Info Sheet

Collection and Transportation Logistics of Electric Vehicle Battery Recycling

What are the logistical issues behind recycling electric vehicle batteries?

Recycling spent electric vehicle (EV) batteries requires resolving not only the technical and economic processes of transforming a spent battery into battery-grade materials for reuse, but also the many collection, logistics and transportation issues in that recycling system.

The collection and transportation of EV batteries concerns how to coordinate the most efficient network for recycling EV batteries to minimize the amount of transport needed and the resulting carbon emissions. The batteries must first be collected from the vehicle owners and then transported from the site of collection to a facility where they are dismantled, processed, or both. Unfortunately, in countries like the U.S. there are no clear standards and protocols for transporting and handling spent batteries, let alone take-back programs.

Handling lithium-ion batteries (LIBs) has become so demanding that dealerships will ship an entire 4,000-pound damaged vehicle across the U.S. by truck to repair or recycle the 1,000-pound battery inside.[1] Companies such as Spiers New Technology (SNT) conduct both the dismantling and recycling at the same facility. The coordination of efficient battery collection networks is therefore key to making sure that spent EV batteries end up at a recycling facility through cost effective means that minimize harms to the environment.

1 Barber, Gregory and Aarian Marshall. 2021. "Cars Are Going Electric. What Happens to the Used Batteries?" Wired Magazine, November 2, 2021. https://www.wired.com/story/cars-going-electric-what-happens-used-batteries.

Why are collection, transportation and logistics important?

Often the cost of collection, transportation and logistics can exceed the value of what can be recovered from a battery. For instance with lead-acid batteries (LABs), the value of the lead recovered from an LAB pays for the transportation, logistics and recycling of the battery. But with LIBs, there is not enough nickel, cobalt or lithium in a LIB to cover those costs.[2] Some studies suggest that transportation costs of spent EV batteries can represent about 40% of the cost of recycling.[3] When the full costs of recycling batteries, including their collection and transportation, exceed the value that can be obtained, proper treatment and/or recycling of LIBs may be discouraged and may therefore fail to take off without proper government incentives and support.

The lack of a coordinated collection and transportation network can have severe environmental justice implications, especially in many Global South countries where end-of-life (EOL) LIBs are often processed in unregulated recycling facilities due to the high costs associated with proper recycling and disposal. This unregulated and informal recycling process typically involves manual handling without adequate infrastructure or safety measures, posing risks to both workers' health and the environment.[4] When mishandled, these batteries can release their contents into the ground, leading to contamination of groundwater through leachate infiltration and surface water runoff.[5] Copper, for example, poses risks such as bioaccumulation, toxicity, and trophic transfer, potentially causing DNA damage.[6]

Nickel, another component of EOL LIBs, binds strongly to small solid particles and may accumulate in soil when released into the environment.[7] High concentrations of nickel can be toxic to plants, inhibiting growth, photosynthesis, seed germination, sugar transport, and causing symptoms such as chlorosis, necrosis, and wilting.[8] Health impacts of nickel exposure include lung fibrosis, kidney and cardiovascular diseases, and respiratory tract cancer.[9]

2 The Big Switch. 2024. "The Battery Recycling Dilemma." Center on Global Energy Policy, podcast audio, March 27, 2024, https://www.energypolicy.columbia.edu/battery-recycling-dilemma.

3 Slattery, Margaret, Jessica Dunn and Alissa Kendall. 2021. "Transportation of electric vehicle lithium-ion batteries at end-of-life: A literature review." Resources, Conservation and Recycling 174: 105755 https://doi.org/10.1016/j.resconrec.2021.105755

4 Ahirwar, Rajesh and Amit K. Tripathi. 2021. "E-Waste Management: A Review of Recycling Process, Environmental and Occupational Health Hazards, and Potential Solutions." Environmental Nanotechnology, Monitoring & Management 15: 100409. doi:10.1016/j.enmm.2020.100409. https://www.sciencedirect.com/science/article/pii/S2215153220303925.

5 Beaudet, Alexandre, François Larouche, Kamyab Amouzegar, Patrick Bouchard, and Karim Zaghib. 2020. "Key Challenges and Opportunities for Recycling Electric Vehicle Battery Materials." Sustainability 12, no. 14: 5837. https://doi.org/10.3390/su12145837.

