



Washington

Green Transportation Program

Moving forward with Washington's public fleets

EV Batteries: Getting Better All the Time

Modern electric vehicles (EVs) came on the market in the United States in 2010. Since then, EV batteries have vastly improved and lithium-ion battery technology is now standard. While concerns about battery cost, safety, range, longevity and environmental impacts have largely been resolved, we address lingering concerns here.

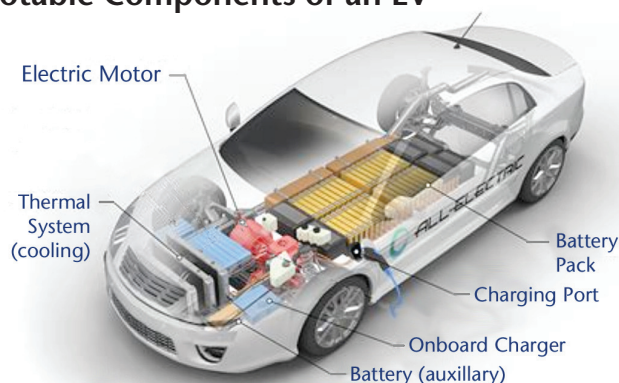
Battery costs are dropping

Battery costs have dropped fast, so EVs are expected to reach cost parity with internal combustion engine (ICE) vehicles soon. Economies of scale have helped reduce costs from \$1,000 per kWh¹ to about \$100 per kWh. For each doubling of manufacturing capacity, we see roughly a 20% drop in the cost of batteries.²

With this reduction in battery costs, manufacturers are finding that it is now cost-effective to expand their vehicle offerings to meet the needs of a wider range of customers. Manufacturers announce the release of new electric pickups, crossovers, SUVs and fleet vehicles every month it seems, and the pace does not appear to be letting up.

As new EVs are introduced, vehicle manufacturers use different battery designs and battery management systems to improve battery performance and safety. Patents for new battery technology are submitted frequently as manufacturers strive to reduce or eliminate environmental impacts while achieving safety, performance and production goals.

Notable Components of an EV



Graphic adapted from U.S. Dept. of Energy Alternate Fuels Data Center

Batteries last longer and can go farther

Do EV batteries need to be replaced every 3 to 5 years? No. Lithium-ion batteries in EVs have never needed to be replaced that often. While fear of battery degradation

¹ A kilowatt-hour (kWh) is a measure of the amount of energy a certain machine needs to run for one hour.

² <https://www.dnv.com/feature/tesla-battery-day-energy-transition.html>



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might have been a concern with lead-acid batteries or in pre-2013 EV models that had a shorter range, the phenomenal gains in battery technology negate this concern about frequent battery replacement. New EV batteries have 4 to 6 times the capacity of older batteries and provide much longer ranges.

Battery safety continues to improve

EV battery safety issues are largely a thing of the past. Significant advances in the battery industry and development of new battery chemistries have led to important improvements in battery safety.

Are EV batteries more likely to catch on fire? EVs with modern batteries are not more prone to catching on fire than ICE vehicles.³ A battery management system (BMS) is used to keep the EV battery at the optimal temperature so it doesn't overheat. This is especially important while charging, during heavy-duty operation or when driving at temperatures below 0°F. The BMS also makes charging more efficient and improves EV battery longevity.

EV batteries have safety systems to prevent electrocution risks. All EVs are designed to meet international standards to ensure they do not present unusual hazards in flooding situations. Electrical components are well sealed and EVs include safety systems to minimize the potential for electrical shock in a crash or water submersion.

