TUBAF
Die Ressourcenuniversität.
Seit 1765.

EIN BLICK IN DIE ZUKUNFT DES RECYCLINGS DER ENERGIESPEICHER - BATTERIE UND WASSERSTOFF

Energy Saxony SUMMIT 2023

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Clean Energy – Technology

Bundesministerium
für Bildung
und Forschung

www.wasserstoff-leitprojekte.de

Wasserstoff
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Clean Energy – Technology:
Functional chemical elements = critical raw materials

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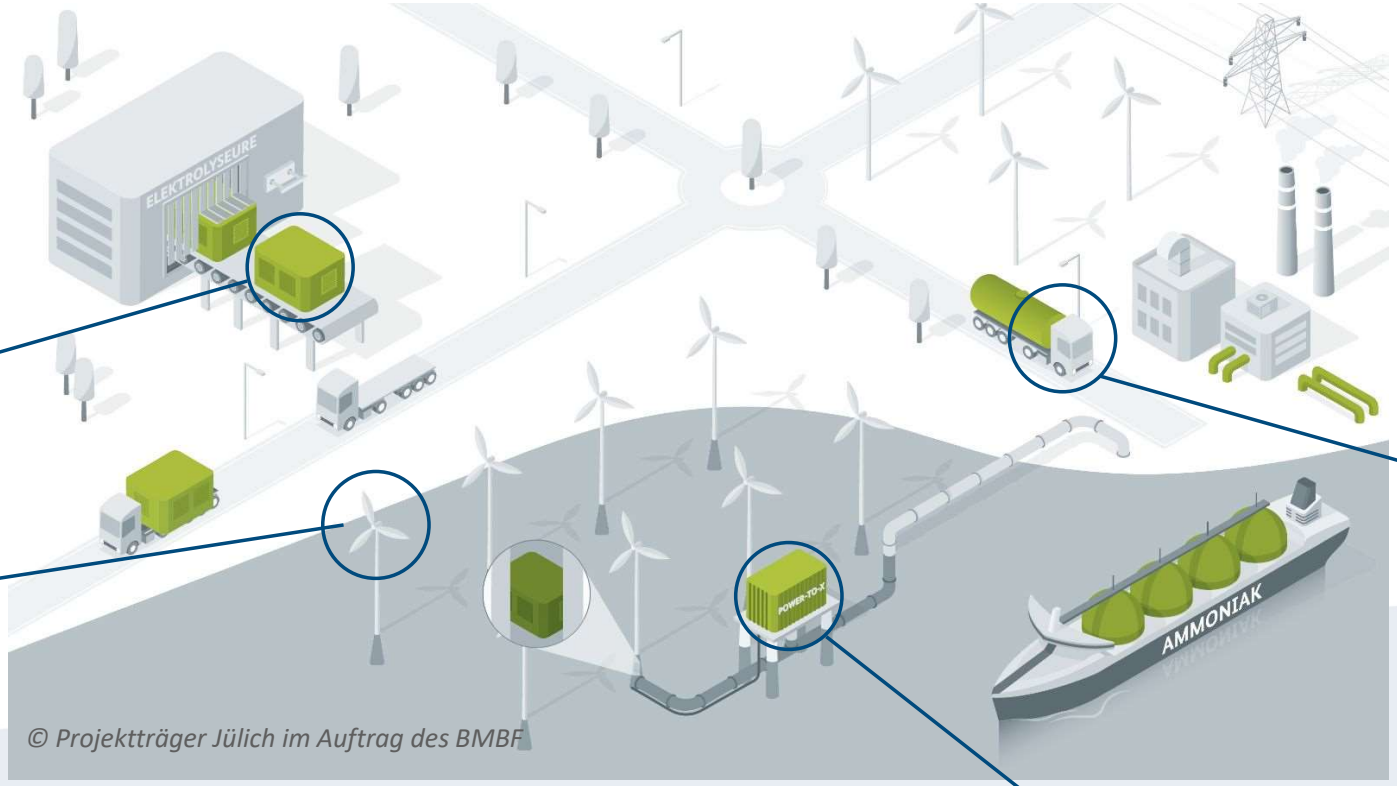
Electrolysis:
Ir, Sc, Ru, Pt, LREE, Ni,

Wind turbine:
LREE / HREE



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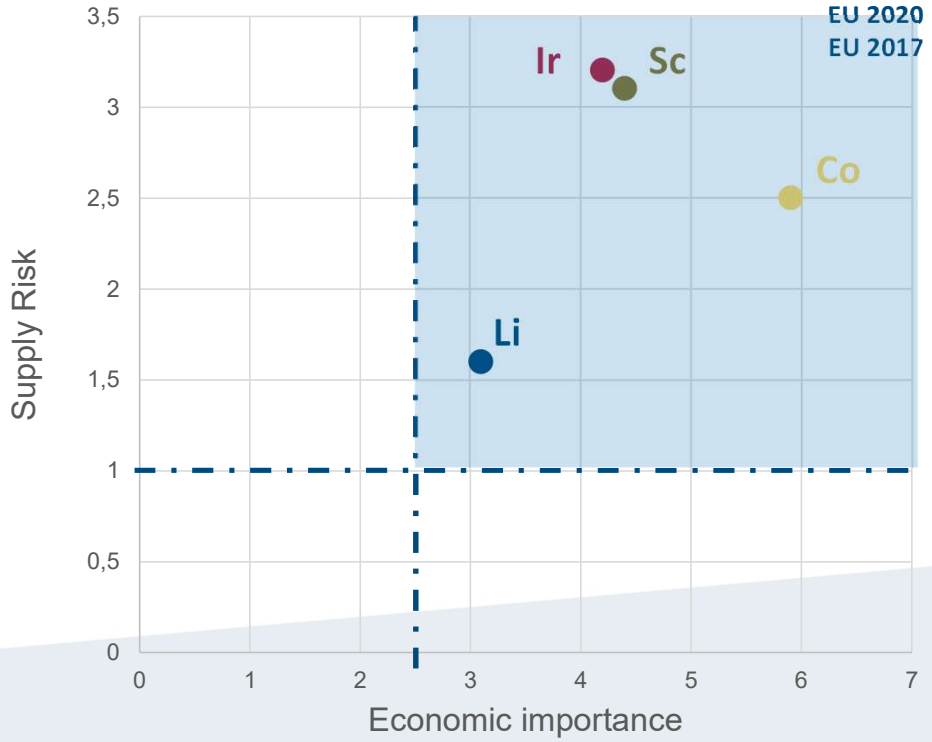
ELV:
Li, Co, Ni, Cu, Graphite

