Recyclability of materials & products

Overcoming technological and legal boundaries

Markus A. Reuter

AGENDA

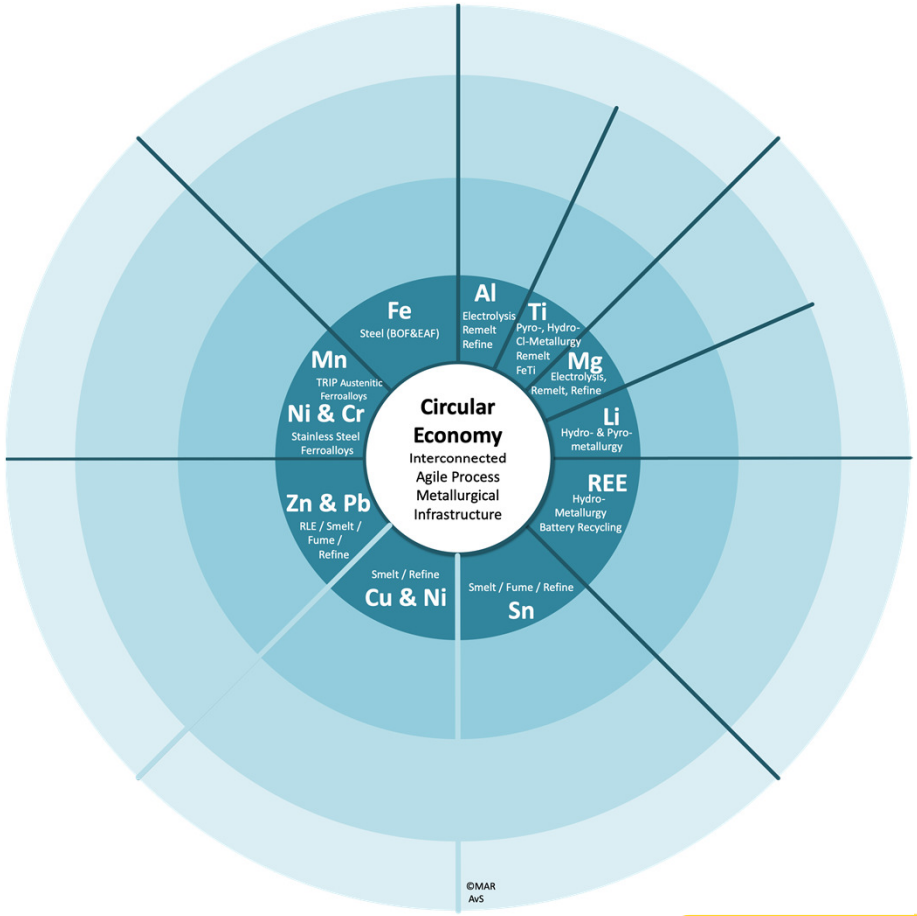
- Metals enable future® (Metalle vernetzen Zukunft®)

- The fundamental role of metallurgy in a circular economy (CE)
  - Metallurgical system provide the metals for renewable energy technologies
  - It enables recycling and maximizes impact of Design for Recycling

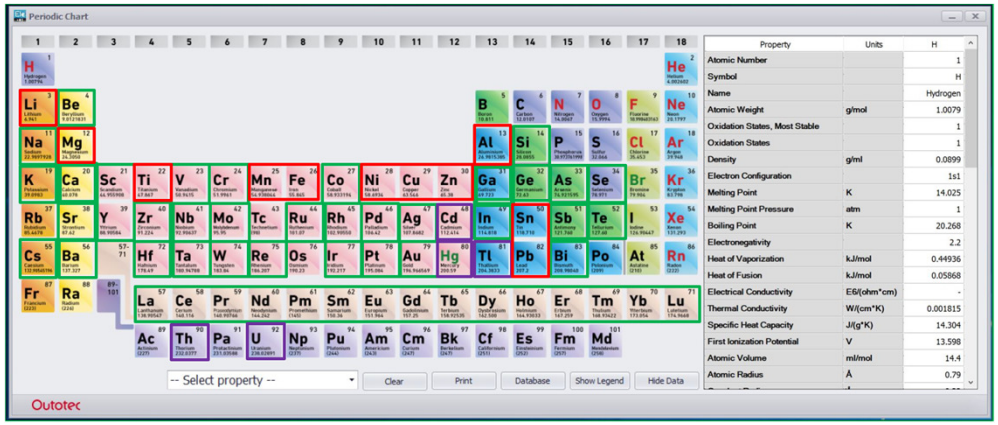
- Policy Recommendation
  - Metallurgical infrastructure criticality should be a focus of the EU's circular society rather than element criticality only!