6 Ameh, Thelma and Christie M. Sayes. 2019. "The Potential Exposure and Hazards of Copper Nanoparticles: A Review." Environmental Toxicology and Pharmacology 71: 103220. doi:10.1016/j.etap.2019.103220. https://www.sciencedirect.com/science/article/pii/S1382668919300912.

7 Mrozik, Wojciech, Mohammad Ali Rajaeifar, Oliver Heidrich, and Paul Christensen. 2021. "Environmental impacts, pollution sources and pathways of spent lithium-ion batteries." Energy & Environmental Science 14, no. 14: 6099-6121. doi: https://doi.org/10.1039/D1EE00691F.

8 Bhalerao, Satish, Amit Sharma, and Anukhti Poojari. 2015. "Toxicity of Nickel in Plants." International Journal of Pure & Applied Bioscience 3: 345-355. https://www.researchgate.net/publication/304133561_Toxicity_of_Nickel_in_Plants.

9 Genchi, Giuseppe, Alessia Carocci, Graziantonio Lauria, Maria Stefania Sinicropi, and Alessia Catalano. 2020. "Nickel: Human Health and Environmental Toxicology" International Journal of Environmental Research and Public Health 17, no. 3: 679. https://doi.org/10.3390/ijerph17030679.

Challenges in collection, transportation & logistics

Cost to transport long distances

Transportation and collection costs are a key barrier to effective recycling in industrial facilities. In China, most LIB recycling facilities are located in the southeastern area, and in the US, mainly on the east and west coasts, which requires transportation over long distances for recycling.[10] For this reason, the collection and transportation of used batteries make up nearly half the cost of recycling in the U.S. High logistical cost is one of the reasons why some battery recycling companies are mostly taking manufacturing scrap, which is usually excess or defective material created during battery construction, and therefore relatively simple to transport.[11]

TEXT BOX

Lessons learned from a centralized collection system for lead-acid batteries in the U.S.

While 99 percent of LABs are recycled globally,[12] used-lead acid battery recycling is the world's worst polluting industry,[13] known to emit high concentrations of lead and other heavy metals resulting in air, soil, and water contamination. LAB recycling plants in the U.S. have been major sources of soil contamination that contribute to lead exposures in fence line communities and surrounding areas. Moreover, due to lenient federal waste export laws, 75 to 95 percent of used LABs from the U.S. are exported to Mexico for recycling where the costs are externalized onto communities there.[14] Even though their collection rate is almost 100 percent, the recycling of lead-acid batteries therefore serves as a cautionary tale rather than a model to follow when it comes to the recycling of spent LIBs.

10 Yu, Xiaolu, Weikang Li, Varun Gupta, Hongpeng Gao, Duc Tran, Shatila Sarwar, and Zheng Chen. 2022. "Current Challenges in Efficient Lithium-Ion Batteries' Recycling: A Perspective." Global Challenges 6 (12): 2200099. https://doi.org/10.1002/gch2.202200099.

11 Leber, Rebecca. 2022. "The end of a battery's life matters as much as its beginning." Vox News, October 24, 2022. https://www.vox.com/the-highlight/23387946/ev-battery-lithium-recycling-us.

12 "New Study Confirms Lead Batteries Maintain 99% Recycling Rate | Battery Council International." https://batterycouncil.org/new-study-confirms-lead-batteries-maintain-remarkable-99-recycling-rate.

13 "Key Facts about Used Lead-Acid Battery Recycling | Reuters." https://www.reuters.com/business/sustainable-business/key-facts-about-used-lead-acid-battery-recycling-2021-04-20.

14 Gottesfeld, Perry, Sofia C. Chavez Arce, and Luis Macias Raya. "Hazardous Exports Contribute to Soil Contamination at Lead Battery Recycling Plants in Mexico." Occupational Knowledge International. http://okinternational.org/docs/SoilMexico_Final%20eng.pdf.

