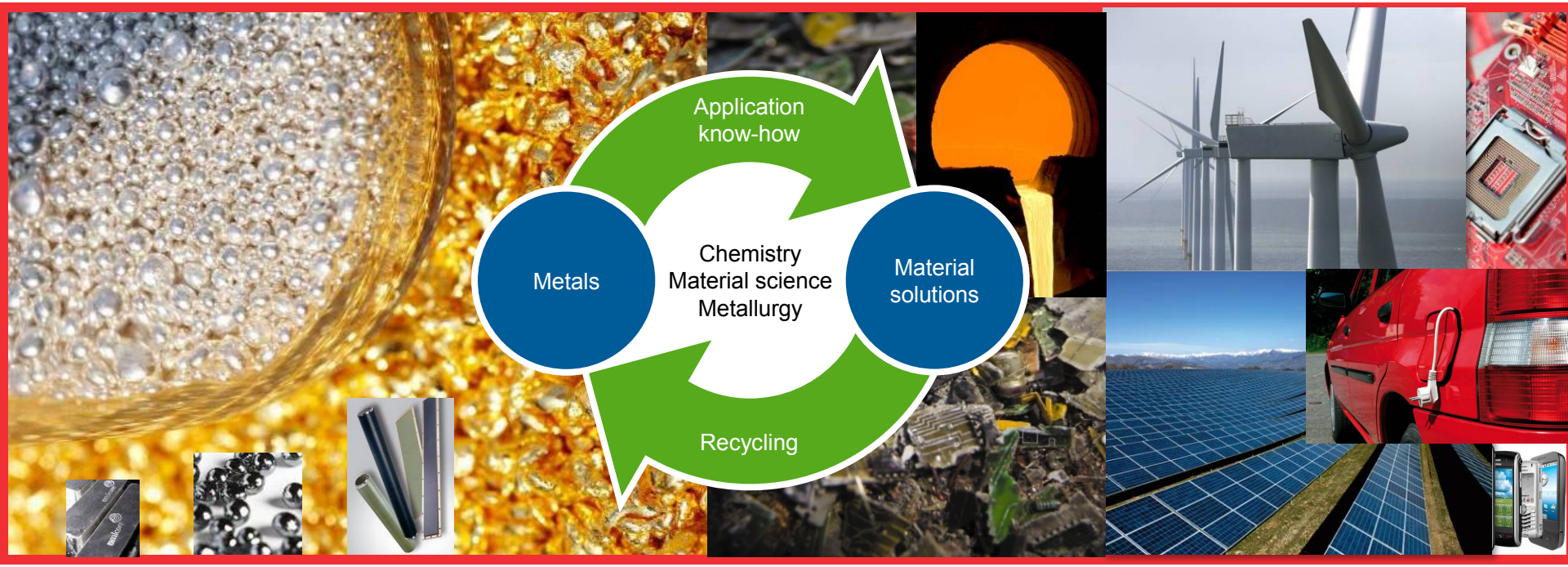
umicore
materials for a better life

Recycling of technology metals from electronics

A good opportunity – and a complex challenge

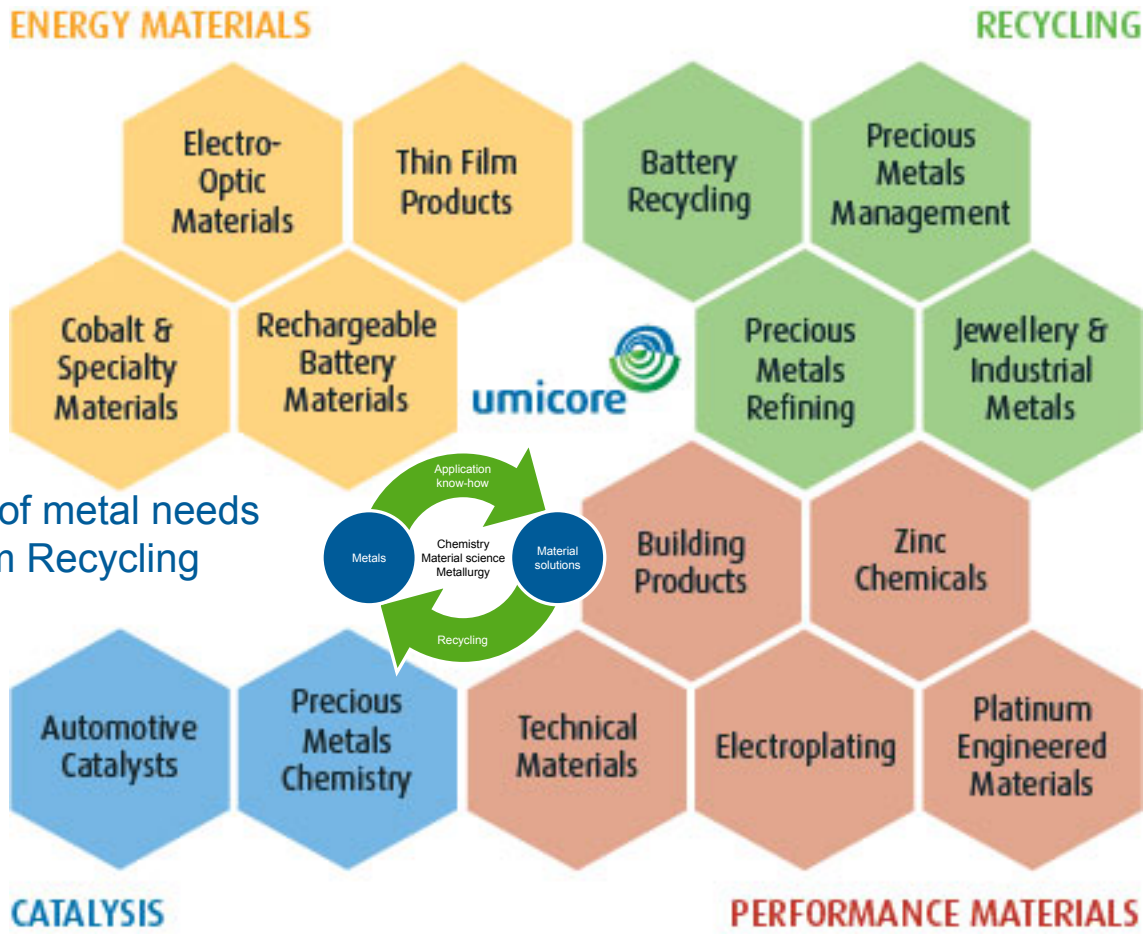


Dr. Christian Hagelüken

Closing the Loop

Scherpenzeel, NL
2.10.2013

Umicore – a materials technology company



Ø 50% of metal needs from Recycling