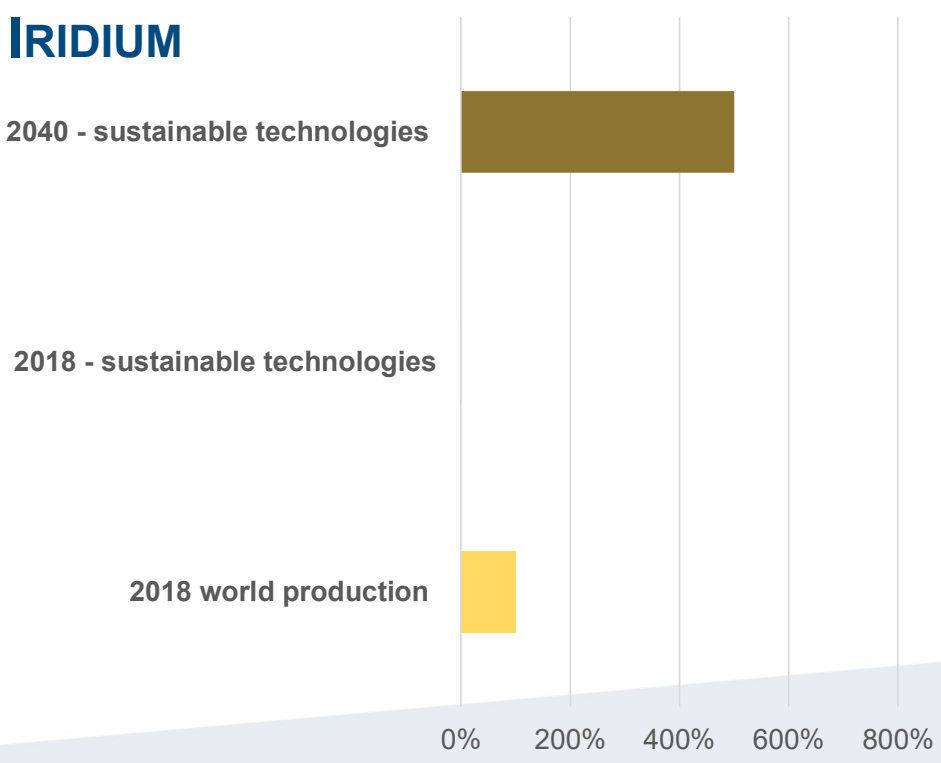
Catalysts:
Pt, Ru,

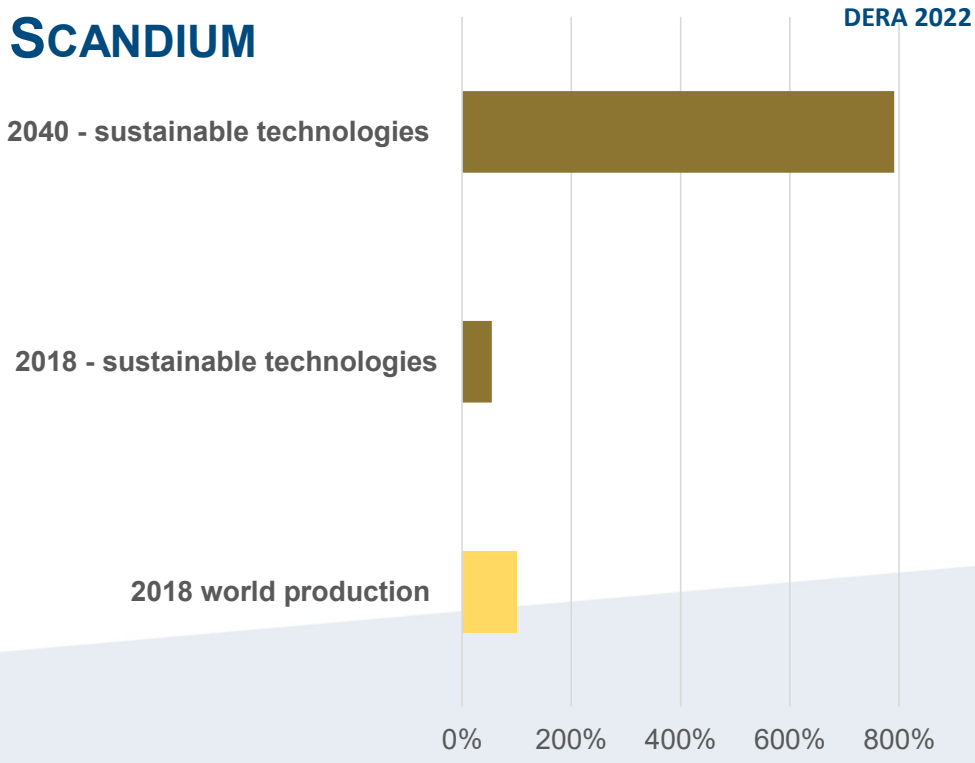
Criticality of raw materials

The EU Green Deal Communication adopted on 11 December 2019 recognizes access to resources as a strategic security question to fulfil its ambition towards 2050 climate neutrality and increasing our climate ambition for 2030

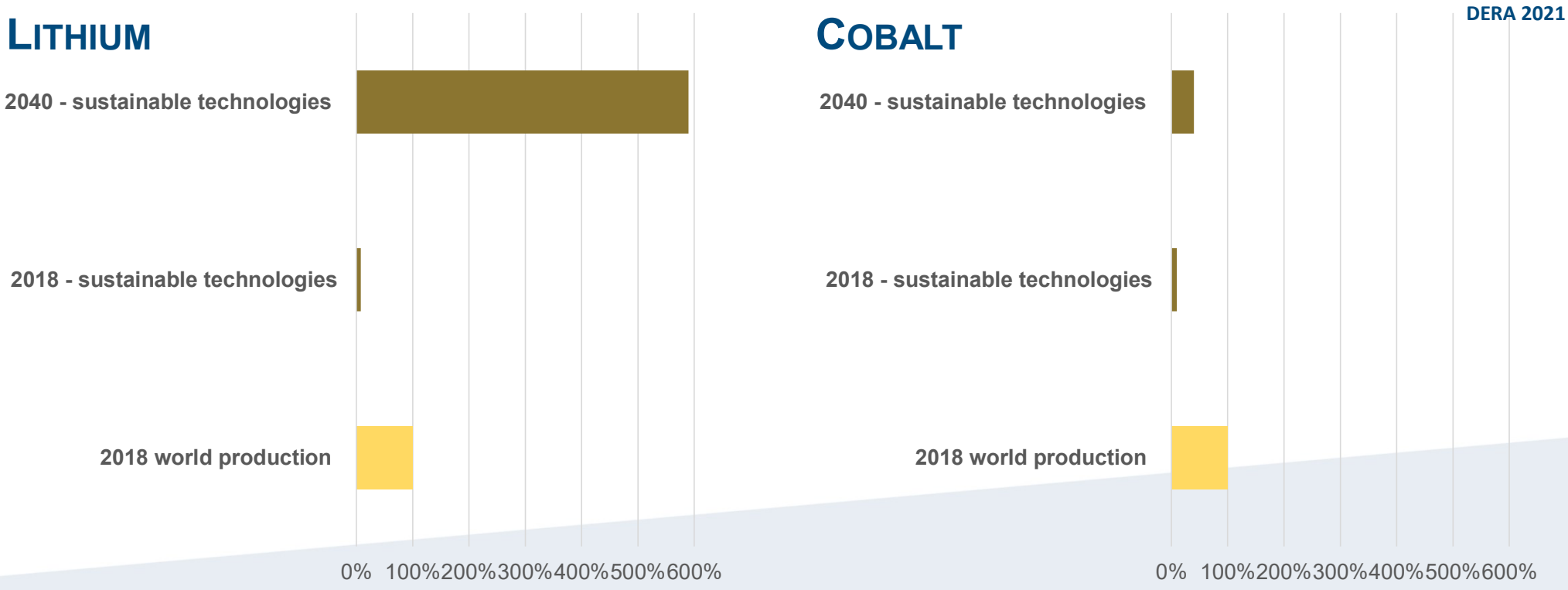


Availability of selected relevant critical raw materials for battery manufacturing (electrolysis technology PEM-EL / HT-EL)



