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TRANSPORT RESEARCH ARENA
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LCA and ECO-Design for Li-ion Battery sustainability

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Outline

Background

- What is LCA and what does it bring to us?
- Methodological challenges for a unified and battery LCA approach (Sub- Cluster LCA COLLABAT)
- New European regulation: Recycling/2nd life and battery passport

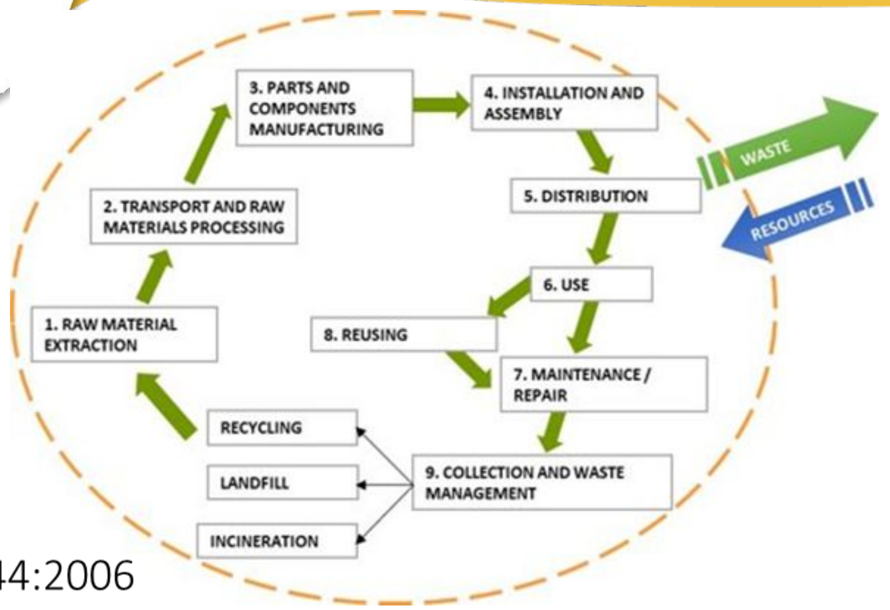
EU battery project overview (LC-Bat 10, LC-Bat 5, LC-Bat 1)

- Helios-LC-Bat 10
- COBRA-LC-Bat 5
- SafeLimove-LC-Bat 1 - 2019
- Recycling vs Eco-design in the European Project context

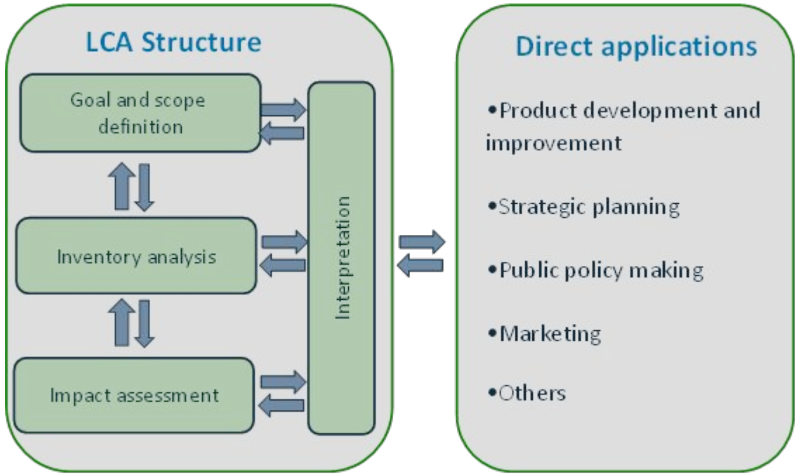
Questions & Answers

Background

- What is LCA and what does it bring to us?



