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Lithium Market Assessment

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A brief outlook

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Abstract

The market assessment for lithium presents a comprehensive analysis of the global lithium industry, focusing on market size, trends, key players, and future prospects. Lithium, a crucial component in rechargeable batteries, electric vehicles, and renewable energy storage systems, has witnessed significant growth in demand due to the increasing adoption of clean energy technologies worldwide.

This market assessment examines the factors driving the demand for lithium, including the rapid expansion of the electric vehicle market, government initiatives to reduce carbon emissions, and the growing need for energy storage solutions. It explores the various lithium production methods, including traditional mining, brine extraction, and lithium recycling, highlighting their respective advantages and challenges.

The assessment explores the competitive landscape of the lithium market, profiling key industry players, their market share, and strategies. It also investigates the potential for market consolidation, mergers and acquisitions, and collaborations within the industry.

Furthermore, the assessment addresses challenges and risks associated with the lithium market, including environmental concerns, geopolitical factors, and potential supply chain disruptions. It also discusses the regulatory landscape and evolving sustainability standards, emphasizing the need for responsible and ethical lithium production practices.

Based on the analysis of current trends and future projections, the market assessment provides insights into the growth potential of the lithium market, highlighting opportunities for investors, manufacturers, and stakeholders. It concludes with a forward-looking perspective on the market, outlining potential market drivers, challenges, and opportunities that are likely to shape the future of the lithium industry.

Overall, this market assessment serves as a valuable resource for industry participants, policymakers, and investors seeking a comprehensive understanding of the global lithium market, its current state, and its future trajectory.

Keywords
Market assessment, lithium, supply, demand, prices, value chain, impacts, lithium chemistry

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Map sheet

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1. INTRODUCTION

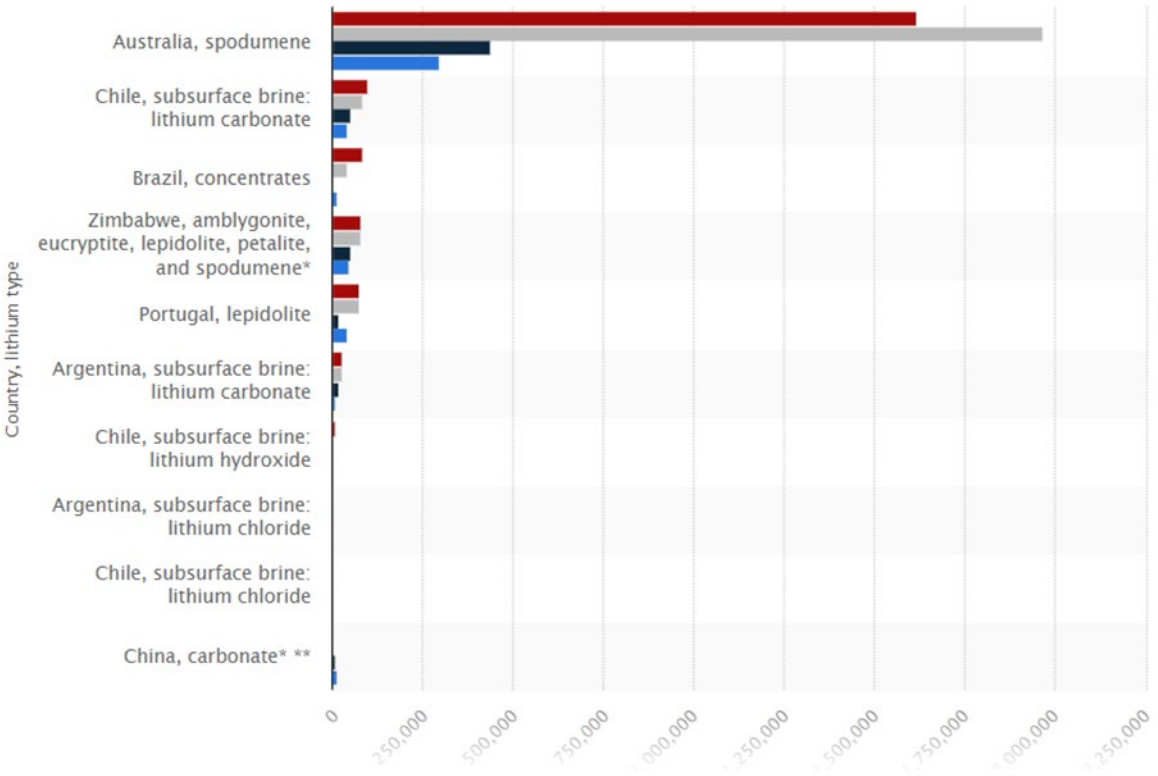
The market assessment of lithium provides a comprehensive analysis of the global lithium industry, examining key factors such as market size, trends, major players, supply chain dynamics, and future prospects. Lithium, a vital element in the production of rechargeable batteries, electric vehicles, and renewable energy storage systems, has gained significant attention due to the growing demand for clean energy technologies worldwide. As the world transitions toward a low-carbon economy and seeks to reduce reliance on fossil fuels, lithium has emerged as a critical resource for the energy storage sector. The market assessment aims to provide a comprehensive understanding of the lithium market, its current state, and its future trajectory.

The assessment explores the factors driving the demand for lithium, including the rapid growth of the electric vehicle market, increasing renewable energy installations, and government initiatives promoting clean energy adoption. It delves into the role of lithium in enabling energy storage solutions that facilitate the integration of renewable energy sources into the grid, addressing the intermittency challenge and improving overall energy efficiency. Furthermore, the assessment analyses the various methods of lithium production, including traditional mining, brine extraction, and recycling. It examines the advantages, challenges, and geographical distribution of these production methods, providing insights into the global lithium supply chain and the concentration of reserves in different regions.

Market trends and dynamics are examined, encompassing factors such as pricing patterns, trade regulations, technological advancements, and emerging lithium exploration and mining projects. The assessment investigates the competitive landscape of the lithium market, profiling major industry players, their market share, and strategies. Importantly, the assessment considers the environmental and social aspects of lithium mining, addressing concerns related to water usage, habitat disruption, and the impact on local communities. It emphasizes the need for responsible and sustainable mining practices that mitigate environmental impacts and respect the rights and well-being of affected communities. By examining the present market landscape and projecting future developments, the assessment aims to contribute to the development of a sustainable lithium market that supports the ongoing shift towards clean energy technologies and a more environmentally conscious future.

2. LITHIUM MINING

Australia is the largest producer of lithium globally (Figure 1). The Greenbushes lithium mine in Western Australia is one of the world's largest and most significant lithium mines. Chile is another major player in lithium production. The country possesses vast lithium reserves in the Salar de Atacama, which is one of the world's richest lithium deposits. China is a significant producer of lithium and is involved in both mining and processing of lithium resources (Figure 1). The country has several lithium mines and also imports lithium concentrates from other countries for further processing. Argentina is known for its lithium-rich salt flats, particularly in the Salar del Hombre Muerto and the Salar del Rincon (Figure 1). It has emerged as a prominent lithium producer in recent years. Zimbabwe has significant lithium resources, particularly in the Bikita Minerals deposit. The country has been ramping up lithium production and attracting investment in the sector. Canada is home to the Whabouchi lithium mine in Quebec, which is one of the largest and highest-grade lithium deposits globally (Figure 1). The country is expanding its lithium production capacity to meet growing demand.



* Estimated.
** Produced from subsurface brine and concentrates.

Figure 1: Lithium production worldwide from 2010 to 2019 by country and type (coloured) (in metric tons) (Statista 2022).

