# Recirculation of Electric Vehicle (EV) Batteries

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Bærekraftige batterier – hvor går veien videre?
Det Norske Videnskaps-Akademi, Oslo.
27th February, 2024

Norwegian University of Science and Technology

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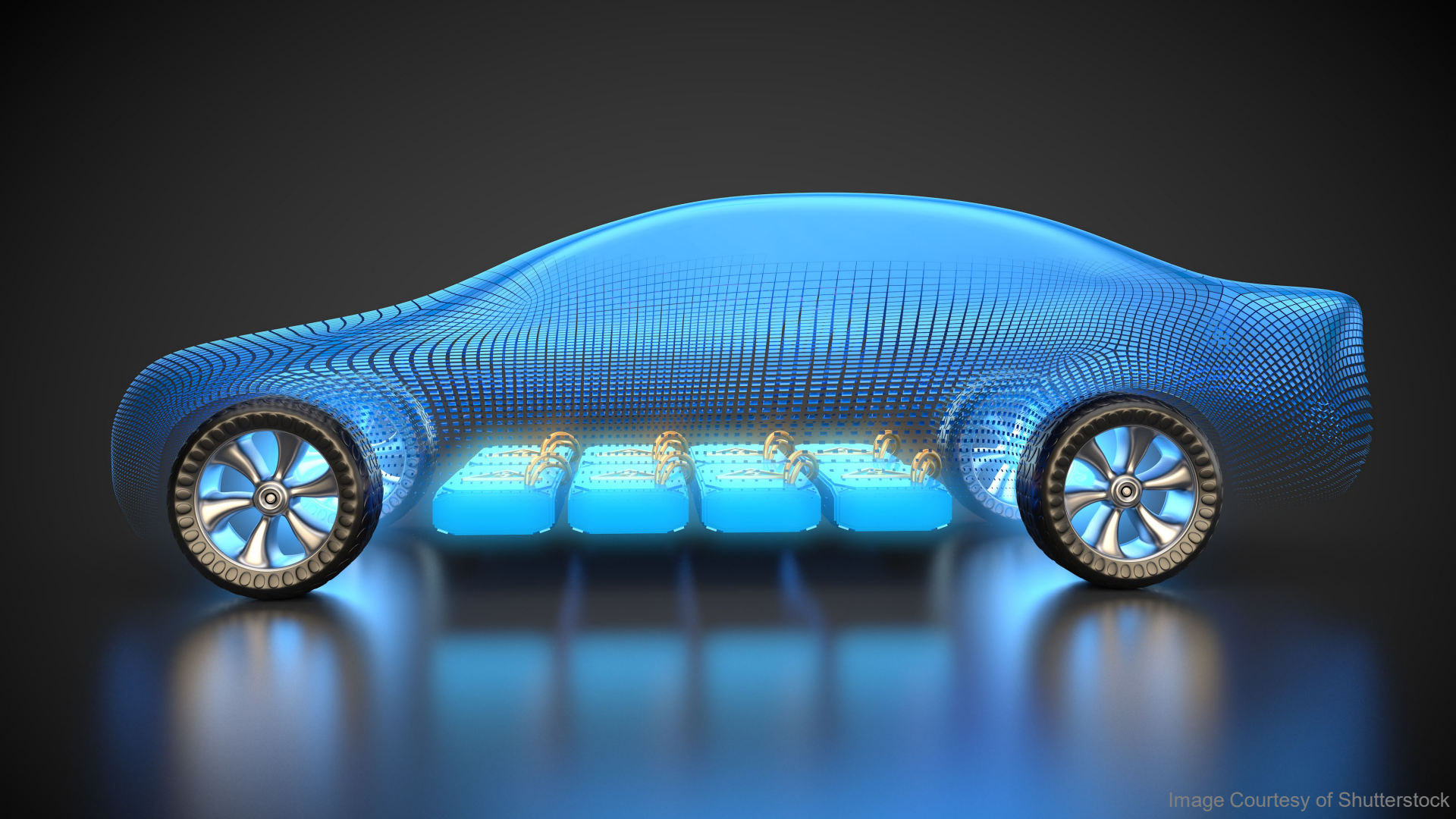