ISO 14040/140044:2006



Environmental impact categories

GWP: Global Warming Potential, **[kgCO_2 eq]**

AP: Acidification Potential, **[kgSO_2 eq]**

EP: Eutrophication Potential, **[kg PO_4 eq]**

ATP: Aquatic Toxicity Potential, Ecotoxicity **[CTUe]**

HTP: Human Toxicity Potential, Human Toxicity, cancer **[CTUh]**

ADPe: Abiotic Depletion Potential Elements, **[kg Sb eq]**

PED: Primary Energy Demand from renewables and non-renewables **[MJ]**

Background

 Methodological challenges for a unified and battery LCA approach

Sub- COLLABAT cluster - LCA, Recycling & sustainability

The LCA as the suitable methodology

LCA is a valuable tool to identify environmental hotspots within the battery life cycle, however, is a **complex exercise and can be challenging to compare and communicate the results.**

Existent methodologies

- **PEFCR**-Product Environmental Footprint Category Rules for High Specific Energy Rechargeable Batteries for Mobile Applications
- PAS 2050
- Product GHG Protocol
- **ISO 14067**

Carbon footprint calculation

Challenges

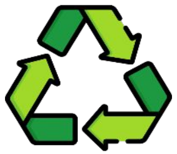
- Consistent scope
- Common System boundaries
- Homogenized Functional unit
- Data availability-LCI
- Environmental metrics for result communication
- 2nd life and Recycling integrated approaches

Common LCA Guidelines in the LC-Bat 10 battery projects

Background

Methodological challenges for a unified and battery LCA approach

LCA- COLLABAT – Reuse vs Recycling



Recycling

LCA Recycling approaches show the option of recycling is not only useful for sustainability reasons, but also from an economical perspective, as it makes sense to regain precious materials after the EoL of a battery system

2nd Life applications

One LCA generalised method cannot provide an optimal approach for all cases. It is important to have a detailed study on each of the battery reusing applications

Until now, it is safe to say that reusing the battery is a good option as it would give some time to recycling companies to develop cost and energy-efficient methods

Some LCA recycling figures

-Total production and materials GWP range 61-146kg CO_2-eq/kWh battery capacity

-The PEFCR battery study reports that **12% of the GHG emissions of a lithium-ion battery's lifetime occur in the end-of-life stage**

-**70**% of emission and energy consumption can be reduced by extracting the materials and components by recycling

-**This overall percentage can be increased up to 91%** (combination of mechanical and hydrometallurgical processes

Background

- New European Regulation: Recycling/2nd life and battery passport

This new regulatory framework is the first proposed initiative under the Commission's new Circular Economy Action Plan ("**Action Plan**"), published on 11 March 2020, which is a key part of the European Green Deal and the Commission's plan to make the EU's economy sustainable.

COM(2020) 798 final - PROPOSAL for a regulation concerning batteries and waste batteries repealing Directive 2006-66-EC and amending Regulation (EU) 2019-1020

Introducing a wide range of new requirements for batteries and key battery raw materials, with a specific focus on electric vehicle batteries.

Main requirements

1. Sustainability and Safety

-Carbon footprint (CF) declaration
Methodology to calculate CF of batteries

-Recycled content
To declare the content of recycled materials

-Safety and supply chain due diligence
System of controls and transparency over the supply chain

2. Labelling and Information

-EU declaration of conformity (all batteries)
Labelling requirements: lifetime, charging, presence of hazardous and safety risks

-BMS availability
Storing information and data needed to determine the state of health and expected lifetime of batteries

-Battery passport
Register and provide to the public information about every battery model placed on the EU market

