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Additional submitted attachment is included below.

BERKELEY LAB

Lithium Resource Research
and Innovation Center

28 October 2022

To the Blue Ribbon Commission on Lithium Extraction in California,
and the Stakeholders of Lithium development in Southern California,

Lawrence Berkeley National Laboratory (Berkeley Lab) supports the work of the Commission as an important forum for dialogue and information exchange on the complex issue of lithium production from geothermal resources. As participants, researchers and stakeholders, we see considerable benefits arising from the processes and outcomes overseen by the Commission. The draft report highlights some of the key takeaways learned to date, and reveals the need for ongoing research that is motivated by both technological and societal imperatives. Here, we offer additional context to the high level conclusions of the report and suggest minor but specific changes to the language for clarity and consistency.

Our feedback is based, in part, on our comprehensive project to better understand the impacts, positive and negative, of Direct Lithium Extraction (DLE) development from Salton Sea geothermal resources. The purpose is to identify the source of the lithium in the Salton Sea geothermal brine, quantify how much lithium is present and can be extracted, and evaluate any potential environmental impacts and their corresponding mitigation measures. In parallel, we are engaging directly with community stakeholders and analyzing the proceedings of the Commission to better inform how our taxpayer-funded research addresses topics of greatest interest and concern to community members. Our research project team includes scientists and engineers from Lawrence Berkeley National Laboratory, UC Riverside, Geologica Geothermal, UC Davis, and MIT and is funded by the Department of Energy's Geothermal Technologies Office. We will provide a full report that is open to the public and freely available once the study is complete in the summer of 2023, with preliminary results to be presented at the 2023 Stanford Geothermal Workshop and the 2023 Society for Mining, Metallurgy, and Exploration conference. Here, we highlight two key points that have emerged from our work so far that we believe add important context to the Commission's draft report.

1. Lithium extraction from geothermal brines is a significant technological undertaking that remains unprecedented at the scales and rates required to realize optimistic visions for Lithium Valley.

2. Continual technological developments in geothermal DLE and highly volatile minerals markets require ongoing evaluation of impacts, risks, and benefits; the draft report reflects a snapshot from a narrative that extends further backward and forward in time.

Many important facets of the impacts, risks and benefits are discussed in the Commission's draft report. We wish to emphasize here the specific topics currently under investigation that should help provide clarity on certain issues after the report is released.

Quantification of Lithium Resources and Environmental Impact

While many studies have estimated the environmental impact of lithium production, they have focused on other production methods, specifically evaporation and hard rock mining. The companies in Lithium Valley plan to use DLE technology, which has not yet been deployed at a commercial scale for hypersaline geothermal brines. As a result, the environmental impact is uncertain, although it is expected to be significantly more sustainable than status quo lithium production methods. Accurate estimations of how much lithium could be produced at the site and for how long are also important to plan for regional development and understand the potential economic impact for the community. Numerous studies have attempted to estimate the Li resource potential of these fluids; however, this project will provide greater insight about long-term lithium production.

Research Questions

- How much lithium is present, and what is the source of the lithium?
- How much lithium is recoverable?
- How rapidly will the concentration decrease, and will lithium present in minerals in the reservoir help recharge the geothermal brine lithium?
- How much water is needed, and how does this fit into current and future water use?
- What are the environmental impacts?
    - Evaluate use of chemicals, byproduct generation, and waste stream
    - Evaluate pollutant emission
    - Conduct risk assessment of induced seismicity

Community engagement

We are incorporating community engagement as an ongoing aspect of the project to facilitate an open exchange of information between researchers and interested community members, advocacy groups, policymakers, and industry. The Blue Ribbon Commission has been instrumental as it has given us the opportunity to observe public meetings and understand what topics are of interest, and what questions people in the surrounding communities have about lithium extraction. In addition, members of our team have regularly visited the region to better understand the local context and identify future outreach opportunities to make sure the information generated by our study is transparent and accessible. We are grateful to Comite Civico del Valle, Leadership Counsel, and Alianza Coachella Valley for their support in this area.

Goals of Community Engagement:

- Inform the local community about the anticipated production capacity of the lithium resource, any potential impacts of extraction, and the status of development
- Interact with local stakeholders to ensure that research about lithium effectively addresses their concerns and reflects their lived experience
- Develop best practices for communicating technical information and gathering feedback

Connection to Battery Manufacturing

The opportunities in Lithium Valley are well aligned with capabilities that the Berkeley Lab Energy Storage Center brings to U.S. battery manufacturing, which includes a focus on integrating domestic lithium sources into battery supply chains for improved resilience and reduced environmental impact. Detailed analyses of the consequences of co-location, including total battery cost, total embodied emissions, and many other risks and benefits should be undertaken in parallel to an assessment of the resource. The economics of next-generation batteries being developed at Berkeley Lab and elsewhere, which may rely on alternative forms of lithium and a different set of chemical precursors, could dramatically alter the business case for resource project development. For example, battery cathodes that rely on manganese instead of cobalt as a redox active transition metal could utilize both lithium and manganese from the same geothermal resource. Given the similar technology readiness levels for large scale lithium extraction processes and next-generation lithium batteries, we recommend investigating co-development as a means to holistically assess project impact and leverage market synergy.

