Washington
Green Transportation Program
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EV Batteries: Issues Driving Improvements

Growing Demand for Batteries

From 2021 to 2022, worldwide demand for lithium-ion (Li-ion) batteries increased nearly 65%. This is an increased demand from 220 GWh to 550 GWh. This increased battery demand was felt primarily in China, which saw an 80% increase in EV purchases from 2021 to 2022.

In the U.S., battery demand also grew by 80% even though EV sales increased only by about 55%. This growth highlights the varied applications for battery technology across the consumer spectrum.

The average EV battery size in the U.S. grew by about 7% in 2022; EV batteries here are about 40% larger than in other countries due to our large demand for EV SUVs and longer ranges.

Acquiring Raw Minerals Differently

A significant percentage of raw materials for batteries comes from politically unstable countries with substandard labor practices. This creates vulnerabilities in the supply chain for global EV manufacturing, including:

- Chokepoints that could affect EV production, decarbonization, and policymaking.
- Political disruptions that could make global reserves of critical materials unavailable, including:
- Cobalt: 48% of reserves are in the Democratic Republic of Congo.
- Lithium: 36% of reserves are in Chile.
- Nickel: 21% of reserves are in Indonesia.

China processes 76% of the cobalt, 61% of the lithium, 59% of the manganese, and 25% of the nickel worldwide, increasing our vulnerability. Western regions are attempting to address this vulnerability by increasing construction of critical mineral processing operations in North America and Europe.[1]

China is also responsible for 70% to 80% of the world's anode and cathode production, 75% of the world's battery production, and over 50% of the world's EV production. With tensions rising between China and the West, it is crucial that these relations do not strain markets and for the West to become dramatically more self-reliant in mineral, cell, battery, and EV production.[2]

Alternative battery technologies

EV battery chemistry is changing as researchers explore more efficient combinations of minerals.

- By far the dominant battery chemistry is a **lithium nickel, manganese, cobalt** (NMC) mix, comprising 60% of EV batteries made today.
- **Lithium iron phosphate** (LFP) chemistry is used in 30% of EV batteries made today. LFP batteries are growing in popularity because they use minerals that are more readily available and less expensive than NMC batteries, but they are less energy dense so have smaller capacities.
- **Nickel cobalt aluminum** (NCA) technology is used in about 8% of today's EV batteries.
- A **sodium-ion** battery is being built by Chinese company CATL. Sodium is widely available and cheaper than lithium. However, sodium-ion batteries have a lower energy density than Li-ion and bring the same concerns as Li-ion batteries.

- **Silicon** is now a major new material in anode and cathode technologies because of its higher energy density compared to graphite. This allows for longer ranges and quicker charge times. However, silicon is more susceptible to degradation and battery wear.

University of Texas researchers are testing a cobalt-free, nickel-based EV battery cathode to reduce the social and environmental costs of acquiring cobalt, and to increase energy density, range, and battery lifetimes.[3] Their cathode is 89% nickel, with manganese and aluminum comprising most of the rest of the cathode.

Chinese company SVOLT is working on a similar nickel/manganese (NMx) cathode. They are scaling production to reduce the demand for cobalt, increase energy densities, and reduce battery costs.[4]

IBM is developing a prototype for an EV battery derived from seawater elements that will be non-flammable and can be recharged to 80% in about five minutes. There is some skepticism about these claims, however, because IBM has not released their technical specifications or peer-reviewed data.[5]

The company Focus believes that graphene is going to be the material of choice for batteries in the 2030s, with society-wide applications. As the price of graphene drops, and extraction and manufacturing processes become more efficient, Focus believes this technology will become a popular choice to improve EV performance and meet emission-reduction goals.[6]

Zinc-air batteries could replace traditional Li-ion batteries. They are not flammable and have higher energy densities, but are currently very expensive, and have lower specific energy and voltage levels.

Bringing Battery Production to the U.S.

By 2030, the Li-ion battery market is expected to grow in value to $400 billion, and increase in capacity from 700 GWh[7] to 4.7 TWh.[8] Mobility applications such as EVs will consume about 4.3 TWh of that capacity.

China currently produces approximately 75% of the world's EV batteries. According to Bloomberg,[9] China's production alone came close to matching the global demand for batteries.

