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Assessing future European lithium project's supply potential

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Executive Summary

Electric Vehicles (EVs) increase the demand for critical raw materials (CRMs). Many of these CRMs are mined in just a handful of countries, raising security concerns among business and policymakers. Lithium is particularly precarious due to its high geographic supply concentration, high demand growth rate, and few near term substitutes.

This study conducts a bottom-up assessment of European lithium extraction projects. It identifies 20 projects within Europe that could commence mining before 2030. If all of these projects start as envisioned by the mining companies, the European lithium supply would amount to 378kt lithium carbonate equivalent (LCE). Many of the projects are costlier than international peers, making their financial viability sensitive to international prices. Additionally, some of the projects will likely be delayed or cancelled due to a lack of permits, capital, new extraction technologies, and social acceptance. Policymakers need to assess and prioritise the value of self-sufficiency compared to other societal goals.

Keywords: Supply and value chain, social equity, Mining, Battery Manufacturing, Materials for EVs.

1 Electrification increases primary lithium demand

Electrification of transport is key to decarbonising the sector and society. Decarbonisation reduces the total demand for minerals, as demand for fossil fuels declines, but it does increase demand for non-fuel minerals embedded in low-carbon technologies. Some of these are perceived as critical raw materials (CRMs) as they are extracted in just a handful of countries and difficult to substitute in the near term [1]. Policymakers in the main import-dependent countries are responding by identifying the materials that are critical for them and developing supply security strategies [2]. Lithium, used in EV batteries, is the most included material on CRM lists [3]. Lithium is geologically abundant, but it has historically been extracted in small quantities e.g., for manufacturing glass, ceramics, some lubricants and medicine. EV batteries are now the biggest market for lithium, and the potential for recycled material is negligible compared to demand [4]. Although different battery cathode chemistries (e.g. LFP, NMC) are used today and contain different materials, the metal intensity for lithium is about the same for all of the commercialised chemistries. Future lithium demand will therefore grow at about the same pace as demand for battery storage capacity until non-lithium chemistries (e.g., sodium-ion), lithium chemistries with significantly other intensity (e.g., solid-state batteries), or sufficient spent batteries becomes available. IEA estimates that global lithium demand will increase by about five times from 2020 to 2030 and 2.5 times from 2030 to 2040 [5].

Plenty of studies have estimated how much lithium will be needed for the low-carbon transition, see e.g. [6]. Often, these studies compare the assessed lithium demand (flow) with current mining rates, reserve estimates or top-down bell curves, see e.g. [7]. The existence of plentiful lithium reserves that can be extracted at costs below, or similar to today's market price, indicates that geological scarcity is unlikely to constrain global output over the next decades [8]. However, other factors, such as logistical challenges and permits required to start mining, can constrain supply over the short period. Geoeconomic and geopolitical issues, such as trade restrictions, can compromise accessibility for individual countries. Thus, it is valuable to complement analysis of global supply potentials with regional assessments. Studies assessing likely future mining rates and feasibility for expanding regional output are lacking. These are the focal points of the present study, conducting a case study of European lithium production projects.

2 Method

This study estimates maximum lithium supply capacity in 2030 based on a bottom-up assessment methodology. It compiles a dataset containing all individual European lithium mining projects that have been announced as of 2024 and could commence before 2030. The dataset was compiled by gathering data on projects' geographical location, capacity and planned start up-year. The data was gathered by searching through feasibility studies and preliminary feasibility studies, mining company investor presentations and mining journals. Early-stage exploration projects are excluded as these are unlikely to result in new mines prior to 2030. While it is possible to fast-track exploration projects, its potential to materially impact supply prior to 2030 is *very* limited in the light of the lengthy time from (early) exploration to mine start, often 10 years or more.

When possible, we validated the assessment by comparing it with publicly available national forecasts developed by, e.g., national geological surveys and market intelligence firms. The validation showed that the assessment covers more projects than previously identified. This study should therefore be interpreted as explorative, not the most likely forecast of future supply.

3 A supply wave in the making?

3.1 Current global lithium supply

Lithium has traditionally been extracted through either rock mining or as brine. Australia currently dominates lithium mining. Rock with typically 1-2% lithium content is mined, concentrated to 5.5-6% and then exported to China that refines it to battery grade lithium hydroxide or carbonate [9]. Chile is presently the biggest producer of lithium from brine. The brine typically contains around 400-700mg Li/l, it is pumped up to evaporation ponds, and the dry climate gradually increases the lithium content. Brine projects, most of which are in the South American lithium triangle (Argentina, Bolivia and Chile), tend to be bigger in size than most rock projects. Historically, brine projects took longer time to ramp-up than rock projects because of the evaporation process. However, this has started to change with the introduction of direct lithium extraction (DLE) techniques [10]. Europe only had one operational lithium mine in 2024, its size is minor, and its products are solely used for manufacturing ceramics.

