

Lithium Supplies – additional datapoints and research

Additional Points on Lithium Constraints and Opportunities in 2025

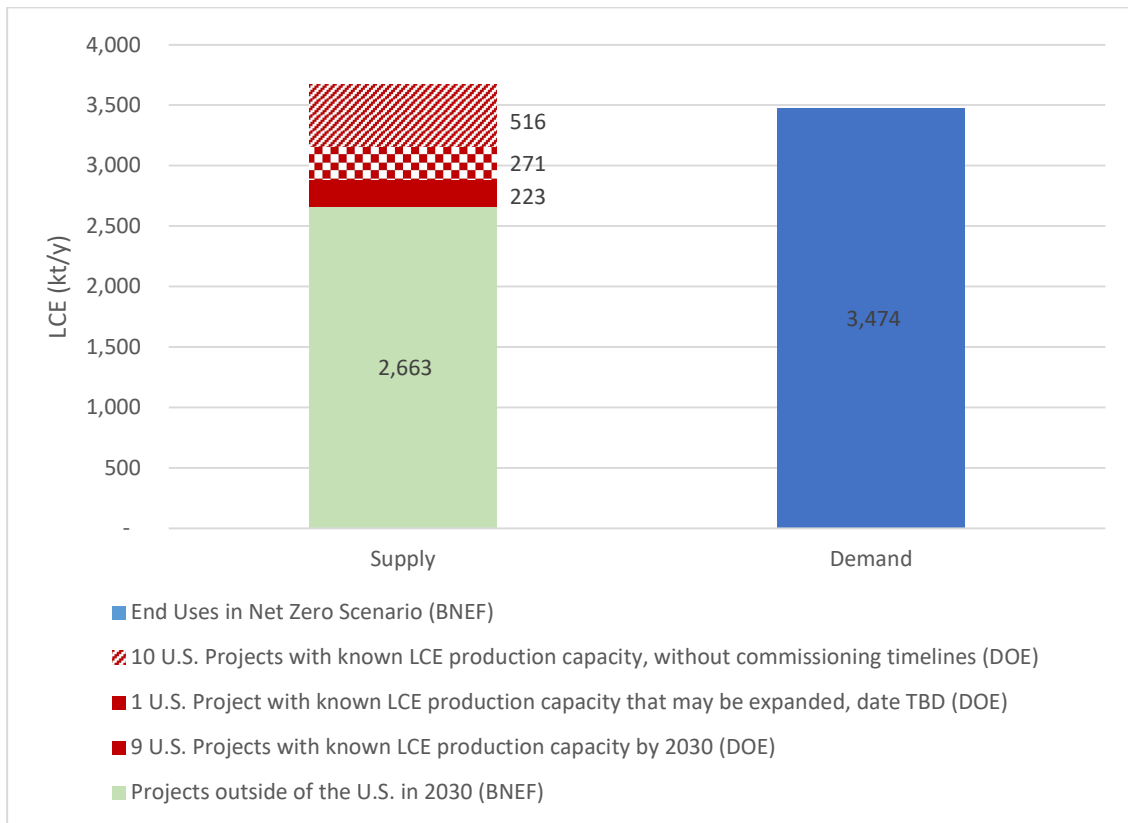
The IEA Global EV Outlook 2022 projecting a lithium supply shortage after 2025 was published in May 2022. However, more recent information indicates that the market is responding to demand ([Lithium-ion Battery Pack Prices Rise for First Time to an Average of \\$151/kWh | BloombergNEF \(bnef.com\)](#)); lithium supplies are expanding as new resources are characterized, projects continue through engineering economic assessments, and others begin permitting or construction. The information provided below demonstrates how momentum has picked up in the lithium market since IEA’s May 2022 report. For example:

