Executive Insights

Charged-Up Demand Brings Challenges to the Battery Value Chain

It's easy to get excited about investing in the battery space. Demand is expected to soar over the next decade, powered by the growing penetration of electric vehicles (EVs), the widespread application of battery storage, and substantial financial incentives from governments both in the U.S. and abroad, all driven by the rapid intensification of the climate change debate. Meanwhile, improvements in technology and production capabilities are making the manufacturing of batteries more economically feasible and, therefore, more competitive compared to incumbent solutions.

But the battery value chain is quite complex. The dynamics that take place at each step — from the mining and processing of raw materials to the manufacturing of the various components and their subsequent assembly, all the way through to the utilization patterns of end users and recyclers — are unique. The competitive landscape also varies at each of those steps, even as it continues to consolidate. And there are numerous pain points along the way, such as raw material and mineral shortages in addition to issues accessing those resources, the impact of traditional mining on both the environment and nearby populations, cost issues around the procurement and recycling of core materials, and expectations that manufacturing will lag the growth in demand.

Taken together, these dynamics are yielding five key issues that both current and would-be investors in the battery value chain need to take into consideration:

1. The expansion of manufacturing capabilities and capacity in the U.S. and Europe
2. Further consolidation and vertical integration, mainly moving upstream
3. An expectation of improved reuse, repurpose, and recycling capabilities and capacity mandates
4. The drive for commercial scale production that enables opportunities to create alternative, more innovative battery technologies
5. A need for supporting aftermarket services and diagnostic technologies

A surge in demand

Several use cases are driving the need for battery technology, led by the shift to sustainability. The continued penetration of battery electric vehicles (BEVs), which is expected to rise from just 2%

Charged-Up Demand Brings Challenges to the Battery Value Chain was written by **Franco Ciulla**, **Nilesh Dayal**, **Amar Gujral** and **Mazen Skaf**, Managing Directors in L.E.K. Consulting's Energy practice. Franco, Nilesh, Amar and Mazen are based in Houston.

For more information, contact industrials@lek.com.

L.E.K.

of new car sales in the U.S. to around 50% by 2040 or before, and which relies largely on lithium-ion batteries, is one key factor. The other big one is the need for renewable energy, in particular energy generated by wind and solar, whose intermittence necessitates utility-scale energy storage solutions powered by batteries.[1] Renewable energy generation is expected to increase roughly 5% a year through 2030 alone. And demand for batteries is expected to grow more than 30% a year by 2030, increasing by some 23% a year for EV batteries and approximately 50% a year for utility-scale energy storage solutions (see Figure 1).

In the U.S., there is financial support for both sectors at the federal and state levels. Not only has the Biden administration's infrastructure plan allocated some $15 billion to expanding EV infrastructure (including e-buses) and $65 billion to power and renewable technologies (including energy storage), but also there are tax incentives and subsidies in place for individuals and corporations that are designed to spur increased adoption.[2] And the U.S. is not alone. Several Asian nations, in particular China and Japan, have been instituting policies, incentives or funding that will drive demand for batteries. The Chinese government, for example, recently introduced a mandate requiring 40% of car sales to be EV by 2030, as have 20 out of the 27 EU member countries. The European Commission also authorized $3.5 billion to subsidize lithium battery production in the region, and the EU is funding Horizon Europe, a $100 billion R&D project that will support energy storage research, including batteries, through 2027.

In the meantime, technology and production capabilities continue to improve, pushing costs related to utility-scale and EV batteries lower, while improved battery accessibility and reliability have, in turn, helped fuel growth.

