Lithium Extraction from Geothermal Brine in the Salton Sea Region

The Thacker Pass Project: An Analysis of the Political Work Performed by the Largest Lithium Deposit in the U.S.

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On my honor as a university student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

As concerns over the global climate emergency rise, there has been a significant push for the adoption of cleaner, more renewable energy sources. Indeed, the transportation sector was the primary source of greenhouse gas (GHG) emissions in the U.S. in 2021, and several strategies have been proposed to reduce reliance on carbon-based fuels, and in turn, transportation-related emissions (United States Environmental Protection Agency, 2023). A highly favored solution is the utilization of lithium-ion batteries to power vehicles. However, one major complicating factor associated with large-scale implementation is material acquisition. Traditional methods of lithium extraction are highly energy, land, and freshwater intensive.

Direct lithium extraction (DLE) is an alternative method of lithium sourcing, reducing land use, water requirements, and energy consumption when compared to traditional lithium extraction methods (National Renewable Energy Laboratory, 2021). Although this process has currently only been implemented on small-scales, early studies have proven promising. Thus, my technical project group and I aim to scale-up DLE, or more specifically, design a process that directly extracts lithium from geothermal brine in the Salton Sea region of southern California. DLE is an innovative solution to answer the growing global demands of lithium for vehicle electrification. With lithium being identified as a "critical mineral" essential to the economic and national security of the U.S., it is necessary to understand how emerging technologies used to source lithium can affect relations of power and privilege among groups of people (Geothermal Technologies Office, n.d.). To examine how a technology can advantage some while marginalizing others, I will draw upon the Science, Technology, and Society (STS) framework of Technological Politics to investigate the inherent political qualities of the Thacker Pass Project, the largest lithium mine in the U.S..

Attending to the technical aspects, while ignoring social aspects, will leave the problem of climate change only partially resolved. Certainly, developing lithium extraction techniques aid in preventing a global lithium shortage, and in a larger context, decreasing GHG emissions from the transportation sector. However, if the political work performed by such technologies is not soon realized, then potential harm directed towards certain groups will intensify as the need to combat climate change continues. Therefore, because the climate crisis is sociotechnical in nature, it requires attending to both its technical and social aspects. In what follows, I elaborate further on two related research proposals: first, a technical project that involves lithium extraction from geothermal brine in the Salton Sea area and an STS project that examines the political work performed by the largest lithium mining operation in the U.S., the Thacker Pass Project. As the technical project is developed, I will apply insights from the Thacker Pass Project such that my group addresses concerns of power, justice, and care throughout technological design.

Technical Project Proposal

Amid growing vehicle electrification efforts, the global market for lithium, a key component in lithium-ion batteries, is projected to rise dramatically. The World Economic Forum estimates that the global demand for lithium will reach more than 3 million metric tons by 2030, a prediction significantly higher than current production capacities (Ying Shan, 2023). With such a rapidly scaling market, the International Energy Agency predicts there will be a global lithium shortage in as few as 2 years (Shine, 2022). Furthermore, while the U.S. has among the highest demonstrated lithium reserves, much of these resources are untapped, with almost the entirety of the lithium in the U.S. being imported. Coupling rapid market growth with significant foreign dependance, the U.S. Department of Energy Geothermal Technologies Office has identified lithium as a “critical mineral” essential to the economic security of the U.S. (Geothermal Technologies Office, n.d.).

Traditional methods of lithium extraction, including underground or open pit mining, are highly energy, land, and freshwater intensive. Furthermore, global lithium reserves are commonly concentrated in South America and China where there are less stringent labor laws, leading to human rights violations (Earnshaw-Olser, 2023).

To decrease reliance on externally sourced and often harmful traditional extraction techniques, a new method of lithium sourcing, direct lithium extraction (DLE), is currently being researched by multiple groups, including the National Renewable Energy Laboratory. DLE is designed to retrofit to geothermal energy plants, selectively extracting lithium from underground brines before they are reinjected. By incorporating into existing processes, DLE requires less land disturbance than traditional lithium extraction methods (National Renewable Energy Laboratory, 2021). Furthermore, water requirements are reduced by relying on the closed loop circulation of underground water. By harnessing waste heat generated by the plant, the energy requirement for lithium extraction is also minimized. DLE has only been executed at small-scales, so the current challenge lies in scaling-up the process to achieve market viability.

Our project involves the direct extraction of lithium from geothermal brines in the Salton Sea region of southern California. The final product, lithium hydroxide monohydrate ($LiOH \bullet H_2O$), is collected through a series of operations including lithium adsorption and regeneration, electrodialysis, and crystallization. The proposed process is designed to retrofit to a geothermal power plant. Figure 1 depicts the block flow diagram to accompany the process.