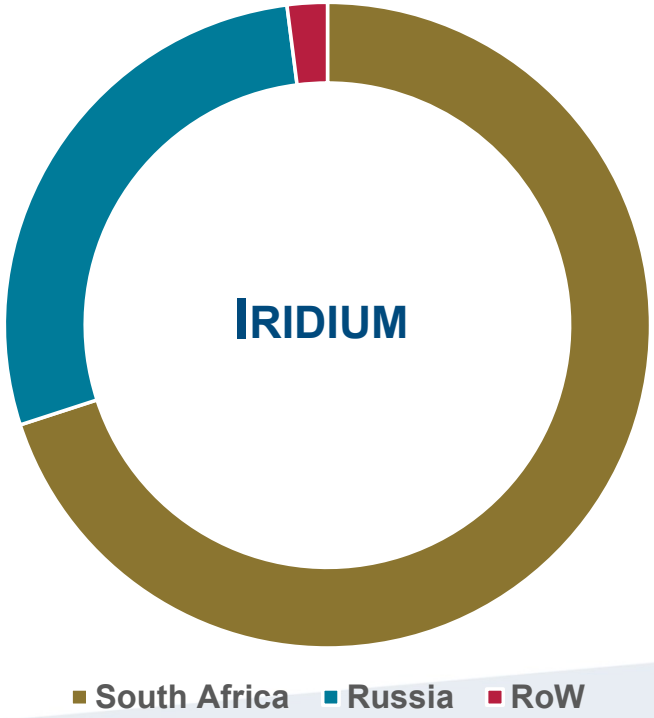


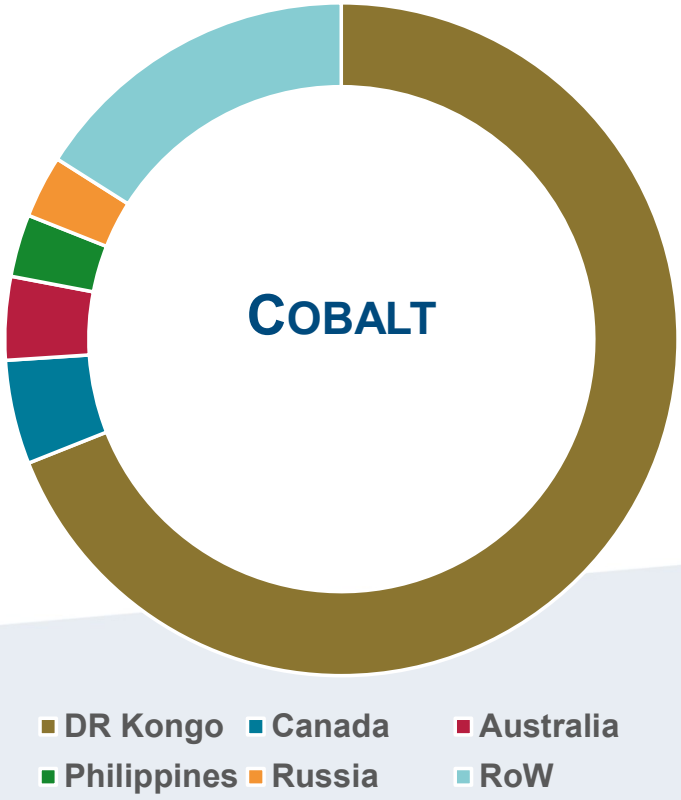
Availability of selected relevant critical raw materials for battery manufacturing (lithium-ion-batteries)



Geostrategic aspects of raw materials:
restricted number of potential suppliers – location in political / economic unstable regions

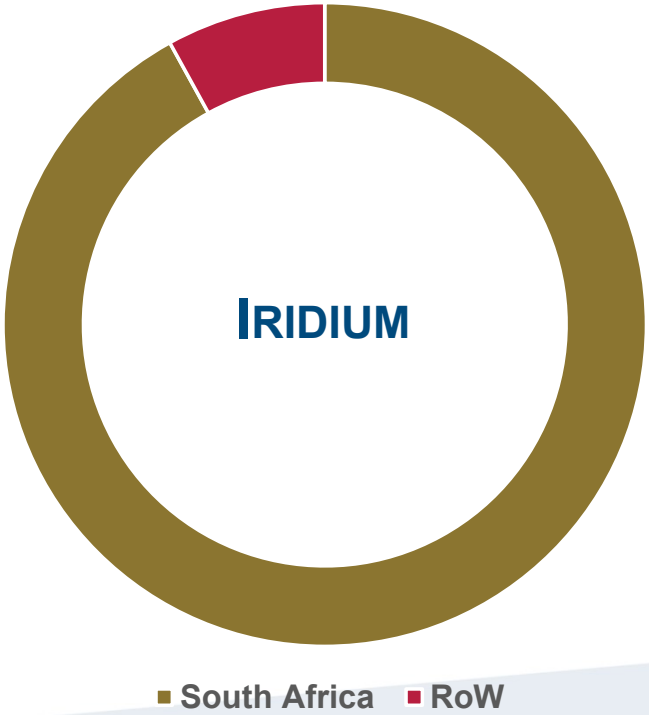
Minke, C. 2021
DERA 2021

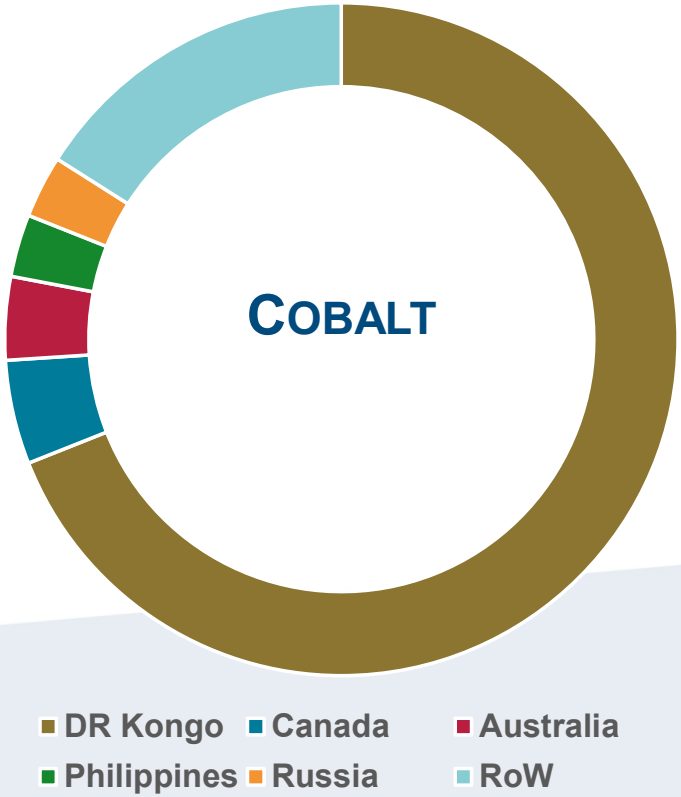




Geostrategic aspects of raw materials:
restricted number of potential suppliers – location in political / economic unstable regions

EU 2020
DERA 2021





Recycling and Recovery of critical raw materials

- Raw material are not ubiquitous
- Raw materials are an key factor for future technology development (and economic strength)
- Raw materials become a strategic aspect for future development
- The production (mining / processing refining) the of raw materials to introduce them into the materials cycle has a significant CO_2-impact

Keep the raw materials in the cycle!

