Geothermal Lithium in Europe

An industrial strategy for the geothermal lithium battery value-chain

May 2020
Contents

Key Findings
Introduction
Chapter 1. What is geothermal lithium?
Chapter 2. The European batteries value chain: important reliant without geothermal lithium
Chapter 3. Geothermal lithium: the solution for an environmentally Friendly battery value chain
Chapter 4. The foundations of a geothermal lithium Industrial Strategy
Key Findings

Portable batteries are a key feature of the modern, digital, interconnected energy system. They are the engine for the electric mobility revolution that is already altering the cities and regions across the world.

Lithium is the foundation stone for the new industrial revolution, which is based on clean energy production and efficient usage, electric mobility and the internet of interconnectivity. The EU is dependent on lithium imports. Even if more lithium is extracted in the EU, refineries are currently located elsewhere. The European Green Deal needs to embed the entire value-chain lifecycle from raw material extraction to end-use recycling. Developing competitive value-chains in a mission-orientated EU industrial strategy must be a central goal of the European Green Deal. Priority should be given to geothermal heating systems and electricity and combined heat & power plants because they are a source of sustainable and cost-effective lithium extraction. They also provide reliable electricity and heating and cooling at competitive prices.

The multiplicity of advantages from geothermal energy can be a factor of competitiveness for the European economy, where a single renewable resource can provide security of supply for several crucial inputs for the decarbonisation of the EU.

The policy architecture to deliver self-sufficiency in geothermal lithium production requires:

- **Target:** 25% of lithium used in EU battery manufacture should come from indigenous geothermal resources by 2030. It should contribute to the -55% climate target as either a stand-alone target or through an additional increase in the Renewable Energy Directive.
- **Incentivising extraction and lithium processing capacity:** Improvements to the TEN-E and TEN-T should be made to classify geothermal lithium and lithium processing plants as critical to European transport and energy networks to enable Projects of Common Interest classification and access to Connecting Europe Facility funding. This will facilitate establishment of the full value-chain of lithium-ion batteries in the EU.
- **Mapping EU resources:** Funding for mapping this resource is available in the Connecting Europe Facility. The upcoming revision of the TEN-E should be amended accordingly.
- **Reducing administration and licensing for geothermal lithium investments:** The planning process for geothermal lithium plants must be streamlined, without undermining the robustness of the environmental standards. The Renewable Energy Directive, TEN-E and Smart Sectoral Integration legislation should address this issue.
Introduction

A global race is ongoing to secure lithium supply, this raw material which will underpin the new automotive industry. Lithium is a key component of electric vehicle batteries. Its demand is expected to grow exponentially over the coming years. Globally, all regions are looking to tap into lithium. Significant investments have been made into conventional production. Refining capacity came online in China, Australia, Latin America and the US the past few years. However, it has not been able to keep up with the rapid increase in demand let alone meet expected growth, as outlined in Figure 1.

Figure 1. Lithium demand & supply forecast (source: Bloomberg New Energy Finance).

In Europe, where the automotive industry took a late turn towards electric vehicles, notably compared to the Chinese market, demand for batteries (and therefore lithium) is rapidly accelerating, despite very small domestic production. The European Commission estimates a EU Battery Market Potential of EUR 250 billion by 2025 and that the EU could represent 7% to 25% of global battery manufacturing
(from 3% in 2018). Lithium mining has been developed in Portugal, but the high-impact on land drew considerable local opposition.

Geothermal energy is a renewable energy source in form of heat beneath the surface of the earth. For decades the presence of materials, such as lithium, in the geothermal brine has been know. High temperature lithium-rich brine can be pumped to the surface from a geothermal reservoir. The heat is removed from the brine for use in renewable electricity/heat and whilst raw lithium carbonate – the form of lithium used in batteries for uses such as ICT or electric vehicles – is converted into numerous products.