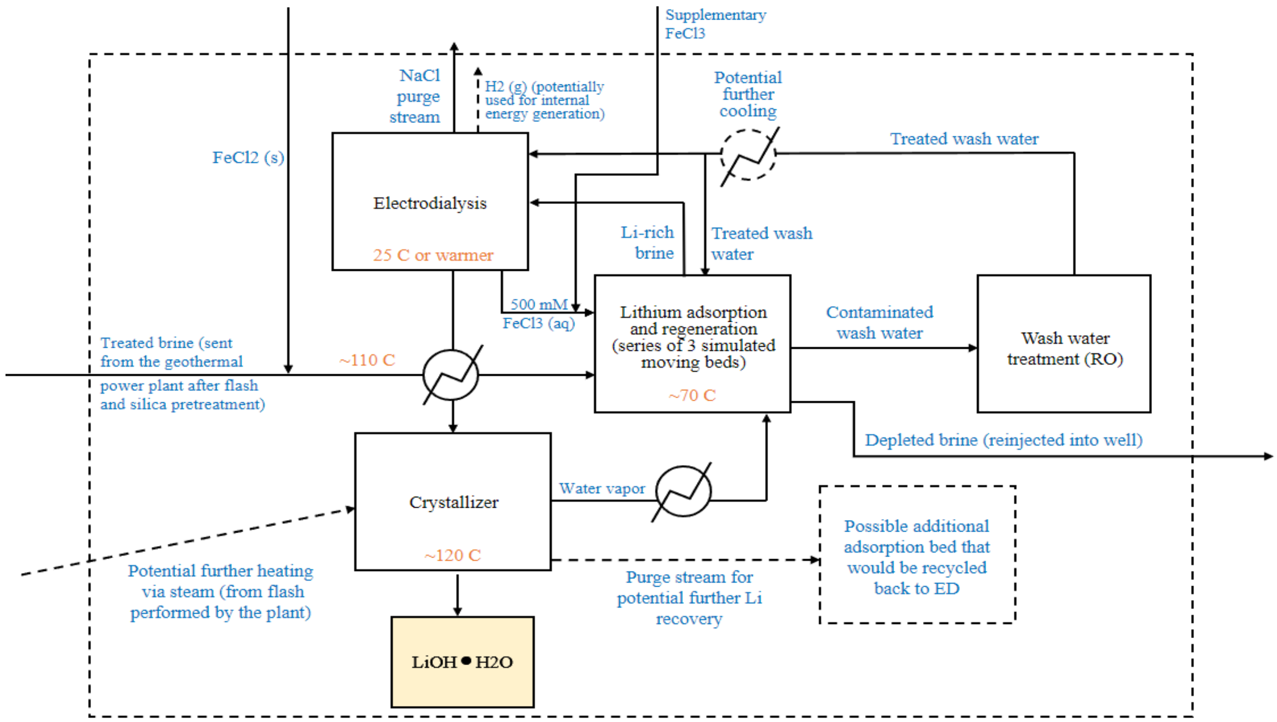

Figure 1. Generalized block flow diagram

Geothermal brine is pumped out of underground wells where it flashes and produces steam. The steam is sent to be used for power generation, which is outside the scope of this process. The plant must treat the remaining liquid brine prior to reinjection; as such, the brine entering will be considered silica-treated at its saturation temperature and atmospheric pressure. Iron (II) chloride powder is first added to the treated brine, supplementing the iron (II) ions already present, to facilitate the adsorption of lithium ions in the downstream adsorption beds. The brine is then transported to a heat exchanger for cooling before it enters the lithium adsorption and regeneration unit, which consists of a series of 3 simulated moving beds. In general, two beds are constantly adsorbing lithium ions onto an iron (III) phosphate bed, along with iron (II) ions, while the third is stripped of all adsorbed lithium.

After adsorption, depleted brine is reinjected into the well while the lithium-concentrated bed undergoes desorption. A stripping solution recycled from the electrodialysis (ED) unit removes lithium ions and regenerates the iron (III) phosphate sorbent. Supplementary iron (III) chloride is added to the stream leaving the ED unit to aid in the desorption process. Following desorption, the spent stripping solution (i.e., the lithium-enriched brine in Figure 1) is sent to the ED unit. In between the adsorption and regeneration processes, the beds are washed with condensed vapor from the crystallization unit. The contaminated wash water is then treated via reverse osmosis (RO). A portion of the treated water is recycled back into the adsorption unit, while the rest of the stream enters the ED unit. Because the ED temperature requirement is lower than that of adsorption, a potential idea is to cool the ED unit using a portion of our treated wash water stream. In the ED unit, lithium ions are drawn through a membrane by an electric current and separated from chloride ions. To maintain charge neutrality, water is split into hydroxide and hydrogen ions, generating lithium hydroxide. At the anode, iron (II) ions are oxidized to iron (III) ions, replenishing the stripping solution that is sent to the adsorber. Additionally, sodium chloride and hydrogen gas purge streams exit the ED. The hydrogen gas stream will potentially be directed to a fuel cell to generate power for this process while the sodium chloride becomes waste. The aqueous lithium hydroxide flowing out of the ED unit is sent through a heat exchanger, where heat from the original brine feed is used, in addition to external heating, to warm the fluid for crystallization. The aqueous lithium hydroxide is crystallized and dried to generate lithium hydroxide monohydrate. If calculations indicate that the purge stream exiting the crystallization unit still contains significant concentrations of lithium, it may be sent to a separate adsorption bed for further recovery. An alternative method, antisolvent crystallization, might be more energy efficient and economically viable than evaporative crystallization. A decision regarding the crystallization method will be made following forthcoming energetic and economic analysis.