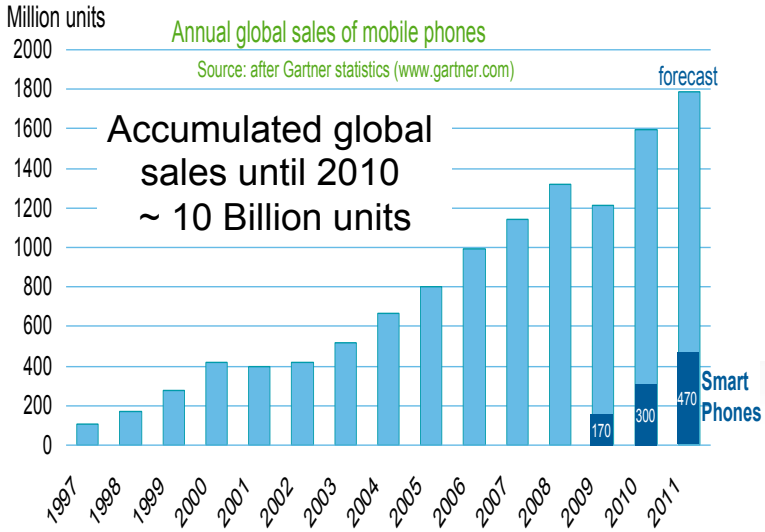
Most Sustainable Corporations in the World GLOBAL100

No. 1 ranking in global index companies (Jan. 2013)

top EMPLOYERS 2012 BELGIE/BELGIQUE CERTIFIED BY THE CRF INSTITUTE

14,400 people in ~ 80 industrial sites worldwide, turnover 2012 €: 12.5 Billion (2.4 B excl. metals)

Booming product sales & increasing functionality drive demand for (technology) metals

