TRENDS IN US-CHINA BATTERY MATERIAL (LITHIUM) SUPPLY CHAINS —ACTIONS REQUIRED OF JAPANESE COMPANIES—

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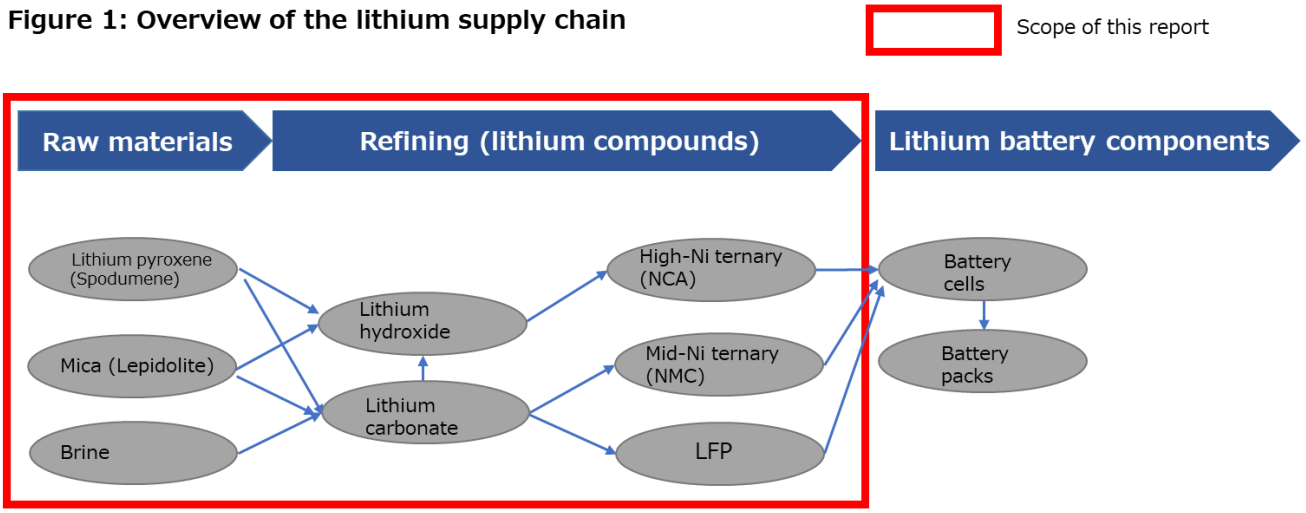
SUMMARY

- The US is rushing to build a new lithium supply chain to become less dependent on China for battery materials, as there are concerns that supply will be unable to keep up with the growing demand for BEVs.
- China has built a robust lithium supply chain through its oligopoly over lithium refining. With the backing of the Chinese government, the country's battery manufacturers have gained a competitive edge in the global market. Market competition is also intensifying within China. In the future, the top two or three companies may dominate the battery manufacturing market, leading to the emergence of giants such as Foxconn and TSMC.
- Japanese companies need to review their advantages and redefine their businesses as they work to build lithium supply chains.

As the global demand for battery electric vehicles (BEVs) continues to rise, the demand for battery materials is also skyrocketing, raising concerns about supply shortages. According to Bloomberg, by 2030, the demand for major battery materials is expected to increase 16-fold for lithium, 14-fold for nickel, and 3-fold for cobalt in comparison to 2020 levels. The reserves and production sites for these minerals are unevenly distributed among the top two or three countries, and China currently has an oligopoly over the refining process. This situation is expected to make it more difficult to secure a stable supply of these minerals than for other energy resources. In particular, lithium acquisition is of high importance. Lithium is used for cathodes in all three types of lithium-ion batteries (NCM, NCA, and LFP),[1] and its demand will likely continue to grow. This report focuses on the US-China lithium supply chain (Figure 1) and examines how Japanese companies should respond in light of recent US efforts toward decoupling from China.