3. End-of-life Management

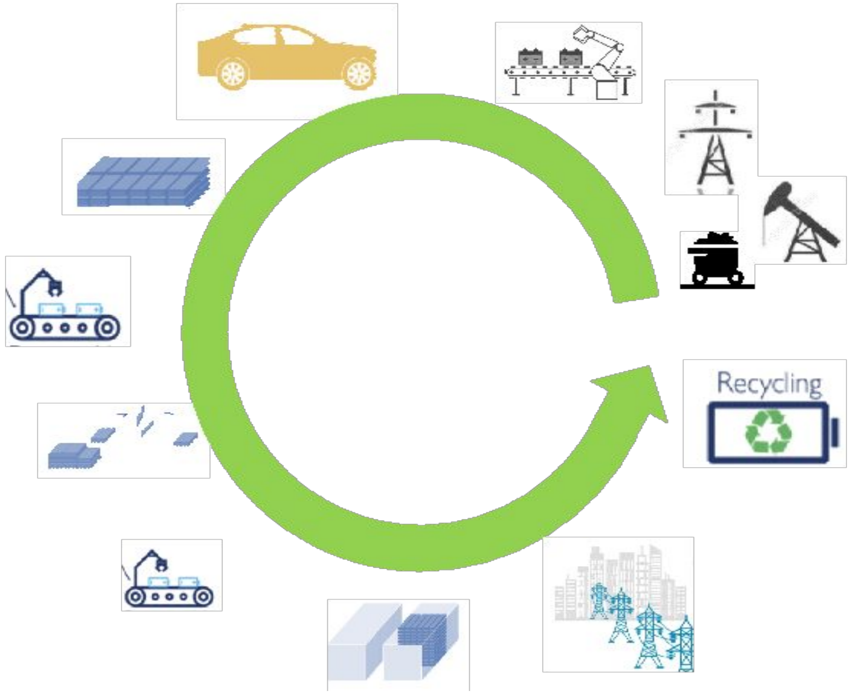
-Collection obligations
Automotive Batteries, industrial batteries and electric vehicles batteries will be reinforced specific reporting to facilite enforcement

Environmental assessment of EU battery projects

 Helios project overview

HELIOS

HIGH-PERFORMANCE MODULAR BATTERY PACKS FOR SUSTAINABLE URBAN ELECTROMOBILITY SERVICES



Main goal: To evaluate the sustainability of the technologies applied to batteries involved in the project, considering up-scale scenarios to foster overall performance and uptake of the HELIOS technology

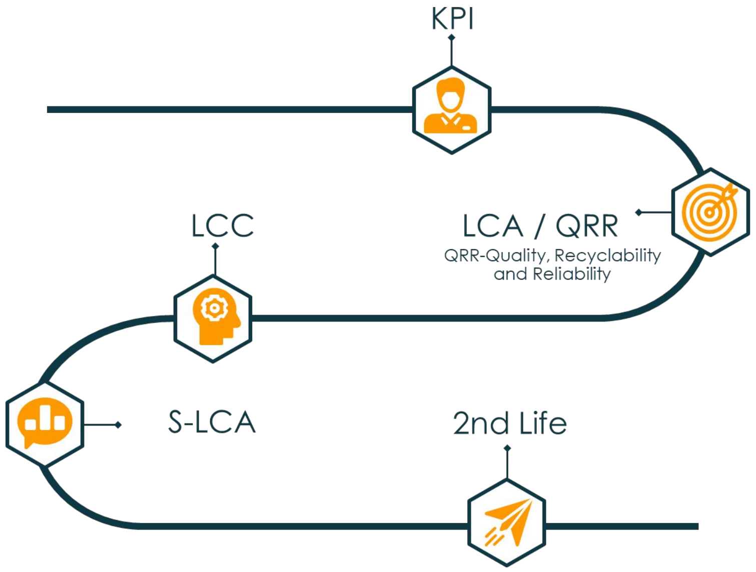
- Eco-Design connecting manufacturing and recycling
- Life Cycle Assessments for proposed technologies
- Cost and Techno-economic analysis

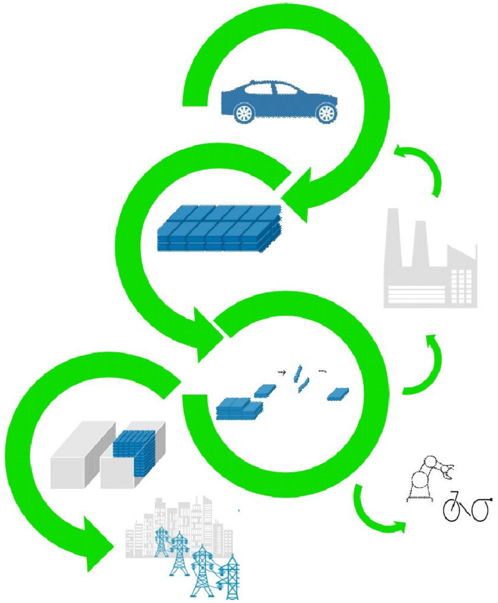
Environmental assessment of EU battery projects

