Positive Scoping Study Confirms Potential for Major European Zero Carbon Lithium™ Project

Highlights

- Scoping Study for Vulcan’s Zero Carbon Lithium™ Project demonstrates the potential for a combined operation producing lithium hydroxide and renewable energy, with net zero carbon footprint.

- The Scoping Study is based on a staged expansion plan:
  - Stage 1: Construction and operation of Direct Lithium Extraction (DLE) and lithium hydroxide plant at an operating, producing geothermal well and power plant1, and;
  - Stage 2: Drilling ten new geothermal production wells, construction of new, combined geothermal, DLE and lithium hydroxide plant at Vulcan’s 100 %-owned Ortenau license2.

- Multi-disciplinary, international in-house and independent expert team, in conjunction with specialist consultants, behind the first of its kind Zero Carbon Lithium™ study.

- Discussions with potential strategic off-take partners and consideration of financing alternatives have commenced.

- Positive Scoping Study outcomes expected to trigger the commencement of mineral processing work and a Pre-Feasibility Study (PFS) targeted for completion in late 2020.

- Vulcan is leading the mining and resources industry with its unique Zero Carbon Lithium™ Project.

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1 Insheim Indicated Resource area. Subject to VUL’s MoU with Pfalzwerke geofuture, ASX announcement 26/11/2019
2 Ortenau Inferred Resource area.
Managing Director, Dr. Francis Wedin commented: “Today marks a major milestone for the Company, and I would like to take this opportunity to thank our in-house team of lithium and geothermal experts, as well as our technical consultants, for their hard work in completing this study within our tight timeframes. The Scoping Study outlines a plan to produce battery-quality lithium hydroxide from Stage 1, ultimately growing with the market in Europe during a considerably larger Stage 2. Over the project life, both stages were found to have a positive outcome. Critically, the project benefits from readily available renewable heat and power to be used in lithium processing, and lack of high cost mining. The smaller Stage 1 provides a sensible first step for the Company.

We have shown with this Scoping Study the potential to commercially produce the raw materials required for the transition to electric vehicles, with a net zero carbon footprint, while decarbonizing the German energy grid with generation of renewable energy. We don’t see commerciality and environmental footprint as being mutually exclusive, indeed we seem them as being inextricably linked going into the 2020s, which is why we designed our Zero Carbon Lithium™ process from the ground up to be a net zero carbon, minimal impact process. This is currently a key differentiator for us in an industry with a very significant carbon footprint, but ultimately we hope that we will be the first of many, as we see a customer-driven push for companies to innovatively decarbonize the battery raw materials supply chain. Our process is the perfect fit for the Vulcan Lithium Project, a combined geothermal and lithium brine resource in the heart of the European lithium-ion battery industry, and the largest lithium resource in Europe by a considerable margin. European lithium-ion battery production is the fastest growing in the world, with new capacity plans announced regularly, and zero local supply of battery quality lithium hydroxide. The Company now has eight major unique selling points:


2. **Positive Scoping Study**: world-leading industry experts in lithium extraction and geothermal behind first of its kind study, provides solid basis for feasibility studies to commence shortly.

3. **Diversified Project**: plan to produce geothermal energy means that project would also benefit from German Renewables Feed-in-Tariff.

4. **Size**: the largest JORC lithium resource in Europe, capable of being the major supplier of battery-quality lithium hydroxide to the European market.

5. **Location – The Right Market, Compelling Supply-Demand Dynamic**: in the centre of the European lithium-ion industry, major advantage for a semi-bulk product. Europe is the fastest growing lithium-ion production centre globally in the 2020s, with zero local supply of lithium hydroxide.

6. **Rapidly Advancing Lithium Project**: Maiden Resource & Scoping Study completed in just five months. Access to producing well & a fast-track to production.

7. **Team**: In-house and independent geothermal and lithium expertise in-country for project execution.

8. **Local Partners & Infrastructure Access**: MoU with German operator Pfalzwerke geofuture allows for project to be de-risked via detailed test work on live brine, whilst providing pathway to short-term production.

We are already planning the next steps as we look towards our mineral processing test work and Pre-Feasibility Study, and we plan to maintain our momentum of being one of the fastest growing lithium projects in the world.”
Scoping Study – Cautionary Statements

The Scoping Study referred to in this announcement is a preliminary technical and economic study of the potential viability of developing the Vulcan Lithium and Geothermal Project by constructing a series of wells, geothermal and lithium plant to produce a battery-quality, lithium hydroxide with net zero carbon footprint. The Scoping Study referred to in this report is based on lower-level technical and preliminary economic assessments and is insufficient to support estimation of Ore Reserves or to provide assurance of an economic development case at this stage, or to provide certainty that the conclusions of the Scoping Study will be realized. The entirety of Stage 1 is in the Indicated Mineral Resource category and dependent on brine production from a currently in-operation geothermal production well. For Stage 2 when both Stage 1 and 2 facilities will be operating concurrently, the majority of production is in the Inferred Mineral Resource category. Stage 2 is dependent on Vulcan being able to permit and drill the Company’s own geothermal production wells. Since the majority of planned production across both stages is in the Inferred category, in accordance with ASX and ASIC guidance, Vulcan cannot at this point in time disclose production targets, forecast financial information or income-based valuations related to the Scoping Study, but instead discloses appropriate information of a technical nature to ensure the market is properly informed of the Company’s prospects. Vulcan instead makes aspirational statements, announces exploration targets and discloses parts of the study that do not contain production targets. The aspirational statements are based on the Company’s current expectations of future results or events and should not be solely relied upon by investors when making investment decisions. Further evaluation work and appropriate studies are required to establish sufficient confidence that this target will be met.

The Scoping Study is based on the material assumptions outlined elsewhere in this announcement. These include assumptions about the availability of funding. While the Company considers all the material assumptions to be based on reasonable grounds, there is no certainty that they will prove to be correct or that the range of outcomes indicated by the Scoping Study will be achieved.

To achieve the potential project development outcomes indicated in the Scoping Study, additional funding (beyond the PFS stage) will be required.

Investors should note that there is no certainty that the Company will be able to raise funding when needed. It is also possible that such funding may only be available on terms that may be dilutive to, or otherwise affect the value of the Company’s existing shares. It is also possible that the Company could pursue other strategies to provide alternative funding options.

Given the uncertainties involved, investors should not make any investment decisions based solely on the results of the Scoping Study.
Life Cycle Analysis: Independently Verified Zero Carbon Lithium™ Credentials

A Life Cycle Assessment (LCA) from cradle-to-gate was carried out for the Vulcan Project and benchmarked with different lithium industry production routes that could supply the European market\(^3\).

