

Managing complex lifecycles – closing the loop for precious & special metals

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Wuppertal Institute
for Climate, Environment
and Energy



Precious & special metals have become irreplaceable for (consumer) product markets

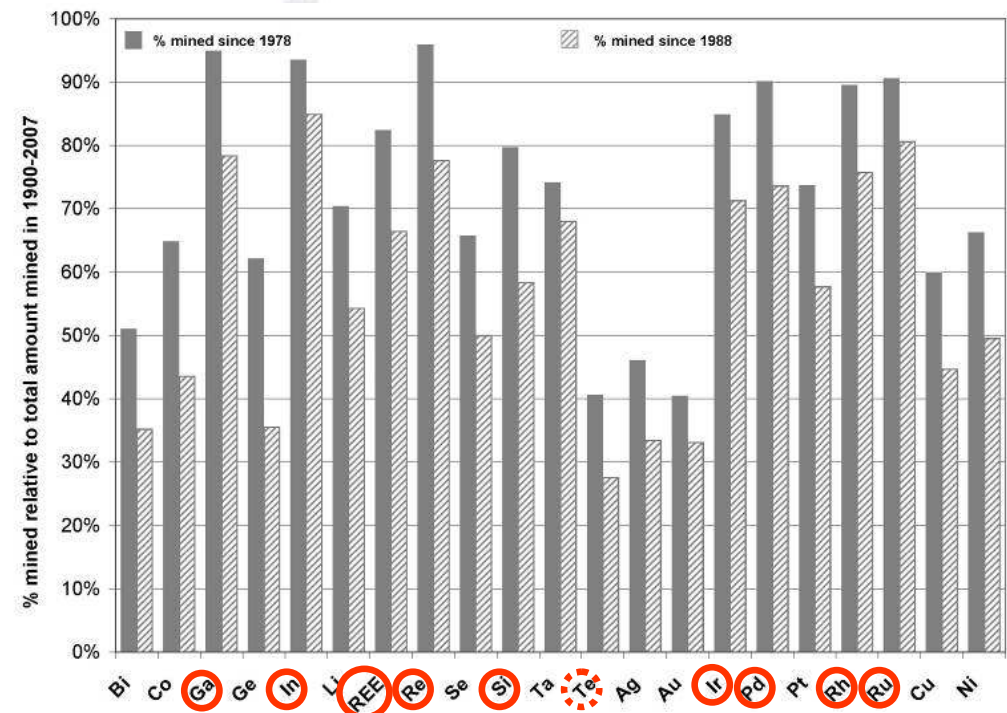
Material composition of a mobile phone

■ mobile phone substance (source Nokia)

