Memorandum

PREPARED FOR: Representative Andersen
DATE: May 15, 2023
BY: Shauna Petchel, LPRO Analyst
RE: Minerals Recovery from Electric Vehicle Batteries

LPRO
LEGISLATIVE POLICY AND RESEARCH OFFICE

This memorandum is in response to your request for information regarding recycling infrastructure for electric vehicle (EV) batteries during the House Climate, Energy, and Environment committee's informational meeting on May 10, 2023. Specifically, you asked what proportion of an EV battery's minerals can be recovered through recycling.

The proportion of minerals recovered from an EV battery through one of three recycling processes, described below, varies and is dependent on the process used. The most efficient process, which recovers the most minerals, can recover over 95 percent of minerals from an EV battery. The least efficient process recovers over three-quarters of minerals.

Battery Recycling Processes

A systematic review of recycling technology for EV batteries identified three recycling processes that may be used to recover minerals from lithium-ion batteries, the most common battery type in use in today's EVs.[1]

- **Pyrometallurgy** uses high-temperature physical and chemical treatments to recover battery minerals. The process does not require pre-treatment of batteries and results in high recovery rates for some minerals (cobalt, nickel, and copper). However, it cannot recycle lithium, aluminum, or organic materials. Pyrometallurgy releases toxic wastewater and gaseous byproducts.[1]
- **Hydrometallurgy** involves pre-treatment of batteries through mechanical sieving and separation followed by lower-temperature chemical treatment in liquid acid or basic agents. The process can result in high recovery rates for minerals including lithium. The hydrometallurgy process produces toxic wastewater but is emission-free.[1]
- **Direct recycling** involves complex separation and treatment of individual battery components to restore them for direct reuse in new batteries. It has potential to recover all parts of the battery, including cathodes. Direct recycling is an emerging approach with limited research on use at industrial scales.[1]

These processes vary in efficiency (the proportion of minerals recovered) and the purity of recovered materials. See Table 1, next page.

[1] Beaudet, Alexandre, François Larouche, Kamyab Amouzegar, Patrick Bouchard, and Karim Zaghib, *Key Challenges and Opportunities for Recycling Electric Vehicle Battery Materials,* 12 Sustainability, (5837) (current options for recycling lithium-ion batteries). Available at: https://www.mdpi.com/2071-1050/12/14/5837.

Table 1. EV Battery Recycling Processes, Efficiency, and Purity

Process	Efficiency	Purity of Recovered Materials
Pyrometallurgy	80–98.8%	98–99.95%
Hydrometallurgy	76–98.2%	96.5–99.7%
Direct recycling	>95%	Comparable to hydrometallurgy (96.5–99.7%)

Source: Legislative Policy and Research Office.
Data: Pražanová Anna, Vaclav Knap, and Daniel-Ioan Stroe. Literature Review, Recycling of Lithium-Ion Batteries from Electric Vehicles, Part I: Recycling Technology, 15 Energies. Available at https://www.scopus.com/inward/record.uri?eid=2-s2.0-85124994032&doi=10.3390%2fen15031086&partnerID=40&md5=d2c653aa93291b063df99ef4d67c0f78