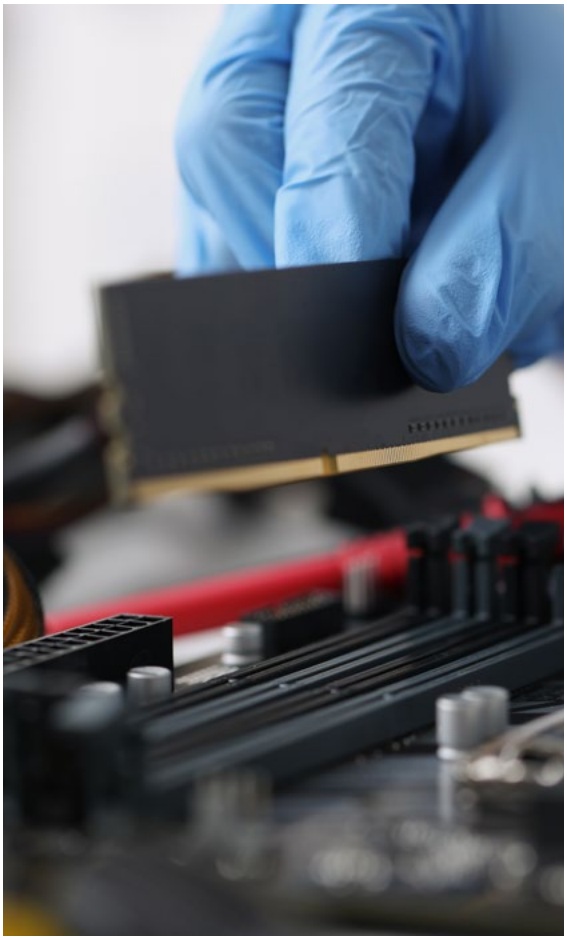
Drive Electric
MINNESOTA

Key Things to Know about Electric Vehicle Battery Production

Ensuring ethical and environmentally friendly production processes is a challenge for every industry that uses critical minerals, and electric vehicles (EVs) are no exception. This fact sheet addresses common questions and progress on EV battery production. Each point is followed with references from studies and articles for those who want to dive deeper.

BATTERY COSTS ARE DECLINING



Battery prices have significantly declined over the years due to factors like technological advancements, economies of scale, innovations in battery chemistry, manufacturing efficiencies, improved supply chains, and increased competition. The cost per kilowatt-hour (kWh) of battery capacity is set to continue to drop, making EVs even more affordable and accessible.

- According to the US Department of Energy's Vehicle Technologies Office, the cost of electric vehicle lithium-ion battery packs went from $1,355/kWh in 2008 to $153/kWh in 2022, a remarkable 89 percent decline.[1] Batteries are the most expensive component of electric vehicles,[2] so a reduction in battery costs means a reduction in EV purchase price. Between 2010 and 2019, the average purchase price of an EV went from $55,220 to $36,900, a 33 percent decrease.[3]
- A study released by RMI predicts that by 2030, battery prices will fall even further to $32–54/kWh, making many EVs cheaper to produce than comparable combustion engine vehicles.[4]

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[1] "FOTW #1272: Electric Vehicle Battery Pack Costs in 2022 Are Nearly 90 percent Lower than in 2008, according to DOE Estimates," US Department of Energy, Office of Energy Efficiency and Renewable Energy, January 9, 2023, https://www.energy.gov/eere/vehicles/articles/fotw-1272-january-9-2023-electric-vehicle-battery-pack-costs-2022-are-nearly.

[2] Sean Tucker, "The Most Expensive Part of Electric Cars Is Getting Cheaper," Kelley Blue Book, September 22, 2023, https://www.kbb.com/car-news/the-most-expensive-part-of-electric-cars-is-getting-cheaper/.

[3] "Average price and driving range of BEVs, 2010-2019," International Energy Agency, last updated May 27, 2020, https://www.iea.org/data-and-statistics/charts/average-price-and-driving-range-of-bevs-2010-2019.

