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Geopolitics of Lithium

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Summary
Lithium is a silvery-white metal that plays a key role in the decarbonization strategy to fight climate change which includes the development and promotion of electric and hybrid cars with Lithium-ion batteries as energy storage medium. The decarbonization should also significantly reduce the massive capital transfer from the industry states to the oil and gas producers. The rapidly growing lithium demand for Lithium-ion batteries led to intensified exploration activities and an increase of known lithium reserves and resources.
Currently, it seems possible to cover the rapidly rising lithium demand by production increases and exploration, but there are various uncertainties as batteries need very high-grade lithium compounds. New mining projects and extraction technologies are uncertain long-term plans. The recycling quote of batteries is steadily increasing, but lithium recycling is still technically challenging and batteries made from recovered lithium might not have the same quality.
In addition, the battery production is dependent from other critical metals like cobalt and nickel as well. The production of minerals such as lithium, cobalt, nickel, and graphite will need to increase by nearly 500% by 2050 to meet the growing demand for clean energy technologies.
In the past decade, China has strengthened its geopolitical role by systematic strategic investments and meanwhile produces 60% of the world's lithium products and 75% of all lithium-ion batteries. It is leading in refining, battery component production, battery assembly, large-scale production in Gigafactories and recycling.
In a bigger picture, raw materials as lithium, nickel, cobalt, graphite, copper, and rare earth elements are not only needed for electric and hybrid cars, but are essential for other clean energy products like solar panels and wind turbines as well. China produces more than 70% of the world's solar modules and has almost 50% of the global wind turbine manufacturing capacity.
Another critical strategic issue is the growing energy need for electric and hybrid cars and other clean technologies which may stretch the capacities and stability of electric grids. From the Western perspective, the decarbonization strategy aimed to reduce long-standing dependencies from oil and gas suppliers and to reduce the capital transfer. The situation on the Lithium market shows that the turn to renewable and clean energies creates new dependencies and capital transfers. In summary, lithium is a key resource from an ecological, technical, and geopolitical perspective with many uncertainties for the future.

Content

1 Introduction

Lithium is a silvery-white metal that is present brines, clay, hard rock, and sea water. The decarbonization strategy aims to fight climate change which includes the development and promotion of electric and hybrid cars with Lithium-ion batteries as energy storage medium. These batteries are the key drivers of the rapidly growing global lithium demand[1].

The **decarbonization strategy** has an environmental and a strategic dimension[2]. Within the *United Nations Framework Convention on Climate Change (UNFCCC)* with 197 members, the *Paris Agreement 2015* at the *UNFCCC's conference of parties 21 (COP21)* resulted in voluntary obligations to limit anthropogenic greenhouse gas (GHG) emissions to limit global temperature increase to 1.5°C. In a broader context, this activity is part of the United Nation's *Sustainable Development Goals* [3].

In practice, this means the reduction of fossil energy like gas and oil which has a direct impact on car industry. **Electric Vehicles (EVs)** with lithium-ion batteries as energy storage medium are the globally dominant solution. From the Western perspective, the switch should also significantly reduce the massive capital transfer to the oil and gas producers. The geopolitical difference is also known as difference between 'Electro states' and 'Petrostates'.

An important difference between oil and lithium is that lithium is only an energy storage medium and the stored energy needs to come from external electricity sources, e.g., renewable energy or nuclear power[4].

In 1992, lithium batteries were introduced for cars and due to steady technical progress, the average energy density of *lithium-ion batteries (Li-ion batteries)* is much higher than of the originally leading *nickel-metal hydride (NiMH) batteries* resulting in a lower weight of the Li-ion batteries and reduced production costs. Li-ion batteries achieved a 93% global market share in 2020[5].

The rapidly growing lithium demand for batteries led to intensified exploration activities and an increase of known lithium reserves (which could be utilized with the current state of technology) and resources (as potential sources), lithium is also called *oro gris* (gray gold).