Specific data will be obtained from University of Virginia Professors Geoffrey Geise, Gary Koenig, and Gaurav Giri. Additional information will be obtained from literature sources. Most of the process will be modeled using Aspen Plus V14. For other calculations that cannot be done in Aspen, we will use Excel and MATLAB. The team will divide the work amongst the different process blocks, with one member taking "lead" of each unit operation. That said, we aim to be actively collaborating with one another on all calculations, especially if a unit operation requires many calculations, such as the ED or adsorption unit.

STS Project Proposal

Located in Humboldt County, Nevada is the largest lithium deposit in the United States and one of the largest known in the world (Uji, Song, Dolšak, & Prakash, 2023). Aiming to produce battery-grade lithium carbonate, a critical component in the manufacturing of advanced electric vehicles (EVs), Lithium Americas Corporation and their subsidiary, Lithium Nevada Corporation, proposed to construct, operate, reclaim, and close an open pit lithium mining and processing operation in the northern Nevada area (Lithium Nevada Corporation, 2019; Nevada Division of Environmental Protection, n.d.). Often referred to as the Thacker Pass Project, the proposal was approved by the U.S. Bureau of Land Management (BLM) in January 2021 (Rodeiro, 2023).

Although Lithium Nevada expects the mine to generate up to 80,000 tons of lithium carbonate a year, roughly equal to a fifth of global lithium production in 2020, the project has faced strong opposition coming from nearby indigenous communities and environmental groups (Graham, Rupp, & Brungard, 2021; Hill, 2023). Indeed, such groups first initiated litigation in 2021 to halt the project's progress, however, a final decision was made in February 2023 when U.S. District Judge Miranda Du ruled for construction to continue (Webber, 2022). Some writers have focused specifically on the environmental issues of Thacker Pass, stating that it is just one example of how the mining industry is exploiting the political climate that favors green energy (Price, 2021). However, their arguments inadequately address the way in which the project marginalizes the nearby indigenous groups. More specifically, the site is near the Fort McDermitt-Paiute Shoshone Tribes of the Fort McDermitt Reservation (Berglan, Miller-McFeeley, & Folds, 2022). Known as Peehee mu'huh, Thacker Pass is not only significant to the Fort McDermitt-Paiute Shoshone Tribes, but also to the Reno-Sparks Indian Colony, Burns Paiute Tribe, and Pyramid Lake Paiute Tribe (Berglan, Miller-McFeeley, & Folds, 2022). Arlan Melendez, chair of the Reno-Sparks Indian Colony, has said, "Annihilating old growth sagebrush, Indigenous peoples' medicines, food, and ceremonial grounds for electric vehicles isn't very climate conscious" (Hill, 2023).

Considering the Thacker Pass Project as only a step towards meeting sustainable development and energy security goals in the U.S. ignores the political work it performs by affecting power relations among the nearby indigenous groups and those benefited by the mining operation. For example, General Motors has provided the project with substantial commercial support with an equity investment of $650 million in return for exclusive access to the lithium carbonate produced for ten years (Timbie, Deutch, Ewing, Ellis Jr., Ram, Park, & Fedor, n.d.). Meanwhile, tribal leaders have argued that the now approved project is to be on sacred land with cultural, historical, and spiritual significance (Webber, 2022). Drawing on the STS framework of Technological Politics, I argue that the Thacker Pass Project performs powerful political work by privileging the Lithium Nevada Corporation, project investors, and several others while marginalizing the local tribal communities. In his framework, Langdon Winner defines "politics" as, "arrangements of power and authority in human associations as well as the activities that take place within those arrangements" (Winner, 2014). Winner further outlines two varieties of interpretation that indicate how artifacts can have political qualities, including "technical arrangements as forms of order," and "inherently political technologies." I argue that the Thacker Pass Project represents what Winner describes as the point where the two varieties of interpretation overlap and intersect. In other words, Thacker pass has political qualities, where the intractable properties of the technology, such as the relatively large size of the lithium deposit, provide a convenient means of establishing patterns of power and authority (Winner, 2014).

To support my argument, I will draw upon sources that demonstrate the historical pattern of power and authority waged against Native Americans in the U.S. While there are several sources that outline the significance of Peehee mu'huh specifically, I plan to provide additional evidence that shows the repetitive marginalization of indigenous communities. Furthermore, I will lay out the various stakeholders in the Thacker Pass Project who are either directly or indirectly benefiting from its continuation.

Conclusion

The technical project will entail designing a DLE process that extracts lithium from geothermal brine in the Salton Sea region of southern California. The accompanying STS research will aim to investigate how the Thacker Pass Project, located in northern Nevada, affects power relations among the nearby indigenous groups and those benefited by the mining operations. By seeing firsthand how technology can perform powerful political work, I will work to address concerns of power, justice, and care while designing an innovative system. Overall, climate change is a sociotechnical problem, and building upon a way to garner resources for combative technologies while also considering the potential political work performed by the method is a promising solution.

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