The Vulcan Zero Carbon Lithium™ Project is planned to be a combined geothermal energy and lithium hydroxide monohydrate production project. The results of the study indicate that Vulcan has the potential to be the \textbf{first negative carbon lithium project in the world, helping to decarbonize a highly CO\(_2\)-intensive product}. The Vulcan project has the potential to have the lowest impact with a negative climate change impact due to CO\(_2\) emissions being offset through the co-generation of geothermal energy along with LiOH-H\(_2\)O.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Climate change impact for the production of 1 tonne of battery quality lithium hydroxide monohydrate through five distinct production routes to Europe. Note, the graph compares projects in production or advanced stages of feasibility with the Vulcan Project, which is an early stage project.}
\end{figure}

\(^3\) The CO\(_2\) Impact of the 2020s Battery Quality Lithium Hydroxide Supply Chain, Dr. Robert Pell, Dr. David Deak, Alex Grant, ISO-compliant LCA. https://static1.squarespace.com/static/5c9aa323c46f6d499a2ac1c5/t/5e1cf0d3a126a33c900c8ea/1578954965079/The+CO2+Impact+of+the+2020s+Battery+Quality+Lithium+Hydroxide+Supply+Chain.pdf
Project Configuration and Staging

A number of configurations and flowsheets were investigated, with the following selected for further engineering in the Scoping Study:

- **Configuration**: Brine extraction, power generation, lithium direct extraction plant and brine reinjection to be co-located. Three production areas are required for full production – a single well geothermal plant, including a DLE and lithium production plant, at Insheim, a four-well geothermal and DLE plant and a six-well geothermal and DLE plant in Ortenau. A single lithium production plant will process concentrate from the two Ortenau lithium direct extraction plants.

- **Geothermal Plant**: Binary Organic Rankine Cycle (ORC) power plant incorporating air cooled condensers as well as reinjection equipment for non-condensable gases.

- **Lithium Direct Extraction Plant**: An absorbent based technology was selected as the preferred direct extraction technology, with pretreatment for silica removal.

- **Lithium Production Plant**: Two flowsheets were selected for development in the scoping study. Following impurity removal, lithium hydroxide is produced via industry-standard methods from the lithium chloride stream. This involves either directly crystallizing lithium hydroxide using chlor-alkali type methods, or with a lithium carbonate precipitation step using sodium carbonate and carbon dioxide from lime regeneration to precipitate lithium carbonate, and lithium carbonate cake is re-pulped and reacted with calcium hydroxide slurry to form lithium hydroxide Carbon dioxide formed during calcination is captured via an amine-based carbon dioxide recovery plant, with the separated carbon dioxide directed to the lithium carbonate precipitation stage. The plant is designed to achieve typical battery-grade lithium hydroxide monohydrate product quality. Outcomes from both methods were found to be similar.

- **Project Staging**: The following staging and configuration of wells, direct extraction and lithium plants were selected:
  - **Stage 1 Production Plant (Insheim License)**: direct extraction and lithium plant to be located at the Insheim geothermal power plant. It is contemplated that this would commence a year prior to the larger Stage 2, as a means of scaling up commercial production.
  - **Stage 2 Production Plants (Ortenau License)**:
    - Plant one: four well pads, four extraction and four injection wells, geothermal power plant, direct extraction and lithium plant.
    - Plant two: six well pads, six extraction and six injection wells, geothermal power plant, direct extraction and trucking of lithium concentrated liquor to the Stage 2 lithium plant. For both Stage 2 plants, it is contemplated that production would start in 2024.

A schematic of the project layout is presented in Figure 2. Stage 2 is dependent on Vulcan being able to permit and drill the Company’s own geothermal production wells.

Mass and energy balance and process block flow diagrams were developed to support the capital and operating cost estimates. The brine composition and thermal properties are estimated from adjacent geothermal power operations in the Upper Rhine Valley.
The study identified the required future test work for the Pre-Feasibility Study which includes:

- Further definition of the geothermal brine resource and testing for pretreatment options to optimize lithium recovery.
- Bench-Scale and Pilot Plant Test Work to define engineering data and minimize process risk.
- Amenability and optimization test work for direct extraction to provide confidence in the flowsheet design and target production of a small sample of high purity product.
- Further development of engineering to a Pre-Feasibility Study level to better define the process flowsheet and site-specific infrastructure requirements.

Recommendations were included for further test work in later engineering stages, including test work for locked-cycle operation, vendor equipment and pilot or demonstration plant continuous operation.

**Scoping Study Outcomes**

Based on a proposed staged ramp-up, with an initial Stage 1 comprising lithium hydroxide monohydrate production at an existing geothermal plant\(^4\), and a future Stage 2 adding considerably larger capacity, the Scoping Study has demonstrated positive metrics at the Vulcan Zero Carbon Lithium™ Project. Possible premium pricing for the carbon savings associated with Vulcan’s lithium hydroxide products have not been factored in the outcomes presented and will be discussed in future studies.

The Scoping Study is based on the Mineral Resource Estimate for the Vulcan Project including the Insheim MoU area, comprising combined Indicated and Inferred Resources totalling 13.95 Mt of contained LCE. The entirety of Stage 1 is in the Indicated Mineral Resource category. At Stage 2 when both Stage 1 and 2 facilities will be operating concurrently, the majority is in the Inferred Mineral Resource category. Because of this, the Company is not able to provide forward-looking statements, such as production targets or forecast financial information, at this point in time. There is a low level of geological confidence associated with Inferred Mineral Resources and there is no certainty that further exploration work will result in the determination of further Measured or Indicated Mineral Resources or that the Production Target or preliminary economic assessment will be realized.

\(^4\) Subject to VUL’s MoU with Pfalzwerke geofuture, ASX announcement 26/11/2019
Figure 2: Simplified Flowsheet of Zero Carbon Lithium™ Process
Next Steps

Growth Potential – Exploration Targets

In addition to its Inferred Mineral Resource on the Ortenau license and Indicated Mineral Resource in the Insheim MoU license, Vulcan has one exploration license (Mannheim) and three license applications (Ludwig, Rheinau and Taro) which contain Exploration Targets. These were presented and reiterated in Vulcan’s announcements on 20th of August 2019 and 22nd of January 2020. Vulcan aims to conduct development work, such as processing testwork and seismic data acquisition and evaluation, to continue to convert Exploration Targets to Inferred Resource, and Inferred Resources to Indicated, where possible.

Vulcan anticipates purchasing existing 3D seismic and geological information; the interpretation of which will guide the delineation and drilling of geothermal production well targets. Successful exploration programs, and subsequent brine assay testing, may result in advancement and re-classification of existing resources and/or elevating exploration targets to the mineral resource category.

Lithium Extraction Testwork

Vulcan aims to conduct lab-scale and pilot plant lithium processing and recovery studies on live brine sourced from the Insheim plant, to test and refine the flowsheets developed during the Scoping Study. These tests will be conducted in conjunction with Vulcan’s Direct Lithium Extraction CTO, Alex Grant, with input from Vulcan’s local team in Germany and external engineering consultants Hatch.

Environmental Assessment and Community

An initial GIS study of potential production well drill sites within Vulcan’s Ortenau license has already been conducted as part of this study, which filtered for residential areas, conservation areas and groundwater protection areas. Whilst a high-level study, this showed good potential for siting of the production wells as planned by Vulcan within Ortenau, in geologically suitable (i.e. faulted) zones for anticipated high brine flow rate. Vulcan will commence more detailed environmental and community studies as part of its Pre-Feasibility Studies, which it expects to commence shortly.

