EXECUTIVE INSIGHTS

Powering Up the US Battery Supply Chain

The energy transition from fossil fuels to lower-carbon energy sources is well underway in both the power and transport sectors. Rapid declines in the cost of solar and wind energy, as well as the development of battery electric vehicles (BEVs), are facilitating the process. Batteries, which are used to both power BEVs and store intermittent renewable energy in residential, commercial and utility-scale applications, are essential to achieving energy transition and climate goals. Until relatively recently, most battery manufacturing has taken place overseas. But a number of factors have transpired that make a domestic battery production industry increasingly attractive and even critical.

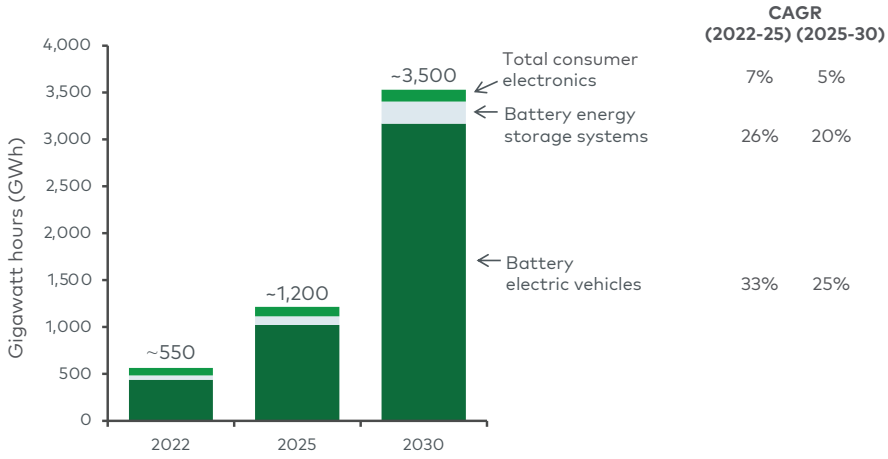
Accelerating demand

Global demand for lithium-ion batteries is growing at a rapid clip. It is forecast to increase by 29% annually through 2025 and to continue growing at 24% per year from 2025 to 2030 (see Figure 1). BEVs account for the majority (70%) of demand for lithium-ion batteries and are the biggest driver of demand growth. In 2022, 6% of U.S. new vehicle sales were BEVs. They are projected to reach around 30% by 2030, as government policies limit sales of internal combustion engine (ICE) vehicles, subsidies encourage consumers to purchase electrified vehicles, BEVs grow closer in price parity to ICE vehicles, ranges improve, charging infrastructure is built out, and OEMs eliminate ICE vehicles from their lineups.

Battery energy storage systems (BESS) account for 8% of global lithium-ion battery demand. BESS are critical to store and dispatch intermittent renewable resources, particularly solar, but use cases are evolving that are creating even more demand. BESS demand is primarily

tied to utility-scale solar projects. Strong government subsidies, coupled with decreasing production and installation costs, are incentivizing more solar installations and improving BESS' value proposition.

Figure 1
Global lithium-ion battery demand (2022-30)



Note: CAGR=compound annual growth rate
Source: L.E.K. research and analysis

In residential markets (i.e., home rooftop installations), BESS help homeowners lower their electricity costs by storing power during the day, when electricity demand is low and prices are cheaper, and discharging the battery in the evening when demand peaks. Pooled together, batteries across homeowner communities are starting to serve as meaningful sources of power that utilities can tap on demand; this is commonly referred to as a virtual power plant. A final use case is microgrids, self-sufficient — though often still grid-connected, energy systems that serve specific geographic areas or facilities. For commercial and critical infrastructure applications, they can be paired with solar power and a fuel cell or generator to provide a resilient, clean backup power solution. All told, solar installations and attachment rates of battery storage to utility-scale projects, home installations and commercial applications are expected to dramatically increase, ratcheting up demand for BESS.

Consumer electronics account for 22% of global lithium-ion battery demand. Lithium-ion batteries power many consumer electronic devices, most notably smartphones. Consumer electronics will continue to be a source of increasing demand but are expected to grow at a much slower rate than demand for BEVs and BESS.

