



Advancing Lithium-Ion Battery Recycling through Life Cycle Assessment

From Material Flows to Environmental Impacts: Life Cycle Assessment in LIB Recycling

In one of our prior newsletters of project 1 (number 9, 4th quarter 2024), we highlighted how **Material Flow Analysis (MFA)** helps to map and quantify the pathways of raw materials in Lithium Ion Battery (LIB) recycling processes. MFA provides the foundation for efficient circular strategies. But while MFA shows us *what goes where*, it does not answer the question: *What are the environmental consequences of these flows?* This is where **Life Cycle Assessment (LCA)** comes into play being part of Sub-Project 1 of the COMET Module FuLiBatteR.

Why is LCA essential for battery recycling?

LCA is an internationally recognized method to evaluate the **environmental impacts of products and processes across their entire life cycle** – from raw material extraction through production and use, all the way to recycling or disposal. For LIB, this means, we can assess how different recycling routes affect the environment and identify the most sustainable option. But one rule always applies: *Garbage in – Garbage out*. Reliable conclusions require high-quality, complete, and representative data. That is why data quality, process completeness, and the inclusion of waste management steps are crucial in any LCA.

Underrepresented processes – a gap we aim to close

Many LCA studies on battery recycling focus almost exclusively on the metallurgical processing stage. However, processes that are **essential in practice** are often underrepresented, such as:

- **Collection** of end-of-life batteries
- **Logistics** between collection points and recycling plants
- **Disassembly** of complex battery packs

These steps not only account for significant costs but also contribute measurably to environmental impacts. Their omission leads to a systematic bias in results. Within FuLiBatteR, we aim to **close this gap and provide a more holistic picture**.

Objective: Comparing recycling scenarios

A core ambition of our work is to **compare different recycling scenarios on the basis of robust data generated within the FuLiBatteR Module and its other Sub-Projects 2 and 3**. These projects investigate and develop a range of recycling technologies, including:

- **Pyrometallurgical** recovery of secondary materials from battery black mass including the CFD simulation of the thermal LIB deactivation step
- **Biohydrometallurgical** approaches for recovery of elements from black mass

By integrating these technological insights into our LCA studies done with the openLCA software and with accompanied use of the Ecoinvent database, we can systematically assess their relative environmental benefits and drawbacks. This allows us to highlight **which pathways contribute most effectively to resource conservation and a circular economy**.

Our contribution to the circular economy

With LCA, we extend the perspective from mapping material flows to **quantifying environmental impacts**. Together with data from P2 and P3, we aim to provide **scientifically sound, comparable assessments** of different recycling routes. This knowledge will support industry, policymakers, and society in making informed choices about the future of sustainable battery recycling – and demonstrate its pivotal role in building a truly circular economy.

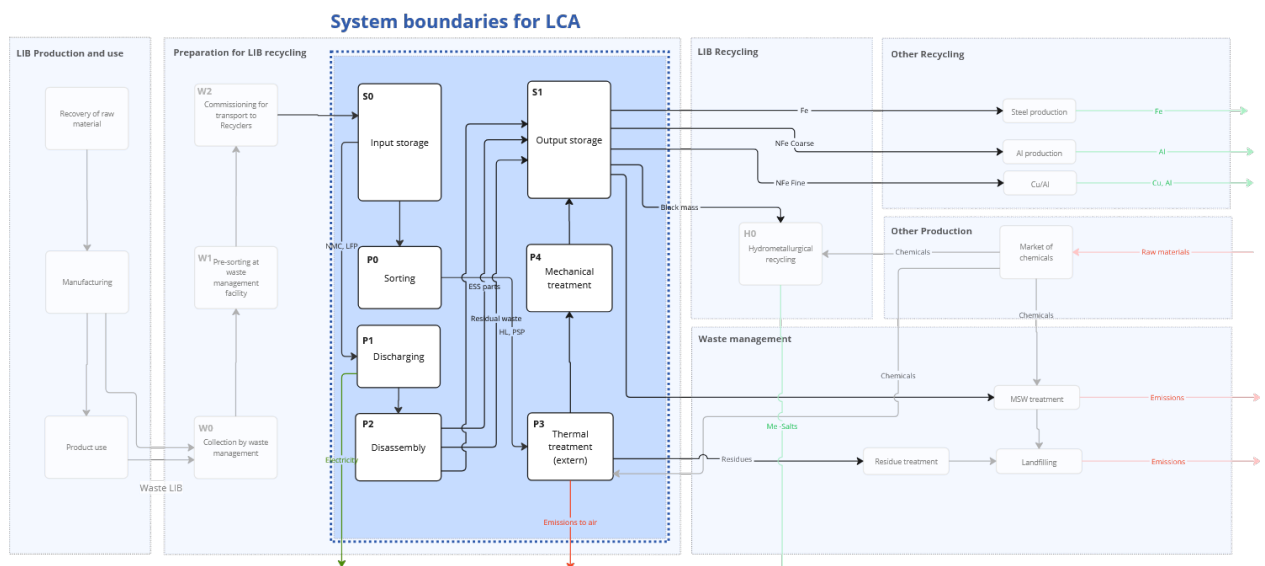


Figure 1: Exemplary system boundaries for the LCA study of LIB recycling.

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For more information about FuLIBatteR and its progress, please visit [LinkedIn](#) and the [K1-MET-Website](#).