Recycling Schemes for Consumer Electronics and Cars, a Different Approach

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Umicore
Global material technology & recycling group

~ 11.000 people, 50 sites & 15 R&D centers, 20.5 bn € turnover, 3.4 bn € revenues

1

One of three global leaders in emission control catalysts for light-duty and heavy-duty vehicles

2

A leading supplier of key materials for rechargeable batteries and fuel cells

3

The world leading recycler of complex waste streams containing precious and other valuable metals

Umicore metals portfolio

Li	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Ru	Rh	Pd	Ag	In	Sn	Sb	Te	Ta	W	Re	Ir	Pt	Au	Pb	Bi	La	Ce	Pr	Nd
[illegible]	Cobalt	Nickel	Copper	Zinc	Gallium	Germanium	Arsenic	Selenium	Ruthenium	Rhodium	Palladium	Silver	Indium	Tin	Antimony	Tellurium	Tantalum	Tungsten	Rhenium	Iridium	Platinum	Gold	Lead	Bismuth	Lanthanum	Cerium	Praseody...	Neodymium

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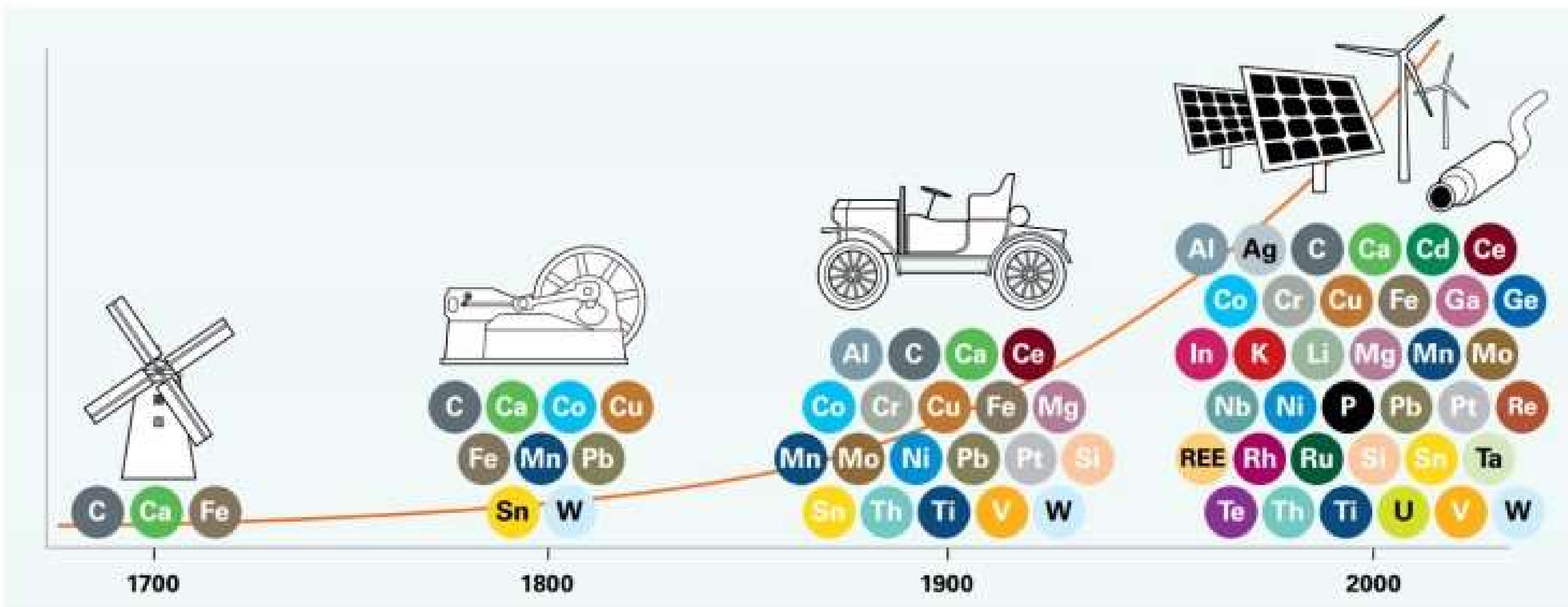
Increasing product complexity