[1] Lithium-ion batteries differ based on the cathode material: Lithium ternary (NCM), lithium nickel cobalt aluminum oxide (NCA), and lithium iron phosphate (LFP). NCM and NCA are expensive but offer higher energy density and a longer cruising range. LFP is less expensive but has a lower energy density and a shorter range.

Figure 1: Overview of the lithium supply chain



Source: Compiled by MGSSI based on materials from Deutsche Bank, Benchmark Mineral Intelligence, etc.

1. TRENDS IN THE US

1-1. Building a lithium supply chain

The current lithium supply chain, which accounts for 70% of the global battery cell supply and 60% of the EV battery market, is dominated by Chinese companies. The US government wants to find a way out in order to ensure economic security and to create jobs. The US sees outsourcing all production of products critical to its industries, such as batteries, to foreign countries as a risk to its national interests and security. The US also fears that access to the lithium supply chain could be restricted and used as a diplomatic card.[2] The country is therefore working to build its own lithium supply chain domestically.

1-2. Policy trends

To avoid the aforementioned risks, the US government is providing enormous support in building a supply chain for battery materials, from mine development through to BEV sales, to strengthen its own industries. Specifically, this entails (1) providing mining companies with subsidies to construct mining and processing plants under the Infrastructure Investment and Jobs Act, (2) providing mining and battery companies with low-interest loans from the Department of Energy, and (3) enacting measures to support battery materials industry under the Inflation-Reduction Act (IRA). As an aspect of item (3), those who purchase EVs, PHEVs, and FCVs for which final assembly was conducted within North America are allowed tax credits of up to $7,500 per vehicle. To qualify for these tax credits, the vehicle must meet the following requirements: A) a certain percentage of the battery components were manufactured or assembled in North America, and B) a certain percentage of the lithium and other critical minerals contained in the battery were extracted and processed either in the US or in a country which has an FTA with the US, or they were recycled within North America. The US is also trying to exclude China, such as by denying tax credits for vehicles that contain battery components and other parts produced or processed by entities in countries of particular concern.[3]

1-3. Changes in OEM behaviors

Ever since 2022, when the IRA was enacted, US-based OEMs have been working to secure lithium either within the US or from countries that have an FTA with the US. GM has invested the equivalent of nearly 100 billion yen in a joint development lithium project with Lithium Americas (Canada), and Tesla is building a lithium refining plant in Texas (Figure 2). Battery materials used to be procured by component manufacturers and battery

[2] Atlantic Council, "The US wants to end its reliance on Chinese lithium. Its policies are doing the opposite." January 23, 2024 (accessed on March 6, 2024; the same applies to all subsequent links)
[3] China, Russia, Iran, and North Korea

manufacturers, but now, EV manufacturers have no choice but to secure battery materials on their own through direct supply contracts with mines and by participating in the refining process.[4]

Figure 2: OEMs move to secure battery materials in the US or from countries that have an FTA with the US

(US OEMs)

Company name	Minerals	Overview	Date of announcement
Tesla	Lithium	Entered into a long-term lithium offtake agreement with Liontown (Australia)	February 2022
	Lithium	Created a lithium supply term sheet with Core Lithium (Australia)	March 2022
	Lithium	Entered into a long-term lithium offtake agreement with Piedmont Lithium (US)	January 2023
	Lithium	Announced plans to construct a lithium smelting facility in Texas, US (operation scheduled to launch in 2024)	May 2023
GM	Nickel	Invested in nickel and cobalt projects in Australia led by Queensland Pacific Metals (Australia)	October 2022
	Cobalt		
	Nickel	Entered into a long-term agreement to offtake nickel from the Vale Quebec Plant (Brazil)	November 2022
	Lithium	Jointly invested in a US lithium project with Lithium Americas (Canada)	January 2023
Ford	Lithium	Entered into a long-term lithium offtake agreement with Liontown (Australia)	June 2022
	Lithium	Entered into a long-term agreement to offtake lithium from a US mine lithium project by Ioneer (Australia)	July 2022
	Lithium	Entered into a long-term lithium offtake agreement with SQM (Chile)	May 2023