These countries mine lithium from different sources, including lithium-rich brine deposits and hard rock (spodumene) deposits. Lithium can be extracted from lithium-containing minerals through various processes, such as traditional mining and concentration, as well as newer technologies like lithium brine extraction and lithium extraction from clay deposits. Lithium mining involves the extraction of lithium-containing minerals from the Earth's crust. Lithium is a soft, silver-white metal that is highly reactive and has a range of industrial applications, particularly in the production of batteries for electric vehicles (EVs), portable electronics, and renewable energy storage systems.

Lithium mining process:

1. Exploration and Site Selection:

   Mining companies conduct geological surveys and exploration activities to identify potential lithium-rich deposits. This involves analyzing rock formations, mineral samples, and geophysical data to pinpoint areas with high lithium concentrations. Factors such as economic viability, environmental considerations, and infrastructure availability are also assessed.

2. Extraction Methods:

   a. Open-Pit Mining: Most lithium is extracted through open-pit mining, which involves the removal of overburden (topsoil and vegetation) to expose the lithium-bearing ore underneath. Large equipment such as bulldozers, excavators, and trucks are used to extract and transport the ore to a processing plant.

   b. Underground Mining: In some cases, lithium deposits may be deep enough to require underground mining. This method involves creating tunnels and shafts to access the lithium ore. Underground mining is typically employed when the lithium deposit is of higher grade and the ore body is situated at significant depths.

3. Processing:

   a. Crushing: The extracted lithium ore is crushed into smaller pieces to facilitate further processing.

   b. Beneficiation: Various techniques, such as gravity separation, magnetic separation, and flotation, are used to separate lithium minerals from other unwanted minerals and impurities. Beneficiation helps increase the lithium concentration and improve the quality of the ore.

   c. Roasting or Calcination: The lithium concentrate undergoes roasting or calcination to convert it into a more soluble form. This step enhances the extractability of lithium from the ore.

   d. Acid Leaching: The roasted or calcined ore is then subjected to acid leaching, during which it is mixed with sulfuric acid or other chemicals to dissolve the lithium compounds. This solution is then processed to isolate the lithium.

4. Conversion and Purification:

   The resulting lithium-rich solution undergoes further chemical processes to convert it into a more refined and usable form. This involves removing impurities, adjusting the pH levels, and precipitating out undesirable elements.

5. Concentration and Evaporation:

   The purified lithium solution is concentrated through evaporation, which involves heating the solution to evaporate water and increase the lithium concentration.

6. Precipitation and Drying:

   The concentrated lithium solution is treated with additional chemicals to cause the lithium to precipitate out as a solid compound. This solid lithium compound is then filtered, dried, and processed into a usable lithium product.

7. Refining:

   The dried lithium product is further refined to improve its purity and remove any remaining impurities. This step is crucial for ensuring the quality and reliability of the lithium for its intended applications.

It's worth noting that the specific techniques and processes involved in lithium mining may vary depending on the type of lithium deposit (brine or hard rock) and the geological characteristics of the mining site. Additionally, environmental considerations, such as water management and waste disposal, are important factors that mining companies need to address to minimize their ecological impact and ensure sustainable practice.

3. LITHIUM VALUE CHAIN

The value chain for lithium involves various stages from exploration and extraction to processing, manufacturing, and ultimately end-use applications such as batteries, ceramics, and glass.

Lithium Mining: The first step in the lithium value chain is the extraction of lithium-bearing minerals from the Earth's crust. The exploration and extraction of lithium involves locating and evaluating deposits of lithium minerals and brines and extracting them using different methods such as conventional mining or in-situ recovery. Currently, lithium is mostly extracted from brines in South America and from hard rock mines in Australia, China, and Canada.

a. Brine Deposits: Brine deposits are large underground reservoirs of salty water that contain dissolved lithium. The extraction process involves pumping the brine into evaporation ponds, where the concentration of lithium content is facilitated through solar evaporation. After several months, the concentrated brine is further processed to extract lithium carbonate or lithium chloride.

b. Hard Rock Deposits: Hard rock deposits contain lithium minerals, such as spodumene, petalite, and lepidolite. Mining operations extract the lithium-bearing ore, which is then crushed and heated to convert it into a more soluble form. Chemical processes are employed to extract lithium carbonate or lithium hydroxide from the ore.

Lithium Refining: Once lithium has been extracted from either brine or hard rock sources, it undergoes refining to purify and enhance its quality. The refining process can vary depending on the initial form of lithium obtained. The processing may involve several steps, including crushing, milling, and flotation, among others.

a. Lithium Carbonate: Lithium carbonate is a common form of lithium obtained from both brine and hard rock sources. The refining process involves converting lithium carbonate into a high-purity form suitable for further processing. Impurities like iron, aluminum, and other metal ions are removed through precipitation and filtration techniques.

b. Lithium Hydroxide: Lithium hydroxide is another refined form of lithium that is often preferred for certain applications, such as lithium-ion batteries. It is typically produced from lithium carbonate through a chemical conversion process that involves reacting it with sodium hydroxide.

Lithium Chemical Production: Once the lithium has been refined into lithium carbonate or lithium hydroxide, it can be further processed into various chemical compounds used in different industries.

a. Lithium-ion Batteries: Lithium carbonate or lithium hydroxide is a crucial ingredient in the production of lithium-ion batteries, which are widely used in electric vehicles, portable electronics, and renewable energy storage systems. The refined lithium chemicals are combined with other materials, such as cobalt, nickel, and graphite, to manufacture battery cathodes, anodes, and electrolytes.

b. Lubricants and Greases: Lithium-based greases and lubricants are widely used in automotive, industrial, and aerospace applications. Lithium hydroxide is transformed into lithium stearate or lithium complex greases through various chemical reactions, providing excellent lubrication properties.

c. Ceramics and Glass: Lithium compounds are used in ceramics and glass manufacturing to improve thermal and mechanical properties. Lithium carbonate can be converted into lithium oxide, which acts as a flux to lower the melting temperature of glass and ceramic materials.

End Products and Applications: The final stage of the lithium value chain involves the utilization of lithium-based products across multiple industries. Lithium compounds are then used in various manufacturing processes, such as the production of lithium-ion batteries, glass and ceramics, and lubricants. The lithium compounds are transported to manufacturers and end-users through various channels, including pipelines, trucks, and ships. The final stage of the value chain involves the use of lithium compounds in various applications, such as batteries, glass, ceramics, lubricants, and pharmaceuticals.

a. Electric Vehicles (EVs): Lithium-ion batteries power electric vehicles, enabling sustainable transportation with reduced emissions. The growing demand for EVs is driving the need for lithium as a critical component.

b. Energy Storage Systems: Lithium-ion batteries are essential for grid-scale energy storage, allowing renewable energy sources like solar and wind to be stored and utilized efficiently. These systems contribute to the integration of renewable energy into the power grid.

c. Consumer Electronics: Lithium-ion batteries power a wide range of consumer electronics, including smartphones, laptops, tablets, and wearable devices. The high energy density and long life cycle of lithium-ion batteries make them ideal for EVs.

4. LITHIUM ECONOMY

4.1 Channels of trade

The channels of trade for lithium are diverse, reflecting the global nature of the lithium market and the different stages of the lithium value chain. Here are some of the main channels of trade for lithium:

Mining companies:

Lithium is primarily produced by mining companies, which extract lithium from ores or brines and then sell the lithium to downstream manufacturers. Mining companies typically sell their lithium products to chemical companies, battery manufacturers, or traders.

Chemical companies:

Chemical companies are major buyers of lithium, as they use it to produce lithium compounds such as lithium carbonate and lithium hydroxide, which are used in the production of lithium-ion batteries. Chemical companies typically sell their lithium compounds to battery manufacturers, electronic companies, and other end-users.

