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SPOTLIGHT

EV battery recycling – a primer

Charged and ready to power ahead

The unstoppable rise of electric vehicles is creating a new challenge and question: what to do with all the dead batteries?

We look at the process for recycling EV batteries and why it would enable a closed-loop ecosystem for the industry

The full note looks at the other significant opportunities recycling will offer in the years ahead, with the turning point likely arriving in 2025

This is a Free to View version of a report with the same title published on 29 Nov 2022. The full report looks at the many advantages recycling offers, the different technologies available, the scope for capacity expansion, the rising competition and the opportunities for Korean companies in this rapidly expanding industry. Please contact your HSBC representative or email AskResearch@hsbc.com for more information.

EV battery recycling

- The unstoppable rise of electric vehicles is creating a new challenge and question: what to do with all the dead batteries?
- In the full note, we look at the fast-growing recycling industry and why it is going to offer significant opportunities in the years ahead
- The turning point should arrive in 2025, when a large number of EV batteries start to reach the end of their natural life

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In 2025e, close to one million batteries that run the world's growing fleet of electric vehicles (EVs) will no longer be fit for purpose, in our view. We think this will signal the take-off point for a new, important and fast-growing industry that is only going to get bigger: the recycling of EV batteries to extract the valuable metals, such as lithium, cobalt, nickel and manganese, they contain.

While the sales of EVs go from strength to strength, their batteries only began to be retired in 2021, so there will be a significant increase in the number available for recycling in the next few years. Given that we expect the global EV adoption rate to increase further, the direction of travel for the recycling business is clear.

Not surprisingly, given China's dominant role in the production and sales of EVs, the country is leading the way, with more than 80% of global battery recycling capacity as of 2021.

It is not just the significant growth in volume and the obvious environmental benefits that will drive this business. Carmakers will likely soon have to take action as policymakers tighten industry regulations, including the introduction of minimum levels of recycled material batteries must contain.

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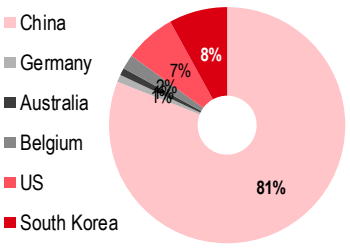
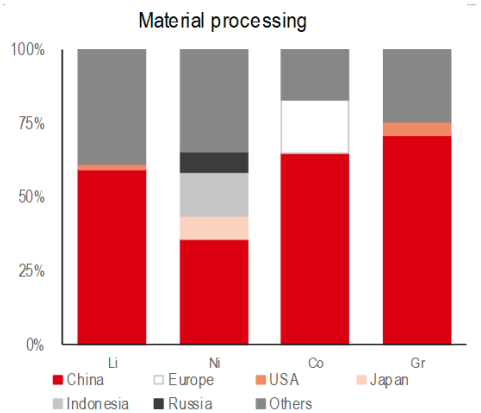
Exhibit 1. Commissioned battery recycling capacity by region (286kt as of 2021)



Source: BNEF

Exhibit 2. Battery materials processing by region (2022)



Source: IEA. Note: Gr – Graphite.

Recycling 101

- Recycling begins with collection and diagnostics, which are part of the pre-treatment process
- The three key battery recycling processes are pyrometallurgy, hydrometallurgy and direct recycling
- The industry is moving towards the hydrometallurgical process, which is less energy-intensive and has a higher recovery rate

The battery recycling process

A closed loop

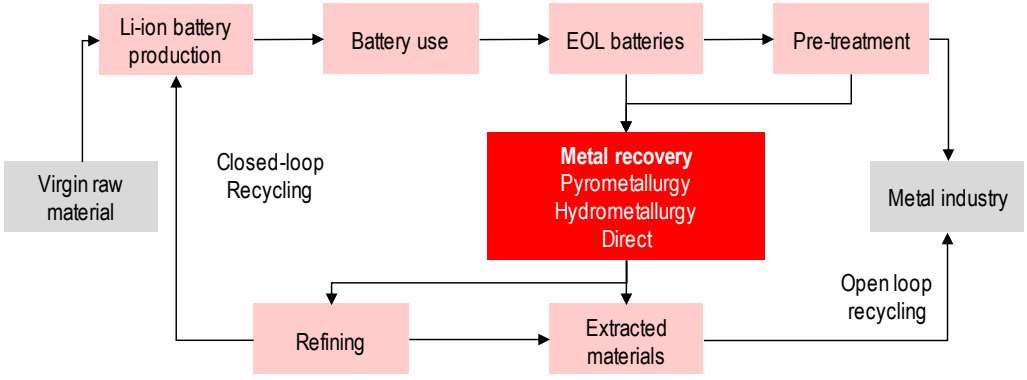
The use of recycled metals enables a closed-loop ecosystem for the EV LIB industry. We take a detailed look at the overall process of recycling LIB.

The two main sources of recycling feedstock are used batteries and manufacturing scrap

The two main sources of recycling feedstock are used batteries and manufacturing scrap from the production stage. Manufacturing scrap supply contracts are made with the battery cell manufacturers through either private contracts or a bidding process. Manufacturing scrap is then transported to the pre-treatment production lines to be sorted and processed.