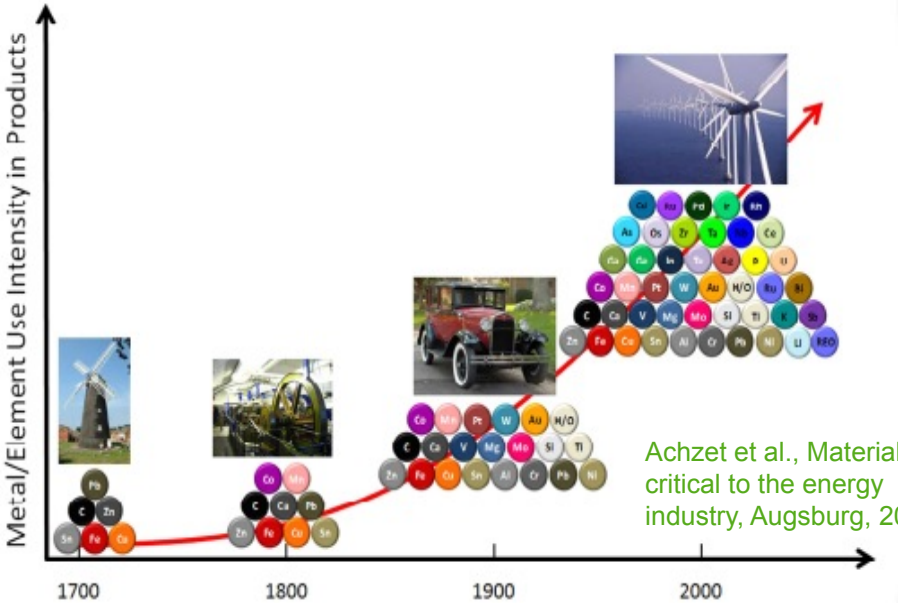


… next wave: tablet computer:

- 2013 tablets will overpass laptops
- 2015 more tablets than laptops + PC

Drivers:

- growing population (Asia!)
- growing wealth
- technology development & product performance



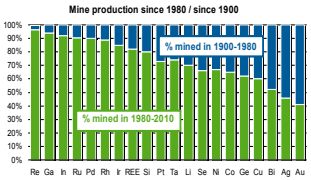
Achzet et al., Materials critical to the energy industry, Augsburg, 2011

Massive shift from geological resources to anthropogenic “deposits”

- <u>Electric & electronic equipment (EEE)</u>
  Over 40% of world mine production of copper, tin, antimony, indium, ruthenium & rare earths are annually used in EEE

- <u>Mobile phones & computer</u>
  account for 4% world mine production of gold and silver and for 20% of palladium & cobalt.

- <u>Cars</u>
  > 60% of PGM mine production goes into autocatalysts, increasing significance for electronics (“computer on wheels“) and light metals



- In the last 30 years we extracted > 80% of the REE, PGM, Ga, In, … that have ever been mined

- Clean energy technologies & other high tech applications will further accelerate demand for technology metals
  (precious metals, semiconductors, rare earths, refractory metals, …)
  <u>⇨without access to these metals no sustainable development in EU</u>

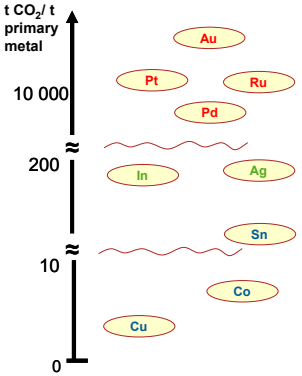
How to avoid clean solutions with dirty feet?

No foreseeable <u>absolute</u> scarcity of metals, but:

- Declining grades & increasing complexity of ores
- Need to mine from greater depths and/or in ecological sensitive areas (artic regions, oceans, rain forest etc.)

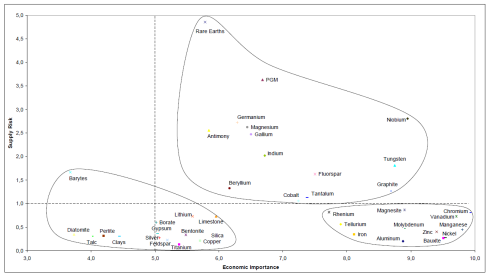
⇨footprint of primary metals production can be high

- Energy needs & related climate impact
- Other burden on environment (land, water, biodiversity)



Other supply risks (political, trade restrictions, economical/ speculation; regional or company oligopolies, …) and demand surges already today lead to market imbalances & temporary scarcities.

