Feeling Electric

Economics of the Lithium Boom & Future Implications

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Lithium Overview

- Lithium is primarily used in lithium-ion batteries and it is highly valued in cleantech for its high energy density by mass and by volume.
- Solid-state batteries promise higher energy density, but the technology is not ready for the mass market until after 2030.
- Hydrogen fuel cells are another competitor, but without mass deployment of green hydrogen tech, the cost is still twice as high (per mile) when compared to lithium-ion batteries.
- Batteries are also instrumental in microgrids, and for distributed generation of renewable energy.
- The price rally through 2021, saw the 8 kg of lithium that usually go towards a standard EV battery go up from just under US $1, at the beginning of the year to ~ $3.7 by the end.
- Analyst future outlooks for Lithium surplus or deficits vary widely - Lithium supply remains relatively elastic compared to similar metals used in battery production.
- Lithium market and mining face additional headwinds in the future, particularly political pressure from left-leaning governments, causing some uncertainty around future projections.
- The mining and trade of lithium, particularly in lithium-rich Latin American and African countries, is becoming a battleground for global juggernauts each vying for energy supremacy.
- Lithium demand is expected to outpace supply in 2022 and supply deficits are expected to continue into 2023. Price of lithium will remain high for the foreseeable future
- Boom in EV demand is one of the main culprits of the boom in lithium demand in recent years. It is expected that by 2040 more than 66 million EVs will be on the road.

Lithium Applications

There are a number of precious metals that are key to the development of clean technologies as society transitions into a low-carbon economy. One that has been making headlines lately and throughout most of 2021 is lithium, the lightest of all metals in existence. The price of lithium has seen a meteoric rise through 2021, increasing approximately 280% in that year alone. In this brief, we explore the uses of lithium towards clean technologies, the reasons for the price rally, geopolitical implications, and our outlook moving forward.

Lithium is found in trace concentrations in virtually all rocks, but larger amounts are commonly found in brine deposits and as salt metals in mineral springs. It has a plethora of uses from supplements or mood stabilizing medications, to rechargeable lithium-ion batteries. In industry, it is also commonly used in the production of synthetic plastics and as a scavenger metal to remove impurities in the refinement of other metals such as iron, nickel, zinc and their alloys. It is this industrial property that leads to lithium being used in small quantities towards most clean-technology applications like Solar Photovoltaics. Elsewhere in the low-carbon transition, the production of geothermal energy is also promising as a way to generate renewable energy with the added benefit of extracting lithium from the process. Geothermal brine is pumped up from deep in the earth's crust and separated into a gas and a mineral-rich brine from which lithium can be extracted. The gaseous component is run through a turbine used to generate clean electricity. It is this exact same process that is being considered for deposits at the Salton Sea in California, where historically, capital expenditure costs were too high and lithium prices too low to make the investment profitable.

Lithium's main application within the low-carbon transition is towards rechargeable lithium-ion batteries for electric vehicles (EVs) and energy storage. The two main benefits that lithium offers are its lightness and its large negative electrochemical potential, in comparison to other battery technologies (Figure 1). This essentially translates into batteries that are more energy dense per mass and volume (100-265 Wh/kg, and 250-670 Wh/L respectively) than any other type of rechargeable battery technology currently in existence. Lithium could also be used towards solid-state batteries, which can deliver even more energy density and weight benefits.

The main difference is that while lithium-ion batteries use a liquid electrolyte solution, typically composed of lithium salts, an all-solid-state battery would use a solid lithium electrolyzer (Figure 2). Solid-state batteries could deliver up to twice the energy density, and therefore deliver up to twice the range of current EV batteries with the same size and weight, or alternatively reduce the weight of the battery by half. The problem is that the technology is not quite developed yet, and as of right now is expected to be ready for the mass market after 2030. Meanwhile, many jurisdictions are phasing out combustion engines soon enough to require mass deployment of alternative technology sooner than 2030. An example of this is the European Union (EU) and it's plans to completely rule out combustion engines by 2035.