- In October 2022, the IEA projected that Lithium Carbonate Equivalent (LCE) production from operating mines and those under construction may sufficiently meet primary demand until 2028 under the Stated Policies Scenario. [Committed mine production and primary demand for lithium, 2020-2030 – Charts – Data & Statistics - IEA](#)
- In December 2022, BNEF projected lithium mine production can meet end-use demand until 2028. Notably, the BNEF data is not exhaustive and includes only three U.S. projects: Silver Peak (phase I and II), Rhyolite Ridge (phase I), and Carolina Lithium (phase I). <https://www.bnef.com/interactive-datasets/2d5d59acd9000031?tab=DashboardDemand&view=8472b6c7-e8cc-467f-b4a4-fe85468fba3a> and [Metal Mine Supply Forecast | BloombergNEF \(bnef.com\)](#)
- In March 2023, DOE and Argonne National Laboratory (Argonne) identified 21 additional lithium production projects in the United States in addition to the three identified in the December 2022 BNEF data. Note that these do not include recycling projects which could increase domestic lithium supply. [2023.03.06 U.S. Lithium Production in 2030 DOE OP & ANL.xlsx](#) These additional projects range from early-stage projects (e.g., still undergoing geological exploration) to producing projects. The 24 U.S. projects – those in the BNEF report and those identified by DOE/ANL – can be broadly categorized:
 1. 9 projects accounting for 223 kt/y LCE with estimated production volumes in 2030 ramped from current existing capacities.
 - 1 of the 10 projects may be expanded by 271 kt/y LCE by an unknown date beyond current capacity.
 2. 10 projects accounting for 516 kt/y LCE without defined commissioning timelines.
 3. 5 of the 24 projects have no specific annual production volumes identified.

Were the 24 U.S. projects to achieve commercial operations, they would produce an additional 1,000 kt/y LCE not accounted for in the December BNEF analysis. The sum of the U.S. projects (per DOE/Argonne and BNEF) and non-U.S. projects (per BNEF) exceed the BNEF Net Zero demand scenario (see chart below). Developing the U.S. projects may eliminate the supply deficit until at least 2030, the last year of the projection. Several of the project owners state that the Inflation Reduction Act’s critical minerals provisions, including the Clean Vehicle Credit and the Critical Mineral Advanced Manufacturing Production Tax Credit incentivized their project development. Although some of these U.S. projects under development may not achieve commercial operations, we could also see new projects in the U.S. and elsewhere start development in coming years.

Chart: Global Lithium Supply and Demand

Excluding 5 mining projects in the U.S. without known LCE capacity.



- Li Bridge, a public-private alliance committed to accelerating the development of a robust and secure domestic supply chain for lithium-based batteries, has set forth a goal that by 2030 the United States can capture 60% of the economic value associated with the U.S. domestic demand for lithium batteries. Achieving this target would double the economic value expected in the U.S. under business as usual growth. [Li-Bridge Industry Report 2.pdf \(anl.gov\)](#)
- In February 2023, PNNL documented the growth in the North American lithium battery industry. <https://www.pnnl.gov/projects/north-american-lithium-battery-materials-industry-report>

Additional government efforts aim to accelerate lithium and critical minerals production.

- The Inflation Reduction Act’s requirement that critical minerals for clean vehicles be sourced from the U.S. or countries with which the U.S. has a free trade agreement to qualify for a \$3,750 tax credit has spurred other countries to consider action that would expand lithium supply. The European Union (E.U.) is seeking to improve the policy environment in their member countries and among trade partners to benefit E.U. battery supply chains. Per a March 2023 meeting of the European Battery Alliance, supportive actions may include easing permitting, reducing regulatory burdens, accelerating large private investment, and others. These measures could encourage the development of new supplies of critical minerals not currently anticipated in market projections. [Main takeaways 7th High-Level Meeting of EBA.pdf \(europa.eu\)](#) and [U.S. Eyes Trade Deals With Allies to Ease Clash Over Electric Car Subsidies - The New York Times \(nytimes.com\)](#) To secure critical raw materials,

including lithium for batteries that are essential for Europe’s green transition, the European Parliament proposed a Critical Raw Materials Act on March 16, 2023. [European Critical Raw Materials Act \(europa.eu\)](#)