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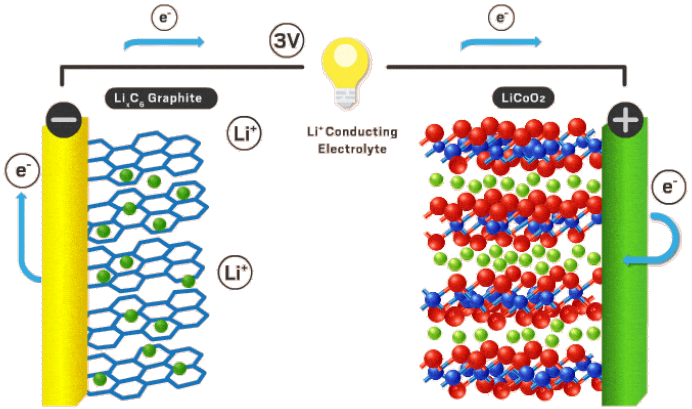
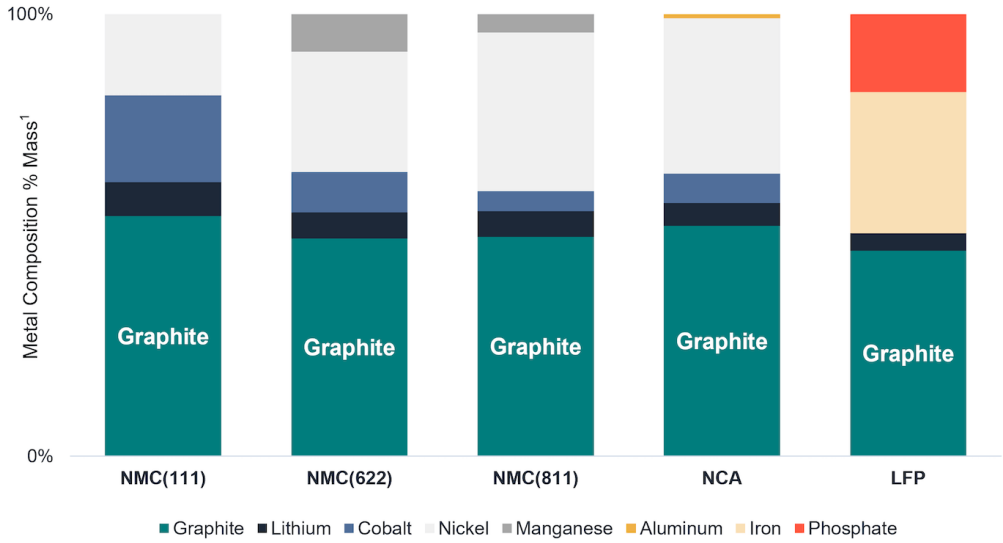
# Battery - Composition