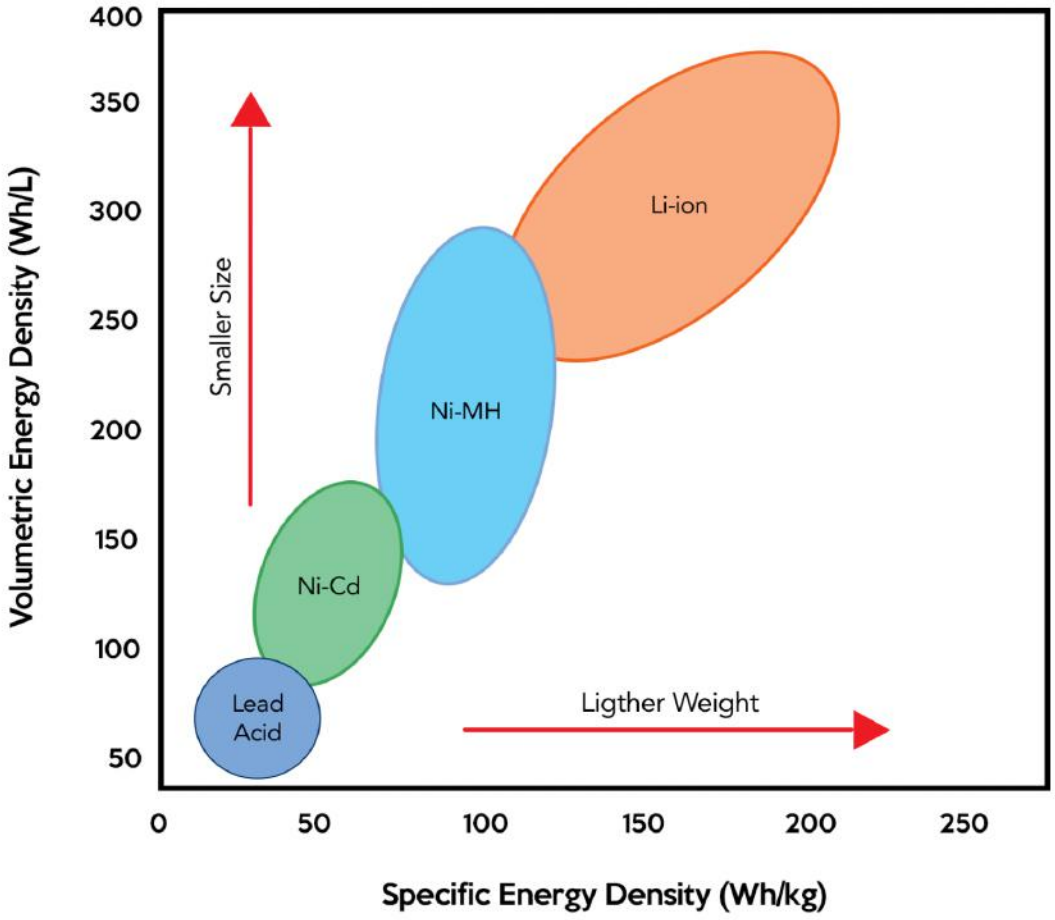


Figure 1: Specific Energy Density, and Volumetric Energy Density of contemporary battery technologies. Source: NanoPower Research Laboratories