What happens if the EV is damaged and parts of the electrical system are exposed? The following three systems are included in EVs to safeguard against this possibility:

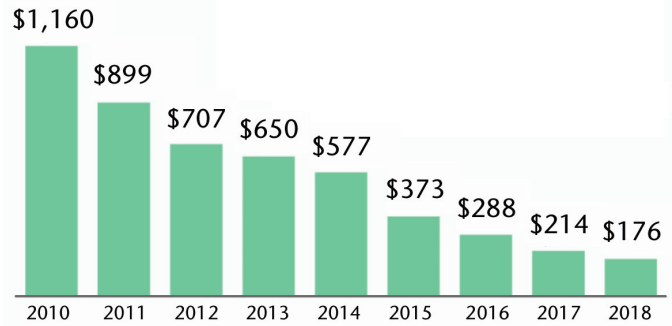
- An impact sensor (which exists in all modern cars) triggers a series of safety systems to disconnect the high-voltage battery electrics from the rest of the car.
- Ground-fault detection systems built into EVs continually test for electrical connections between the metal vehicle body and the high-voltage system. If a fault is detected, the ground-fault system shuts off the electrical supply to the high-voltage components.

³ People do not often associate their fossil-fuel vehicle with the nearly 200,000 highway vehicle fires that occur each year in the U.S. (National Fire Protection Association: <https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/US-Fire-Problem/osvehicfires.pdf>)

⁴ The heat release and hazards of an EV fire are comparable to those of a fossil-fuel vehicle fire. (The Driven: <https://thedriven.io/2018/12/04/is-a-battery-electric-vehicle-safe-in-a-flood/>)

Can Falling Battery Prices Push Electric Cars?

Average price of battery packs for electric vehicles (\$ per kWh)*



* Prices in 2018 dollars, averages weighed based on volumes sold. Based on November 2018 survey of 1,279 vehicle owners in the U.S.

Graphic adapted from Statista. Source: Cargugus, Bloomberg NEI

- Fuses inside the EV battery pack disconnect different areas of the battery if needed.⁴

First responders are trained to use reasonable caution when responding to an EV battery fire.

These fires can be more difficult to suppress because an EV battery is less accessible to externally applied suppressant and can re-ignite if it is not sufficiently cooled. As a result, lots of suppression agent is needed to extinguish an EV battery fire, cool the battery and prevent re-ignition. Fire safety research, training and policy changes are underway to improve the safety of each generation of EV batteries.

Battery production is evolving to reduce human and environmental impacts

A lithium-ion EV battery pack is made up of hundreds – even thousands – of individual cells bundled together to hold the electrical charge. Each cell includes a positive terminal (cathode), negative terminal (anode) and a fluid that allows electrons to travel between the cathode and anode so charging and discharging can occur. A battery pack enclosure keeps the cells together and operating as a single unit.

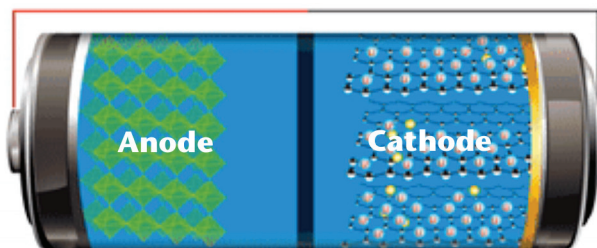
Since the late 1990s, lithium-ion battery technology advances have been driven by demands from portable electronics such as laptop computers, mobile phones and power tools. The EV marketplace has benefitted from these advances both in the performance and energy density of lithium-ion batteries.

These batteries contain many specific minerals, including lithium, nickel, cobalt, copper, manganese and graphite. Battery manufacturers monitor and investigate material supply chains to:

- Address concerns about mining and material processing
- Identify unique demands for mining and processing of precious and critical minerals (lithium, cobalt and nickel)
- Suggest alternative battery composition that decreases cobalt usage
- Suggest increasing domestic mining and other strategic solutions for raw material extraction and processing

Inside a Lithium-ion Battery

Lithium ions move in the battery between the anode and cathode. Electrons go through the external circuit to run an EV.



Graphic adapted from U.S. Dept. of Energy

Does increased battery manufacturing cause supply tightening?