- If there are no economic drivers – legislation can create drivers

Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL concerning batteries and waste batteries, repealing Directive 2006/66/EC

Measures	Option 2 - medium level of ambition	Option 3 - high level of ambition
5. Recycling efficiencies and recovery of materials	Lithium-ion batteries and Co, Ni, Li, Cu: • Recycling efficiency lithium-ion batteries: 65% by 2025 • Material recovery rates for Co, Ni, Li, Cu: resp. 90%, 90%, 35% and 90% in 2025	Lithium-ion batteries and Co, Ni, Li, Cu: • Recycling efficiency lithium-ion batteries: 70% by 2030 • Material recovery rates for Co, Ni, Li, Cu: resp. 95%, 95%, 70% and 95% in 2030

EP Debates - Tuesday, 13 June 2023 - Strasbourg

Green Deal: EU agrees new law on more sustainable and circular batteries to support EU's energy transition and competitive industry

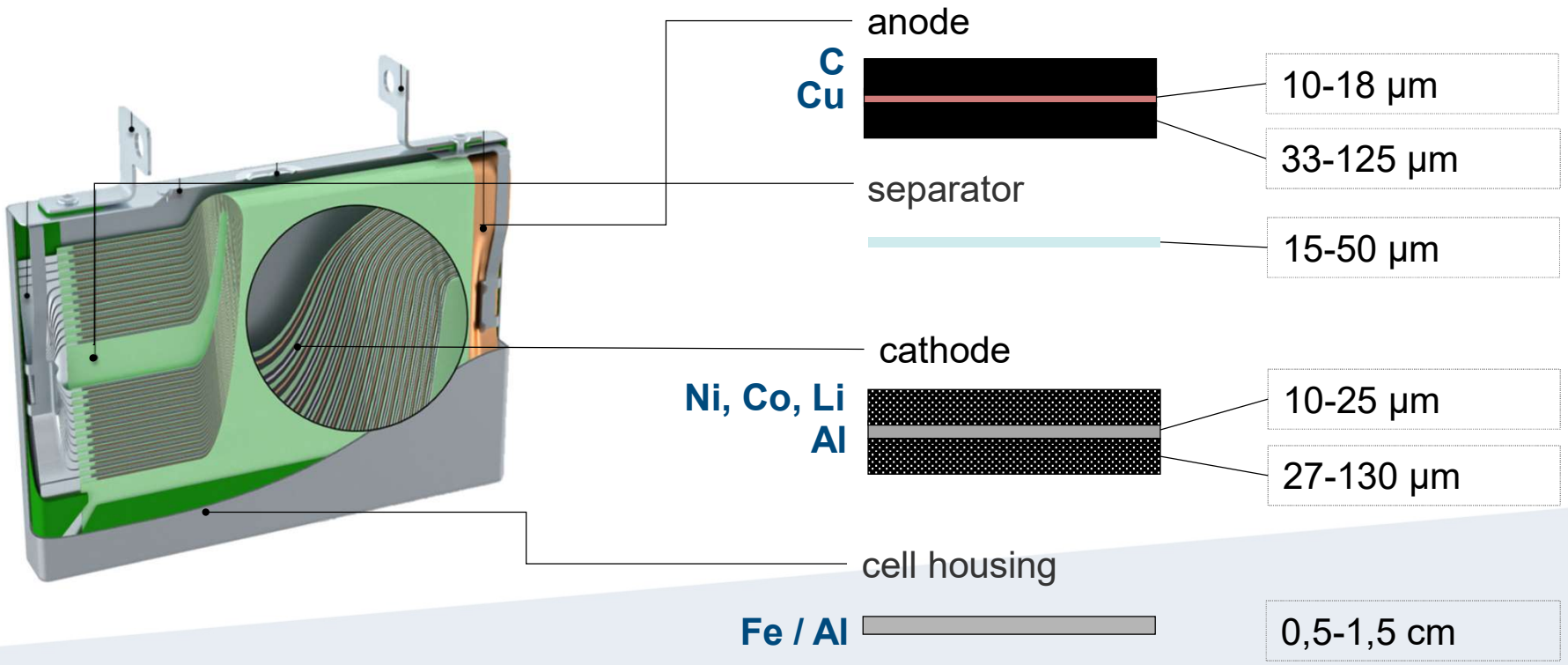
….. This will guarantee that **valuable materials are recovered** at the end of their useful life and brought back in the economy by adopting stricter **targets for recycling efficiency and material recovery** over time. Material recovery targets for lithium will be 50% by 2027 and 80% by 2031.

