Recycling von Traktionsbatterien aus Elektrofahrzeugen bei Librec
Denis Werner, Technischer Leiter, Librec AG

Welcome!

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Battery Production in Europe driven by the rise of electric mobility

Existing and Planned Giga Factories in Europe

LIB production and recycling capacity in Europe

Increasing Demand for Battery Recycling

- Manufacturing Scrap for Recycling
- Spent Batteries for Recycling
- Recycling Capacity Today
- Recycling Capacity Needed by 2025

Battery Recycling Capacity Gap by 2025

Europe Needs Tripling of Battery Recycling Capacity by 2025!!!

Waste management of automotive LIBs - “Spoke-and-Hub”

Spoke-and-Hub Collection Model

SPOKE: collection & battery-to-black mass

HUB: black mass-to-active material

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Process routes (high, medium, low temperature route)

Source: Werner 2020, Recycling chain for spent Lithium-Ion batteries, metals, J(3), 316; https://doi.org/10.3390/met10030316
# LIB Recycling routes and technological differences

## "Battery-to-Black Mass" Process Evolution

<table>
<thead>
<tr>
<th></th>
<th>Smelting</th>
<th>Pyrolysis</th>
<th>Cold</th>
</tr>
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<td><strong>Total Mass Recovery</strong></td>
<td>20 - 40%</td>
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<td><strong>European Representatives</strong></td>
<td>Umicore (BEL, 7), Nickelhütte (GER, 4), Glencore / GEM (CN, &gt;6)</td>
<td>TES, SNAM (FRA, &lt;3), Accurec, Redux (GER, 3–12), Akkuser (FIN, 3)</td>
<td>GER: Duesenfeld 3, VW 1, Ecobat; TES (NL, 15); Hydrovolt (NOR, 8); Northvolt (SWE, 125)</td>
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**LIBREC Closed-loop Battery Recycling**

"Battery-to-Black Mass" Process Evolution

**Table:**

- **Total Mass Recovery**
  - Smelting: 20 - 40%
  - Pyrolysis: 40 - 60%
  - Cold: >70%
- **Energy Consumption**
  - Smelting: 100%
  - Pyrolysis: 50%
  - Cold: 15 - 20%
- **Key Process Technology**
  - Smelting: Electric Furnace (1'000–2'000°C)
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- **European Representatives**
  - Smelting: Umicore (BEL, 7), Nickelhütte (GER, 4), Glencore / GEM (CN, >6)
  - Pyrolysis: TES, SNAM (FRA, <3), Accurec, Redux (GER, 3–12), Akkuser (FIN, 3)
  - Cold: GER: Duesenfeld 3, VW 1, Ecobat; TES (NL, 15); Hydrovolt (NOR, 8); Northvolt (SWE, 125)
  - LIBREC (CH, 10), International sites to come

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Battery-to-black mass Process - setup and R&D activities

LIBREC recycling centre for Lithium-Ionen (traction) batteries: battery-to-black mass

Input

Acceptance/Storage

Discharging

Disassembly

Libation (2nd life)

Production

Shredding

Pre-module: inert atmosphere

Condensation

Drying

LiPF₆ washing/extraction

Mechanical separation 1

Mechanical separation 2

Mechanical delamination

Process group 1

Process group 2 – electrodes

Process group 2 – solvent separation

Rectification and condensation

FE-separation

NE-separation

Sensor based sorting

Process group 2 - housing

Process group 3 – black mass

Further mechanical processing

Wet density separation

Wet magnetic separation

Dry classification

Active carbon filtration

Gas scrubbing

Post-combustion

Output

Legend

Main process group

Process step

Process group

R&D

Fixed process/material stream

Potential process/material stream

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Collection & Pre-treatment of Manufacturing Scrap and Batteries to Provide Black-mass

- **battery manufacturing**
- **car manufacturing**
- **refining (hub) scrap**
- **black mass & battery materials**
- **pick-up**
- **upcycling to 2nd life**
- **use of residual energy**
- **closed-loop recycling**
- **battery materials delivered**

New battery

New car

2nd life

Defective & end-of-life batteries
LIBREC Serves 3 Types of Customers

**Selection of Clients**

**Refining & Battery Manufacturing**
- Producing batteries for use in full-electric & hybrid cars

**Car Manufacturing**
- Batteries used in car production
- Take-back obligation in EU

**Car Importer**
- Importer of battery-equipped cars
- Take-back obligation in local market

**Selection of Clients**

- ABB
- Hyundai
- Tesla
- Glovis
Revenue from Selling Black-Mass & Recycling Services Pricing Linked to Raw Material Prices (LME)

**Flow of Goods & Money**
- **FLOW OF GOODS**
  - CONSUMER
  - CAR MANUFACTURER, IMPORTER OR DEALER
  - REFINING OR BATTERY MANUFACTURER
  - black mass
  - Scrap
  - LIBREC

**Revenue from Black-Mass Indexed to LME**
- **PURCHASING BATTERIES**
  - Revenue from Black-Mass depends on raw material prices (LME)
  - ⇒ LIBREC purchases battery from client

- **SELLING RECYCLING SERVICES**
  - Revenue from Black-Mass does not cover LIBREC’s cost
  - ⇒ Client pays LIBREC for recycling services

LIBREC’s cost for pick-up & recycling

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LIBREC follows two Models

Contracts with Battery Manufacturer and plants next to/in battery production to recycle scrap.

Site Selection Opportunistic: Depending on location of battery manufacturer (exemplary)

Demonstration with Swiss Plant important. Discussion with clients started.

Two contracts to build capacity for clients by 2025.

Plants independently to attract scrap and end-of-life batteries.