3.2 Potential future European supply

This study identifies 20 projects that the industry envisions could commence before 2030, see table 1. Although they are smaller than their international peers, their combined capacity still amounts to 378kt LCE. Most of these projects follow the traditional supply route from rock. However, some of the projects aim to recover lithium from geothermal deposits, e.g., in Alsace and Upper Rhine Valley. Their success hinges on commercialisation of new DLE-technologies, as the geothermal deposits have lower Li-concentration than traditional brine deposits in South America, and evaporation ponds are not applicable. They also depend on development of geothermal deposits as energy sources, because recovering the lithium will only be financially viable if lithium can be co-produced with energy.

Table 1: Identified European lithium mining projects per country and their maximum supply capacity in 2030.

	Number of projects up to 2030	2030 Max capacity (kt LCE eq.)
Australia	1	9
Chez Republic	1	26
England	5	59
Finland	1	13
France	3	67
Germany	2	21
Portugal	3	46
Spain	3	68
Serbia	1	58
Sum	20	378

[1] Note that maximum production capacity is higher than output as mines and processing do not operate at name-plate capacity.

3.3 Main lithium bearing minerals and their impacts on a future European battery value chain

Lithium occurs geologically in many different rock minerals and brine. Of the European lithium projects assessed here, rock-minerals make up 76% of the supply capacity and brines the remaining 24%. All brine projects are geothermal brine projects; no conventional European brine project was identified in this study. The rock projects target different lithium minerals. Spodumene ($LiAl(Si_2O_6)$), is the most common mineral, followed by Zinnwaldite ($KLiFeAl(Al,Si_3)O_{10}(OH,F)_2$), Jadarite ($LiNaSiB_3O_7(OH)$), Lepidolite ($K(Li,Al)_3(Si,Al)_4O_{10}(OH,F)_2$) and Petalite ($LiAl(Si_4O_{10})$), see Fig.1. One small project, corresponding to 3% of the supply capacity, did not specify the mineral composition.

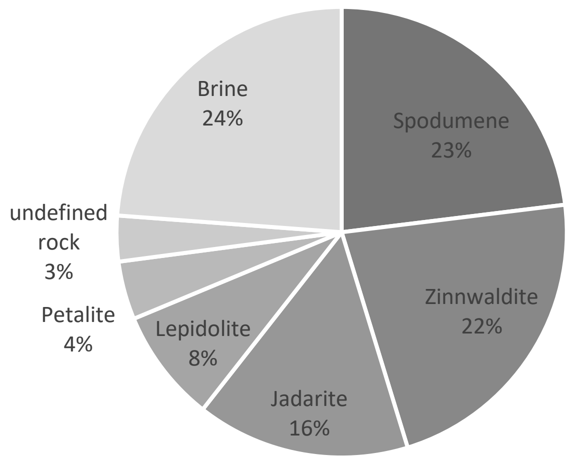

Figure 1: Share of the main lithium bearing minerals of the European lithium projects. Values correspond to the share of the supply capacity.

Compared to the lithium-minerals currently extracted globally, the European supply potential deviates. Europe does not have any conventional brine projects, a source that make up more than one-third of the current global output. Unconventional brine projects from geothermal deposits only operates at pilot scale, and its output share is negligible at the global scale but makes up one-fourth of the European potential. Globally, spodumene is the most common extracted rock-mineral, followed by lepidolite whereas zinnwaldite and jadarite are not extracted. Of the assessed European projects, spodumene and zinnwaldite have about the same share of the supply capacity, and jadarite comes third.

Because the potential European extraction projects differ from the current global supply, they will contribute to increased supply diversity. For the European lithium projects to also increase self-sufficiency and autonomy, i.e. the capacity to act independently of other states, it is important to also develop regional capacity to refine lithium and manufacture batteries. New processing and metal refiners will have to be developed to accommodate the specific European minerals. Today, demand for battery-grade lithium is split between 39% lithium hydroxide (LiOH) and 61% lithium carbonate (Li_2CO_3) [11]. Lithium from brines is often processed to lithium carbonate, as it is more cost-efficient than converting it into lithium hydroxide. Lithium hydroxide often trades at a premium because it is more versatile and can be used to produce nickel-rich high-performance batteries, such as NCM811, compared to lithium carbonate, which is used for producing LFP-batteries. Thus, the European lithium extraction projects are more suited for producing high-performance LIB than the lower-cost LFP-batteries. The market share for LFP has increased over the last few years as a result of a more attractive cost-performance ratio and has been forecasted to continue to gain market share [12]. This has mainly been driven from increased Chinese demand, whereas Europe and the USA have demanded the higher-performance chemistries. The European lithium projects are thus well suited to meet the region's type of lithium product demand. However, it should be remembered that it is possible to convert between hydroxide and carbonate, but such processes come with an added economic and environmental cost.