(Non-US OEMs)

Company name	Minerals	Sources of supply, regions of investment	Date of announcement
Stellantis (Netherlands)	Manganese	Entered into a long-term agreement to offtake manganese from a project in Western Australia by Element 25 (Australia)	January 2023
	Cobalt	Entered into a long-term cobalt and nickel offtake agreement with Alliance Nickel (Australia)	April 2023
	Nickel		
	Lithium	Invested in a lithium mining project in the US by Controlled Thermal Resources (US)	August 2023

Source: Compiled by MGSSI based on company press releases, media reports, and JOGMEC materials

1-4. What the US needs for the development of its lithium industry

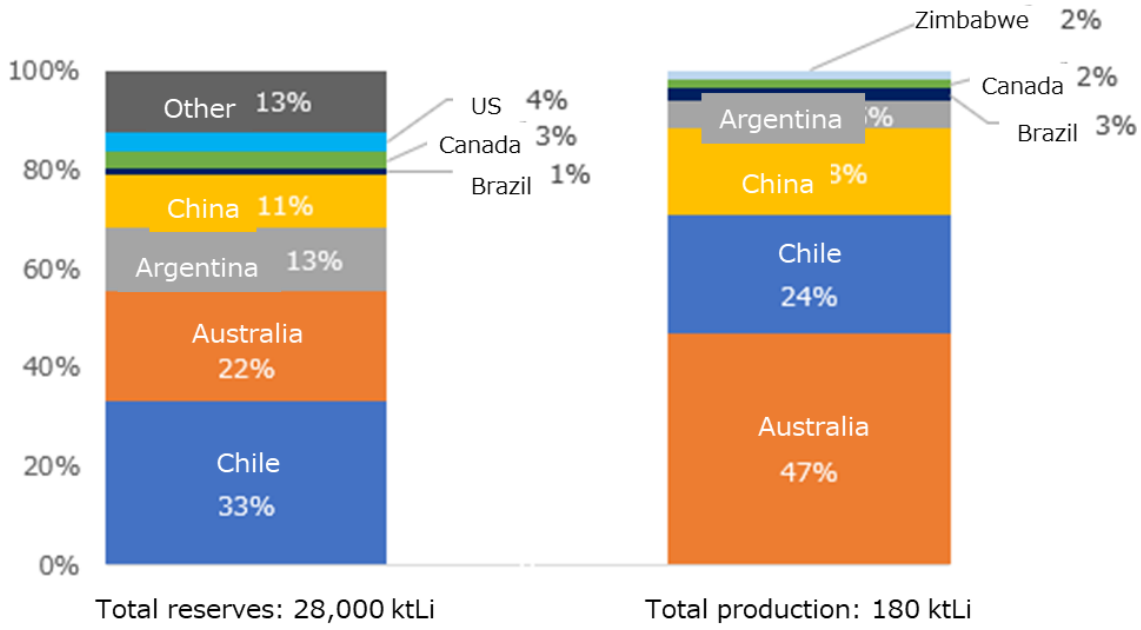
The US will be unable to mine enough lithium domestically to meet demand. The country will have to rely on imports from friendly countries and therefore support them in developing their lithium mining and refining industries. Lithium deposits exist in Australia, Chile, and Canada, all of which have FTAs with the US, as well as in Argentina and Brazil (Figure 3).[5] Some in the US say that, for the sake of economic security, the State Department should provide these countries with the support needed to build a supply chain.[6] There are also strong calls for the US to support not only large corporations but also start-ups in relevant fields to make the US a hub for the development of related technologies.

[4] Securing lithium resources is of utmost priority for the EV industry as there is expected to be a supply shortage over the mid- to long-term (JOGMEC).

[5] Lithium production is categorized into ore-based production, in which lithium is extracted from crushed ore resources, and brine-based production, in which lithium is extracted from the brine in salt lakes. Australia accounts for 90% of the former and South America for 80% of the latter.

