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THE GLOBAL BATTERY ARMS RACE: LITHIUM-ION BATTERY GIGAFACTORIES AND THEIR SUPPLY CHAIN

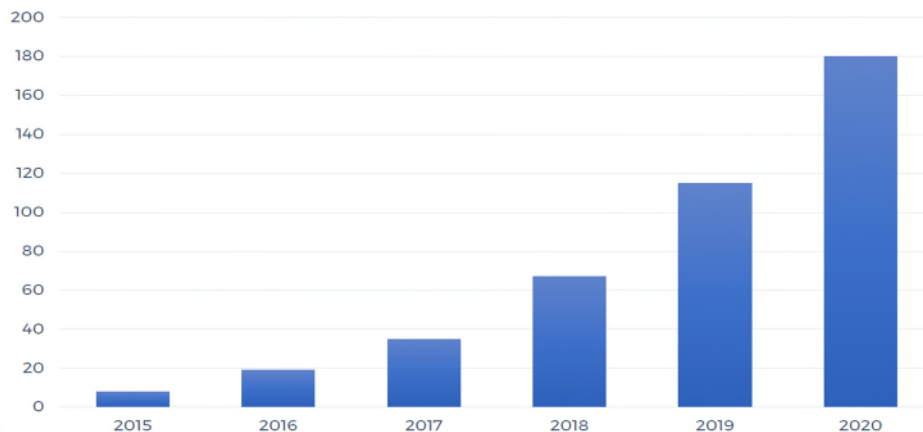
Simon Moores

The coronavirus pandemic has turbocharged the lithium-ion-battery-to-electric-vehicle (EV) supply chain and accentuated a global battery ‘arms race’ between China, the United States, and Europe. The build-out of this supply chain is the blueprint for the 21st century automotive and energy storage industries, and since the onset of the pandemic in March 2020, lithium-ion battery and EV plans have accelerated. Data from Benchmark Mineral Intelligence shows that the number of individual battery megafactories, also referred to as gigafactories, in the pipeline over the next 10 years increased from 118 in 2019 to 181 in 2020. (For context, only four were being planned in 2015). Of the 181, 136 are based in China, 10 in the US, and 16 in continental Europe. As I testified to the US Senate Committee for Energy and Natural Resources in 2019: ‘We are in the midst of a global battery arms race in which the US is presently a bystander’ ([Moores, written testimony, 5 February 2019](#)).

Battery megafactories are super-sized producers of lithium-ion battery cells, which will be the platform technology for all EVs, and China has taken the initiative to build battery capacity at speed and scale. Of the 181 battery megafactories in various stages of planning and construction, 88 are currently active, making cells for EVs. While there may be a ‘global battery arms race’, the furore has a real and tangible bedrock of battery production.

Build-out of battery megafactories (>1 GWh), 2015–2020

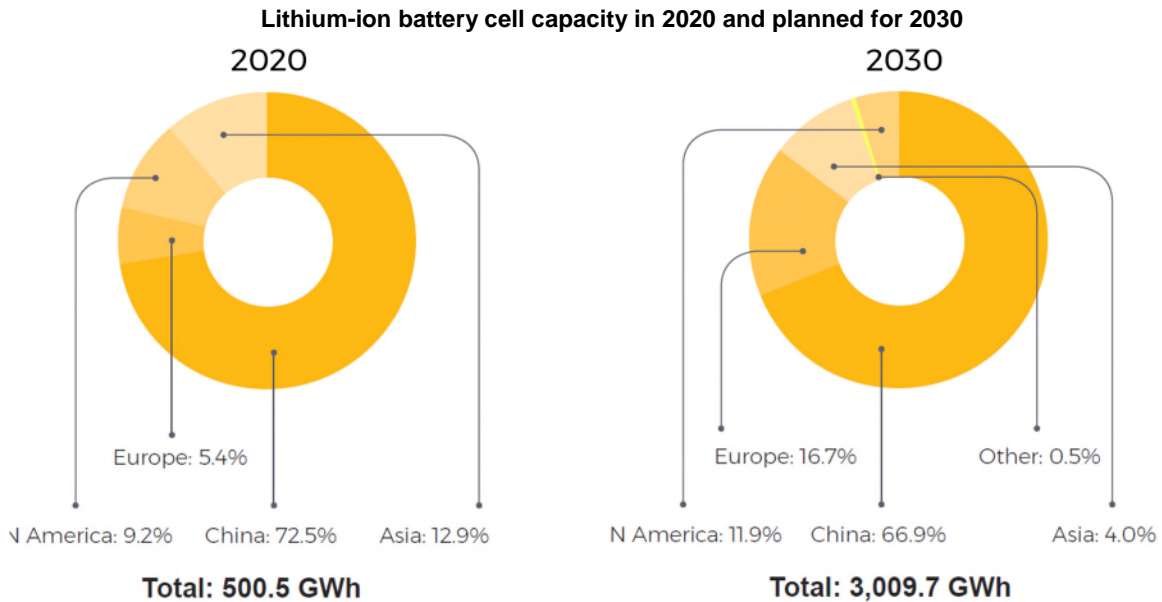
The build out of EV battery megafactories / gigafactories since 2015 (> 1GWh)