→ critical metals identification for the EU



Recycling & circular economy as key contributors

Primary mining

- ~ 5 g/t Au in ore
- Similar for PGMs

Urban mining

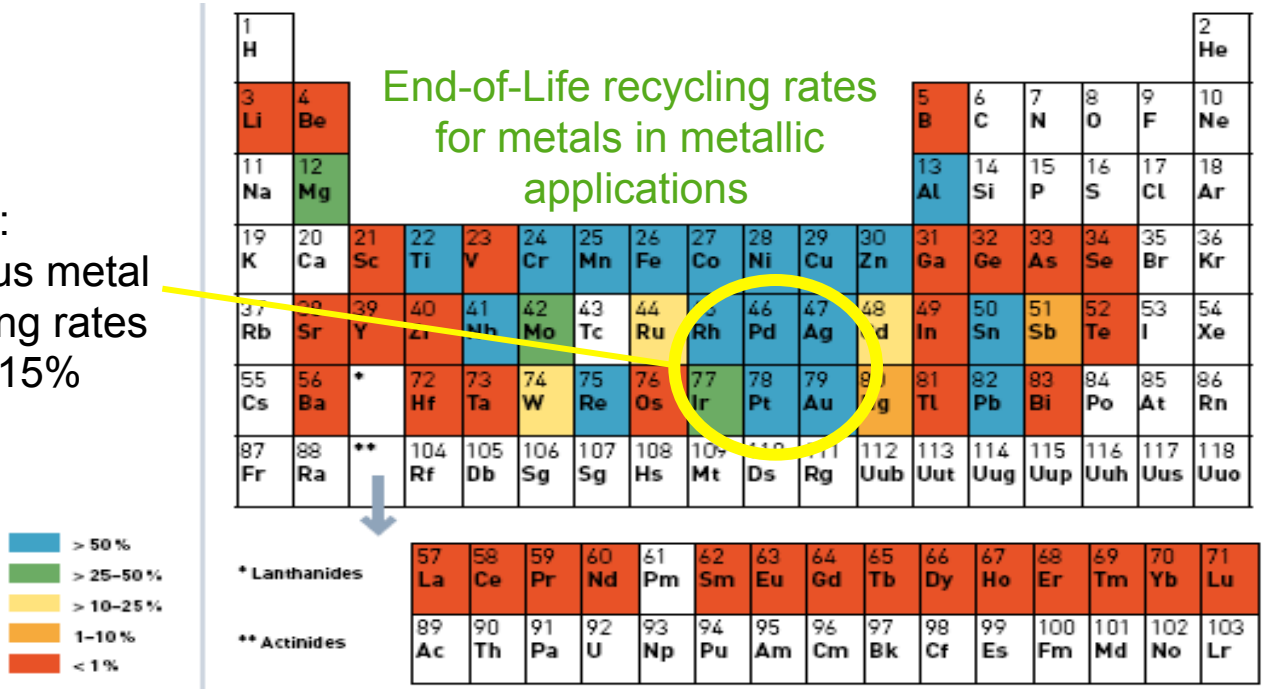
- 200 g/t Au, 60 g/t Pd & Cu, Sn, Sb, … in PC motherboards
- 300 g/t Au, 60 g/t Pd … in cell phones

factor 40 & more

Challenge 1: how to accumulate millions of discarded EoL product into „urban mines" of a reasonable (= economically viable) size

Recycling of most technology metals still lags way behind …

WEEE: precious metal recycling rates below 15%



UNEP (2011) Recycling Rates of Metals – A Status Report, A Report of the Working Group on the Global Flows to the International Resource Panel.

http://www.unep.org/resourcepanel/Publications/AreasofAssessment/Metals/Recyclingratesofmetals/tabid/56073/Default.aspx