EU 2022

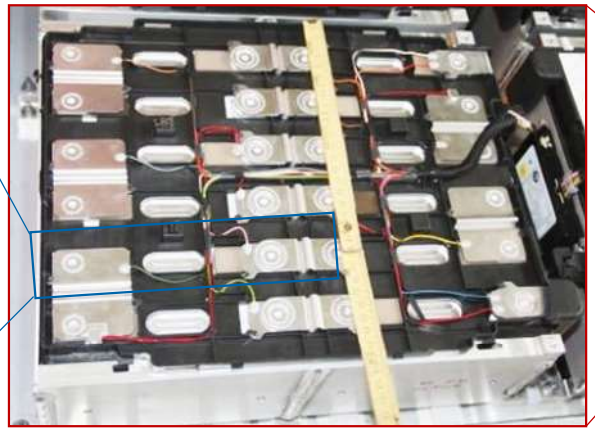
BATTERY RECYCLING

Hunting Li, Ni, Co

Challenges in recycling: Lithium-ion-batteries

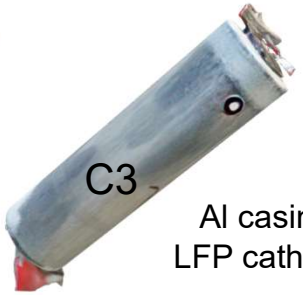


Batteries internal structure and setup



Cell type examples

Steel casing
NCA cathode

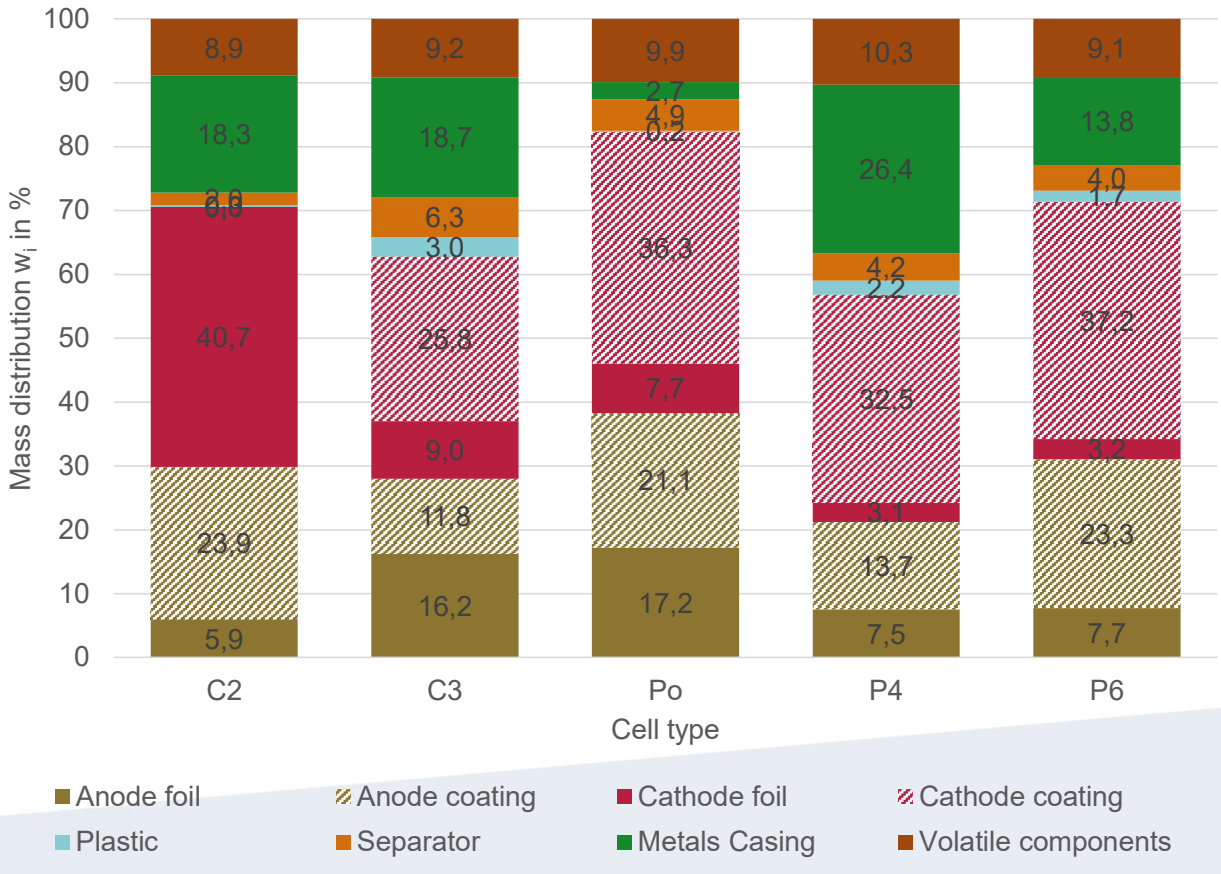


Al casing
LFP cathode

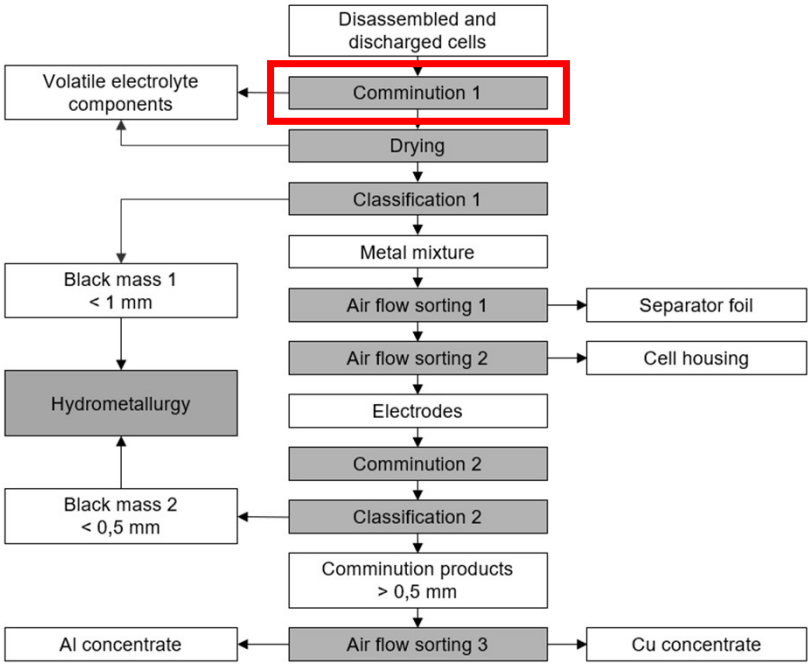
Al casing
LCO cathode

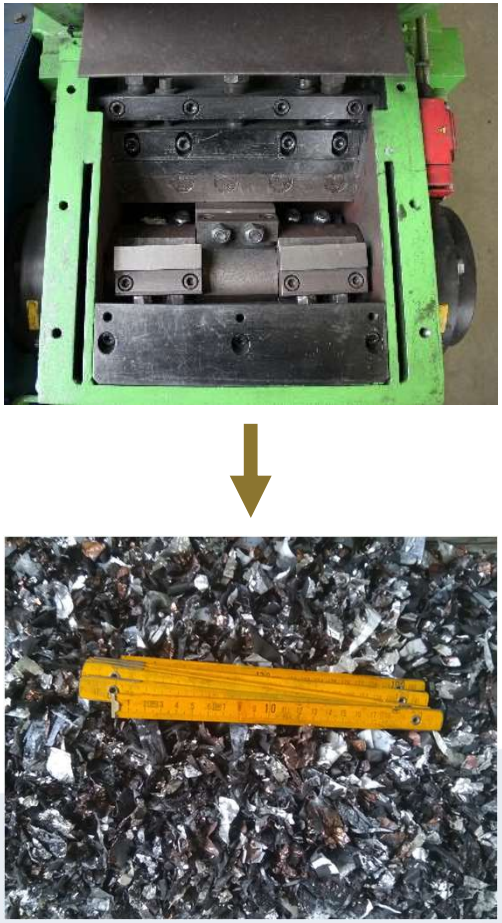
Steel casing
LMO cathode

Al casing