Risk Assessment and Mitigation

Vulcan has identified a number of risks that will be addressed as part of future studies. These include:

- Correctly siting production wells to achieve targeted brine flow rate;
- Consistency of lithium grade and potential dilution where re-injection fluids come into contact with production brine;
- Refining the inputs used in the Scoping Study to a higher degree of accuracy;
- Possible falling prices related to increased market supply.

Given the strong pedigree of Vulcan’s geothermal team expertise in Germany, as well as the quality of Vulcan’s lithium experts and external geological engineering consultants, the Company is confident it can satisfactorily address the potential risks. Analyst consensus points to a lithium hydroxide supply deficit by the mid-2020s, and Vulcan’s diversified revenue stream with geothermal energy and low OPEX provides further protection against a lower price environment.
Scoping Study Parameters & Assumptions

The Scoping Study was completed using the key parameters and assumptions set out in this section. The Study was completed with the assistance of a highly experienced and reputable group of independent consultants, including: Mr. Roy Eccles M.Sc. P. Geol. of APEX Geoscience Ltd. (Edmonton, AB Canada) coordinated the overall Scoping Study; Dr. Michael Kraml Ph.D. and Mr. Tobias Hochschild of GeoThermal Engineering GmbH (Karlsruhe, Germany) conducted Vulcan’s 2019 brine sampling program, prepared the hydrogeological work; Mr. Dylan van den Berg of Hatch Ltd. (Perth, Australia) completed the mineral processing section; Mr. Warren Black M.Sc. P. Geo. of APEX completed the mineral resource modelling and estimation work; Mr. Jason Froud of Optiro Ltd. completed the Economic Analysis, and; Dr. Robert Pell and Mr. Alex Grant, of Minviro and Jade Cove Partners respectively, completed the Environmental Studies. As Scoping Study report coordinator and Vulcan’s CP, Mr. Eccles worked collaboratively with these geologists/engineers, has reviewed all work and concepts, is independent of Vulcan and the Vulcan Property, and takes responsibility for the resource estimations and selected work contributions of colleagues (hydrogeological characterization, geothermal brine reservoir evaluation and a life cycle assessment). Mr. Froud is independent of Vulcan and the Vulcan Property and takes responsibility for the Economic Analysis. Stage 1 considers the production of lithium hydroxide (only) through an agreement with an existing geothermal operator and Vulcan holding a contemplated 80% equity interest in the lithium project. Vulcan currently has zero percent interest in the Insheim license contemplated in Stage 1, but by completing a successful PFS and DFS study, has a pathway to earn 80%, subject to advancing the MoU to formation of a formal JV. Stage 2 expansion considers Vulcan holding a 100% interest in both geothermal energy and lithium production by drilling its own production and re-injection wells at its own Ortenau License. The Vulcan project base case model comprises the inputs as shown in Table 1.
Table 1: Key production schedule inputs (source: Hatch)

<table>
<thead>
<tr>
<th>Input</th>
<th>Stage 1</th>
<th>Stage 2 (Plant 1)</th>
<th>Stage 2 (Plant 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of wells</td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Li grade (mg/l)</td>
<td>181</td>
<td>181</td>
<td>181</td>
</tr>
</tbody>
</table>

**Market Studies & Contracts**

No offtake contracts had been signed at the time of writing however discussions are ongoing with numerous parties for the sale of lithium hydroxide. Lithium hydroxide (LiOH) prices are based on publicly available documents published by peer companies and forecasting services in Europe for battery grade lithium hydroxide (min 57.5% LiOH). Major industry analysts expect that from 2022 to 2023 onwards there will be a significant increase in lithium demand in Europe, particularly for lithium hydroxide. This will be driven by the shift into nickel-rich batteries, which have an increased proportion of lithium and reduced share of cobalt. Although markets are currently in a technical surplus, major analysts expect ramp up rates at new lithium-ion and cathode facilities, both integrated and non-integrated, to be constrained as qualification processes are complex. The market is widely expected to be in a supply deficit in the mid-2020s in Europe, with associated favourable price environments and a premium for battery quality, lithium hydroxide products over technical grade or carbonate products. Based on a peer review of publicly available documents studying the battery quality lithium hydroxide market specific to Europe, an average price per tonne for battery quality lithium hydroxide of US$11,500/t is considered reasonable for 2022, US$12,750/t in 2023, average of $15,626/t between 2024 to 2028 and a long term price average beyond 2028 of US$17,238/t.

**Project Location and Tenure**

The Vulcan Property is comprised of five separate and non-contiguous Exploration Licences within the Upper Rhine Valley of southwest Germany that include: Mannheim; Ludwig; Taro; Rheinaue and Ortenau (Figure 3). In addition, Vulcan has formed a binding Memorandum of Understanding with Pfalzwerke geofuture GmbH that establishes an initial collaboration period to test lithium from brine extraction feasibility at the Insheim Exploitation Licence, which represents an established and operating geothermal Exploitation Licence. The Vulcan Lithium Project is strategically located at the heart of the European auto and lithium-ion battery manufacturing industry. Collectively, the five Exploration Licences encompass a land position of 788.19 square kilometres (78,819 hectares) with the Insheim Exploitation Licence adding another 19.00 square kilometres (1,900 hectares). The total size of the Vulcan land position is 807.19 km² (80,719 hectares). All licences occur within the German states of Baden-Württemberg and Rheinland-Pfalz near the cities of Mannheim and Karlsruhe, Germany and the France-Germany border city of Strasbourg. With respect to the Insheim Exploitation Licence, the binding Memorandum of Understanding was announced on November 26, 2019 (see Vulcan News Release dated November 26, 2019). The agreement has an initial collaboration period in which Pfalzwerke geofuture GmbH will supply brine and well data from its operational Insheim Geothermal Power Plant for Vulcan to conduct geological, lab-scale pilot test work and engineering, and financial studies toward a Pre-Feasibility Study. Upon successful completion, a legal Joint Venture may be formed with Vulcan earning up to 80% Joint Venture interest in the lithium-brine project and lithium rights at the Insheim Geothermal Plant by successfully completing a Definitive Feasibility Study.
Mineral Resource and Geology

Stage One – Insheim Indicated Resource

The Insheim Exploitation Licence and one of the five Vulcan Property Exploration Licences (Ortenau) have been assessed using the resource modelling and estimation process outlined in a Technical Report with an Effective Date of 20 January 2020 and is utilized in this Scoping Study.

Statistical analysis, three-dimensional (3-D) modelling and resource estimation was prepared by Mr. Black, M.Sc. P. Geo. of APEX. The resource modelling and estimation work were performed in direct collaboration and supervision of Mr. Eccles, P. Geol. who reviewed all work and takes responsibility for the resource estimations utilized in this Scoping Study. The workflow implemented for the calculation of the Vulcan lithium-brine resource estimations was completed using the commercial mine planning software MICROMINE (v 18.0).