- COBRA project overview

COBALT-FREE BATTERIES FOR FUTURE AUTOMOTIVE APPLICATIONS) IS A COLLABORATIVE RESEARCH AND INNOVATION PROJECT ON NEXT-GENERATION BATTERIES

WP8 - (Economic, Environmental and Social Assessment)





Main goal: To analyze the environmental, economic and social sustainability of the proposed COBRA chemistry batteries free of Cobalt considering recyclability and eco-design concepts "

- Environmental KPIs definition
- Full data collection (material and energy flows)
- LCA cradle-to-Gate:

focus on materials at cell level

- LCA Cradle-to-Grave and Eco-design guidelines

Environmental assessment of EU battery projects

SafeLimove project overview

SAFE Li MOVE

ADVANCED ALL SOLID STATE SAFE LITHIUM METAL TECHNOLOGY TOWARDS VEHICLE ELECTRIFICATION

WP8 - Industrialization Perspective and Roadmap towards 2030

GOAL 1

To analyze the environmental sustainability of the innovative battery developed within the project

GOAL 2

To identify most suitable recycling routes for the battery ensuring optimal recovery of material

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D8.3 – complete LCA study from cradle to grave

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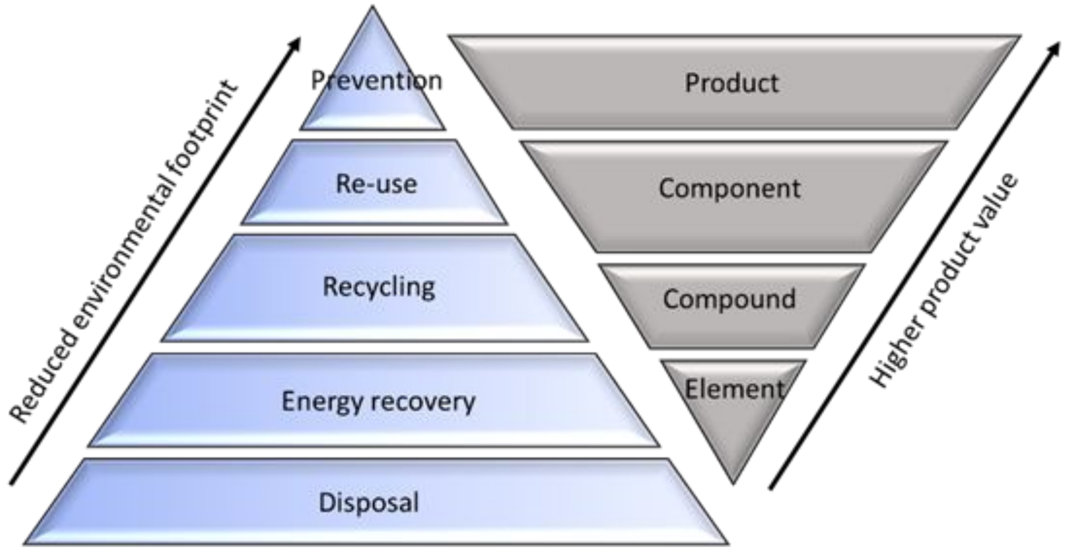
D8.4 – recycling study on Safelimove technology and expected recovery rates

Recycling vs Eco-design

- From Eco-design perspective the manufacturing process should have the smallest possible environmental footprint, after which LIBs are used as long as possible. When they cannot be used any longer in an EV, their lifetime should be extended in a second life application and finally recycled with maximal material recovery and minimum waste.