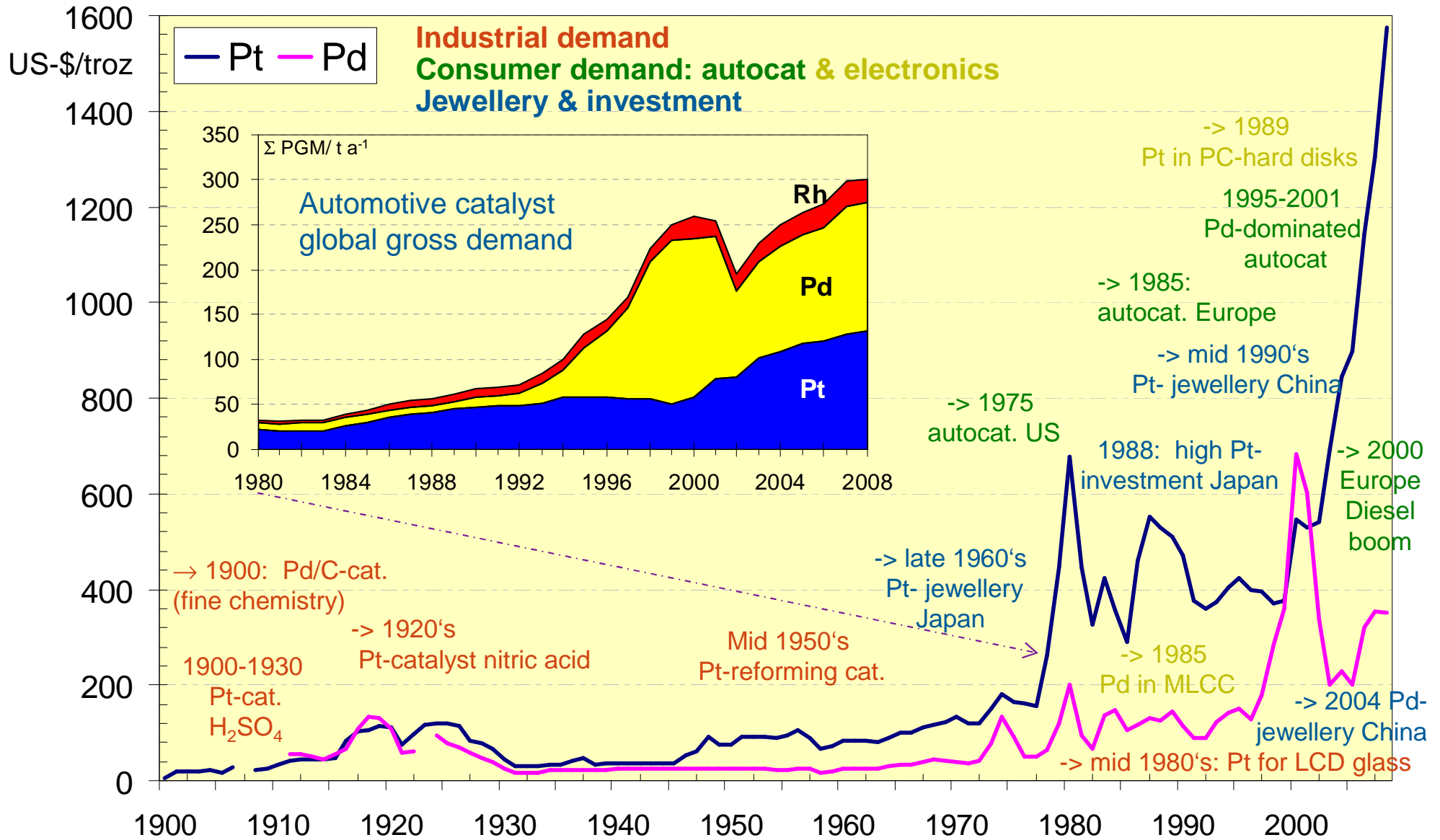
1 IA																	18 VIIA	
1																	2	
1	H																	He
	WASSERSTOFF																	HELIUM
2	3	4															10	
	Li	Be															Ne	
	LITHIUM	BERYLLIUM															NEON	
3	11	12															18	
	Na	Mg															Ar	
	NATRIUM	MAGNESIUM															ARGON	
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
	KALIUM	CALCIUM	SCANDIUM	TITAN	VANADIUM	CHROM	MANGAN	EISEN	KOBALT	NICKEL	KUPFER	ZINK	GALLIUM	GERMANIUM	ARSEN	SELENIUM	BROM	KRYPTON
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
	RUBIDIUM	STRONTIUM	YTRITIUM	ZIRKON	NIOB	MOLYBDAN	TECHNETIUM	RUTHENIUM	RHOIDIUM	PALLADIUM	SILBER	KADMUM	INDIUM	ZINN	ANTIMON	TELLUR	IOD	KSENON
6	55	56	57-71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
	CÄSIUM	BARIUM	Lanthaniden	HAFNIUM	TANTAL	WOLFRAM	RHENIUM	OSMIUM	IRIDIUM	PLATIN	GOLD	QUEKSILBER	THALLIUM	BLEI	BISMUT	POLONIUM	ASTAT	RADON
7	87	88	89-103	104	105	106	107	108	109	110	111	112	113	114				
	Fr	Ra	Ac-Lr	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub	Uuq					
	FRANCIUM	RADIUM	Actiniden	RUBERFORDIUM	DUBNIUM	SEABORGIUM	BOHRICIUM	HASSIUM	METTERICIUM	UNUNNILLIUM	UNUNUNIUM	UNUNBIUM	UNUNQUADRIUM					



- „Technology metals“
→ crucial for functionality
- Booming demand since 20/30 years
- ○ > 80% mined since 1978
- Clean tech drives further growth



Example platinum / palladium: long term price development & milestones in use

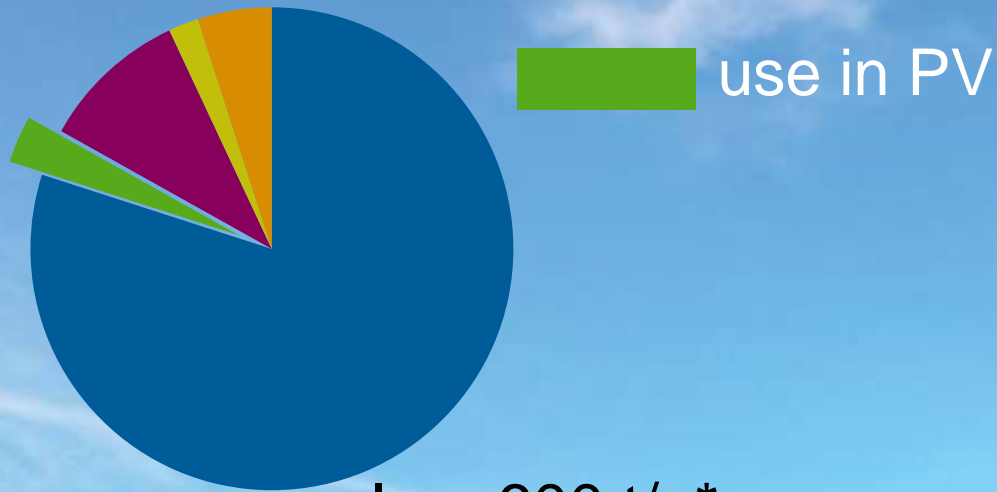


Important clean-/high-tech applications competing for „affordable“ technology metals supply