[4] Daan Walter, Kingsmill Bond, Sam Butler-Sloss, Laurens Speelman, Yuki Numata, and Will Atkinson, "X-Change: Batteries," Rocky Mountain Institute, December 2023, https://rmi.org/insight/x-change-batteries/.

EMISSIONS ASSOCIATED WITH EV BATTERY PRODUCTION ARE DECLINING

Emissions from battery manufacturing have decreased, and we expect them to continue decreasing as the production process becomes more efficient and less reliant on fossil fuels.

- The study *Lithium-Ion Vehicle Battery Production* by the IVL Swedish Environmental Research Institute found that greenhouse gas (GHG) emissions from battery production decreased by up to 59 percent from 2017 to 2019 in large part due to running facilities at full capacity and incorporating more fossil-free electricity, which made battery facilities more efficient.[5]
- According to the article *Battery 2030: Resilient, sustainable, and circular* by McKinsey & Company, continued improvements in battery development processes and investments in renewable energy as a power source for battery manufacturing facilities could drop carbon dioxide emissions per vehicle 90 percent by 2030.[6]
- Minerals used in EV batteries are recyclable, and they're used to produce new batteries

Most materials used in EV battery manufacturing, such as copper, steel, nickel, cobalt, manganese, lithium, and aluminum, can be recycled, reducing the need for new raw materials.

- The study *Batteries vs. oil: a systematic comparison of materials requirements* found that a 60 kilowatt-hour (kWh) contains, on average, 10.8 percent copper,[7] and that's a good thing! Copper lasts a long time, conducts electricity well, and can be recycled forever without losing those advantages.[8]
- While lithium has been more challenging to recycle, the increase in EV adoption creates more demand and spurs more recycling research and development. For example, Canadian company Li-Cycle can recover up to 95 percent of lithium-ion battery materials.[9] Founded in 2016, the company can now process over 100,000 tons of lithium-ion battery material, or approximately 675,000 EV batteries, annually throughout its operations in North America. Some of its facilities can process full EV battery packs without having to discharge or dismantle them.[10]

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[5] Erik Emilsson and Lisbeth Dahllof, "Lithium-Ion Vehicle Battery Production," IVL Swedish Environmental Research Institute, November 2019, 22-27, https://www.ivl.se/download/18.34244ba71728fcb3f3faf9/1591706083170/C444.pdf.

[6] Jakob Fleischman et al, "Battery 2030: Resilient, sustainable, and circular," McKinsey & Company, January 16, 2023, https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/battery-2030-resilient-sustainable-and-circular.