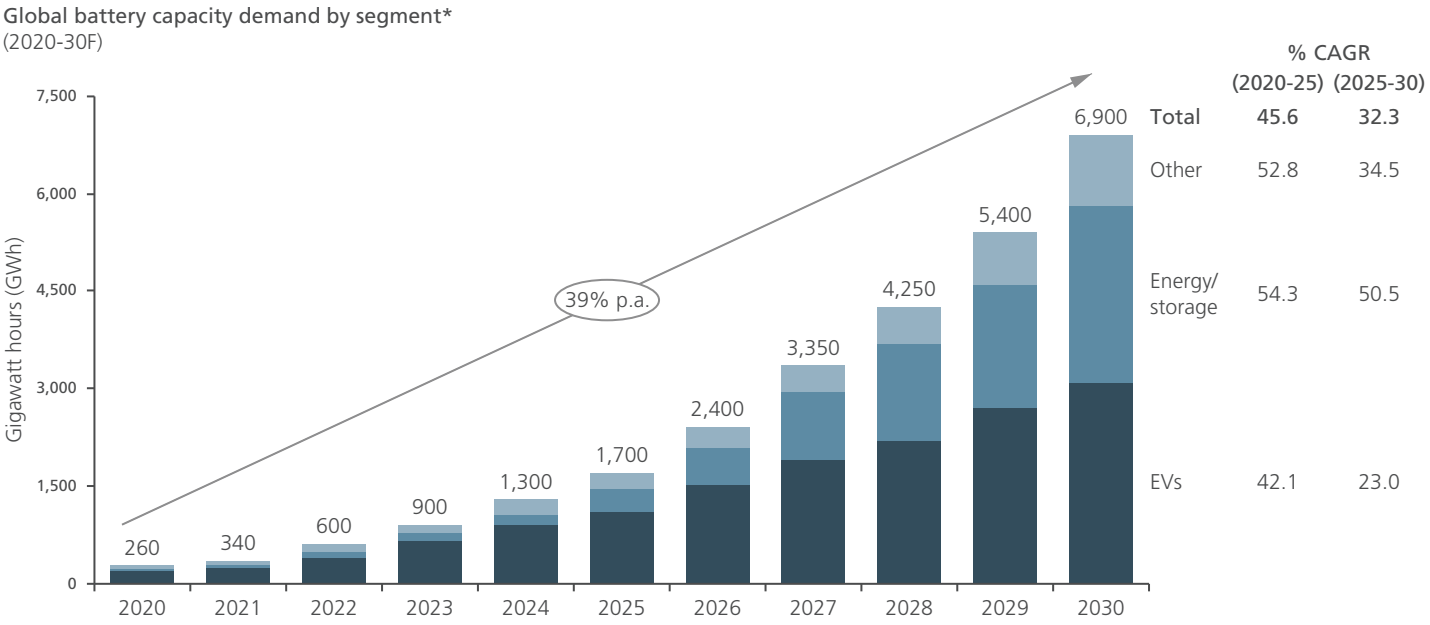
A value chain rife with complexity

The battery value chain that serves the power infrastructure, industrial customers and the EV market is composed of three segments: upstream, which consists of raw materials and their processing; midstream, where the various components are manufactured and assembled; and downstream, which includes assembly of those components and their end users (see Figure 2).

Upstream

While the demand for energy storage solutions and related technology is expected to grow for the foreseeable future, it has naturally led to a surge in demand for certain minerals such as lithium, cobalt and nickel. Such demand creates dependence on mineral-rich countries, some of which have business and labor practices that may not be up to par with commonly accepted standards. The Democratic Republic of the Congo, for example, is responsible for more than 70% of the global cobalt supply;

Figure 1
Global industrial battery demand forecast



*Excludes personal use batteries
Source: Rystad battery materials white paper; L.E.K. research and analysis

manganese production is heavily concentrated in Africa and South America, while Southeast Asia accounts for the majority of nickel; and there are only eight countries where lithium is mined, with 85% of the global supply coming from Australia, Chile and China. With that in mind, several public- and private-sector initiatives are underway to boost domestic production of these raw materials.

Currently, the majority of processing for battery materials resides in China; the country accounts for some 89% of the world's processing of lithium, for example. And the competitive landscape is consolidated; larger companies continue to embark on capacity expansion and acquisitions in order to gain share and drive competitive edge in the market. However, market experts note that both Europe and the U.S. are expected to strengthen supply chain operations — including raw material processing — in order to challenge the Asian markets.

