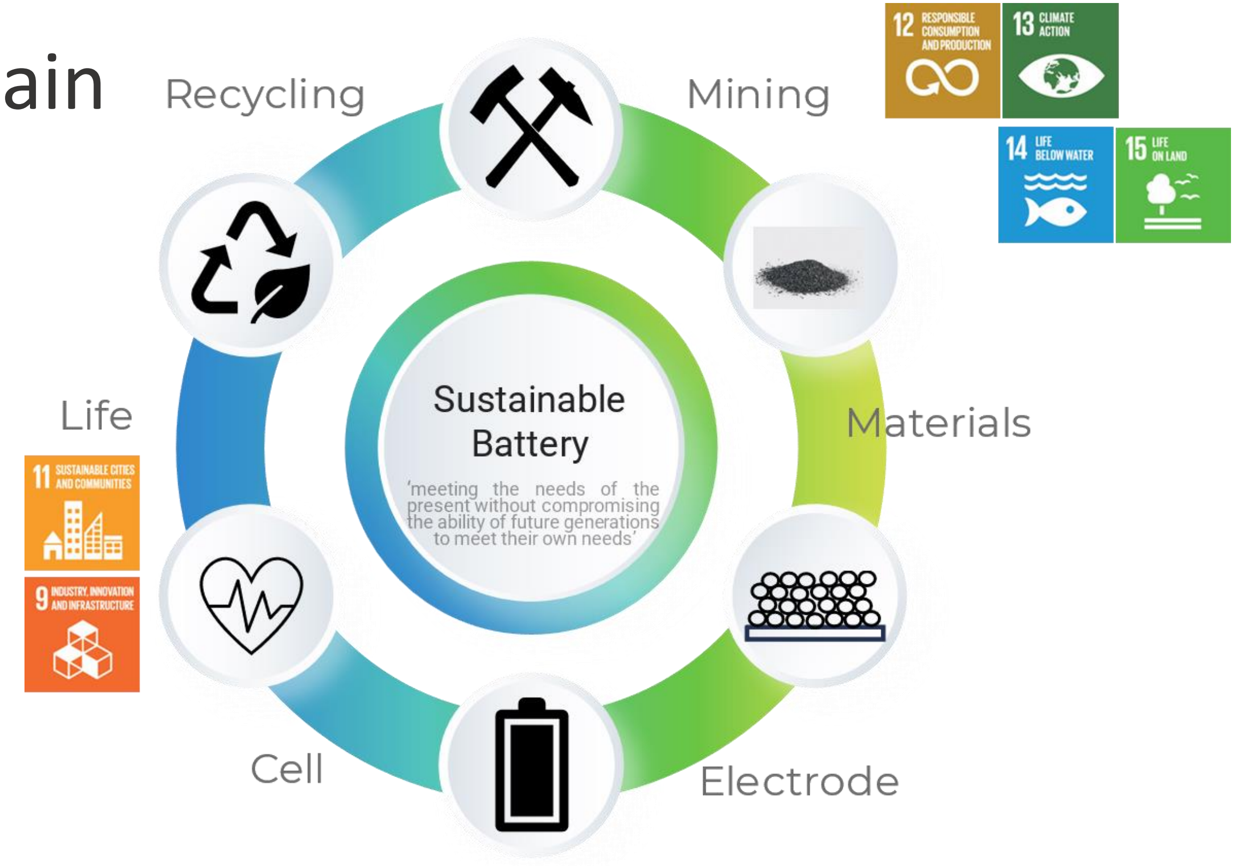
SIMBA-Disassembly and Recycling

Emma Kendrick, Lin Chen, Brij Kishore, Tengfei Song, Bowen Lui, Anton Zorin, Subha Samanta, Osaze Omoregbe, Peter Slater, Farouk Tedjar, Zijun Lu

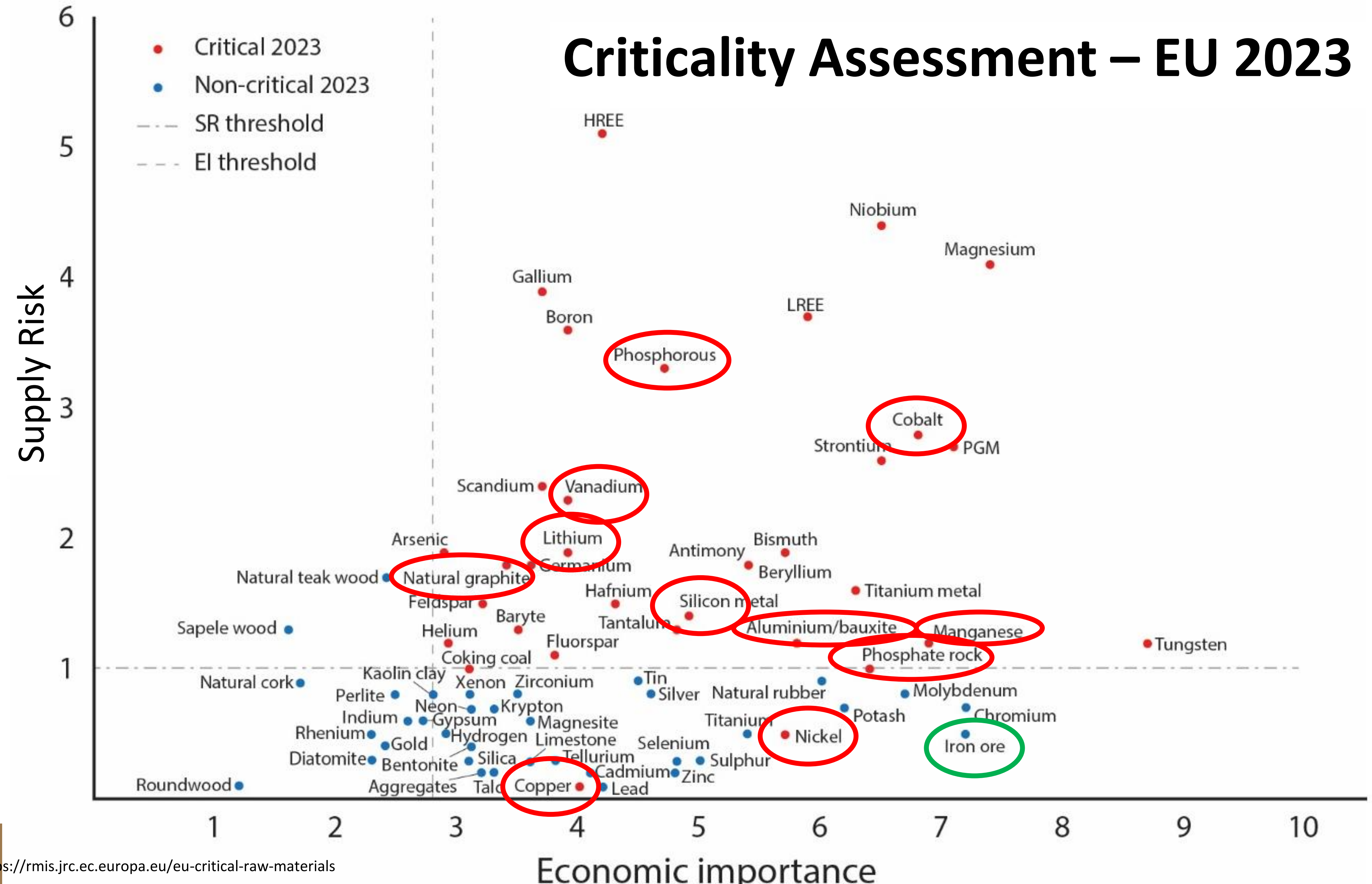
CONFIDENTIAL *This project has received funding from the European Commission under grant agreement No 963542*

Contents

- Critical Materials and Supply Chain
- Routes to Recycling
- SIMBA reclamation routes
  - Base-line Cell
  - Solid State Cell
- SIMBA reuse cases
  - Hard Carbon,
  - Prussian White