Currently, it seems possible to cover the rapidly rising lithium demand by production increases and exploration, but there are various uncertainties, as batteries need very high-grade lithium compounds[6] and batteries made from recovered lithium might not have the same quality. The recycling quote of batteries is steadily increasing, but lithium recycling is still technically challenging[7]. In addition, the battery production is dependent from other critical metals like cobalt and nickel as well. The production of minerals such as lithium, cobalt, nickel, and graphite will need to increase by nearly 500% by 2050 to meet the growing demand for clean energy technologies[8].

In 2021, 120,000 electric vehicles were sold worldwide every week, while the same amount was sold in 2012 in a year and lithium prices are up by almost 900 percent since 2020[9]. World demand for lithium may increase 40 times from now to 2040, mainly for electric vehicles and

[1] Altiparmak 2022
[2] National Intelligence Estimate 2021
[3] Hafner/Tagliapietra 2020
[4] National Intelligence Estimate 2021 The fight against plastic pollution, e.g., caused by microplastic, is part of the strategy as plastic is an oil product.
[5] Altiparmak 2022
[6] Stampatori et al. 2020
[7] Altiparmak 2022
[8] Wang et al. 2023
[9] Bastida et al. 2023

batteries for renewable energy storage[10]. The European Union (EU) demand for lithium could grow by 18 times by 2030, and 60 times by 2050[11]. The future demand for lithium may be higher than the existing capacities and new mining projects and alternative extractive technologies are uncertain, long-term processes[12]. The paper will analyze the role of lithium as strategic resource.

2 Technical Background

Simply spoken, batteries have two poles, a positive electrode (cathode) and negative electrode (anode), an electrolyte solution that is transporting the electricity (ions) and a separator between the poles. The battery cells are then assembled to battery modules (parallel or serial connections) and then to battery packs (consisting of multiple modules). For example, the *Tesla Model 3 Long Range's* battery contains 4416 cells and weighs 480 kg lithium[13]. The assembly can be quite complex and requires additional compounds like cables which make recycling of batteries more difficult.

The mining and production process includes 5 major steps. Each step requires more investments and generates higher value than the previous one:

- Mining and refining
- Production of cathodes, anodes, and separators
- Battery cell manufacturing
- Battery pack assembly and finally
- Production of electric vehicles and hybrid motors[14].

The negative electrode is typically made of carbon graphite, while the cathode is composed of lithium products with five main technologies: lithium cobalt oxide (LiCoO2, abbreviated as LCO), lithium manganese oxide (LiMn2O4, LMO), lithium iron phosphate (LiFePO4, LFP), and the lower-cost nickel containing lithium nickel cobalt aluminum oxide (LiNiCoAlO2, NCA) and lithium nickel manganese cobalt oxide (LiNiMnCoO2, NMC) batteries[15].

Theoretically, billions of tons of lithium are available in sea water, but only brines and mining are currently economically available for lithium exploitation[16]. Producing lithium from brines in Latin America is easier than mining from than hard rocks like in Australia, because the brines can be evaporated, i.e., they are pumped to the surface in large pools and then exposed to the desert sun and winds which can take about 12 to 18 months. The resulting concentrates needs be cleared from impurities[17]. From the ecologic standpoint, the brine evaporation requires a lot of space and results in loss of groundwater. Recent evidence revealed a 10 percent decline in flamingo populations near brine operations in Chile[18].

The refining of raw lithium into lithium hydroxide and lithium carbonate creates the basic products for industrial needs[19] and as lithium carbonate is required for lithium-ion batteries, the demand is expected to increase from 270,000 metric tons of Lithium Carbonate Equivalent

[10] Vásquez 2023
[11] van Wieringen/Fernández Álvarez 2022
[12] Sanchez 2022
[13] ACS 2022
[14] Sanchez-Lopez 2022
[15] Stampatori et al. 2022, Vasquez 2023
[16] Stampatori et al. 2020
[17] Stampatori et al. 2022
[18] Graham/Rupp 2023
[19] Sanchez-Lopez 2022

(LCE) in 2018 to more than 1,000,000 metric tons of LCE by 2025[20]. Li-ion batteries are not only the dominating battery type, but also the most important lithium-end product with 80% global market share compared to other products like ceramics and glass (7%), lubricating greases (4%) continuous casting mold flux powders (2%), air treatment (1%), medical (1%) and other uses (5%)[21].