Battery manufacturers:

Battery manufacturers are major buyers of lithium compounds, which they use to produce lithium-ion batteries for a variety of applications, including electric vehicles and consumer electronics. Battery manufacturers typically sell their batteries to end-users, including automotive companies and electronics manufacturers.

Traders:

Traders play an important role in the lithium market, buying and selling lithium products on behalf of mining companies, chemical companies, battery manufacturers, and other end-users. Traders typically buy lithium products from producers and then sell them to buyers in other parts of the world.

End-users:

End-users include a wide range of industries, including automotive, electronics, and energy storage. End-users typically buy lithium products from chemical companies, battery manufacturers, or traders and use them to produce finished products such as electric vehicles or consumer electronics.

Overall, the channels of trade for lithium are complex, reflecting the global nature of the lithium market and the different stages of the lithium value chain. Lithium products are typically sold through a series of intermediaries, including mining companies, chemical companies, battery manufacturers, traders, and end-users, each adding value to the product along the way.

4.2 Price development

The development of lithium prices has been influenced by several factors over the past few years, including changes in supply and demand, geopolitical issues, and technological advancements.

2015−2017: During this period, lithium prices saw a significant increase due to growing demand for lithium-ion batteries, which are used in electric vehicles and energy storage systems. The price of lithium carbonate increased by over 50% in 2015 and by over 30% in 2016. This led to an increase in production of lithium from new and existing producers, and an influx of investment into the lithium industry.

2018−2019: In 2018, the lithium market experienced a period of oversupply due to a surge in production from new and existing mines. This led to a decline in lithium prices, with the price of lithium carbonate falling by around 20% in the second half of 2018. The oversupply was compounded by the slowdown in the Chinese electric vehicle market, which is the largest consumer of lithium-ion batteries. The oversupply led to a correction in the lithium market and resulted in some companies delaying or cancelling their expansion plans.

2020−2021: The lithium market rebounded in 2020 due to several factors, including the recovery of the Chinese electric vehicle market, the increasing demand for energy storage systems, and the growth of the electric vehicle market in Europe. Additionally, the COVID-19 pandemic led to disruptions in the supply chain, which resulted in a temporary shortage of lithium supply. As a result, lithium prices saw a sharp increase, with the price of lithium carbonate increasing by over 80% from the beginning of 2020 to mid-2021.

2022–Present: In early 2022, lithium prices began to decline due to several factors, including increasing supply from new mines, the easing of disruptions in the supply chain caused by the pandemic, and the easing of uncertainty surrounding government policies regarding electric vehicles and energy storage systems (Figure 2).

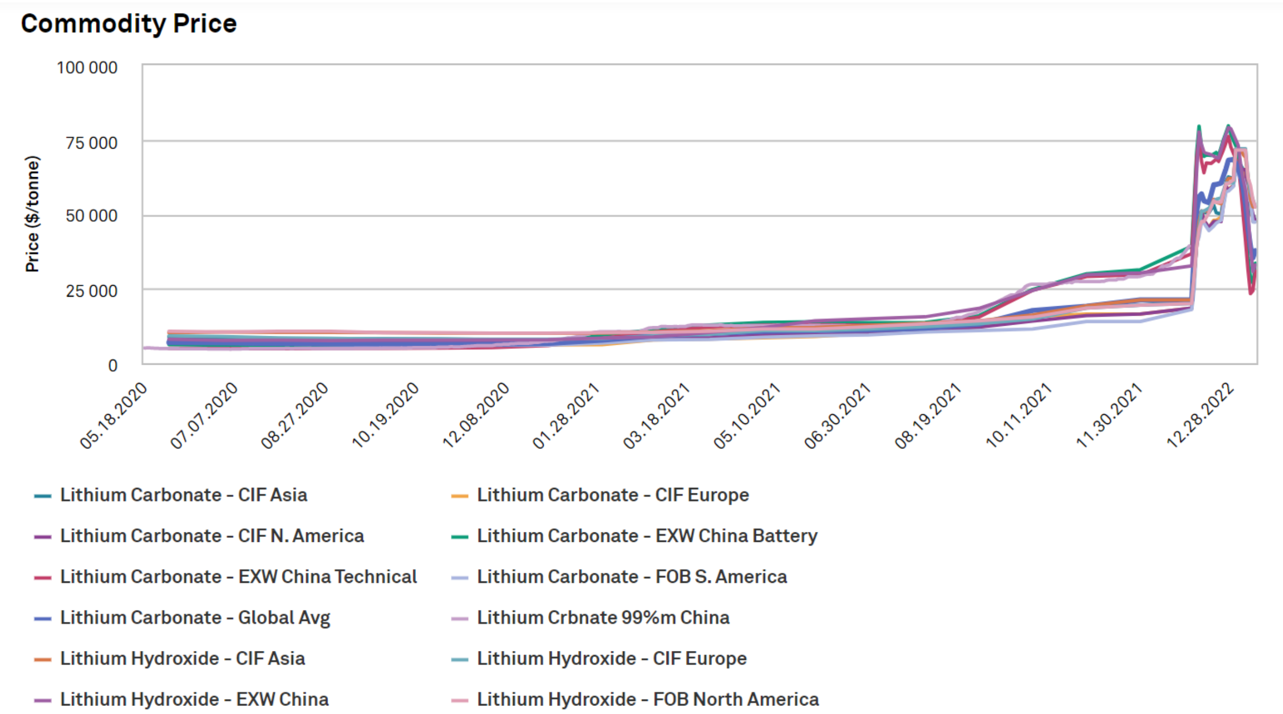


Figure 2: Commodity prices lithium (S&P Global 2023).

Typically, commodity prices are shown in CIF, EXW or FOB price.

In case of CIF (Cost Insurance and Freight) the buyer will demand that the seller assume risk or secure insurance for the good till the destination port. The risk of the products up until the destination port is assumed by the seller, who also pays for all shipping expenses. The buyer is responsible of paying the duty, but the vendor is also in charge of clearing customs.

EXW is the simplest shipping Incoterm a provider can offer. The seller makes the item accessible for factory pick-up but is not liable for it once it has left the building. The buyer is responsible of shipping it all the way from the factory and is also responsible for paying for any export and import clearance fees and insurance.

FOB refers to the shipping of the products to the closest port, after which the seller is in charge of all further arrangements. The Buyer will either pick it up themselves or, more frequently, work with a goods forwarder to send it for them after the Seller drops it off at the port of shipment. The seller must authorise the products for export, and the buyer is in charge of the commodities after they arrive at the port. It's crucial to have the name of the port where the products will be delivered when requesting FOB estimates.

Overall, the development of lithium prices has been influenced by various factors, including changes in supply and demand, geopolitical issues, and technological advancements. The lithium market is expected to continue to grow in the coming years due to the increasing demand for electric vehicles and energy storage systems, which will likely result in price volatility and fluctuations in supply and demand.

4.3 Supply

The global mine production of lithium was estimated to be around 130,000 metric tons of lithium content per year, in 2022 (Figure 3). It's important to note that this is an approximate figure and can vary depending on various factors such as production rates, new mining projects, and changes in market conditions.

Australia, Chile, and China have traditionally been the largest producers of lithium, accounting for a significant portion of the global supply. Australia, in particular, has been a leading producer with significant lithium resources and several established mines. Chile, on the other hand, has vast lithium reserves in the form of lithium-rich brine deposits.