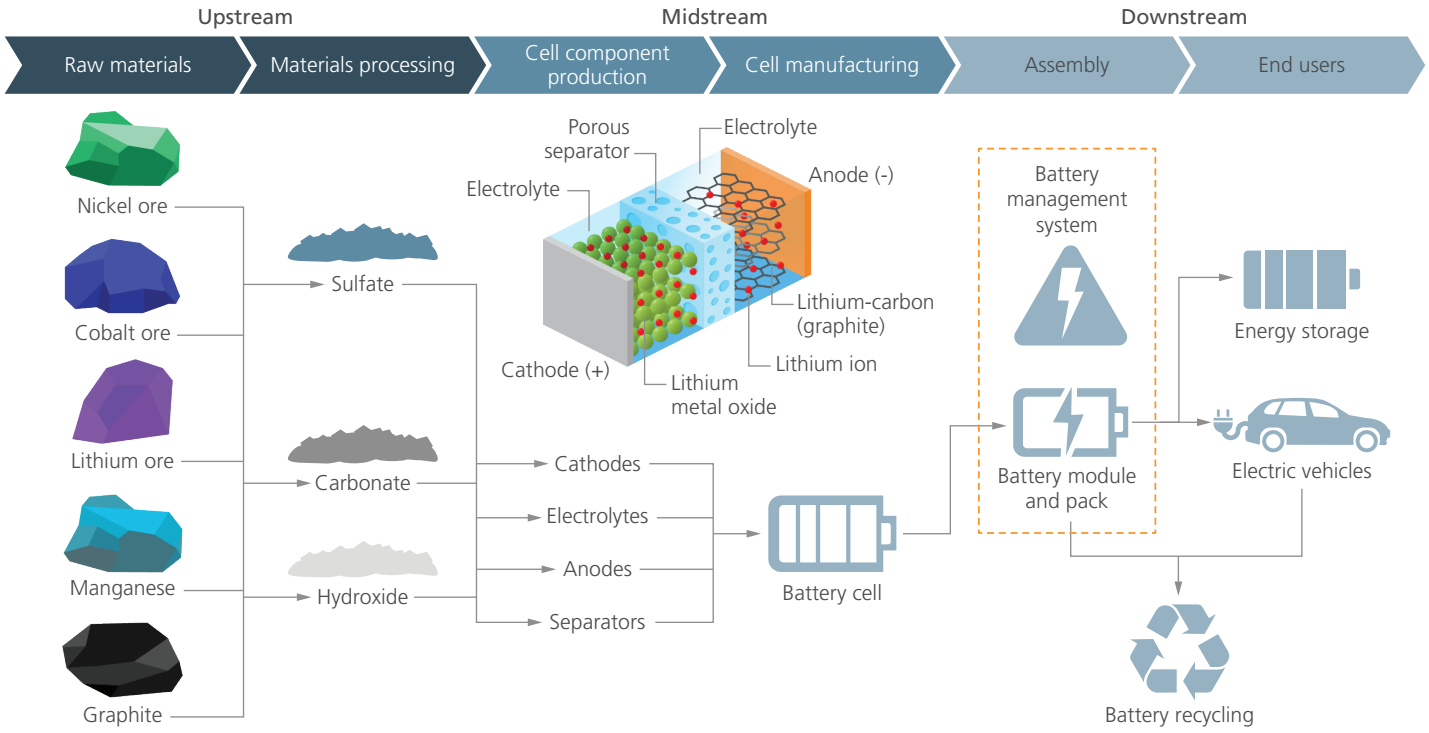
Midstream

China also dominates the midstream lithium-ion battery supply chain, controlling 60% of the world's component manufacturing, according to BloombergNEF; this market is forecast to grow just shy of 5% a year through 2026 to reach $54 billion. While the U.S. is predicted to surpass Japan to take the No. 3 spot, China and Korea are expected to remain the top cell and component manufacturers through 2025. Meanwhile, efforts to strengthen local supply chains, combined with additional investment in domestic assembly, have poised North America to become the second-largest player in the battery assembly market behind Asia. This change has driven most of the technology innovation in battery components with emphasis on cost-effective solutions that would accelerate commercial scale of new materials. For example, one innovation has been a shift from nickel manganese cobalt (NMC) to lithium iron phosphate (LFP) as the emerging standard for non-Chinese EV battery manufacturers; another has been a trend toward innovative materials and components being developed by U.S.-based startups, such as Sila-Nano's silicon-carbon-based anode technology and Enovix's lithium-metal-based products.