METALS ENABLE FUTURE® (METALLE VERNETZEN ZUKUNFT®)

METALS ARE THE BALL BEARING OF THE CIRCULAR ECONOMY



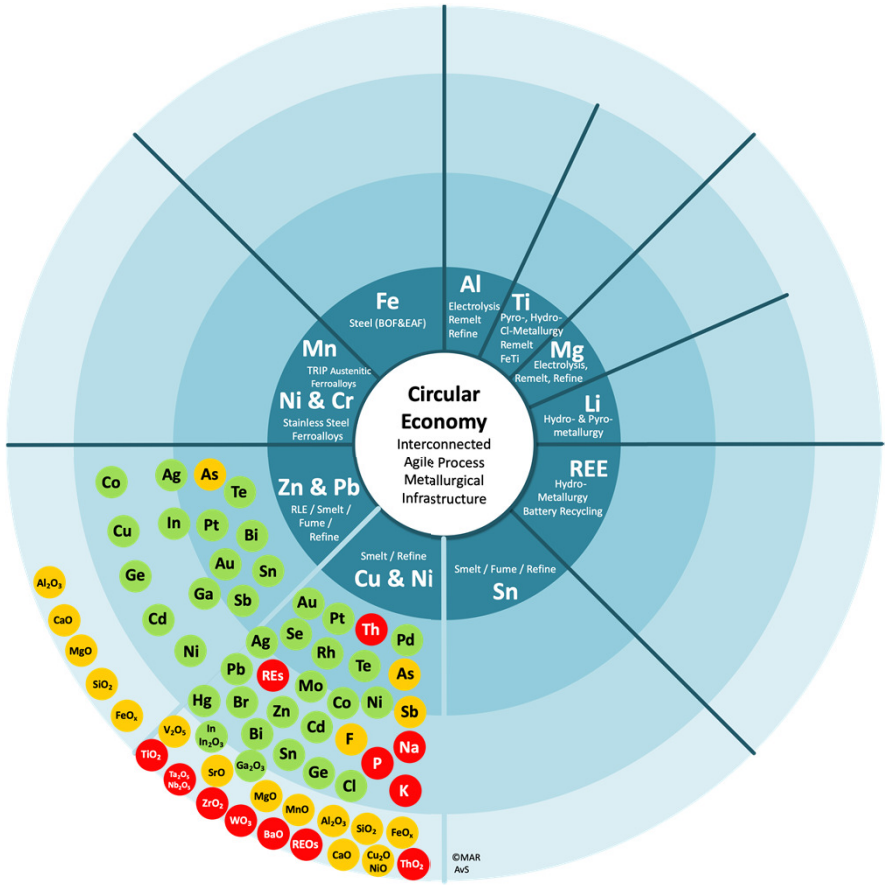
WHERE DO ALL ELEMENTS & COMPOUNDS GO IN THE CE?