Due to the complexity of Li-ion batteries, the recycling is a complex process and recycled lithium may not have the same quality than raw material.[22] The recycling rate of Li-ion batteries is rapidly increasing, but these processes are costly and the recycled material alone cannot cover the rapidly rising lithium demand.[23] Risks are the so-called *Thermal runaway* by flammable substances and chemical chain reactions, fire due to internal or external short circuits of cells or modules and escape of chemicals, e.g. the electrolyte, due to mechanical damage[24].

Recycling of Li-ion batteries materials is done by pyrometallurgy (heat and fire to create slag which can be smelted) or hydrometallurgy (with separation, acid leching and precipitation); a new alternative could be direct recycling[25]. The recycling of these batteries allows to regain copper, nickel, and cobalt, while lithium recycling was not the primary focus which will change in future[26].

3 The Lithium-Ion Battery Market

3.1 Lithium

The rapidly growing lithium demand for Li-ion batteries led to intensified exploration activities and an increase of known reserves (which could be utilized with the current state of technology) and resources (as potential sources). In 2023, lithium resources are about 98 million tons, leading countries are Bolivia with 21, Argentina with 20, USA with 12, Chile with 11, Australia with 7.9, China with 6.8 and Germany with 3.2 million tons[27].

The three countries of Chile, Bolivia, and Argentina have a concentration of high-quality salt flats ('*salares*') in the Central Andes' *Puna Plateau* with lithium-containing brines, known as the **Lithium Triangle** (Bolivia's *Salar de Uyuni*, Chile's *Salar de Atacama*, and Argentina's *Salar de Arizaro*)[28]. The Lithium Triangle (*triángulo del lítio* aka *Saudi Arabia of Lithium*) is believed to contain over 75% of existing known lithium reserves[29]. In 2022, the highest reserves were known for Chile with 9.3, Australia with 6.2, Argentina with 2.7 and China with 2 million tons[30].

Bolivia has the largest resources, but has not yet developed the production, because Bolivia wants to control the production on their own, but would need the know-how of foreign partners[31]. Chile has defined lithium as strategic resource and has introduced private investment

[20] Stampatori et al. 2020
[21] USGS 2023. Lithium competes with sodium in the nerve signal transmission and leads after some time to a kind of stabilization. Long-term lithium uptake is effective against certain neuropsychiatric disorders.
[22] Altiparmak 2022
[23] Graham/Rupp 2023
[24] VDMA 2021
[25] Stampatori et al. 2020ä
[26] Buchert/Sutter 2023
[27] USGS 2023
[28] Bastida 2023, Vásquez 2023
[29] Altiparmak 2022
[30] Vásquez 2023
[31] Seefeldt 2020, Sanderson 2023

restrictions and brine extraction caps and lost its role as top producer to Australia[32]. Argentina is now target of multiple extraction companies who want to invest and extract lithium there[33].

In 2022, Australia was the top producer of lithium with 61,000 tons, followed by Chile with 39,000 tons, China with 19,000 tons and Argentina with 6,200 tons, respectively[34].

Five large companies dominate the lithium production, in this order *Albemarle* (United States), *Ganfeng* (China), *SQM* (Chile), *Tianqi* (China), and *Livent Corp* (United States)[35].

Albemarle is a United States company with 5,000 employees and a current market value of 26 billion US dollars. *Sociedad Química y Minera de Chile SA* (SQM) is the leading Chilean company with a current market value of 19 billion US dollars while *Ganfeng Lithium* is the largest Chinese lithium compound producer and *Chengdu Tianqi Industry Group Co.* (with the affiliate *Tianqi Lithium Corporation*) the largest hard-rock producer[36].

The world's largest lithium producer, the Australian *Talison Lithium*, was supplying approximately 35% of the world's lithium market, but was meanwhile taken over by *Tianqi* and the German *Rockwood Holdings*, but *Rockwood* was then taken over by *Albemarle*[37]. *Tianqi* has also acquired 26 percent of the Chilean lithium company *SQM*[38].

