Duesenfeld

LEADING THE CHARGE IN LITHIUM-ION BATTERY RECYCLING

Innovative solutions by ANDRITZ & Duesenfeld

ANDRITZ

Powering a greener future: Sustainable battery recycling

At ANDRITZ, we are committed to sustainable solutions for the growing challenge of battery waste, driven by the expanding electric vehicle (EV) market. In collaboration with battery recycling pioneer Duesenfeld, we offer innovative processes, cutting-edge equipment, and comprehensive services for eco-friendly recycling. Together, we are transforming lithium-ion battery recycling and making a significant positive environmental impact.

THE GROWING NEED FOR LITHIUM-ION BATTERY RECYCLING

The rapid adoption of EVs is a significant step towards reducing carbon emissions. However, it also presents the challenge of recycling rare and valuable materials in lithium-ion batteries. Improper disposal of these batteries poses severe environmental risks, including soil and water contamination. With an expected exponential increase in end-of-life batteries and current production waste from gigafactories, responsible management is crucial. Additionally, new regulations worldwide heighten the importance of resource recovery, making it imperative for industries to adopt innovative and effective recycling solutions.

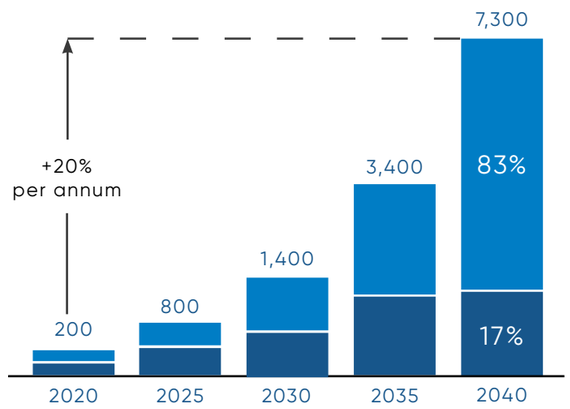
EFFECTIVE RECYCLING OF END-OF-LIFE BATTERIES AND PRODUCTION WASTE IS CRUCIAL FOR SEVERAL REASONS:

- **Environmental protection:** Proper recycling prevents harmful substances from polluting the environment, safeguarding ecosystems and human health.
- **Resource recovery:** Recycling allows the recovery of valuable materials such as lithium, cobalt, and nickel, reducing the need for new mining activities and conserving natural resources.
- **Economic benefits:** By recovering and reusing materials, recycling reduces the overall cost of battery production and supports the circular economy.
- **Sustainability:** Recycling supports the sustainable growth of the EV industry by ensuring that battery waste and production scrap are managed responsibly and efficiently.

Together, ANDRITZ & Duesenfeld address these challenges with innovative processes and state-of-the-art equipment that optimize lithium-ion battery recycling, making a substantial positive environmental impact while ensuring economic competitiveness.

GROWTH OF EVS AND BATTERY WASTE

Available battery material for recycling by source, kt



Values represent an average across all battery types.
Source: McKinsey Battery Insights, 2022

Mechanical pre-treatment excellence: Unlocking value from battery waste

ANDRITZ stands as a comprehensive front-end supplier in battery recycling, specializing in mechanical pre-treatment, commonly known as black mass production. This process includes several stages: discharging, shredding, drying, and finally sorting and separation.

THE MAIN OUTPUT FRACTIONS FROM THESE PROCESSES ARE:

- **Black mass:** A mixture of graphite and valuable metals, including lithium, cobalt, nickel, and manganese from NMC batteries, and lithium, iron, and phosphate from LFP batteries. These metals are crucial for producing new batteries and electronic components, promoting sustainability and resource efficiency.
- **Copper and aluminium foils:** Recovered from the anode (copper) and cathode (aluminum) electrodes. Recycling these metals reduces the environmental impact of mining and processing new materials, essential for manufacturing new batteries.
- **Heavy parts:** Structural components from the battery housing, such as steel, plastic, and cooper. Recycling these materials minimizes waste and allows for the reuse of valuable resources in new products.
- **Solvents and electrolytes:** Low-boiling solvents and electrolyte are recovered during the recycling process. Proper recovery prevents environmental contamination and allows these substances to be reused in industrial applications.
- **Separator foil:** Shredded and separated during the process. The separator foil can also be used as Refuse-Derived Fuel (RDF), providing an alternative energy source and reducing waste.