	Bi	Co	Ga	Ge	In	Li	REE	Re	Se	Si	Ta	Te	Ag	Au	Ir	Pd	Pt	Rh	Ru
Pharmaceuticals	■																		
Medical/dentistry		■	■	■	■			■	■		■	■		■		■	■		
Super alloys		■					■	■			■								■
Magnets		■					■		■			■							
Hard Alloys		■								■									
Other alloys					■	■		■	■	■		■							
Metallurgical*	■					■			■										
Glass, ceramics, pigments**	■	■			■	■		■	■			■	■			■	■	■	
Photovoltaics			■	■	■				■	■		■	■						■
Batteries		■			■		■						■						
Fuel cells						■										■	■	■	■
Catalysts		■	■	■			■	■	■			■	■	■	■	■	■	■	■
Nuclear					■	■	■												
Solder	■				■								■						
Electronic		■	■	■	■		■	■	■	■	■	■	■	■		■	■	■	■
Opto-electric			■	■	■		■		■	■		■							
Grease, lubrication			■			■													

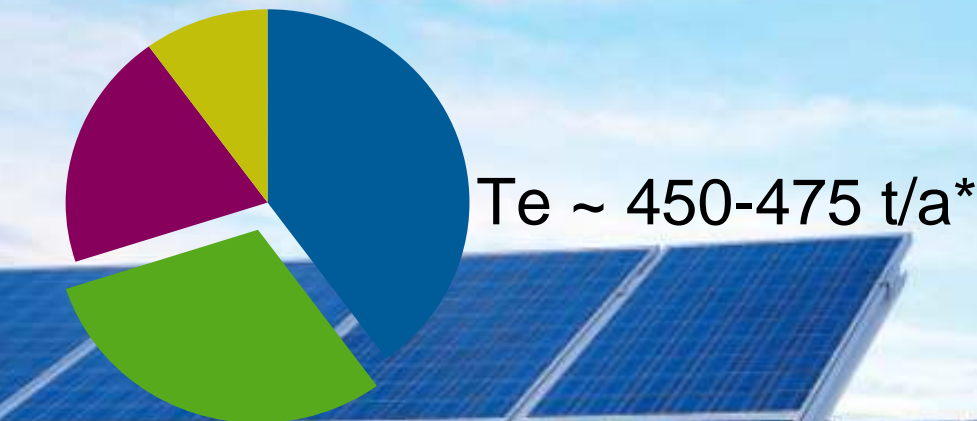
* additives in smelting, ..., plating. ** includes Indium Tin Oxide (ITO) layers on glass

Example indium, selenium, tellurium – strong growth expected in thin film photovoltaics (PV)

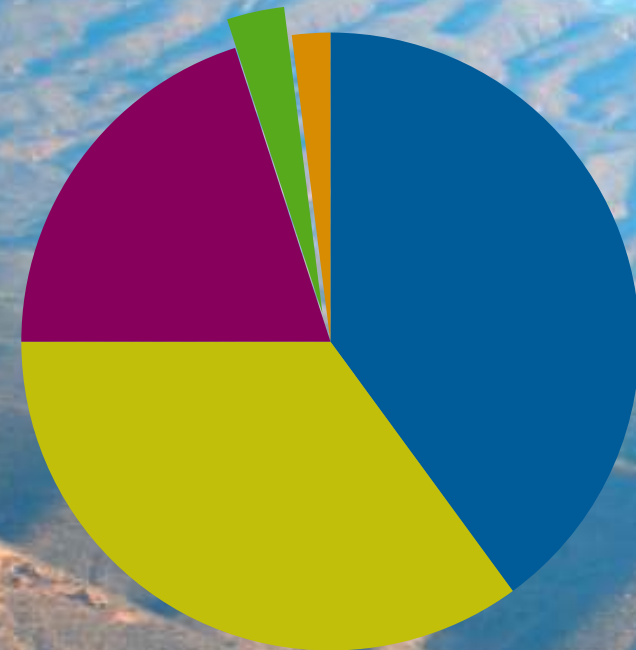


In ~ 600 t/a*

- ITO for LCD & plasma 80%
- Alloys for LMPA, dental 10%
- Electronics 5%
- Photovoltaics 3%
- Jewellery 2%



- Metallurgy incl Cu & Pb non-ferrous alloys 40%
- Photovoltaics 30%
- Chemicals & Pharmaceuticals incl rubber vulcanisation 20%
- Electronics incl thermo-electrics, flash memories & others 10%



Se ~ 2700-3000 t/a*

- Glass & Pigments 40%
- Metallurgy incl Electrolytic Manganese Metal 35%
- Chemicals incl animal feed, pharma, fertilizers 15%
- Photovoltaics 3%
- Others, incl optics 2%

* World primary production
(Umicore estimates)