Ganfeng Lithium acquired an Argentine lithium project for almost $1 billion in 2022, another Chinese company has invested more than $500 million in Argentina's lithium sector in the same year[39]. These were only two of multiple strategic investments by China in the lithium sector in the past decade. Moreover, *Ganfeng Lithium* is a vertically integrated company active in mining, refining, and processing, battery manufacturing, and battery recycling[40] and has supply agreements with the car manufacturers *Tesla, VW, BMW,* and the Korean battery manufacturer *LG Chem*[41].

As a result, China produces in early 2023 60% of the global lithium products and 75% of all lithium-ion batteries[42]. China controls 89% of the global lithium refining capacities while Chile contributes the remaining 11%[43].

Of battery components (cathodes, anodes, separators), more than 65% are produced in China, followed by Japan with 27%, while the battery manufacturing capacity is mainly in China (75%), followed by South Korea (15%)[44]. Meanwhile, 78% of the world's cathode production comes from China, as well as 91% of anodes[45]. The battery assembly is primarily located in China with 60% and USA with 9%. Of note, the important Chinas electric and hybrid car producer *BYD Auto Company Limited (BYD)* is already active in all these production steps. The Chinese *Contemporary Amperex Technology Co. Limited (CATL)* is now the largest global manufacturer of batteries for EVs[46] and produces *battery management systems (BMS)*.

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[32] Vásquez 2023
[33] Sanderson 2023
[34] Vásquez 2023. **Note:** the numbers presented in this section sometimes vary in literature, because the market is very dynamic and sometimes the numbers are based on estimates.
[35] Sanchez-Lopez 2022
[36] InvestingNews 2023
[37] Rodrigues/Padula 2017
[38] Vasquez 2023
[39] Sanderson 2023
[40] Sanchez-Lopez 2022
[41] InvestingNews 2023
[42] Zhang 2023
[43] Sanchez-Lopez 2022
[44] Sanchez-Lopez 2022
[45] Sanderson 2023
[46] Vásquez 2023

The production of electric and hybrid cars is in China (43%), Germany (22%), USA (9%) and Japan (8%)[47].

The strategic trends for the future are **Gigafactories** and vertical integration of battery and car production or, where not possible, diversification of battery sources. A Gigafactory produces electric and hybrid cars with a capacity of gigawatt hours (GWh). The leading US manufacturer *Tesla* made e.g., agreements with *Panasonic* and *LG Chem* for its Gigafactory in Nevada. Again, China dominates the Gigafactories for battery production, with 71 of 106 factories counted in 2021 and 92 of 128 planned factories[48]. The US tries now to attract the lithium battery producers with financial incentives from the *Inflation Reduction Act (IRA)* of the Biden Administration[49].

The leading battery recycling capacities for Lithium-ion batteries are 188,000 tons in China, 92,000 tons in Europe and 21,500 tons in Japan.[50]

3.2 Other Raw Materials

China dominates the processing of battery raw materials[51]. It refines 69% of nickel, 75% of cobalt, 40% of copper, and almost all graphite for batteries[52].

The top cobalt producers are *Glencore* (South Africa) with 19.3% and *Eurasian Natural Resources* (controlled by Kazakhstan) with 11.6%[53], but the *Democratic Republic of Congo* provides more than 70% of the global cobalt that is needed for batteries, wind generators, and digital technologies and China owns meanwhile 70% of Congo's mining industry[54]. To achieve this, China secured equity stakes and supply agreements with over half of the local cobalt producers[55].

The copper market is less concentrated, top producer is Chile with 27.8%, Peru with 10.4% and China with 8.3% and no company currently has more than 8.4% market share[56].

The nickel market looks similar, top producer is Indonesia with 39.4%, the Philippines with 12.5% and Russia with 8.9% and no company currently has more than 6.7% market share[57].

4 Discussion

In a bigger picture, raw materials as lithium, nickel, cobalt, graphite, copper, and rare earth elements are not only needed for electric and hybrid cars, but are essential for clean energy products like solar panels and wind turbines as well.

