



## Toward a circular economy for lithium-ion batteries

Lithium-ion power is gaining traction in the material handling market, just as the supply chain is stepping up with recycling services and sourcing initiatives that support a greener energy landscape.

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If you've transitioned some of your forklifts to lithium-ion (li-ion) battery power recently, you may be wondering what happens to those batteries at the end of their life. Sure, they've likely got years before you have to worry about it, and the manufacturer will take them back when they reach their end point, but what happens next? An increasingly environmentally conscious business world wants to know, driven by companies' desire to meet internal sustainability goals and address supply chain sourcing concerns. Recycling can help address both issues, but until recently there hasn't been much activity, and the lithium-ion recycling business remains in its infancy.

"What's missing is that there wasn't a huge business case [for recycling these products] a few years back," explains Vincent Caron, director of legal affairs for (<https://ugowork.com>)UgoWork, (<https://ugowork.com>) a Quebec City-based provider of lithium-ion batteries and energy-management solutions. He points to the growing popularity of li-ion batteries for use in automotive and material handling applications as a catalyst for change. "Now, it's a very, very huge market. Recyclers are trying to capture that."

A long and successful history of recycling forklift batteries, especially the lead-acid variety, is also a factor. All forklift batteries are large and chemically complex, and they can't just be thrown in the trash when their useful life ends. Rules and regulations surrounding lead-acid have given way to a circular economy for those products; they are virtually 100% recyclable today. As demand for li-ion builds, so do expectations for recycling them, and Caron says a growing number of companies are trying to get ahead of that demand as more of the products enter the market—some researchers predict

double-digit growth in li-ion battery use over the next five to seven years. As a result, battery makers and end-users are beginning to form partnerships with recyclers to make the circular economy a reality for these increasingly popular products.

As the process unfolds, here are three things to know about li-ion battery recycling.

## 1. THE BUSINESS CASE IS GROWING

Demand for li-ion recycling has been intensifying over the last 10 years or so, driven by the proliferation of personal electronics and, more recently, electric vehicles, all of which rely on advanced battery technology, according to Peter Geantil, special projects manager for li-ion battery maker (<https://www.fluxpower.com/>) Flux Power, (<https://www.fluxpower.com/>) based in San Diego. But the process for recycling li-ion batteries can be

difficult and expensive.

There are several reasons for that. For one thing, the design of some batteries can make it tough to access and extract the lithium and other elements inside. For another, it requires finding a recycler that handles that particular battery's type of "chemistry." There are different battery chemistries that fall under the li-ion umbrella, and manufacturers choose which to produce based on how well they work for a particular application. (Nickel manganese cobalt, or NMC, and lithium iron phosphate, LFP, are two examples of common chemistries used in material handling applications.) Recyclers don't always handle the gamut of chemistries on the market, making it difficult to find the right partner for the type of battery you want to recycle.

"[Because] you have these different chemistries, you have to find a recycler that can take any lithium-ion battery and extract whatever valuable materials it can from it," Geantil explains, adding that such sources are beginning to emerge. "As lithium began to be deployed throughout our economy, people realized they needed to figure out how to recycle it. Initial recycling rates were low—they weren't even capturing the lithium. Nowadays, they are getting more out of it."

Also complicating the issue is that li-ion batteries for material handling are one part of a larger system that includes electronic components, steel, wires, and other elements, all of which are involved in the recycling or repurposing process, according to Marcio Oliveira, vice president for global quality and sustainability at battery and energy systems maker (<https://www.enersys.com/en/>) EnerSys, (<https://www.enersys.com/en/>) based in Reading, Pennsylvania.

"The recycling process will require deconstructing the batteries," he explains. "The real point, though, when it comes to [sustainability], is that the opportunity is much bigger than just the li-ion battery portion and [actually extends to] the recycling of all the other materials that are part of the whole system."

Like other battery makers, EnerSys is working with recyclers to handle the various aspects of the process and looking to develop partnerships down the road. Oliveira says the company has not yet had to take back any of its li-ion forklift batteries—they were recently launched and are all still in service—but is working with local recyclers to handle the scrap generated from the production process, another aspect of the growing li-ion recycling market.

And like Geantil and Caron, he agrees that the growing volume of li-ion batteries in automotive and industrial applications is helping to drive the business case for change.

"The cost of recyclability is dependent both on the volume to be recycled and also the chemistry used in the batteries," Oliveira says. "The more those business segments increase [their use of li-ion technology], the easier it will be for the recyclability to become a net positive."

## 2. INFRASTRUCTURE DEVELOPMENT IS UNDERWAY

The global lithium-ion battery market was valued at \$32.9 billion in 2019 and is expected to grow at a compound annual growth rate (CAGR) of 13% from 2020 to 2027, according to (<https://www.grandviewresearch.com/press-release/global-lithium-ion-battery-market>) a 2020 market report from research firm Grand View Research. (<https://www.grandviewresearch.com/press-release/global-lithium-ion-battery-market>) Investors are digging in to capture a piece of that pie, and many are helping to lay the groundwork for a lithium-ion recycling infrastructure.