Increased battery manufacturing may result in tightening of the supply and increased cost of raw materials due to supply and demand dynamics. To address this concern, manufacturers are working to increase mineral supplies and improve battery manufacturing to meet growing demand. For example, a number of large battery gigafactories are in development to increase battery supplies worldwide, producing billions of watt-hours of cells to support the transition to EVs.

It bears repeating that the battery market is dynamic. Manufacturers are always looking for solutions that reduce or eliminate reliance on overseas mining and processing of raw minerals needed for EV batteries. Fortunately, the international automakers have developed solutions such as using different raw materials that are readily available, like silicon and ceramics; new battery chemistries and designs; and returning mine production to the U.S. where possible. According to the U.S. Dept. of the Interior and Bureau of Land Management, the U.S. has enough lithium, cobalt and graphite to build its own battery supply chain.⁵

In the case of rare earth minerals, all vehicles – electric and internal combustion – rely on mining and extraction of these minerals. To reduce safety concerns, mining is highly regulated and monitored by the Initiative for Responsible Mining Assurance, and overseen by groups such as Amnesty International to prevent human rights abuses.

Battery re-use and recycling are improving

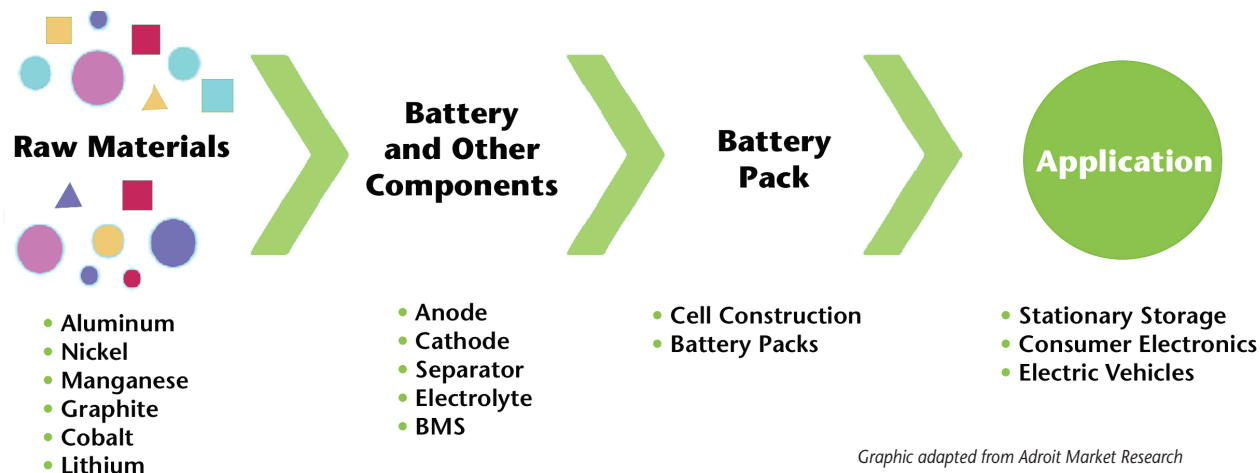
When the capacity of an EV battery drops below 70 to 80 percent after about 10 years of use, it is no longer strong enough to power the car.⁶ But it can still be put to good use, such as providing energy storage for residential solar or adding capacity to older EVs.

The battery pack itself can also be refurbished by replacing spent cells. Refurbished batteries are readily

⁵ <https://www.visualcapitalist.com/the-new-energy-era-the-lithium-ion-supply-chain/>

⁶ World Economic Forum: Batteries can be part of the fight against climate change – if we do these five things

Global Lithium-ion Battery Materials Market Value Chain



Graphic adapted from Adroit Market Research

available. However, depending on the application, the rapidly falling cost of producing new batteries and the complexity of some proprietary battery designs may make it cost-prohibitive to use repurposed batteries. But if an EV battery can't be re-used, it can be recycled.