Critical steps in the determination of this Vulcan Li-Brine Resource Estimates include: 1) definition of the geometry and volume of the Buntsandstein Group and Permo-Triassic aquifer domains; 2) hydrogeological characterization of the specific yield, or in the case of the confined aquifer, the average effective porosity; 3) calculating the total volume of in situ brine; and 4) determination of the concentration of lithium within the brine and at the Property.
The Buntsandstein Group aquifer, and Permo-Triassic aquifers at the Insheim Licence, represent large-scale aquifer(s). The Buntsandstein Group aquifer is bound by two aquitards (subject to fracture zones that could form hydraulic connections in the strata overlying, and including, the crystalline basement). The Insheim Geothermal Plant production well includes perforation points that occur above and below the Lower Buntsandstein Group aquitard providing brine access points in both Lower Triassic and Permocarboniferous sandstone aquifers (i.e., Permo-Triassic domain).

The average effective porosity of the Buntsandstein Group within the Upper Rhine Graben and the Property is 9.5%, which has been applied to the Taro, Rheinaue and Ortenau resource calculations. With respect to Insheim, an average porosity of 9.0% was used because the underlying Rotliegend Group porosity was determined to have a slightly lower than porosity associated with the Buntsandstein Group.

Geothermal projects in the Upper Rhine Graben have documented sufficiently high flow rates within fault zones associated with the Buntsandstein Group and Permo-Triassic strata. These structural sub-domains within the Buntsandstein Group represent key determinants for locating zones of high fluid flow. The 3-D models created for the Taro, Rheinaue and Ortenau licences shows that the licences were deliberately targeted by Vulcan for their high degree of faulting, and the Competent Person reasonably assumes that the licences could have high fluid flow potential within the faulted Buntsandstein Group aquifer. The same can be said for Insheim which is already producing geothermal power from brine related to highly faulted/fractured Permo-Triassic strata.

The average lithium-in-brine concentration used in the Insheim resource estimations is 181 mg/L Li and was based on 24 separate analytical results on Permo-Triassic brine at the Insheim Geothermal Plant that included data derived from Pfalzwerke geofuture GmbH, Vulcan’s 2019 sampling and assay program, the CP site inspection samples and analyses, and historical Li-brine values. The brine was analyzed by trace metal ICP-OES analysis at 3 independent laboratories.

No top cuts or capping upper limits have been applied to the lithium assay values or are deemed to be necessary. Confined Li-brine deposits typically do not exhibit the same extreme values as precious metal deposits.

Critical matters likely to influence the prospect of economic extraction of Li-brine from the Buntsandstein Group and Permo-Triassic aquifers include aquifer dimensions, brine composition, fluid flow, brine access and mining methods, recovery extraction technology and environmental factors. These criteria were reviewed by a multi-disciplinary team that include geologists, hydrogeologists and chemical engineers with relevant experience in the Buntsandstein Group and Permo-Triassic brine geology/hydrogeology and Li-brine processing. There is collective agreement that the Vulcan lithium-brine project has reasonable prospects for eventual economic extraction.

A lower cutoff of 100 mg/L Li was used in this Li-brine resource estimation. It is the opinion of the author that this cutoff is acceptable because: 1) confined aquifer deposits traditionally have lower concentrations of lithium (in comparison to unconfined lithium-brine salar and hard rock lithium deposits), and 2) numerous commercial, academia and independent laboratories are now experimenting with rapid lithium extraction techniques using low lithium concentration source brine.

The resource estimation presented in this Scoping Study is presented as a total (or global value), and was estimated using the following relation in consideration of the Permo-Triassic aquifer domain at the Insheim Licence and the Buntsandstein Group aquifer domain within the Taro, Rheinaue and Ortenau licences, or resource areas:

\[ \text{Lithium Resource} = \text{Total Volume of the Brine-Bearing Aquifer} \times \text{Average Porosity} \times \text{Average Concentration of Lithium in the Brine}. \]
Mineral resources are not mineral reserves and do not have demonstrated economic viability. There is no guarantee that all or any part of the mineral resource will be converted into a mineral reserve. While it would be reasonable to expect that most of the Inferred Mineral Resources would upgrade to Indicated Mineral Resources with continued exploration, due to the uncertainty of Inferred Mineral it should not be assumed that such upgrading will always occur. There is no direct link from an Inferred Mineral Resource to any category of Ore Reserves.

This Scoping Study incorporates an Indicated Mineral Resource for the Permo-Triassic aquifer domains within the Insheim Licence. The Insheim Exploitation Licence has been classified as an Indicated Resource because of the binding Memorandum of Understanding, which permits continued access to the Permo-Triassic aquifer brine, and the enhanced understanding of the Insheim subsurface geology via seismic and well log data. The Indicated Vulcan Li-Brine Resource estimation for the Insheim Licence is estimated at 136,000 tonnes of elemental lithium (Table 2). The total lithium carbonate equivalent (LCE) for the main Indicated Resource is 722,000 tonnes LCE.

Table 2: Indicated Vulcan Li-Brine Resource Estimate of lithium-bearing brine within the Permo-Triassic strata aquifer domain at the Insheim Licence.

<table>
<thead>
<tr>
<th>Reporting parameter</th>
<th>Insheim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer volume (km³)</td>
<td>8.322</td>
</tr>
<tr>
<td>Brine volume (km³)</td>
<td>0.749</td>
</tr>
<tr>
<td>Average lithium concentration (mg/L)</td>
<td>181</td>
</tr>
<tr>
<td>Average effective porosity</td>
<td>9.000</td>
</tr>
<tr>
<td>Total elemental Li resource (tonnes)</td>
<td>136,000</td>
</tr>
<tr>
<td>Total LCE (tonnes)</td>
<td>722,000</td>
</tr>
</tbody>
</table>

Note 1: Mineral resources are not mineral reserves and do not have demonstrated economic viability. Note 2: The weights are reported in metric tonnes (1,000 kg or 2,204.6 lbs). Numbers may not add up due to rounding of the resource values percentages (rounded to the nearest 1,000 unit). Note 3: The volume and weights are estimated at an average porosity of 9.0% and assumes brine occupies 100% of the pore space. Note 4: The Vulcan Li-brine Project estimation was completed and reported using a lower cutoff of 100 mg/L Li. Note 5: In order to describe the resource in terms of industry standard, a conversion factor of 5.323 is used to convert elemental Li to Li₂CO₃, or Lithium Carbonate Equivalent (LCE).

Stage Two – Ortenau Inferred Resource

An Inferred resource estimation at the Ortenau Exploration Licence was presented in a Vulcan News Release and Technical Report effectively dated December 4, 2019 and remains unchanged. The Ortenau License was assessed using the resource modelling and estimation processes and prospect of economic extraction outlined above (for the Insheim Licence) with the following exceptions:

- Conservatively, only the Lower Triassic Buntsandstein Group aquifer was wireframed and modelled for the Ortenau Licence, because the resource area is not as well defined and Insheim has an abundance of subsurface information.
The Ortenau resource estimated used an average porosity of 9.5 % (With respect to Insheim, an average porosity of 9.0 % was used because the underlying Rotliegend Group porosity was determined to have a slightly lower than porosity than the Buntsandstein Group and therefore the Permo-Triassic porosity is lower).