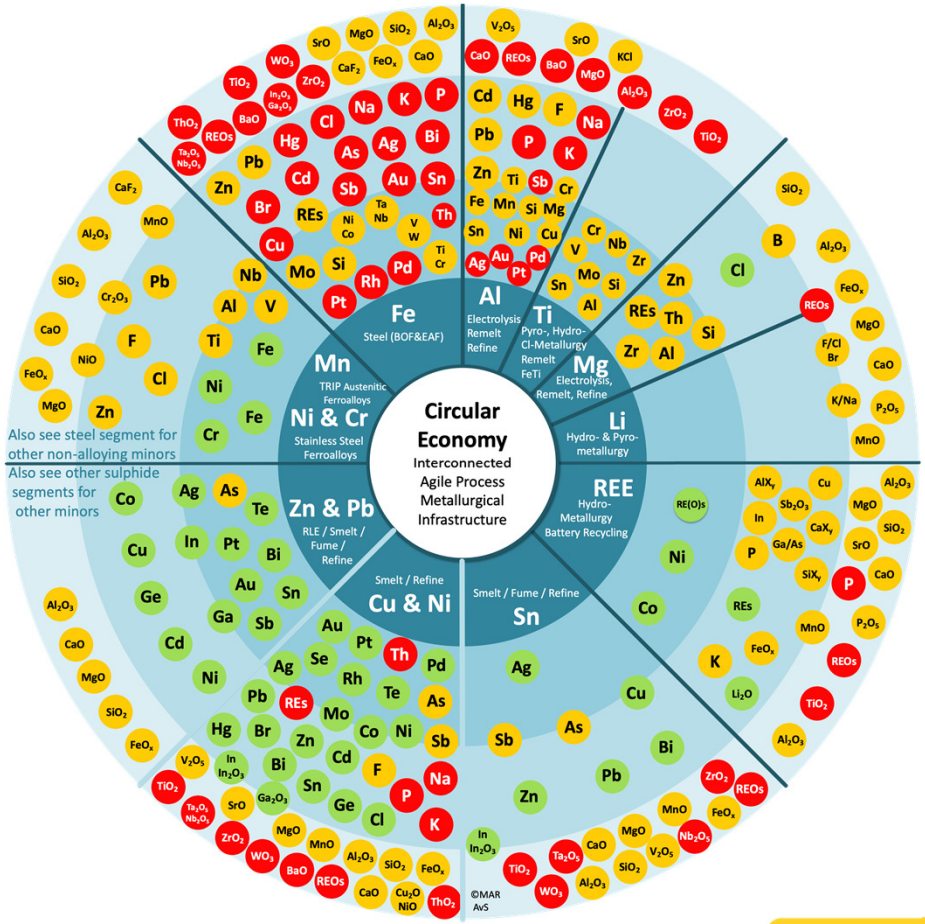
Base/Carrier Metals

Technology Elements

Accompanying (minor) elements

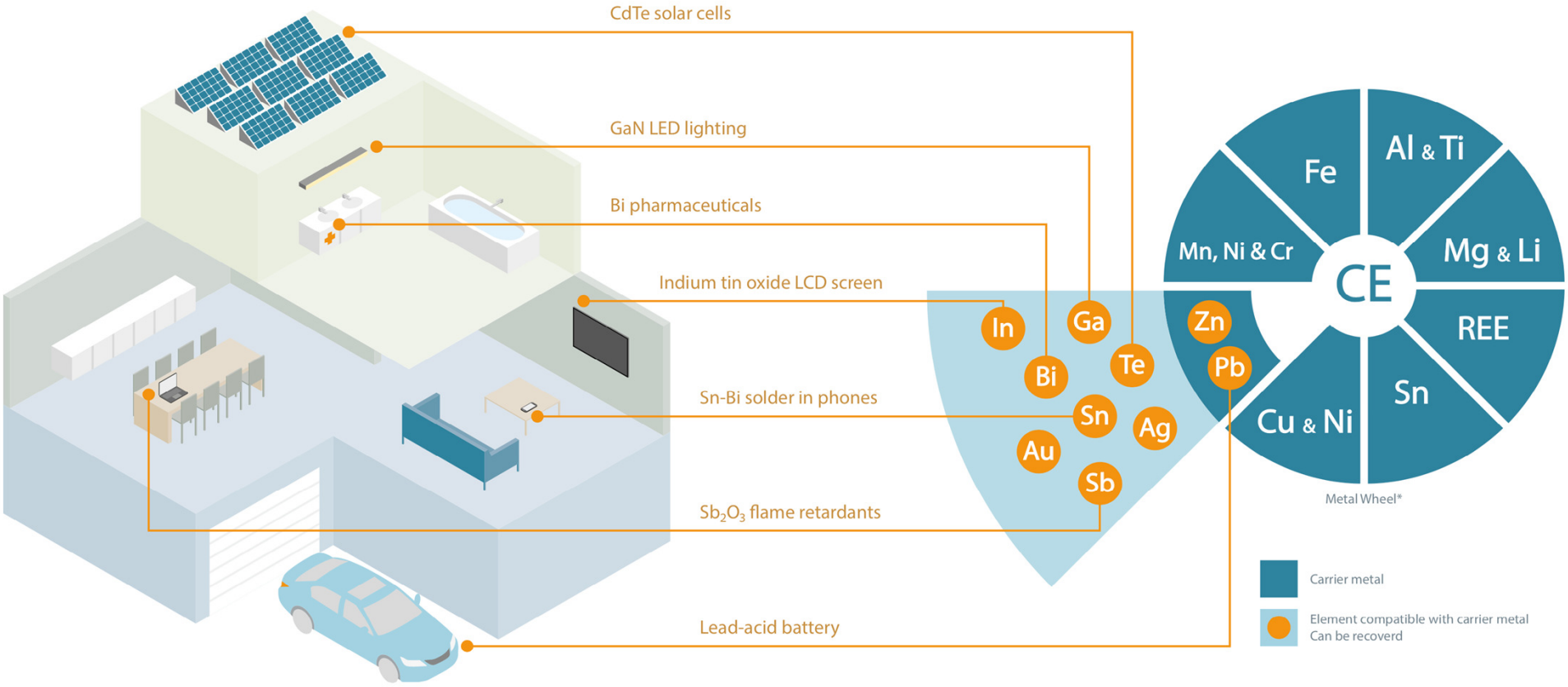


THE BEAUTY AND HARMONY OF METALLURGY



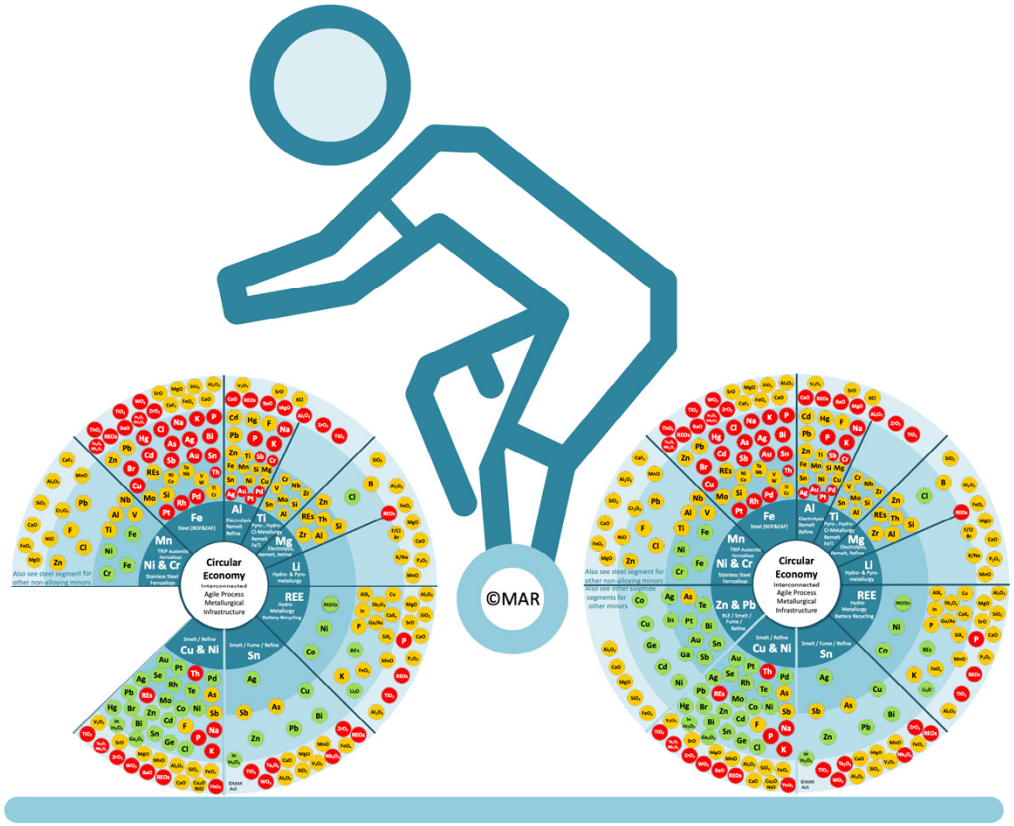
Green: Recovered
Orange: Recovered if economics work
Red: Lost