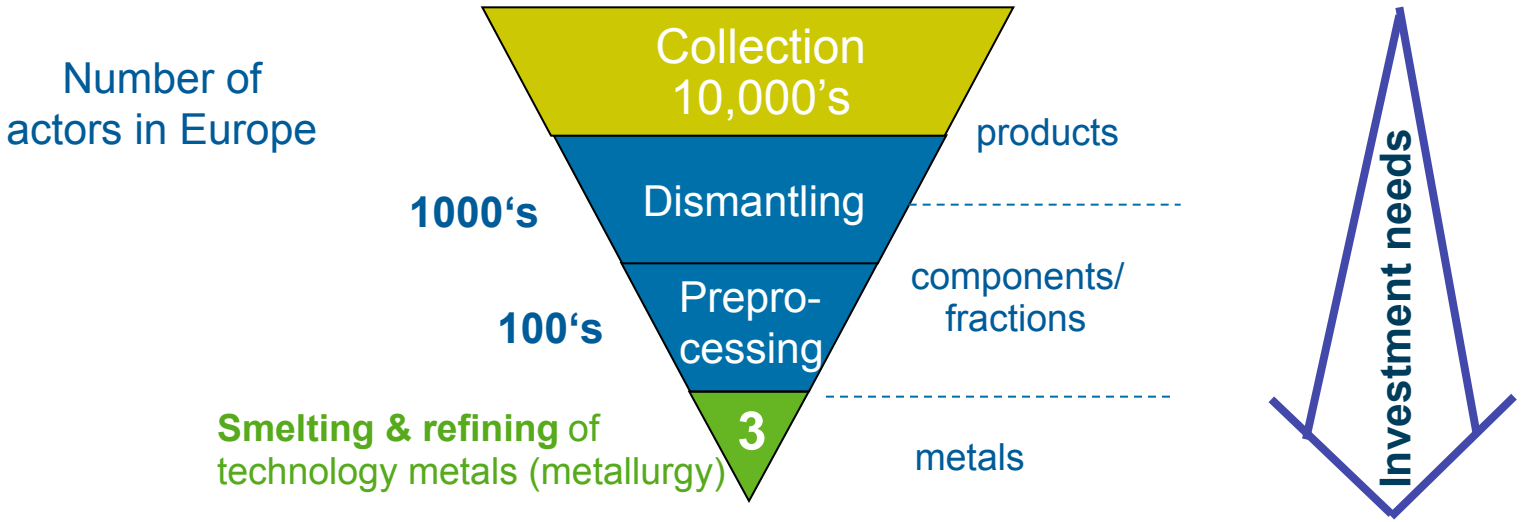
New report (April 2013):

Metal Recycling: Opportunities, Limits, Infrastructure

http://www.unep.org/resourcepanel/Publications/MetalRecycling/tabid/106143/Default.aspx

Recycling needs a chain, not a single process
- system approach is crucial

Example recycling of WEEE
Recovery of technology metals
from circuit boards

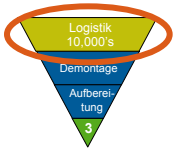


Total efficiency is determined by weakest step in the chain
Make sure that critical fractions reach these plants

Example: 30% x 90% x 60% x 95% = 15%

Challenge 2: relevant products/fractions don‘t reach suitable recycling processes

a) Low collection






⇨ambitious targets & new business models are required

b) “Deviation” of collected goods
⇨ dubious exports ⇨low quality ”recycling”





⇨“Tracing & Tracking“, controls & enforcement, stakeholder responsibility, transparency

Technology metals need smart recycling

- mass focussed traditional European recycling does not fit

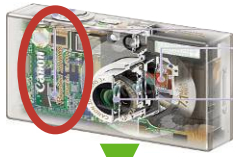
Bottle glass

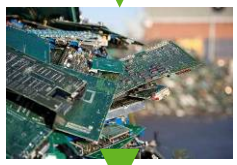
Green glass
White glass
Brown glass

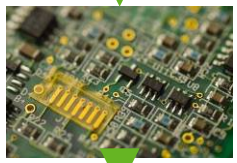
Steel scrap

+

Circuit boards







PM & specialty metals

Autocatalysts

PGMs

- "Mono-substance" materials without hazards
- Trace elements remain part of alloys/glass