- making use of almost the entire periodic table of elements



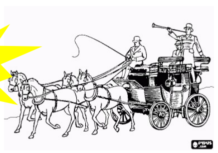
Elements widely used in energy pathways

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

The continuing need for mobility…
… creates significant needs for new metals

1900s

Mobility



1920s

Power

1950s

Style

+ steel alloys & decoration

1980s

Clean air

+ catalyst

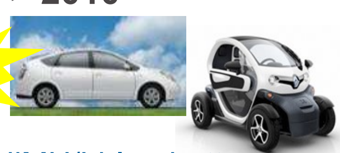
2000s

Intelligence

+ electronics
+ aux. electric motors
+ lightweighting

> 2010

Low carbon



+ NiMH/Li-Ion battery
+ FC stacks
+ e-drives

Metals*

Fe Pb Cu Cr
Al Zn Pt Pd
Rh Ce La Au
Ag Sb Sn Ge
In Ga Nd Pr
Sm Tb Dy Mg
Li Co Ni Mn

*non exhaustive list

The Urban Mine becomes bigger and increasingly complex to ‘mine’

Urban mining deposits - much richer than primary ores

- **Primary mining**
  - << 5 g/t Au in ore
  - Similar for PGMs

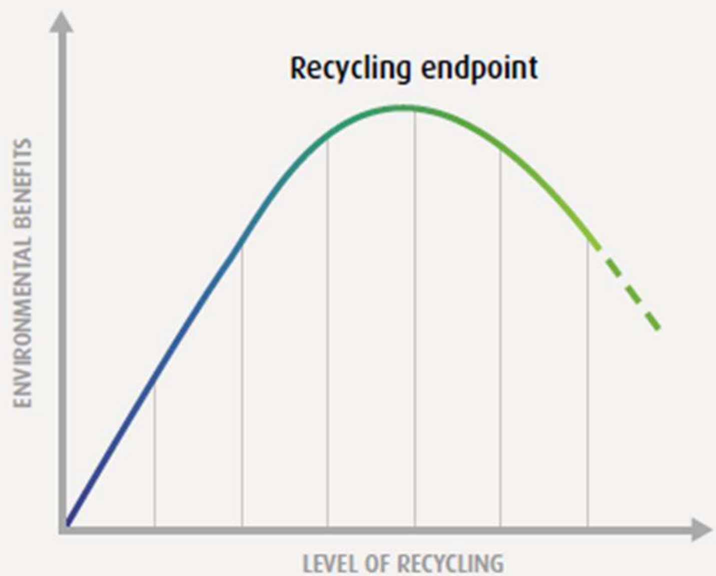
- **“Urban mining”**
  - 100-150 g/t Au; Pd, Ag, Cu, Sn, Sb, … in PC motherboards
  - 200-300 g/t Au; Pd … in cell phones
  - 2000-3000 g/t PGM in automotive catalysts

factor 30
& more

How to accumulate millions of discarded EoL product into urban mines of a reasonable (= economically viable) size?