"...Lithium is a valuable raw material. To reclaim one ton, 28 tons of batteries have to be recycled. But to extract one ton of virgin lithium from Chile, 1,250 tons of earth must be dug up.

"Overall, recycling is promising. But it is currently obstructed by several barriers, including the limited scale of batteries available for recycling; lack of battery standards to simplify recycling; an insufficient policy and incentive scheme to incentivize collection; and limited clarity about liability."

– World Economic Forum

A dynamic market for recycling battery materials is developing.

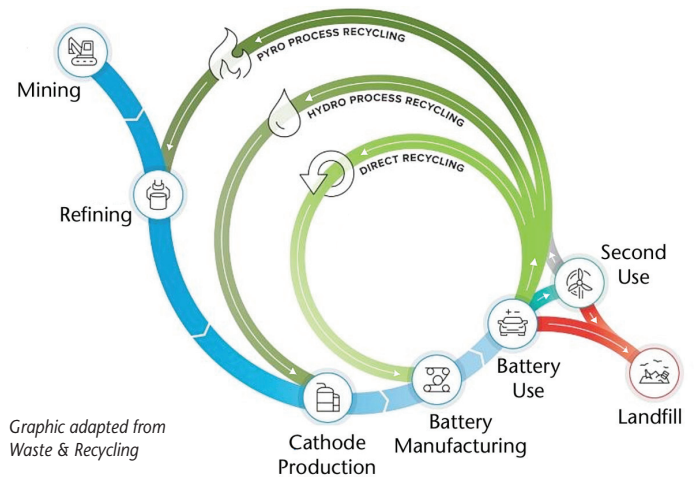
The ReCell Center (recellcenter.org) was established by the U.S. Department of Energy in 2019 to support closed-loop recycling in response to the increasing number of lithium-ion batteries used in electronics and EVs.

The ReCell Center is researching new ways to recycle these batteries, encourage local markets to use the recovered mineral components (lithium, cobalt and manganese), and embrace new secondary uses, such as battery storage and distributed energy projects. These repurposed batteries could serve an "additional 6 to 10 years in a lower-power, stationary application" such as storing energy from solar.⁷

Manufacturers are beginning to standardize battery designs and develop new battery chemistries that make it easier to disassemble, reuse and recycle components recovered from spent batteries. This reduces the need for new raw materials, lowers the battery's life-cycle impact and improves energy security by reducing imports. Companies have developed circular supply chains where end-of-life products like batteries and electronics are "mined" for elements that can be re-used, transforming a waste stream into a supply chain.

⁷ CleanTechnica: <https://cleantechnica.com/2020/03/06/quick-guide-to-ev-battery-reuse-recycling/>

Lithium-ion Battery Recycling



Assessing the entire lifecycle of EV batteries is a net positive today and promises greater improvements in the future. A Life Cycle Assessment is used to analyze the lifelong environmental impact and waste stream of products such as EVs and EV batteries by examining:

- Raw material extraction
- Battery chemistry
- Battery size and charging patterns
- Manufacturing requirements
- Electricity generated and used by the EV
- Lifetime mileage potential
- Product end-of-life expectations

EV batteries are ready for prime time

From cradle to grave, driving an EV is cleaner than driving an ICE vehicle. Especially in Washington, our electricity is mostly renewable and getting cleaner all the time. Batteries have perhaps the biggest potential impact on EV adoption. But as batteries improve with better, safer materials and new end-of-life options extend battery use and encourage more recycling, the life-cycle comparison only gets better. Many public agencies and companies are embracing this challenge.

In 2019, the Washington State Legislature passed legislation directing the WSU Energy Program to establish and administer a technical assistance and education program for public agencies on the use of alternative fuels and vehicles. The Green Transportation Program provides education and assistance to public agencies, including cities, counties, transit agencies, school districts, colleges and universities, utilities and PUDs, tribes, ports, and other state political subdivisions.

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