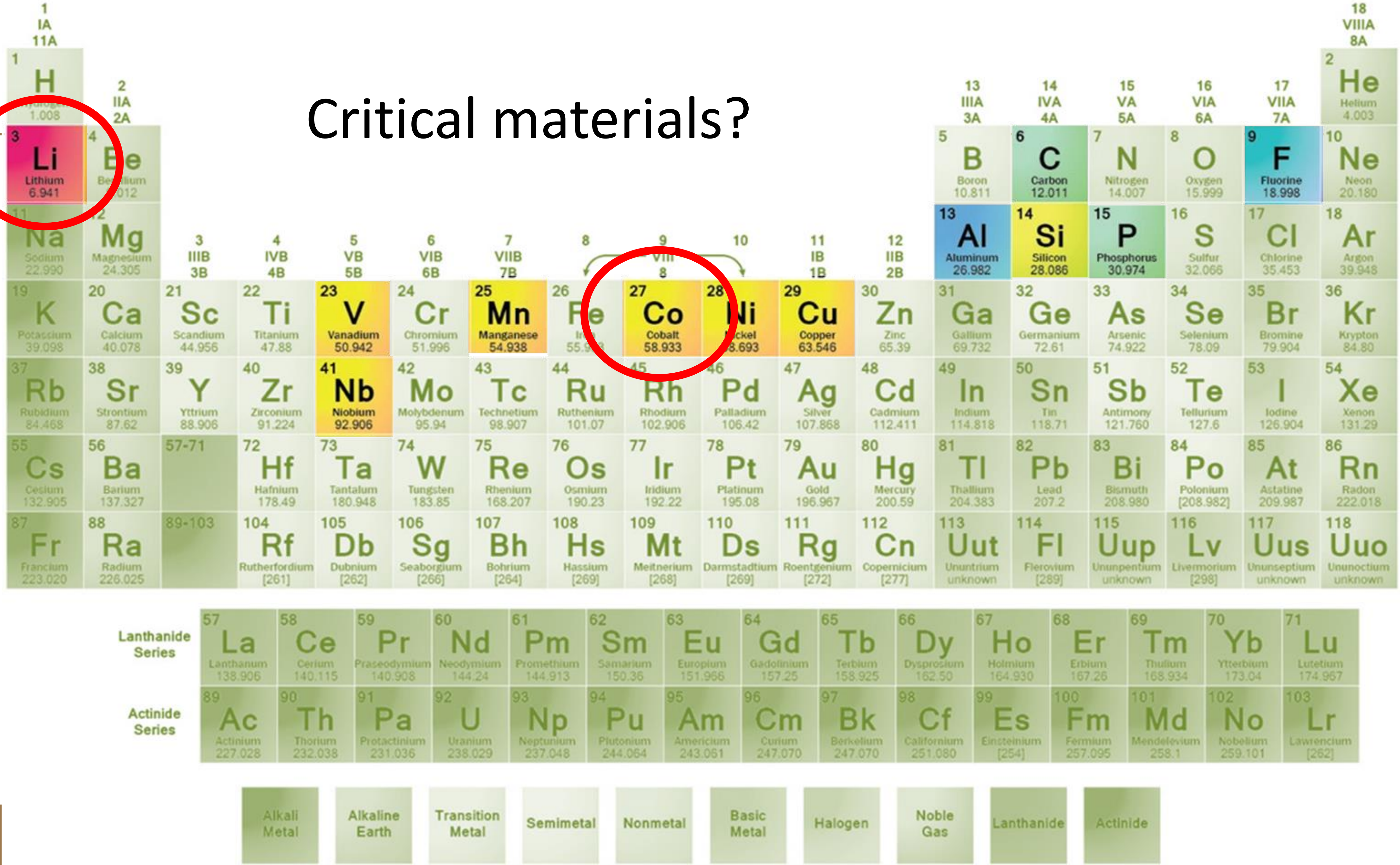
Criticality Assessment – EU 2023



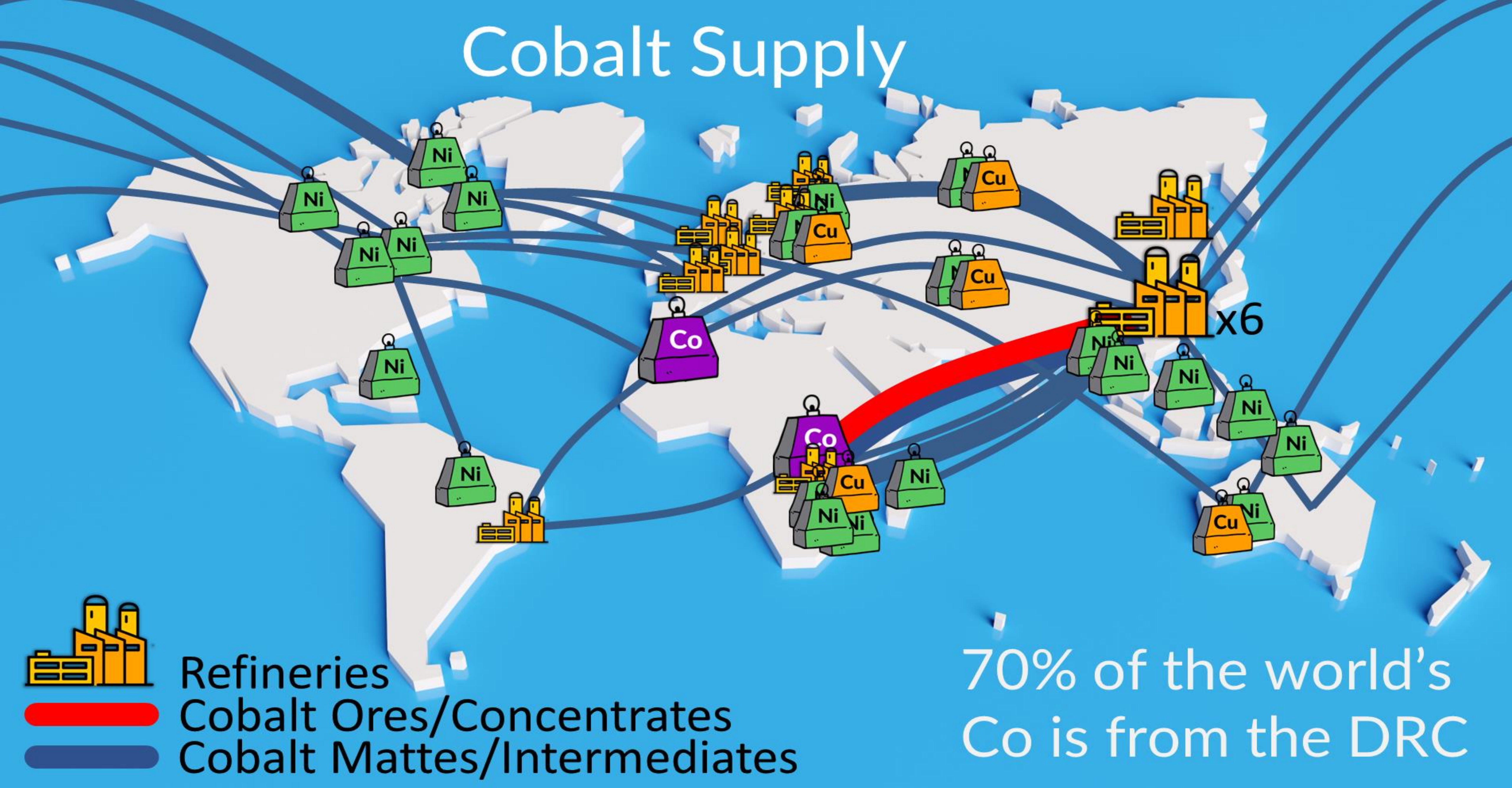
https://rmis.jrc.ec.europa.eu/eu-critical-raw-materials

Figure 1. The Periodic Table of the Elements (Source: Science Notes and Projects)

Critical materials?