In Europe, some projects, at the innovation and demonstration stage, are currently being implemented to establish a geothermal lithium production. This environmentally friendly technology, which does not impact the landscape or water resources is an opportunity for the European economy in this global race.
Geothermal lithium is the extraction of lithium from geothermal brine, typically in the form of lithium carbonates which can then be used to manufacture batteries. Geothermal lithium differs from traditional lithium mining in that it has minimal environmental impacts with marginal ground and/or water footprints. While traditional lithium brines rely on evaporation processes to collect the precious mineral, with significant environmental impacts, geothermal lithium maintains the brine as a nearly closed loop to ensure the sustainability of the geothermal reservoir. From one single installation, electricity, heating and cooling and lithium can be produced.

A global race is on to bring to market the technology that will allow the large-scale exploitation of geothermal lithium, giving a competitive edge in an economy where batteries will have a more prominent role through the electrification of transport and digitalisation. The US, Latin America, New Zealand and Europe are currently the most active in the geothermal lithium race. Many global economies, including China, are however looking at every resource to strengthen their batteries value chain. Some ongoing projects include:
<table>
<thead>
<tr>
<th>Country</th>
<th>Location</th>
<th>Name of the project</th>
<th>Production</th>
<th>Consortium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>Leduc</td>
<td>Alberta Lithium Project</td>
<td>Lithium/Heat</td>
<td>E3 METALS CORP.</td>
</tr>
<tr>
<td>Chile</td>
<td>Laguna Brava, La Rioja</td>
<td>Laguna Brava Project</td>
<td>Lithium only</td>
<td>MGX Minerals – PurLucid</td>
</tr>
<tr>
<td>France</td>
<td>Vendenheim</td>
<td>Vendenheim</td>
<td>Lithium/CHP</td>
<td>Fonroche</td>
</tr>
<tr>
<td>France</td>
<td>Soultz-Sous Forêt</td>
<td>Soultz-Sous Forêt</td>
<td>Lithium/Elec</td>
<td>ES Geothermie</td>
</tr>
<tr>
<td>France</td>
<td>Rittershoffen</td>
<td>Rittershoffen</td>
<td>Lithium/Heat</td>
<td>ES Geothermie</td>
</tr>
<tr>
<td>Germany</td>
<td>Insheim</td>
<td>Insheim</td>
<td>Lithium/CHP</td>
<td>Pfalzwerke geofuture GmbH, Vulcan Energy Resources Ltd.</td>
</tr>
<tr>
<td>Kenya</td>
<td>Olkaria</td>
<td>Olkaria geothermal plant</td>
<td>Lithium/CHP</td>
<td>KenGen</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Taupo</td>
<td>Ohaaki</td>
<td>Lithium/Elec</td>
<td>Geo40</td>
</tr>
<tr>
<td>USA</td>
<td>Hell’s Kitchen, California</td>
<td>Hell’s Kitchen Lithium</td>
<td>Lithium/Elec</td>
<td>Controlled Thermal Resources, HATCH (engineering consultant)</td>
</tr>
<tr>
<td>UK</td>
<td>Gwennap</td>
<td>Cornish Lithium</td>
<td>Lithium only</td>
<td>Cornish Lithium</td>
</tr>
<tr>
<td>USA</td>
<td>California</td>
<td>Various</td>
<td>Lithium only</td>
<td>MGX Minerals - PurLucid</td>
</tr>
<tr>
<td>USA</td>
<td>Goldfield, Esmeralda County</td>
<td>Kibby Basin lithium brine property</td>
<td>Lithium only</td>
<td>MGX Minerals - Belmont Resources - (Quantec MT, Harris Drilling)</td>
</tr>
</tbody>
</table>

**Geothermal lithium is at the heart of the European batteries value chain:** a single project in France (Soultz Sous-Forêt) has an estimated annual production capacity of 1,500 tons of lithium carbonate, 10% of the French industry demand for this raw material (notably for the car industry). Fewer than a dozen such plants would be able to cover the country’s entire current needs.

**In Europe, there are well identified exploitable reserves for lithium in upper Rhine Graben,** going from Alsace in France, around Basel in Switzerland and to Germany near Frankfurt. There, wells at depth around 4 to 5 kilometres give access to the resource, enabling the production of lithium, renewable electricity and heat. **Further exploration is necessary to identify the full potential of geothermal**
lithium across Europe. Moreover, as innovation bring the geothermal lithium technologies further, more and more area will become suitable for the economic development of geothermal lithium projects (enabling projects with lower Li concentration and lower temperature to be developed as technology costs come down). Geothermal lithium brines have also been located in Cornwall, UK. Further exploration is ongoing at depths between 400 – 4,000 metres.