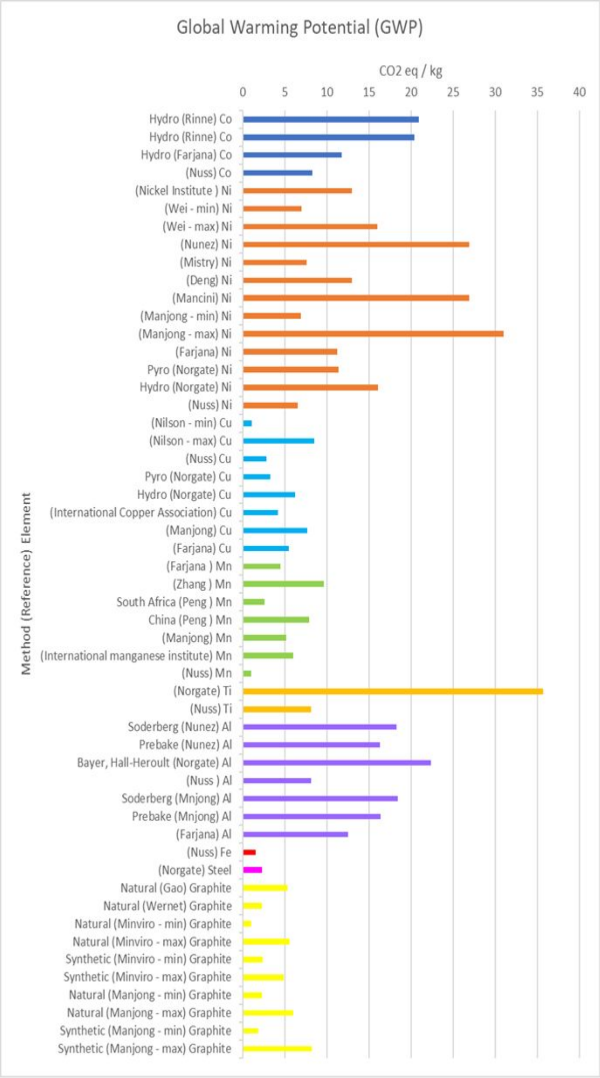


Lansinks Ladder according to the Council Directive 75/442/EEC representing the waste management hierarchy and the correspondence of product value levels to recycling.

Environmental assessment of EU battery projects

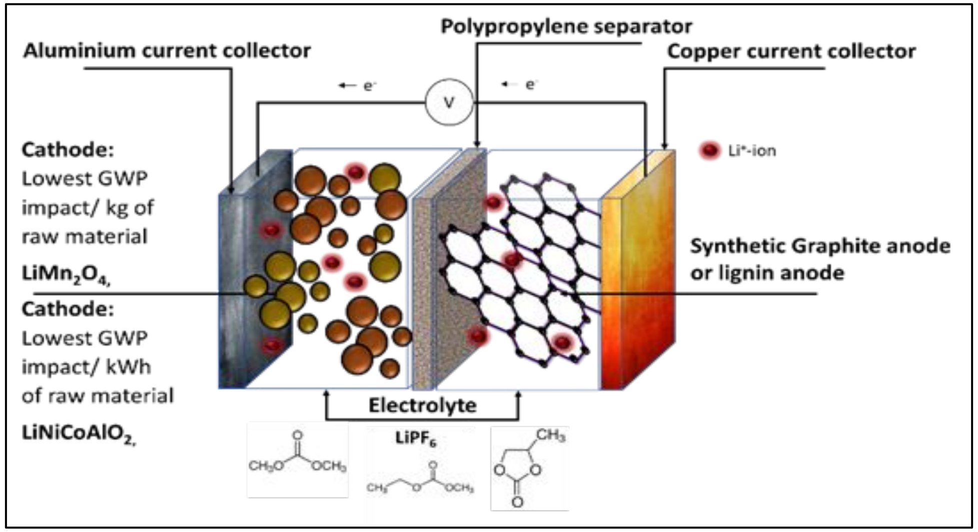
Recycling vs Eco-design in the European Projects context