Downstream

EVs are projected to account for roughly 45% of capacity demand by 2030 and energy storage for approximately 40%, while industrials will make up the remaining 15%. It's a concentrated market, featuring just a few mature players. Prominent among

Figure 2
Electric battery value chain



Source: L.E.K. research and analysis

them are major car manufacturers, which are ramping up their manufacturing of EV models. Tesla is one example. Together with startups such as Lucid Motors Inc. and Nikola, these large players could become the driving force behind increased competition in the space going forward.

In terms of differentiating factors, most of the technology efforts have been focused on the assembly of batteries and, more specifically, on cell construction. New startups have been experimenting with alternative configurations — such as solid-state technologies being developed by QuantumState and SolidPower — pointing to much more efficient batteries, while others have been more focused on lower total ownership cost solutions to enable overall commerciality of EVs.

When it comes to using batteries to increase the flexibility and reliability of the electricity grid by integrating renewable energy into the system, the market has traditionally been consolidated. However, an influx of new market entrants like Form Energy, Bloom Energy and Eos Energy should increase competition going forward.

Meanwhile, the industrial market — where batteries are used to provide a stable supply of electricity to the likes of factories and commercial facilities and to power industrial equipment and other devices — remains fragmented. It features not just a few key players but also a fairly long tail of small-to-midsize competitors.

Value chain pain points

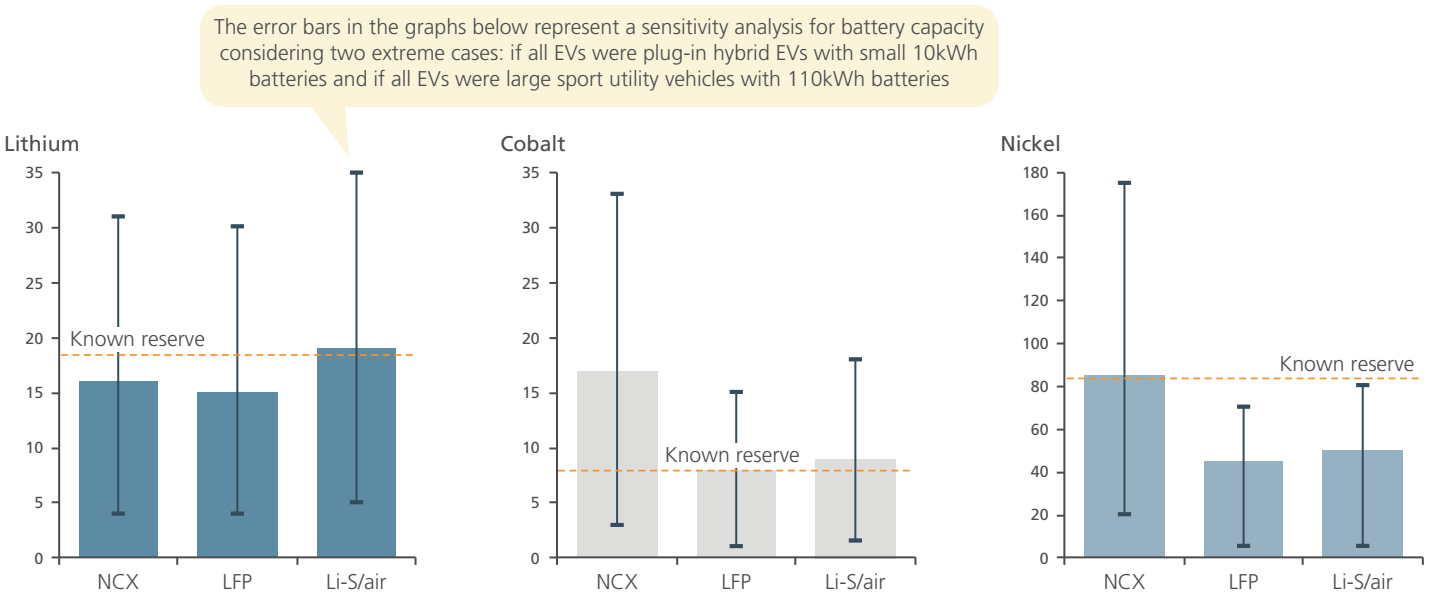
The battery value chain also has its share of pain points that all investors need to be aware of as these could curtail growth of the industry going forward. That said, there are a number of solutions being explored to address them.