- In February 2023, President Biden signed a presidential waiver of some statutory requirements (Waiver) authorizing the use of the Defense Production Act (DPA) to allow the Department of Defense (DoD) to more aggressively build the resiliency of America's defense industrial base and secure its supply chains including for critical minerals and energy storage. Since many of the investments needed in areas like mining and processing of critical minerals can be very costly and take several years, the Waiver permits the DoD to leverage DPA Title III incentives against critical vulnerabilities, and removes the statutory spending limitation for aggregate action against a single shortfall exceeding \$50 million. This in turn allows the DoD to make more substantial, longer-term investments. [President Biden Signs Presidential Waiver of Statutory Requirements for Supply Chain Resilience > U.S. Department of Defense > Release](#)
- In December 2022, the Blue Ribbon Commission on Lithium Extraction in California issued a report detailing actions to support the further develop geothermal power with the potential co-benefit lithium recovery from existing and new geothermal facilities in the Salton Sea geothermal resource area. The three owners developing projects in California may produce 600 kt/y LCE from geothermal brines around 2030, as tabulated above. <https://efiling.energy.ca.gov/GetDocument.aspx?tn=247861>
- In June 2022, the United States formed the Minerals Security Partnership, whose goal is to ensure that critical minerals are produced, processed, and recycled in a manner that supports the ability of countries to realize the full economic development benefit of their geological endowments. The MSP will help catalyze investment from governments and the private sector for strategic opportunities — across the full value chain —that adhere to the highest environmental, social, and governance standards. [Minerals Security Partnership - United States Department of State](#), [The diplomat securing responsibly sourced critical minerals - POLITICO](#) , [Italy Joins US-Led Mineral Security Partnership for Ethical Mining \(voanews.com\)](#)

Additional points on DOE’s investments to expand the lithium supply chain

EPA notes DOE’s announcement about Manufacturing and Energy Supply Chain projects that increase domestic battery processing capability funded by the Bipartisan Infrastructure Law (BIL) ([DOE BIL Battery FOA-2678 Selectee Fact Sheets \(energy.gov\)](#)) but does not mention the most recent projects from the Loan Programs Office funded by the Inflation Reduction Act (IRA) ([CRITICAL MATERIALS | Department of Energy](#)) . Several of these DOE projects will aid in the extraction, processing and recycling of lithium and other critical minerals that will support continued market growth:

- A \$50M BIL grant to Lilac plans to build out domestic manufacturing capacity for the company’s patented ion-exchange technology to increase production of lithium from brine resources with minimal environmental impact and streamlined project development timelines, and develop domestic lithium projects. [Lilac Solutions Selected by U.S. Department of Energy for \\$50 Million Award to Unlock U.S. Lithium Production – Lilac Solutions](#)
- A \$141.7M BIL grant to Piedmont Lithium plans to accelerate the construction of the Tennessee Lithium project in McMinn County as a world-class lithium hydroxide operation, which is expected to more than double the domestic production of battery-grade lithium hydroxide. The project is being designed to produce lithium hydroxide from spodumene concentrate using the innovative Metso:Outotec process flow sheet, enabling lower emissions and carbon intensity as well as improved capital and operating costs relative to incumbent operations. [Piedmont Lithium Selected for \\$141.7 Million Grant by United States Department of Energy for Tennessee Lithium Project | Business Wire](#)

- A \$150M BIL grant to Albemarle plans to support a portion of the cost to construct a new, commercial-scale U.S.-based lithium concentrator facility at Albemarle's Kings Mountain North Carolina location. Albemarle's "mega-flex" conversion facility would be capable of accommodating multiple feedstocks, including spodumene from the proposed reopening of the company's hard rock mine in Kings Mountain; its existing lithium brine resources in Silver Peak, Nevada, and other global resources; as well as potential recycled lithium materials from existing batteries. The facility is expected to eventually produce up to 100,000 metric tons of battery-grade lithium per year to support domestic manufacturing of up to 1.6 million EVs per year. [Albemarle Secures DOE Grant for U.S.-Based Lithium Facility to Support Domestic EV Supply Chain \(prnewswire.com\)](#)
- A \$700 million DOE loan to Ioneer Rhyolite Ridge LLC plans to help develop domestic processing capabilities of lithium carbonate for nearly 400,000 EV batteries from the Rhyolite Ridge Lithium-Boron Project in Esmeralda County, Nevada. [LPO Announces Conditional Commitment to Ioneer Rhyolite Ridge to Advance Domestic Production of Lithium and Boron, Boost U.S. Battery Supply Chain | Department of Energy](#)
- A \$2 billion DOE loan to Redwood Materials plans to construct and expand its battery materials recycling campus in McCarran, Nevada. It would be the first U.S. facility to support production of anode copper foil and cathode active materials in a fully closed-loop lithium-ion battery manufacturing process by recycling end-of-life battery and production scrap and remanufacturing that feedstock into critical materials, supporting EV production of more than 1 million per year. Redwood Materials will use both new and recycled feedstocks—comprised of critical materials like lithium, nickel, and cobalt—to produce approximately 36,000 metric tons per year of ultra-thin battery-grade copper foil for use as the anode current collector, and approximately 100,000 metric tons per year of cathode active materials. [LPO Offers Conditional Commitment to Redwood Materials to Produce Critical Electric Vehicle Battery Components From Recycled Materials | Department of Energy](#)
- A \$375 million DOE loan to Li-Cycle plans to help finance a high efficiency, low-emission resource recovery facility for batteries in Rochester, New York. The Li-Cycle project will use hydrometallurgical recycling to efficiently recover battery-grade lithium carbonate, cobalt sulfate, nickel sulfate, and other critical materials from manufacturing scrap materials and used batteries to enable a circular economy. [LPO Announces a Conditional Commitment for Loan to Li-Cycle's U.S. Battery Resource Recovery Facility to Recover Critical Electric Vehicle Battery Materials | Department of Energy](#)