At present, there is no direct access to Buntsandstein Group aquifer brine at Ortenau Licence. There has been limited geological sampling that is limited to brine from geothermal wells neighboring the licence. Accordingly, the geological evidence of lithium-enriched brine is sufficient to imply but not verify geological grade or quality continuity and the Ortenau licence requires further brine sampling detail to elevate the resources to higher levels of mineral resource classification.

The average lithium-in-brine concentration used in the Ortenau resource estimations is 181 mg/L Li and was based on the average of 13 samples collected throughout the Vulcan Property by Vulcan during the 2019 sampling program.

As outlined in Vulcan News Release dated December 4, 2019, the Inferred lithium-brine resource estimate at the Ortenau Licence was 2.48 million tonnes of elemental lithium, or 13.225 M tonnes of LCE (Table 3). Mineral resources are not mineral reserves and do not have demonstrated economic viability. There is no guarantee that all or any part of the mineral resource will be converted into a mineral reserve. While it would be reasonable to expect that the majority of Inferred Mineral Resources would upgrade to Indicated Mineral Resources with continued exploration, due to the uncertainly of Inferred Mineral Resource it should not be assumed that such upgrading will always occur. There is no direct link from an Inferred Mineral Resource to any category of Ore Reserves.

### Table 3: Inferred Vulcan Li-Brine Resource Estimate of lithium-bearing brine within the Buntsandstein Group aquifer domain at the Ortenau Licence (see Vulcan’s December 4, 2019 News Release for more information). The table also includes the Indicated Vulcan Li-Brine Resource Estimate at the Insheim Licence (see previous text) to provide a combined global Resource now estimated at 13.95 Mt LCE (Indicated & Inferred).

<table>
<thead>
<tr>
<th>Category</th>
<th>Aquifer Volume (km³)</th>
<th>Brine Volume (km³)</th>
<th>Average Lithium Concentration (mg/L Li)</th>
<th>Average Effective Porosity</th>
<th>TotalContained Elemental Li Resource Tonnes</th>
<th>Total Lithium Equivalent Million Tonnes</th>
<th>Contained Carbonate (LCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicated (Insheim License)</td>
<td>8.322</td>
<td>0.749</td>
<td>181</td>
<td>9.00</td>
<td>136,000</td>
<td>0.722</td>
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<tr>
<td>Inferred (Ortenau License)</td>
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<td>13.726</td>
<td>181</td>
<td>9.50</td>
<td>2,484,000</td>
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<td>Total</td>
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<td>14.475</td>
<td>181</td>
<td>9.47</td>
<td>2,620,000</td>
<td>13.95</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Mineral resources are not mineral reserves and do not have demonstrated economic viability. Note 2: The weights are reported in metric tonnes (1,000 kg or 2,204.6 lbs). Numbers may not add up due to rounding of the resource values percentages (rounded to the nearest 1,000 unit). Note 3: The volume and weights are estimated at average porosities of 9.0 % and 9.5 % for the Insheim and Ortenau resources, respectively. Note 4: The Vulcan Li-brine Project estimation was completed and reported
using a lower cutoff of 100 mg/L Li. Note 5: In order to describe the resource in terms of industry standard, a conversion factor of 5.323 is used to convert elemental Li to Li2CO3, or Lithium Carbonate Equivalent (LCE).

Processing and Flowsheet Development

Geothermal Power Plant

A geothermal power plant and wells already exist for Stage One, at the Insheim Plant, therefore no geothermal process design is required. For Stage Two, details of plant design are provided below to inform the reader of the material factors around geothermal plant development.

The Stage Two Geothermal Power Plant is responsible for four main functions; receiving brine from all geothermal production wells to generate power from ORC units, reduce the temperature of the brine to levels adequate for the lithium extraction circuit, generate steam for use in the Li product dryer (only in the four well plant) and to reinject the brine with any NCGs produced. Scaling prevention is also an important component of the process design. Based on references from other facilities, 50 µm filters are used on both the production and reinjection lines to prevent clogging of fractures within the reservoir with fine particles. Additionally, scaling inhibitors are injected into the brine stream to reduce scaling on equipment, most notably to reduce cleaning frequency of heat exchangers.

Power Production

The brine will be maintained at a gauge pressure above 20 bar(g) to a shell and tube heat exchanger, termed the “Main Power Plant Heat Exchanger”. This pressure requirement will help ensure the longevity of the upstream piping and heat exchangers, although will require refinement when more specific detail is known of the brine. These heat exchangers will reduce the temperature of the brine to roughly 65 C, transferring the thermal energy to an ORC unit. ORCs are highly modularized, limiting both complexity and footprint.

A by-pass connection will be included downstream of the ORC unit to allow the Geothermal Power Plant to remain in operation when the Lithium Plant is offline. The key process design criteria used to develop the Geothermal Power Plant are summarized in Table 4.

Table 4: Geothermal Power Plant & Wellfield Design Criteria

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four Well Geothermal Power Plant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Production Wells/Doublets</td>
<td>#</td>
<td>4/2</td>
<td></td>
</tr>
<tr>
<td>Number of Reinjection Wells/Doublets</td>
<td>#</td>
<td>4/2</td>
<td></td>
</tr>
<tr>
<td>Distance to HV Interconnection</td>
<td>km</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Six Well Geothermal Power Plant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Production Wells/Doublets</td>
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<td></td>
</tr>
<tr>
<td>Number of Reinjection Wells/Doublets</td>
<td>#</td>
<td>6/3</td>
<td></td>
</tr>
<tr>
<td>Distance to HV Interconnection</td>
<td>km</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Production wells will be combined into common power plants, incorporating larger ORC units between multiple doublets. The layout would include the following:

a) One ORC unit utilizing two production doublets. The plant will be located at one of the doublets, only requiring brine to be transferred to and from the other doublet.

b) One ORC unit utilizing three production doublets. The plant will be located at one of the doublets, requiring brine to be transferred to and from the two other doublets.

The benefit of this configuration would be:

c) Reduced total capital and operating costs due economies of scale.

d) Likely to operate at a higher capacity on average (well maintenance will likely have a lesser effect on the ORC capacity).

The drawback of this configuration would be:

e) Increased piping and pumping costs. Brine would have to be pumped from the wells to the ORCs.

**Brine Production**

The material assumptions described below apply to both Stage 1 and Stage 2.

The mineral resource is contained within hot, high salinity brine, that is within porous rock in the subsurface. This brine will be brought to the surface through deviated production wells that penetrate the reservoir. Brine produced from these production wells will be directed to the Geothermal Power Plant.

**Brine Production – Stage Two-Specific Commentary**

The number of wells is defined to satisfy the production target of the Lithium Plant. In the cases of the four well and
six well plants, a total of six wells will have to be directed over pipelines to a central power plant. Not enough pressure exists at depth to produce a pressurized brine above-ground, so in-line shaft pumps will be installed at roughly 650 m into the wells in order to generate a high enough pressure to transfer the brine to the Geothermal Power Plant as to avoid flashing and the release of NCGs (when below the bubble point).