A shortage of raw materials and minerals. Impending shortages of key raw materials such as lithium, cobalt and nickel are likely to hamper production and, with the shortages, the growth of the overall market (see Figure 3).

Although there are several currently active mines, demand is expected to outstrip supply. However, the industry is taking steps to expand its sourcing of raw materials; both the U.S. and Europe are increasing their lithium mining capacity, for example. Meanwhile, individual companies are working to produce alternative technologies such as solid-state batteries and hydrogen fuel cells.

The environmental impact of traditional mining. The processes required to mine the materials needed to make batteries, among them lithium ore, rely heavily on the use of natural resources and cause numerous adverse impacts to the environment. Sourcing is also costly and highly concentrated in particular regions of the world, such as Chile, Australia and China, while global geopolitical tensions pose a threat to the

Figure 3
Cumulative primary material demand (Mt) 2020-50



Note: NCX = nickel-cadmium; LFP = lithium iron phosphate; Li-S/air = lithium-sulfur and lithium-air chemistries, assuming emergence of solid-state technology
Source: Nature.com; L.E.K. research and analysis

security of supply. With that in mind, manufacturers (e.g., Tesla, BMW) are building new lithium cell production facilities adjacent to their existing plants, and interest around opening more mines stateside is growing. Brine extraction methods are also being utilized to minimize environmental harm.

Considerations around ethical extraction in sourcing countries. The key raw materials used to make batteries — namely lithium, cobalt and nickel — are found in regions of the world where environmentally sensitive areas, operations exposure to protected territories and questionable extraction practices are likely to create legal implications. Chile, Australia, China and Argentina are responsible for some 95% of the world's lithium mining, which results in pollution of and water shortages for surrounding communities. Cobalt is primarily mined in the Democratic Republic of the Congo, which has a history of conflict, corruption and child labor. The serious injuries to and deaths of children working in cobalt mines have already prompted accusations and even lawsuits against the likes of large manufacturers such as Apple, Google, Microsoft and Tesla. Indonesia and Australia are the largest suppliers of nickel, and those mines are often located on the lands of Indigenous people, forcing local populations to relocate.

Potentially higher cost of procurement due to underlying shortages. The growing demand for lithium, nickel and cobalt, itself the most expensive battery metal in the world, has driven soaring prices in recent years and is expected to continue to rise for the foreseeable future, increasing pressure on manufacturers' procurement costs.

Probability that battery manufacturing will lag expected growth in demand. Fueled largely by the EV market, global demand for battery capacity is expected to continue growing at a rapid pace, reaching 6.8 terawatt hours (TWh) by 2030. But supply of critical materials (e.g., lithium, cobalt, nickel, graphite) may fail to keep pace with skyrocketing demand as slow financing and extraction act as barriers to bolstering new capacity.

A need for more cost-effective recycling of lithium. Recycling lithium batteries is a highly complex, capital-intensive process, one that requires sophisticated equipment in order to treat the resulting hazardous emissions. And different batteries contain different lithium-based materials, which in turn require different recycling processes. Plus, while recycling will recover the value of raw materials in the near term, the value of these raw materials fluctuates significantly from year to year and, with it, the overall profitability of recycling them. The good news is that the number of recyclers and second-life players, which take batteries that no longer meet automotive standards and utilize them for less-demanding energy storage applications, is expected to rise in coming years. Market consolidation is also expected to continue, and larger players will be able to repurpose batteries at costs that are significantly lower than the costs at which they repurpose today.

Five issues for consideration

In light of all these factors, current investors in the battery value chain as well as those contemplating investing in the space need to consider the following five key issues.