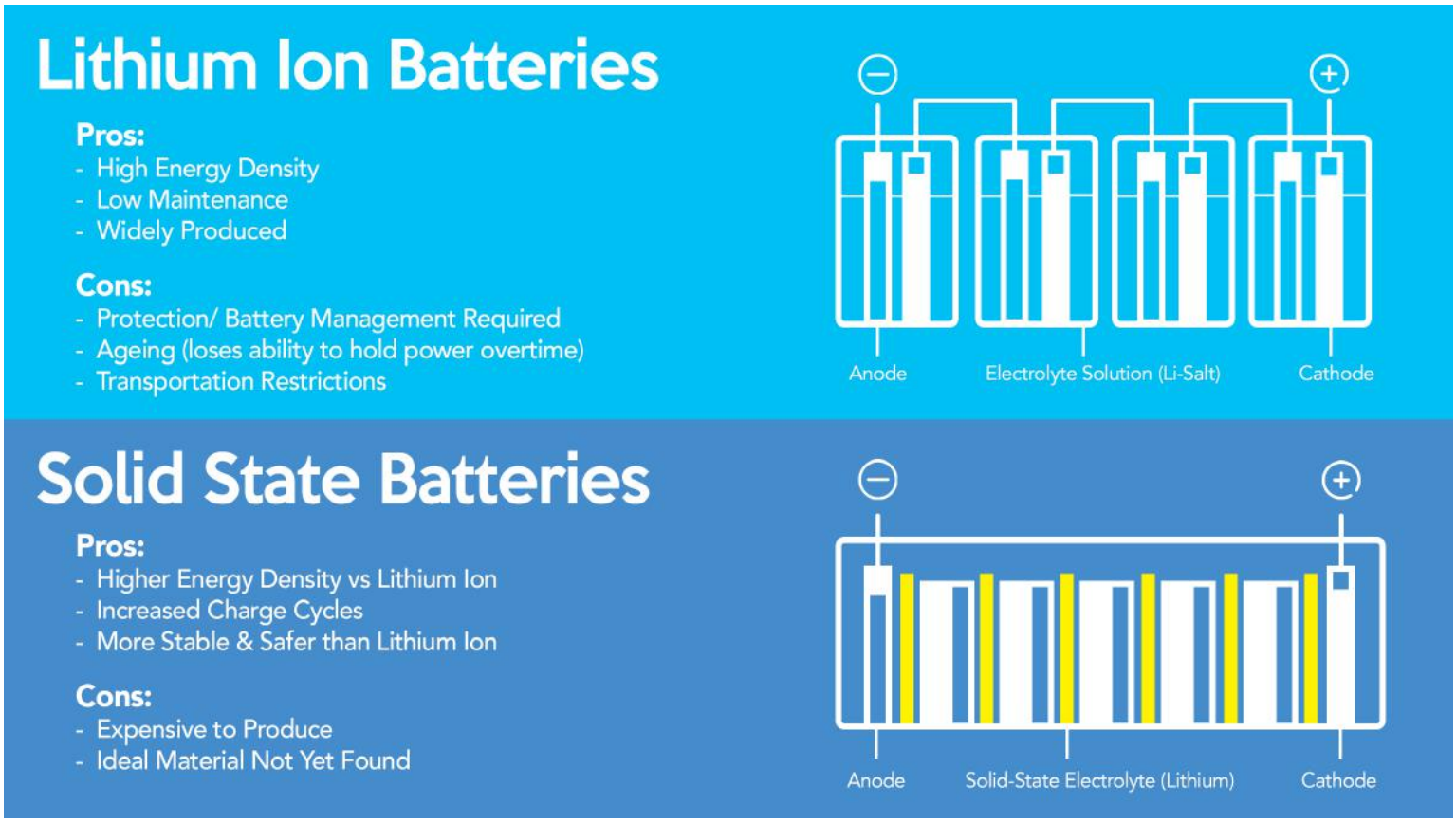


Figure 2: Solid-State vs. Lithium-ion Batteries

The other contender for the upcoming electrification of vehicles is hydrogen fuel cells. These essentially work the same as a battery, but a special electrolyte strips electrons from hydrogen fuel and creates a current. This means that these types of vehicles have to be refueled instead of recharged but are still propelled by electricity. The main benefit of this technology is that it offers up to ten times the energy density of current lithium-ion batteries, increasing both the range and decreasing the necessary weight. Additionally, hydrogen fuel cells recharge much faster, requiring only 3-5 minutes to refuel. They are arguably also a cleaner tech when utilizing green hydrogen in the manufacturing process, but as is the case for green hydrogen tech overall, adoption has not reached a point where the cost is competitive with lithium-ion battery vehicles. At the moment, hydrogen fuel cell cars are estimated to cost twice as much per mile.

Current technologies for lithium-ion batteries in EVs use an average of 8 kg of lithium, which is not an insignificant amount. At the prices we were seeing during Q1 of 2021, this meant ~ US $0.92/EV battery, whereas towards the end of the year this had climbed to US $3.7/EV battery. While in absolute terms the price remains manageable, it is more significant when considering projected electric vehicle demand to 2035 and the supply elasticity of lithium, both of which will be discussed in the following sections.

Lithium is also being used towards larger scale energy storage for distributed generation applications, such as in Tesla's Powerwall product to be used in homes in conjunction with distributed generation solar power systems. These home batteries would allow for excess energy stored during the day to be used at night. In the same vein, batteries have the capacity to help build microgrids to extend renewable electricity to the remaining 850 million people in the world who still live without it. The World Economic Forum (WEF) advocates for the use of batteries in this case as the people who still remain without electricity are either far away from existing grids, and/or live under extreme poverty - making market-based solutions less effective.

The Price Rally

Lithium prices have been volatile in recent years, briefly peaking at the start of 2018 before dwindling to a low point of $115/tonne in the fall of 2020. Following the gradual re-opening of the world economies in early 2021, prices began to exponentially increase, hitting a new record peak of $461/tonne in December of last year. (see Fig.3)

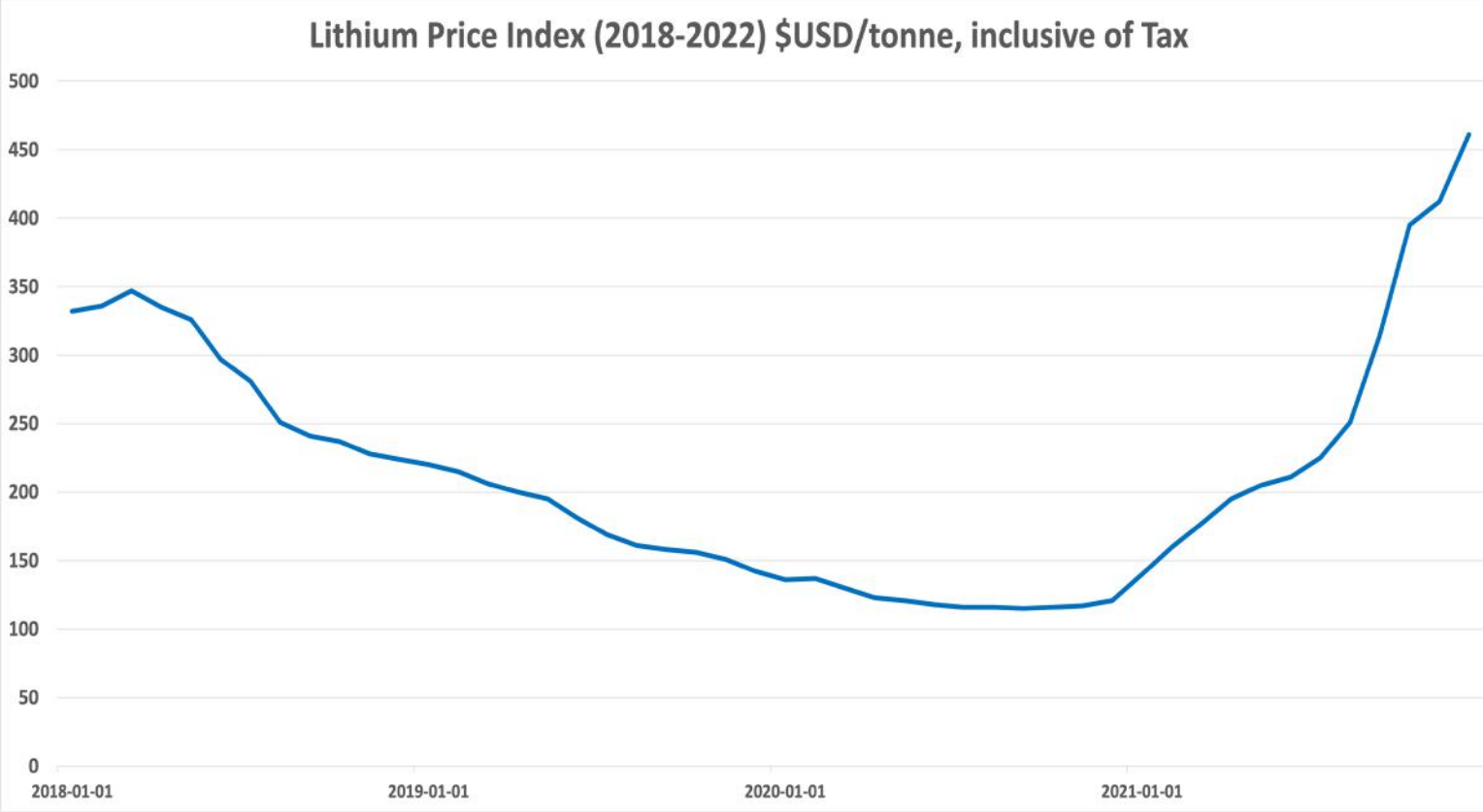


Figure 3 - Source: Bloomberg Benchmark Material Intelligence

The price surge in the mineral comes as a result of EV sales booming, especially in China, where EV sales have increased fivefold in the past year. EV sales are accelerating as consumers are becoming more energy conscious and governments are incentivizing clean energy. (see Fig.4)