[6] Atlantic Council, "The US wants to end its reliance on Chinese lithium. Its policies are doing the opposite." January 23, 2024

Figure 3: Global lithium reserves and production volumes



Compiled by MGSSI based on materials from JOGMEC, USGS Mineral Commodity Summaries 2024, etc.

In April 2023, GM invested $50 million in Energy X, a startup developing direct lithium extraction (DLE) technology. The DLE process directly extracts lithium by pumping brine through a filter or adsorption membrane. In addition to removing impurities, this also shortens production time. The process does not require much space, and the recovery rate is more than twice that of conventional production methods.[7] It also significantly shortens lead times for development and production.[8] It has been pointed out that the technology used is generating disruptive innovation,[9] drawing attention to the US's ability to innovate.

1-5. Changes resulting from the 2024 presidential election

If Joe Biden is reelected and Democrats gain control of both the House and Senate, the shift toward clean energy could accelerate. Even so, despite transitions toward renewable energy as well as practical applications of CCS[10] technology, fossil fuels will likely remain a large part of the US energy mix. Even if the Biden administration enacts ambitious emission regulations, internal combustion engine (ICE) vehicles will still account for one-third of all vehicles owned up to 2032 and possibly beyond.

If Donald Trump wins and the Republicans take control of both the House and Senate, they are expected to revise the IRA and change the policy of promoting clean energy. Republicans are likely to ease restrictions on fossil fuels and formulate policies to expand production. However, they may retain tax incentives for clean energy, including EV purchases under the IRA. This is because 80% of all investments attracted by the IRA are in Republican constituencies and are to their benefit. Companies are expected to continue investing in renewable energy, EVs, lithium, and battery production. In other words, the importance of lithium in the US will not be significantly affected regardless of who the president is.

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[7] Currently, 60% of all lithium production methods involve extraction from crushed ore resources, which is how it is performed in Australia, etc. In South America, lithium is primarily extracted by evaporating brine from huge salt-water ponds, and this accounts for 32% of the total. Lead times for development and production are roughly at least 18 months for the former, and three years or longer for the latter. The latter also requires a large amount of water, meaning that these methods have challenges in terms of time and environmental impact.

[8] As the DLE process is able to extract lithium in a highly pure state, it is also expected to significantly shorten the refining process.

[9] Goldman Sachs points out that DLE will generate disruptive innovation on par with shale gas technology.

[10] CCS = carbon capture, utilization, and storage

2. TRENDS IN CHINA

2-1. China continues to secure lithium from overseas

In the 2000s, the Chinese government took the lead in securing interests in lithium, nickel, cobalt, and other mineral mines. Since the late 2010s, it has steadily developed an oligopoly by increasing investments in the refining process and other high-value-added areas. China primarily imports lithium from Australia, Chile, and Argentina.[11] Chile and Argentina account for 33% and 13% of the world's lithium reserves and 24% and 5% of all lithium production, respectively, and China continues to deepen ties with both countries to ensure access to lithium. China is seeking mutually beneficial cooperation by establishing energy resource partnerships[12] with resource-supplying countries and engaging in joint development.

Lithium prices have recently fallen sharply, and while many lithium producers are cutting back production, Chinese companies have begun to significantly increase the volume of their lithium purchases (Figure 4). This is a shrewd strategy aimed at further expanding their share of the global lithium market and increasing their degree of dominance during the recession.

Figure 4: Chinese companies move to secure lithium resources in South America

Country	Date	Company name	Details
Chile	April 2023	BYD	Won bid for rights to obtain lithium carbonate produced by SQM (Chile) from Atacama Salt Lake at preferential prices until 2030
Argentina	July 2022	Ganfeng Lithium	Ganfeng Lithium won the Pozuelos Pastos Grandes Lithium Project from Litica Resources for $962 million
Brazil	July 2023	BYD	BYD announced the construction of an EV plant in the State of Bahia
Brazil	October 2023	BYD	Plans to purchase lithium mines in Brazil for a new Brazilian plant

Compiled by MGSSI based on JOGMEC materials, etc.