It's worth noting that the global supply of lithium has been increasing in recent years to meet the growing demand driven by the rise of electric vehicles, renewable energy storage systems, and other lithium-ion battery applications. With the expansion of lithium mining projects and increased production capacities in various regions, the global supply has been experiencing growth to keep up with the market demand. However, it's important to monitor the evolving supply situation as the demand for lithium continues to rise. Factors such as the development of new mining projects, advancements in lithium recycling technologies, and potential supply chain constraints can impact the global supply amount of lithium.

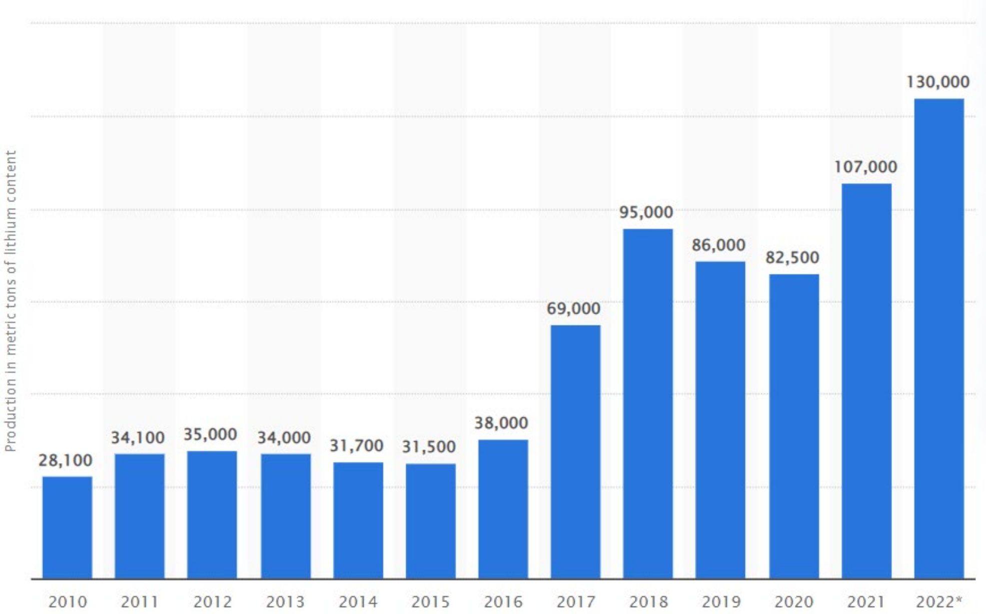


Figure 3: Mine production of lithium worldwide from 2010 to 2021 (in metric tons of lithium content) (Statista 2023).

Global lithium supply was about 450,000 tons LCE in 2021 and it is expected to increase in the current decade to approximately higher than 1 Mio tons of LCE. Several consultancies (Fitch, Benchmark Int., Bank of America, BMO and Citi) forecasted LCE supply until 2025 (Figure 4). It varies between approximately 1 Mio tons LCE to 1.3 Mio tons LCE.

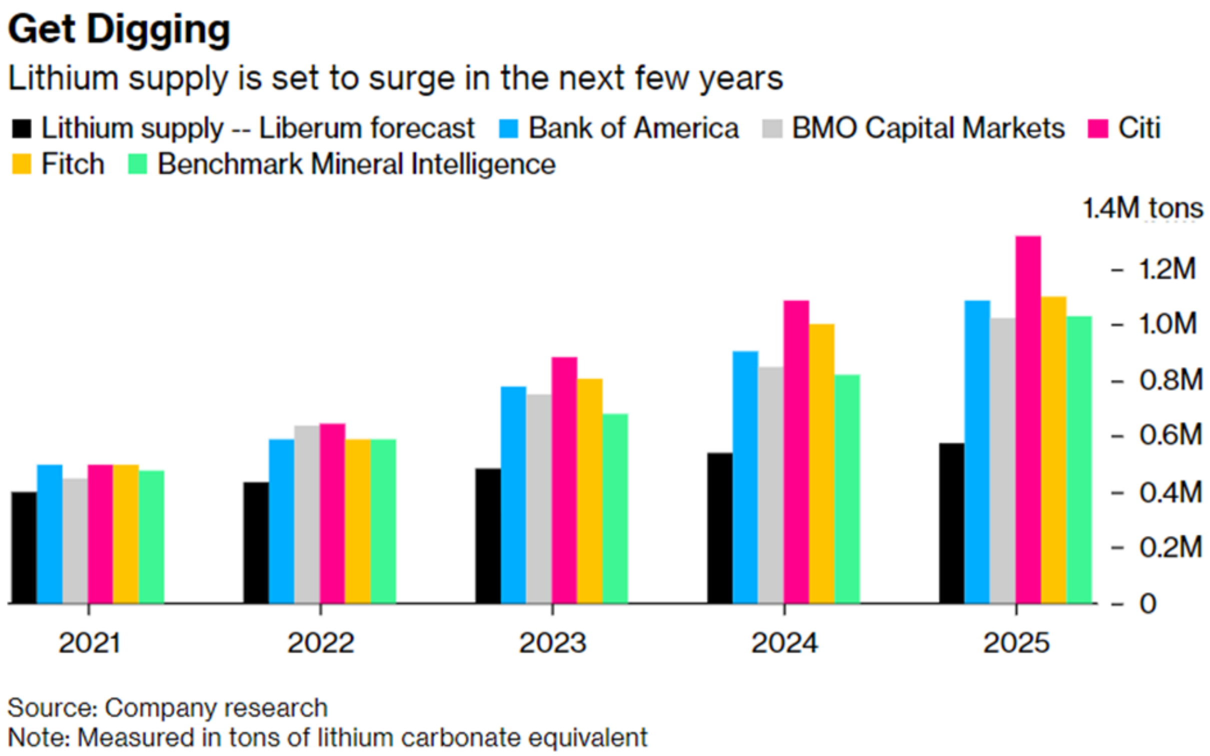


Figure 4: Lithium supply forecast (LCE) until 2025 (Bloomberg 2022).

Lithium supply impact factors

The global supply of lithium has been characterized by a growing demand and increasing production capacity to meet that demand. However, it's important to note that the supply situation can evolve rapidly.

Major Producers:

The majority of global lithium production is concentrated in a few countries. Australia, Chile, and China have been the leading producers of lithium, accounting for a significant portion of the global supply. Other countries with notable lithium production include Argentina, Zimbabwe, and Canada.

Mining Methods:

Lithium is typically produced through two primary methods: traditional mining and brine extraction. Traditional mining involves the extraction of lithium from hard rock deposits, while brine extraction involves extracting lithium from saltwater brine pools. Both methods have their unique challenges and considerations.

Expanding Production Capacities:

In response to the growing demand for lithium, many companies and countries have been actively expanding their production capacities. New lithium mining projects and expansion plans have been announced in various regions, including Australia, Argentina, and the United States.

Lithium Recycling:

In addition to primary production, lithium recycling has gained attention as a means of supplementing the supply and reducing environmental impact. Recycling lithium from batteries and other electronic devices can recover valuable lithium resources and reduce reliance on new mining activities.

Potential Supply Constraints:

While lithium resources are abundant globally, there are concerns about potential supply constraints in the future due to factors such as increasing demand, geopolitical considerations, and environmental regulations, e.g. Chile is going to nationalize country's lithium industry and Mexico doing the same to its lithium deposits. However, technological advancements, exploration efforts, and the development of new lithium sources can help mitigate these concerns.

Market Price and Volatility:

The increasing demand for lithium, coupled with potential supply constraints, has contributed to price volatility in the lithium market. Price fluctuations can impact the cost-effectiveness of lithium-based technologies and influence investment decisions in the industry.

It's worth noting that the supply situation for lithium can be influenced by various factors, including market dynamics, technological advancements, government policies, and environmental considerations.