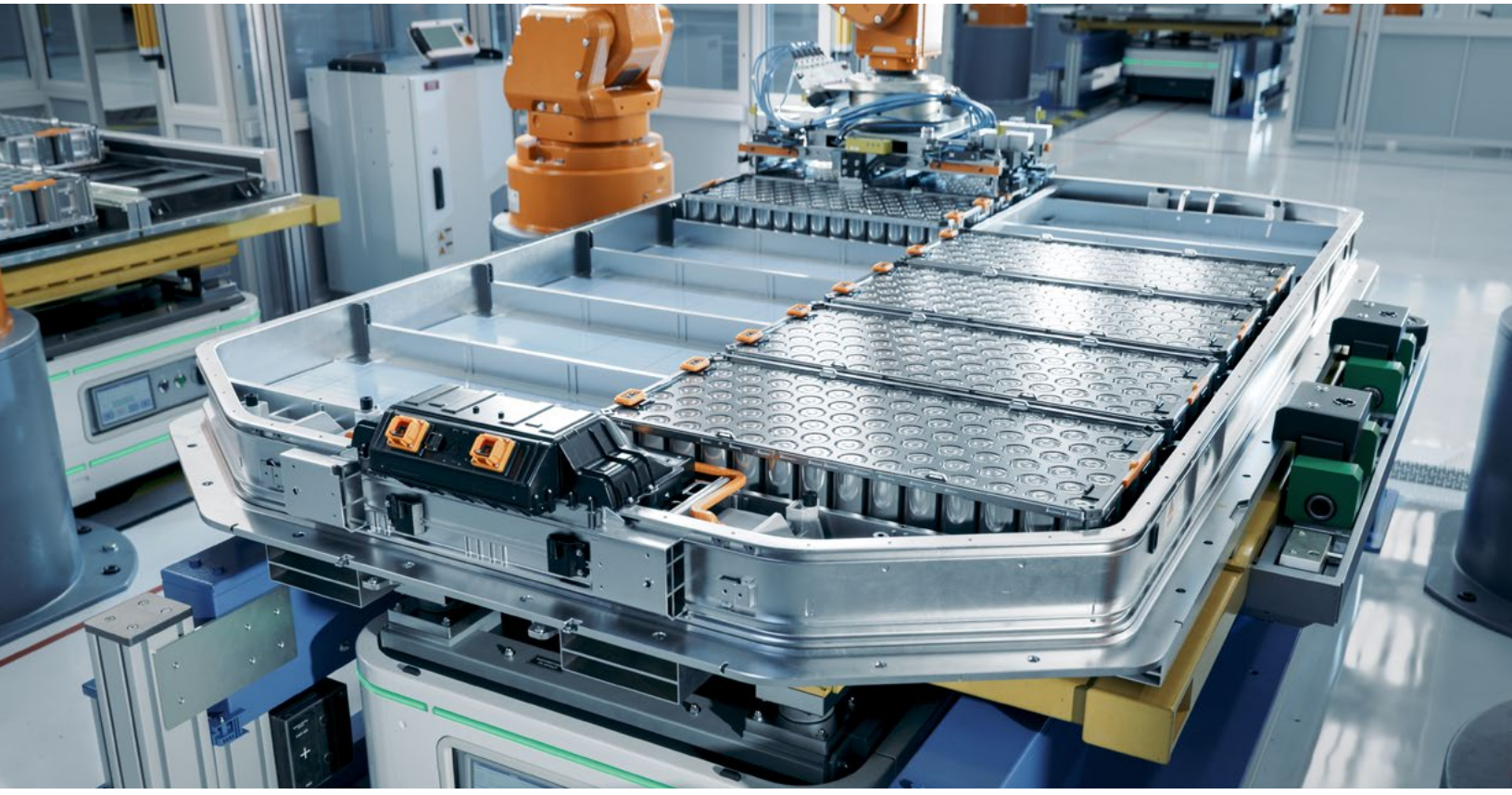
[7] Lucien Mathieu and Cecilia Mattea, "Batteries vs. Oil: A Systemic Comparison of Material Requirements", Transport & Environment, March 2021, https://te-cdn.ams3.cdn.digitaloceanspaces.com/files/2021_02_Battery_raw_materials_report_final.pdf.

[8] Copper Drives Electric Vehicles (Copper Development Association Inc., accessed November 4, 2020), https://www.copper.org/publications/pub_list/pdf/A6191-ElectricVehicles-Factsheet.pdf.

[9] "Technology: Innovative, safe, scalable, and sustainable process to recover critical materials from all types of lithium-ion batteries," Li-Cycle, accessed January 22, 2024, https://li-cycle.com/technology/.

[10] "Li-Cycle reports Second Quarter 2023 Operational and Financial results," Li-Cycle, August 14, 2023, https://investors.li-cycle.com/news/news-details/2023/Li-Cycle-Reports-Second-Quarter-2023-Operational-and-Financial-Results-Spoke--Hub-Network-on-Path-to-Become-A-Top-Global-Producer-of-Key-Battery-Grade-Materials/default.aspx.