1. **Expansion of manufacturing capabilities/capacity in the U.S. and Europe.** While battery demand is projected to increase globally, the majority of production is in Asia and specifically in China. In order to ensure better security of supply, Europe and the U.S. will be increasingly investing in new/more-efficient battery production capabilities.
2. **Consolidation/vertical integration.** Led by companies such as Tesla, OEMs are moving upstream to secure battery supply and leverage the economics of captive production. As processing moves closer to the mining site, there may be increased consolidation of miners and processors as well.
3. **Expectation of improved recycling capabilities and capacity mandates.** Given the current trajectory, battery demand is likely to outpace supply in the next five to 10 years. Even if production capacity can ramp up to meet demand, over the longer term, reserves of critical raw materials are also likely to fall short of demand projections, indicating the need for improved recycling technology and recycling operations at scale — assuming there are no major shifts in battery composition/materials.
4. **Commercial scale ramp-up that drives opportunities for alternative/innovative battery technologies.** As battery production achieves real lower-cost commercial scale production, the market will enable continued innovation in battery technology. This includes advances that can expand the useful life of batteries, improve range and cell energy density, reduce charging time, and improve efficiency while reducing the amount of key raw materials required per battery, or that can transition away from lithium-ion batteries to those that utilize different, more abundant raw materials.
5. **Need for supporting services and technologies.** As battery proliferation continues, additional services are likely to be required, including battery maintenance and upkeep and software and other technologies that manage and optimize things such as battery functionality and performance, disposal, and more.

Significant tailwinds are driving the growth in demand for batteries and, with that demand, the investment opportunity the space presents. But the complexity and related pain points of the battery value chain are also significant, and they extend all the way from the procurement of necessary raw materials to a downstream segment that is both consolidated and highly fragmented, depending on the application. Investors, therefore, need to be aware of the core issues underlying this opportunity.

And they need to be prepared to apply them to every battery value chain decision they make.

Endnotes

[1]L.E.K. Consulting, "Battery Energy Storage: Choosing a Winning Path in a Rising Tide." https://www.lek.com/insights/ei/battery-energy-storage-choosing-winning-path-rising-tide

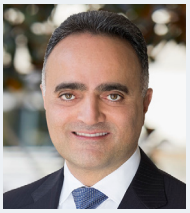
[2]L.E.K. Consulting, "US Infrastructure Plan: A Window of Opportunity in the Building and Construction Industry?" https://www.lek.com/insights/pt/us-infrastructure-plan

About the Authors

Franco Ciulla is a Managing Director and Partner in L.E.K. Consulting's Houston office. Franco has 25 years of experience working for the oil and gas industry in technical, operational, commercial and strategic roles, with a focus on upstream activities and oilfield supply chain strategies. He specializes in aboveground risk assessment, oil and gas asset performance analysis, cost and supply chain strategies, fiscal benchmarking and optimization, competitiveness assessment, M&A support, and corporate growth strategy.

Nilesh Dayal is a Managing Director and Partner in L.E.K. Consulting's Houston office. Nilesh is head of the firm's Energy practice and is also focused on the oil and gas and chemicals sectors. He has more than 20 years of experience advising clients on growth strategies related to acquisitions, divestitures and new business venture launches; corporate restructurings; supply chain management; public sector and regulatory strategy; profitability and operations improvement; and post-merger integration and planning.

Amar Gujral is a Managing Director and Partner in L.E.K. Consulting's Houston office. Amar is focused on growth and commercial strategy, M&A, and due diligence in the energy sector. He has supported strategy engagements and M&A processes with major and midsize E&Ps, oilfield service companies, utilities, equipment manufacturers, private equity firms, and other financial institutions. Prior to joining L.E.K., Amar was on the energy deals team at Strategy& and covered oilfield services at Guggenheim Partners.



Mazen Skaf is a Managing Director and Partner in L.E.K. Consulting's Houston office and a member of the Energy practice. Mazen has more than 17 years of strategy consulting experience and has advised clients in a variety of sectors including energy, technology and private equity. His areas of expertise include strategy development and execution, business model innovation, corporate development, and strategic portfolio management. Prior to joining L.E.K., Mazen served as a Partner and Managing Director at Strategic Decisions Group.

About L.E.K. Consulting

L.E.K. Consulting is a global management consulting firm that uses deep industry expertise and rigorous analysis to help business leaders achieve practical results with real impact. We are uncompromising in our approach to helping clients consistently make better decisions, deliver improved business performance and create greater shareholder returns. The firm advises and supports global companies that are leaders in their industries — including the largest private- and public-sector organizations, private equity firms, and emerging entrepreneurial businesses. Founded in 1983, L.E.K. employs more than 1,600 professionals across the Americas, Asia-Pacific and Europe. For more information, go to www.lek.com.