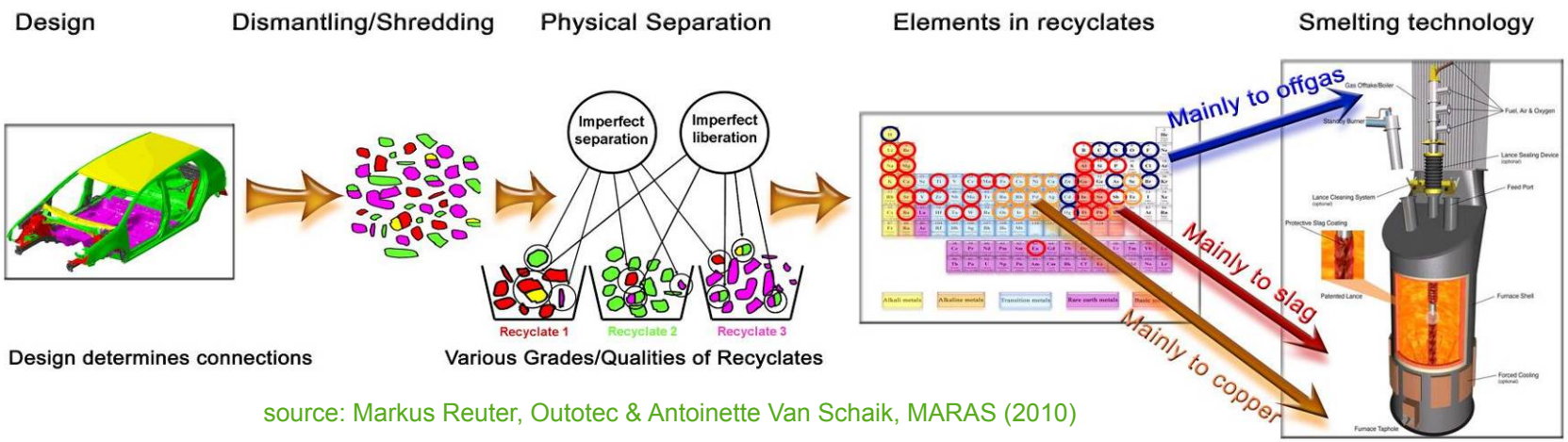
Recycling focus on mass & costs

- "Poly-substance" materials, incl. hazardous elements
- Complex components as part of complex products

Place focus on trace elements & value

Recycling – technical fundamentals

Success factors are product design & technical-organisational set-up of the recycling chain



source: Markus Reuter, Outotec & Antoinette Van Schaik, MARAS (2010)

Product manufacturing ↔ manual/mechanical preprocessing ↔ metallurgical recovery

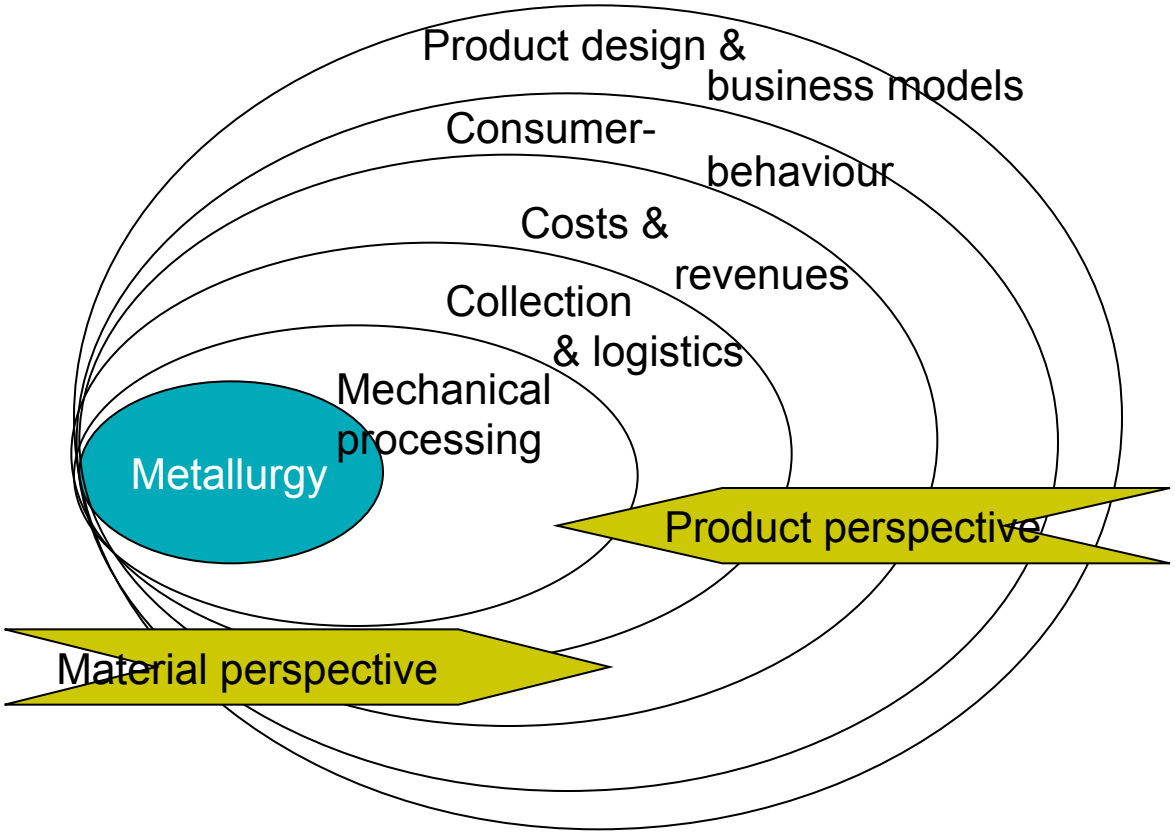
Challenge 3: How to recover low concentrated technology metals from complex products