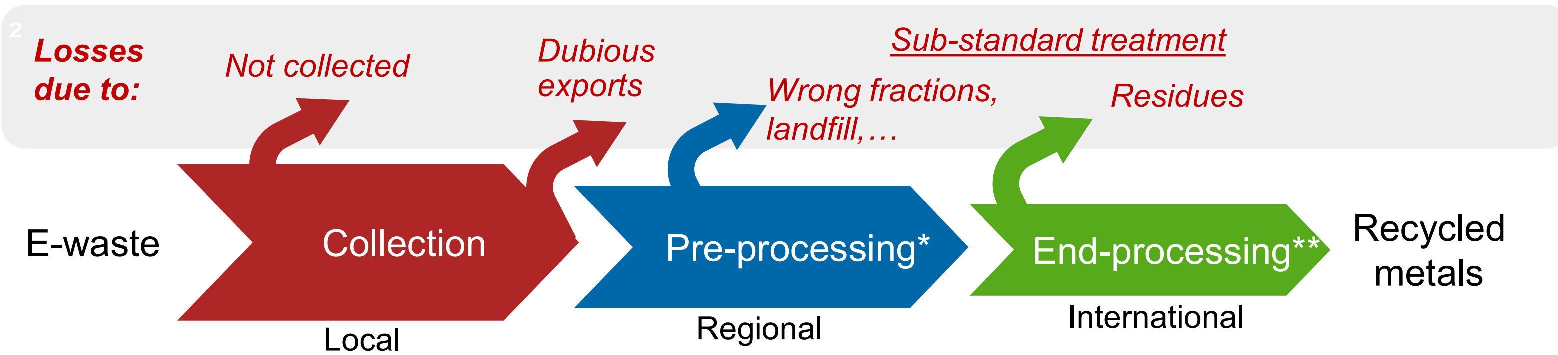
The first law of recycling

Be aware of an overambitious recycling efficiency target



The first law of recycling is that recycling only makes sense if there is a net environmental benefit. Recycling needs energy and chemicals and produces emissions and waste. If at a certain point in the recycling process, the process footprint becomes higher than the additional credits for saved environmental impacts thanks to additional recovered products, further recycling does not make sense. Even with innovation and scale leverage effects that could shift the optimum to a higher level of recycling, sooner or later all recycling processes come to an endpoint where further recycling results in net environmental damage.

Effective recycling requires optimised chains



Recycling efficiency determined by weakest link in the chain (usually collection)

e.g. Au yield: 50% X 70% X 95% = 33%

* manual-mechanical
** chemical-metallurgical

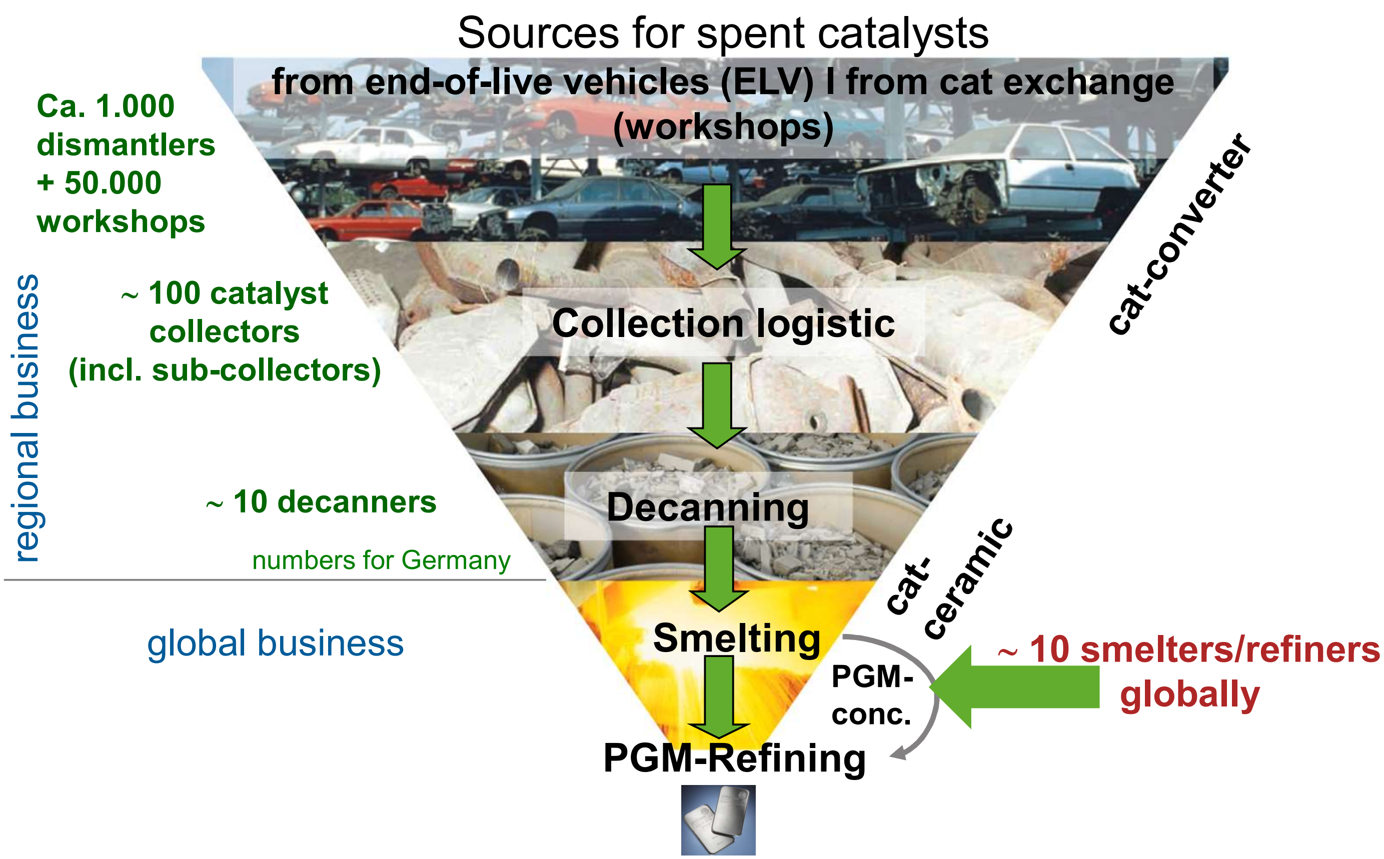
Main recycling drivers:

- Economic value, business models & legislation (if well enforced)

Main challenges:

- Insufficient collection, illegal waste exports, sub-standard treatment
  ⇒ high metal losses & environmental damage

Recycling chain for autocatalysts



Total efficiency determined by weakest step in the chain

Example: 90% x 70% x 95% x 98% = 59%

Dismantling - Collection - decanning - refining

Recycling supply contribution to autocat PGM demand (globally)

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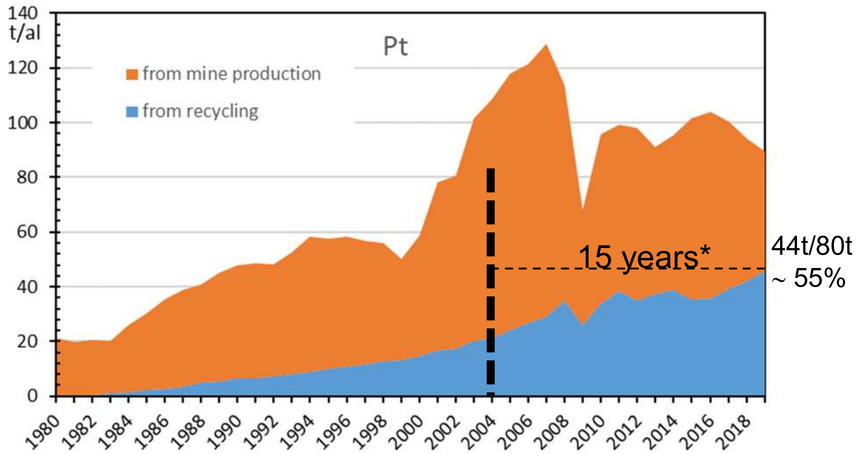
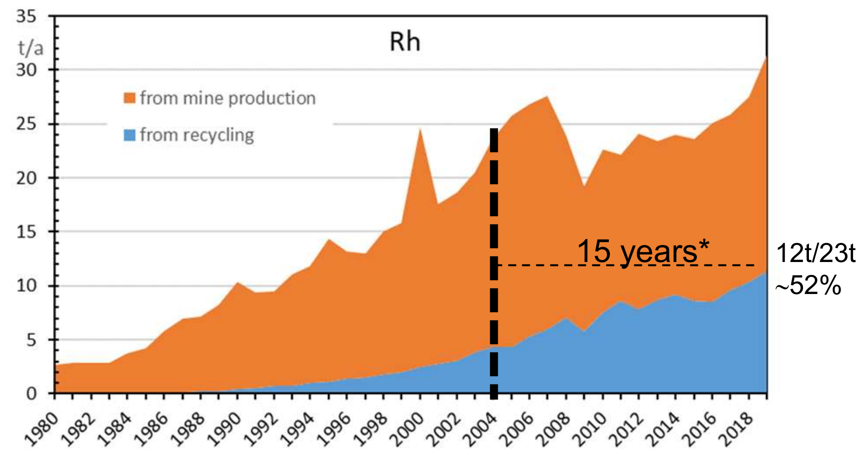
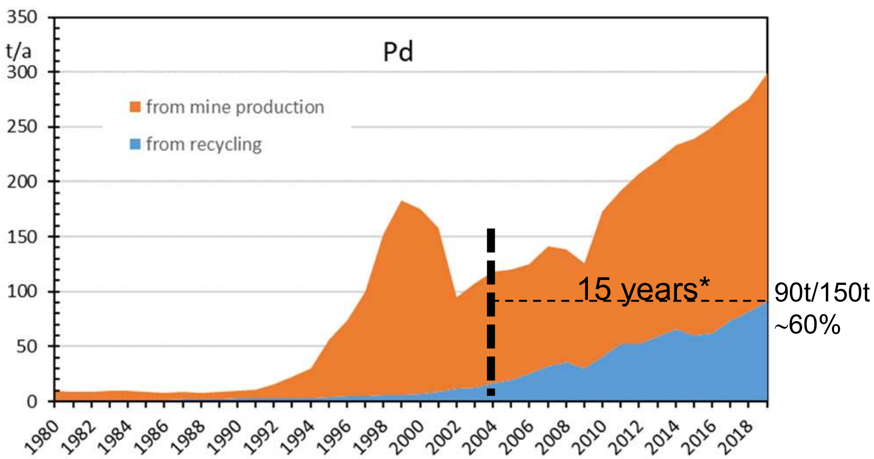