Main output fractions (left to right): Cooper foil, aluminium foil, black mass, solvents, heavy parts, separator foil © Duesenfeld

Key features protected by Duesenfeld Intellectual Property (IP)

DEEP DISCHARGING

Duesenfeld's protected deep discharge process for lithium-ion batteries ensures safe and efficient energy recovery and handling during mechanical processing.

Their patented technology and intelligent control software automate discharging, regardless of the battery's state, voltage, age, or manufacturer. This results in high throughput and maximum efficiency, with recovered electricity powering part of the recycling plant or fed into the grid.

- **Maximum safety:** Continuous software monitoring guarantees safe operation and easy replacement of connected batteries.
- **No electrical risks:** Patented technology eliminates electrical risks in subsequent steps, removing the need for high-voltage authorized personnel.
- **High efficiency:** Achieve large throughput and optimal energy recovery, ensuring process safety and employee protection.

LOW-TEMPERATURE THERMAL DRYING

The Duesenfeld protected low-temperature thermal drying process for lithium-ion batteries ensures efficient solvent recovery and minimizes environmental impact.Operating below 80°C and under vacuum prevents the formation of hazardous hydrogen fluoride (HF) and eliminates the need for exhaust gas scrubbing and corrosion-resistant stainless-steel equipment. This process allows for the safe and effective drying of batteries, ensuring that solvents are efficiently recovered and reused.

- **Eco-friendly:** No toxic fluorine compounds are produced, reducing the need for high-grade equipment materials and gas scrubbing.
- **High efficiency:** Efficient evaporation of low-boiling solvents and recovery of pure electrolytes for reuse.
- **Cost-effective:** Lower operating costs due to the elimination of exhaust gas scrubbing and reduced CO2 emissions.

A perfect match in battery recycling

ANDRITZ RECYCLING

We as ANDRITZ, act as a solution provider (EPC/EPS), delivering a customized recycling plant according to all relevant standards including service offerings throughout the plant's lifetime.
We manufacture key equipment within the process namely tailor-made shredder and drying equipment designed to meet specific process needs. Our proficiency in plant development and engineering, combined with a global presence through numerous subsidiaries and manufacturing sites, ensures comprehensive support and innovative solutions for battery recycling projects.

DUESENFELD

Duesenfeld acts as a licensor of their patented processes, particularly in discharging and low-temperature thermal drying.

They leverage extensive field test insights from their operating pilot plant and ongoing R&D work to optimize the recycling process and stay prepared for future changes in battery developments.

Customer-centric value proposition design

PRIMARY PAIN POINTS AND KEY VALUE DRIVER FOR OUR POTENTIAL CUSTOMERS

Battery Manufacturers | Electric Vehicle Manufacturers | Recycling Companies

BENEFITS

Innovative Solutions: The collaboration between ANDRITZ and Duesenfeld brings together cutting-edge technologies and processes, ensuring state-of-the-art recycling solutions.

Comprehensive Expertise: Customers benefit from the combined knowledge and experience of two industry leaders, providing a robust foundation for efficient and effective battery recycling.

Customized Equipment: Tailor-made solutions from ANDRITZ ensure that each recycling plant is equipped with the best possible technology for optimal performance.

Global Support: With ANDRITZ's extensive network of subsidiaries and manufacturing sites, customers receive consistent and reliable support worldwide.

Proven Processes: Duesenfeld's field-tested processes and operational insights guarantee that recycling plants operate smoothly and efficiently from the start.

Together, ANDRITZ and Duesenfeld offer a powerful partnership that drives innovation and excellence in battery recycling, delivering unmatched value to customers.