2-2. China's advantages in the lithium supply chain

China's oligopoly over the refining process early in the supply chain (Figure 5) provides it with additional advantages in lithium iron phosphate (LFP) battery manufacturing.[13] Tesla, Volkswagen, Ford, Daimler, and other leading EV manufacturers make use of LFP batteries. Initially, major patents relating to LFP battery production were managed by a consortium of Chinese universities and research institutes and were available to battery manufacturers in the country on a license-free basis.[14] Government backing incentivized focusing on LFP battery production, which resulted in further refinements to the production technologies. This situation has given them an edge in global market competition. While LFP batteries were once considered to be at a disadvantage due to their low energy density, this has been resolved through cell-to-pack technology,[15]

[11] China imports 2,625,000 tons of lithium concentrate from Australia. This accounts for 67% of China's lithium imports. China also imports 122,000 tons of lithium carbonate from Chile and 13,000 tons from Argentina, accounting for 24% and 3% of its total lithium imports, respectively.

[12] China is running short of lithium, cobalt, nickel, and other minerals, which are needed for battery production. China is working to build relationships with Argentina, Chile, Congo, and Indonesia as they have rich reserves of these resources.

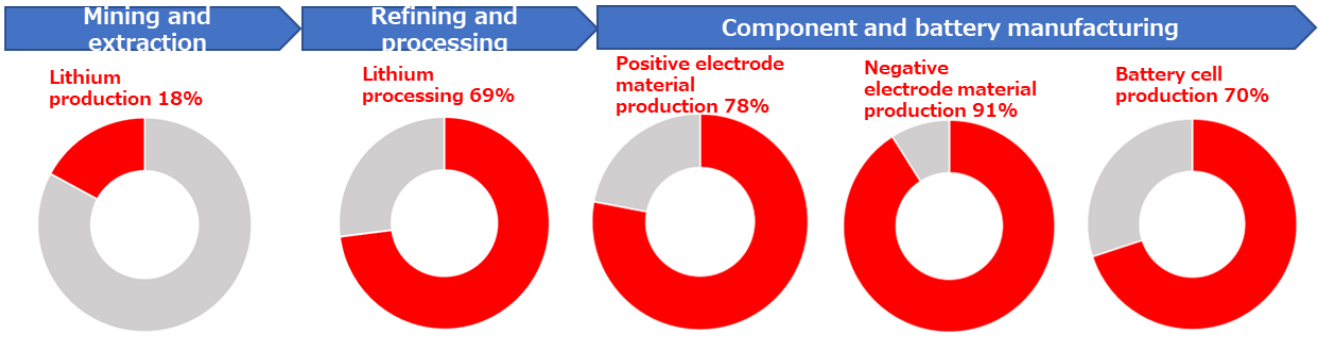
[13] In terms of cathode materials for liquid lithium-ion batteries, Chinese manufacturers focus on LFP, while Japanese, European, and American manufacturers focus on NCM and NCA, and Korean manufacturers produce both. LFP batteries have cost advantages, and are safer than the other two because they are less flammable. Cathodes are made from rare metals that are estimated to account for half of the total battery cost. Cobalt is particularly expensive, and since LFP batteries are cobalt-free, the costs of LFP batteries can be reduced to a quarter of that of NMC batteries depending on the market price.

[14] The duration of major patents managed by this consortium of Chinese universities and research institutes expired in 2022, and the actions of Korean companies and others are attracting attention.

[15] A method of directly integrating cells into battery packs instead of modularizing them. Generally, this provides 15 to 50 % more space, allowing 1.15 to 1.5 times the number of batteries to be installed to improve the energy density of the pack (extending the

ensuring a competitive advantage as low-cost, high-quality batteries.

Figure 5: China's global share of the lithium supply chain



Source: Compiled by MGSSI based on materials from IEA, BENCHMARK, BNEF, etc.