Recycling contribution 2019
(static recycling rate = "recycling input rate")

Pt: 51%, Pd: 31%, Rh: 36%

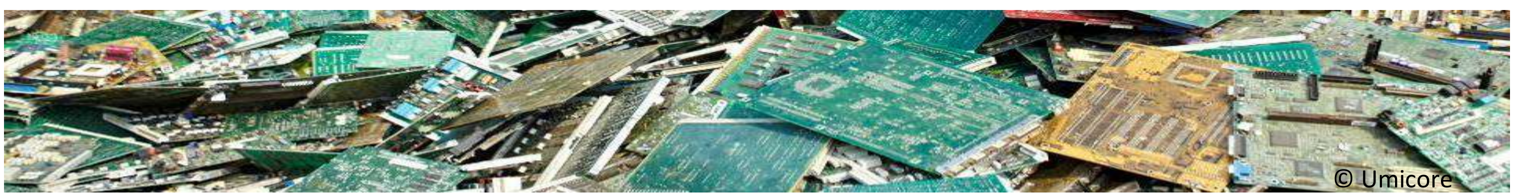
*~15yrs time between put on market and end of recycling ⇒ **dynamic = EoL recycling rate > 50 %**

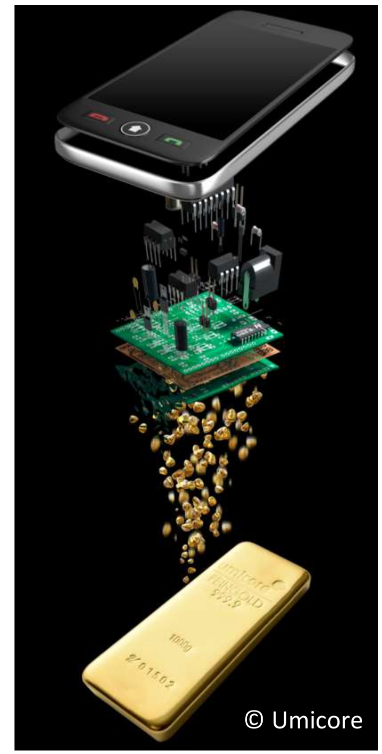
cumulated PGM demand	7830 t out of ~16000 t ever mined
recycled so far	1750 t
still on the road	≈ 4800 t
losses	≈ 1300 t