Multi-metal recycling with modern technology

➲ High tech & economies of scale

- **Recovery of 20 metals with innovative metallurgy** from WEEE, catalysts, batteries, smelter by-products etc.
  Au, Ag, Pt, Pd, Rh, Ru, Ir, Cu, Pb, Ni, Sn, Bi, Se, Te, Sb, As, In (via versatile multi feed process).
  Co, REE (via specialised process for battery materials)
- Value of precious metals enables co-recovery of specialty metals ('paying metals')
- **High energy efficiency** by smart mix of materials and sophisticated technology
- **High metal yields, minimal emissions & final waste**

Concluding - Recycling success factors



Recycling prerequisites

1. Technical recyclability as basic requirement
2. Accessibility of relevant component → product design
3. Economic viability
   intrinsically or externally created
4. Completeness of collection
   business models, legislation, infrastructure
5. Keeping within recycling chain → transparency of flows
6. Technical-organisational set-up of chain → recycling quality
7. Sufficient recycling capacity

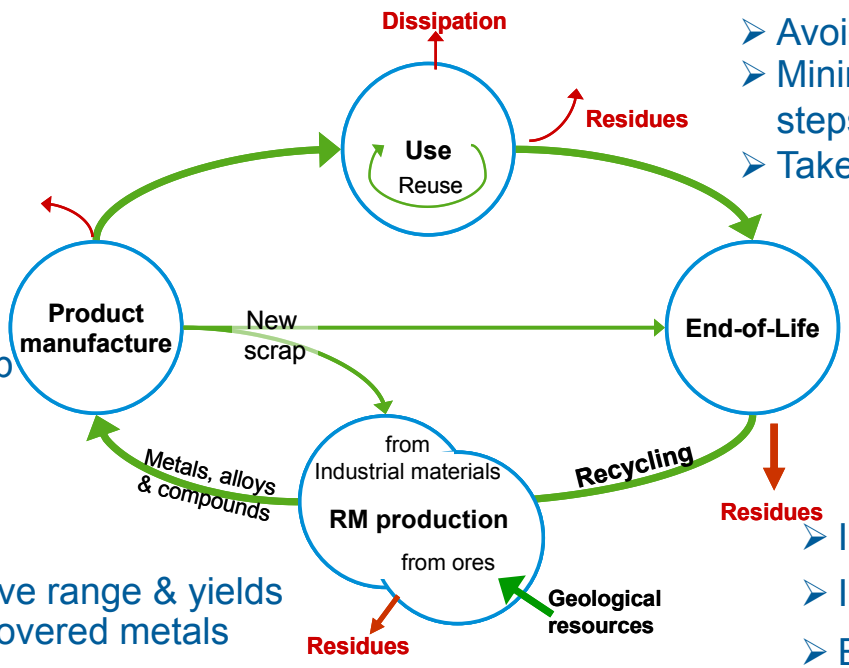
Complex products require a systemic optimisation & interdisciplinary approaches
(product development, process engineering, metallurgy, ecology, social & economic sciences)

Focus circular economy

- significant improvements still needed at every step

- Avoid dissipation
- Minimise residue streams at all steps & recycle these effectively
- Take a holistic system approach

- Consider recycling in product design
- Develop business models to close the loop
- Recycle production scrap



- Improve range & yields of recovered metals
- Improve efficiency of energy & water use

- Improve collection
- Increase transparency of flows
- Ensure quality recycling
- Go beyond mass recycling (more focus on technology metals)
- Develop innovative technologies to cope with technical recycling challenges

Mining & Recycling are complementary systems!