COMPLEXITY OF THE CE SYSTEM, METALLURGY & RECYCLING



Blanpain, Reuter, Malfliet (2019): Lead Policy Brief: https://www.linkedin.com/feed/update/urn:li:activity:6531862315858423808

THE WHEELS OF THE CE DON'T TURN, DESIGN FOR RECYCLING HAS NO VALUE IF A SECTOR IS REMOVED BY UNWISE POLICY



THE FUNDAMENTAL ROLE OF METALLURGY IN A CIRCULAR SOCIETY

Policy Brief

SOCRATES Zero Waste
EU MSCA-ETN

February 2019

Bart Blanpain
Markus Reuter
Annelies Malfliet

Lead Metallurgy is Fundamental to the Circular Economy

Metals are eminently recyclable, and by recycling and refining complex materials, the EU's interconnected metals sector is responding to the increasing scarcity of certain metals. In this way, we are delivering and recovering the technology and base metals for the EU's Circular Economy (CE). Moreover, metals are at the heart of the energy infrastructures that now run Circular Cities, and they will play an even greater part in the future. One of these metals is lead. With respect to this familiar metal, industry is fully aware that in order to keep on using it, the associated risks need to be well managed at all times. Importantly, lead is a key enabler in the CE, as it is capable of dissolving and carrying a multitude of technology elements. The recovery and recycling of several critical technology elements is based on refining them from lead through well-developed metallurgical processes in which the lead acts as a carrier metal. Limiting lead metallurgy would have a detrimental impact, not only on the lead industry itself, but on all the industries linked to it. It is therefore critical that we maintain and further develop the lead infrastructure and know-how in Europe. To put it simply, lead metallurgy is fundamental if the EU wants to retain its leading position in the global CE.

Executive Summary the 5 lessons learned:

- **Lesson 1:** Lead is frequently seen as a problematic metal that can be detrimental to human health; what is much less well known is its fundamental role in extractive metallurgy and how this is closely associated with the Circular Economy.
- **Lesson 2:** Molten lead has unique properties that means it can act as an efficient liquid carrier for critical raw materials such as In, Bi, Cd and Te.
- **Lesson 3:** Restricting lead metallurgy in the EU would not only have a detrimental impact on the lead industry, but also on all the industries linked to it that work with elements like Ag, Cu, Sb, Sn, Te, and Zn.
- **Lesson 4:** The focus must be on correctly and comprehensively minimising the risks of lead-containing materials for society and carefully managing them, rather than attempting to ban the use of lead.
- **Lesson 5:** An environmentally friendly and energy-efficient lead infrastructure together with the associated research and know-how in Europe is absolutely vital if the continent is to maintain its global leadership in the Circular Economy.

European Commission
This project has received funding from the European Union's EU Framework Programme for Research and Innovation Horizon 2020 under Grant Agreement No 690088
SOCRATES Zero Waste EU MSCA-ETN
This project has received funding from the European Union's EU Framework Programme for Research and Innovation Horizon 2020 under Grant Agreement No 721385

https://kuleuven.sim2.be/wp-content/uploads/2019/02/SOCRATES-Policy-Brief-2019-Lead.pdf

RE / THINK

DESIGN FOR RECYCLING

Inconvenient truths of the circular economy

Everyone's talking about recycling. It feels like Europe is the global leader in this area. "Unfortunately, that's not always the case," says metallurgy and recycling expert Prof. Dr. Dr. h.c. mult. Markus Reuter. He's been researching and implementing system methods and technology in this field both in academia and industry for over 35 years, sometimes drawing attention to inconvenient truths and challenges – but also pointing out opportunities for a better future.

Prof. Dr. Dr. h.c. mult. Markus Reuter has been director at the Helmholtz Institute Freiberg for Resource Technology (HIF) since 2015. He is involved in the topics of recycling, recycling-friendly product design, resource efficiency, and process metallurgy.

PROF. REUTER, EUROPE IS NOW RECYCLING MORE THAN EVER. ISN'T THAT ENOUGH?