Suggested editorial corrections to the draft report

page 5 - change “global enter” to “global center”

page 15, footnote 44 - change “ground, separated, separated,” to “ground, separated,”

page 18 - Note that geothermal production wells at the Salton Sea are not pumped. We suggest changing the text from “As shown in Figure 7, flash steam geothermal power plants, like the geothermal power plants in the Salton Sea KGRA, use a multistep process that begins with drilling production wells deep into an underground geothermal reservoir to pump either a mixture of steam and hot brine or hot brine alone to the surface under high pressure. When the brine reaches the surface, the pressure is dropped producing steam that a turbine connected to a generator to produce electricity.” to “As shown in Figure 7, flash steam geothermal power plants, like the geothermal power plants in the Salton Sea KGRA, use a multistep process that begins with drilling production wells deep into an underground geothermal reservoir to deliver a mixture of steam and hot brine or hot brine to the surface under high pressure. When the brine reaches the surface, the pressure is dropped, producing more steam, which drives a turbine connected to a generator to produce electricity.” Below are two more accurate schematic depictions of a flash power plant akin to those found at the Salton Sea geothermal field; you might consider using one of these in place of the current Figure 7:

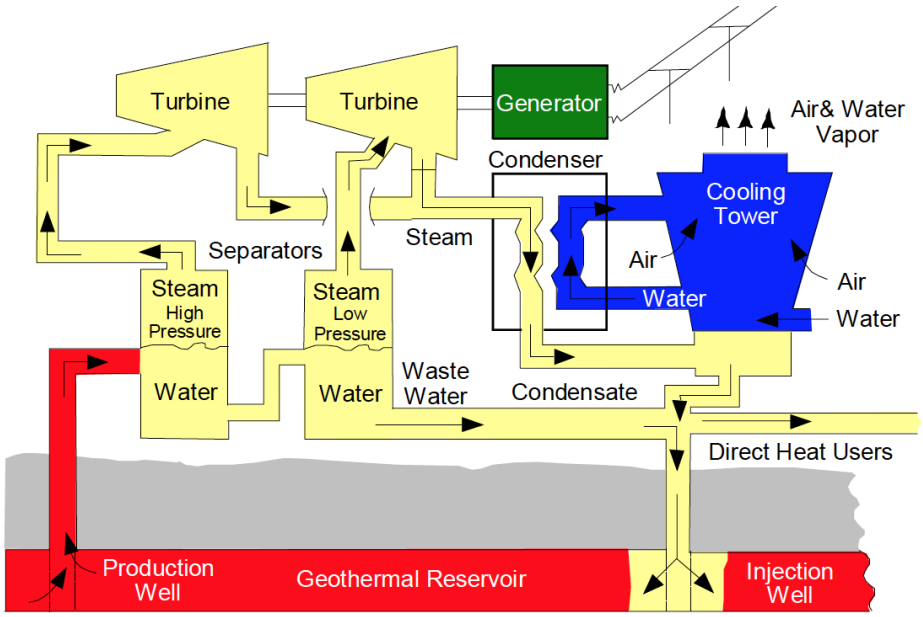

Figure from Kagel, A. (2008) The state of geothermal technology Part II; Surface Technology. Geothermal Energy Association. A Publication by the Geothermal Energy Association for the U.S. Department of Energy. https://www.geothermal.org/sites/default/files/2021-02/Geothermal_Technology-Part_II_Surface.pdf