Manufacturing of LIBs



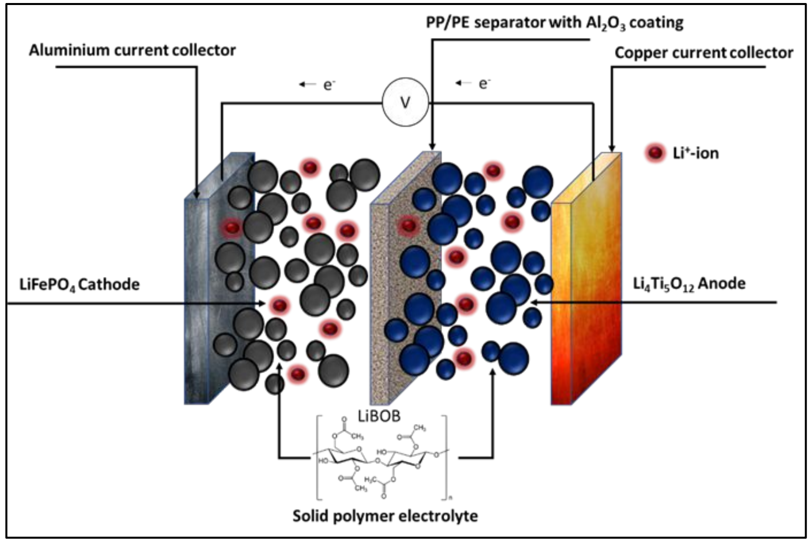
- Majority of the total manufacturing greenhouse gas emissions are allocated to the production of the LIB cell raw materials.
- Certain elements such as Co, Li, natural graphite and phosphate are predicted to face supply risks in the future, highlighting the importance of sustainable management of their extraction, use, reuse, and recycling.

LIB cell electrode selection for reducing environmental impacts of manufacturing



Re-use of LIBs in energy storage applications

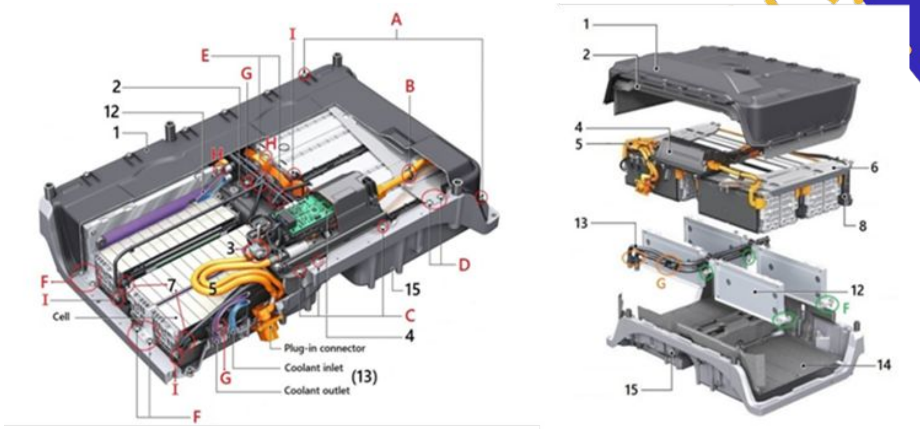
- Longer lifetime reduces the environmental impact of LIBs in a second life application.
- Pack and module imbalances (cell spreading) and increased risk of failures are the main technical challenges of LIBs re-use.



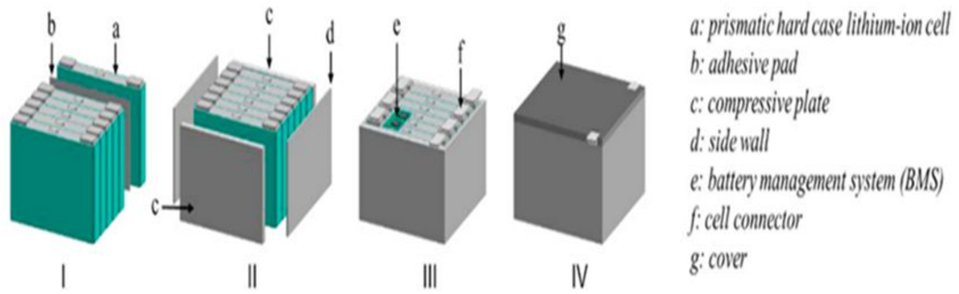
Lithium-ion battery cell design for improved safety and long lifetime

Recovery and Recycling

- The key limiting factor for EV battery recycling is the lack of automated processes of dismantling.
- Eco-design for automated dismantling would require:
  - ❖Using screws rather than glues and welds as joining methods.
  - ❖Preferring other detachable structures (busbars rather than wires)
  - ❖Minimizing the number of features and components
- Development of computer vision technologies for detecting pre-designed laser cutting points can provide a compromise between manufacturing, use and recycling needs.



