Power battery recycling insights from Asia: Upgrading resources efficiency on the whole life-cycle

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Resource generation: Solution for Supply & Environmental risk

www.botree.tech
Botree provide full solutions for battery metal refining and regeneration, including Consulting, technology service, Equipment, Operation.

We’re focusing on developing innovative technology and processes to support a sustainable battery metal supply chain.
Closing the loop on Li-ion batteries by critical metal regeneration.
PART 01
Overview of NEV & LIB Industry in 2020

PART 02
Emerging Market of LIB in China

PART 03
Botree Cycling in EV battery recycling

PART 04
Further challenge and cooperation
PART 01
Overview of NEV & LIB Industry in 2020
NEV Market Share in Europe (by Mar. 2021)

- Norway: 51.6% (BEV), 22.9% (PHEV)
- Sweden: 9.3% (BEV), 22.7% (PHEV)
- Netherlands: 20.2% (BEV), 4.6% (PHEV)
- Germany: 6.4% (BEV), 6.9% (PHEV)
- France: 6.7% (BEV), 4.5% (PHEV)
- Belgium: 3.3% (BEV), 7.8% (PHEV)
- UK: 6.4% (BEV), 4.3% (PHEV)
- Spain: 2.1% (BEV), 2.8% (PHEV)
- Italy: 2.3% (BEV), 2.0% (PHEV)

**China 5.4%**

Source: Statista
China's Power Battery Market Share in 2020

- CATL: 50.0%
- BYD: 14.9%
- LG Chem: 6.5%
- CALB: 5.6%
- Gotion: 5.2%
- Panasonic: 3.5%
- EVE: 1.9%
- REPT: 1.5%
- Lishen: 1.4%
- Farasis: 1.3%

Source: CABIA
Plan & Ambition

2030 Carbon Emission Reduction ~55%
2050 Carbon Neutrality

2030 Peak Carbon Dioxide Emissions
2060 Carbon Neutrality

2019.12.11

2020.09.22
Plan & Ambition

Green Deal

90% reduction in greenhouse gas emissions in transport by 2050

Plan for Development of NEV Industry (2021-2035)

>20% NEV
By 2025

Source: European Alternative Fuels
Regulations


- Circular Economy;
- Sustainability;
- Responsibly sourced materials;
- Collection Rate;
- Recycling Rate;
- Traceability;
- ...

‘Technical Specification of Pollution Control for Treatment of Waste Power Lithium-ion Battery’ (Draft for Comments)

- Pollution control in dismantling, shredding, recycling processes;
- Waste water, VOCs, Solid waste;
- Hydro, Pyro Processes;
- ...

Critical Metal Regeneration Expert
PART 02

Emerging Market of LIB in China
Innovation of Battery Material

- High Nickel, Low Cobalt
- LFP
- LMO
- Solid-state
- ...

Energy density & Safety

Source: Drexel University
Innovation of Battery Design

- CTP
- GCTP (Blade Battery)
- Magazine Battery

Unified cell vs Specific cell

Energy density & Safety
New Application Scenarios

10K in 2020 (100K in 2021, 1M in 2025) customized EV for online car-hailing services/ride-sharing

Source: Didi
Emerging Market

Battery Swap

Source: Nio, CCTV, Souhu, EV Partner
Emerging Market

Wuling MINI EV

Source: Bitauto

Electric Bicycle
- Battery Upgrades: from lead to LIB
- >350 million by 2023

Mini EV
2020: No.2 in China, No.3 in world
2021: No.1 in world
Emerging Market

Energy Storage & V2X
Part 04

Botree Cycling solutions for spent LIB recycling
Botree team in battery and battery recycling

Major authors of
- Blue book of power battery (Annual report NEV power battery industry in China)
- White book of spent power battery recycling technology and industry
- National standards related to spent battery recycling
R&D and test platform

1000 hours continuous operation test
Consulting & Technical Service

- Recycling of Critical Metals from spent LIB
- Refining of Critical Metals from Ores
- Battery materials preparation
- Intelligent Equipment design and manufacturing

- Front to end technical solution
- Market research and analysis
- Feasibility study
- Product and process development
- Laboratory characterization, analysis and synthesis
Design & Engineering Service

- Requirements and process demand checklist;
- Raw materials analysis;
- Flowsheet and process details (including laboratory test to determine the preliminary parameters);
- Pilot scale test for process verification (if needed);
- Processes optimization and check.

Process Feasibility Analysis

- Decision for materials of equipment.
- Comprehensive docking (including demand of process, automatic control, etc.);
- Engineering design regarding process, electrical, automatic control, civil engineering, etc.;
- Standard equipment procurement;
- Non-standard equipment manufacturing.

Engineering Design & Procurement

- On-site installation;
- Debugging;
- Operation and training;
- Maintenance service;
- Process optimization and devices update;
- Lifecycle assessment and management (if needed).

