SCIENCE NOTES

EV Battery Technology

by Francis Ofori-Awuku

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RESEARCH HIGHLIGHTS

- **Rapid EV growth is increasing demand for batteries as countries transition away from fossil fuels.**
- **EV batteries reach end-of-life at ~80% capacity, and poor management poses environmental and safety risks.**
- **Strong producer-responsibility policies are needed to support reuse, recycling, and safe disposal.**

EV Batteries

EV batteries are battery packs made up of multiple "modules" or identical parts that contain many electrochemical cells. These cells contain layers (anode, cathode, and separator layers) that are in contact with an electrolyte (typically a liquid), and those components are then stacked or rolled together in steel or aluminum, making up a cell (see diagram on back). Different chemicals can be used in the cathode of batteries, but lithium nickel cobalt aluminum oxide chemistries are more frequently used in EV batteries due to their relatively high energy storage capacity to support propulsion, with lithium-ion batteries being the most common. There are, however, competing alternatives, including lead acid, nickel metal hydride, and others. Materials used for the manufacturing of EV batteries (if variably) tend to be costly and environmentally intensive to mine and refine. In addition to these chemistries, cells may contain other materials such as copper, plastics, manganese, and graphite. EV batteries drive a significant portion of the market for some of these materials. According to the International Energy Agency (IEA), "in 2022, about 60% of lithium, 30% of cobalt and 10% of nickel demand was for EV batteries."

EV Battery End-of-Life Pathways

Typically, after their use in vehicles, EV batteries and their components follow three paths at their "end-of-life" (EOL): reuse, recycling, or disposal. EOL batteries from EV cars are typically identified for reuse or recycling by car manufacturers, dealerships, mechanics, or disassemblers, and are then sent to other collection, intermediate processing, and recycling facilities.

Reuse

A battery is typically considered to have exceeded its useful automotive life, when its storage capacity is 80 percent or lower of its initial capacity. While it may not be sufficient for an EV, some are reused in "second life" applications like grid storage or home backup systems, and batteries can be tested and repaired to make sure they function adequately. This market is, however, still limited by relatively high testing and certification costs.

Recycling

EV batteries that can no longer be reused may be recycled to recover valuable metals and materials to create further EV batteries. Estimates for the percent of EV batteries recycled, according to recent data from 2023, vary widely—from 5 percent (commonly cited) to 59 percent. Advanced methods can achieve up to 95–98 percent recovery of materials, though infrastructure remains limited. Recycling can mitigate supply risks, enabling a more circular economy for critical materials, reducing resource extraction impacts, and strengthening supply chains. In California, for instance, it is estimated that recycling can cover around 61

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QUICK FACTS

The EV battery reuse and recycling market is estimated to grow from **$8 billion in 2024** to over **$28 billion in 2029**.

In 2023, US battery recycling facilities had the capacity to reclaim over **35,000 tons** of materials. In 2024, the Department of Energy projected that planned facilities over the following few years would add **76,000 tons more capacity**.

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ABOUT SCIENCE NOTES

Science Notes are short memos that describe scientific and technological artifacts, concepts, principles, and research related to policy topics and legislative proposals.

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percent of the overall EV battery demand annually by 2050. However, there have been environmental and public health risks associated with battery recycling practices when sufficient protections and enforcement were not in place, as has been recently reported occurring overseas.

Disposal

Landfilling is the least desirable option for managing EOL EV batteries, as it can be detrimental to the environment. When not reused or recycled, battteries may be stockpiled or discarded in ways that pose environmental and fire risks if existing regulatory guidance and requirements are not followed.