Additional points on near-term commercial alternatives to Lithium

High demand and prices for lithium from transportation and other energy storage applications may motivate substitution toward sodium and aluminum-based batteries and hasten the commercialization of solid state batteries.

- BNEF estimates that sodium-ion batteries are scaling for use in applications that do not require the high-performance capabilities of large EV batteries, including stationary energy storage and 2- and 3-wheeled vehicles. Substitution from lithium to alternative chemistries could alleviate price pressures as soon as 2026. [Top 10 Energy Storage Trends in 2023 | BloombergNEF \(bnef.com\)](#) and [Technology Radar: Sodium-Ion Batteries | BloombergNEF \(bnef.com\)](#)
- A new PNNL molten salt battery design, which uses Earth-abundant and low-cost materials, has demonstrated superior charge/discharge capabilities at lower operating temperatures while maintaining high energy storage capacity compared to conventional sodium batteries. [New Sodium, Aluminum Battery Aims to Integrate Renewables for Grid Resiliency | PNNL](#)

- NASA’s Solid-state Architecture Batteries for Enhanced Rechargeability and Safety (SABERS) research for aerospace applications will likely have spin-off benefits for the automotive sector. As lithium-ion based liquid electrolytes are not suitable for aircraft, the development of a scalable, solid state battery that is safer, more energy dense, and capable of faster charging has high commercialization potential in on-road vehicles applications, and can reduce lithium demand. [NASA Seeks to Create a Better Battery with SABERS | NASA](#) and [NASA battery for electric aircraft ready to take-off | Electronics360 \(globalspec.com\)](#)

Additional points on R&D to increase circularity and effective use of lithium and critical minerals

Beyond commercial technologies, continued research and development with industry and academia through the US Automotive Battery Consortium (USABC), Critical Minerals Institute (CMI), and ARPA-E will expand the recycling and recovery of lithium to help expand the use of unconventional supplies to help pace the growing demand for EVs.

- A \$2M USABC grant to American Battery Technology Company (ABTC) in Fernley, Nevada will help develop a recycling development program to demonstrate a scaled, fully-domestic, integrated processing cycle for the universal recycling of large format Li-ion batteries in coordination with partners in the battery supply chain. [USABC Project – American Battery Technology Company](#)
- The CMI’s EC-LEACH project successfully demonstrated a 10x scale-up of electrochemical leaching for lithium-ion batteries black mass, e-waste comprised of crushed and shredded battery cells, with a capacity up to 500 g/day, achieving over 96% leaching efficiency for all metals. The scale up demonstrated leaching under higher voltage while maintaining lower currents and used conventional power electronics. [CMI Project 3.1.11: Lithium, cobalt & platinum group metals recovery from lithium-ion batteries & e-waste | Ames Laboratory](#) and [Scale-up of electrochemical leaching cell | Ames Laboratory](#)
- \$39 million in ARPA-E funding for the Mining Innovations for Negative Emissions Resource Recovery (MINER) program will help develop market-ready technologies that will increase domestic supplies of critical elements, including copper, nickel, lithium, cobalt, rare earth elements, that are required for the clean energy transition. The MINER program will fund research that increases the mineral yield while decreasing the required energy, and subsequent emissions, to mine and extract energy-relevant minerals. [MINER Final Project Descriptions.pdf \(energy.gov\)](#)