Thanks for your attention

umicore
materials for a better life

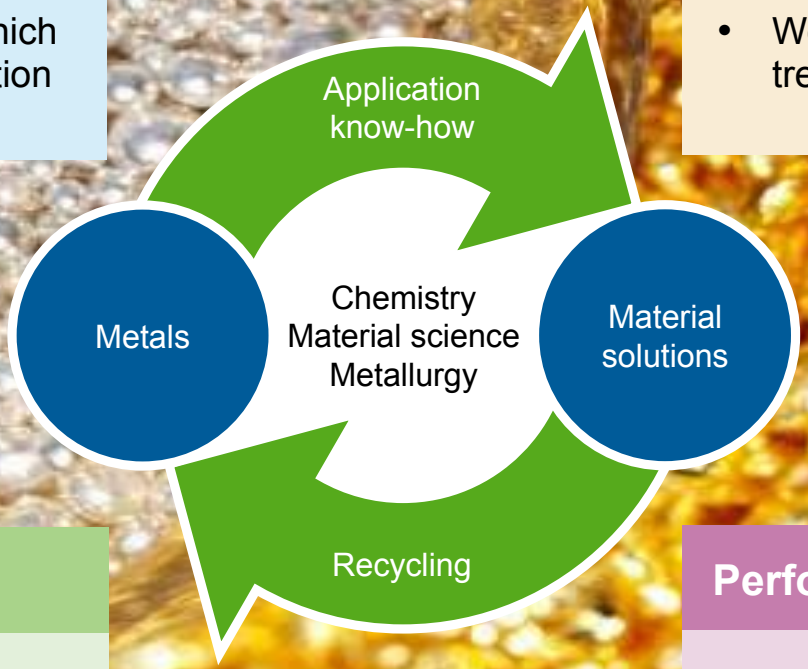
Energy Materials

- We develop materials which enable the clean production and storage of energy

Catalysis

- We develop technologies to treat automotive emissions

Umicore – A Materials Technology Company



Recycling

- We operate a unique recycling process to deal with complex industrial residues and end-of-life materials

Performance Materials

- We produce a range of essential materials and chemicals based on precious metals and zinc

Contact: christian.hagelueken@eu.umicore.com; www.umicore.com

Confusion in public debate about metals

– ? critical metals – rare metals – rare earths - …?

H																	He
Li	**Be**											B	C	N	O	F	Ne
Na	**Mg**											Al	**Si**	P	S	Cl	Ar
K	Ca	**Sc**	Ti	V	Cr	Mn	Fe	**Co**	Ni	Cu	Zn	**Ga**	**Ge**	**As**	**Se**	Br	Kr
Rb	Sr	**Y**	**Zr**	**Nb**	**Mo**	Tc	**Ru**	**Rh**	**Pd**	**Ag**	**Cd**	**In**	**Sn**	**Sb**	**Te**	I	Xe
Cs	Ba	**La***	**Hf**	**Ta**	**W**	**Re**	Os	**Ir**	**Pt**	**Au**	Hg	Tl	Pb	**Bi**	Po	At	Rn
K	Ca	**Ac-Lr**	Rf	Db	Sg	Bh	Hs	Mt									

*	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

Precious Metals (PM)	Semi-conductors	Rare Earth Elements (REE)
Edelmetalle	Halbleiter	Seltene Erden

Technology metals

EU critical metals

Technology metals: descriptive expression, comprising most precious and special metals

- crucial for technical functionality based on their often unique physical & chemical properties (conductivity; melting point; density; hardness; catalytic/optical/magnetic properties, …)
- mostly used in low concentrations and a complex substance mix ('spice metals')
- Key for "Hi-Tech" and "Clean-Tech"

Efficient production and use of energy will further boost demand for technology metals