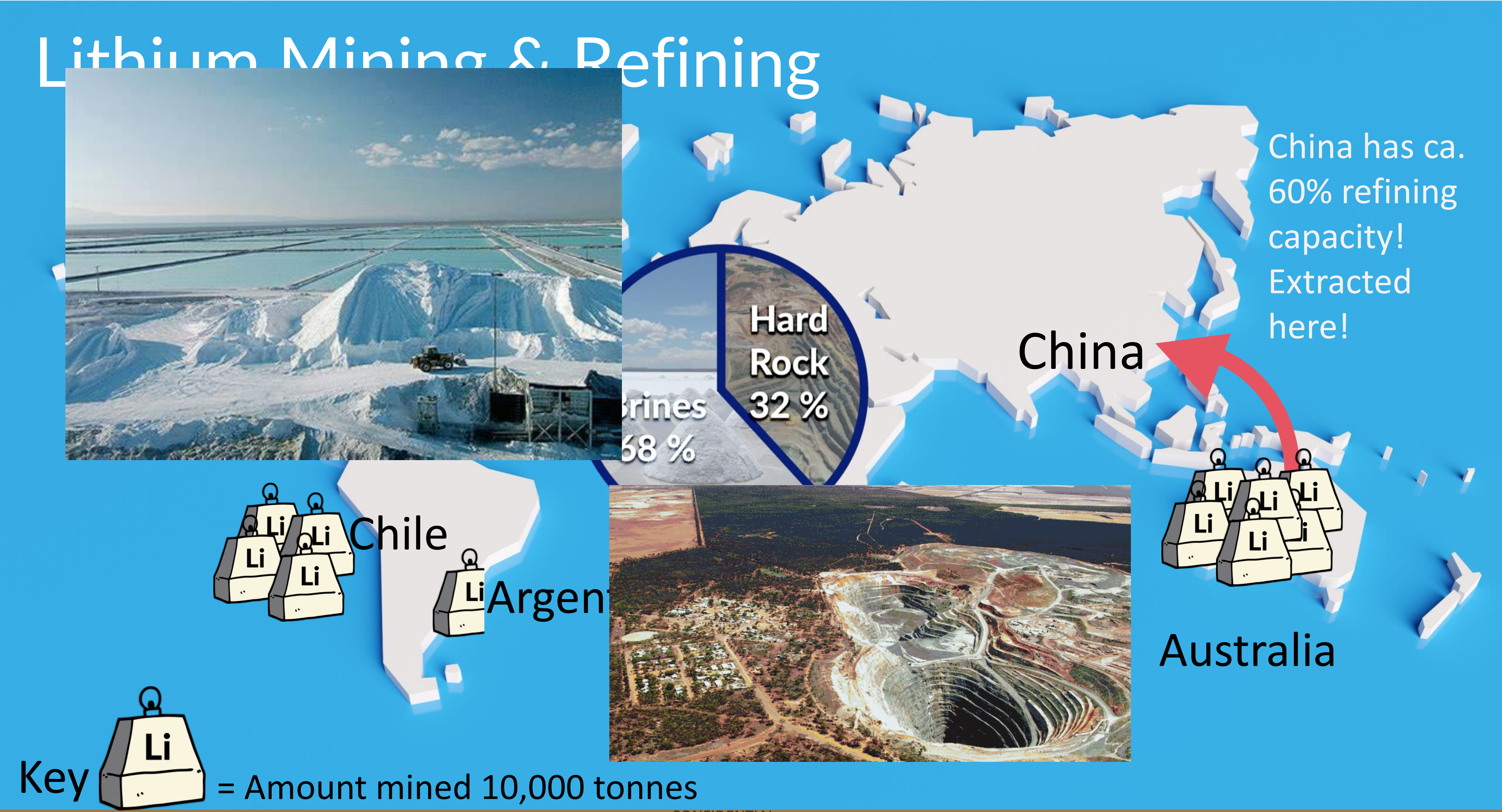


Cobalt Supply

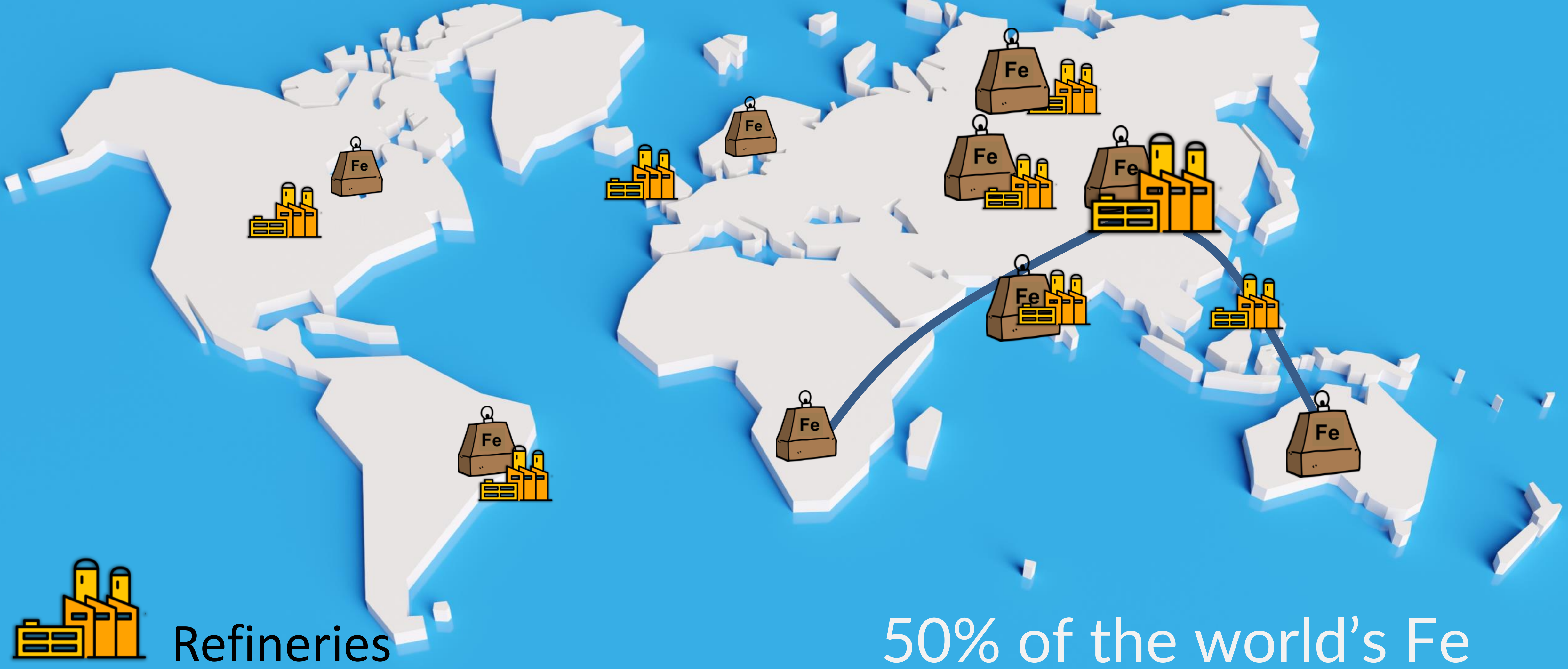


70% of the world's Co is from the DRC

Reference: S. van den Brink *et al.*, Resource, Conservation and Recycling, 2020, 156, 10473. Graphics adapted from Adobe Stock.


Lithium Mining & Refining
China has ca. 60% refining capacity! Extracted here!
China
Hard Rock 32 %
rines 68 %
Li
Chile
Argent
Australia
Key
= Amount mined 10,000 tonnes

Sodium and Iron Ore



50% of the world's Fe is Refined in China

Reference: S. van den Brink *et al.*, Resource, Conservation and Recycling, 2020, 156, 10473.
Graphics adapted from Adobe Stock.

Credit – Elizabeth Driscoll

D1.3 SIMBA Supply Chain Dec 2022

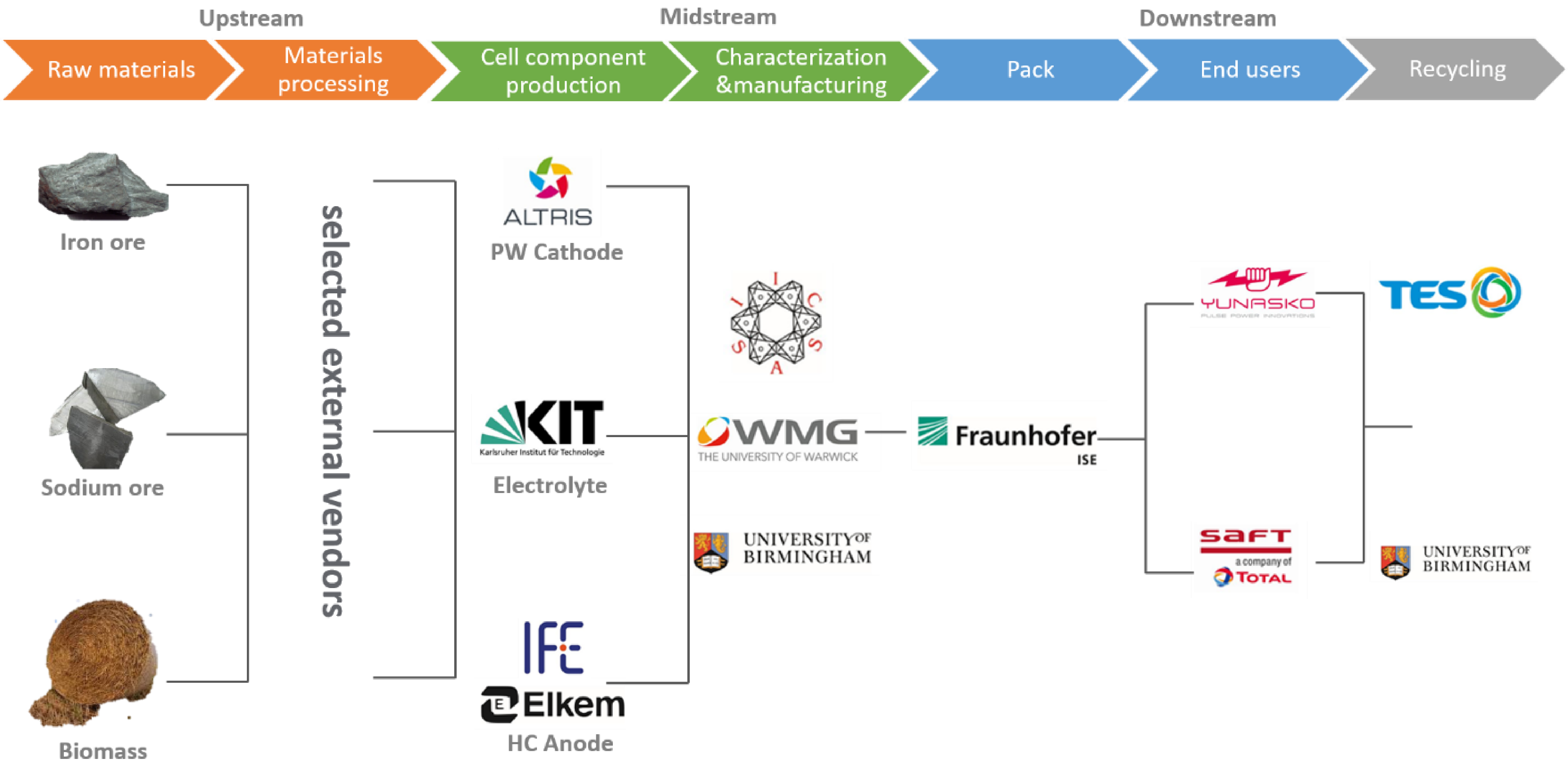
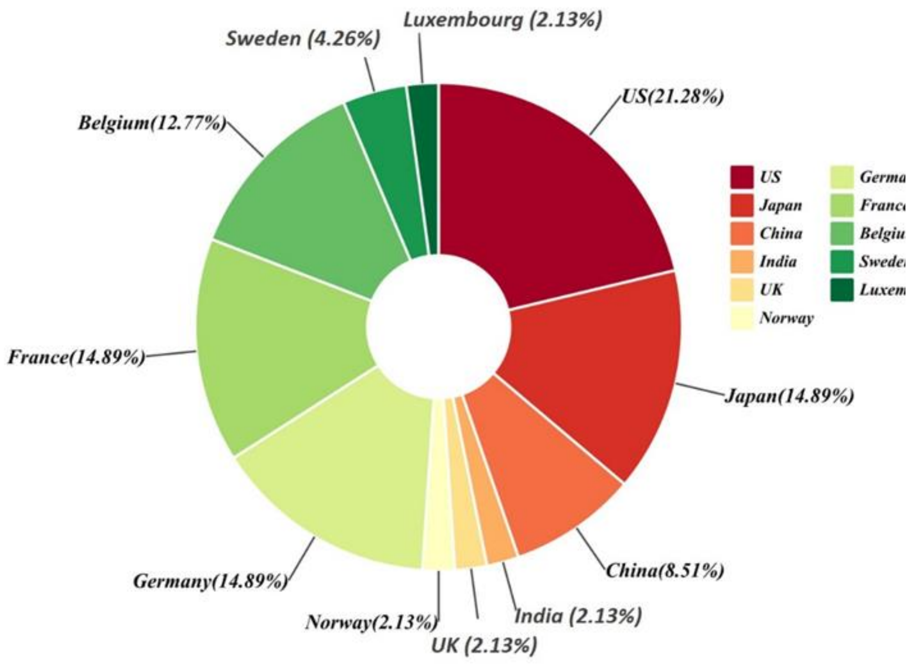
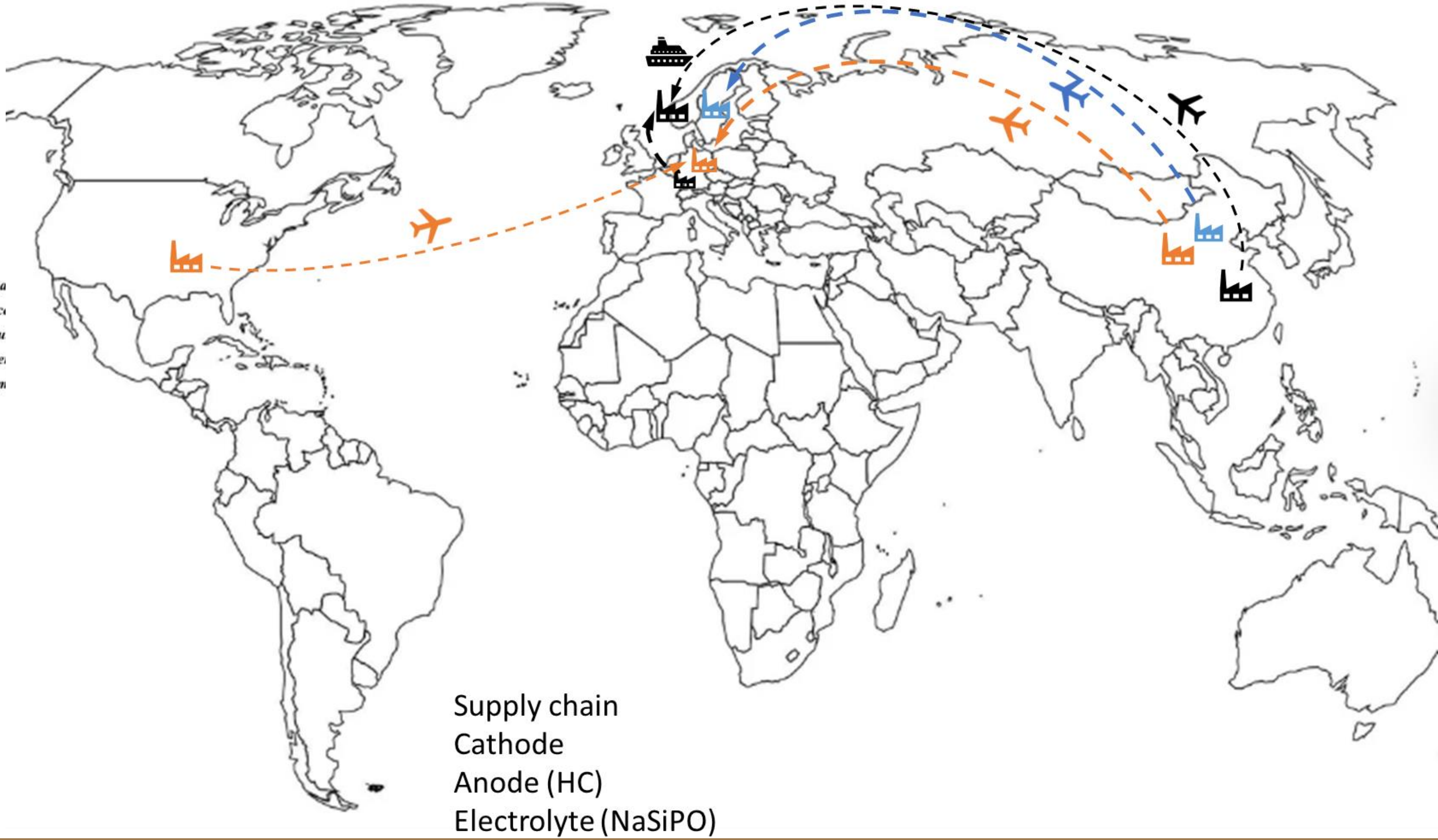