BYD, the world's second-largest battery manufacturer, led the world in EV sales during the October-December period of 2023, surpassing Tesla. BYD achieved its cost competitiveness through vertical integration, including in-house production of LFP batteries. The Chinese market has been experiencing a major price war since 2023, and BYD responded by aggressively lowering prices in November of that year. The company aims to lower prices by expanding the scale of production (Wright's Law[16]) and eliminate competitors through price competition.[17] This is likely a winning model in the EV business, which combines both expansion and high rate of use. Some have pointed out that China is facing a period of restructuring amid intense competition, while at the same time overproducing both batteries and OEM EVs.[18] The top two or three companies are expected to dominate the market on battery manufacturing, possibly resulting in the emergence of giants such as Foxconn and TSMC.[19]

3. ACTIONS TO BE TAKEN BY JAPANESE COMPANIES

Companies need to redefine their businesses while keeping a close eye on actions taken by the US and Chinese governments regarding their lithium supply chains in the course of green transformation.[20] In November 2023, Exxon Mobil announced its intention to launch lithium production using the DLE process, and the company plans to invest billions of dollars with the goal of producing more than one million EVs[21] per year by 2030. EV manufacturers have also begun entering into direct supply agreements with mines and engaging in the refining process. POSCO, the largest steel producer in South Korea, aims to build a supply chain covering every step from lithium procurement through to production, supply, and recycling of cathode materials and other components.[22] The company could be considered to have redefined its business to become able to play a role

cruising range). "Differences between cell-to-pack, cell-to-chassis and cell-to-body in EV battery mounting" [in Japanese] | hasimoto-soken.com

16 The law whereby the planned expansion of production capacity will lower production costs. Specifically, this means that costs should decline at a constant rate for each doubling of the cumulative production volume.

17 Li Zejian, Professor, Osaka Sangyo University; January 26, 2024; Japan Center for Economic Research, China Study No. 7 "China's Prospering Auto Industry‐Can it Lead the World in EVs?" [in Japanese]

18 A.T. Kearney pointed out that, by 2026, the first and second largest battery companies in China will hold 96% of the market share, eroding the market shares of other companies.

19 In the Chinese battery market, batteries for power storage systems showed significant growth in the first half of 2023. Over the mid- to long-term, growth is expected not only in China but also in the global market, leading to even further growth for Chinese battery manufacturers.

20 While global demand and supply capacity for lithium are predicted to be 1270 kt and 2200 kt by 2025, respectively, through the course of achieving green transformation (GX), demand for lithium is expected to exceed supply capacity by 2030, with demand reaching 2460 kt and supply capacity reaching only 2360 kt.

21 Equivalent to roughly 100,000 tons of lithium carbonate annually. In addition to Exxon, other oil and gas companies are also beginning to participate in lithium production using the DLE process.

22 *Weekly Economist Online* "Korean business community works together to make the country a 'battery superpower,' with steel manufacturer POSCO involved in every step of battery production" [in Japanese]

in supplying materials essential for industrial development.

Japanese companies need to similarly review their advantages and expand their business beyond their current domain. Building a lithium supply chain with sales to automobile and battery manufacturers that operate in the US market will be an important step in adding new sources to a business's procurement portfolio within Japanese industries. Japanese companies adept with other environmental technologies look promising in DLE technology, which is attracting attention for lithium development.[23] McKinsey expects global demand for lithium-ion batteries to grow from around 700 GWh in 2022 to 4,700 GWh by 2030. Growth in Europe and the US has also been specifically noted. Japanese companies should see these changes as business opportunities.

[23] At the CHILE-JAPAN Workshop on Lithium Strategies and Low Environmental Impact Technologies held in Chile in July 2023, JOGMEC and others promoted their eco-friendly contributions in the technologies underlying DLE (e.g., adsorbents, ion exchange resins, solvent extraction). https://mric.jogmec.go.jp/reports/current/20231013/179289/
Other issues facing existing lithium development include massive water consumption and the need to treat wastewater. It has also been pointed out that sustainability criteria may become important in the future.