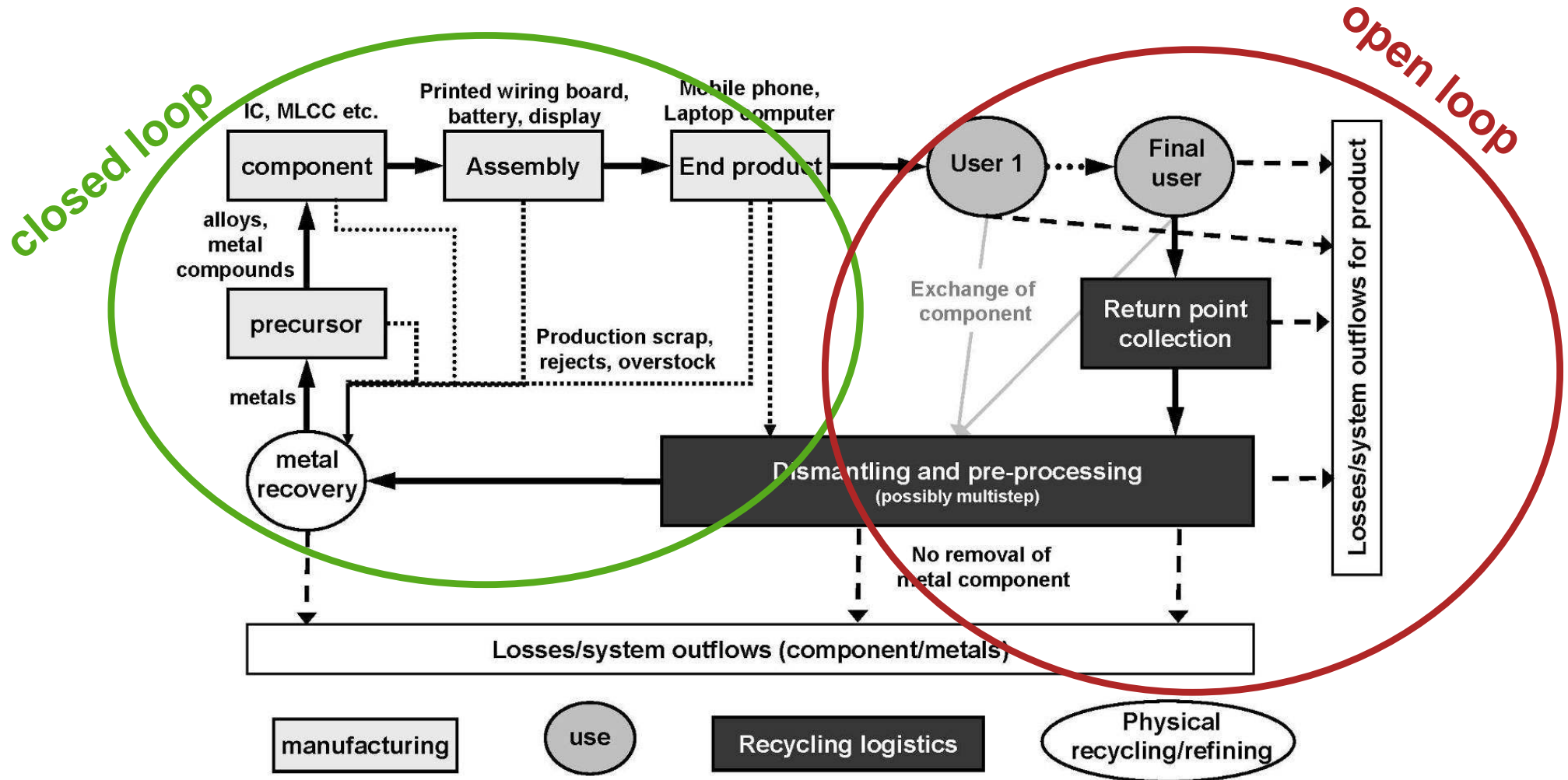
“Urban mining” – recycling can make an important contribution to future supply



- + “Eternal” recycling of metals
- + High yields obtainable with state-of-the-art technologies
- + Significantly less CO₂/environmental footprint of modern recycling compared to mining (especially for precious & special metals)
- Economic & technical limits for dissipated metals
- Technical challenges within recycling chain for complex products with (e.g. ELVs, WEEE)
- Thermodynamic limits for certain metals from complex mixtures (Ta, REE, ...)
- Challenges to effectively close the loop for end-of-life products

Complex lifecycles for precious & special metals

– high losses for consumer products (open loops)



- High product mobility, unclear material flows
- Multiple change of ownership, sequential locations of use around the globe
- High exports of EoL products, lack of appropriate recycling infrastructure in developing countries

- Low consumer awareness on resource value & missing economic incentives, but combined mass flows have big impact on metal demand
- Hibernating goods, discarding as trash & informal activities reduce significantly recycling efficiency.

In spite of all efforts – mobile phone recycling largely fails today

Recycling potential 2007: 500 million units per anno x 100 g = 50,000 t/a

collected

Not collected

%?

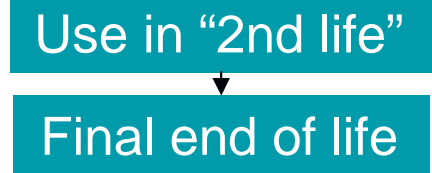
%?