Figure 1 - Micro supply chains within the SIMBA project Dec 2022

D1.3 SIMBA Supply Chain Dec 2022

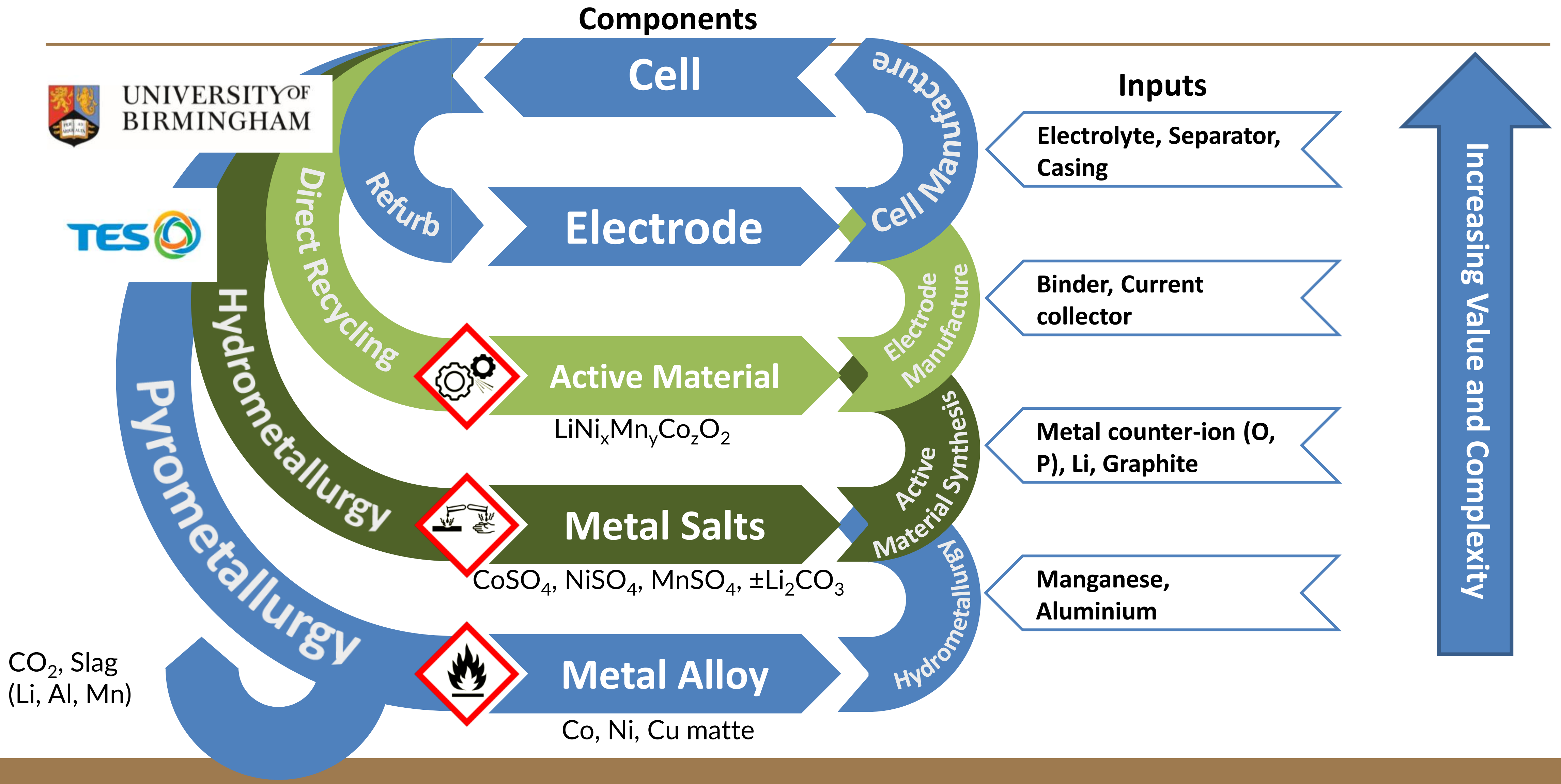
SODIUM-ION AND SODIUM METAL BATTERIES



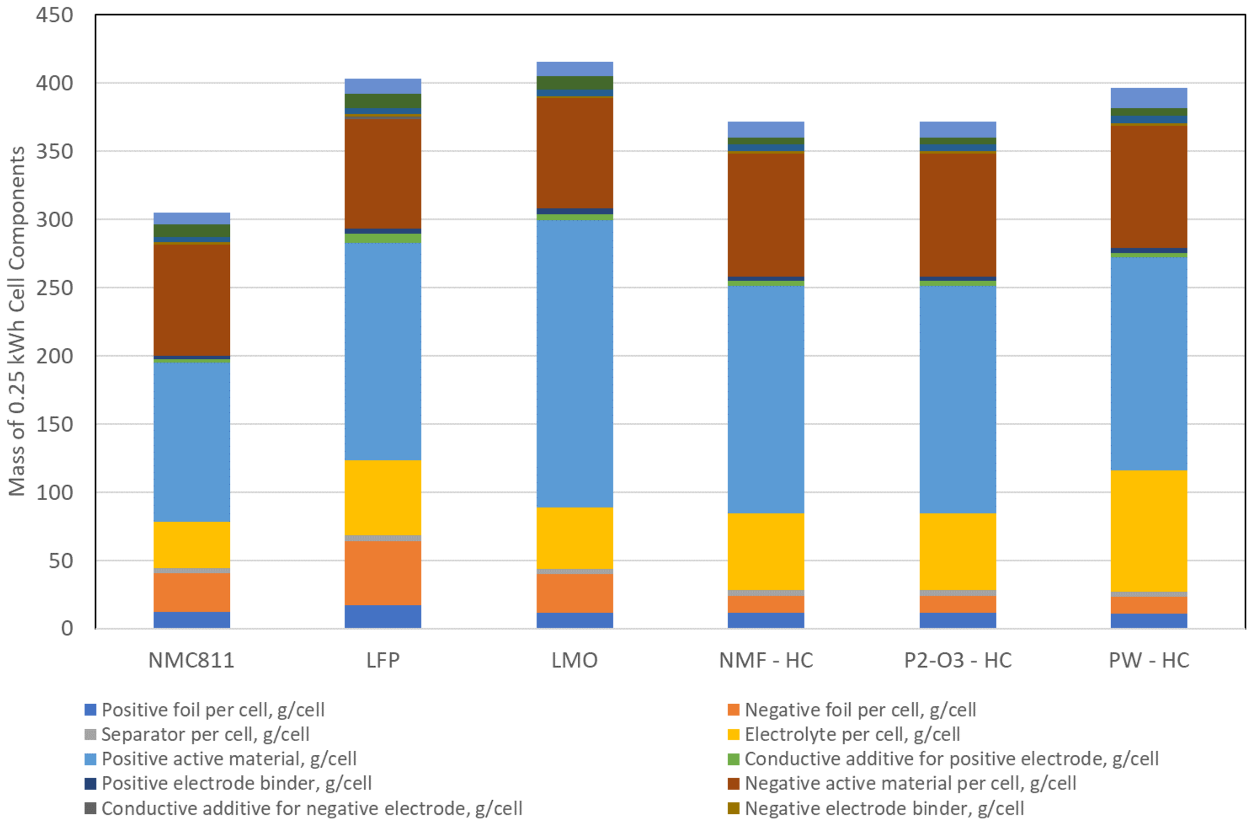


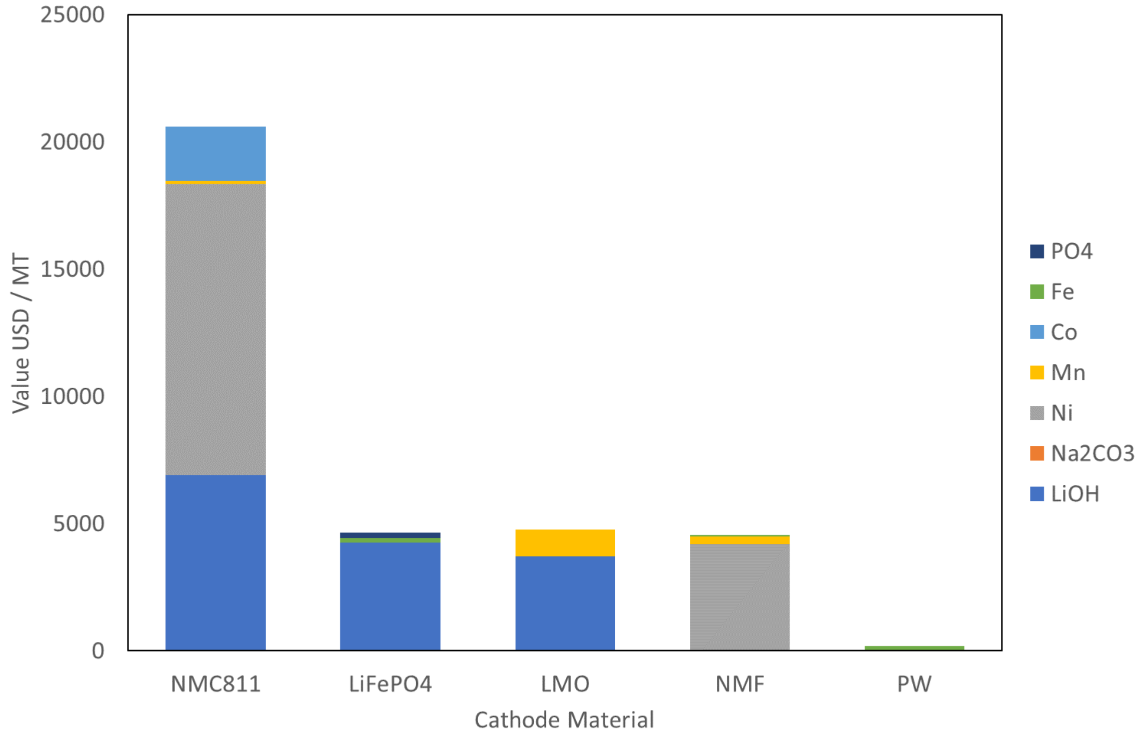
Recycling Routes

+SIMBA
SODIUM-ION AND SODIUM METAL BATTERIES

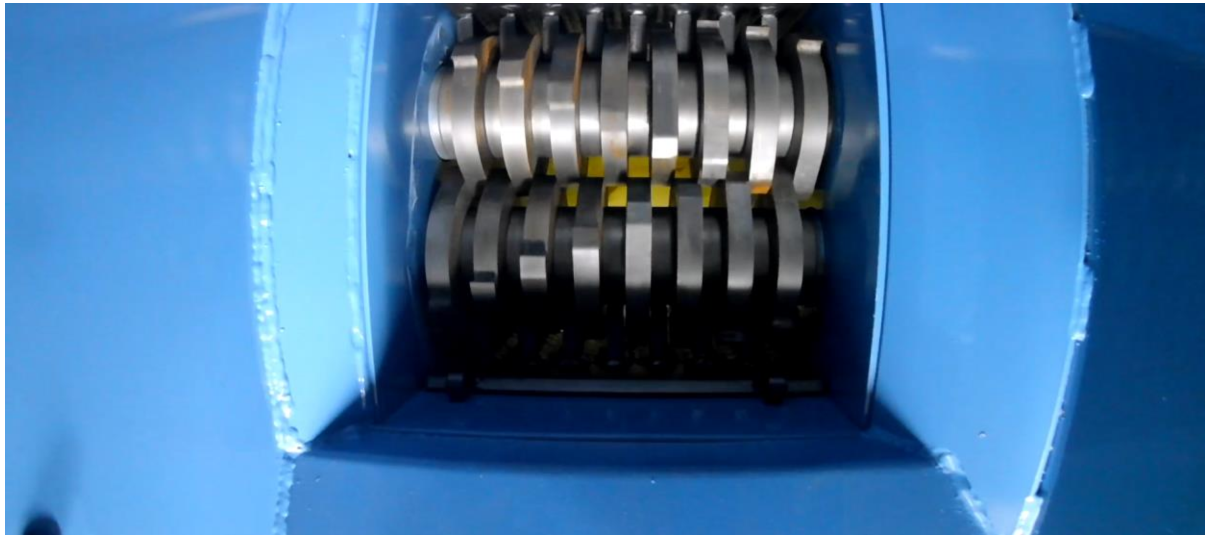


Cathode Content and Value





Shredding vs Disassembly

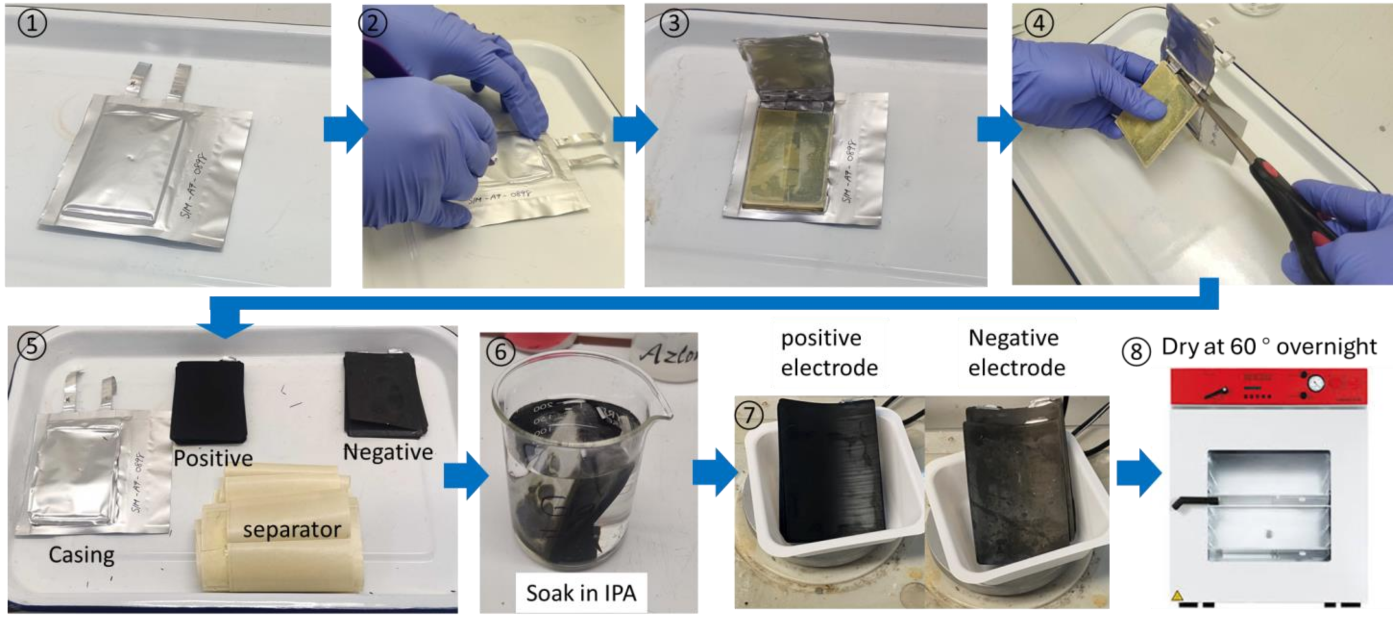


SK tes

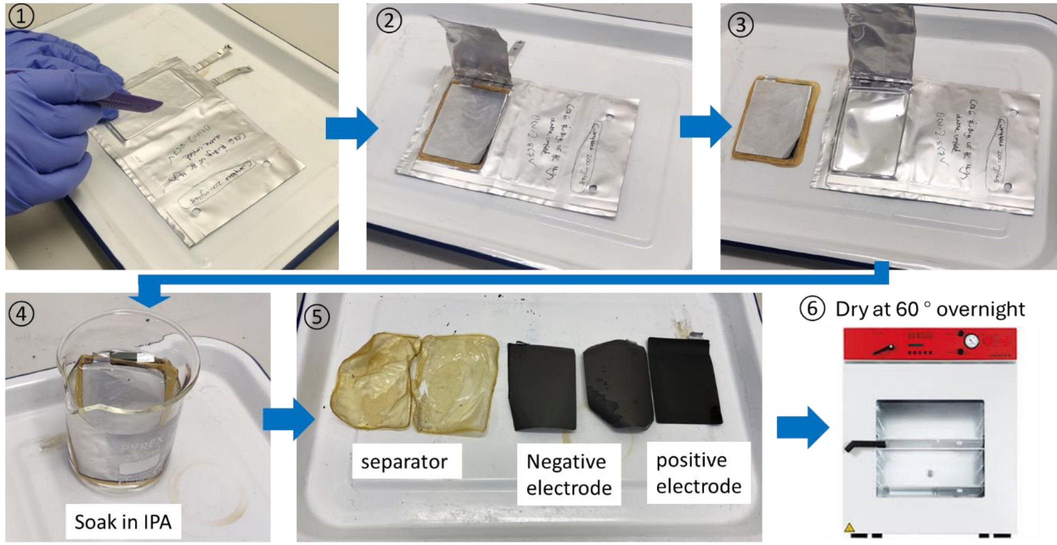
UNIVERSITY OF BIRMINGHAM