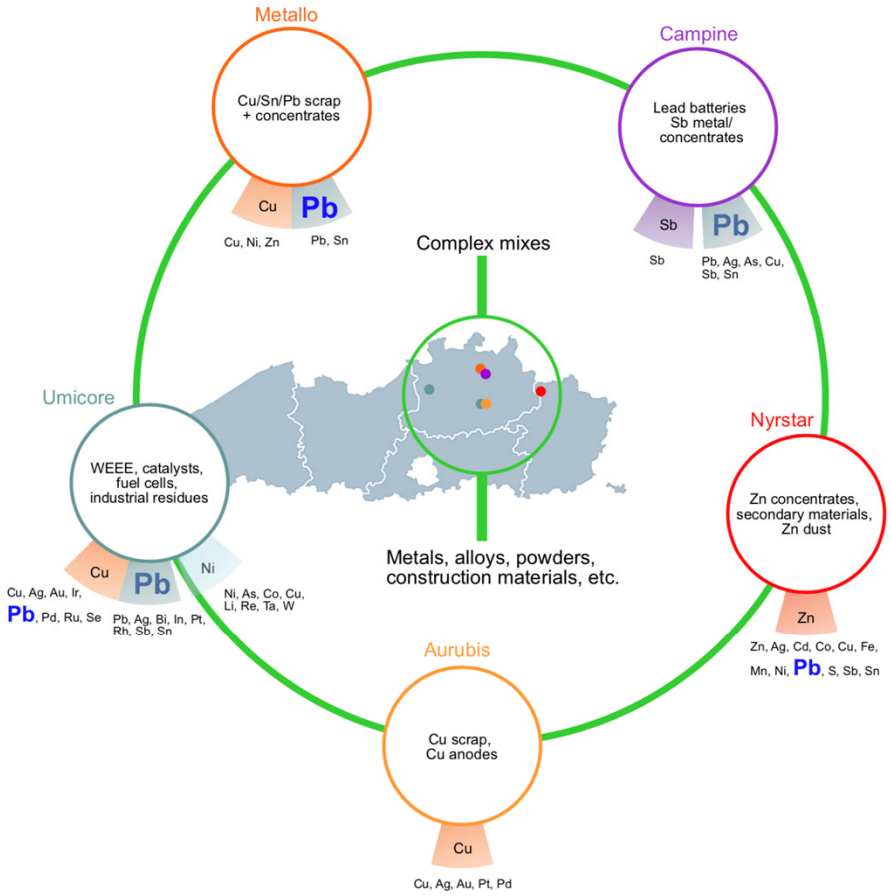
Recycling doesn't end when dropping something into the garbage can. True recycling recovers and produces valuable, high-purity raw materials from old products for reuse in high-tech products. Consider your smartphone: it is a complex functional mix of metals, plastics, and glass. One does not require much of an imagination to picture how complex it is to physically and chemically separate these components again to ultimately retrieve the metals. It's just about as difficult as recycling your morning cup of coffee into its ingredients, so pure water, sugar, milk, and coffee. There are no simple answers here – at some point, the amount of effort also outweighs the value of the metal content. This knowledge should prompt a consciousness shift in our utilization of our limited resources.

THAT'S WHY THE EU IS PRESSING AHEAD WITH THE CIRCULAR ECONOMY (CE), RIGHT?

The image of the closed loop of the CE is a convenient one. It conveys the impression that everything that enters the cycle also emerges in a way that can ultimately be used again without the use of energy. The inconvenient truth is that closing the loop is impossible! Therefore, an honest discussion involves speaking transparently about losses in the process: in the form of energy, metals, and dust, for example. There are technological and economic limits to closing the loop. As a result, policy conditions are necessary that promote recycling instead of hindering it.

https://geschaeftsbericht2018-19.aurubis.com/magazin/rethink/design-for-recycling