Stage 2 Wells

The factors that could impact the estimated costs from current estimates include:

- Ultimately, exploration plays a major role in determining the expected productivity and thermal potential of wells, including the target drilling locations, depths and deviated paths. As exploration continues, it will reduce the inherent risks and increase the probability of success.

- Further definition of geology will reduce the risk and potentially the costs. It has been indicated that swelling clays pose a problem for drilling in the region which requires experienced drillers.

- Changes in regulation could pose an impact on estimated costs. For example, it was indicated there are currently discussions going on in Germany regarding well integrity that may lead to extra liner requirements, thus increasing well costs. This could be accounted for by assuming a double completion for both production and reinjection wells as a risk mitigation measure.

- Production wells and reinjection wells will be drilled with the same budget, diameter and depth.

Brine Feed

The material assumptions described below apply to both Stage 1 and Stage 2.

The characteristics of the feed brine were assumed based on average geochemical properties from a selection of historically published brines in the Upper Rhine Valley. The brine composition is as per Vulcan’s resource announcements on 20/01/2020 and 4/12/2019, with an average lithium content of 181 mg/L Li.

DLE and Lithium Plant – Stage One

For Stage One, a single Direct Extraction plant and lithium production plant could be constructed on site at the existing geothermal plant and wells.

DLE and Lithium Plant – Stage Two

For Stage Two, it was decided to install a single ‘mother plant’ for lithium production from the direct extraction concentrate to be located at the largest geothermal and direct extraction plant. Direct extraction concentrates from the other locations would be trucked in to the central ‘mother plant’ for lithium production.

The following flowsheets and staging configuration were selected for the Scoping Study:

- Stage 2 Production Plant 1: four extraction wells, geothermal plant, direct extraction and lithium plant
- Stage 2 Production Plant 2: six extraction wells, geothermal plant, direct extraction and trucking of lithium concentrated liquor to the lithium plant.
Direct Extraction and Lithium Production Plant

The material assumptions described below apply to both Stage 1 and Stage 2 plants.

The preliminary pretreatment design is based on guidance from direct extraction technology suppliers with reference to the expected Project Vulcan brine composition. The pretreatment will be operated at around 65°C. Absorbent Based Direct Extraction Treated lithium chloride brine enters the direct extraction process which selectively extracts lithium from the brine while rejecting other ionic species. Lithium is stripped from the adsorbent using water to form an eluate at 1.6 g/L Li with a volume approximately one tenth of the feed brine. The depleted brine is pumped back at pressure to the reinjection wells to recharge the brine reservoir. Noncondensable gasses recovered during the feed brine let-down would be reinjected into the returning brine. The purified eluate is concentrated through a reverse osmosis package to increase the lithium content to 6 g/L. The lithium liquor (retentate) is preheated and further concentrated to 25 g/L lithium in a falling film mechanical vapor recompression (MVR) evaporator. This step reduces the downstream equipment size and allows for efficient trucking of concentrate to the lithium production site (for remote direct extraction plant options).

The concentrated brine is reacted stage-wise with sodium hydroxide and sodium carbonate to increase pH and precipitate magnesium and calcium respectively. The fine precipitates are removed by a candle-type polishing filter with precoat and body feed added to improve filterability. Filter cake is discharged to a bunker and stored in containers for disposal by trucks. Ion exchange is used to further purify the lithium chloride liquor, utilizing hydrochloric acid for elution and sodium hydroxide for regeneration. Residual contaminants, including magnesium, calcium and iron are removed from solution down to levels below 1 ppm to achieve the target product purity.

Following impurity removal, lithium hydroxide is produced via industry-standard methods from the lithium chloride stream. This involves either directly crystallizing lithium hydroxide using chlor-alkali type methods, or with a lithium carbonate precipitation step using sodium carbonate and carbon dioxide from lime regeneration to precipitate lithium carbonate, and lithium carbonate cake is re-pulped and reacted with calcium hydroxide slurry to form lithium hydroxide Carbon dioxide formed during calcination is captured via an amine-based carbon dioxide recovery plant, with the separated carbon dioxide directed to the lithium carbonate precipitation stage. The plant is designed to achieve typical battery-grade lithium hydroxide monohydrate product quality. Financial outcomes from both methods were found to be similar; in the results presented in this study, the former method of direct lithium hydroxide production is used.

![Figure 4: Simplified Flowsheet of Zero Carbon Lithium Process](image-url)
Project Funding

It is most likely that any financing would be undertaken via a combination of debt and equity, similar to a number of comparable projects in the lithium sector which have been funded in the past 24 months. Under current conditions, debt may be secured from several sources including Australian and/or European banks, international banks, the high yield bond market and resource credit funds. It is difficult to finance metals that cannot be easily hedged with banks and for this reason, along with the size and volatility of the lithium market, debt funding is more likely to be sourced from resource credit funds. On this basis, it is likely that the Vulcan Lithium Project will require the support of a resource credit fund or alternatively it may be possible in the bond market. There are several factors that will influence the ability of Vulcan to secure funding including (but not limited to) a requirement to have “bankable” lithium offtake agreements and favourable prevailing market conditions (being both the lithium market and the wider equity and debt market). It may also be necessary and/or desirable to have an offtake partner invest in the Company or the Project. It is possible that funding may be dilutive to, or otherwise affect the value of the Company’s existing shares. It is also possible that the Company could pursue other strategies to provide alternative funding options including undertaking a corporate transaction, seeking a joint venture partner or asset sales.

Implementation and Schedule

Pre-Feasibility Studies will now commence and are expected to be completed in late 2020, after which Definitive Feasibility Studies, permitting and construction will follow. It is currently estimated that Stage 1 could commence in 2023, and 2024 for Stage 2.

For and on behalf of the Board

Mauro Piccini

Company Secretary

For further information visit www.v-er.com

Zero Carbon Lithium™
Disclaimer

Some of the statements appearing in this announcement may be in the nature of forward-looking statements. You should be aware that such statements are only predictions and are subject to inherent risks and uncertainties. Those risks and uncertainties include factors and risks specific to the industries in which Vulcan operates and proposes to operate as well as general economic conditions, prevailing exchange rates and interest rates and conditions in the financial markets, among other things. Actual events or results may differ materially from the events or results expressed or implied in any forward-looking statement. No forward-looking statement is a guarantee or representation as to future performance or any other future matters, which will be influenced by a number of factors and subject to various uncertainties and contingencies, many of which will be outside Vulcan’s control.