Recycling¹

reuse

Stored “in drawer”
(potential for recycling at later stage)

Disposed with household waste
(unrecoverable loss)



Recycling reality²:
< 1000 t
(< 10 M)
in 2007

EOL not collected



- ¹ 25-35% of professionally collected phones are not fit for reuse and sent directly to recycling.
- ² global quantities treated for material recovery efficiently and environmentally sound
- ³ low yields, uncontrolled release of fumes, effluents and waste

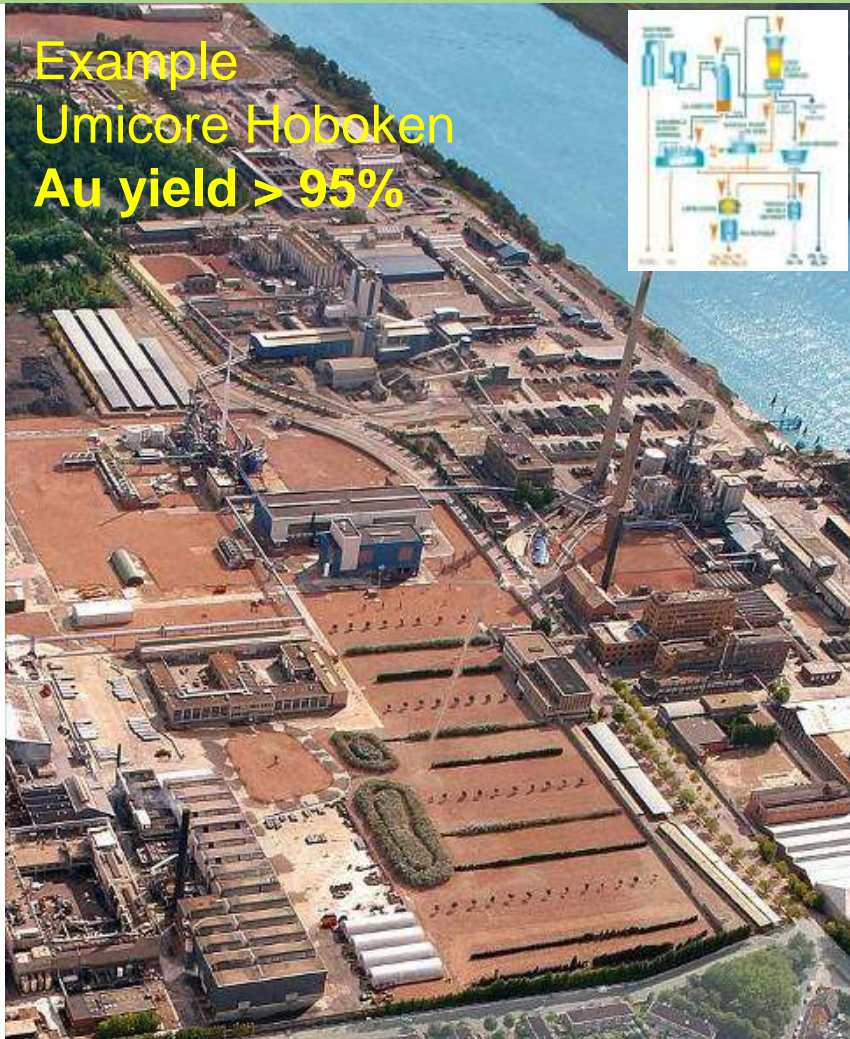
Global Sales of new phones:

2001:	400 M
2002:	420 M
2003:	520 M
2004:	670 M
2005:	800 M
2006:	990 M
2007:	1140 M
2008:	1320 M forecast



High-tech recycling is key - how to ensure that the right processes are used ?

Example
Umicore Hoboken
Au yield > 95%



**integrated metals
smelting/refining ▶ “high tech”**



backyard recycling ▶ “low tech”

- High losses, few metals recovered only (cherry picking)
- Dramatic environment & health impacts
- Typical for most Asian & African countries



foto: EMPA/CH

- + Focus secondary materials, input 1000 t/day
- + 17 metals recovered, value 3 billion USD (2007)
(Au, Ag, Pt, Pd, Rh, Ru, Ir, Cu, Pb, Ni, Sn, Bi, Se, Te, Sb, As, In)
- + ISO 9001 & 14001, OHSAS 18001

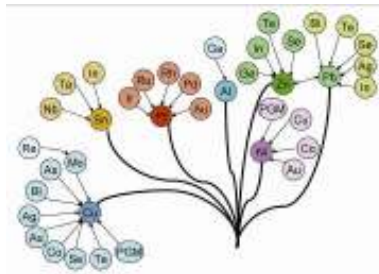
**Illegal & dubious WEEE & ELV exports
deplete Europe's „urban mines“**

Recycling of technology metals needs to deal with complexity ... and interdependences