The development of a domestic supply chain for lithium is a strategic European priority, as there are so far only a handful of countries that dominate the international market for production and consumption. This technology has been defined as a high priority for Research and Innovation in the ETIP-DG Roadmap. Research funding are needed to win the global race for this innovation.

Moreover, the environmental impacts of traditional lithium exploitation (salars or rock mining) render them unsuitable for Europe where robust environmental standards prevents such harmful activities. Geothermal lithium is a solution for a European supply chain that is accepted and welcomed by local communities.

Geothermal lithium is lucrative. It traded around €12,000 in 2019. The price oscillates between demand and supply lags. For instance, between 2016 and 2018 the price doubled as demand increased in the automotive industry. A domestic supply chain would protect the European industry from global volatility.
The European Commission estimates that the development of a sustainable batteries value chain could enable the creation of 3 to 4 million jobs in Europe, notably crucial for regions that rely on the competitiveness of the automotive industry. It launched a European Batteries Alliance 2050 in a bid to strengthen the European industry and tap into the potential of this rapidly growing market in 2017.

Global battery manufacturing is dominated by Asian companies. China accounted for 68% of supply in 2018 compared to 4% from Europe. Despite this late start in battery manufacturing, Europe has a potential to catch up, notably by consolidating its domestic electric vehicle value chain, as the European car industry finally shifts its focus away from the polluting internal combustion engine.

Countries with an established battery value chain in Europe include the UK and Germany, the heart of the European automotive industry, with some so-called “gigafactories” set to open in Poland, Hungary, Sweden, Norway. These developments are carried forward by a massive policy support, which attracts leading Asian companies to establish manufacturing capacity in European countries.
**Battery metals**

We see lithium hydroxide spot prices staying at around $7,500-$8,000/t, and lithium carbonate around $7,000/t in 2020, with more upward pressure than downward pressure. Major producers, notably Albemarle and producers in Australia, have scaled back capacity expansion plans enough to bring the lithium resource market back into balance. Challenges over developing new lithium chemical conversion capacity outside of China, as well as new capacity in China under development by non-tier 1 producers, means the hydroxide market is likely to stay tight.

Head of Metals & Mining, Bloomberg New Energy Finance

<table>
<thead>
<tr>
<th>Company</th>
<th>Headquarters</th>
<th>EV plant location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northvolt</td>
<td>Sweden, Norway</td>
<td>European Company</td>
</tr>
<tr>
<td>Nissan-NEC-Tokin</td>
<td>UK</td>
<td>Japanese Consortium</td>
</tr>
<tr>
<td>LG Chem</td>
<td>Poland</td>
<td>Korean company</td>
</tr>
<tr>
<td>Samsung SDI</td>
<td>Hungary</td>
<td>Korean company</td>
</tr>
<tr>
<td>SK Innovation</td>
<td>Hungary</td>
<td>Korean company</td>
</tr>
<tr>
<td>Tesla</td>
<td>Germany</td>
<td>American Company</td>
</tr>
<tr>
<td>BMZ</td>
<td>Germany</td>
<td>European Company</td>
</tr>
<tr>
<td>CATL</td>
<td>Germany</td>
<td>Chinese Company</td>
</tr>
</tbody>
</table>

Other European companies involved in the development of a European battery value chain include notably ERAMET, BASF (which is involved in a geothermal lithium project), Solvay, Siemens, SAFT, Umicore and European carmakers are working with battery manufacturers to secure the supply of the core element in the making of electric vehicles.
EGEC Geothermal joins the European Battery Alliance

Geothermal brine can contain lithium. The geothermal industry is therefore able to produce this raw material in a clean way, while also generating renewable heat and electricity for surrounding communities. This is why in February EGEC joined the European Battery Alliance.