Vulcan does not undertake any obligation to update publicly or release any revisions to these forward-looking statements to reflect events or circumstances after today’s date or to reflect the occurrence of unanticipated events. No representation or warranty, express or implied, is made as to the fairness, accuracy, completeness or correctness of the information, opinions or conclusions contained in this announcement. To the maximum extent permitted by law, none of Vulcan, its Directors, employees, advisors or agents, nor any other person, accepts any liability for any loss arising from the use of the information contained in this announcement. You are cautioned not to place undue reliance on any forward-looking statement. The forward-looking statements in this announcement reflect views held only as at the date of this announcement. This announcement is not an offer, invitation or recommendation to subscribe for, or purchase securities by Vulcan. No forward-looking statement is a guarantee or representation as to future performance or any other future matters, which will be influenced by a number of factors and subject to various uncertainties and contingencies, many of which will be outside Vulcan’s control.

Competent Person Statement:

The information in this report that relates to Mineral Resources for the Vulcan Geothermal-Lithium Project is extracted from the ASX announcements “maiden JORC (2012) Mineral Resource Estimate for its Ortenau licence” and “Maiden Indicated Resource Insheim Vulcan Zero Carbon Lithium” released on the 4th of December 2019 and 20th of January 2020 which are available on www.v-er.com. The information in this report that relates to Mineral Resources for the Vulcan Geothermal-Lithium Project is extracted from the ASX announcement “Maiden Indicated Resource Insheim Vulcan Zero Carbon Lithium” released on the 20th of January 2020 which is available on www.v-er.com. The Scoping Study Report – and associated third-party consultant reports – are intended to be used as internal documents by Vulcan for the Company’s planning purposes. The Company confirms that it is not aware of any new information or data that materially affects the information included in the previous market announcement and that all material assumptions and technical parameters underpinning the estimates in the relevant market announcement continue to apply and have not materially changed. The technical information relating to exploration results and Mineral Resource Estimates reported in this News Release has been prepared and reviewed by Mr. Roy Eccles P. Geol. of APEX Geoscience Ltd. in Edmonton, Canada. Mr. Jason Froud MAIG of Optiro Pty Ltd. in West Perth, Western Australia prepared the Economic Analysis. Both Mr Eccles and Mr Froud are deemed to be ‘Competent Persons’. Mr. Eccles and Mr. Froud have sufficient experience relevant to the style of mineralization and type of deposit under consideration and to the activity which they are undertaking to qualify as Competent Person as defined in the 2012 Edition of the Australian Code for the Reporting of Exploration Results, Mineral Resources, and Ore Reserves (JORC Code). Mr. Eccles P. Geol. and Mr. Froud MAIG consent to the disclosure of the aforementioned technical information in this News Release in the form and context in which it appears. CAPEX, OPEX and DLE plant parameters were generated by Vulcan in consultation with Hatch Ltd.
Appendix 1

Vulcan Project Summary: Unique Zero-Carbon Lithium™ Production

The **Vulcan Zero Carbon Lithium™ Project** is aiming to be Europe’s and the world’s first Zero Carbon Lithium™ project. It aims to achieve this by producing battery-quality lithium hydroxide from hot, sub-surface geothermal brines pumped from wells, with a renewable energy by-product fulfilling all processing energy needs.

The Vulcan Zero Carbon Lithium™ Project is strategically located, within a region well-serviced by local industrial activity, at the heart of the European auto and lithium-ion battery manufacturing industry, just 60km from Stuttgart. The burgeoning European battery manufacturing industry is forecast to be the world’s second largest, with currently zero domestic supply of battery grade lithium products.

**World’s First & Only Zero-Carbon Lithium™ Process**

Co-generation of geothermal energy from production wells will power lithium extraction. Unique process will satisfy OEMs’ stated desire for ISO-compliant, zero carbon Electric Vehicle (EV) raw materials supply.

**Europe’s Largest JORC Lithium Resource**

Recent JORC Mineral Resources contain a total combined Indicated and Inferred estimates of 13.95 million tonnes of Lithium Carbonate Equivalent (LCE). Large enough to be Europe’s primary source of battery-quality lithium hydroxide.

**Most Optimally Positioned for Supply Chain Security & Footprint Reduction**

Located in Germany, in the centre of the European lithium-ion battery industry. Removes dependence on South America/China for this designated Critical Raw Material. Removes carbon footprint of supply chain.

**Europe’s Lowest Impact Lithium Project**

No hard-rock mining, no evaporation ponds required in Vulcan’s Zero Carbon Lithium™ process. Instead lithium extraction the European way, from renewable energy-producing geothermal brine wells rich in Li.

**World’s Most Rapidly Advancing Lithium Project**

Recent agreement with German geothermal operator provides access to existing wells and potentially a fast-track to production.

**Unprecedent Demand Forecast for Lithium Hydroxide in Europe**

Ramp-up of lithium-ion battery manufacturing for auto industry in Europe in 2020s forecast to dwarf China expansion of 2016-18. Zero local supply of battery quality lithium hydroxide.
Figure 5: Schematic of the Zero Carbon Lithium project

Figure 6: Vulcan’s Zero Carbon Lithium™ process
Unprecedented Demand for Lithium in Europe - The Next China?

- In the 2010s, China experienced the world’s highest growth in lithium-ion battery production for electric vehicles. It caused a lithium supply shortage & 300% lithium price spike.
- In the 2020s, the same is forecast to happen in Europe, on a larger scale.
- “European battery cell production capacity is set to increase rapidly in the coming decade. Europe currently has no commercial lithium production or refining capacity of its own to meet this demand, but plans are afoot to change this” (Benchmark Mineral Intelligence, 2019).

There is an unprecedented ramping up of lithium-ion and associated cathode production in Europe. Forecasts show that the European Union (EU) is set to require the equivalent of the entire current global battery quality lithium demand by the mid-2020s, with 2023 being the main inflection point. There is currently zero EU production of battery-quality lithium hydroxide, let alone a CO₂-neutral product. A severe battery-quality lithium chemical supply shortfall is thus developing in the EU.

Figure 7: Forecast battery production in EU and associated lithium demand

Why Vulcan? Zero Carbon Supply Chains Required

BEV raw material supply chains have a carbon footprint problem, producing more CO₂ during production than Internal Combustion Engines (ICE). Car manufacturers are actively trying to reduce the carbon footprint of their battery supply chains to bolster the credibility of their BEV offerings. This will enable them to avoid financial emissions penalties and obtain premium pricing for lowest carbon footprint in production. Volkswagen, among

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5 Adapted from Benchmark Mineral Intelligence and Individual Lithium-Ion Battery Manufacturing Company Announcements from Tesla, Northvolt, CATL, Leclanche, PSA, SVolt, TerraE, BMZ, Freyr Energy, Microvast, Farasis, LG Chem, Johnson Matthey, Umicore, SK Innovation, Samsung, BYD.
others, is placing great importance on having a CO2-neutral production supply chain for its very extensive new EV line-up, with a raw materials purchasing metric for sustainability put on par with price\(^6\), and the goal of producing net zero carbon BEVs as delivered to the customer. The European Commission is following suit, recently flagging that “CO2 Passports” will be issued to BEVs detailing the full CO2 footprint of each battery. The aim is to differentiate EU lithium-ion battery and BEV production, by producing uniquely low CO2 products. The EU has declared a climate emergency and aims to cut 55% of emissions by 2030, net zero by 2050. Currently, there is no “zero carbon” lithium chemical product in the world, since all current extraction, processing and transport routes are very carbon intensive. Spodumene converted by fossil fuel-fired processes and lithium products transported from South America will always emit significant quantities of CO2 to sell their lithium products in Europe.