Source: Benchmark Mineral Intelligence.



In terms of battery capacity, in 2020, cell capacity plans to 2030 increased by 845 GWh to a fraction over 3 TWh. This is the biggest single annual increase in pipeline battery capacity since Benchmark started collecting this data in 2014. China once again surged ahead in 2020 by building even more lithium-ion battery megafactories and increasing future capacity. Of the total capacity of all of the lithium-ion battery plants either active or under construction, China accounts for 66.9 per cent, while the US is only forecasted to account for 11.9 per cent. As I [explained](#) to the US Senate Committee for Energy and Natural Resources in 2020: ‘China is building one battery gigafactory a week; the US one every four months’.



Source: Benchmark Mineral Intelligence.

Battery megafactories could become geopolitical hot potatoes

Another trend to watch is the emergence of joint-venture battery megafactories by a major automotive producer and a major battery producer. With the vast majority of auto majors being Western and most lithium-ion battery majors being Asia-based, these plants are at risk of becoming geopolitical hot potatoes—especially as most are government-backed in some way.

The first wave of battery megafactories saw South Korean producers, especially LG Chem and Samsung SDI, establish operations in mainland China and Europe between 2015 and 2017. Once the EV momentum hit the mainstream, Europe’s response was to encourage European auto and battery conglomerates to team up: VW Group with Sweden-based but EU-backed Northvolt to establish a plant in Germany, and France’s SAFT (owned by French oil producer Total) with PSA Group. A similar response was seen in the US with General Motors and LG Chem planning a megafactory in Ohio, a blueprint inspired by Tesla and Panasonic’s original Gigafactory in Nevada. The US response was driven by Tesla’s momentum rather than government involvement, unlike in the European Union, which is one reason the US lags behind in this race.

The bigger question remains: What happens when China wants to establish battery megafactories outside of its borders? The battery producer CATL (Contemporary Amperex Technology Co. Limited), founded in 2011, was barely on the EV radar in 2015. Today, it has become the Chinese government’s champion for the industry and is the world’s biggest producer of lithium-ion batteries. In 2020 it had a capacity of 110 GWh, 22 per cent of the world’s total of 500 GWh. CATL has five operational battery plants and six under construction, of which one is based in Erfurt, Germany. There is little doubt that its next move is to establish operations in the US and expand its presence in Europe and other global automotive hubs.

A global lithium-ion economy is being created

What does this build-out of lithium-ion battery capacity actually mean, besides the world needing a lot more batteries? It demonstrates a fundamental shift for a number of the world’s most important industries—the implications of which are fully understood by European and Chinese leaders but less so in Washington, DC.

This shift is the ability to store energy in widespread locations, both large and small, at a reasonable cost. Lithium-ion batteries make this possible, and they are becoming more abundant (as shown above) as well as better and less expensive. The lithium-ion battery megafactory is an engine for growth.