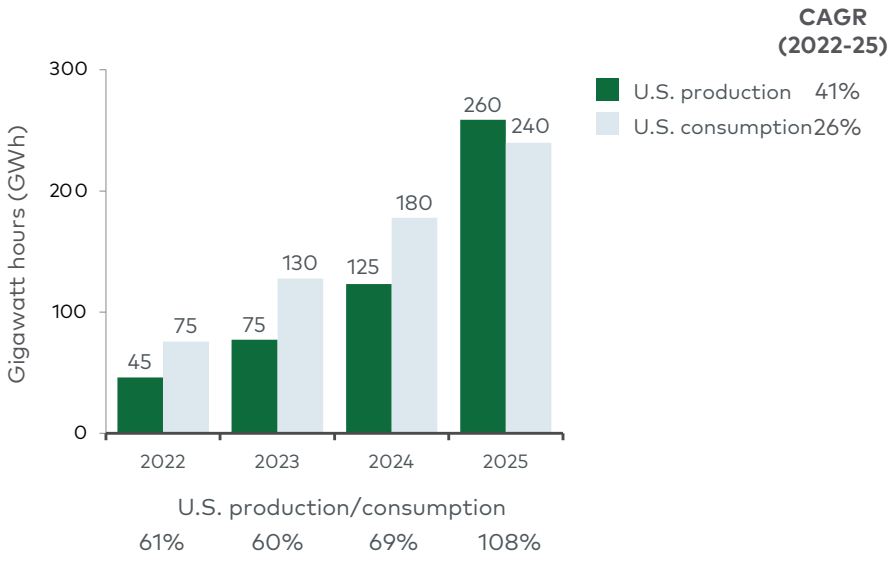
Made in the USA

The U.S. is on track to become a major producer of battery cells by 2025. The country is expected to produce 260 GWh of lithium-ion battery cells by 2025, enough to account for 108% of U.S. lithium-ion battery demand (see Figure 2).

The federal government has passed multiple laws subsidizing the development of the battery cell manufacturing industry. The Inflation Reduction Act includes $32 billion in advanced manufacturing tax credits, $40 billion in Department of Energy loans, and $3 billion in direct subsidies to build and expand commercial-scale production of batteries, components and minerals. It also includes a $7,500 tax credit for EVs with 40% of their battery materials and 50% of their battery components sourced from U.S. manufacturers or Free Trade Agreement partners.

This heavy investment in battery manufacturing capabilities is expected to meet 100% of the U.S.' forecast battery cell demand by 2025. The investments are a clear first step to building a robust domestic battery supply chain, but given the rapid growth of battery demand and ongoing electrification, further investment is still required to keep pace.

Figure 2
U.S. lithium-ion battery production vs. consumption (2022-25)



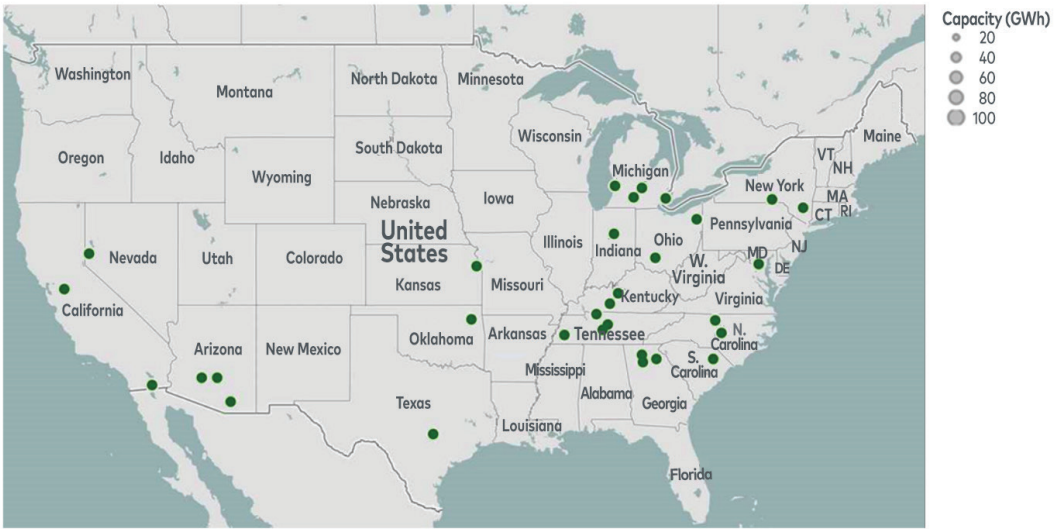
Note: CAGR=compound annual growth rate
Source: L.E.K. research and analysis