Canadian firm [\(https://li-cycle.com/\)](https://li-cycle.com/)Li-Cycle [\(https://li-cycle.com/\)](https://li-cycle.com/) is a key part of that growing infrastructure. Launched in 2016, the company aims to make li-ion batteries a circular and sustainable product; the firm has developed technology that can recover the resources in any type of li-ion battery chemistry and produce battery-grade li-ion chemicals for use in new products. Li-Cycle recycles thousands of tons of li-ion batteries every year and claims it can recover 95% of all critical materials inside them. The company announced plans to go public earlier this year through a merger with Peridot Acquisition Corp., a publicly traded special purpose acquisition company (SPAC). The deal was expected to close in the second quarter.

Li-Cycle operates two facilities in North America, with a third planned to open early next year. The firm's expansion illustrates the growing market for li-ion recycling as well as larger goals for creating that circular economy, according to Geantil.

"We should have a closed ecosystem," Geantil says, pointing to the growing number of li-ion batteries in the market. "Everyone knows there are valuable materials in them. The economics are there, the desire is there. We're already doing it; it's just that we're getting better and better. People are focusing on it now."

A host of other projects underscore the growing infrastructure. Earlier this year, [\(https://www.ultiumcell.com/\)](https://www.ultiumcell.com/)Ultium Cells LLC, [\(https://www.ultiumcell.com/\)](https://www.ultiumcell.com/) a joint venture between General Motors and [LG Energy Solution](https://www.lgensol.com/en/index), [LG Energy Solution](https://www.lgensol.com/en/index), [LG Energy Solution](https://www.lgensol.com/en/index) formed a [partnership with Li-Cycle](https://investor.gm.com/news-releases/news-release-details/ultium-cells-llc-and-li-cycle-collaborate-expand-recycling-north) [partnership with Li-Cycle](https://investor.gm.com/news-releases/news-release-details/ultium-cells-llc-and-li-cycle-collaborate-expand-recycling-north) [partnership with Li-Cycle](https://investor.gm.com/news-releases/news-release-details/ultium-cells-llc-and-li-cycle-collaborate-expand-recycling-north)

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to recycle up to 100% of the material scrap from battery cell manufacturing.

[\(https://www.redwoodmaterials.com/\)](https://www.redwoodmaterials.com/)Redwood Materials, [\(https://www.redwoodmaterials.com/\)](https://www.redwoodmaterials.com/) a recycling startup led by former Tesla executive J.B. Straubel, is also making headlines, [recently announcing the tripling](https://www.forbes.com/sites/alanohnsman/2021/06/14/redwood-materials-spending-hundreds-of-millions-to-speed-recycling-for-ev-batteries/?sh=beceee47b643) [recently announcing the tripling](https://www.forbes.com/sites/alanohnsman/2021/06/14/redwood-materials-spending-hundreds-of-millions-to-speed-recycling-for-ev-batteries/?sh=beceee47b643)

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of its operations in Nevada to scale up recovery of lithium, cobalt, nickel, and other metals it then sells to makers of lithium-ion batteries for electric vehicles. And earlier this year, Canada-based [\(https://www.lithionrecycling.com/\)](https://www.lithionrecycling.com/)Lithion Recycling [\(https://www.lithionrecycling.com/\)](https://www.lithionrecycling.com/) [announced a partnership with Hyundai Canada](https://www.lithionrecycling.com/hyundai-canada-and-lithion-recycling-announce-agreement-on-recycling-of-hybrid-and-electric-vehicle-batteries/) [announced a partnership with Hyundai Canada](https://www.lithionrecycling.com/hyundai-canada-and-lithion-recycling-announce-agreement-on-recycling-of-hybrid-and-electric-vehicle-batteries/)

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to recover and recycle high-voltage batteries from its hybrid, plug-in hybrid, and electric vehicles. Lithion Recycling is one of UgoWork's recycling partners, according to Caron.

### [subhead] 3. A HOLISTIC APPROACH RULES THE DAY

Battery makers are quick to point out that recycling is just one part of the larger drive toward decarbonization, and that li-ion battery technology plays a big role in that process.

"We really believe that the main challenge in lithium-ion is how to get the industry to the broader transition to lower carbon [emissions]," EnerSys's Oliveira explains. "Lithium technology will be part of this decarbonization process."

Caron and his colleague, Director of Marketing Jean-Francois Marchand, agree and point to other considerations when developing a green energy strategy, such as the logistics and transportation issues around both sourcing and end-of-life processes.

"If we want to limit the carbon footprint, does it make sense to send huge battery packs [for recycling] all over the continent and [create] a lot of transportation and carbon-dioxide emissions? We need to optimize the supply chain logistics," Caron says, adding that some recyclers are tackling this issue by creating local collection options where they crush the lithium into "black mass,"

a mixture that contains a blend of all the battery materials from which recyclable metals can be extracted and then sold back to the battery makers for use in new products. This is what Li-Cycle and others do. "If we have clients in Texas, Washington, and all over Canada, we're looking for someone able to support our various locations in a way that's environmentally friendly."

And, increasingly, that's what end-users tell battery makers they want as well.

"More and more, [sustainability] is one of the top priorities of our customers," says Marchand, adding that how UgoWork handles end-of-life for its products is "definitely one of [customers'] decision criteria. One thing, though, is they don't know how to handle this. They don't want to take care of it themselves. We anticipate that this [will become] a trend, and that more customers will be concerned about this issue and will ask about it."

Victoria Kickham, an editor at large for Supply Chain Quarterly, *started her career as a newspaper reporter in the Boston area before moving into B2B journalism. She has covered manufacturing, distribution and supply chain issues for a variety of publications in the industrial and electronics sectors, and now writes about everything from forklift batteries to omnichannel business trends for*

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