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https://claudiusreview.blog/tag/lithium-ion-battery/; https://www.syrahresources.com.au/about/battery-anode-market
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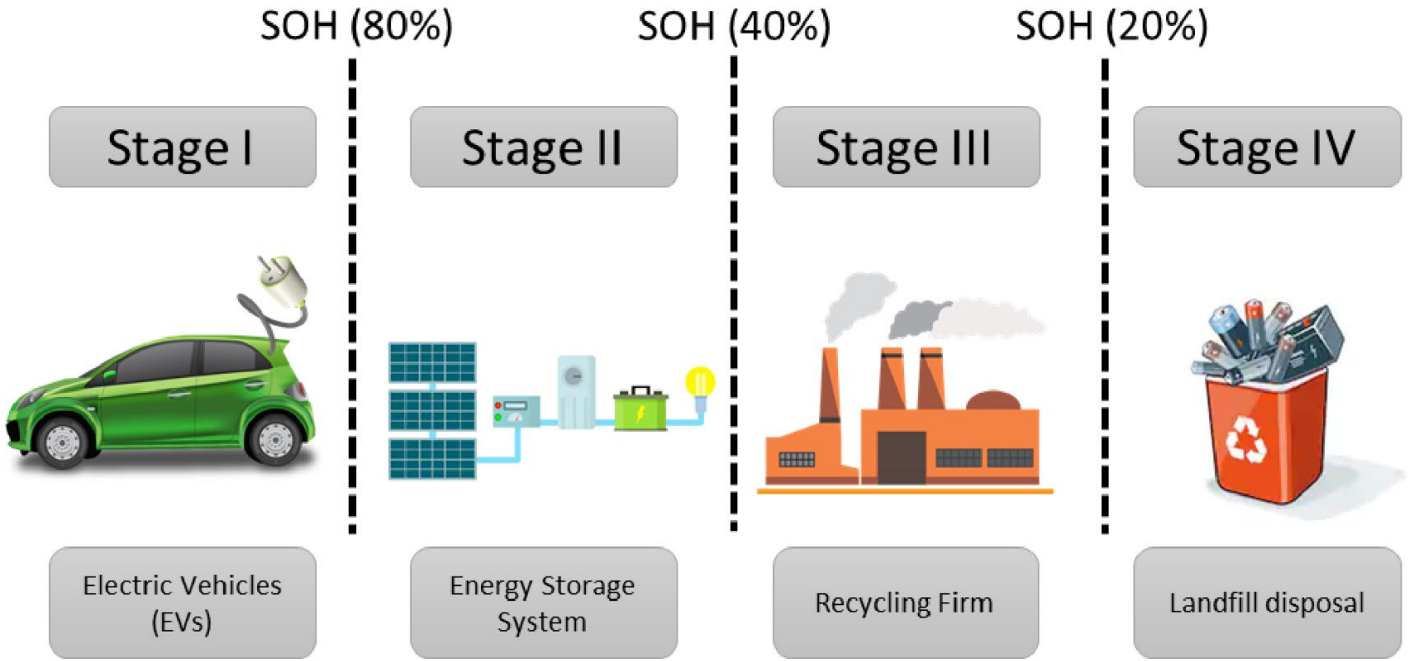
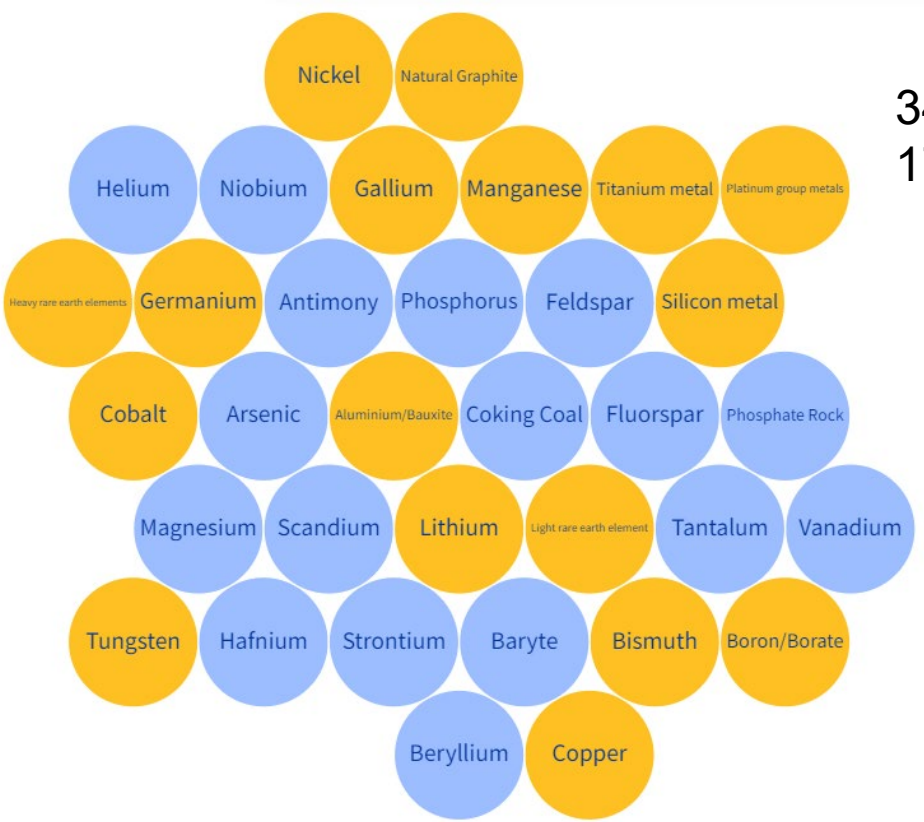
# Just a thought!