For used batteries, the first step begins with collection. Some countries already have regulations in place for LIB collection. We expect more countries to adopt and enhance regulations regarding LIB collection, which should accelerate the growth of the recycling industry.

Exhibit 1. The LIB value chain



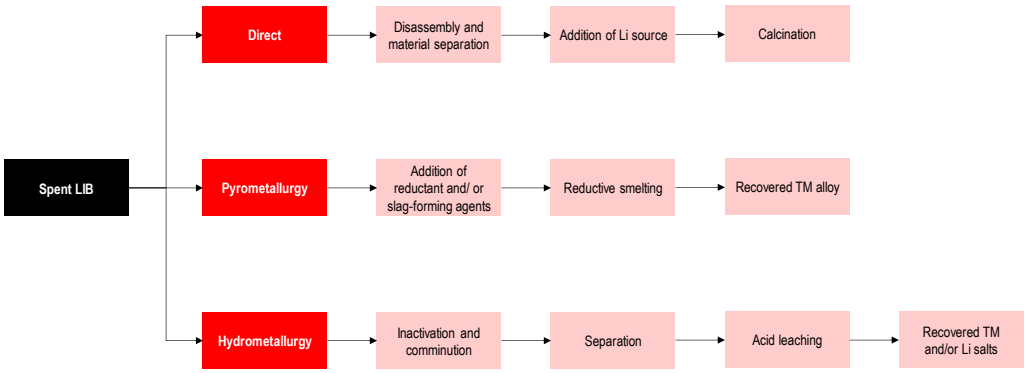
Source: MDPI, HSBC

The pre-treatment process

Used EV batteries go through a series of steps before the recycling process starts.

1. **Testing and diagnostics:** EV batteries are tested to determine whether they can be re-used or should go straight to the recycling process. Damaged EV LIB go straight to the next stage (discharging).
2. **Discharging:** Batteries that are not fully discharged can short circuit and ignite. There are several methods for discharging: 1) draining the power for batteries in good shape; 2) low-temperature pryolosis heating; and 3) discharge through salt solutions.
3. **Disassembly:** The discharged batteries are then disassembled into modules or cells. This stage is the most labour-intensive, as much of the process is manual. Disassembly differs, depending on the form factor and shape of the battery.
4. **Heat treatment, crushing and sorting:** In the final stage of pre-treatment, heat treatment removes electrolyte, binder and separator, which results in a higher black powder recovery. EV LIB cells are crushed to 2-3cm and subsequently shredded to 5mm. After the process, the black powder is shredded to 0.2mm and sent to the metallurgy process. The sorting process separates other metals, such as aluminium and copper.

Exhibit 4. Overview of different recycling processes



Source: ACS, HSBC

The pyrometallurgical process

This process is somewhat outdated and uses more energy, as it is based on high temperatures. One of the key advantage is that it does not require extensive pre-treatment, as the batteries are directly processed in a high-temperature smelting furnace without shredding and separation.

The pyrometallurgical process produces metal alloys (Co, Ni, and Cu), slag (Li2O and Li2CO3) and gases. The metal alloys can be then separated in the hydrometallurgical process into solution forms. It is difficult to achieve high-purity lithium recovery rates due to contaminants in the slag.

The hydrometallurgical process

This process can achieve a 98%-plus recovery rate for key metals, such as cobalt, nickel and lithium. The process is also less energy-intensive and can be adjusted for different battery chemistries. The key processes are: acid leaching and extraction (chemical precipitation, solvent extraction and electrochemical separation).

The process begins with the pre-treated black powder, as the key feedstock, which is processed through acid leaching. The acid leaching process is divided into organic acids, inorganic acids and mixed acids. The order of leaching can also impact the recovery rate and efficiency of the process. After the leaching process, the metals can be collected through various methods:

- **Solvent extraction** is liquid extraction used to recover cobalt, lithium and copper. The key limitation is the high cost of the extractants.
- **Chemical precipitation** is simpler than solvent extraction and results in high-purity products with low costs.
- **Electromechanical separation** can achieve the highest purity of recovered metals. The downside is higher electricity costs.

Recycling companies currently use various extraction methodologies to improve and increase the recovery rate of the metals.

Direct recycling process

The direct recycling process, which is also referred to as cathode-to-cathode recycling, aims to reuse the active cathode materials directly after regeneration. Accordingly, direct recycling has the advantage of low carbon emissions and is a relatively simple process. However, some of batteries have different types of chemistries and a mixture of more than one active material.

Exhibit 5. Comparison of different LIB recycling methods

Recycling method	Pros	Cons
Pyrometallurgical	Capable of dealing with different types of batteries simultaneously Pre-treatment not needed High recovery rate	Significant capital investment High energy consumption Refining process required Toxic gas emissions
Hydrometallurgical	High recovery rate and purity Process adjustable for different battery chemistries Energy savings	Pre-treatment needed Used chemical compounds need to be post-treated Lower efficiency
Mechanical	Capable of dealing with different types of batteries simultaneously Straightforward process	Organic compounds decompose to toxic materials High energy consumption Insufficient selectivity
Direct recycling	Cheap and efficient More environmentally benign compared to pyro and hydro methods	Pre-treatment needed Improvement needed for the performance of harvested cathode material High energy consumption (if a furnace is used)

Source: Journal of Energy Storage

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