Driven by the automotive industry

U.S. automotive manufacturers, in partnership with East Asian battery manufacturers, have been the driving force behind the domestic battery production industry. About 95% of planned battery manufacturing in the U.S. is associated with automotive manufacturers.

Traditionally, automotive OEMs have owned the design and manufacturing of engines, and outsourced production of other major systems. The shift to BEVs threatened to disrupt this model. Without battery manufacturing capabilities, automotive OEMs had to cede control to battery cell manufacturers. In order to reestablish their traditional model, automotive OEMs are prioritizing upstream vertical integration into battery manufacturing. To build battery manufacturing capabilities, automotive OEMs like Ford, GM, Stellantis, BMW and Tesla have formed joint ventures with major South Korean and Japanese battery manufacturers, including SK On, LG Energy Solution, Panasonic and Samsung. A number of facilities are now operating in the U.S., with many others either planned or underway (see Figure 3 and sidebar "Major factory announcements").

Figure 3
Locations of announced battery cell manufacturing facilities in the US and Canada



Source: National Renewable Energy Library

Major factory announcements

U.S. automotive OEMs are pursuing vertical integration in an effort to capture the benefits of battery manufacturing. These are just a few of the facilities announced or currently underway:

- Ford is partnering with SK On to build three battery plants in Tennessee and Georgia by 2025, with a combined capacity of 129 GWh.[1] These plants will produce nickel-manganese-cobalt (NMC) batteries for Ford's popular F-150 Lightning. Ford has also announced its intention to create its own battery manufacturing in Marshall, Michigan, licensing CATL's lithium-ferro-phosphate (LFP) chemistry.
- General Motors' joint venture with LG Energy Solution, Ultium Cells, is building three battery manufacturing facilities in Michigan, Ohio and Tennessee. These facilities are expected to have a capacity of more than 130 GWh.[2] The Warren, Ohio, facility, which is currently operating, produces NMCA batteries, a proprietary variant of an NMC battery with added aluminum for improved cyclability.
- Tesla partnered with Panasonic to produce nickel-cobalt-aluminum (NCA) batteries at its gigafactories in Nevada, California and Texas. While Tesla primarily uses Panasonic NCA batteries for its vehicles, the company manufactures and uses LFP batteries at its gigafactory in Shanghai, with plans to use this format in all standard-range vehicles globally. Tesla has indicated that it is pursuing cathode chemistry flexibility across its vehicle lineup to best respond to market conditions and technological improvements.

Challenges and risks

As battery manufacturers set up domestic facilities, they face some important strategic decisions and potential risks.

Finding the right chemistry: LFP vs. NMC

Battery factories are billion-dollar bets on the performance of a specific chemistry. Once a factory is built, switching between chemistries can be extremely difficult. Therefore, selecting the ideal battery chemistry is a pivotal strategic decision for battery manufacturers. Today that choice comes down to two main options: NMC and LFP. A third option, NCA, is being phased out due to its high price to performance when compared to NMC.

NMC batteries have higher energy density than LFP batteries, allowing for longer ranges, but the latter are around 15% cheaper[3] since they don't use either nickel or cobalt. LFP batteries are popular in the more price-sensitive Chinese market. Some U.S. OEMs — in particular Ford and Tesla — are planning to introduce LFP chemistry into the U.S. market, as they may value lower cost over the range that NMC batteries can bring. However, the emergence of battery recycling could meaningfully reduce nickel and cobalt prices, making NMC technology prices competitive with LFP.

In the long run, emerging battery technologies, such as solid state, sodium ion and lithium sulfur, could become viable alternatives to existing chemistries since these chemistries, at least in theory, have superior energy density or significantly lower cost. However, as the market scales up, there will be significant incumbent advantages for the leading chemistry since production techniques will likely have optimized its production, making it difficult for other smaller-scale technologies to catch up.