4.4 Demand

The demand for lithium has been growing rapidly, driven by several factors including the increasing adoption of electric vehicles (EVs), renewable energy storage systems, and portable electronics. The demand for lithium is closely tied to the expansion of these industries and the global push for clean energy and decarbonization. Here are some key points about the demand for lithium:

Electric Vehicles (EVs):

The electrification of transportation, particularly the growing market for electric vehicles, has been a major driver of lithium demand. Lithium-ion batteries are the preferred choice for EVs due to their high energy density and long life cycle. As governments and consumers prioritize sustainable transportation solutions, the demand for lithium in EV batteries has been steadily increasing.

Renewable Energy Storage:

Lithium-ion batteries play a crucial role in storing energy generated from renewable sources like solar and wind power. These batteries help address the intermittency of renewable energy generation and facilitate the integration of renewable energy into the grid. As the share of renewable energy in the global energy mix continues to grow, the demand for lithium-based energy storage systems is expected to rise.

Portable Electronics and Energy Storage:

Lithium-ion batteries are widely used in portable electronics such as smartphones, laptops, tablets, and wearable devices. The increasing reliance on these devices in daily life has contributed to sustained demand for lithium. Additionally, the need for energy storage solutions in various industries, including telecommunications, industrial applications, and grid-scale storage, has further bolstered the demand for lithium.

Energy Transition and Government Policies:

Government initiatives and policies aimed at reducing carbon emissions and transitioning to clean energy sources have been significant drivers of lithium demand. Many countries have set ambitious targets for EV adoption and renewable energy generation, creating a favorable environment for the growth of the lithium industry.

Technological Advancements and Innovation:

Ongoing research and development efforts to improve battery technologies and increase energy storage capacity have also contributed to the increasing demand for lithium. Advances in lithium-ion battery chemistry, including higher energy density and longer lifespan, continue to drive the demand for lithium.

It's important to note that the demand for lithium is expected to continue growing in the coming years as the transition to clean energy technologies accelerates. However, the specific demand figures can vary depending on various factors such as market conditions, policy support, and advancements in battery technologies.

5. LITHIUM VALUE CHAIN BOTTLENECKS

The lithium value chain includes several stages, including exploration, mining, processing, refining, and manufacturing of batteries or other products that use lithium. Here are some potential bottlenecks that could impact the efficiency and effectiveness of the lithium value chain:

1. Limited lithium resources: According to **the United States Geological Survey (USGS)**, the world's identified lithium resources in 2020 were estimated to be 80 million metric tons (MT), with the majority of the reserves located in Australia, Chile, Argentina, and China (USGS 2021). However, the potential for resource constraints remains, as the demand for lithium is expected to continue to rise rapidly in the coming years due to its use in electric vehicle (EV) batteries and other applications.
2. Mining challenges: Both hard rock mining and brine extraction have their challenges. Hard rock mining requires significant energy input and creates a significant amount of waste, which can lead to environmental impacts. On the other hand, brine extraction involves large quantities of water, which can lead to competition with other water users and environmental concerns related to the disposal of the brine after extraction.
3. Processing and refining: According to a 2020 report by the **International Energy Agency (IEA)**, the lithium-ion battery value chain is currently the largest source of energy-related carbon emissions, with processing and refining accounting for around 40% of the total emissions (IEA, 2021). The report also notes that scaling up production and reducing emissions will require significant investment in infrastructure and new technologies.
4. Battery manufacturing: The production of high-quality lithium-ion batteries is essential for the success of the EV market, which is projected to grow rapidly in the coming years. However, manufacturing batteries is a complex process that requires significant investment in research and development, quality control, and worker training. A report by the **World Economic Forum (WEF)** estimates that global demand for EV batteries could reach 1,200 GWh by 2030, up from just 70 GWh in 2016 (Word Economic Forum 2019).
5. Recycling and disposal: According to the IEA report mentioned earlier, the recycling rate for lithium-ion batteries is currently less than 5%, which means that the majority of the lithium, cobalt, nickel, and other valuable materials used in battery production are lost (IEA 2021). The report notes that scaling up recycling capacity will be essential to meet future demand for these materials and reduce the environmental impact of battery production.
6. Transportation: The lithium value chain is global, with raw materials and finished products transported across multiple countries and regions. This requires significant investment in transportation infrastructure, including ports, roads, and rail systems. Additionally, the transportation of lithium-ion batteries poses unique safety risks, which require specialized handling and regulatory compliance.

Overall, the bottlenecks of the lithium value chain are complex and interconnected. Addressing these challenges will require cooperation and investment across the entire value chain to ensure the efficient and sustainable production and use of lithium.

6. NEW TECHNIQUES

6.1 IEA report

The IEA report, titled "The Role of Critical Minerals in Clean Energy Transitions", highlights the critical importance of minerals such as lithium, cobalt, and nickel in the transition to a low-carbon energy system (IEA 2021). According to the report, the demand for these minerals is expected to grow significantly in the coming decades, as countries around the world seek to decarbonize their economies (IEA 2021).

In particular, the report notes that the demand for lithium is expected to increase by more than 40 times by 2040, compared to current levels (IEA 2021). This growth in demand is being driven by the adoption of electric vehicles, which require large amounts of lithium-ion batteries, as well as other clean energy technologies such as grid-scale energy storage (IEA 2021).

However, the report also highlights the challenges associated with the current methods of lithium extraction, which can be expensive and environmentally damaging (IEA 2021). In addition, the report notes that the concentration of lithium resources is geographically limited, with the majority of known reserves located in just a few countries (IEA 2021).

To address these challenges, the report suggests that new and more sustainable methods of lithium extraction will be needed (IEA 2021). One approach that the report highlights is Direct Lithium Extraction (DLE), which involves extracting lithium ions directly from brine or other solutions, without the need for traditional mining and processing methods.

The report notes that DLE technologies are still in the early stages of development but have the potential to significantly reduce the environmental impact and cost of lithium production (IEA 2021). However, the report also cautions that significant technical and economic challenges remain, and that it will be important to develop new and innovative business models to support the development and deployment of DLE technologies.

In conclusion, the IEA report highlights the critical importance of lithium in the transition to a low-carbon energy system and emphasizes the need for new and more sustainable methods of lithium extraction (IEA 2021). The report suggests that DLE technologies could play an important role in meeting the growing demand for lithium, but notes that significant challenges remain (IEA 2021).

The IEA report "The Role of Critical Minerals in Clean Energy Transitions" was published by the International Energy Agency (IEA) in May 2021. The report can be found on the IEA's website: https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions.

6.2 New techniques in lithium mining & processing

New techniques in lithium mining and processing are being developed and tested to improve the efficiency, sustainability, and environmental impact of the lithium value chain. Here are some examples of new techniques in lithium mining and processing:

Direct lithium extraction (DLE):

DLE is a process that involves pumping lithium-rich brine from underground reservoirs and then extracting the lithium using specialized ion exchange membranes or sorbents. DLE is faster, more efficient, and more environmentally friendly than traditional evaporation methods.

Selective mining:

Selective mining is a technique that involves identifying and mining only the highest-grade lithium deposits, reducing waste and environmental impact while increasing production efficiency.

Solvent extraction:

Solvent extraction is a process that involves using solvents to selectively extract lithium from ores or brines, allowing for more efficient and sustainable lithium extraction.

Recirculation technology:

Recirculation technology involves using the waste brine from lithium production to produce fresh water, reducing water consumption and improving sustainability.

Sustainable energy sources:

Lithium producers are increasingly using sustainable energy sources such as solar and wind power to power their operations, reducing their carbon footprint and improving sustainability.