NMC111 cathode

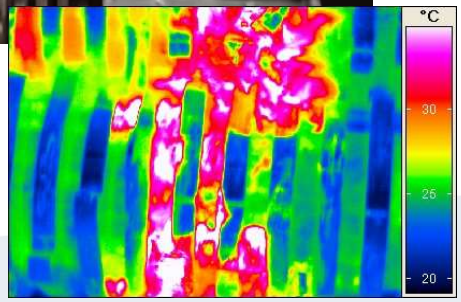


Comminution





Crushing, sorting, re-crushing, sorting,… generation of secondary raw materials



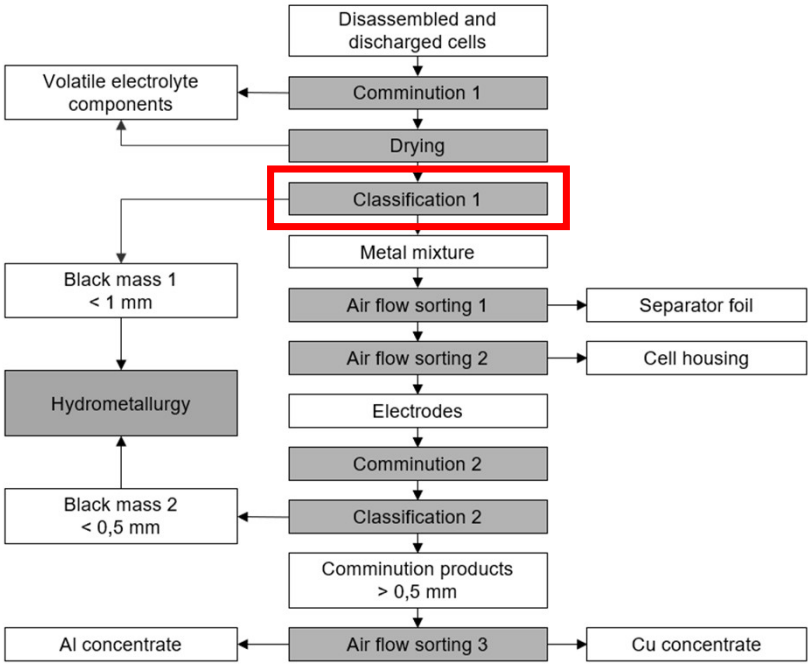
Fe / Al

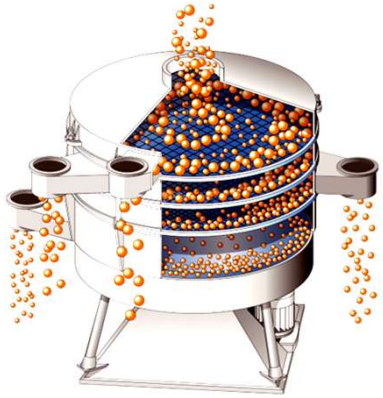
Ni, Co, Li

Al

Cu

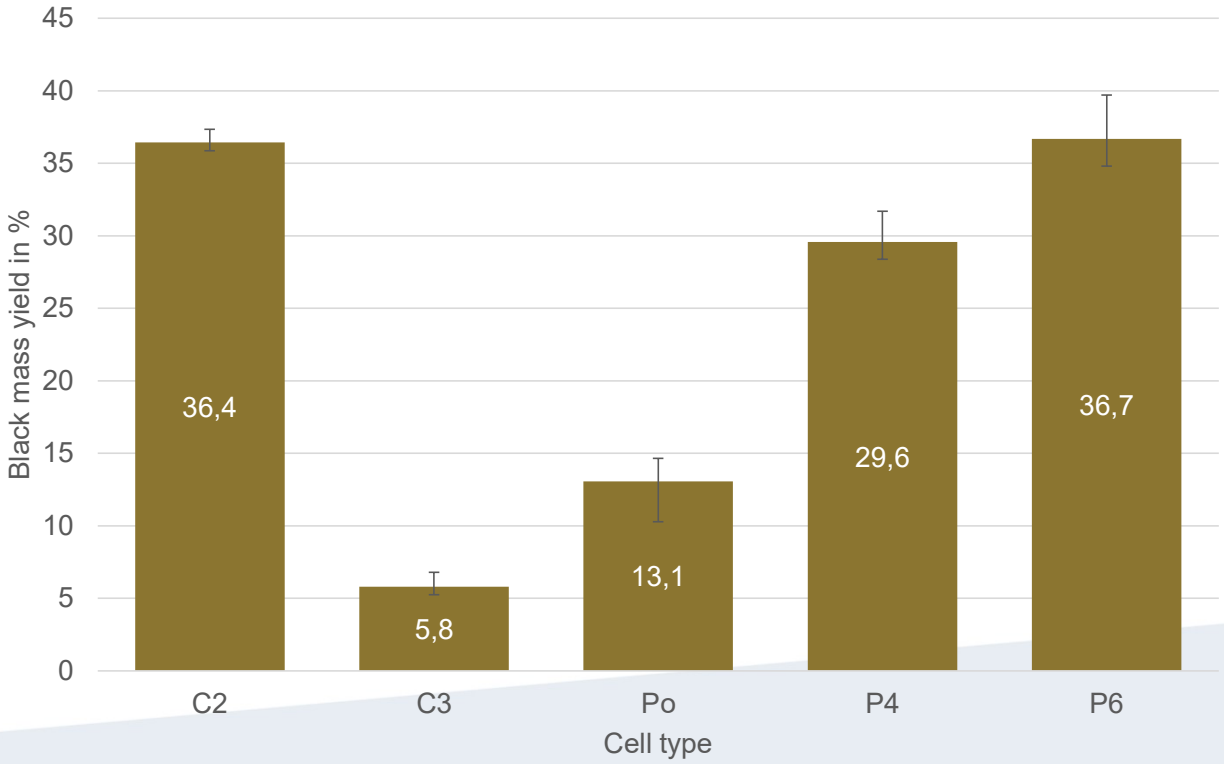
Classification



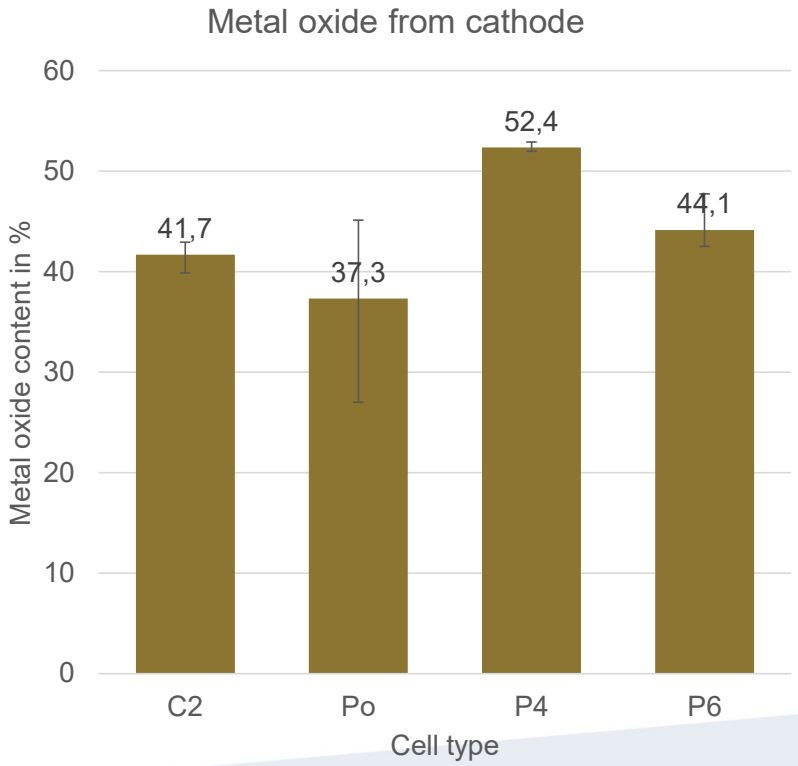


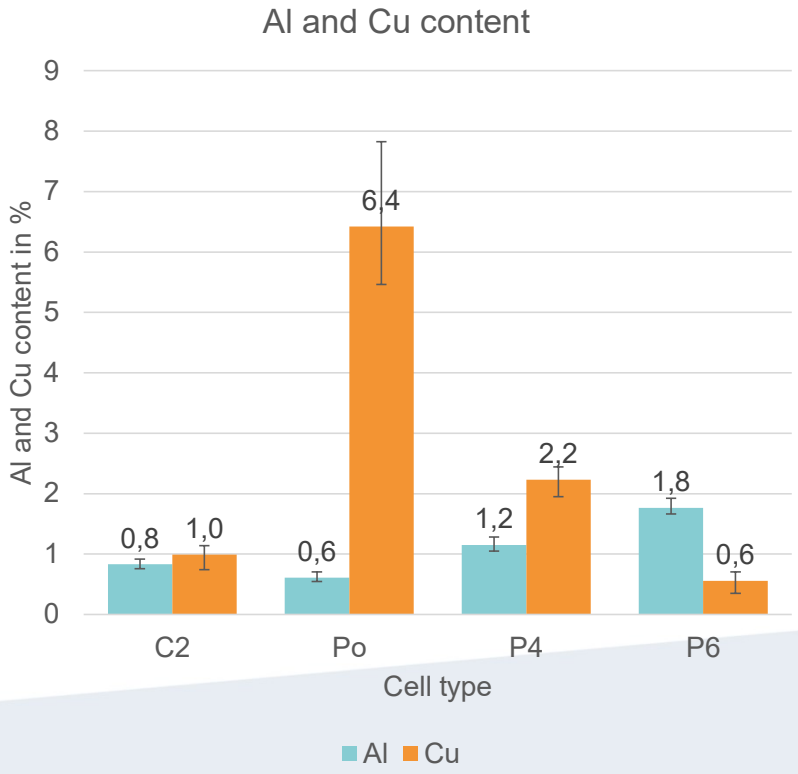
Source: Allgaier Group

Black mass yield – Batteries behave differently



