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Revolt Metals Response to CEC RFI - Lithium Brine Recovery Research Needs

Please see attached our response to RFI.

Additional submitted attachment is included below.

ReVOLT Metals

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California Energy Commission

Electric Program Investment Charge

Docket#: 23-ERDD-01

Response to: Request for Information (RFI) to gather information on critical challenges and research needs for geothermal power production and lithium recovery from geothermal brine Lithium Recovery from Geothermal Brine

Dear CEC:

ReVolt Metals is planning on deployment of a sustainable lithium extraction process from geothermal brines. The following is our response to this RFI, specifically addressing the topic area related to "Lithium Recovery from Geothermal Brine".

ReVolt Metals is a woman-owned California-based company working, closely with a DOE National lab partner, to develop and commercialize advanced separation technologies to recover critical minerals such as lithium from geothermal brines. The company is also commercializing a metal recovery process from batteries.

Thank you for the opportunity to present our responses. Please do not hesitate to contact me should you have any questions about this submittal.

Sincerely,

Azita Yazdani, P.E.
Founder & CEO

Overall Comments

Geothermal brines offer a significant domestic source of domestic lithium (Li), however efficient recovery has proven challenging. Deployment of technologies for the extraction and recovery of Li from geothermal brines should look beyond just the focus on high purity LiOH and aim to co-recover other metals present in these brines, such as manganese (Mn) and zinc (Zn) as well. At the same time, emission of CO_2 is one of the challenges faced with geothermal power (GTP) as it constitutes over 95% of the non-condensable gases emitted. An average of 107 gCO_2/kWh are estimated as potential emissions from California geothermal power plants. While this value is less than a quarter of the estimated CO_2 emissions from natural gas power plants, these emissions still affect public perception and the overall life cycle analysis of geothermal power generation.[1] Hence, the ReVolt project proposes the deployment and demonstration of a pilot process that can be powered by GTP, through electrochemical-based Li separation and includes recovery of LiOH, and possible co-recovery of other valuable additional metals present in the geothermal brine.

Additionally, one of the main challenges in high throughput LiOH production from geothermal brines is the presence of a wide variety of metals which greatly exceed Li content. Hydrometallurgical processing requires significant addition of lime and other chemicals, which affect the economy of Li recovery[2]. Direct extraction methods through selective adsorption have been implemented to produce LiCl, as an intermediate to produce LiOH.[3] However, low loading capacity of the adsorption materials is a significant drawback for scale-up. ReVolt process promises to reach Li yields beyond 60% and concentration factors over four orders of magnitude.

1 Ventura, S., Bhamid,I, S., Hornbostel, M., Nagar, A., https://www.energy.ca.gov/publications/2020/selective-recovery-lithium-geothermal-brines.

2 Zavahir, S., et. al. Desalination, 2021, 500, 114883.

3 Warren, P. (2021). (No. NREL/TP-5700-79178). National Renewable Energy Lab.(NREL), Golden, CO (United States).

An additional main challenge in the processing of geothermal brines is the high concentration of monovalent ions (Na^+, and K^+), which further challenges any recovery process.

The Target Performance: ReVolt and its partners have been developing the proof-of-concept of the individual steps of a Li separation scheme. The individual processes have reached TRL of 3-4 while employing surrogate solutions under relevant operating conditions in bench scale laboratory studies. ReVolt plans to scale up and integrate the different unit operations to demonstrate a pilot scale system that can operate under steady state conditions and produce up to 20 kg/day of LiOH monohydrate, advancing this technology to TRL 5-6, before scaling to commercial scale pilot processing.

Key Technical Risks, Issues and Development: The ReVolt Li brine recovery process not only addresses the other metal impurities in a comprehensive manner but also applies concepts of process intensification, which are reflected in a significant reduction in the chemical consumption, approaching the zero discharge, where all streams can be re-used within the process to reduce waste generation.

ReVolt will bring pilot scale and full scale-up experience, including system design, engineering and operations of electrochemical separation systems and deployment and operations of such system in a variety of industrial setting. This will bridge rapid technology development to the pilot plant demonstration and commercialization of the proposed approach. The Company's main purpose is to develop and produce the processing hardware in the United States, with US based suppliers and resources.

Lithium Recovery from Geothermal Brine

The following section is the response to the questions posed in the RFI:

4.What are the greatest technical barriers to the commercialization of lithium recovery from geothermal brine? What technologies provide the greatest opportunities to facilitate the commercialization of lithium recovery from geothermal brine? What would be the most effective use of R&D funding to advance commercialization of lithium recovery from geothermal brine? What specific technologies or approaches are presenting a particular challenge, and what are some alternatives?

In addition to the points stated previously, in our view, low concentrations and high solid content in the brines affect the performance of direct Li recovery (DLE) technologies in the long term. Recyclability and stability of the adsorbents is an issue to be solved and that is an area where we have developed a different approach.

Advanced separation technologies provide the opportunity to leverage green electrons as main reagents for the separation and recovery of metals.

Our current plans are to scale up the piloting program and eventually move to a commercial scale pilot plant operation.

5. What brine pretreatment issues have been especially challenging to overcome? What technologies or techniques have been successfully tested at a TRL of 3, 4, or 5?

The presence of solids in geothermal brines require pretreatment before effective separation. Otherwise, it will increase the difficulties of processing further along in recovery and treatment operations.

ReVolt has not specifically lab tested any solids separation processes in this application, but the management is very familiar with commercial technologies for this step, which we feel will address the required solution to solve this challenge.

6. What technologies or processes can reduce waste products from the lithium recovery process (such as by decreasing mass or by recovering additional co-products in the lithium recovery process)? What TRL are these technologies?

ReVolt process allows the recycling of processing agents which reduce waste products from the process. This has been tested to TRL 3-4.

7. What co-products are the most feasible to recover? What technologies or processes are available to produce them? What TRL

Manganese is one of product present in geothermal brines from which co-recovery with Lithium can be performed.

Our patent pending process allows for a processing step that concentrates and removes other ions such as Mn, Ca, Mg, and Zn, from the brine, prior to Li separation. Removal of divalent ions will facilitate the application of technologies for selective Li separation.

The current state of our testing is at TRL 2-3 where the overall system has been tested in relevant environments. However, further development is still needed in the recovery/regeneration of the reactive reagents to demonstrate the closed loop process.