Recycling:

Lithium-ion battery recycling technologies are being developed and improved to recover valuable metals such as lithium, cobalt, and nickel from used batteries, reducing the pressure on primary lithium sources and providing a sustainable source of raw materials for the future.

Overall, new techniques in lithium mining and processing are focused on improving efficiency, sustainability, and environmental impact. Lithium producers and researchers are investing in innovative technologies that can help to address the environmental and social impacts of lithium production while meeting the growing demand for lithium-ion batteries.

6.3 DLE (Direct Lithium Extraction)

The text in chapter 6.3 is based on Yan, Y. (2019), U.S. Department of Energy (2020) and Zhang et al. (2020).

DLE is an emerging technology for extracting lithium from brine or other sources of lithium-containing solutions. Traditional lithium extraction methods involve mining lithium-bearing rocks, such as spodumene, and then processing the ore to extract the lithium. This process can be expensive and environmentally damaging, and it may not be feasible in some areas where lithium resources are located. DLE, on the other hand, offers the potential for more sustainable and cost-effective lithium extraction. By directly extracting lithium ions from brine or other solutions, DLE can reduce the environmental footprint of lithium production and lower the cost of production.

There are several different DLE technologies being developed, each with its own advantages and challenges:

Adsorption:

This method involves using a sorbent material to selectively adsorb lithium ions from solution. The sorbent material is then treated to recover the lithium, which can be used in battery production. One advantage of this method is that it can be easily scaled up for commercial production. One example of an adsorption based DLE technology is the Lithium Adsorption Technology (LAT) developed by Standard Lithium (Standard Lithium 2022).

Membrane separation:

This method involves using a membrane to selectively separate lithium ions from other ions in solution. The separated lithium ions can then be recovered and used in battery production. One advantage of this method is that it can be more energy efficient than other DLE methods. One example of a membrane based DLE technology is the Direct Lithium Extraction (DLE) technology developed by E3 Lithium (E3 Lithium 2022).

Precipitation:

This method involves adding a chemical agent to the solution to selectively precipitate lithium ions. The precipitated lithium can then be recovered and used in battery production. One advantage of this method is that it can be easily integrated into existing brine processing operations.

Despite the potential benefits of DLE, there are still many technical and economic challenges that must be overcome before these technologies can be deployed at a large scale. For example, DLE methods may require large amounts of energy or chemicals to extract lithium ions, which could increase the cost and environmental footprint of lithium production. In addition, DLE technologies may require significant capital investment to build and operate, which could limit their adoption in the short term.

Nevertheless, the demand for lithium is expected to continue to grow rapidly in the coming years, driven by the increasing adoption of electric vehicles and other clean energy technologies. According to a report by the International Energy Agency (IEA), the demand for lithium could increase by more than 40 times by 2040, compared to current levels (IEA 2021). This growth in demand is expected to put significant pressure on lithium producers to find new and more sustainable ways to extract lithium (IEA 2021).

In conclusion, DLE is an emerging technology for extracting lithium that offers the potential for more sustainable and cost-effective production. While there are still many challenges to be overcome, DLE technologies are being developed by a number of companies and could play an important role in meeting the growing demand for lithium in the global transition to a cleaner energy future.

6.4 Selective Mining

Lithium selective mining refers to the process of selectively extracting lithium-containing minerals from a mining site while minimizing the extraction of non-lithium minerals. The goal of lithium selective mining is to optimize the lithium recovery and reduce processing costs by focusing on the targeted lithium-rich materials. The selective mining of lithium involves various techniques and strategies, depending on the type of lithium deposit being mined. Here are a few methods commonly employed in lithium selective mining:

Geophysical Surveys:

Geophysical surveys, such as electromagnetic (EM) surveys or induced polarization (IP) surveys, can be conducted to identify and map areas with higher lithium concentrations. These surveys measure the electrical properties of the subsurface, helping to locate lithium-rich zones within the deposit.

Resource Characterization:

Through thorough geological studies, including drilling and sampling, lithium-rich zones can be characterized based on their lithology, mineralogy, and lithium grade. This allows miners to target specific areas with higher lithium content during extraction.

Ore Sorting:

Ore sorting technologies can be utilized to separate lithium-bearing rocks from non-lithium materials early in the mining process. These technologies use sensors and sorting algorithms to identify and separate the desired lithium ore from waste rock, improving overall efficiency and reducing processing costs.

Grade Control:

Continuous grade control measures are implemented throughout the mining operation to monitor the lithium grade being extracted in real-time. This enables adjustments in mining operations to focus on areas with higher lithium grades and optimize the lithium recovery process.

Environmental Considerations:

Lithium selective mining also takes into account environmental considerations, aiming to minimize the impact on surrounding ecosystems and minimize the generation of waste. This can include appropriate waste management practices and the implementation of sustainable mining techniques.

By employing lithium selective mining techniques, mining companies can enhance the efficiency of lithium extraction, reduce costs, and maximize the recovery of valuable lithium resources while minimizing the extraction of non-lithium materials.

6.5 Solvent Extraction

Solvent extraction, also known as liquid-liquid extraction or solvent extraction-ion exchange (SX-IX), is a common method used for the separation and purification of lithium from a liquid solution. It is often employed in the lithium mining and processing industry to extract lithium from brine solutions or other lithium-containing solutions.

Solvent extraction processes for lithium:

Feed Solution:

The process begins with a feed solution that contains lithium ions, along with other impurities or unwanted elements. The feed solution can be derived from lithium-rich brine, lithium-bearing minerals, or other sources.

Extraction Solvent:

An organic solvent, known as the extractant, is selected based on its ability to selectively bind with lithium ions and separate them from other elements in the feed solution. Commonly used extractants for lithium extraction include organic compounds such as crown ethers, calixarenes, or other lithium-selective ligands.

Contacting and Mixing:

The feed solution and the extraction solvent are brought into contact and mixed together. This allows the lithium ions to transfer from the aqueous phase of the feed solution to the organic phase of the extraction solvent. The solvent and the feed solution are typically mixed in an extraction mixer or stirred tank to facilitate mass transfer.

Selective Extraction:

The extraction solvent selectively captures the lithium ions due to its affinity for lithium. The lithium ions form complexes with the extractant molecules, which are soluble in the organic phase. Meanwhile, other impurities or unwanted elements tend to remain in the aqueous phase.

Phase Separation:

After sufficient contact time, the mixture of the extraction solvent and the feed solution is allowed to settle or is passed through a separation unit such as a settler or centrifuge. The organic phase, containing the lithium complex, separates from the aqueous phase.

Stripping:

The next step involves the separation of lithium from the extraction solvent to obtain a concentrated lithium solution. This is achieved by contacting the loaded organic phase with a stripping solution or a different solvent that has a stronger affinity for lithium than the extractant. The lithium ions transfer from the extraction solvent to the stripping solution, forming a concentrated lithium-rich solution.

Recovery and Purification:

The concentrated lithium solution obtained from the stripping process is subjected to further purification steps to remove any remaining impurities or unwanted elements. These purification techniques can include precipitation, crystallization, or other chemical processes specific to the desired lithium compound.

Solvent extraction is an effective method for selectively extracting lithium from liquid solutions and obtaining concentrated lithium solutions suitable for further processing or conversion into various lithium compounds. It allows for the efficient separation and purification of lithium while minimizing the co-extraction of unwanted elements, facilitating the production of high-quality lithium products.

6.6 Recirculation technology

Recirculation technology, also known as closed-loop extraction or closed-loop processing, is an innovative approach used in lithium extraction from brine solutions. It aims to improve the efficiency and sustainability of the lithium recovery process by reducing water consumption, minimizing environmental impact, and increasing lithium extraction rates.