3.4 The lithium projects impact on supply of other raw materials

In addition to the targeted lithium, the mining projects will also extract other minerals. The environmental impact assessment of the Jadar deposit in Serbia reports that boron will be recovered as a by-product, but most of the projects do not include such information. The composition of the byproducts, and potential for economic recovery, requires further investigations. However, based on available geoeconomic datasets for lithium deposits [13], they may for example contain tantalum, tin, magnesium, potassium and boron. The European Union is import-dependent of these and classifies most of them as critical for the Union (tantalum, magnesium, boron) or conflict minerals (tin) with problematic supply.

3.5 Exploration and prospective new projects

This study only included projects with near-term developments plans by the industry. Lithium resources have been identified in many other places in Europe, such as Sweden and Ukraine, see e.g. [14]. More exploration would be needed to make it possible to assess which of these projects could be developed and when. The European Critical Raw Materials Act requires member states to have active exploration programmes, but so far, this has often not been the case. Recent research has found that lithium price signals impact the development of lithium projects [15]. The European lithium projects appear to be further up on the cost cure than their international peers that are typically larger and have higher ore grades, making the European projects less favourable on both CAPEX and OPEX basis. It could therefore be challenging for market forces to develop the European projects, as these are less profitable and are more exposed to declining prices.

4 Feasibility of scaling up European lithium extraction

4.1 Local acceptability

Many of the assessed European lithium projects face opposition from local communities, see e.g. [16, 17]. Examples of issues raised include opposition to the use of natural resources such as land and water, the use of chemicals, outflows such as air-pollution and noise, and its impact on the natural environment. These impacts occur throughout the life of the mine and often have a lasting impact on the mine site after the mine has closed. Risks and accidents, such as collapse of mine dams, have additional environmental impacts if they materialise.

In some cases, risk and cost-benefit sharing mechanisms may contribute to increase the acceptance of the adverse impacts by mines. This may include financial compensation for local communities. More research is needed to understand how such schemes could be successfully constructed within the EU, including which actors should pay compensation at who should be compensated.

4.2 National acceptability and priorities

In particular one of the proposed mining projects included in this assessment, the Jadar Valley project in Serbia, has been delayed following a national political debate on, for example, how its economic and geopolitical importance for the country compares to its negative impacts. Some argue that outside states, namely Russia, have intervened in the discussions and supported those opposing the mine in order to undermine European autonomy and unity, see [18].

4.3 Capital, technology and experienced workforce

The assessed projects target lithium ores that deviate from what is extracted internationally; some of the projects target geothermal brines, and European actors are inexperienced in mining lithium. Most of the projects have not received final investment decision (FID), and funding is lacking or pending. A recent survey among the global metals and mining industry found that they perceive capital to be the biggest risk they face [19]. Funding constraints can impact the mining companies´ technological development investments. The lithium market may be more exposed to capital constraints than often envisaged, as many smaller and less experienced, i.e. “junior”, companies are active.

5 Concluding discussion: Significant but uncertain supply potential

Commodity markets are cyclical, shifting from scarcity to abundance and back. EU has adopted the CRM-

Act with targets for increased self-sufficiency, stipulating that at least 10% of demand shall be supplied from domestic sources by 2030. For lithium, this study identifies projects corresponding to 378kt LCE_{eq}. Thus, Europe's geological conditions and its mining projects are equipped to respond to the increased demand for battery materials and for the continent to become less import dependent. Lithium-ion batteries typically contain 0.5 kg LCE_{eq}/kWh (i.e. 100g Li/kWh). The identified supply capacity would thus be sufficient for producing around 700 000 000 kWh battery storage capacity annually, or 10 million EVs with 70kWh battery capacity. However, it is far from certain that the supply potential will materialise as outlined above.

Previous studies [20] have stressed that the EU needs to better align its raw material and sustainability policies to enable reducing its import dependencies. This study focused on the potential to expand output. More research is needed to assess possibilities to mitigate demand increase and how this compares with identified supply potential.

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Presenter Biography

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