Example of an expensive product, containing gold …

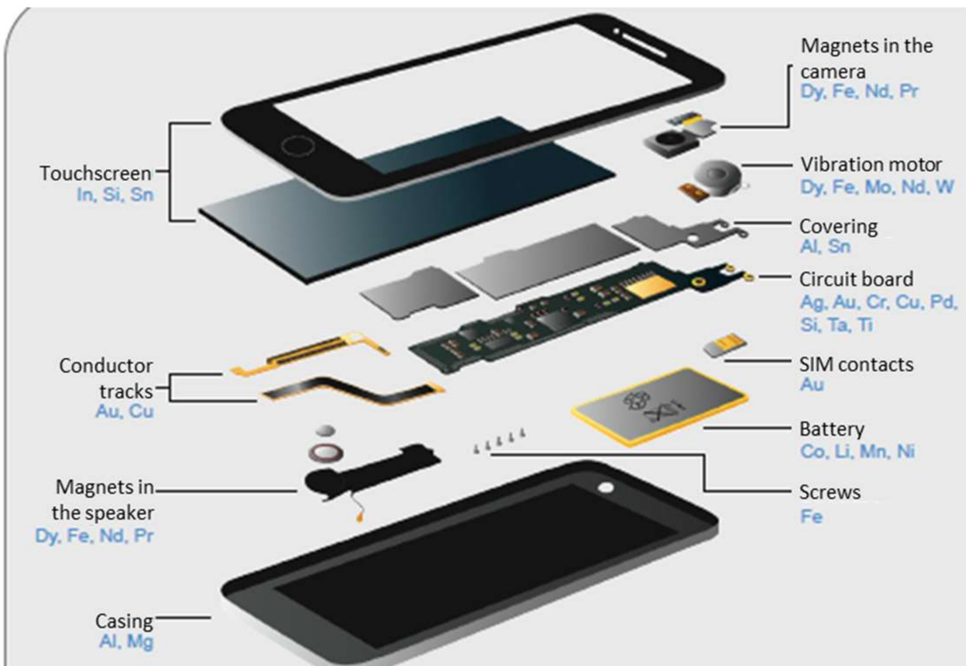
Mobile phones & E-scrap, a complex mix …

- Precious metals: Ag, Au, Pd…
- Base & special metals: Cu, Al, Ni, Sn, Zn, Fe, Bi, Sb, In…
- Hazardous substances: Hg, Be, Pb, Cd, As, …
- Halogens (Br, F, Cl...)
- Plastics & other organic materials
- Glass, ceramics, wood, …