Hard-rock lithium production has a high OPEX and high CO2 footprint due to its inherent energy requirement for mining, crushing and processing to producing battery quality lithium chemicals, as well its transport distance to major global markets. A processing bottleneck has also developed for spodumene concentrate going through lithium refinery plants in China, creating downward pressure on concentrate prices. South American lithium brine operations make up the balance of current production. Because of their distance to market, remoteness and substantial use of reagents from North America, there is a substantial CO2 footprint inherent in these operations also. These operations can also be very slow and unreliable in terms of producing battery quality lithium chemicals, as the evaporation process makes them vulnerable to weather events. The evaporation can also cause stresses on local environment and communities.

The world’s conventional lithium supply chains are not geared towards low carbon intensity production, so Europe will need to build its own.

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**Figure 8: EVs’ carbon problem, and the industry goal to fix the problem**

\(^6\) Volkswagen ID presentation, 2019
The Solution: Vulcan’s Zero Carbon Lithium™ Project

The Company believes that the solution lies in the **Vulcan Zero Carbon Lithium™ Project**. This comprises a very large, lithium-rich geothermal brine field in the Upper Rhine Valley of South-West Germany, in the heart of the EU’s battery “giga-factory” production.

**Summary**

- Unique flowsheet developed by Vulcan, making use of **binary cycle geothermal electricity & heat** to create a **Zero Carbon Lithium™ product**.
- Direct Lithium Extraction (DLE) process to produce LiOH•H2O from the brine,
- Zero carbon electricity generated and used to produce premium, Zero Carbon Lithium™ with no gas input.
- Spent brine re-injected into reservoir with no evaporation losses.
- Processing time **hours instead of months**, not dependent on weather like South American brines.
- Creates high purity, high concentration solution that is easily converted on site into **battery quality LiOH•H2O**.
- Excess power will be sold at a Feed-in-Tariff, displacing coal and decarbonizing the German electric grid.
- No need for high energy mining, crushing, grinding and conversion processes used in hard-rock lithium deposits.

Vulcan intends to test and de-risk this flowsheet in 2020, during its feasibility studies.

The Zero Carbon Lithium™ production stems from a clever, unique process:

1. Standard geothermal production wells will be drilled into high flow rate, lithium-rich brine reservoir units, including the Buntsandstein unit. Geothermal energy wells have been successfully doing this for decades in the Upper Rhine Valley, so there is strong precedent. The heated brine is pumped up and produces geothermal energy via a binary cycle plant, which emits no CO₂.

2. Usually the spent brine would then be re-injected into the reservoir. In the Vulcan process, the spent brine gets diverted through a Direct Lithium Extraction (DLE) plant, where the vast majority of the lithium is extracted in less than an hour, while leaving other impurities. The brine is then re-injected into the reservoir minus the lithium. A new lithium stream of much higher concentration is formed for further processing and nothing is added to the brine. Livent has used a similar process to produce LiOH•H2O from Argentine brine for over 30 years. Importantly, such technologies have been successfully tested in California for the Salton Sea geothermal lithium field, which has similar brine characteristics to the Upper Rhine Valley brine, meaning a similar process can be used. Vulcan will fast-track project development through its relationships with the most successful groups in the DLE industry who have already de-risked the methods used.

3. A series of chemical operations convert the lithium stream into battery quality lithium hydroxide using conventional processes all previously demonstrated at commercial scale. Water is recycled, no toxic wastes are produced, and no gases are emitted. Heat and power from the geothermal plant are used, meaning no fossil fuels are burned, eliminating carbon emissions from lithium hydroxide processing. On top of being a zero-carbon product, it is expected that the Vulcan flowsheet will be a very low cost LiOH•H2O operation.
Vulcan Project, Germany: Strategic Location, Large License-Holding

Summary

- Most well-explored graben system in the world: large quantities of existing 2D and 3D seismic data to shortcut development timeline.
- Dominant license landholding in lithium-rich brine field - ~800 km² of license area.
- Thousands of historical wells and multiple operating geothermal wells in the region provide a wealth of data and readily accessible brine.
- Geothermal brine production socially & environmentally accepted in region with vineyards and communities next to existing operations.
- Lithium hydroxide is a “semi-bulk” commodity. Vulcan’s short distance to markets is a major cost advantage as well as carbon advantage.
- Strategic, secure domestic supply for EU OEMs at a time of global trade insecurity.
- Located in Germany just 60km from Stuttgart; the centre of the burgeoning European lithium-ion supply chain.

The Vulcan Zero Carbon Lithium™ Project is situated within one of the most well-studied and well-explored graben systems in the world. This means that the lithium-rich brine in the field is very well understood, and large amounts of seismic and geochemical data are readily available, reducing the need for exploration time and spend. Drilling data and existing wells are also available and can be used to shortcut project development. Based on historical data, the Upper Rhine Valley brines have been shown to have grades in the same order of magnitude as typical South American salars, in the hundreds of ppm Li, but with the advantage of readily available heat and power. Commonly, grades are >150 mg/l Li in the Upper Rhine Valley at the depths targeted, with grades sometimes up to 210mg/l Li. The means that the Upper Rhine Valley brine field is one of the only geothermal brines in the world, the Salton Sea in California being the other main example, with both high flow rates and lithium grades within the brine reservoir. The Vulcan project represents a dominant licence landholding within this brine field.

Importantly, as well as being European, the project is just 60km away from Stuttgart, the home of the German auto-industry. It is perfectly placed to reduce the transport footprint of lithium chemicals down to almost negligible amounts, both from a carbon cost and direct financial cost perspective. In addition, existing and recently permitted geothermal operations within the area are testament to the social and environmental acceptance of drilling geothermal wells within the region, in contrast with hard rock mining projects elsewhere in Europe. Indeed, the Insheim geothermal operation, which is the subject of Vulcan’s MoU with Pfalzwerke geofuture, is surrounded by vineyards, showing the harmony of such operations with local communities.
Figure 9: Vulcan Zero Carbon Lithium™ Project Location
German Utility Partnership: Shortcut to Development

Summary

- MoU agreement signed in November 2019 with subsidiary of German utility Pfalzwerke Group – Pfalzwerke geofuture, for JV at operational Insheim geothermal plant to produce lithium hydroxide.
- Transformational agreement for Vulcan, gives access to lithium-rich, producing brine operations neighbouring Vulcan’s existing project area.
- Potential to significantly short-cut timescale to production of Zero Carbon Lithium™ hydroxide.
- Vulcan to earn up to 80% of lithium rights at Insheim by completing Pre-Feasibility (PFS) and Definitive Feasibility (DFS) studies.
- Pfalzwerke Gruppe is a German and international energy provider with annual revenue in excess of €1.3 billion.
- Insheim geothermal plant a shining example of geothermal best-practice, operating in harmony with local community and environment for 7 years.