CRITICALITY OF THE METALLURGICAL INFRASTRUCTURE



Blanpain, Reuter, Malfliet (2019): Lead Policy Brief

CE DIGITAL TWIN OF PV AND BATTERY MANUFACTURE

223 metallurgical processes, 860 streams, 30 elements + all their compounds

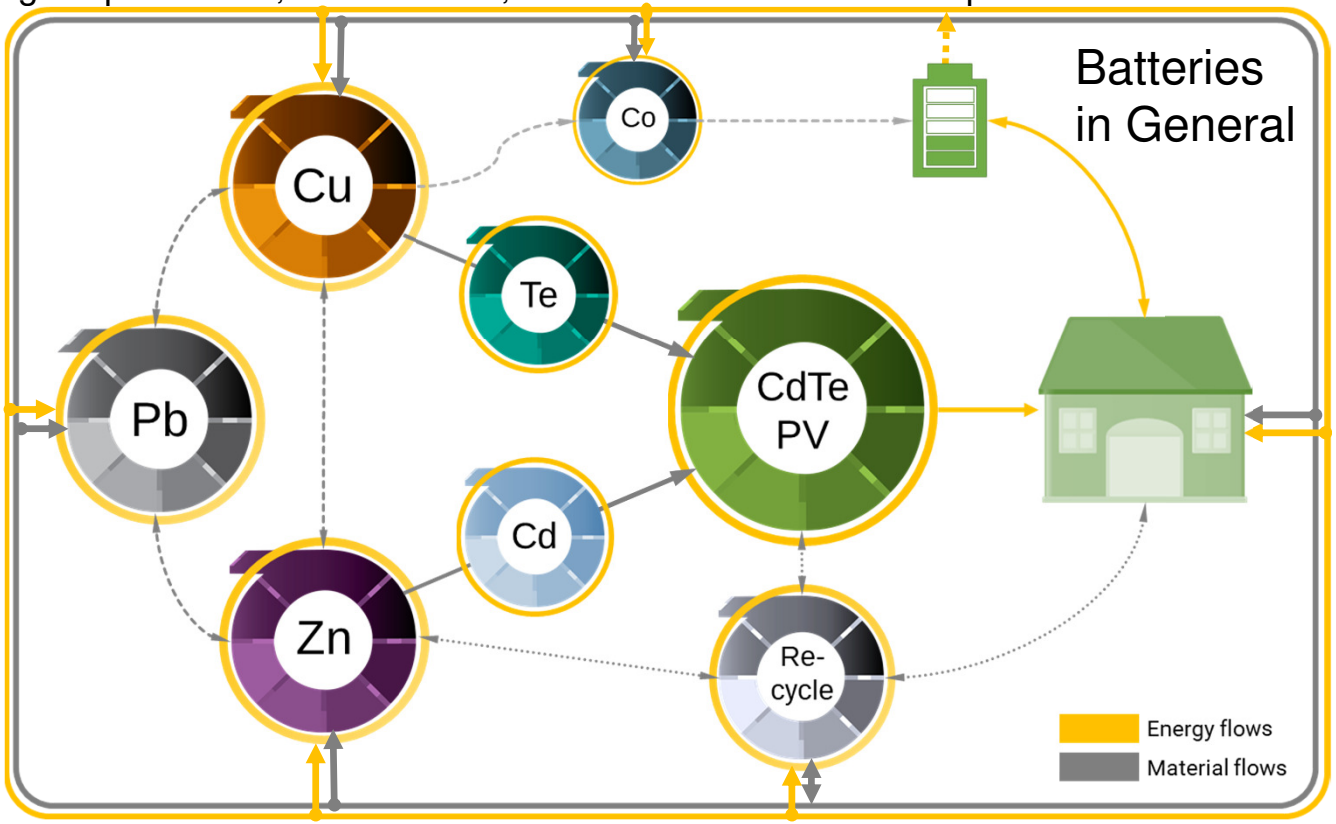
Water

Chemicals

Electricity

Fuels & reductants

Capital goods (Iron / steel Cement)



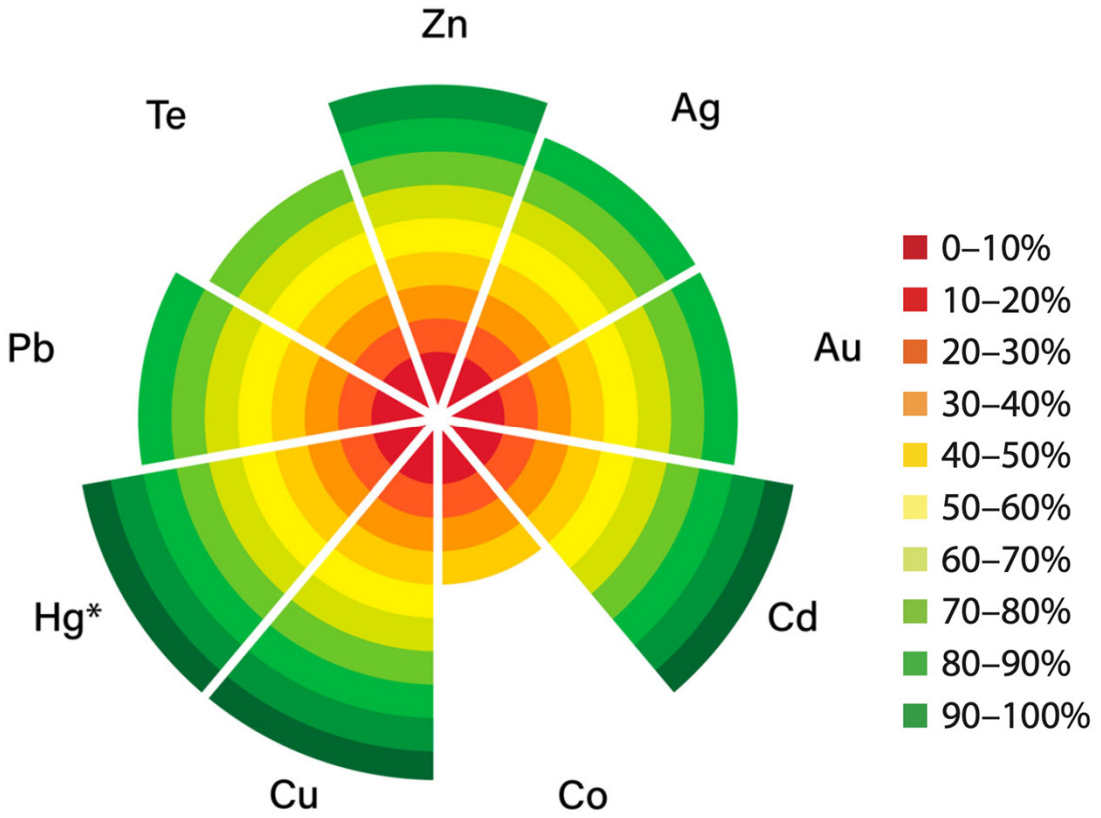
Emissions, impacts

Dissipative losses
- materials
- exergy

→ HSC Sim Simulation

Bartie et al. (2019): The simulation-based analysis of the resource efficiency of the circular economy – the enabling role of metallurgical infrastructure, Mineral Processing and Extractive Metallurgy (TIMM C) (online).