Overview of recirculation technology for lithium extraction:

Brine Extraction:

The process starts with the extraction of lithium-rich brine from underground aquifers or salar deposits. The brine contains dissolved lithium ions along with other minerals and impurities.

Pre-Treatment:

Before entering the recirculation loop, the brine undergoes pre-treatment steps to remove solid particles, organic matter, and other contaminants. This pre-treatment may involve filtration, sedimentation, or other processes to improve the quality of the brine.

Recirculation Loop:

In recirculation technology, the brine is continuously circulated in a closed-loop system. The loop typically consists of various processing stages, including extraction, concentration, purification, and lithium recovery.

Selective Extraction:

Within the recirculation loop, the brine is directed to an extraction stage where lithium is selectively extracted from the brine. Various techniques, such as solvent extraction, ion exchange, or membrane processes, may be employed to selectively capture and separate the lithium ions from other elements.

Concentration:

After the extraction stage, the lithium-enriched brine undergoes concentration processes to increase the lithium concentration. This can be achieved through evaporation, precipitation, or other techniques to reduce the brine volume and increase the lithium content.

Purification:

The concentrated lithium brine is then subjected to purification steps to remove impurities and unwanted elements. Purification techniques may involve additional chemical processes, filtration, or adsorption to enhance the purity of the lithium solution.

Lithium Recovery:

In the final stage of the recirculation loop, the purified lithium solution is processed to recover lithium in the desired form. This may involve precipitation, electrolysis, or other techniques to convert the lithium ions into a solid compound or extract lithium metal.

Recirculation and Water Management:

One of the key aspects of recirculation technology is the efficient use of water resources. Instead of disposing of the brine after lithium extraction, the brine is recirculated back into the closed-loop system for further processing. This minimizes water consumption and reduces the environmental impact associated with brine disposal.

Sustainability Considerations:

Recirculation technology aims to promote sustainable practices in lithium extraction by minimizing water usage, reducing energy requirements, and optimizing resource utilization. It helps mitigate the environmental impact of lithium extraction and supports the responsible development of lithium resources.

Recirculation technology offers a more sustainable and efficient approach to lithium extraction from brine sources, contributing to the growth of the lithium industry while minimizing its environmental footprint.

6.7 Sustainable Energy Resources

Sustainable energy resources for lithium primarily refer to renewable energy sources used in the extraction and processing of lithium, as well as the operation of lithium-ion battery manufacturing facilities. Here are some examples:

Solar Power:

Solar energy is a sustainable resource widely used to power lithium mining and processing operations. Photovoltaic (PV) solar panels convert sunlight into electricity, which can be utilized for various stages of lithium production, including mining, crushing, beneficiation, and chemical processes. Solar power helps reduce the carbon footprint and reliance on fossil fuels in the lithium supply chain.

Wind Power:

Wind energy is another sustainable resource that can be harnessed to support lithium operations. Wind turbines generate electricity from the kinetic energy of the wind, providing a clean and renewable energy source for mining activities, processing plants, and battery manufacturing facilities. Integrating wind power helps reduce greenhouse gas emissions associated with conventional energy sources.

Geothermal Energy:

Geothermal power utilizes the heat energy from the Earth's subsurface to generate electricity. Geothermal power plants can provide a sustainable energy source for lithium extraction and processing operations, particularly in regions with geothermal resources. Direct use of geothermal heat may also be employed in certain stages of lithium production.

Hydropower:

Hydropower harnesses the energy of flowing water to generate electricity. Hydroelectric power plants can supply sustainable energy to lithium operations, such as powering mining machinery, operating mineral processing facilities, and supporting battery manufacturing. Hydroelectricity is considered a reliable and renewable energy resource.

Biomass Energy:

Biomass refers to organic materials derived from plants or animals. Biomass energy can be generated through processes like combustion, gasification, or anaerobic digestion. Biomass power plants can provide renewable energy for various stages of lithium production, offering an alternative to fossil fuel-based energy sources.

Grid Integration and Offsetting:

In addition to on-site renewable energy generation, lithium companies can prioritize purchasing electricity from sustainable energy sources on the grid. By sourcing electricity from renewable energy providers, they contribute to the overall demand for renewable energy and support the transition to a low-carbon energy system.

Furthermore, sustainable practices in the lithium industry extend beyond energy resources. They also encompass responsible mining practices, efficient water management, recycling initiatives for lithium-ion batteries, and promoting social and environmental responsibility throughout the supply chain.

The adoption of sustainable energy resources in the lithium industry helps reduce greenhouse gas emissions, decrease dependence on finite fossil fuel resources, and mitigate the environmental impact associated with lithium extraction and battery production.

6.8 Recycling

Lithium recycling, also known as lithium-ion battery recycling or battery recycling, involves the recovery and reuse of lithium and other valuable materials from spent or end-of-life lithium-ion batteries. Recycling lithium-ion batteries is crucial for reducing waste, conserving resources, and minimizing the environmental impact associated with battery production.

Lithium recycling process:

Collection and Sorting:

The first step in lithium recycling is the collection and sorting of used lithium-ion batteries. This can be done through various channels, including dedicated battery recycling centers, collection programs, and partnerships with battery manufacturers, retailers, and electronic waste management organizations. Batteries are sorted based on their chemistry, size, and type for efficient recycling.

Battery Discharge:

Before processing, collected batteries are discharged to minimize the risk of thermal events or short circuits during handling and recycling. This is typically done through a controlled discharge process that safely depletes the battery's energy.

Mechanical Shredding:

The batteries undergo mechanical shredding, which involves breaking them down into smaller pieces or fragments. This step helps expose the internal components of the battery for further processing.

Hydrometallurgical Treatment:

The shredded battery fragments are subjected to a hydrometallurgical treatment. In this step, the battery materials are submerged in a liquid solution, usually an acid, to dissolve and separate different components. The solution helps break down the battery and extract valuable materials, including lithium, cobalt, nickel, manganese, and other metals.

Separation and Recovery:

Through a combination of physical and chemical processes, the dissolved materials are separated from the solution. Techniques such as precipitation, solvent extraction, ion exchange, and filtration are used to isolate and recover the desired elements, including lithium.

Purification and Refining:

The recovered lithium undergoes purification processes to remove impurities and contaminants, ensuring the quality and suitability of the recovered lithium for reuse. The purification methods can include precipitation, filtration, electrolysis, or other chemical treatments.

Recycled Material Processing:

The recovered lithium and other valuable materials are further processed and prepared for reuse. This can involve refining the recovered metals into usable forms or preparing them for incorporation into new battery manufacturing or other applications.

Reuse and Manufacturing:

The recycled lithium and other recovered materials are reintegrated into the manufacturing process for new lithium-ion batteries or other applications. The recycled materials can substitute for virgin materials, reducing the reliance on primary mining and minimizing the environmental impact associated with raw material extraction.

Waste Management:

Throughout the recycling process, proper waste management and environmental safeguards are implemented to ensure the safe handling and disposal of any residual waste or by-products.

Lithium recycling plays a crucial role in closing the materials loop, reducing resource depletion, and minimizing the environmental impact of lithium-ion batteries. It allows for the recovery of valuable materials, including lithium, and promotes a more sustainable and circular approach to battery production and consumption.

7. TRENDS TO SUBSTITUTE LITHIUM

7.1 Battery manufacturing

There is ongoing research and development to explore alternative materials to replace or reduce the use of lithium in battery manufacturing. Some of the potential trends to substitute lithium include:

Sodium-ion batteries:

Sodium is more abundant and less expensive than lithium, which makes it a potentially attractive alternative for battery manufacturing. Researchers are currently exploring the development of sodium-ion batteries, which can potentially offer similar performance to lithium-ion batteries.