Sourcing raw materials

Limited battery mineral supplies present an ongoing risk to battery production and the cost structure of battery cells. Leading battery chemistries require lithium, cobalt, nickel, manganese and graphite to form the cathodes, anodes and electrolytes.

Batteries currently account for around 80% of lithium demand. The supply of lithium is somewhat inelastic, as new mines can take four to five years to develop. However, lithium production is forecast to grow 25% annually to 205k MT from 2022 to 2024, while battery demand is forecast to grow by around 28% to 175k MT by 2024, which should allow a sufficient buffer for lithium supply to keep up.

Batteries currently account for 40% of cobalt demand. Some 70% of cobalt is sourced from Congo, which presents end users with significant ethical and geopolitical risks due to the use of artisanal mining. On the positive side, new sources, such as Indonesia, are projected to diversify supply.

In the long run, battery mineral shortages are not expected to threaten the growth of lithium-ion batteries, but there is a significant risk of price volatility in the medium term, which has the potential to impact the economics of both BEVs and BESS. If battery demand over- or undershoots its forecast, there could be meaningful surpluses or shortages of battery minerals. Nickel, cobalt and, especially, lithium, have experienced significant price volatility in recent years due to the rapid growth of lithium-ion batteries.

Strategic priorities for market players

The development of a domestic battery manufacturing industry and the surrounding upstream and downstream markets are creating challenges for manufacturers and investors across the value chain. They will need to focus on specific strategic activities in order to secure their place in this emerging ecosystem:

- **Battery manufacturers:** Maintaining chemistry flexibility should be a key priority. Over-indexing in a single chemistry could place a manufacturer at risk for disruption as new chemistries develop and existing chemistries mature. Major automotive OEMs are investing in both NMC and LFP chemistry cathodes. For pure-play battery cell manufacturers, acquiring or partnering with small-scale specialists with expertise in emerging chemistries can reduce the risk of disruption.
- **OEMs:** Automotive OEMs have traditionally outsourced all noncore elements of their supply chain to optimize costs. But that needs to change. Vertical integration, with its reduced coordination costs, is key to achieving success and promoting innovation in a rapidly evolving space. There is a business case for further vertical integration both upstream by investing in battery production and downstream by investing in the EV ecosystem, such as through charging stations or battery recycling. For example, charging stations developed by independent companies have focused on serving the needs of existing EVs. Automotive OEMs could take a long view and focus on building the infrastructure designed to meet the higher power demands and charging capabilities of future EV models.
- **BESS integrators:** Securing battery supply is the top priority for these players. Given BESS' smaller share of the market, battery manufacturers have prioritized and will continue to prioritize BEVs when there is tightness in the supply chain. BESS integrators need to actively secure supply. Committing to the purchase of novel battery chemistries (such as sodium ion, which offers price savings in exchange for lower energy density) from leading battery manufacturers such as CATL could create a competitive advantage through reliable and cheap battery supply in a price-competitive market.
- **Investors and industrials:** Finding low-risk niches is the ideal way for outside investors to benefit from the development of the domestic battery manufacturing industry. The battery value chain contains operationally risky businesses, such as mining, and capital-intensive businesses, such as manufacturing. Industrial companies and financial investors can more safely participate through indirect opportunities, including services, digital tools and new technologies that enable the productive deployment of batteries to end users.

U.S. battery manufacturing is a rare opportunity for market participants to benefit from sustained industrial growth, but they face some significant strategic challenges in minimizing downside risks and ensuring future business viability. Careful selection of battery chemistry, securing reliable raw material supply, and ongoing investment will all be critical to success.

For more information, please contact energy@lek.com.

Endnotes

[1]Skinnonews.com, "SK Innovation and Ford invest $11.4 billion to seize the top position in U.S. battery market via BlueOvalSK." https://skinnonews.com/global/archives/7245/

[2]Detroitnews.com, "GM, LG investing $275 million to increase Tennessee battery plant capacity." https://www.detroitnews.com/story/business/autos/general-motors/2022/12/02/gm-lg-ultium-spring-hill-tennessee/69695246007/

[3]Goldman Sachs Global Investment Research, Wood Mackenzie, SNE Research

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