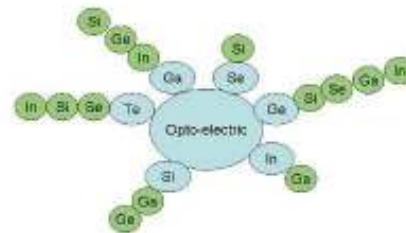
design



Interlinkage metal production systems



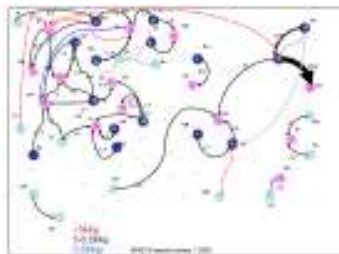
substitution



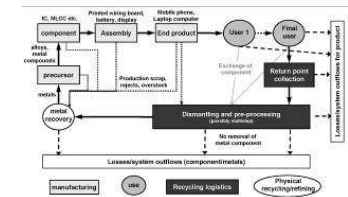
product composition



Flows around the world



life cycle



metal recovery

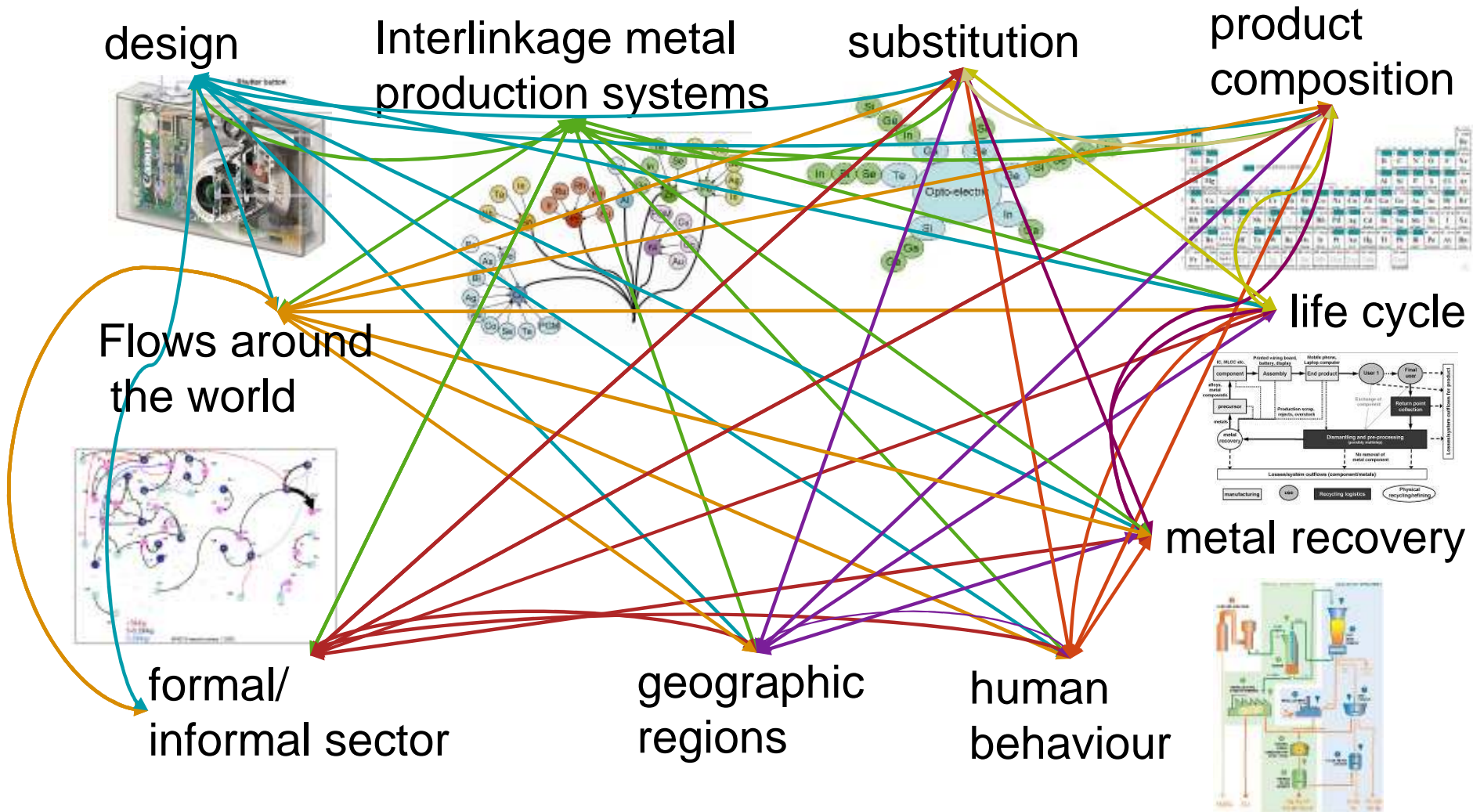


formal/
informal sector

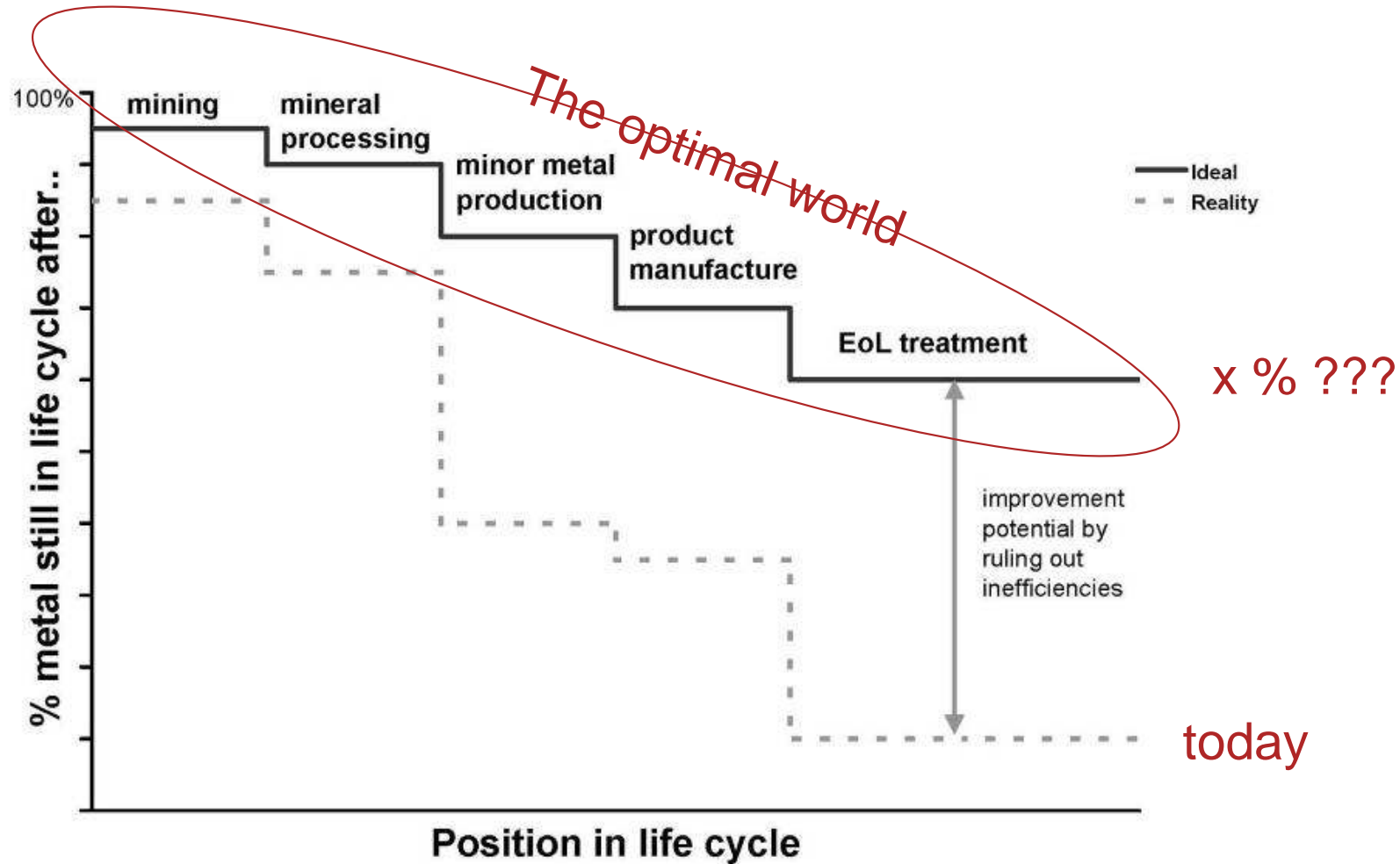
geographic
regions

human
behaviour

Recycling of technology metals needs to deal with complexity ... and interdependences