Hazardous waste

EV batteries are classified in most states as hazardous waste because they present a fire risk when improperly dismantled. Because of this, there are more strenuous packaging and capacity standards for shipping them across the country. With few plants open in the US, the Department of Energy (DOE) estimates that an LIB has to travel some 50 miles for dismantling, and then another 1,000 miles to a factory for processing.[15]

Centralized collection & take-back system

Getting all the spent EV batteries to a recycling facility will not be an easy endeavor. Generally speaking, most countries lack a centralized system for organizing and coordinating the collection of spent EV batteries for recycling, reuse, and remanufacturing. Much of this work is therefore left to the private sector, which is primarily motivated by economic gains rather than issues of sustainability.

In China, spent EV batteries are often collected and transported directly to the recycling facility, which is generally located far from the collection center.[16] As a result, the recycling rate for used EV batteries was only 7.4 percent. Moreover, most spent EV batteries are handled by small unofficial recycling workshops that operate outside of the government-issued whitelist of 156 key industry players, companies that have passed rigorous evaluations covering operations as well as environmental and technological standards.[17] Oftentimes, these informal recyclers are able to offer a higher price for batteries by avoiding many of the costs incurred from following these standards. As a result, many batteries end up in informal recycling networks with little information on their final fate.

One emerging initiative is private partnerships, such as the one announced by global battery maker BASF, graphene energy storage maker Nanotech Energy, LIB recycling company American Battery Technology Company (ABTC), and TODA Advanced Materials will be working together to create a domestic closed-loop system for LIB EV battery cells.[18] Private partnerships such as these, however, are not enough to address the many logistical and economic questions when it comes to the broader system of collection and transport.

15 Ibid.

16 Sohu House. 2019. “GGII：2018年国内锂电池理论报废量24.1万.” Last modified March 15, 2024. https://www.sohu.com/a/301409986_120044724.

17 Bloomberg News. 2023. “Electric Cars With Recycled Batteries Are the Next Green Holy Grail.” Bloomberg News, December 20, 2023. https://www.bloomberg.com/news/features/2023-12-20/recycling-spent-batteries-is-china-s-next-big-electric-car-challenge.

18 Lewis, Michelle. 2023. “In a US first, new EV battery cells will be made with recycled metals.” Elektrek, September 11, 2023. https://electrek.co/2023/09/11/ev-battery-recycled-metals-us-basf.