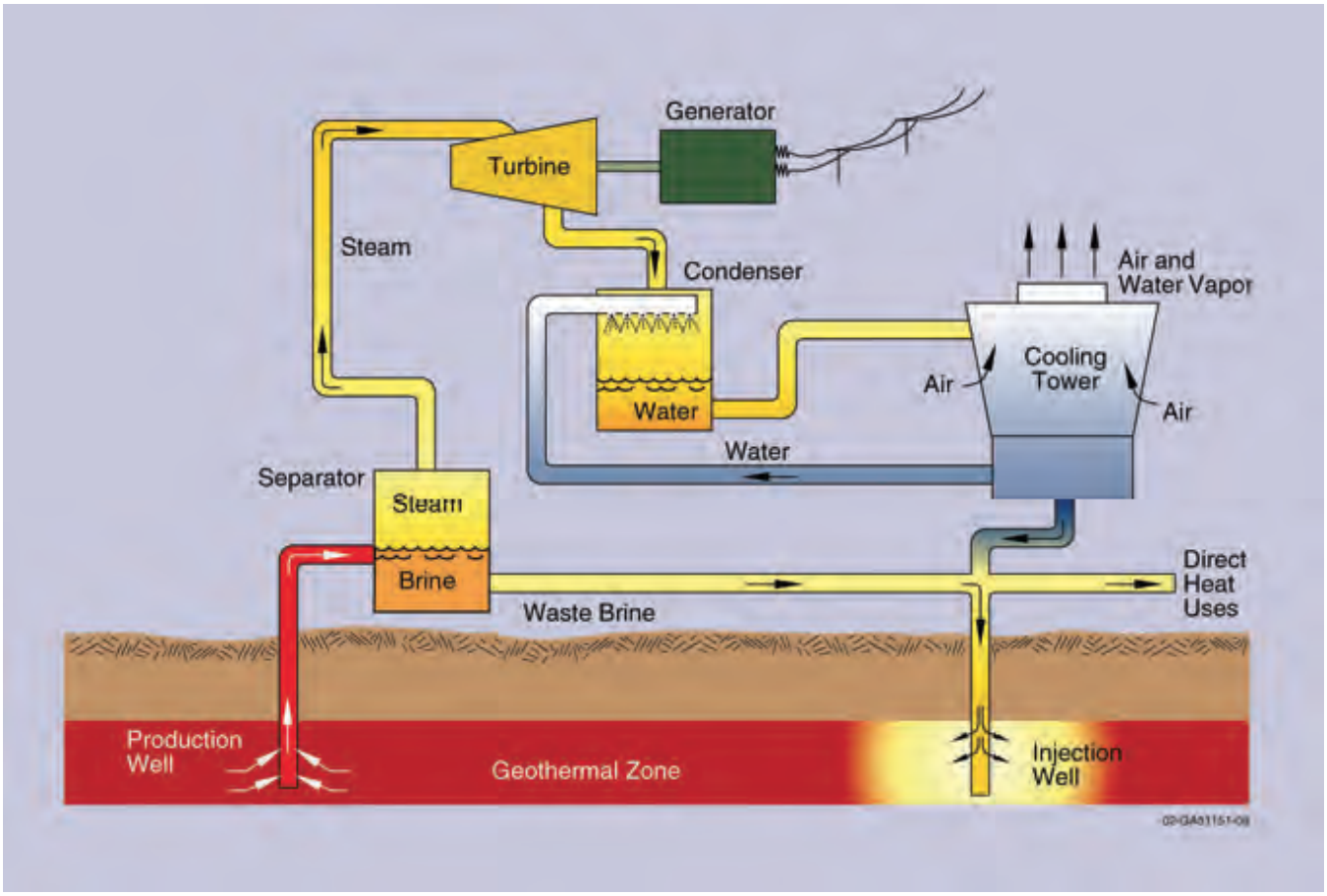

Figure from US DOE Geothermal Technologies Program (2010) A history of geothermal energy research and development in the United States. Energy Conversion 1976-2006. https://www.energy.gov/sites/prod/files/2014/02/f7/geothermal_history_4_conversion.pdf

page 22 - It is important to note the difference between lithium carbonate equivalent and lithium. 1 ton of lithium has the same lithium content as 5.32 tons of lithium carbonate. As noted in Figure 4 on p. 15, the world lithium production in 2020 was ~91 thousand metric tons of lithium - this equates to 484 thousand metric tons of LCE production. This conversion factor should be noted in the text (it is noted on p. 73).

page 23 - suggest changing "recovery of lithium from geothermal brine" to "recovery of lithium in the form of lithium chloride from geothermal brine"

page 25 - Figure 11 indicates that the planned CTR lithium extraction facilities will occupy the area highlighted in light green. This is CTR's geothermal lease footprint; the actual footprint of the planned lithium extraction facilities (yet to be sited) will be much smaller than the highlighted area.

page 36 - The IID may want to consider other potential geothermal development projects within the greater Imperial Valley when looking at future water requirements, and not just limit their evaluation to existing Salton Sea geothermal power plants, proposed and developing lithium recovery and purification facilities, and proposed expansion of geothermal power production from the Salton Sea geothermal field. Note that the new geothermal power plants may come online later than 2024 (if changed here, also modify content on page A-4)

page 42- change "would integrate t" to "would integrate".

The transmission discussion on p. 41-42 may also want to note that adding additional transmission capability for the Imperial Valley area would also be beneficial to other renewable power projects in the region, such as wind and solar farms.

page 50 - change "processing of lithium" to "processing of lithium chloride"

page 56 - change "One addition" to "One additional"
Clarify if the amounts of lithium mentioned here (i.e., 120,000 metric tons of lithium recovery) refers to lithium or to LCE.

page 63 - change "should her be required" to "should be required"

page 73 - Instead of lithium hydroxide, you may want to use the term lithium hydroxide monohydrate ($LiOH \cdot H_2O$)

Signed,

Michael L. Whittaker, Ph.D,
Director, Lithium Resource Research and Innovation Center (LiRRIC)

Noël Bahktian, Ph.D,
Executive Director, Energy Storage Center (ESC)

Lawrence Berkeley National Laboratory
One Cyclotron Rd.
Berkeley, CA 94720