The European Commission launched the European Battery Alliance in October 2017 to address the industrial challenge of electrification in transport. Today, the Alliance brings together more than 400 industrial and innovation actors, from mining to recycling, with the common objective to build a strong and competitive European battery industry.
Lithium mining is a process that typically has significant environmental impacts, in particular regarding land footprint (with large evaporation ponds for lithium salars in Latin America and huge open pit mining facilities for extraction of lithium from rocks in Australia or Portugal), and local environmental impacts (e.g. on water quality, biodiversity...).

Such mining facilities do not provide significant benefits for local communities, and cases such as the Covas do Barroso lithium mine in Northern Portugal highlight the risks of conflicts with local communities in populated areas.

Geothermal lithium projects are a solution that provide value for local communities, notably in the form of locally sourced renewable electricity and low-cost heating and cooling for industry, businesses and households. Geothermal lithium technologies are a process that is much less resource intensive than alternatives, making it a better fit for densely populated areas such as the EU, and to provide the best environmental protection possible.
Geothermal lithium extraction allows to decarbonise the lithium production supply chain, notably compared to hard rock lithium mining. Moreover, geothermal lithium extraction leads the additional benefits linked with the production of geothermal energy for electricity and heating and cooling, which delivers carbon emission reduction by displacing the use of fossil fuels.

Figure 5: Carbon footprint of lithium extraction per technology (Source: Minviro and Vulcan Energy LTD)
Lithium production is a process that can have many other environmental impacts beyond the CO2 footprint, where geothermal lithium technologies are also a solution. Regarding water use for instance, hard rock lithium production requires over 150 cubic meter of water use per tonne of lithium hydroxide, lithium salars use between 250 m3 and 450 m3 per tonne of lithium produced. Geothermal lithium production meanwhile uses less than 50 m3 per tonne.

Lithium mining also is an activity that has a dramatic impact on land use, which drives strong local opposition where the projects are being established, in particular in Portugal where local communities blocked plans to mine in Natura2000 sites. Per tonne of lithium hydroxide produced for use in batteries, geothermal lithium technologies have a negligible land impact (close to 0m2/tonne), compared with 300 m2 per tonne for Portuguese lithium mining, and 3000 m2 per tonne for traditional lithium salars extraction in Chile.

**Besides, geothermal lithium technologies are an opportunity to build the supply chain for other critical raw materials, chiefly rare earth**, which are so far primarily produced in China and central Africa while being crucial for the high-tech industry. Over $8 million have already been invested as public RD&I financing to rare earth extraction from geothermal brine in the USA.

Geothermal lithium technologies are therefore rapidly emerging as a solution for establishing a sustainable lithium value chain, having little impact on their own. This technology has the additional benefit of **joining renewable electricity, renewable heating and cooling and lithium production together to minimise impacts and maximising benefits for local communities.**
Geothermal heating, cooling, baseload electricity and lithium is a vital cog in the European Green Deal and the COVID-19 stimulus package. The policy architecture required to maximise its potential are:

1. **Target driven growth**

Ensuring 25% of 2030 lithium-ion batteries are sourced from indigenous geothermal lithium supplies provides an important foundation to the increased growth of this market. This target could be included in the revised Renewable Energy Directive, which will be increased to meet the -55% climate target.

Geothermal lithium should be included as a separate target to contribute towards the -55% reduction target or included as a separate sectoral sub-target in the Renewable Energy Directive.
2. Incentivising extraction and lithium processing capacity

The Trans-European Networks for Energy (TEN-E) and the Trans-European Networks for Transport (TEN-T) should be revised to classify geothermal lithium and lithium processing plants as critical to European transport and energy networks to enable Projects of Common Interest classification and access to Connecting Europe Facility funding. This will facilitate establishment of the full value-chain of lithium-ion batteries in the EU.

3. Mapping EU resources

There is insufficient data on the quantities and locations of geothermal lithium across the EU. Funding for mapping this resource is available in the Connecting Europe Facility. The upcoming revision of the TEN-E should be amended accordingly.

4. Reducing administration and licensing for geothermal lithium investments

Given the urgent need to develop geothermal lithium to meet increased climate targets whilst establishing industrial leadership, the planning process for geothermal lithium plants must be streamlined, without undermining the robustness of the environmental standards. The Renewable Energy Directive, TEN-E and Smart Sectoral Integration legislation should address this issue.