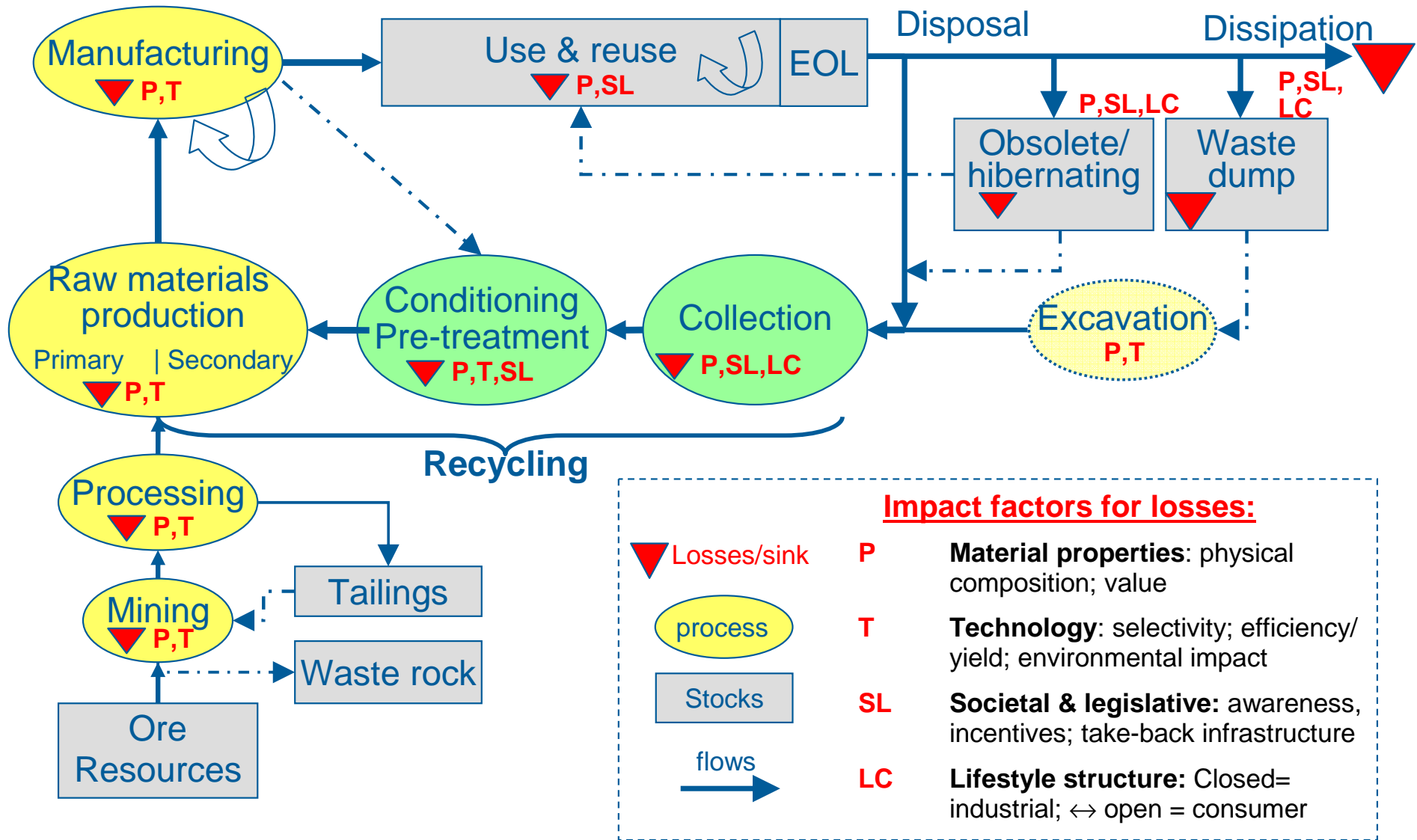


Resource efficiency can be improved on multiple levels ... with huge potential in EoL treatment



... requiring a joint approach of the participants involved in the lifecycle

Losses and respective impact factors along a product/metals lifecycle



- **Booming demand for precious & special metals** (functionality); energy intensive mining; geographic concentration and high degree of coupled production can cause primary supply disruptions.
- Needed: **Design for sustainability** without losing product performance.
- High tech products require **high tech recycling**. Value of precious metals allows by-product recovery of special metals in Umicore type flowsheet.
- **Recyclability** of a product is not enough, it needs to happen at end-of-life.
- **Main constraints are structural**, not technical; “open cycles” for consumer goods → improve collection of consumer goods with technology metals.
- **Research** has to lead to (engineering) solutions → stop reinventing the wheel!
- Outreach to **developing countries** with knowledge transfer and solution-oriented new approaches/business models.
- Efficient **recycling &** responsible **mining** are needed to meet future metals demand.

Complex products need sophisticated recycling systems

- ▶ *simplistic approaches are not useful*

Closing the cycle should be done globally...

- ▶ *holistic approach to life cycle, recycling chain and location*

...at different levels

- ▶ *system, product, process,...*

...and look at all the factors

- ▶ *technology, societal, legislative, economic...*

Push **interdisciplinary approaches** addressing complexities in a holistic way

- ▶ material science + metallurgy + mineral processing + social science + sales/marketing


A „recycling society“ is impossible without closed loops for consumer goods.

→ **New business models required**, e.g. leasing products/ components/metals or selling functionality/services instead of selling products. Set up early recycling incentives for new products (PV, EV/HEV batteries, fuel cells etc.)

Thanks for your attention

For further information: Hagelüken, C., C.E.M. Meskers: Complex lifecycles of precious and special metals, in: Graedel, T., E. van der Voet (eds): Linkages of Sustainability. Strüngmann Forum Report, vol. 4. Cambridge, MA: MIT Press, 2009

For some reason, there is e-scrap that never reaches us




umicore
Precious Metals Refining

So what we do get, we recycle to the maximum

Umicore Precious Metals Refining, as one of the world's largest companies in electronic scrap recycling, is proud to offer its clients the best overall value in recycling and refining of precious metals. Our service includes a high-quality, customized benefit package (ready metal pricing, financing, metal account management, ...), high business standards and ethics. It lays the basis for a beneficial long-term relationship.

But we're even more proud of our eco-efficient and total quality approach, our advanced and environmental sound technology, our openness and transparency towards our customers, employees and society. This is how we view our responsibility in the field of sustainable development. We understand our real job: recycling of your electronic scrap, components, printed circuit boards, mobile phones, etc. ... to the maximum and putting the precious metals back in the cycle for a better life. A better life for you and for future.



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