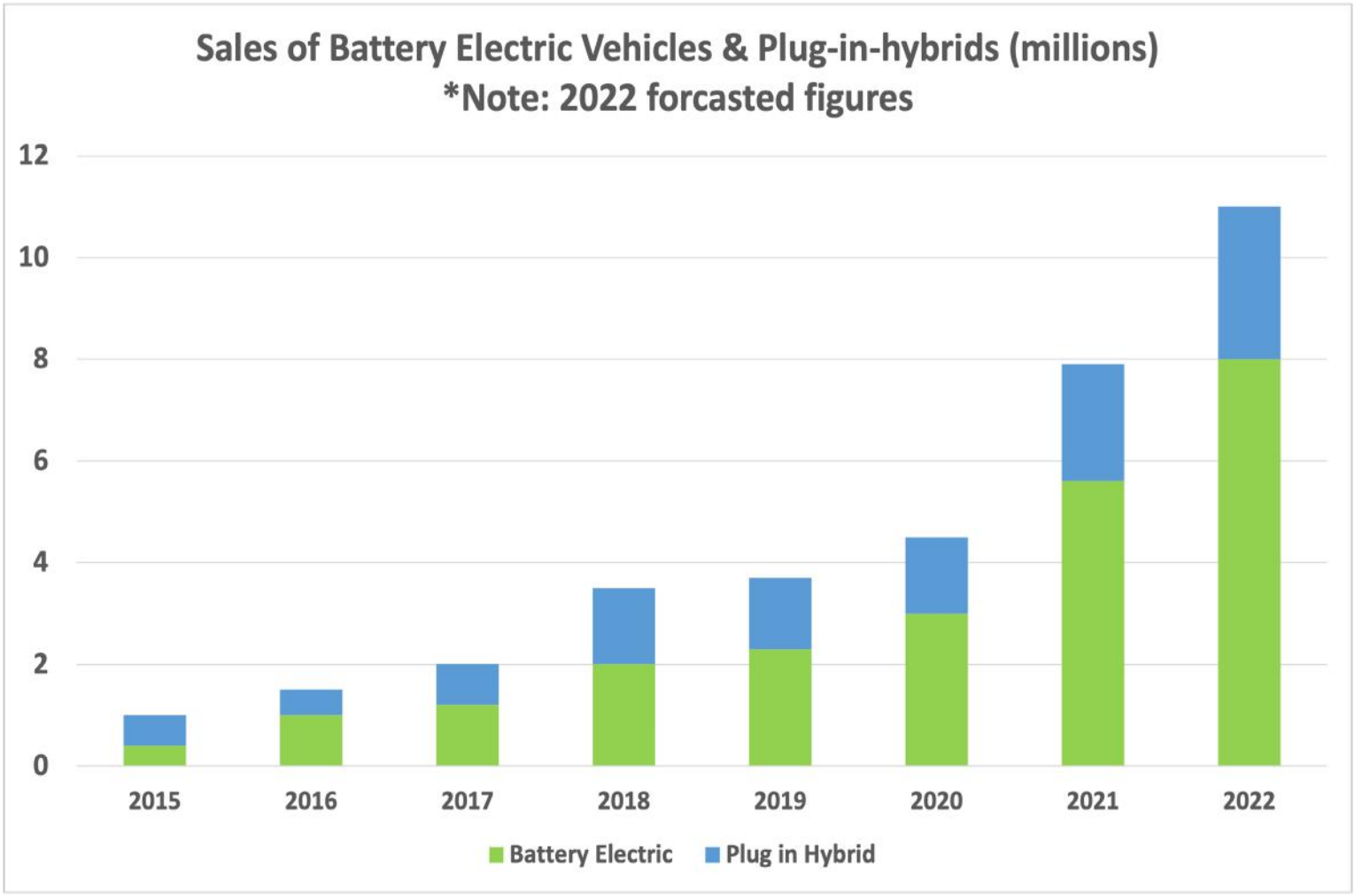


Figure 4 - Bloomberg NEF

China witnessed a 35% month-on-month rise in EV registrations, with 400,000 units being registered in a record December month, of which Tesla supplied 18%. Chinese battery producer Gangfeng Lithium Co. recorded a record 437% increase in profits in 2021, which in part was due to a long-run supply deal with Tesla. The price rally is benefiting lithium producers across the world - including Chile, Argentina, Australia - as carmakers are racing to secure supplies. In the meantime, battery producers and automakers continue to cash in large profits, although this could soon change.