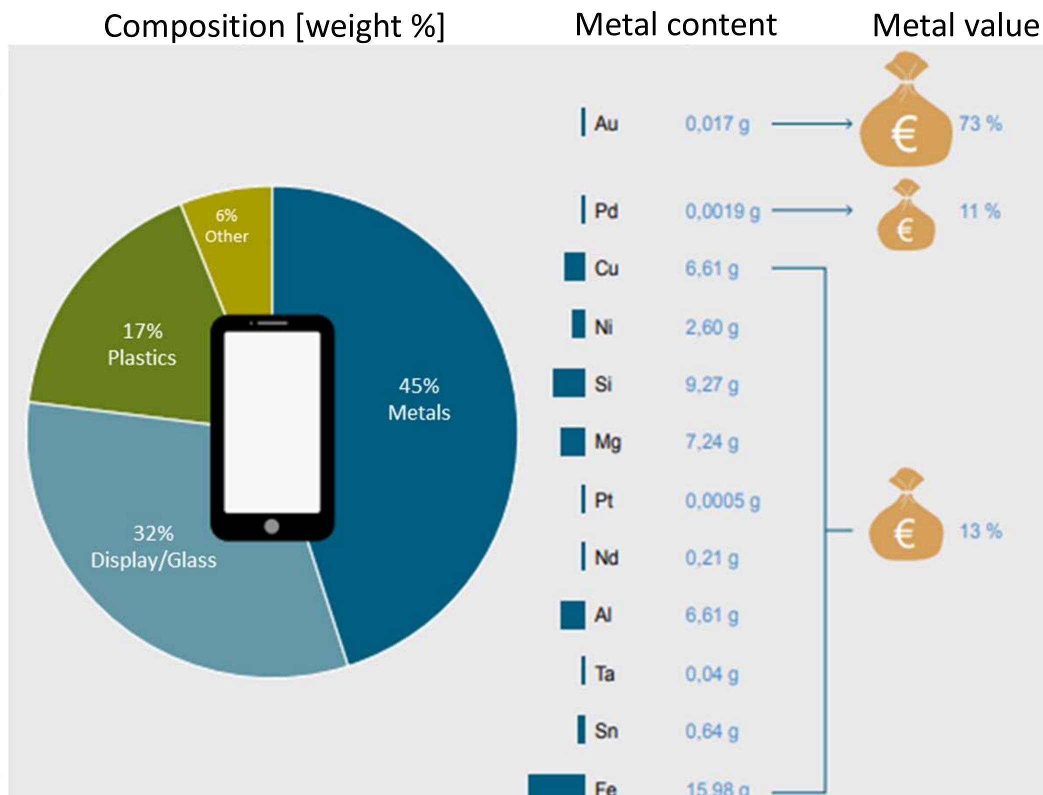




∅ Metal value in a smart phone ≈ 1.10 € (@ prices ∅ Jan-Jul 2020)



[Bookhagen, Bastien (2020)]



[Bookhagen, Bastien (2020)]

Accumulation needed for economic viability

Gross metal value of 1 smart phone: ~ **1.1 €**

Net metal value of 5 t (~ 50,000 units) of mobile phones at gate of Umicore recycling plant: ≤ **50,000 €**

Gross metal value of 1.8 Billion mobile phones sold globally in 2019: ~ **2 Billion €**

Reality Check

Quality recycling of metals in a circular economy

Highly efficient recycling processes available

Umicore process yields: >> 95%

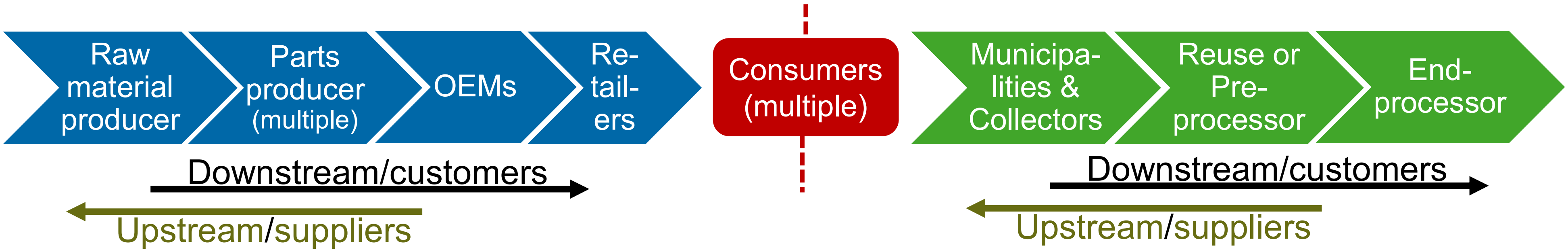
	Jewellery, ingots, coins	Chemical process catalysts	Automotive catalysts	Electronic products
EoL-recycling rates*	**>> 90%**	**> 90%**	**~ 60%**	**~ 25%**
Recycling drivers:	**+ value**	**+ B2B, + value**	**- B2C, + value**	**- B2C, + legislation**

But disappointingly low recycling rates for many consumer products (B2C), considering the entire product lifecycle

