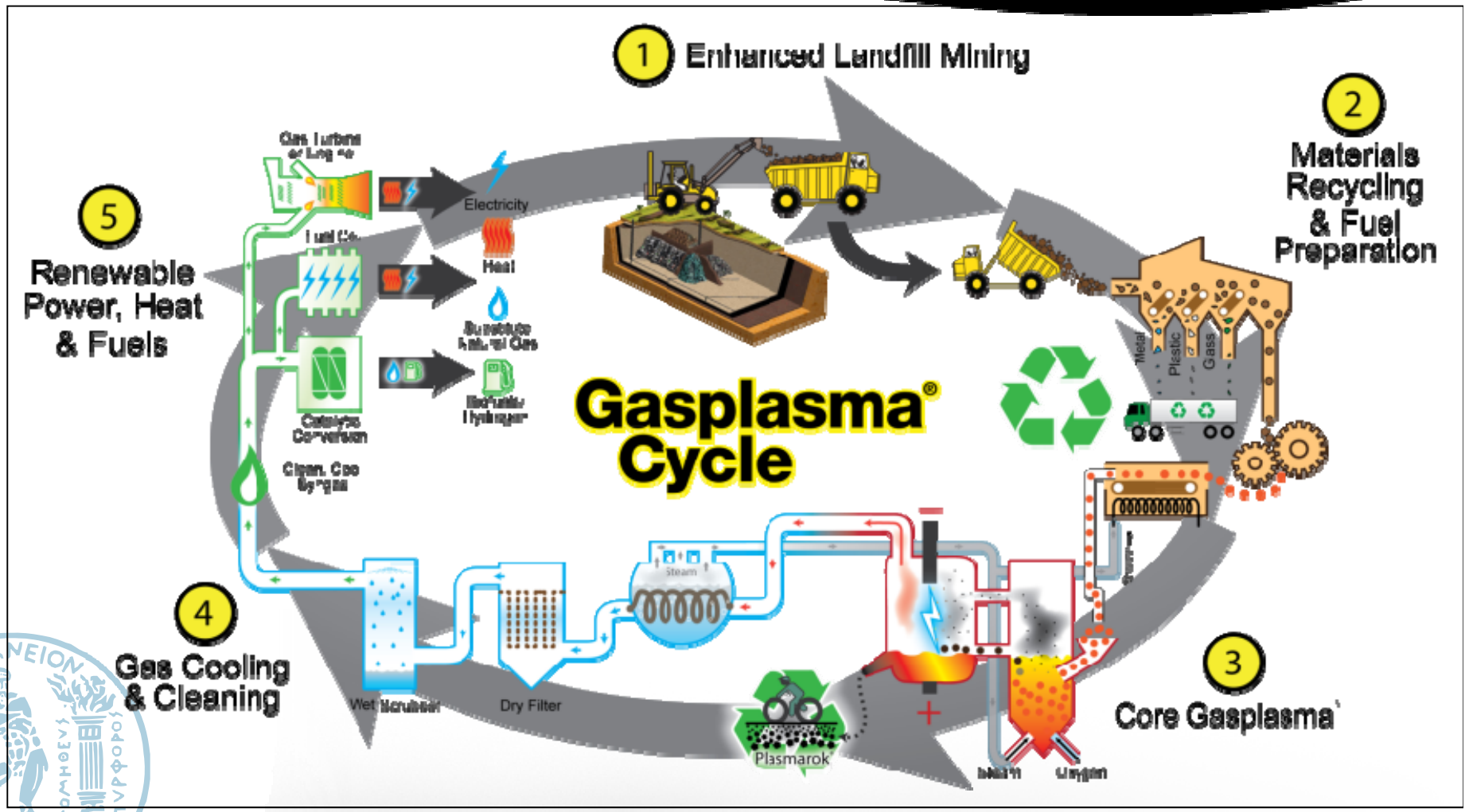
The rise of Enhanced Landfill Mining – the good news

- Enhanced Landfill Mining (ELFM) has gradually obtained more coverage and credibility in the EU:
  - Flanders: Multi-actor research consortium since 2008 (http://www.elfm.eu/en/ELFMConsortium.aspx)
  - Several national research projects are running in Flanders (IWT O&O ELFM, MIP ICON PLASMAT), Wallonia, the Netherlands, Germany, Sweden, Finland, the Baltic Region, Austria, etc.
  - Erection EUROPEAN ENHANCED LANDFILL MINING Consortium in march 2014 : www.eurelco.org
  - EURELCO received EIP RMC Status
  - ELFM to be part of new EIT KIC on Raw Materials

Why was EURELCO set up?

- Nevertheless, acceptance of the concept and commercial breakthrough of ELFM less straightforward than for urban mining of critical metals
- Non-technical barriers are manifest:
  - Legal (e.g. Landfill Directive & Waste Framework Directive)
  - Social acceptance (NIMBYISM)
  - Economics (public versus private benefits)
  - Resistance by several (traditional) industrial sectors

ELFM and GasPlasma – beyond incineration: from downcycling to upcycling



THANK YOU FOR YOUR ATTENTION!

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Questions ?

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