Disassembling

Baseline cell

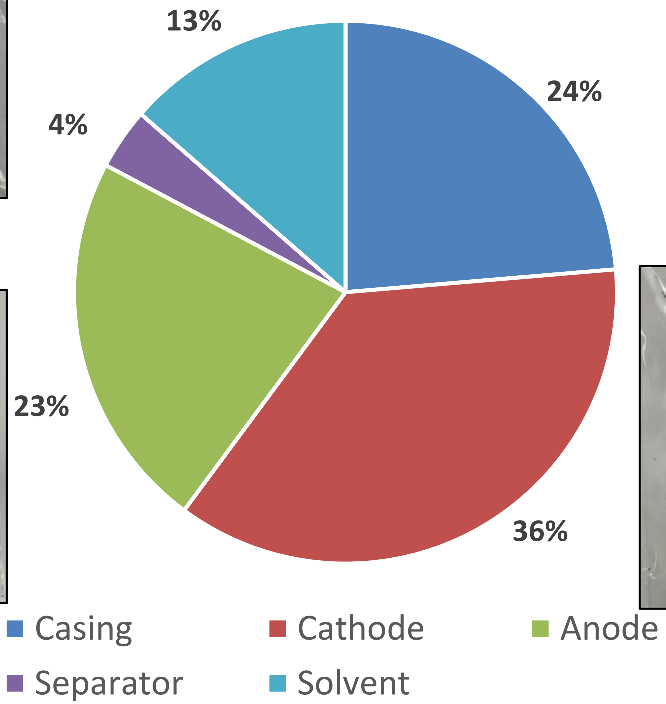


Sodium-ion solid-state battery

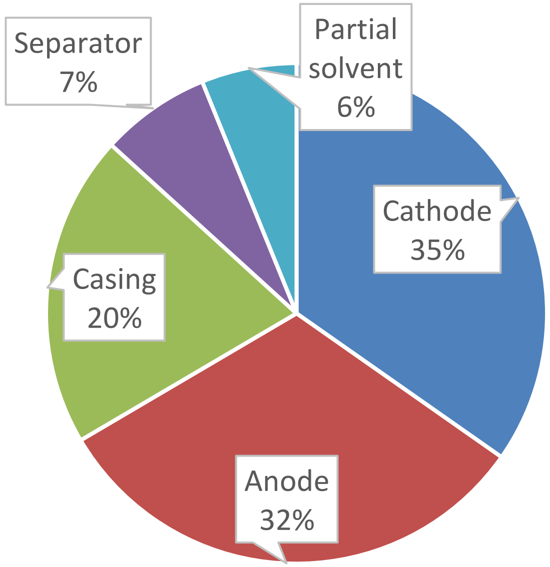


T1.4 | Composition breakdown

Commercial SIB



SIMBA BLC



SODIUM-ION AND SODIUM METAL BATTERIES

T6.2 | Results and outcome M25-M30

UNIVERSITY OF BIRMINGHAM

Ice stripping-modified

$$\text{Coating Separation Sfficiency } CSE_{A/coating} = \frac{\text{mass of separated } A/coating}{\text{initial mass of } A/coating}$$

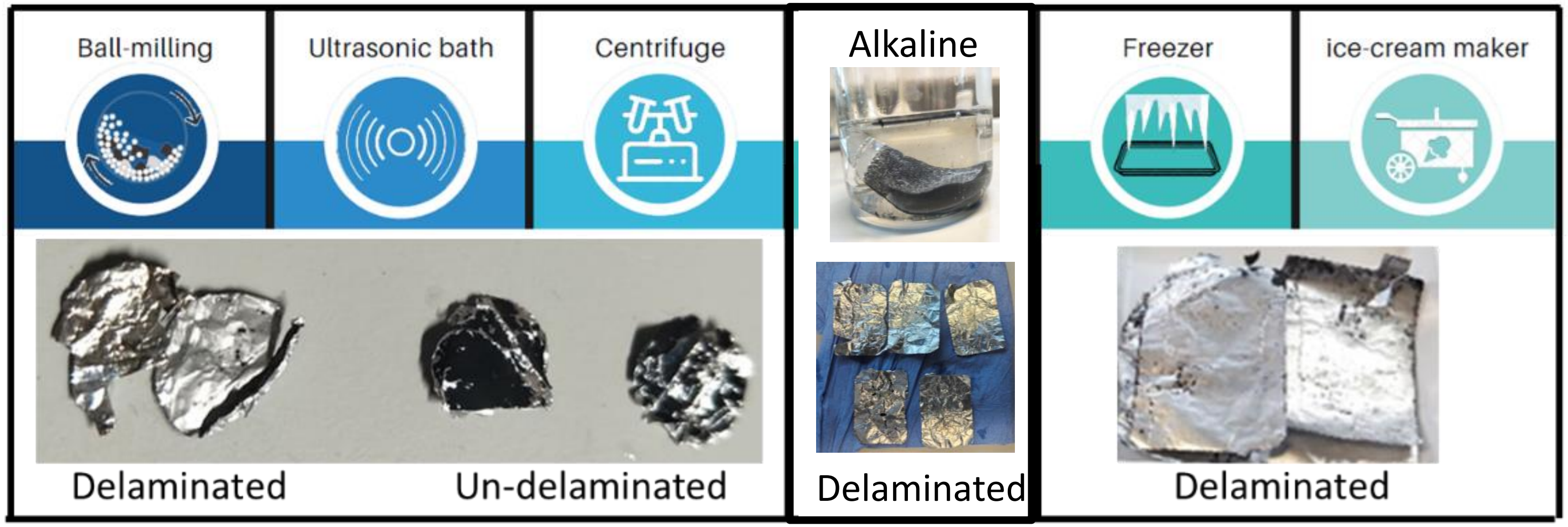
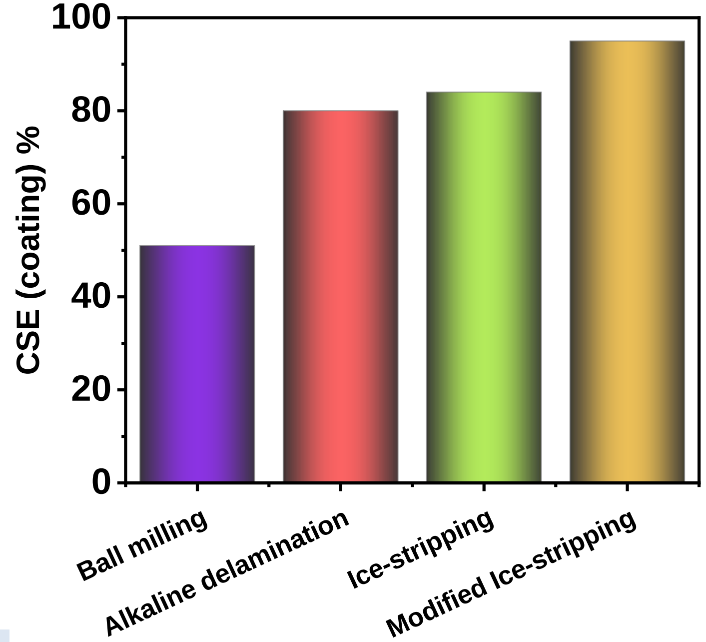