Project Implementation
Comprehensive replacement of traditional processes, significantly reducing construction cycle, investment, and operating costs.

**Innovation 1**
- (Already passed 10,000 ton/year pilot test)
- **True automate** process, short process with high stability
- Achieve 0.1%-0.5% low Al impurities, and 90%-100% key metal materials recovery rate, well above market average

**Innovation 2**
- (Already passed 2,500 ton/year pilot test)
- Manage to **pre-recovers** Li from the hydrometallurgy process. Solve the low Li concentration major issue in the traditional process.
- 94% High Li recovery rate, and reach battery level Li₂CO₃ through one step

**Innovation 3**
- (Complete development, no magnification risk)
- Fundamental innovation from the ground level, develop a new leach-extraction system, especially suitable for “High Ni Low Co” battery type
- Dramatically simplify the process, can achieve 5-20% higher recovery rate, 10% less energy consumption with 60% less investment
Dismantling process

Shorter process, higher recovery & Product purity, fully automatic

Product:
- Cu powder
- Al powder
- Black powder
- Shell

Product index: Total metal recovery rate >90%
Major impurities (Cu, Al...) in Black powder <0.5%

Capability and product (Take 18650 single battery as an example)

<table>
<thead>
<tr>
<th>Spent LIBs t/a</th>
<th>product t/a</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Cu powder</td>
</tr>
<tr>
<td>2000</td>
<td>236</td>
</tr>
<tr>
<td>5000</td>
<td>472</td>
</tr>
</tbody>
</table>
Shorter process, higher recovery & Product purity, fully automatic

Market main process

Botree Process

Designed for high-Ni resource like spent power battery / laterite leaching liquor

Traditional SX inside

Botree SX inside

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<table>
<thead>
<tr>
<th>Equipment Design</th>
<th></th>
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<tbody>
<tr>
<td>Botree Dismantling Process (BCD)</td>
<td>- International leading disassembly technology, suitable for wide range of feeds, high stability.</td>
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<td>- Impurities such as aluminum are stably controlled at 0.1 - 0.5%, and the recovery rate of valuable</td>
</tr>
<tr>
<td></td>
<td>metals is greater than 90%, which is much higher than the industry level.</td>
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<tr>
<td>Botree Leaching Process (BCL)</td>
<td>- Reduce the amount of reduceant by 25%, and the leaching rate of lithium is greater than 94%.</td>
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<td>- The lithium-rich solution has very low impurity content, and the purity of the lithium carbonate</td>
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<td>can reach to battery grade, which is higher than 99.93%.</td>
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<td>- Single stage recovery rate of cathode metals: Nickel&gt; 93.6%, Cobalt&gt; 97.1%, Manganese&gt; 91.3%.</td>
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<tr>
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<td>- Comprehensive recovery rate of process is greater than 98.5%.</td>
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<tr>
<td>Botree Extraction Process (BCE)</td>
<td>- Customized extraction and separation system to achieve efficient and synchronous recovery of</td>
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<td>critical metals such as nickel, cobalt to battery grade materials, especially suitable for high-</td>
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<td>nickel raw materials</td>
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<td>- Compared with traditional separation systems, it reduces investment by more than 40%, reduces</td>
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<td>energy consumption by more than 10%, and improves recovery rate by 5-20%.</td>
</tr>
</tbody>
</table>
Botree Cycling Process, Equipment and Engineering
Botree's ongoing projects of LIB battery recycling

1. >10,000 tpa project outside China (From pack to material regeneration)
2. 2,000 tpa project in China (Hydro-process)
3. 1,000 tpa project in China (Dismantling & Hydro)

......

- Containerized design
- Fast reaction & Movable
- Flexible units & processes
- LCO, NCM, NiMH...

Ores → Materials → Battery → EV → Waste

Source: Botree Cycling
Further challenge and cooperation
Regeneration-native designed LIB for sustainable supply chain

Eco-design based on life cycle resource utilization
(Manufacturing + Demanufacturing)

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静脉产业 (Venous Industry)

Manufacturing

4 3

2 1

消费者使用 Use

分解过程 (Demanufacture)

废物焚烧回收能量
Energy recovery with incineration

通过裂解生产清洁燃料
Clean fuel production via pyrolysis

静脉产业 (Venous Industry)

制备: 大气等形形
Environment recycling

制造过程 (Manufacture)

4 3

2 1

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分解过程 (Demanufacture)

废物焚烧回收能量
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通过裂解生产清洁燃料
Clean fuel production via pyrolysis

静脉产业 (Venous Industry)
Sustainable resource and energy supply chain of EV

Regeneration for sustainability

- 矿产 (Minerals)
- 材料 (Materials)
- 电池 (Battery)
- 新能源汽车 (New Energy Vehicle)
- 报废 (Disposal)

资源回收 (Resource Recovery)

清洁电能 (Clean Energy)

储能 (Energy Storage)

CAUTION HAZARDOUS WASTE (Caution: Hazardous Waste)