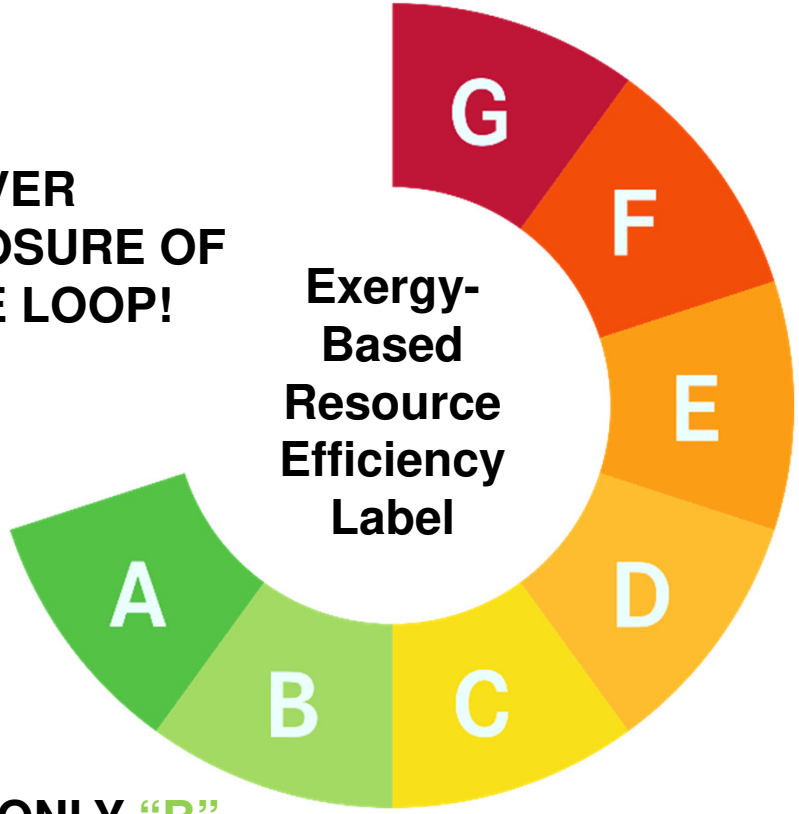
THE RECYCLING LABEL FOR GOODS & PRODUCTS



M.A. Reuter, A. van Schaik, J. Gutzmer, N. Bartie, A. Abadías Llamas (2019): Challenges of the Circular Economy - A material, metallurgical and product design perspective. Annual Review of Materials Research, 49, 253-274.

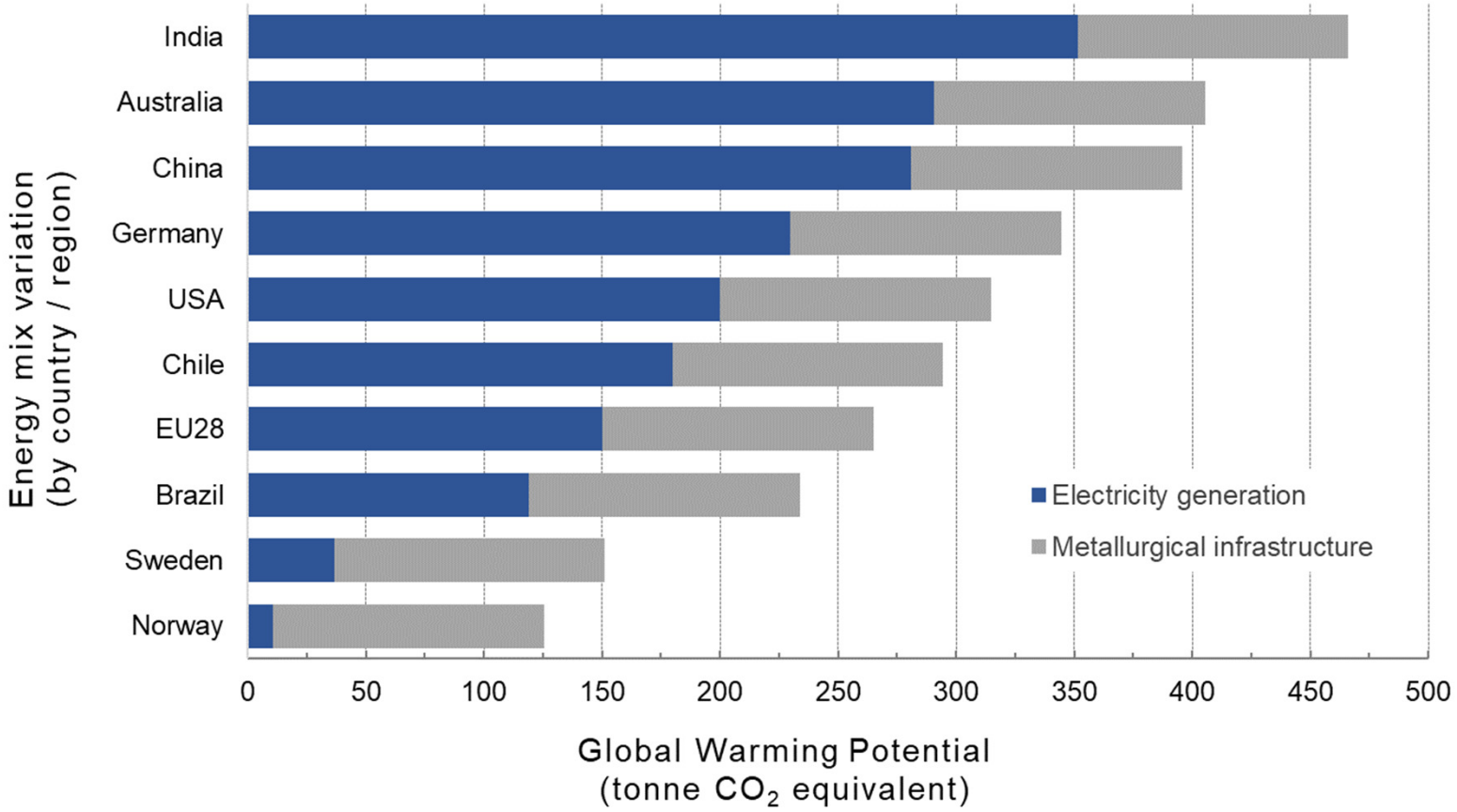
EXERGY RESOURCE EFFICIENCY LABEL FOR THE SYSTEM