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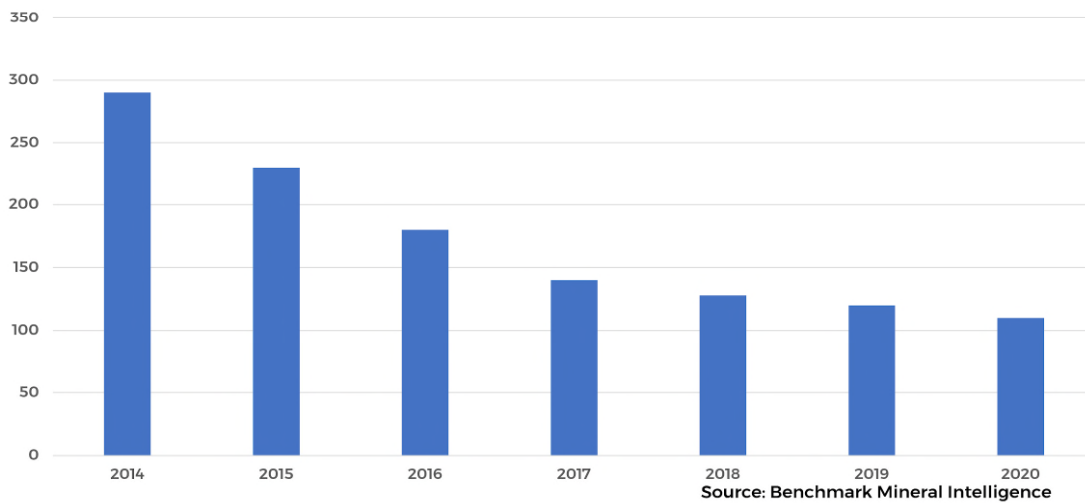


The selling price for lithium-ion battery NCM cells used in electric vehicles fell from \$290/kWh in 2014 to \$110/kWh in 2020, a decline of 14.9 per cent a year, primarily due to increased scale of manufacturing. However, these declines have significantly slowed in recent years, from a compound decline of 21.6 per cent a year between 2014 and 2017 to a decline of 7.7 per cent a year between 2017 and 2020. The slowing is due to raw materials making up a larger proportion of the cost—now 75–80 per cent, compared to 50–60 per cent in 2014, when the batteries were made in much smaller plants. Nonetheless, the cost is expected to fall below \$100/kWh; Benchmark estimates this will occur by 2022/2023.

Declining cost of lithium-ion batteries used in electric vehicles (\$/kWh), 2014–2020



Lithium ion cell price, Large contract, Automotive, \$/kWh



Source: Benchmark Mineral Intelligence.

Technological improvements, falling costs, and increasing prevalence are driving what Benchmark has called the creation of a global lithium-ion economy. Lithium-ion batteries are the enabling technology for the 21st century automotive industry and will be a disruptive technology for the 21st century energy and utility sectors—the first widespread energy storage to couple with increasing production of wind and solar power. Those that control these supply chains will control the balance of industrial power for the remainder of this technological cycle, which could last well into the 22nd century. And the lithium-ion battery supply chain is at the heart of any global lithium-ion economy. It is crucial for governments to understand this.

Understanding this supply chain will be key to auto manufacturing success

The lithium-ion-battery-to-EV supply chain has five fundamental sections. Each is intrinsically linked to the next, and the quality of the raw materials will directly affect the cost and quality of the EV being produced.

Mining

The key battery raw materials of lithium, nickel, copper, cobalt, graphite, and manganese need to be mined from the ground. Lithium and cobalt are particularly challenging due to their scale—measured in the hundreds of thousands of tonnes instead of the millions of tonnes—and will need to evolve from a niche to the mainstream within the decade. Any foreseeable future battery technology shift, such as solid-state technology, will still be lithium based and wholly reliant on the same supply chains and starting points.