Ali, H. et al, *Journal of Energy Storage* **40,** 102690 (2021)

# EU Critical Raw Materials Act



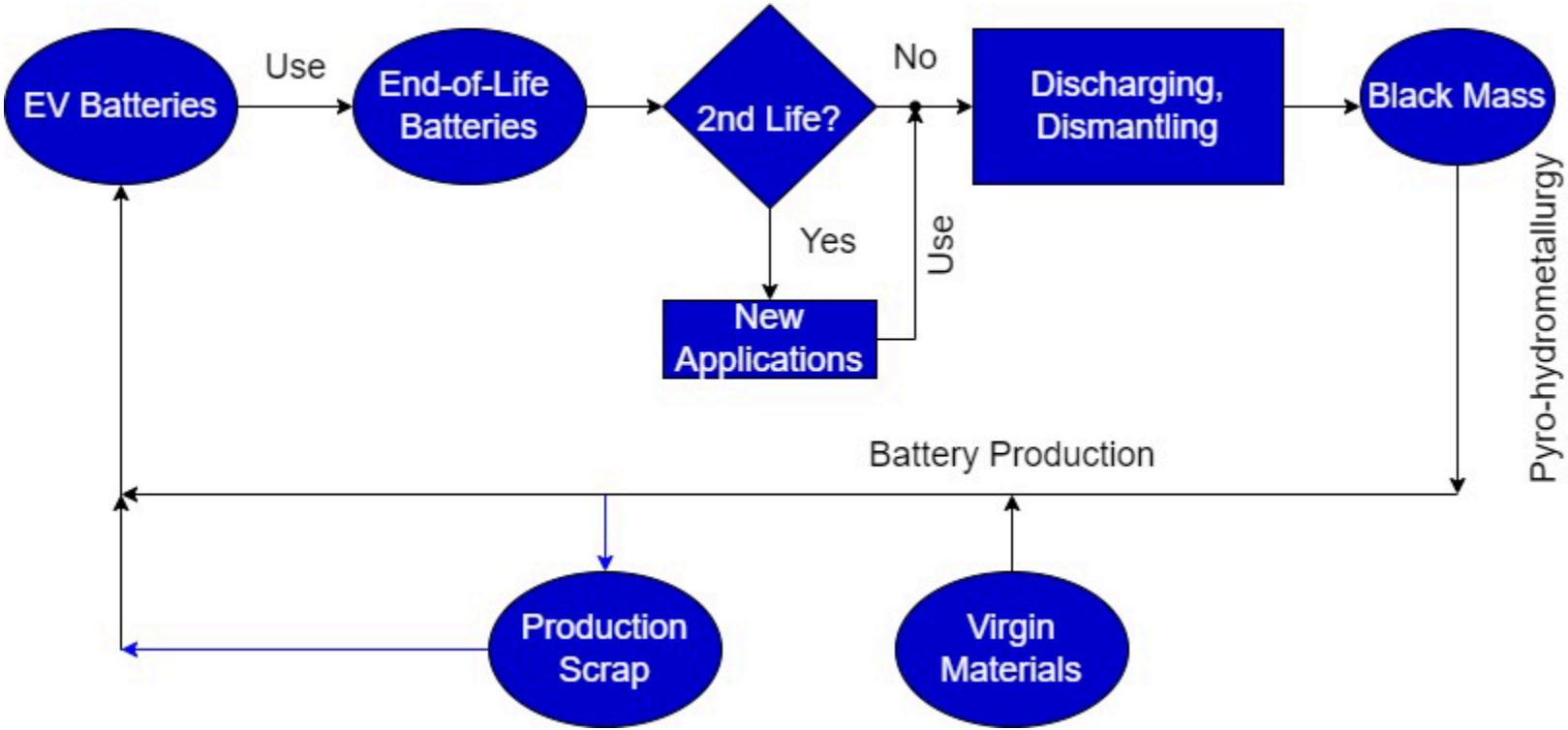

34 Critical Raw Materials
17 of them are strategic (dark yellow)

# LIB Recycling Directives

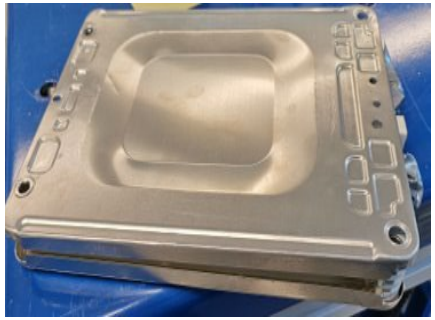
Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries