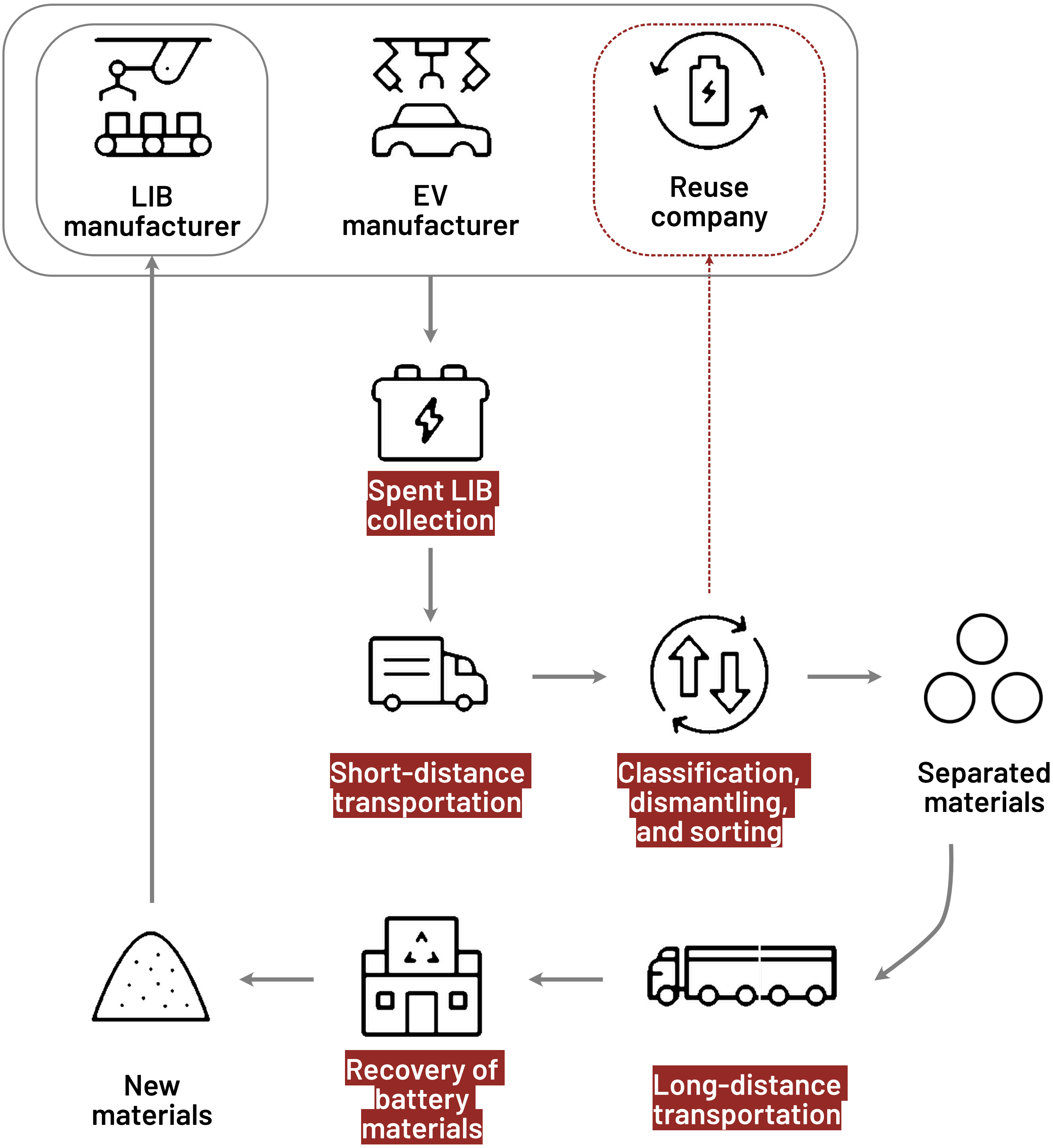
Lack of policy & regulation

Most countries have yet to coordinate the most efficient network for collection and recycling to minimize the amount of transport needed and the resulting carbon emissions. This is often due to a lack of policy and strong government regulation.

The lack of federal recycling standards and coordination between manufacturers and recycling companies in the US has been costly. Based on an economic model developed by the DOE's Argonne National Laboratory, LIB recycling in the US is far more expensive per hour than in China — $50 in the US, compared to $7.50 in China.[16] These issues will become all the more pressing as batteries from used EVs will start to pour in from all over throughout the next decade.

19 Dunn, Jessica, Alissa Kendall, and Margaret Slattery. 2022. "Electric Vehicle Lithium-Ion Battery Recycled Content Standards for the US – Targets, Costs, and Environmental Impacts." Resources, Conservation and Recycling 185: 106488. doi:10.1016/j.resconrec.2022.106488. https://www.sciencedirect.com/science/article/pii/S0921344922003317.

FIGURE: EV battery recycling flow



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Recommendations

20 A powder containing valuable battery metals such as lithium, nickel, and cobalt sourced from shredded EV batteries.

Governments can help to coordinate strategic facility siting that minimizes transportation distances, thereby reducing costs and emissions. This involves working with companies along the supply chain, from battery manufacturing to battery recycling, to plan for more decentralized dismantling facilities. Doing so could help alleviate safety concerns of transporting hazardous waste in the form of black mass rather than spent EV batteries, even though both remain hazardous.[17] Moreover, batteries should be transported to a facility that incurs the lowest environmental impact and maximum social benefit. Each facility should be allowed to take back all spent EV batteries produced by any battery manufacturer.

Battery manufacturers can also provide access to accurate information about the battery's state of health (SOH) in the form of [a battery passport]() in addition to properly labeling LIBs according to their material contents to facilitate the dismantling and sorting process and to ensure that batteries are sent to the appropriate facility early on in the chain of custody. All of this will help to ensure that spent EV batteries are properly disposed of through the most efficient means possible, reducing the emissions required to transport these batteries.

In countries like China, the government can help promote the formal recycling market by providing subsidies to residents based on collection price, making up the difference between the bid prices of formal and informal channels. This way, more batteries can end up with recyclers that have already passed rigorous evaluations covering operations as well as environmental and technological standards.

Acknowledgements

- Author(s): Erica Jung
- Editor(s): Lien De Brouckere, Erica Jung, and Doun Moon
- Design: Doun Moon
- Reviewer(s): Claire Arkin, Jefferson Chua, and Sheila Davis

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