Chemical refining

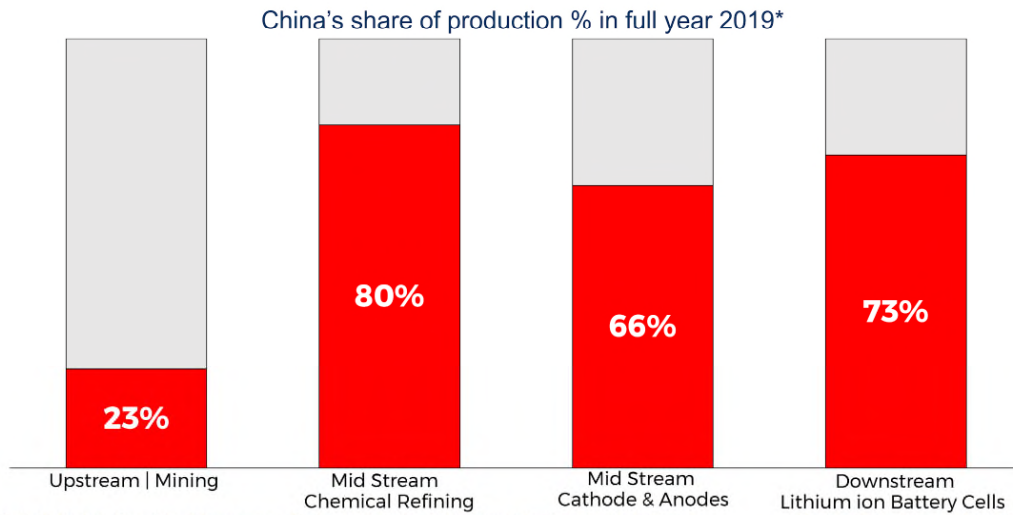
Chemically refining key raw materials into cathode- or anode-ready products is a critical step that is often overlooked when analysing the battery supply chain. It is also often the biggest hurdle when bringing new supply onstream. Many of these raw materials are actually chemically refined and engineered products, with specific purities and particle size requirements that differ per end user. Lithium and graphite especially have challenges related to this step.

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While China only domestically mines 22 per cent of its battery raw materials, it domestically produces 66 per cent of this chemical stage, ensuring the global supply chain arrows point towards China. China’s lack of domestic battery raw material production is compensated by mid-stream supply chain dominance. This is also a strategy to ensure strong battery cell and EV production share.

Share of China’s lithium-ion battery manufacturing produced domestically in 2019



*Lithium, Cobalt, Nickel, Graphite, Manganese, Cathode, Anode, Cells accounted for in calculations

Source: Benchmark Mineral Intelligence

Source: Benchmark Mineral Intelligence. Data account for production of lithium, cobalt, nickel, graphite, manganese, cathode, anode.

Cathode and anode production

The quality of the raw materials, together with the quality of the cathode and anode manufacturing, will determine the quality of the lithium-ion battery cell and with it the performance of the EV that contains the battery. Automakers’ futures will ultimately rely on how well high-quality cathode and anode making scales, an expansion that needs to go hand in hand with the previous two steps.

Lithium-ion cell manufacturing

While lithium-ion battery making is expanding, there is a wide variety of qualities, not all of which can be used in all EVs. High-specification EVs made by western auto manufacturers outside of China will require Tier 1 quality cells—presently made by CATL, Tesla-Panasonic, Samsung SDI, LG Chem SK Innovation, and Envision AESC—which are expected to account for 35 per cent of total output in 2030.

Auto manufacturing

Traditional automakers are fast evolving into battery pack manufacturers and software engineers. An increasingly close relationship between the battery cell makers and automakers is also evolving—for example, with VW Group teaming up with Northvolt, and General Motors and LG Chem jointly creating a battery plant in Ohio. Future success in the automotive industry will not involve dominating an existing and scaled supply chain, but understanding the criticality of asset ownership along the new supply chain as this industry scales over the next 20 years.



Current and potential future supply chains

Current sample Supply Chains for Europe and North America focus on global mining and Asian refining of cathode materials

Growth of battery supply chains allows future sourcing to optimized, reducing shipping and working capital requirements, while reducing political risk



Source: Benchmark Mineral Intelligence.

Automotive decision makers need to understand that the lithium-ion battery and EV supply chain needs to be built from scratch and scaled to a blueprint over the next decade. Those most active in investing in and owning assets and controlling the intellectual property along the supply chain will be in the most dominant position a decade from now. True scale, akin to what traditional auto manufacturing is used to, will arrive in the 2030s.

Automakers who quickly understand the importance of these linked steps in the battery supply chain to the quality and cost of their EVs will be the most successful at navigating the next decade. For governments, the shifts in the economics of the supply chain outlined in this article provide opportunities to create jobs, garner influence over a strategic industry, and establish new trading relationships, particularly relevant as Europe and the United States, under a Biden presidency, will seek to reduce reliance on China as a single point in the supply chain. Those who do not see the importance of the lithium-ion battery will have no meaningful future.