Figure. Comparison of separation efficiency with different delamination techniques.

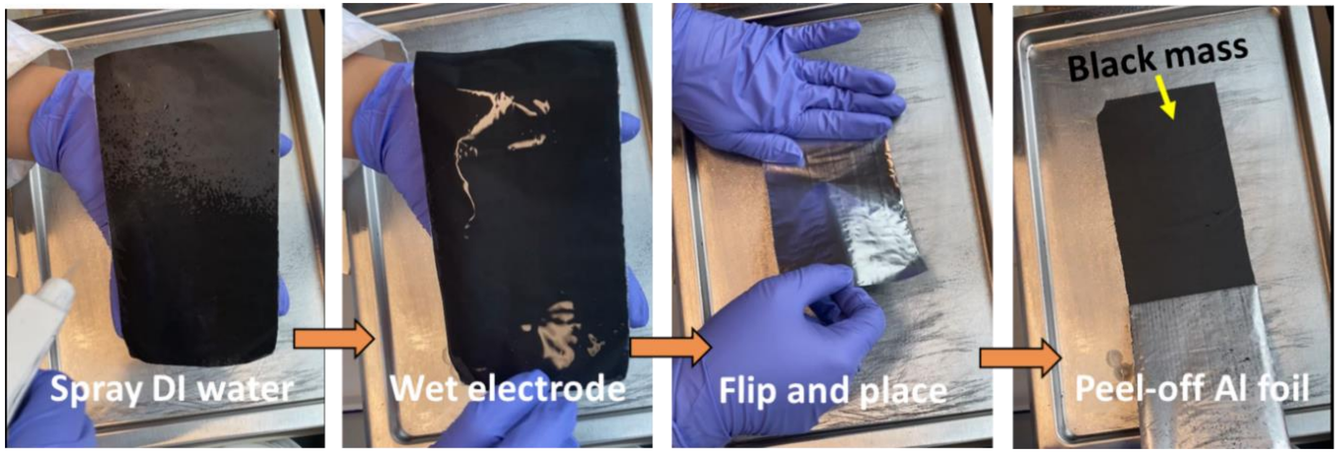


The advantages of the modified ice stripping method were :

- Reduction in amount of water required for the delamination;
- Reduced the process time (freezing time);
- Easier to handle and potential to be scale-up and industrialized.

UNIVERSITY OF BIRMINGHAM

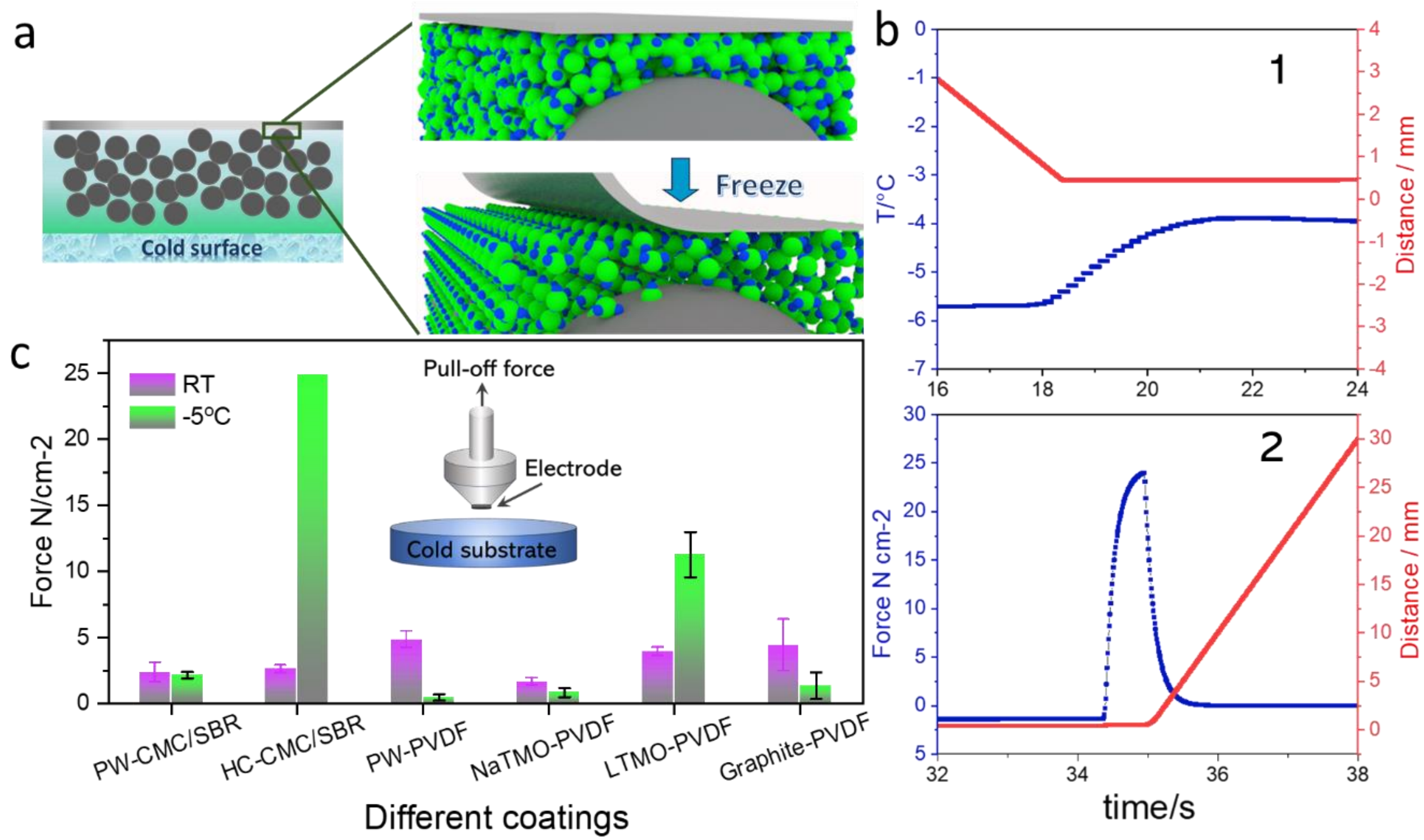
Ice-stripping



- Zero waste procedure: 0.02mL DI water per cm^2
- Highly efficient process
- Fast procedure time ~10s