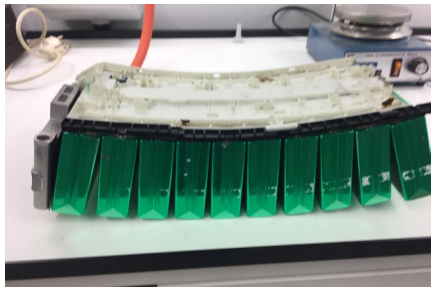
- Aims to promote a circular economy by regulating batteries throughout their life cycle.
- Establishes end-of-life requirements, including collection targets and obligations, targets for the recovery of materials and extended producer responsibility
- Target for lithium recovery from waste batteries: **50%** by the end of 2027 and **80%** by the end of 2031
- Targets for cobalt, copper, lead and nickel recovery form waste batteries: **90%** by 2027, rising to **95%** by 2031.
- Mandatory minimum levels of recycled content for industrial, SLI batteries and EV batteries.

# Research Overview

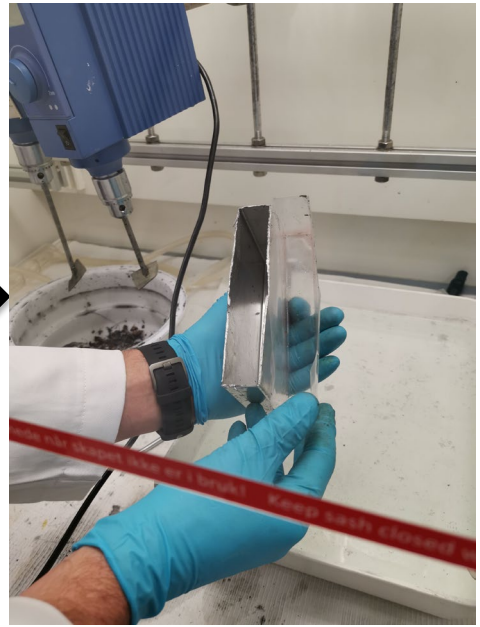


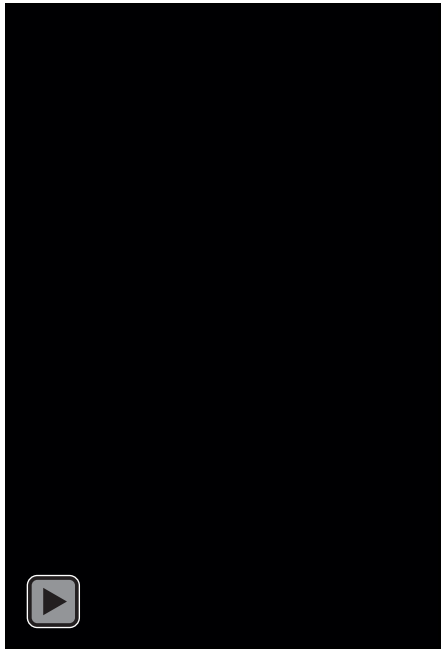
# Black Mass (BM) Production



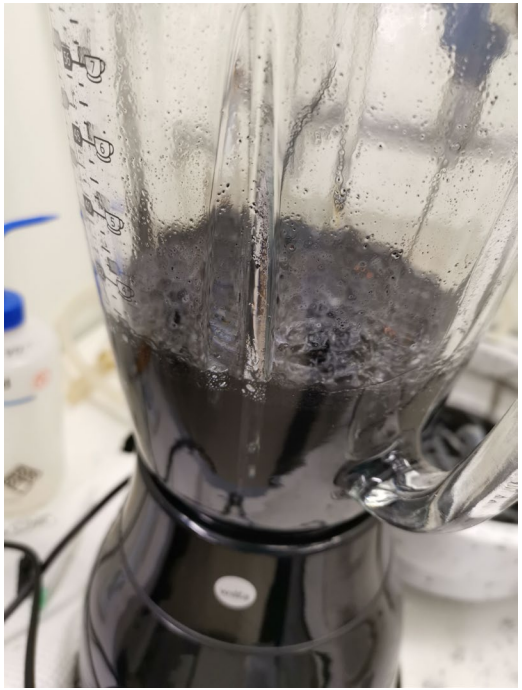


Cells





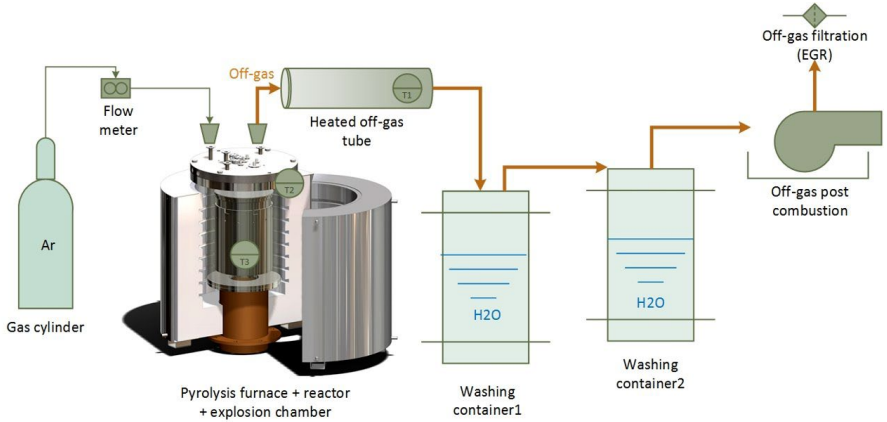
# BM Production



Crushed copper foils

Black mass

# Pyrolyzed BM




T = 800 °C

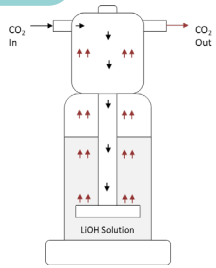
# Industrial Scale BM Production

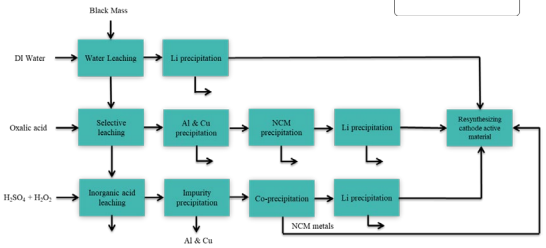
LIBRES IPN Project (2018 – 2022)