Solid-state batteries:

Solid-state batteries use a solid electrolyte instead of a liquid one, which can potentially offer higher energy density and safety compared to traditional lithium-ion batteries. Solid-state batteries can potentially use alternative materials to lithium, such as sodium or magnesium.

Zinc-ion batteries:

Zinc is another abundant and low-cost material that is being explored for use in battery manufacturing. Zinc-ion batteries are currently in development and could potentially offer comparable performance to lithium-ion batteries.

Lithium-sulfur batteries:

Lithium-sulfur batteries use sulfur as the cathode material, which is a cheaper and more abundant material than cobalt or nickel, which are commonly used in lithium-ion batteries. Lithium-sulfur batteries can potentially offer higher energy density and longer life cycle compared to traditional lithium-ion batteries.

Redox flow batteries:

Redox flow batteries use two tanks of liquid electrolytes that are pumped into a cell when energy is needed. The electrolytes can potentially be made from abundant and low-cost materials, such as iron or vanadium, which could reduce the reliance on lithium for battery manufacturing.

While these technologies are promising, there are still many challenges that need to be overcome before they can be commercialized and scaled up for widespread use. Additionally, lithium is still likely to play an important role in battery manufacturing for the foreseeable future, as it offers high energy density, long cycle life, and other desirable properties that are difficult to replicate with other materials.

8. ESG

ESG (Environmental, Social, and Governance) related impacts are becoming increasingly important in the lithium value chain. Here are some ways in which ESG issues are affecting the lithium value chain:

Environmental impact:

The lithium mining and production process can have a significant environmental impact, including water use, air pollution, and habitat destruction. ESG-focused investors and stakeholders are increasingly demanding that lithium producers take steps to minimize their environmental impact, including the use of sustainable production methods and the restoration of affected areas.

Social impact:

Lithium mining and production can also have social impacts, including land-use conflicts, displacement of communities, and labor rights violations. ESG-focused investors and stakeholders are demanding that lithium producers prioritize social responsibility and ensure that they are operating in a socially responsible manner, including respecting the rights of local communities and workers.

Governance:

The governance of lithium producers is also becoming an important issue for ESG-focused investors and stakeholders. This includes issues such as transparency, board diversity, and ethical behavior. ESG-focused investors are increasingly looking for lithium producers that are committed to ethical and responsible governance practices.

Supply chain:

ESG issues are also affecting the lithium supply chain, including the sourcing of raw materials and the end-of-life disposal of lithium-ion batteries. ESG-focused investors and stakeholders are demanding that lithium producers and end-users take steps to ensure that their supply chain is sustainable and responsible, including the use of ethically sourced materials and responsible end-of-life disposal.

Overall, ESG-related impacts are becoming increasingly important in the lithium value chain. Lithium producers and end-users will need to take steps to address these issues if they want to remain competitive in the evolving ESG landscape. This includes investing in sustainable and responsible production methods, prioritizing social responsibility, improving governance practices, and ensuring a sustainable and responsible supply chain.

Example: Mina do Barroso, Portugal

The ongoing protests related to lithium mining at Mina do Barroso in Portugal can be attributed to several factors. Here are some reasons why protests may be taking place:

1. Environmental Concerns: Many activists and local residents are concerned about the potential environmental impact of lithium mining. They fear that the extraction and processing of lithium could lead to habitat destruction, water pollution, and air contamination, harming the local ecosystems and jeopardizing biodiversity.
2. Water Resources: The region already experiences water scarcity issues, and there are concerns that lithium mining operations would further strain the limited water resources. Protests may be driven by the need to protect and preserve water sources for local communities, agriculture, and natural ecosystems.
3. Health Risks: The use of chemicals and heavy metals in lithium extraction and processing raises concerns about potential health risks for nearby communities. Protesting individuals and organizations may advocate for comprehensive health studies and safeguards to ensure the safety of residents.
4. Community Disruption: The establishment of a large-scale mining operation can lead to significant disruptions for local communities. This includes potential displacement of residents, noise and dust pollution, increased traffic, and strains on local infrastructure. Protests may reflect the desire to protect community well-being and traditional livelihoods.
5. Climate Change and Energy Transition: Some protesters may argue that lithium mining, despite being a crucial component of clean energy technologies like electric vehicles and renewable energy storage, can still contribute to carbon emissions and climate change. They may demand a more comprehensive approach to the energy transition, emphasizing renewable energy sources and sustainable mining practices.
6. Transparency and Consultation: Protests may also stem from concerns about transparency, decision-making processes, and public consultation. Activists and community members may feel excluded from discussions and decisions related to the mining project, leading to calls for increased transparency, public involvement, and accountability.

Other global examples for protests against lithium mining:

Argentina:

In the province of Jujuy, Argentina, there have been protests by indigenous communities and environmental activists against lithium mining projects. The protests focus on concerns about water scarcity, pollution, and the potential displacement of local communities.

Australia:

In Western Australia, there have been protests against lithium mining projects, particularly in areas like the Pilbara region. Environmental activists and indigenous communities have raised concerns about the potential impacts on water resources, cultural heritage, and biodiversity.

Chile:

Chile is one of the largest lithium producers globally, and there have been protests and controversies surrounding lithium mining operations in the country. Some protests have centered on the extraction of lithium from brine, which can have environmental implications such as water usage and potential ecosystem disruption.

Mexico:

In Mexico, there have been protests against lithium mining projects, particularly in regions like Sonora and Baja California. Local communities and activists have raised concerns about water contamination, environmental damage, and the impact on agriculture.

United States:

In the United States, there have been protests against lithium mining projects in places like Nevada. Concerns raised by activists and local communities include potential water pollution, habitat destruction, and impacts on cultural heritage.

9. OUTLOOK

The market assessment for lithium presents a comprehensive overview of the global lithium industry, highlighting its significance in the context of clean energy technologies and the transition towards a low-carbon economy. The assessment has shed light on key aspects such as market size, trends, major players, supply chain dynamics, and future prospects.

The demand for lithium is expected to witness substantial growth in the coming years, driven by the increasing adoption of electric vehicles, renewable energy storage systems, and government initiatives to reduce carbon emissions. The market assessment has underscored the pivotal role of lithium in these sectors and its potential to revolutionize the way we produce and consume energy.

The assessment has explored the diverse methods of lithium production, including traditional mining, brine extraction, and recycling, weighing their advantages and challenges. It has provided insights into major lithium-producing countries such as Australia, Chile, China, and Argentina, assessing their reserves, production capacities, and emerging players.

Market trends and dynamics have been examined, encompassing pricing patterns, trade regulations, and technological advancements. The assessment has underscored the competitive landscape of the lithium market, profiling key industry players and analysing their market share and strategies. It has also addressed challenges and risks associated with the market, including environmental concerns and supply chain disruptions.

The regulatory landscape and evolving sustainability standards have been emphasized, highlighting the need for responsible and ethical lithium production practices. As stakeholders increasingly prioritize sustainability, the assessment underscores the importance of adopting environmentally friendly and socially responsible approaches to lithium mining and processing.

The market assessment provides a forward-looking perspective on the lithium industry. It outlines potential market drivers, challenges, and opportunities that are likely to shape the future of the market. The assessment serves as a valuable resource for industry participants, policymakers, and investors, providing them with a comprehensive understanding of the lithium market's current state and future trajectory.

In conclusion, the market assessment has demonstrated the immense potential of the lithium market, driven by the increasing demand for clean energy technologies. However, it also emphasizes the importance of responsible and sustainable practices to mitigate environmental impacts and address social concerns. With continued innovation and collaboration, the lithium industry can contribute significantly to a greener and more sustainable future.

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