A 'cool' route to electrode recovery L. Chen *et al.* https://doi.org/10.21203/rs.3.rs-4504057/v1

Ice-stripping Machanism

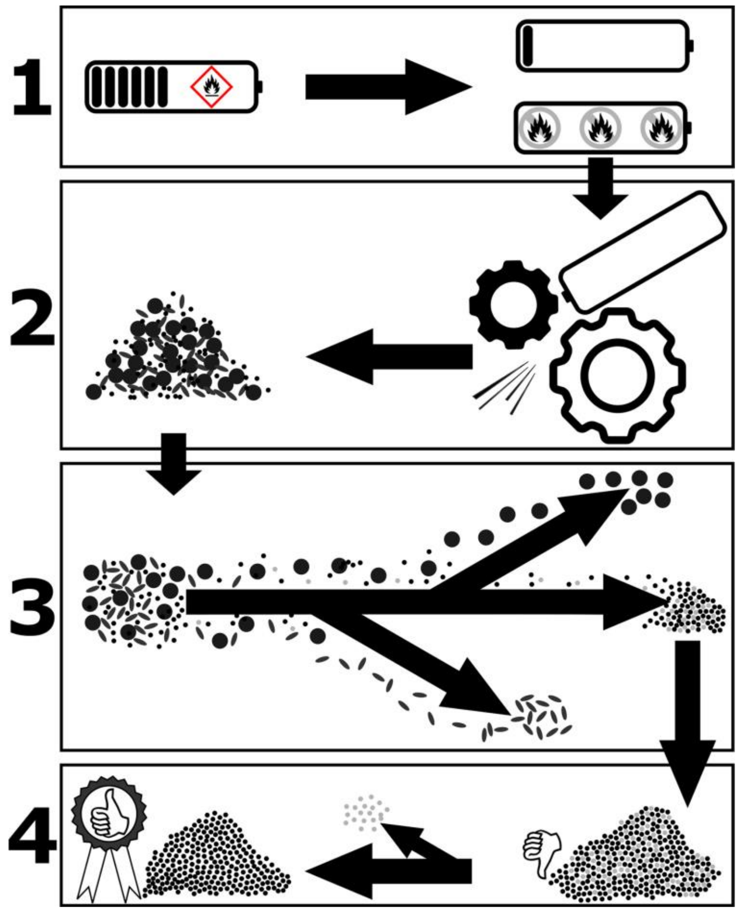


Water was frozen in 5 s

Lowering temperatures to sub-zero levels to harness ice's cohesive strength over the electrode adhesion to delaminate electrode coatings.

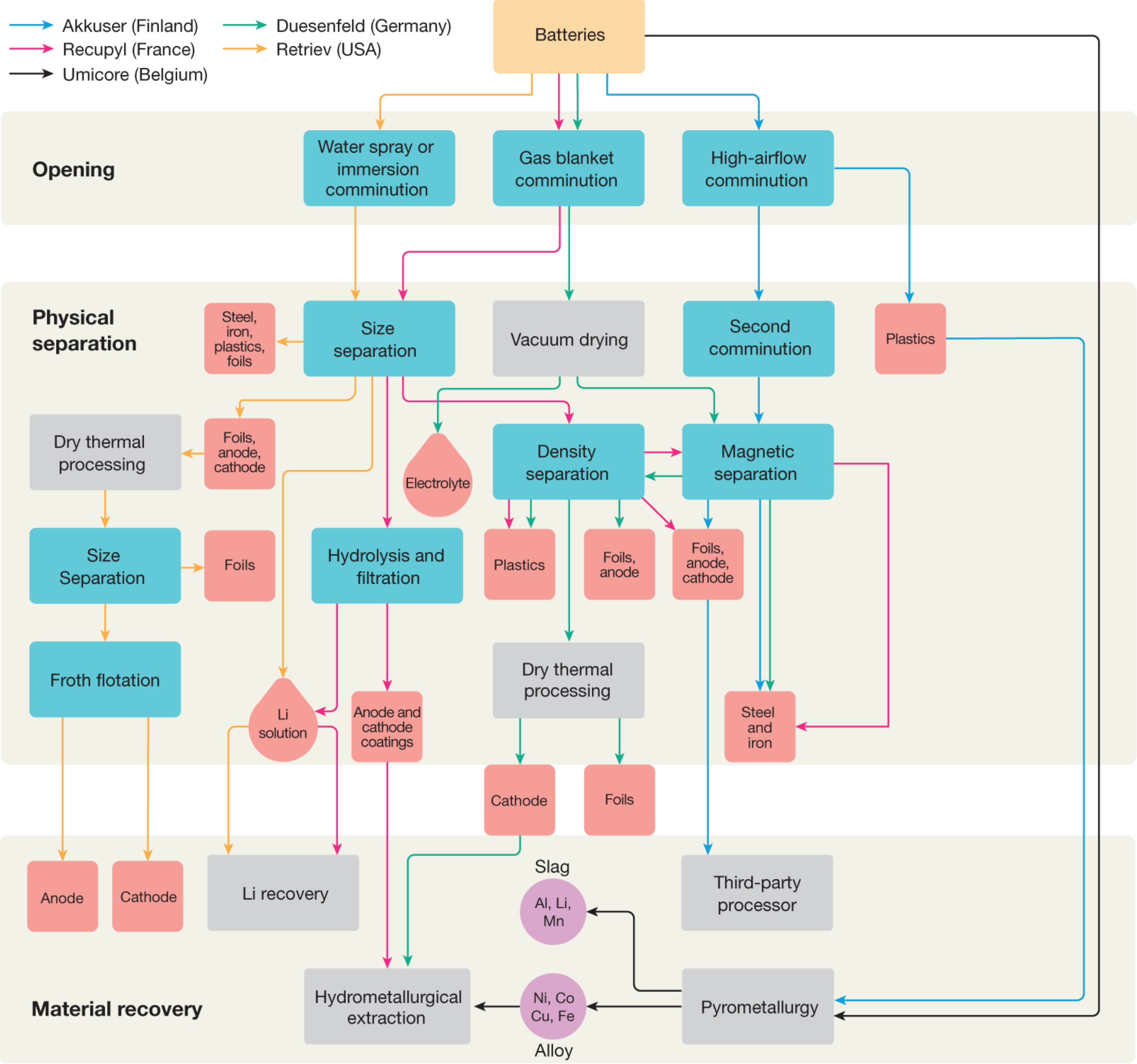
A 'cool' route to electrode recovery L. Chen *et al.* https://doi.org/10.21203/rs.3.rs-4504057/v1

Mechanical Sorting



1. Stabilization,
2. Comminution,
3. Physical separation,
4. Black mass purification.

R. Sommerville, J. Shaw-Stewart, E. Kendrick *et al*, A review of physical processes used in the safe recycling of lithium ion batteries, *Sustainable Materials and Technologies,* 25, 2020, https://doi.org/10.1016/j.susmat.2020.e00197.



Harper, G., Sommerville, R., Kendrick, E. *et al.* Recycling lithium-ion batteries from electric vehicles. *Nature* **575**, 75–86 (2019). https://doi.org/10.1038/s41586-019-1682-5

T1.4 | Mechanical-sorting process

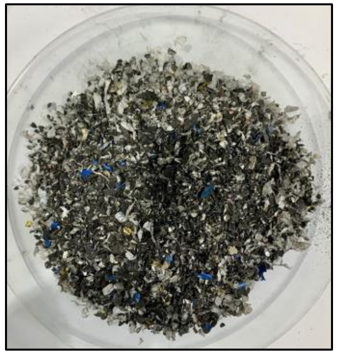
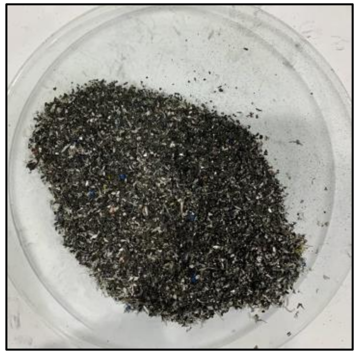
Sorting results of commercial SIB