* of Au, Ag, Pt, Pd, Rh, global averages

Current barriers to closing the loop

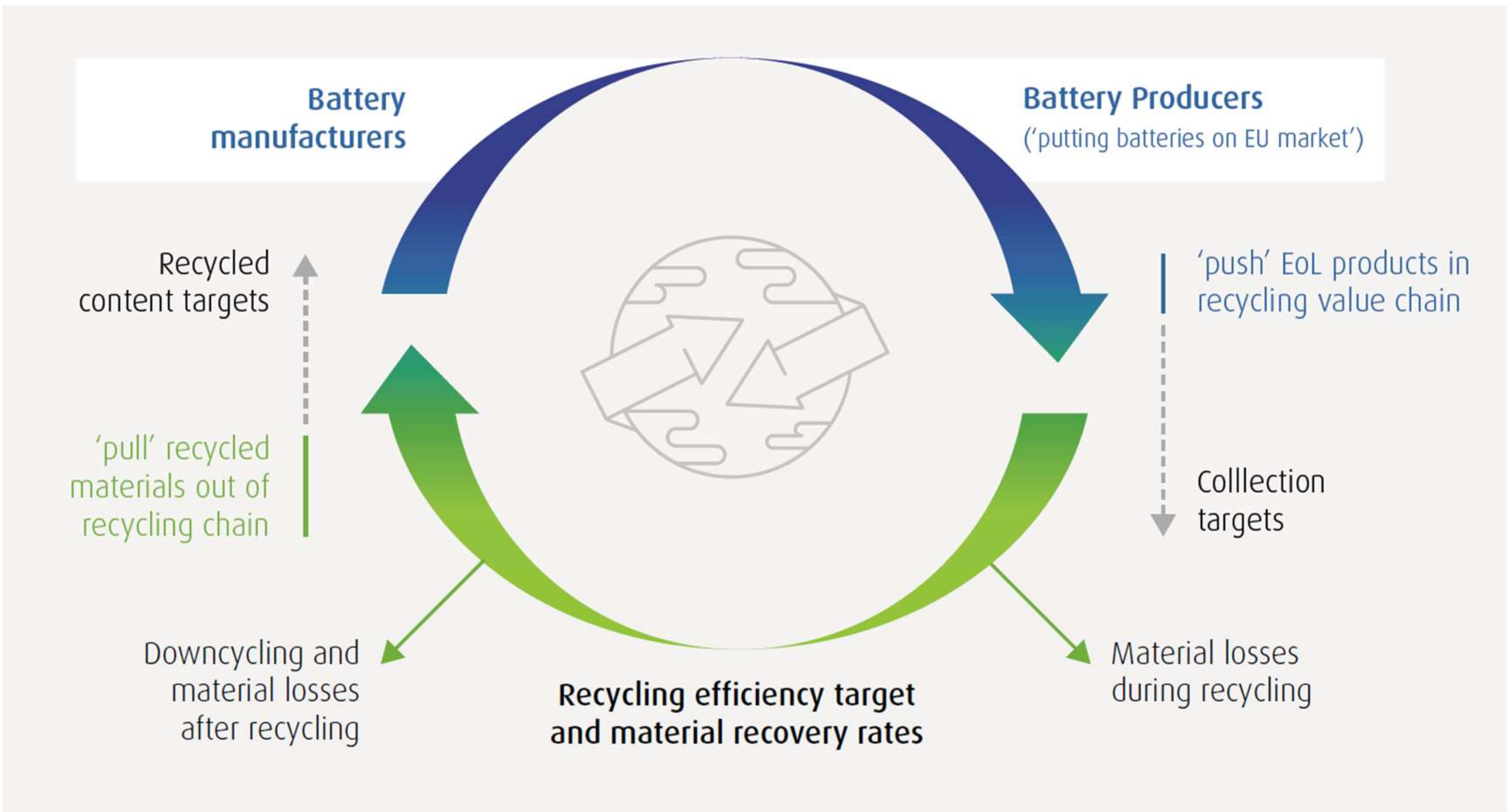
Lifecycle is disconnected @ consumer → 2 <u>independent</u> value chains in <u>B2C</u>



- Missing system approach & overarching collaboration, instead focus on direct customer/supplier interfaces
- No real incentives for OEMs for durable, well repairable & recyclable products
- Little knowledge (and interest) on "fate" of products after their distribution
- Processes, tools and financial systems in companies are tailored to linear business
- @ EoL: More focus on costs/prices than on recycling quality
- Current EPR systems do not reward comprehensive and good recycling, high cost pressure
- OEM focus so far on legal compliance & image, less on genuine circular business models
- Current reported recycling rates do not reflect the physical truth
- Weight based recycling rates focus on mass materials, no incentive to recover low-grade (critical) metals

Recycling concepts in the proposed Battery Regulation

All needed or overshoot?



Key takeaways

- Value chain & application complexity
- Value recycling is like a sailing boat
- Efficient recycling does not make a circular model
- Bridge the Business-to-Consumer and Consumer-to-Business
- Fit-for-purpose policy crucial

Thank you