hydrovolt

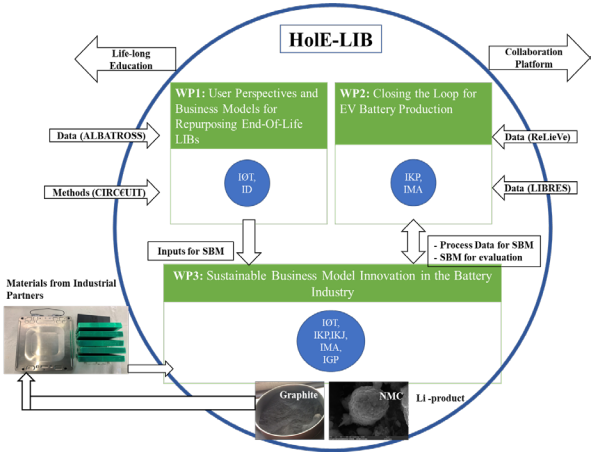
# Research Projects

## ALBATROSS (2021 – 2025)

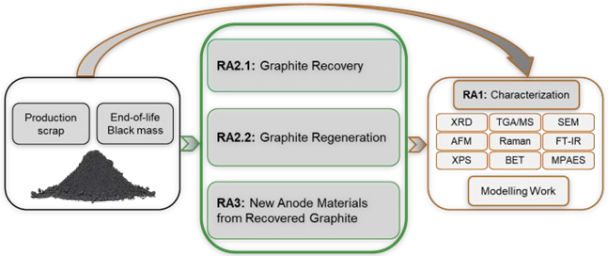



## HolE-LIB (2022 – 2026)




## SUMBAT (2022 – 2026)




## LIBRES (2018 – 2022)

hydrovolt

## REVITALISE (2023 – 2026)

**NMC, LFP, Sodium Ion Batteries Recycling**

# Our Research

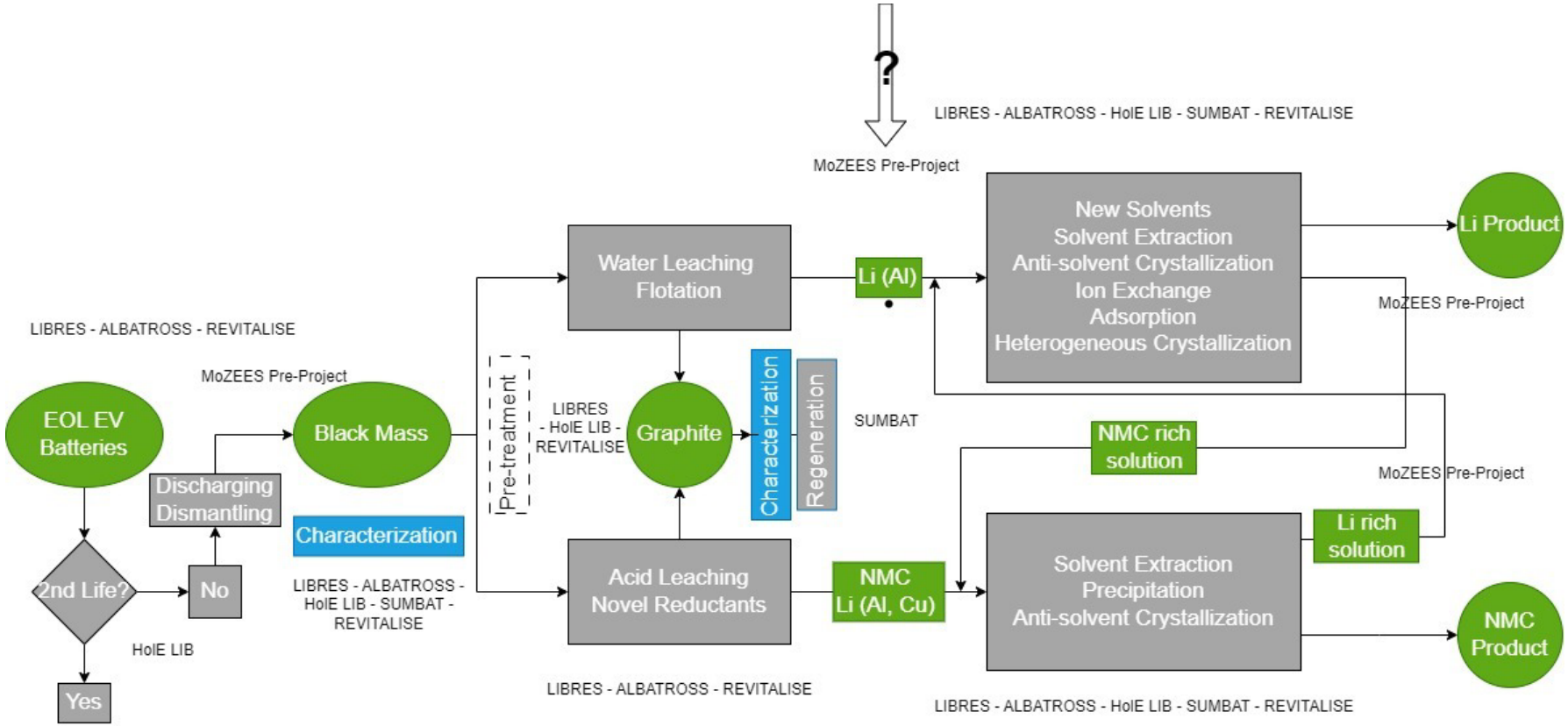


Image Courtesy of Shutterstock

# Current Challenges

- Battery pack disassembly.
- Low volumes of LIBs.
- High capital costs for pyrometallurgical routes.
- No standardized battery design.
- Fast evolving battery chemistry.
- Lack of better sorting technologies.
- No established method for separating electrode materials.
- Lack of “Design for recycling”.

# Funding

The Research Council of Norway

siva

Innovation Norway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NTNU
Norwegian University of Science and Technology

# PEC Members: Autumn 2022

Missing in the photo: Nesrine Bali, Hari Desai, Hassan Ahmed, Bhaskar Joshi, Sams Navith Segu Jaludeen