China meanwhile produces more than 70% of the world's solar modules and is has almost 50% of the global wind turbine manufacturing capacity[58]. Moreover, China plays an important role in the polysilicon production for solar panels and the photovoltaic market[59]. For China, these activities have both an ecologic and a strategic dimension. From the ecologic perspective, China has declared in 2020 to reach carbon neutrality by 2060. From the strategic perspective, the

[47] Sanchez-Lopez 2022
[48] Sanchez-Lopez 2022
[49] Vásquez 2023
[50] ACS 2022
[51] Zhang 2023
[52] Bosch/Rondón 2022, Sanderson 2023
[53] Leruth et al. 2022
[54] van Wieringen/Fernández Álvarez 2022
[55] Meidan 2021
[56] Leruth et al. 2022
[57] Leruth et al. 2022
[58] Median 2021
[59] Bosch/Rondón 2022

control of resources and production gives the country a strong role in future geopolitics and climate governance[60].

From the Western perspective, the decarbonization strategy aimed to reduce long-standing dependencies from oil and gas suppliers and to reduce the capital transfer. The situation on the Lithium market shows that renewable and clean energies bring new dependencies and capital transfers. In the past decade, China has strengthened its geopolitical role by systematic strategic investments.

Currently, it seems possible to cover the rapidly rising lithium demand by production increases and exploration, but there are various uncertainties, as batteries need very high-grade lithium compounds[61] and batteries made from recovered lithium might not have the same quality. The recycling quote of batteries is steadily increasing, but lithium recycling is still technically challenging[62]. The future demand for lithium may be higher than the existing capacities and new mining projects and alternative extractive technologies are uncertain, long-term processes[63]. In addition, the supply of other metals that are used together with lithium like cobalt, copper and nickel needs to be increased.

Another critical strategic issue is the energy need for electric vehicles with a growing demand for electric power[64]. The projected number of new electric and hybrid cars underestimates the lithium and energy demand, because the average batteries may become larger and dense to increase the range of the cars, but also to allow the construction of busses and trucks. The electric grid will also be stretched by other clean technologies like the heat pump. Furthermore, alternative fuels for cars like hydrogen (H2) do not occur naturally, but need to be created by energy input first. As a result, already now there are concerns that current electric grids could be stretched by these new technologies[65].

In summary, lithium is a key resource from an ecological, technical, and geopolitical perspective.

[60] Meidan 2021
[61] Stampatori et al. 2020
[62] Altiparmak 2022
[63] Sanchez 2022
[64] Proedrou 2023
[65] Klatt 2023

5 Literature

ACS (2022): Lithium-Ion Battery Recycling - Overview of Techniques and Trends ACS Energy Lett. 2022, 7, 712-719

Altiparmak, S.O. (2022): China and Lithium Geopolitics in a Changing Global Market Chinese Political Science Review. https://doi.org/10.1007/s41111-022-00227-3

Bastida, A.E (2023): In Need of a New Water Blueprint for Governing Salt Flats For Lithium Production. In: Bastida, A.E., Graham, J.D., Rupp, J.A., Sanderson, H. (2023): Latin America's Lithium Perspectives on Critical Minerals in Vásquez, P.I. (ed.): Latin American Program April 2023 Wilson Center

Bosch, F., Rondón, L.G. (2022): Geopolitics of the Energy Transition: Potentials for EU-LAC Partnerships Policy Brief. Occasional paper. GEG(GC)/CRIES/EU-LAC Fondación EU-LAC

Buchert, M., Sutter, J. (2023): Stand und Perspektiven des Recyclings von Lithium-IonenBatterien aus der Elektromobilität Öko-Institut e.V.