- Advancements in sorting, separation, and design are making lithium-ion battery recycling cheaper.[11] This includes machine learning, new processes, and industry-wide standards.[12]
- In California, where EV adoption is highest in the US, the Lithium-ion Car Battery Recycling Advisory Group developed policy recommendations to create an EV battery recycling supply chain in the state. Recommendations include clearly defining the responsibilities of battery suppliers, vehicle manufacturers, and vehicle dismantlers through the life of the electric vehicle.[13]
- Recycled materials needed for EV battery manufacturing do not have to come solely from old EV batteries. Redwood Materials, a US-based recycling company, separates the materials needed for EV batteries from scrap technology it receives from consumers and companies (e.g., phones and small batteries from electronics). The company can recover 95 percent of key battery elements to produce new EV batteries. Beyond what is lost in the recycling process, the atoms do not degrade. That means the materials can be continuously recycled, reducing the need to mine new materials.[14]



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[11] "Revolutionizing Battery Recycling with Machine Learning," Innovation Origins, December 5, 2023, https://innovationorigins.com/en/revolutionizing-battery-recycling-with-machine-learning/.

[12] Gavin Harper et al., "Recycling lithium-ion batteries from electric vehicles," Nature 575, (November 6, 2019): 75-86, https://doi.org/10.1038/s41586-019-1682-5.

[13] Alissa Klendell, Margaret Slattery, and Jessica Dunn. Lithium-ion Car Battery Recycling Advisory Group Final Report (California Environmental Protection Agency, March 2022), https://calepa.ca.gov/wp-content/uploads/sites/6/2022/05/2022_AB-2832_Lithium-Ion-Car-Battery-Recycling-Advisory-Goup-Final-Report.pdf.

[14] "Solutions," Redwood Materials, accessed January 22, 2024, https://www.redwoodmaterials.com/solutions/.

THE EV INDUSTRY IS LOOKING FOR SOLUTIONS TO ADDRESS THE ETHICAL CONCERNS ASSOCIATED WITH THE EXTRACTION OF CRITICAL MINERALS USED TO MAKE BATTERIES

Due to human rights violations and unsafe mining practices linked to the extraction of minerals such as cobalt, copper, lithium, and nickel, many companies are changing their supply chains or completely discontinuing using some of these minerals in their EV batteries.

- Many human rights violations, including forced and child labor, are associated with cobalt mining in the largest producer of the material, the Democratic Republic of Congo.[15]
- More than half of all new EVs produced by Tesla, the highest-selling EV manufacturer in the US, use cobalt- and nickel-free batteries. The company plans to shift more vehicles to cobalt- and nickel-free batteries.[16]
- Top automobile manufacturers have formed the Drive Sustainability partnership to improve the social, ethical, and environmental performance of automotive supply chains. The group works with automotive suppliers and mines to identify and address ethical and human rights issues surrounding mining practices for raw materials used in EVs.[17] Since its inception, the partnership has educated stakeholders on human rights issues, developed a due diligence and grievance tool for supply chains, and supported ground-level projects that empower local industry associations to establish ethical and sustainable mining and supply networks.[18]
- New sodium-ion batteries, which have lower production costs, a more environmentally friendly footprint, and better performance in extreme temperatures, are starting to be used. Companies like Yiwei, a recently established EV brand in China with backing from Volkswagen, unveiled its inaugural EV powered by a sodium-ion battery in December 2023. Although sodium-ion technology is still in its early stages, it holds promise for introducing affordable EVs as the technology continues to develop.[19]

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[15] "ILAB Lithium-ion Batteries Storyboard," U.S. Department of Labor, Accessed July 30, 2024, https://www.dol.gov/agencies/ilab/reports/child-labor/list-of-goods/supply-chains/lithium-ion-batteries

[16] Tesla Investor Relations, Q1 2022 Report (Tesla, April 2022), https://digitalassets.tesla.com/tesla-contents/image/upload/IR/TSLA-Q1-2022-Update.

[17] "Workforce Wellbeing," Drive Sustainability, accessed January 22, 2024, https://www.drivesustainability.org/workforce-wellbeing-2/.

[18] Drive Sustainability Progress Report 2023,(Drive Sustainability, October 2023), 5-8, https://www.drivesustainability.org/ds-progress-report-2023/.

[19] Peter Johnson, "Volkswagen-backed EV maker rolls out first sodium-ion battery powered electric car," Electrek, December 27, 2023, https://electrek.co/2023/12/27/volkswagen-backed-ev-maker-first-sodium-ion-battery-electric-car/.