Key steps of the mechanical pre-treatment plant

1. DISCHARGING
The process begins with the controlled discharging of battery cells, modules, or packs. The Duesenfeld method ensures safe and efficient discharging by short-circuiting the batteries to 0 volts. This step significantly reduces the risk of thermal runaway and prepares the batteries for subsequent mechanical processing. Duesenfeld's setup allows for parallel discharging of multiple battery formats and chemistries, increasing throughput and flexibility. Key benefits include improved safety, energy recovery, and the utilization of residual electricity to power the plant.

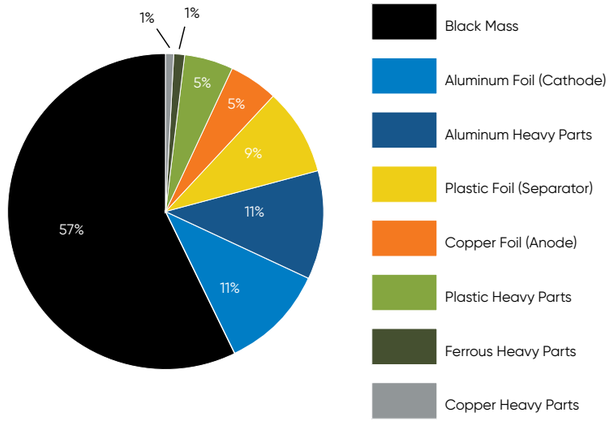
2. SHREDDING
After discharging, batteries are either disassembled or directly fed into the shredding stage. The ANDRITZ battery shredder tower, a two-step solution, includes a rotary shear pre-shredder and a granulator fine shredder. The infeed system handles battery packs up to 1.8 tons, maintaining an inert atmosphere to prevent fires or explosions. Loading is facilitated by an input roller conveyor for packs and a side infeed conveyor for single cells.

3. DRYING
Drying and solvent recovery: Shredded material undergoes vacuum drying below 80° C to efficiently evaporate low-boiling solvents without forming hydrofluoric acid (HF). A cooling system condenses and reclaims solvents, minimizing environmental impact. The process gas stream is cooled to maximize solvent recovery and reduce the load on activated carbon filters.

4. OFF-GAS TREATMENT
The off-gas treatment system ensures emissions meet environmental standards like TA-Luft. Activated carbon filters remove volatile organic compounds (VOCs) and other contaminants, ensuring compliance with regulations and reducing environmental impact. Consulting with filtration-as-a-service providers is recommended for optimal results.

