



# ***Battery Recycling — Sustaining the now; powering the future***

## **#4**

*Recycling is essential to address the quickly growing demand for cells to meet the need for electrification. With a forward-thinking approach, we are paving the way for more efficient recycling.*

# The Importance of Battery Recycling in a Circular Economy

**Recycling is a vital link in the circular model that is worth a closer look. For Alelion, essential components of our strategy include keeping vital resources in use for longer, optimizing product life cycles, and ensuring efficient return of valuable minerals into production of new cells, as well as re-using of other battery materials.**

## Battery Recycling – The Underemphasized Service

Effective recycling processes are important for smart use of our limited mineral resources, reducing the environmental impact of electrification, and supporting innovation in battery technology. However, many battery manufacturers or cell suppliers have not yet fully grasped the importance of recycling and the key role it plays in creating circular battery systems.

### Can Recycling address the growing Cell Shortage?

It's clear that there's a growing shortage of cells, and as electrification picks up further speed, this shortage will be accentuated. For electrification to follow projected trends, we believe recycling of cells will be an essential source for the minerals needed as demand is quickly surpassing global mining production, while at the same time global volumes of battery scrap grew 56% last year. Extracting

*Globally, volumes of battery production scrap grew 56% last year.*

the maximum value from recycled cells could help bridge this growing gap between supply and demand. Effective recycling will be of increasing value as the number of batteries in use is growing.

### Current and Emerging Methods for Recycling

Several techniques for battery recycling exist, and many more are under development. Heat, water, mechanical or biotechnological, they all depend greatly on the disassembly process and rate of contamination of materials. By staying abreast of these technological advances, Alelion ensures that our battery systems are designed with the future of recycling in mind. We also provide a platform for recyclability planning with industry partners.

Table 1. Benefits and challenges of common and emerging recycling methods

Pyrometallurgy	Hydrometallurgy	Direct recycling	Biotechnological Methods (emerging):
<ul style="list-style-type: none"> <li>Common method for recovery of metals like copper, nickel, and cobalt using heat</li> <li>Low complexity of process; high energy consumption and big carbon footprint</li> <li>Limited applications and is essentially only relevant for a few specific battery chemistries</li> </ul>	<ul style="list-style-type: none"> <li>Effective recovery of minerals such as cobalt, nickel, and lithium</li> <li>More complex process consisting of several steps; use of aggressive chemicals and risk for toxic emissions</li> <li>Capable of recovering a wide range of metals including lithium; lower energy consumption compared to pyrometallurgical</li> </ul>	<ul style="list-style-type: none"> <li>Effective as it allows for the direct reuse of battery components</li> <li>Technologically complex; may require pre-treatment steps</li> <li>Safety concerns around potential thermal runaway or fire if the battery is not properly handled or the active materials are contaminated</li> </ul>	<ul style="list-style-type: none"> <li>Using microorganisms for bioleaching with potentially high recovery rates; still largely in the experimental stage</li> <li>Low energy consumption and small CO<sub>2</sub> footprint</li> <li>High recovery yields even for low concentrations of metals, making it an interesting alternative to conventional methods</li> </ul>

## Data Analysis – it Starts in the Lab

Data analysis plays a crucial role in the recycling process. Understanding when a battery system is nearing its end-of-life allows us to maximize its use and determine Total Cost of Ownership (TCO). At Alelion, we collect and analyze battery system data to effectively determine end-of-life, guiding our recycling efforts and ensuring optimal resource utilization. Our Cell Test Lab provides essential data and insights into cell life cycles.

Battery recycling has two valuable products: pure metals like aluminum and copper, and 'black mass'. This is a black powder consisting of a mix of precious metals like manganese, cobalt and lithium. The quality of black mass, used in new cell production, hinges on the assembly of cells and modules, with design for recycling being critical. Alelion's approach, built on 15 years of battery knowledge, focuses on optimizing recovery and purity of these materials, reducing reliance on virgin resources, and promoting sustainable battery production.

## The typical battery recycling process



The typical recycling process opens for many opportunities but also several challenges. The efficiency of the process and hence the end products will depend on the collaboration between the parties involved, especially the early stages of the design on the battery systems. Challenges will appear in dismantling and discharge as this will require both

competence in safety, dismantling techniques as well as modularity of the battery system to be safe, smart and cost-efficient. Improving the efficiency and consequently the quality of the end products will be an important step to improve circularity of the cell production as well as ensuring material availability to support the market growth.

## *Painting the Landscape for Battery Recycling and Circular Flows*

*The landscape for handling battery recycling and establishing circular flows is continually evolving. It requires a concerted effort from manufacturers, recyclers, and policy-makers to create an effective ecosystem for battery recycling.*

At Alelion, we're committed to collaborating with stakeholders at every level to build robust, sustainable circular flows.

In conclusion, Alelion is dedicated to being a part of the solution for sustainable transitions, recognizing the importance of recycling in the circular economy model. As we continuously work with finite resources, we place a high focus on optimization, recycling, and the development of circular systems, contributing to a sustainable, electrified future.

### *Four key questions on recycling every battery system user should ask*

- 1. Inquire about Service Products as in End-of-Life Services:** Ensure to include end-of-life management services in your partnership agreements, in addition to a comprehensive service program.
- 2. Emphasize 'Design for Recycling':** Ensure your battery system supplier understands and implements 'design for recycling' principles. The design of the battery greatly affects the quality and efficiency of recycling.
- 3. Ensure Regulatory Compliance:** Look for a supplier who fully understands and complies with the Battery Directive, which covers essential aspects of regulation compliance and the battery life cycle. This will equip you to handle EU Battery Directive requirements better and also reinforces your sustainability commitments.
- 4. Value Recycling:** Choose a battery system supplier who recognizes the intrinsic value in recycling and has an established recycling ecosystem in place, from cell to complete battery system. The supplier should demonstrate proven practices and commitment to sustainable management of battery resources.

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### *Alelion – Sharing knowledge and experiences*

Alelion is an established developer, manufacturer, and supplier of advanced battery systems for off-highway vehicles in a number of different segments. With more than 15 years of experience, we now share our key learnings in a series of white papers.



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