With lithium prices soaring high, there is a current risk of raw material inflation that in the near term could cause the battery and automotive industries some troubles. Despite the current reaps of profits for firms, analysts expect lithium to move into deeper deficits in the coming years, as producers will find it increasingly difficult to meet demand. It is worth noting, however, that such analyst expectations fluctuate widely, with forecasts for 2025 ranging from a surplus of 17% to a deficit of 13% in demand (see Fig.5). Prices for the mineral have risen due to demand in the batteries market, which are then factored into the EV market downstream. As the demand for lithium has ramped up, the supply for the metal will only slowly react to price signals, thus forecasting a multi-year price rally. The supply of the metal is quite inelastic in the short run, yet becomes increasingly elastic over the longer run, given the shorter lead times for new extraction projects for lithium over other metals.

This inelasticity is primarily due to the high initial capital expenditures at the start of new lithium mining operations, which vary depending on the method used to extract the metal - i.e. either through brine resources or conversion from hard rock mining, through to extraction from geothermal brines or extraction from seawater. However, supply is actually elastic in the 'very short run.' Compared to other metals like nickel and copper, lithium is able to adjust to demand signals faster due to its lower lead time caused by less capital intensive extraction methods - i.e. extraction from brine resources through the process of solar evaporation. This allows for a relatively higher price elasticity of supply for lithium in the 'very short run', so in a time span of up to one year. Analysts state that a hypothetical price shock of 10% caused by an increase in demand would translate to an increase of lithium supply by 16.9% that same year, causing the price elasticity of supply for lithium to be 1.69 and elastic.

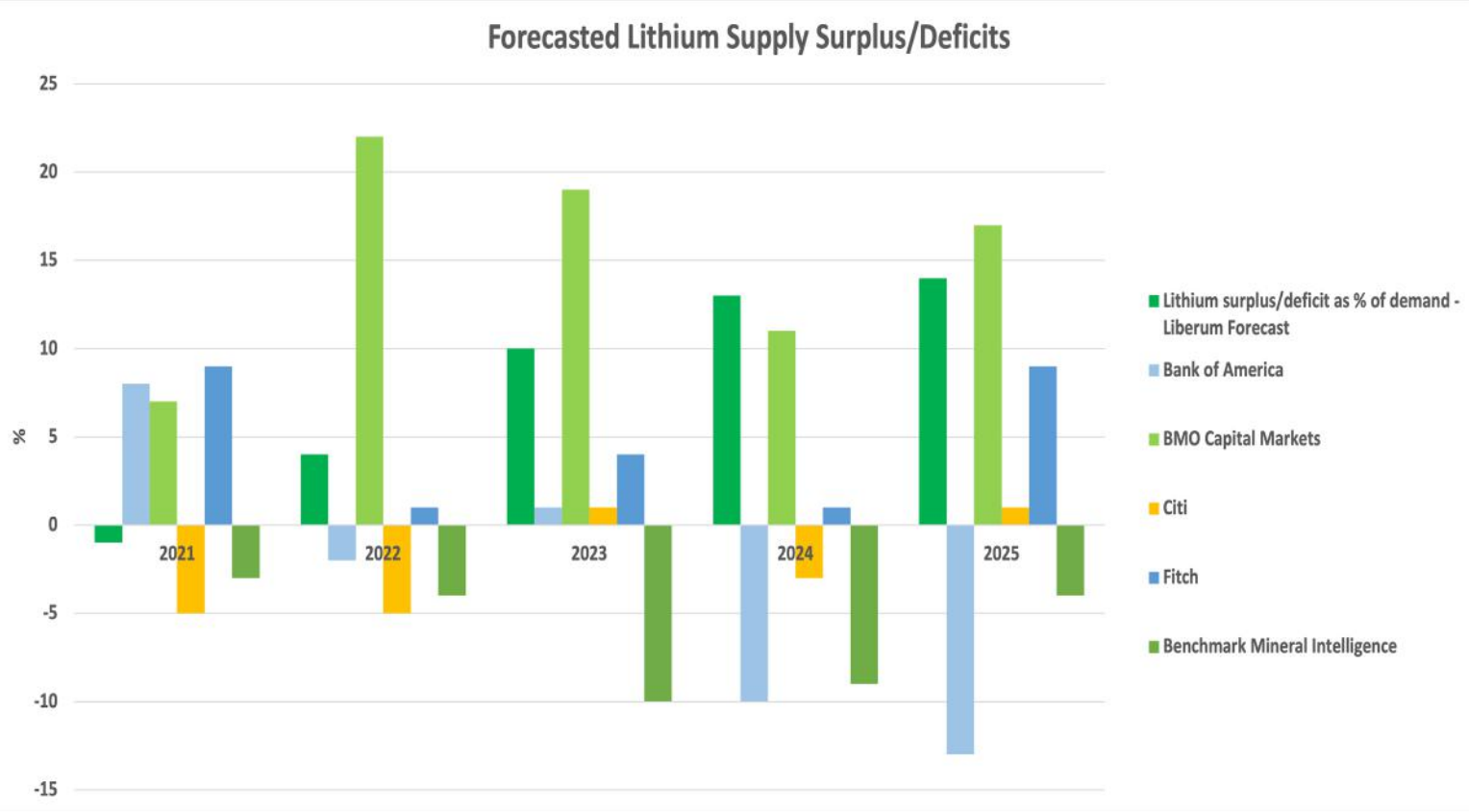
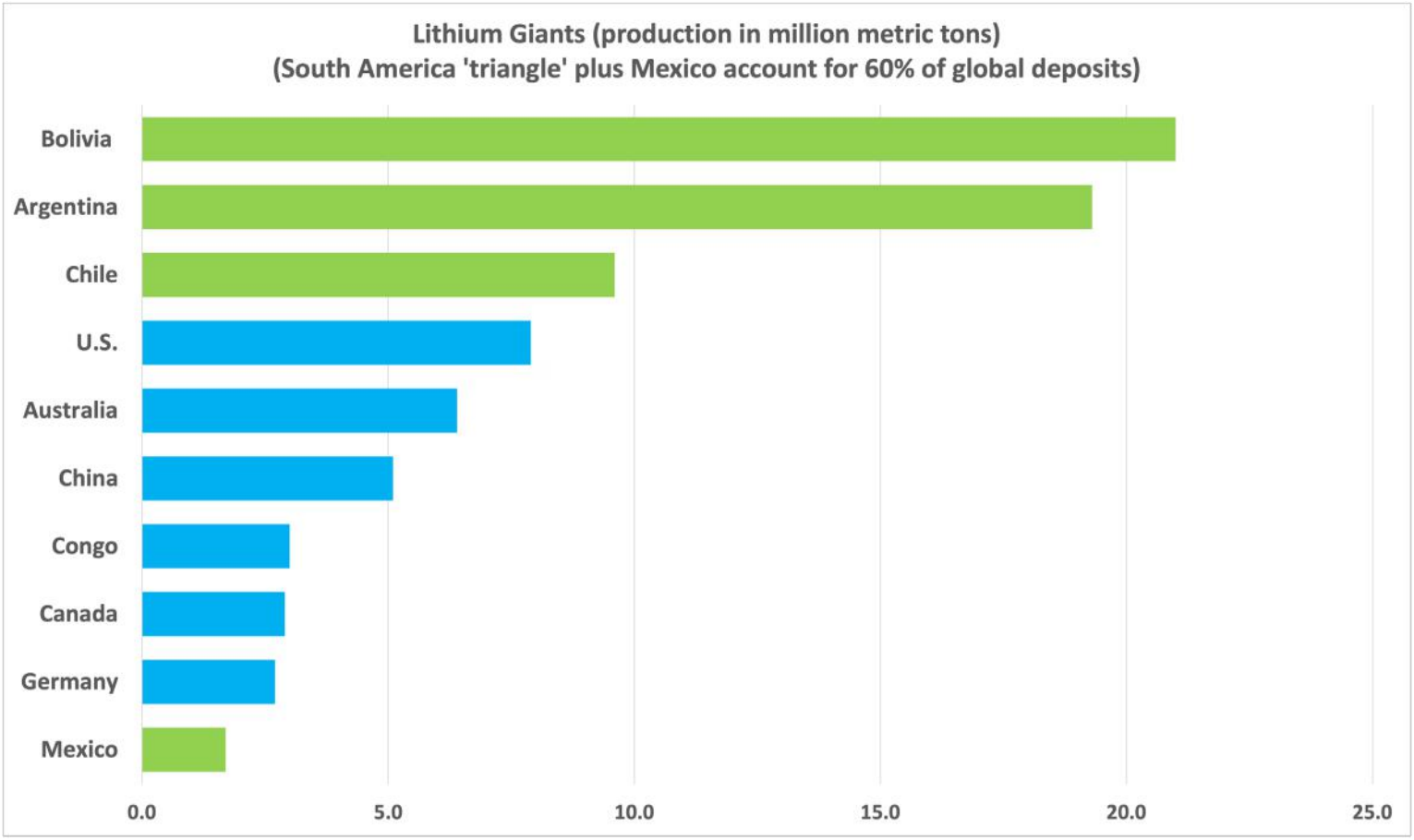