In 2024, 34 battery manufacturing plants were in construction or planned in the U.S., up from two such facilities in 2019. The Inflation Reduction Act provides tax credits to incentivize EV component manufacturing. Close to $112 billion has been invested to increase battery-manufacturing capacity in the U.S. to 1.2 TWh by 2030, enough for 18 million EVs.[10] [11] With this major increase in global battery manufacturing, battery costs are expected to decrease.

Increasing Battery Lifetimes

Conventional EV batteries start to show loss of charge, power, or capacity at 5,000 to 7,000 charging cycles. Researchers are fine-tuning innovations to increase the number of times an EV battery can accept a charge.

Nanowires

Researchers at the University of California Irvine invented a nanowire that is thousands of times stronger than traditional nanowires. In EV batteries, this technology may be useful to extend battery lifetimes. After extensive testing, these nanowires showed no loss of power or charge, and no fracturing.

Dual-carbon battery

Power Japan Plus is developing a dual-carbon battery that utilizes carbon for both the anode and cathode. This technology offers similar energy densities as Li-ion batteries with a longer functional lifetime, better safety metrics, and more sustainable recycling at battery end-of-life.

These batteries are cheaper to produce than Li-ion batteries, can charge up to 20 times faster and provide greater power. Carbon batteries also do not use rare-earth metals and do not rely on a vulnerable supply chain. This battery can charge in the 0% to 100% range without degradation.

Increasing Battery Recycling

The market for recycled batteries is not currently large because most EV batteries are still in use. But as more EV batteries are removed from service, the incentives, prices, and processes to reuse or recycle batteries will become more robust and efficient, potentially even creating a closed loop based on battery chemistry innovations.[12] By 2023, 105,000 tons of battery materials were recycled in the U.S., enough to power 220,000 vehicles a year.

Approximately 650,000 tons of recycling capacity could be built by 2030, enough to process approximately 1.3 million EV batteries at end-of-life. By 2050, the U.S. will have an estimated 1.5 million tons of EV battery end-of-life materials so we will need more recycling capacity to keep up with the increased production of EVs.[13]

Finding New Uses for Retired Batteries

End-of-life EV batteries can be repurposed for stationary grid storage and power. EV batteries are typically considered to be at their end of life at 20% to 30% degradation. But these batteries still have plenty to offer, including "electricity generation and grid distribution, such as time-shifting, seasonal energy storage, large-scale renewable integration, and grid regulation."[14]

Large generating facilities can use these retired batteries to offset intermittent renewable energy production, for peak shaving to reduce demand, and for dip-rising to meet high demand.[15]

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[1] Critical Minerals for Electric Vehicles: What You Need to Know. Resources. March 7, 2024.
[2] Global Supply Chains of EV Batteries. International Energy Agency. July 2022.
[3] New Cobalt-Free Lithium-Ion Battery Reduces Costs Without Sacrificing Performance. UT News. Jul 14, 2020.
[4] SVOLT Reveals First NMx Cobalt-Free Battery Pack. InsideEVs. Aug 31, 2021.
[5] IBM Reveals "Staggering" New Battery Tech, Withholds Technical Details. IEEE Spectrum. Dec 19, 2019.
[6] Graphene is set to disrupt the EV battery market. *Energy Monitor*. Feb 5, 2024.
[7] Gigawatt hour (GWh): unit of energy that represents one billion watt-hours equal to one million kilowatt-hours.
[8] Terawatt-hour (TWh): unit of energy that represents one trillion watts of power used for one hour.
[9] China Already Makes as Many Batteries as the Entire World Wants. Bloomberg. April 12, 2024.
[10] Tracking the EV battery factory construction boom across North America. TechCrunch. July 20, 2024.
[11] Analysis Finds U.S. EV Battery Manufacturing on Track to Meet Demand. Environmental Defense Fund. Jan 3, 2024.
[12] The truth about EV battery recycling. ChargeLab. April 16, 2024.
[13] Will the U.S. EV battery recycling industry be ready for…end-of-life batteries? International Council on Clean Transportation. Sept 29, 2023.
[14] Can EV Batteries Be Reused? AZO Materials. July 11, 2024.
[15] The future holds many…more EV batteries. And therein lies a solution to grid storage. *Anthropocene*. May 28, 2024.

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