M. Alfaro-Algaba, F. Javier Ramirez, Techno-economic and environmental disassembly planning of lithium-ion electric vehicle battery packs for remanufacturing, Resources, Conservation & Recycling 154 (2020) 104461



Jens Schäfer, Ramona Singer, Janna Hofmann, Jürgen Fleischer, Challenges and Solutions of Automated Disassembly and Condition-Based Remanufacturing of Lithium-Ion Battery Modules for a Circular Economy, 17th Global Conference on Sustainable Manufacturing, Procedia Manufacturing 43 (2020) 614–619.

Environmental assessment of EU battery projects

Recycling vs Eco-design in the European Projects context

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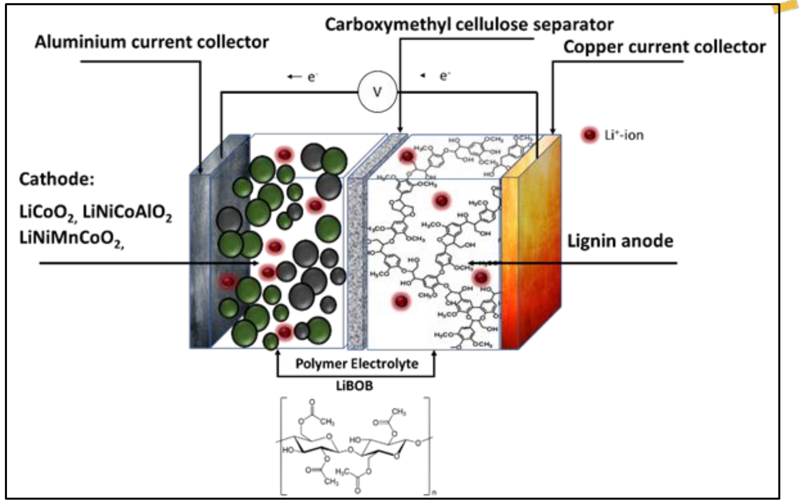
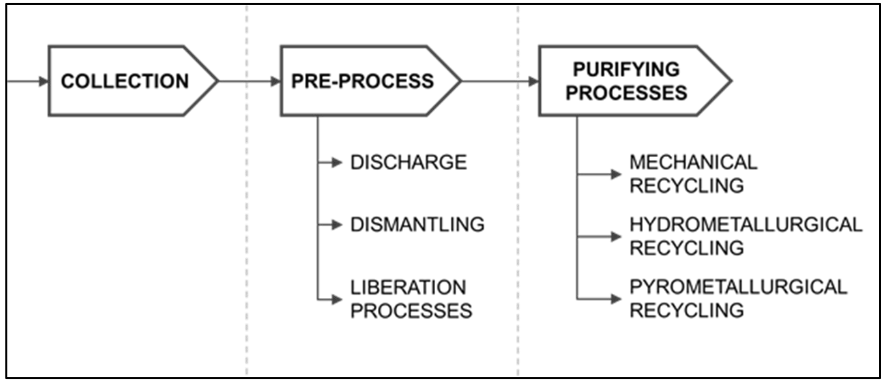
Recovery and Recycling

- PVDF Binder complicates recycling processes, use of alternative water-soluble or cellulose would ease component separation and reduce contamination.
- Organic electrolyte solvents and fluorine create complications during recycling. Research regarding solid bio-polymers and non fluorine containing salts should be encouraged.
- Ideally simple but more importantly, valuable electrode elements are more recyclable compared to low value elements.
- Recycling of metals with high environmental impacts during their mining and processing show greatest environmental benefit by recycling.
- With labelling of cell components to a battery pass, the chemistries of waste steams can be controlled better.



Lithium-ion battery cell design for improved recyclability.



Flowsheet of LIB recycling

Q&A

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