Figure 5 - Bloomberg Company Research
* NOTE * BMO CM forecast excludes potential supply losses from unexpected disruptions

Nonetheless, the surging lithium prices are of essential importance to automakers especially, given their high stakes on industry-wide bets for a battery-powered future. Similarly, battery makers are scrambling to secure supplies in fear that demand continues to outpace supply. More importantly, the rising costs of lithium could impact the low-carbon transition and the climate goals established by COP26, curtailing the momentum towards EV mobility. Rising prices along with smaller government subsidies could make EVs less attractive to buyers. As such, automakers, battery producers, and miners are trying to figure out how to best meet the future demand for the mineral.

In this regard, the future supply of lithium faces two obstacles. For one, the lithium market is still in its infancy, and pricing for the mineral remains opaque. The EV boom as such faces a structural problem given

the infancy stage of the lithium market, which is not nearly as established to meet demand as the oil market was upon the arrival of the combustion engine for cars. This makes it difficult to meet COP26 climate goals and replace the nearly one billion gasoline vehicles with electric ones. Analysts remain positive and point to the inherent bullishness of the lithium market, stating that supplies and governments will find a way of meeting production demand with supplies. The second and more serious obstacle that could strongly impact the future supply of lithium is political headwinds. Political risk is inherent with energy supplies and the future outlook for supplies coming from Chile, Mexico, and Serbia remains ambiguous. While Chile is the only large-scale producer of the three mentioned countries, the other two are still noteworthy as their political developments along with Chile's new government could set the tone for what is to follow (see Fig.6)



Source - Bloomberg (US Geological Survey)

In all three states, political and social sensibilities have changed, especially towards the environment. Chile, the world's second-largest lithium producer, is facing strong headwinds from new president-elect Gabriel Boric, who seeks to create a national lithium mining company and restructure the tax framework for large foreign mining conglomerates. This could have negative impacts on future production of the sector, although it would take years to instigate such reform. Meanwhile, in Mexico, President Andrés Manuel López Obrador announced similar plans in an effort to increase governmental control over the sector by creating a state-run lithium company under the banner "lithium belongs to the people of Mexico". Serbia has simultaneously blocked plans put forth by mining conglomerate Rio Tinto to open Europe's biggest lithium mine, which further points signals towards deficits for the lithium market in the coming years as opposed to stark surpluses.