> 4 mm


Aluminium and separator

30.6 % vs 28.9 % of SIMBA BLC

0.355 - 4mm

Fine Al foil + electrode not fully delaminated

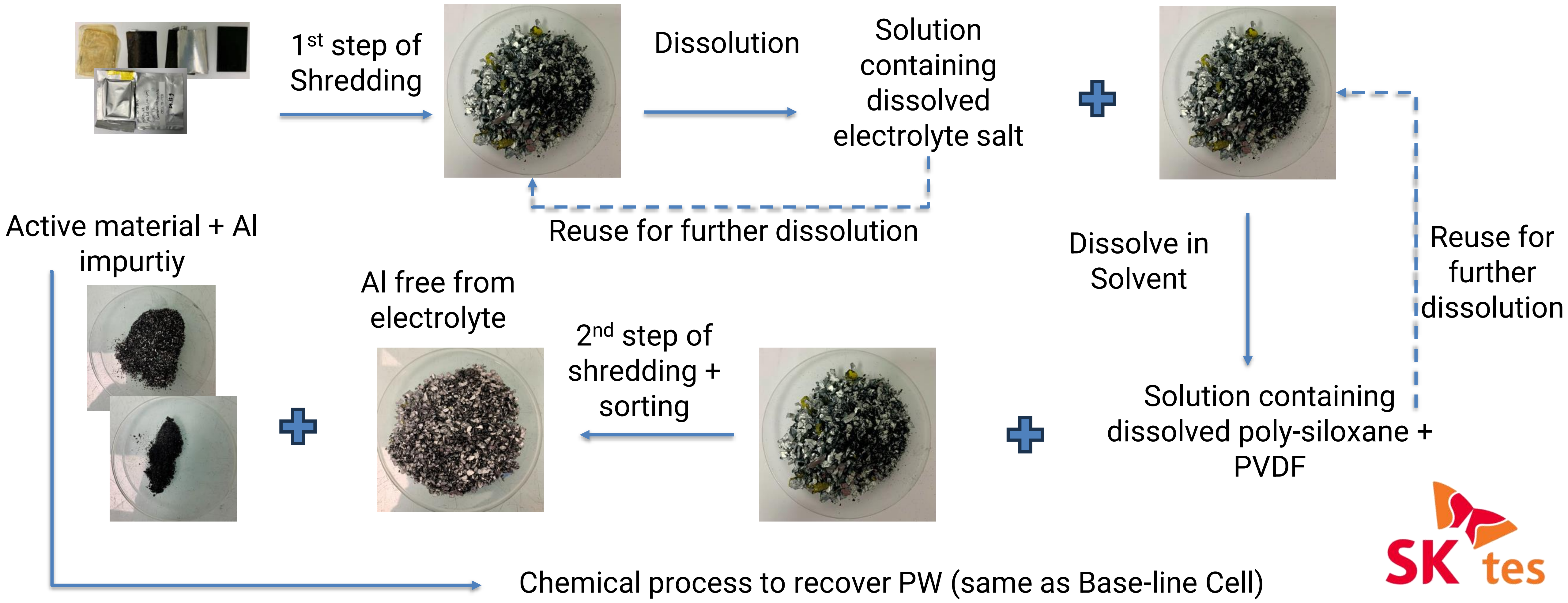
40.3 %

<0.355 mm

Active materials

29.1 % vs 58.8 % of SIMBA BLC

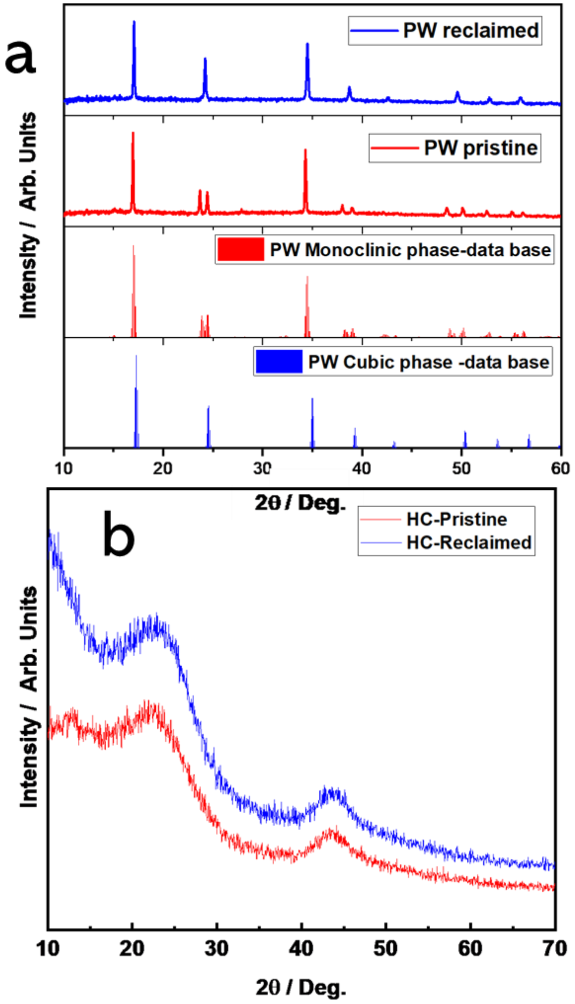
WP6 | Potential process for SIMBA solid-state Sodium-ion Battery

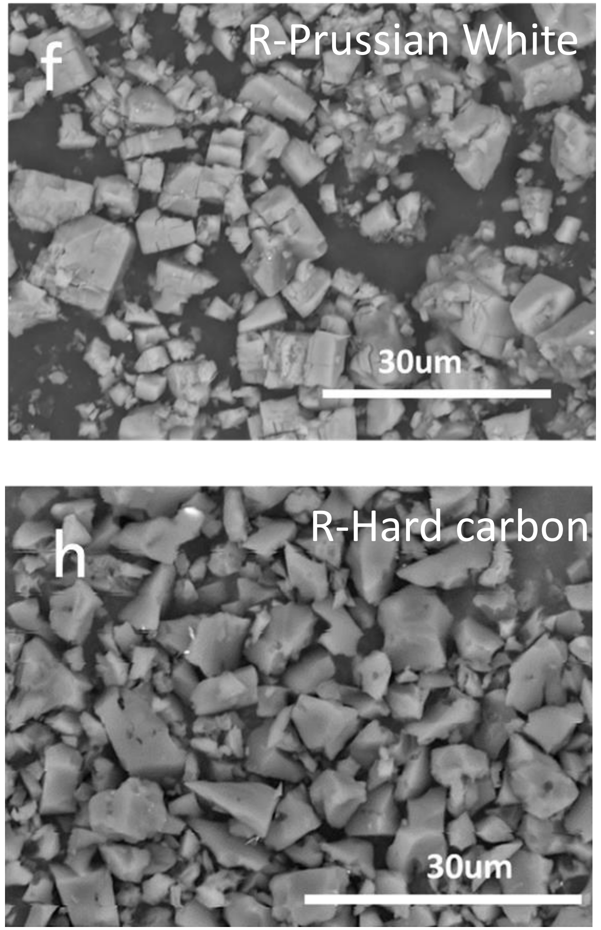


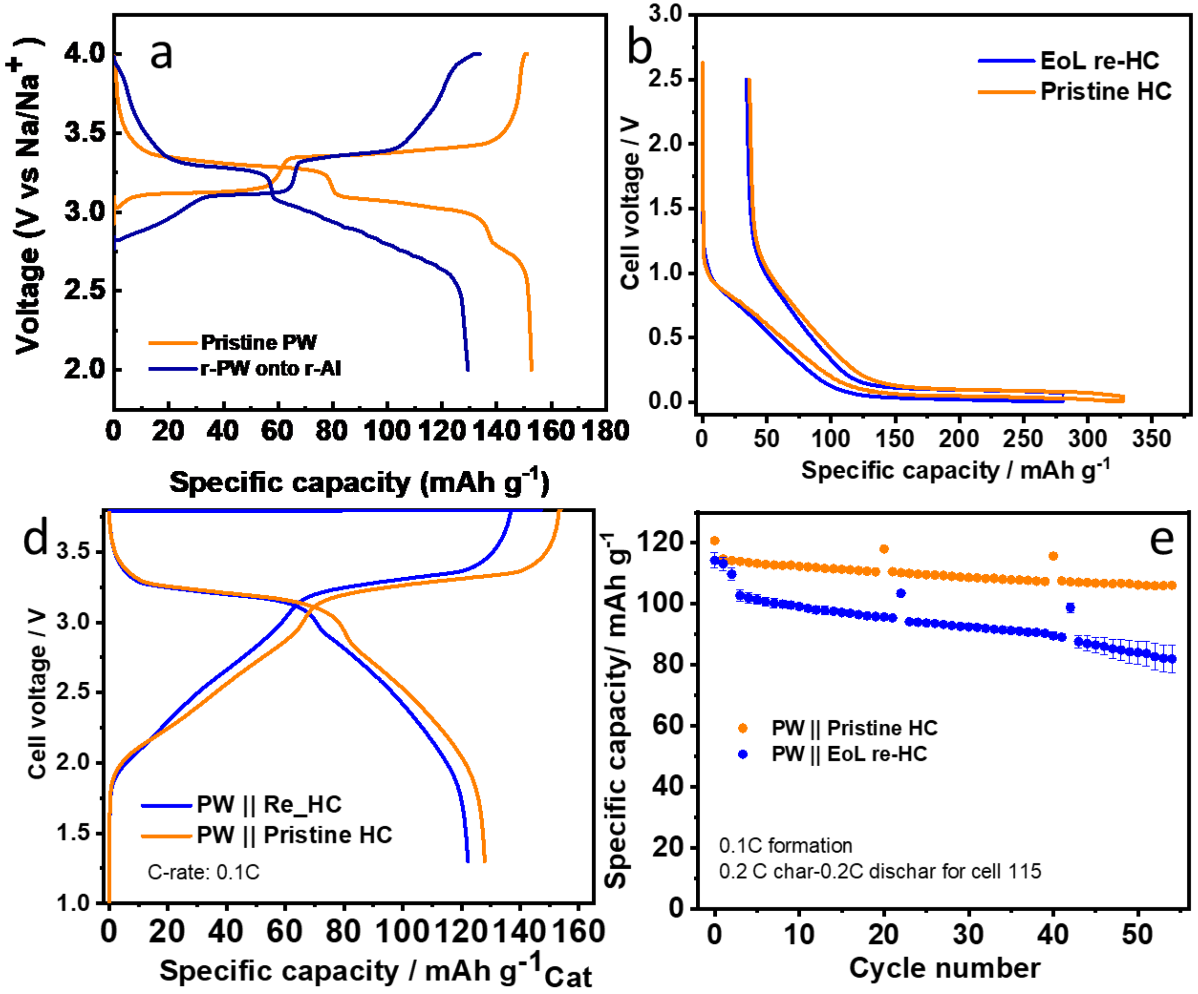
UNIVERSITY OF BIRMINGHAM

+SIMBA SODIUM-ION AND SODIUM METAL BATTERIES

Reclaimed and Directly reused PW and HC







Summary

- Critical Materials and Supply Chain
- Low-value materials – need to retain added value during reclamation processes
- Direct and Short Loop Recycling for Scrap and End of Life
- Ice Stripping delamination retains morphology of components
- Direct Recycling for Hard Carbon Demonstrated

Thank you!