Black mass composition – Batteries behave differently





ELECTROLYSER RECYCLING

Hunting REE, PGM

Challenges in recycling: PEM-Electrolyzer stack

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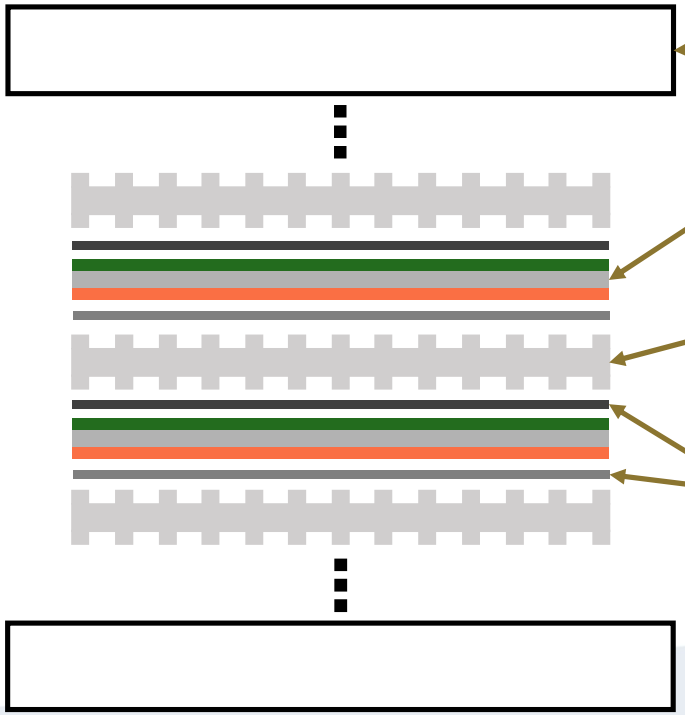


End plate

Cell

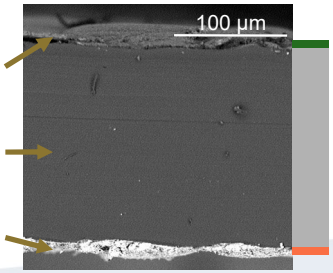
Bipolar plate

Porous transport layer

Valuable materials:

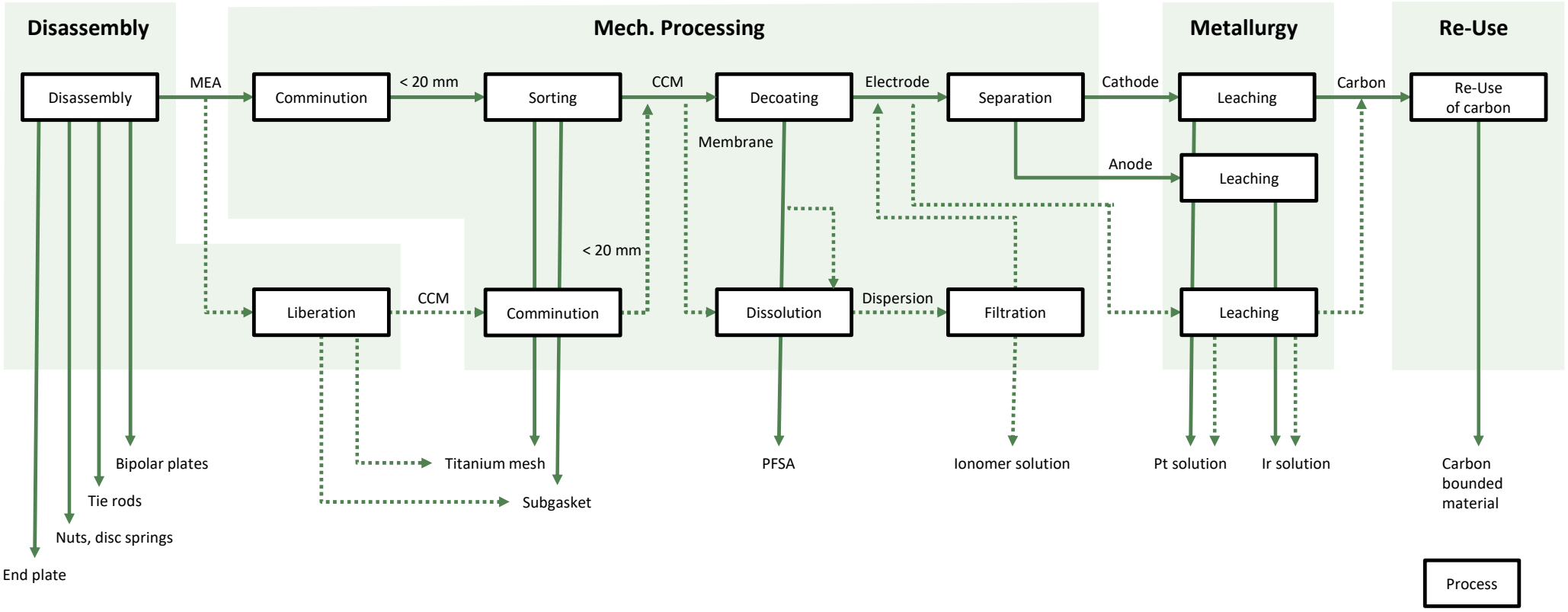
77	78	44
Ir	**Pt**	**Ru**
192,22	195,08	101,07