Site Selection Strategic: Based on proprietary site selection (Poland, Germany, Italy, Spain)

Location analysis started.

Two contracts to build capacity for clients by 2025.

100% Models are combined by closing contract for part of plant’s capacity.

0%
Switzerland: 1st site currently under Preparation

✓ Site evaluation & selection
  1. logistics
  2. optimal process layout
  3. timing/availability
  4. chances for permission
  5. talents available

✓ Layouting & rental contract signed
✓ Max capacity 10’000 tons/a, 6’350 m² total, 2’800 m² floor

⇒ Building permit December 2022
⇒ Moving in April 2024
⇒ Operational Q3 2024
Local & International Collection of manufacturing scrap & end-of-life batteries

Upcycling of batteries to second-life

Recycling of scrap & batteries to black-mass (pre-treatment)

Black-mass forwarded to hydrometallurgical separation for re-use in new batteries

Battery storage capacity 3’000 units

Go-live recycling Q3 2024

Recovery rate Lithium & CAM >97%

Black-mass impurities <2%

Recycling capacity 10’000 t/a
Unique Combination of Customer Benefits

«Closed-loop»
We close the loop with unprecedented recovery rates for all battery components.

Massive CO₂ savings
We don’t smell nor burn anything and we don’t create emissions. The residual energy from the batteries and our solar power cover half of our energy demand.

Full control of your raw material
You decide whether you get back your recycled materials or whether you let your production material or your batteries to us.

Maximum income from your raw material
We return your valuable materials in no time, so that you can use them again profitably.

We come to you
We build a European network to support you on site with minimum logistics cost and individual transport solutions.

Label
With our label you guarantee to your customer a sustainable, climate-neutral “closed-loop” battery recycling.

No Points of Sale needed
We are on the ground for you to collect batteries everywhere.

‘Second Life’
With us you can choose, whether we should make your battery fit for another life and build new batteries from the existing cells.

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Flow Chart

**WP1**
- Battery systems
  - Characterization
    - n.-critical modules/ cells & material composition
      - Dismantling
      - Deep-discharging
    - Shredding
      - Drying
        - Dried material with(out) high boilers, conductive salt
        - Material separation
          - Black mass
          - Metal separation
            - HB/CS/B removal
            - Graphite recovery
            - CAM
          - Black mass
        - Separation
          - EC
          - DMC
          - EMC
          - DEC
      - Separation
        - Cu, Al ($R_m > 99.6\%$)
        - Conductive salt
        - High boilers
        - Binder ($R_m > 95\%$)
        - Graphite ($R_m > 80\%$)
    - Batteries for 2nd life
      - Critical / damaged batteries
      - > 85% of remaining electrochem. energy

InnoSuisse „Librec“
- SIPBB
- BFH
- EMPA
Schweizer Kreislaufwirtschaftsmodell für Lithium-Ionen Batterien (LIBs) in Elektrofahrzeugen

Ziele:

- Entwicklung des technischen und wirtschaftlichen Potenzials einer Kreislaufwirtschaft für LIBs in Elektrofahrzeugen
- Vernetzung der wichtigsten Akteure entlang des gesamten Lebenszyklus von LIBs in der Schweiz
- Dauer: 4 Jahre bis Ende 2025
- Gesamtbudget: 7.54 Mio. CHF
CircuBAT – Schweizer Kreislaufwirtschaftsmodell für Lithium-Ionen Batterien in Elektrofahrzeugen
Next seminars

Biel / Bienne
Quellgasse 21, Aula

30.3.2023 | Mit dem Handy das Auto aufschliessen? Hardware Protected Confirmation macht es möglich
Prof. Dr. Benjamin Fehrensen, Institute for Cybersecurity and Engineering ICE, BFH-TI

6.4.2023 | Von der Laborbank zum Patienten – Erste klinische Resultate zur selektiven Netzhaustherapie
Christian Burri, Institute for Human Centered Engineering HuCE, BFH-TI

13.4.2023 | Intégration d’un ensemble complet de logiciels pour la conduite autonome
Ahmed Hanachi, Institut pour la recherche sur l’énergie et la mobilité IEM, BFH-TI

Biel / Bienne
Quellgasse 21, Aula

27.4.2023 | Die digitale Transformation des Exportgeschäfts
Prof. Dr. Paul Ammann, Institute for Data Applications and Security IDAS, BFH-TI

11.5.2023 | The Relevance and Hands-on Application of Biomedical Record Linkage in the Big Data Era
Prof. Dr. Murat Sariyar, Institute for Medical Informatics IdMI, BFH-TI

1.6.2023 | Averaging Model for Feedback Control of Ultrasonic Transducers
Diego Stutzer, Institute for Human Centered Engineering HuCE, BFH-TI

Burgdorf / Berthoud
Pestalozzistrasse 20, E013

20.4.2023 | How Data Analysis Can Help to Better Understand the Degradation in PV Modules
Prof. Dr. Jasmin Wandel, Institute for Optimisation and Data Analysis IODA, BFH-TI and Sona El Hassani, Institute for Energy and Mobility Research IEM, BFH-TI

4.5.2023 | TPV 5000 – Beitrag zur Defossilisierung des Verkehrs
Dr. Albrecht Tribukait, CEO ad int., Silent-Power AG

25.5.2023 | am jicoweg 1 | What is High Voltage Engineering about?
Prof. Dr. Roman Grinberg, Institute for Energy and Mobility Research IEM, BFH-TI

8.6.2023 | Waghalsige Holzkonstruktionen unter Anwendung moderner Technologie neu denken
Matias Penroz, Institut für digitale Bau- und Holzwirtschaft IdBH, BFH-AHB