NEVER CLOSURE OF THE LOOP!

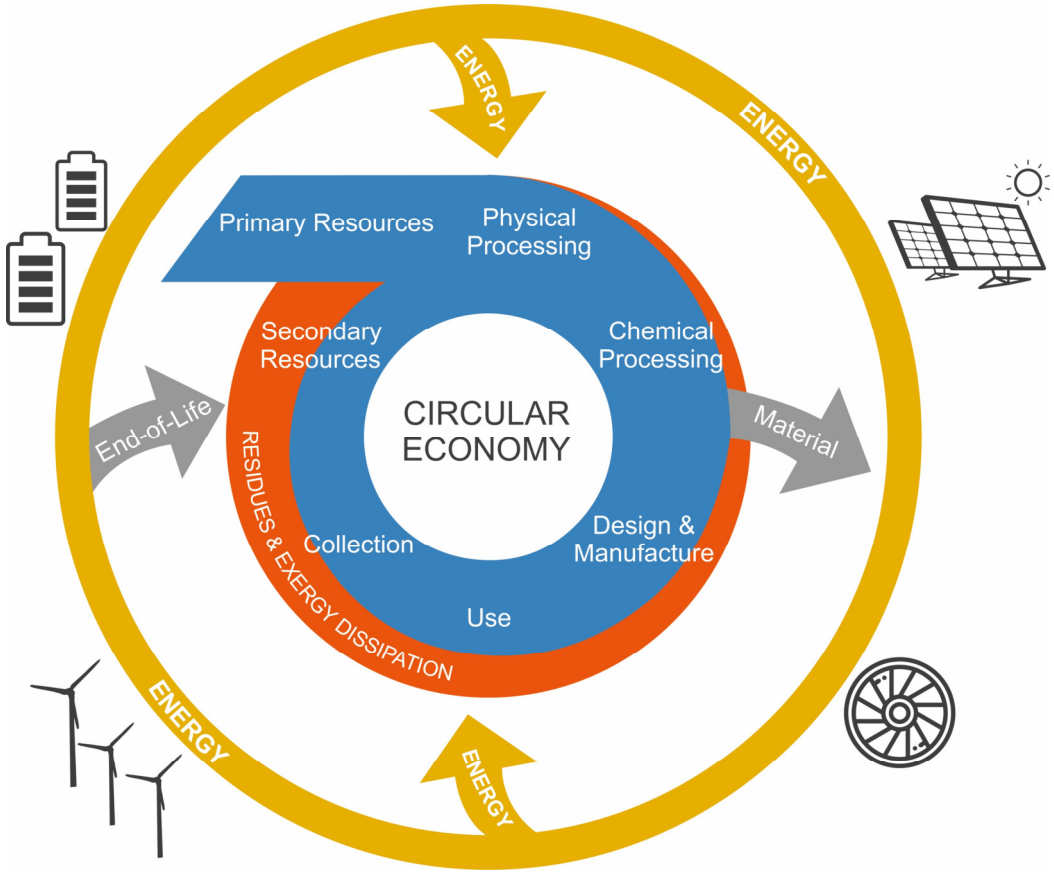


PV SYSTEM ONLY "B"
ca. 55% EFFICIENT, REST IS LOST!

THE FOOTPRINT OF THE COMPLETE SYSTEM



INCOVENIENT TRUTH OF THE CE: IT IS A DOWNWARD SPIRAL!



Abadías et al. (2019): Simulation-based analysis of the circular economy system: Zinc production coupled to CdTe photovoltaic module life cycle as industrial examples, Journal of Sustainable Metallurgy (online).

POLICY RECOMMENDATION

Metallurgical processing infrastructure is critical to a circular society, not only element criticality.

Physics based recycling and resource efficiency labels are required to provide a true basis for the economic evaluation of the CE system