22
Ti
47,88



PEM Water Electrolyzer (WE)

Scheme PEM-Recycling



Mechanical recycling approaches

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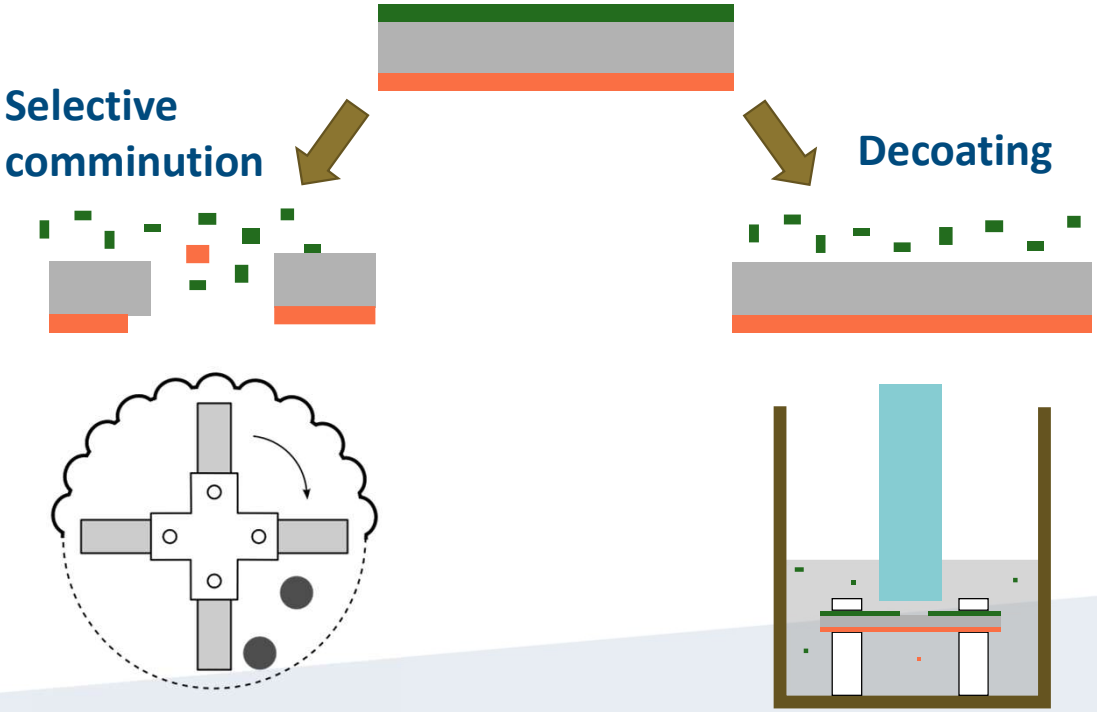
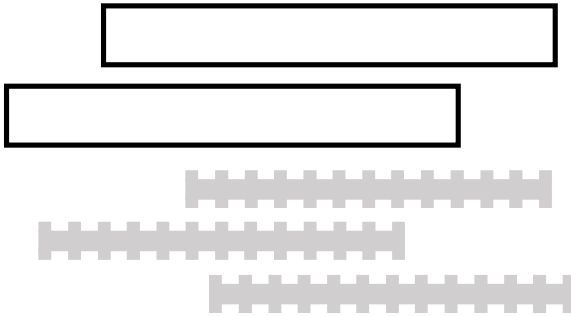
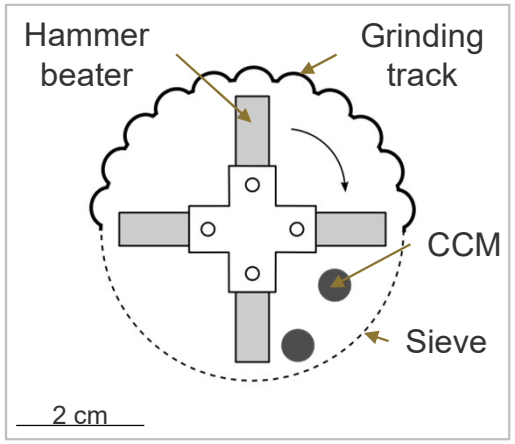




Partial de-mounting / reverse manufacturing

Comminution – Scale Down in Hammer mill

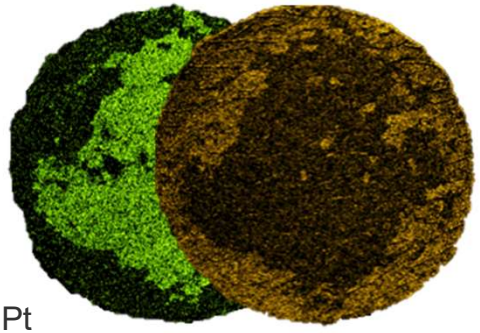
Feed: CCM
Ø 5,6 mm



Laboratory hammer mill on machine platform *Picoline* from *Hosokawa Alpine*

Delaminated and ruptured CCM + electrode powder

Sample holder with CCM for analysis



EDX: Pt

Conclusions - (Critical) Raw Materials and their Recycling as a Key Enabler for Clean Energy Technologies.

Challenges are ahead:

- Criticality of related (raw) materials
- Supply and need differ for certain elements / materials
- Recycling has to keep the critical materials in the life-cycle.
- Are we able to keep the precious materials in the cycle?
    - Suitable technologies
    - Political and legislative boundary conditions
    - Industrial involvement

- Availability of skilled labor force?

Start working on the challenges – success is possible

Activities to boost circular technology in Saxony and esp. in Freiberg

The work on the recycling challenges need concerted actions and the right infrastructure

Infrastructural activities:

- **CircEcon** - pilot scale recycling and de-mounting plant (TU Dresden, TUBAF, TU Chemnitz; HS Zittau-Görlitz)
- **FlexiPlant** – digitalized recycling plant (HZDR, TUBAF)
- **Data Mining Lab Freiberg** – digitalized recycling and re-synthesis network (TUBAF, HZDR, FhG IKTS)

Education and integrated projects:

- Sächsische Wasserstoffunion (TU Chemnitz, TU Dresden, TUBAF)
- Participation in and lead of high level national projects
- Continuous development of teaching content
- Active participation in European activities, i.e. EIT RM, ERMA, Battery Alliance,…