Geopolitics

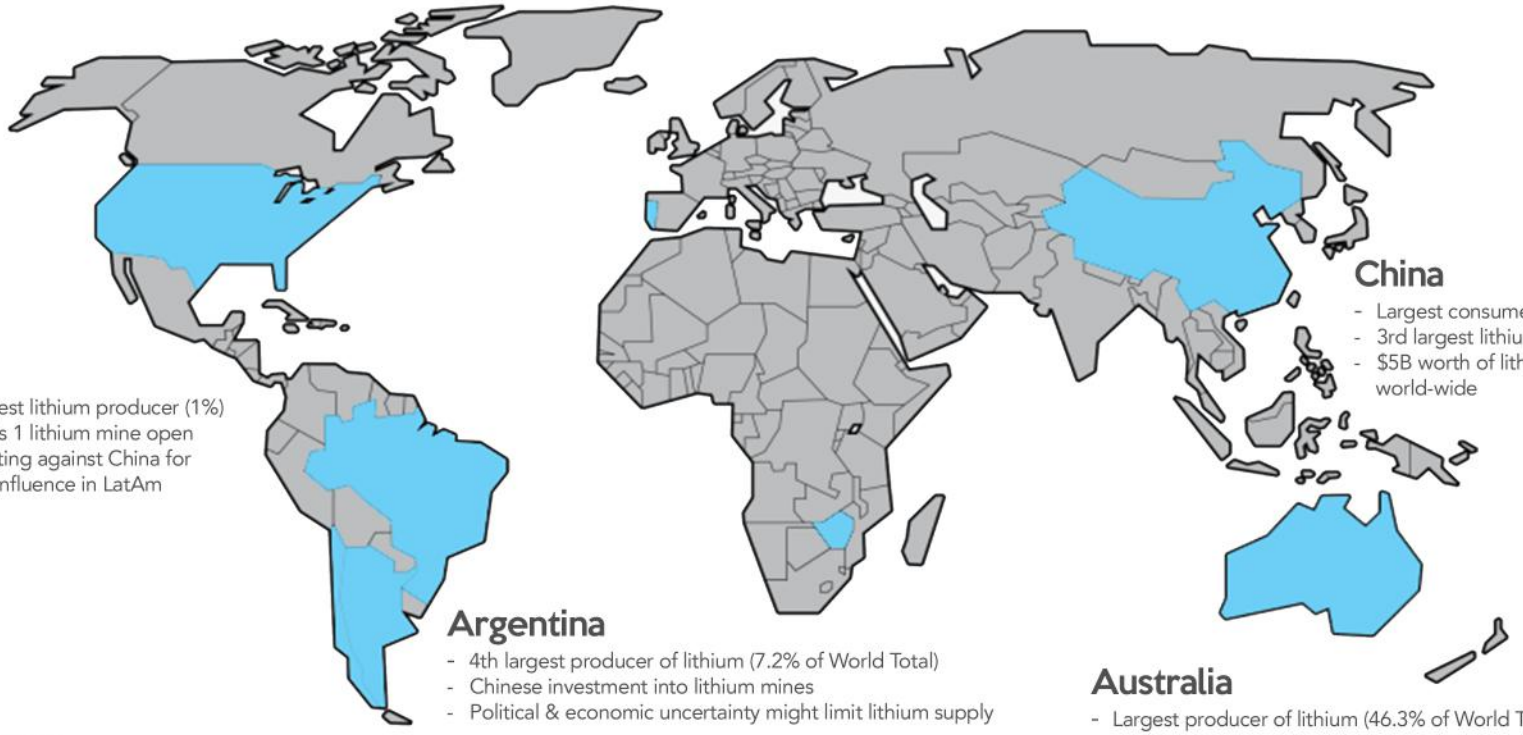
Just as other natural resources, lithium requires mining operations, and is located in different pockets around the world. This has inherently caused a mad dash for securing lithium mining, with the excavation and trade of lithium becoming a lucrative and highly politicized international marketplace.

Much of the lithium deposits around the world are in Latin America and Africa, making it a hotbed for highly industrialized countries such as the United States (US) and China vying for influence on lithium production. Argentina recently became the first major South American country to join China's "Belt and Road Initiative", opening Beijing up to one of the highest concentrations of lithium in the world – the "Lithium Triangle", home to 56% of the world's lithium deposits. While 19 other Latin American and Caribbean countries have partnered with the Chinese infrastructure initiative, Argentina marks a significant breakthrough in the battle for lithium, leveraging its financial stability on the yuan and shifting away from economic dependence on the International Monetary Fund (IMF) and the US.

To the north, Bolivia, home to 21 million tonnes of lithium resources, which is roughly 25% of the world's supply of the precious metal, recently underwent a military coup that deposed President Evo Morales, leaving the future of the Salar de Uyuni salt flats, one of the world's largest known lithium deposits in question. As EV production ramps up, Latin America is becoming a battleground for a hotly contested race towards lithium supremacy.

China has done its part to dominate lithium production, controlling over half of the total volume of the key raw materials required to produce lithium-ion batteries – cobalt, nickel, and natural graphite – as well as over 60% of the global manufacturing capacity and 80% of the world's lithium processing. In 2021, China sold over 3.3 million electric vehicles following a slowdown in 2020, a 154% increase year-on-year. As geopolitical tensions rise with countries looking for alternatives, China continues to expand into Latin America and Africa – acquiring the rights to the Arcadia mine in Zimbabwe for $422 million USD. As China continues to hold leverage over global lithium supply chains, the US, along with their allies including Canada, are desperately searching for ways to ensure they have the capacity to establish a supply chain for lithium-ion batteries by 2030.