Graham, J.D., Rupp, J.A. (2023): Lithium Mining In: South America: The Quest For Sustainable Success. In: Bastida, A.E., Graham, J.D., Rupp, J.A., Sanderson, H. (2023): Latin America's Lithium Perspectives on Critical Minerals in Vásquez, P.I. (ed.): Latin American Program April 2023 Wilson Center

Hafner, M, Tagliapietra, S. (2020): The Geopolitics of the Global Energy Transition. Lecture Notes in Energy 73 Springer https://doi.org/10.1007/978-3-030-39066-2

Heath G.A., Ravikumar D., Hansen, B., Kupets, E. (2022): A critical review of the circular economy for lithium-ion batteries and photovoltaic modules – status, challenges, and opportunities Journal of the Air & Waste Management Association 2022, Vol. 72, No. 6, 478–539 https://doi.org/10.1080/10962247.2022.2068878

InvestingNews (2023): Top Lithium producers. https://investingnews.com Last retrieved 06 July 2023

Klatt, R. (2023): Bundesnetzagentur will Strom für Elektroautos und Wärmepumpen drosseln. 17. Juni 2023 https://www.forschung-und-wissen.de/nachrichten/oekonomie/bundesnetzagentur-will-strom-fuer-elektroautos-und-waermepumpen-drosseln-13377659

Leruth, L., Mazarei, A., Régibeau, P., Renneboog, L. (2022): Green Energy Depends on Critical Minerals. Who Controls the Supply Chains? Peterson Institute for International Economics. August 2022

Meidan, M. (2021): China's Emergence As A Powerful Player In The Old And New Geopolitics of Energy. Oxford Energy Forum February 2021: ISSUE 126

National Intelligence Estimate (2021): Climate Change and International Responses Increasing Challenges to US National Security Through 2040. Director of National Intelligence-National Intelligence Council DNI NIC-NIE-2021-10030-A

Proedrou, F. (2023): EU Decarbonization under Geopolitical Pressure: Changing Paradigms and Implications for Energy and Climate Policy. Sustainability 2023, 15, 5083

Rodrigues, B.S., Padula, R. (2017): Lithium Geopolitics in the 21st Century. provided by Archives of the Faculty of Veterinary Medicine UFRGS e-ISSN 2238-6912 v.6, n.11, Jan./Jun. 2017, p.190-212

Sanchez-Lopez, M.D. (2022): Geopolitics of the Li-ion battery value chain and the Lithium Triangle in South America. DOI: 10.1111/lamp.12285

Sanderson, H. (2023): Great Power Competition in the Lithium Triangle. In: Bastida, A.E., Graham, J.D., Rupp, J.A., Sanderson, H. (2023): Latin America's Lithium Perspectives on Critical Minerals in Vásquez, P.I. (ed.): Latin American Program April 2023 Wilson Center

Seefeldt, J.L. (2020): Lessons from the Lithium Triangle: Considering Policy Explanations for the Variation in Lithium Industry Development in the "Lithium Triangle" Countries of Chile, Argentina, and Bolivia. Politics & Policy, Volume 48, No. 4 (2020): 727-765. 10.1111/polp.12365

Stampatori, D.; Raimondi, P.P., Noussan, M. (2020): Li-Ion Batteries: A Review of a Key Technology for Transport Decarbonization Energies 2020, 13, 2638; doi:10.3390/en13102638

USGS (2023): U.S. Geological Survey, Mineral Commodity Summaries, January 2023

van Wieringen, K., Fernández Álvarez, M. (2022): Securing the EU's supply of critical raw materials. Strategic Foresight and Capabilities Unit of the European Parliamentary Research Service EPRS Document PE 733.586 – July 2022

Vásquez, P.I. (2023): Introduction. In: Bastida, A.E., Graham, J.D., Rupp, J.A., Sanderson, H. (2023): Latin America's Lithium Perspectives on Critical Minerals in Vásquez, P.I. (ed.): Latin American Program April 2023 Wilson Center

VDMA (2021): Recycling von Lithium-Ionenbatterien. Frankfurt am Main, Juni 2021 PEM RWTH Aachen University, BLB TU Braunschweig und VDMA (Eigendruck), 1. Auflage ISBN: 978-3-947920-11-2

Wang, B., Wang, L., Zhong, S., Xiang, N. and Qu, Q. (2023): Assessing the supply risk of geopolitics on critical minerals for energy storage technology in China. Front. Energy Res. 10:1032000. doi: 10.3389/fenrg.2022.1032000

Zhang, M. (2023): The highly charged geopolitics of lithium. East Asia Forum on March 1 2023