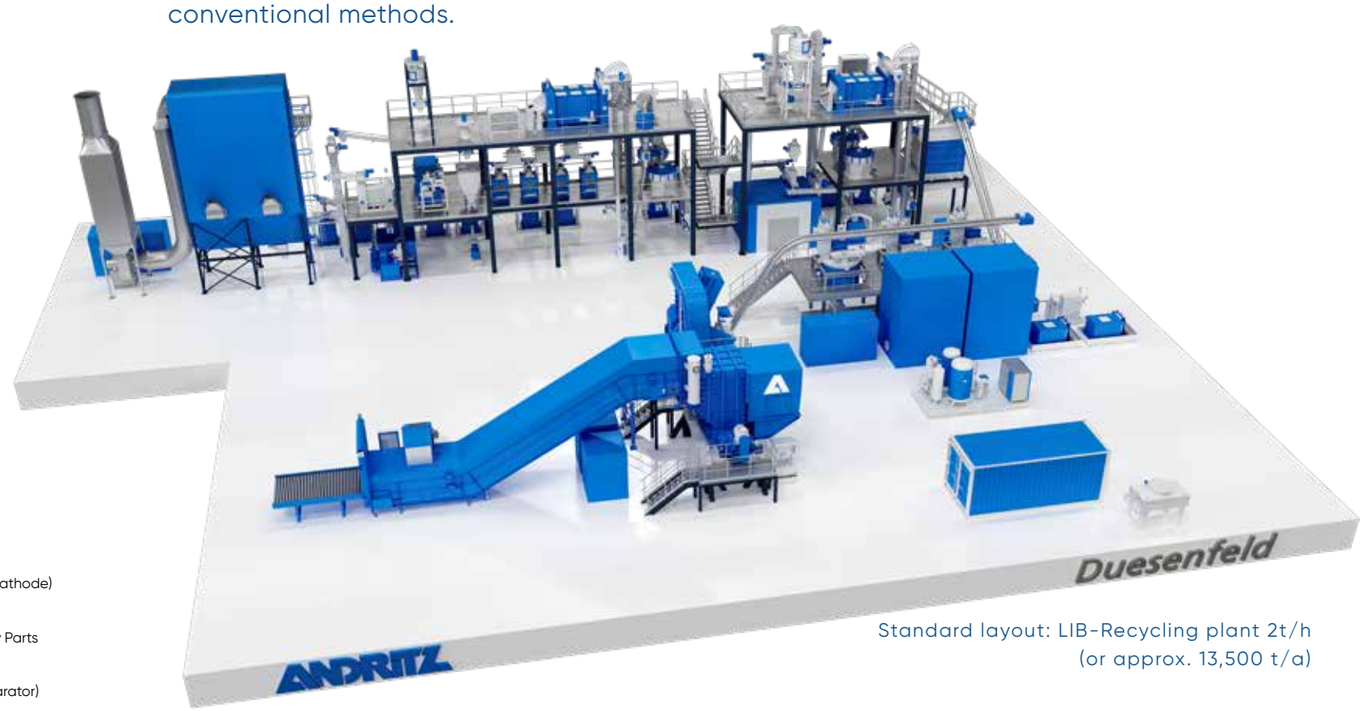
5. INERTISATION AND EXPLOSION PREVENTION
To prevent fires and explosions, the system maintains an inert atmosphere using nitrogen. A nitrogen generator provides low-cost N2 for inertisation, leveraging ANDRITZ's experience from fridge recycling.

6. SEPARATION
The process involves a series of mechanical separation steps designed to sort materials based on their physical properties such as size, weight, and density. Initial stages separate lighter components from heavier ones, followed by further refinement to isolate valuable material fractions. Subsequent steps focus on separating metallic and non-metallic elements to ensure clean, high-quality output streams. The system is engineered for efficient material flow, dust control, and flexible discharge options to support various operational needs.



Setting the standard in battery recycling

At ANDRITZ, in collaboration with Duesenfeld, we deliver a cutting-edge lithium-ion battery recycling solution that sets new industry standards in efficiency, safety, and sustainability. Our technology offers a range of compelling advantages over conventional methods.



Standard layout: LIB-Recycling plant 2t/h (or approx. 13,500 t/a)

AT A GLANCE

LOW TEMPERATURE CONCLUDES EFFICIENT RECYCLING
- Low operating costs (OPEX)
- Moderate capital expenditure (CAPEX)
- Low CO_2-footprint
- Short drying time

HIGH QUALITY OF OUTPUT FRACTIONS
- Great quality of black mass for hydrometallurgical treatment
- Low impurities in black mass
- Very pure electrolyte

SAFE AND CLEAN PROCESS
- No formation of toxic hydrofluoric gas (HF)
- No need for HF scrubbers or extensive corrosion protection

OUR ENVIRONMENT IS A TREASURE TO BE PRESERVED

So are the raw materials contained in your waste products. Let us help you utilize them to best advantage. ANDRITZ Recycling is actively demonstrating its commitment to conserving valuable resources by offering a wide range of capabilities in the recycling industry. Our technologies cover solutions for processing rejects from the paper industry, e-scrap, metal and special waste, organic waste, end-of-life vehicles, wood, plastic and textile waste as well as applications for generating energy from various waste products.

ANDRITZ Recycling Service develops recycling solutions that pay off for the customer for the complete life cycle of your mill or equipment. From the supply of spare parts, routine work during a scheduled shutdown, to quick response during a disruption or the implementation of our latest IIoT solutions, we are available to keep operations running smoothly.

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