Global Lithium Producers



USA
- 7th largest lithium producer (1%)
- Only has 1 lithium mine open
- Competing against China for lithium influence in LatAm

China
- Largest consumer EV market
- 3rd largest lithium producer
- $5B worth of lithium operations world-wide

Argentina
- 4th largest producer of lithium (7.2% of World Total)
- Chinese investment into lithium mines
- Political & economic uncertainty might limit lithium supply

Australia
- Largest producer of lithium (46.3% of World Total)
- 40,000 tonnes of Lithium mined in 2020
-

Chile
- 2nd largest producer of lithium (23.9% of World Total)
- Chinese investment into lithium mines
- Rapidly expanding lithium mining explorations & mining

Australia + Chile + China produces **86%** of the world's total lithium supply

Future Outlook

2021 was an exceptional year for lithium. As mentioned previously, the rebound of the global economy, along with an increase in demand for EVs have driven lithium prices to new highs and it is expected that demand and prices for lithium are to increase throughout 2022. The two dominant lithium sources, lithium carbonate and lithium hydroxide, have both dramatically increased in value, gaining 413% to $32,600/metric ton (MT) and 254% to $31,900/MT respectively. The rise in prices is largely due to a significant supply deficit that will persist throughout 2022 and into 2023 as production and processing facilities are slowly becoming online. Albemarle, the largest supplier of lithium for EVs, stated that lithium demand will continue to be strong with an excess of 30% growth in demand leading into 2025. The company stated that the sustained demand for lithium is largely driven by high EV production and sales in addition to larger battery sizes.

Currently, lithium demand is dominated by lithium-ion battery production with over 70% of all lithium supplies being utilized for production. While lithium-ion battery production is to remain the dominant source of demand, with more industries such as aviation and healthcare are utilizing lithium for applications beyond batteries and are expected to further drive-up demand. Furthermore, as governments around the world are working to transition into renewable energy sources, lithium demand continues to grow, putting further strain on miners and suppliers. While demand continues to increase, mines and refineries are struggling to meet demand as operational capacity has yet to fully recover to pre-pandemic levels. While major lithium producers such as Albemarle, Allkem, Pilbara Minerals and many more have already announced expansion of capacity, many of these projects will not be operating at full capacity anytime soon and are likely to be completed between 2023 and 2025; signalling that lithium demand will continue to outpace supply in 2022 and into 2023. S&P Global Platts Analytics forecasts lithium production will almost triple by 2025 to north of 1.5 million tonnes, outpacing expected demand of 1.03 million tonnes. However, due to pre-existing supply deficits it is expected that lithium supply will be in deficit until 2025. Lithium deficits reached 2,900 tonnes in 2021 and is expected to reach 20,200 tonnes in 2022 despite more capacity projected to come online this year. Macquarie, an Australian investment bank, projected that lithium deficits could widen further to 61,000 tonnes in 2023. With deficits expecting to continue for years ahead, lithium prices are also expected to remain high and continue to rise as deficits worsen.

As mentioned previously one of the driving factors for growing lithium demand is the recent EV boom. EV sales doubled from 2020 in 2021 with 6.5 million vehicles sold worldwide, with the biggest gains in China and Europe. It is projected that in 2022, EV sales will hit more than 10 million vehicles with China and Europe continuing to be the largest consumers of EVs. The projected growth rate of EVs from 2021 to 2022 is lower due to continued supply deficits along with reduced subsidies for EV purchases in China. However, the reduction in subsidies is not significant and will have a smaller impact on EV demand compared to the supply deficit of lithium. It is expected that by 2040, there will be more than 66 million EVs on the road globally. A factor that has enabled the EV boom in recent years is the dramatic reduction in battery costs from $1,400/kwh to $100/kwh, allowing for massive scaling up of EV production and sales. Additionally, in 2019, a Volkswagen executive stated that they were paying less than $100/kwh for batteries, allowing production of EVs to become more cost effective than producing combustion engines. As such, the price target has shifted from $100/kwh to $60/kwh for battery packs, which will make EVs significantly cheaper to produce compared to combustion engine vehicles and is expected to be achieved by the end of this decade.

It is also important to mention here how the rapid rise in EV demand will affect lithium demand in the future. It takes on average 8kg of lithium per EV battery, which means 6.5 million EV sales in 2022 utilized a total of 52,000 metric tonnes of lithium. With EV sales expected to jump from 6.5 million to 10.4 million in 2022, this represents a growth rate of 62.5% in one year alone and expected lithium demand in 2022 from EVs alone will reach 83,200 metric tonnes; and by 2040 where EV sales are expected to reach 66 million, which puts lithium demand to 528,000 metric tonnes for EVs alone. Given that lithium production peaked around 100,000 metric tons in 2021, it is evident that lithium production needs to increase dramatically to meet future demands.

While there is limited data, the recent outbreak of the Ukrainian Russian War has dramatically raised oil and gas prices around the world. With Russia being the world's largest oil and gas producer and exporter, the current crisis has driven up oil prices to record highs of $124 a barrel and the price rally is expected to continue with prices expected to reach $150 a barrel soon. With oil prices exceeding $5 a gallon in many states in addition to nearing $2 a litre in Canada, this might accelerate demand for EVs even further, putting further strain on lithium supplies in addition to driving up lithium prices even further.