Lithium Extraction from Geothermal Brine

Technology and Impacts

CCST — California Council on Science & Technology

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John L. Featherstone Geothermal Power Plant in Imperial County, California | Rhianna Hohbein

Summary Points

Lithium is a key component of rechargeable lithium-ion batteries and is considered critical for the clean energy transition.

Brines of the developed portion of the Salton Sea Geothermal Field—which is distinct from the Salton Sea itself—contain an estimated 4.1 million metric tons of dissolved lithium as **lithium carbonate equivalent** (LCE).* The total lithium resource in the extended geothermal reservoir may amount to 18 million metric tons LCE—enough to produce more than 375 million batteries for electric vehicles.

Researchers across universities, national labs, and industry are working to improve methods for extracting the lithium from geothermal brines before they are reinjected back underground.

Much work is needed to ensure that communities are benefited by this new industry and that it does not worsen environmental conditions near the Salton Sea.

Global Resources and Reserves

Lithium resources are known deposits of lithium that are not currently accessible due to economical or technological limitations. **Lithium reserves** are economically-retrievable lithium deposits. Most lithium is produced from brines, followed by pegmatite (a type of rock), and clays.

Lithium Resources

The U.S. Geological Survey estimates that there are 98 million tons of lithium resources worldwide (or 521 million tons LCE). Bolivia, Argentina, and Chile collectively contain more than 53% of the estimated lithium resources. Together, the three countries are sometimes referred to as the "Lithium Triangle."

Lithium Reserves

Most of the world's known lithium reserves are in Chile (36%), Australia (24%), Argentina (10%), China (8%), and the United States (4%). The U.S. Geological Survey is leading a national effort to update the U.S. lithium reserve assessment.

*__Lithium Carbonate Equivalent (LCE):__ the standard unit used by industry that allows for the comparison of lithium resources regardless of the type of lithium product generated (e.g., lithium carbonate versus lithium hydroxide). Actual lithium content is significantly less since lithium carbonate is comprised of only 18.8% lithium by mass.

Disaster Resilience

Ongoing, complex, and intersecting disasters—including climate change, extreme heat, power outages, and the COVID-19 pandemic—are radically disrupting the ways in which Californians live and work. CCST is committed to delivering science and technology advice to improve our resilience to disasters, reduce harm, and improve the lives of all Californians.

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HOW IT WORKS

Geothermal Energy with Lithium Extraction

Geothermal power plants in Imperial Valley take advantage of hot salty water found miles beneath the earth's surface. They bring this brine to the surface where—once relieved from the pressure of being underground—it turns into steam. This steam turns a turbine which generates electricity. Much of the steam recondenses to water. This water is then recycled back underground in a more-or-less closed system along with minerals like lithium that it originally contained.

Researchers are developing and piloting technologies that would allow them to filter lithium out of the brine before it is reinjected back into the earth.

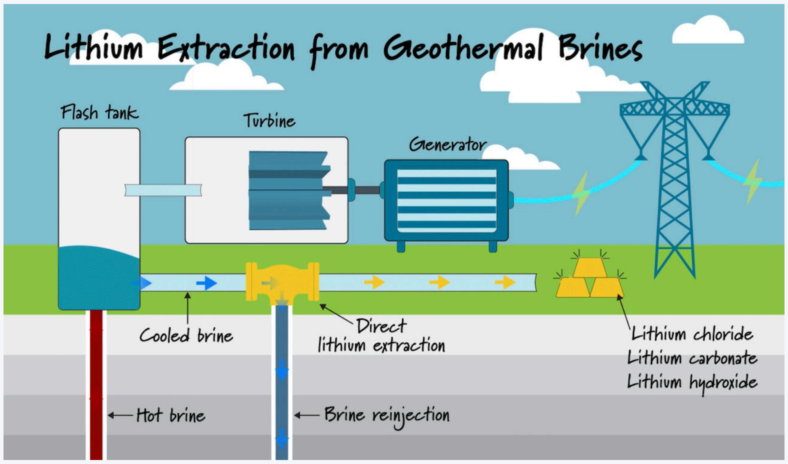

Figure. Diagram of lithium extraction from geothermal brines.

Source: U.S. Department of Energy and the National Renewable Energy Laboratory

Lithium Extraction In-Depth

Extraction Technologies

The precise methods being developed by companies at the Salton Sea Geothermal Field are proprietary. However, they will likely rely on "adsorption" or ion-exchange technologies.

During adsorption, geothermal brine—which is hot, salty water found in geothermally active parts of the earth's crust—is introduced to a material called an "adsorbent" (or sorbent). Adsorbents are materials engineered to selectively attract lithium ions. The lithium adheres to the adsorbent and is thereby separated from other substances in the brine (like salt, manganese, and silica). In the next phase, the adsorbent is flushed with a chemical that removes the bonded lithium from the adsorbent—the chemical will vary depending on which adsorbent is used. This process leads to lithium chloride and a "regenerated" adsorbent ready to attract more lithium. The lithium chloride can then be refined into lithium carbonate or lithium hydroxide, both of which can be used to create lithium-ion batteries.

Researchers are actively working to develop adsorbents that can a) more selectively isolate lithium from other, chemically-similar substances in the brines; and b) withstand the incredibly corrosive geothermal brines without rapidly deteriorating. **Dr. Andrew Haddad** of Lawrence Berkeley National Laboratory is investigating these and other methods of ion separation.

Estimating Lithium Reserves

Brines of the developed portion of the Salton Sea Geothermal Field likely contain at least 4.1 million tons of dissolved lithium carbonate equivalent. The entire reservoir potentially contains as much as 18 million tons if assumptions about lesser-known portions of the reservoir hold true. These values are based on the estimated volume of brine in the geothermal field and the known concentration of lithium in those brines. However, a key question remains: how quickly does lithium dissolve into the brine from the surrounding rock formations? It is possible that once the lithium-depleted brines are reinjected underground, they could readily pull more lithium from the surrounding rock.

Geochemist **Dr. Maryjo Brounce** of UC Riverside is investigating the processes by which lithium is dissolved into the geothermal brines. The answers her team finds will determine the long-term sustainability of lithium extraction projects at the Salton Sea. Preliminary results suggest that the rate at which lithium dissolves into the brine may be too slow for this resource to be sustainable over the long-term.

Environmental Impacts

Lithium extraction at the Salton Sea Geothermal Field will use new extraction methods that are markedly different than the lithium extraction or mining projects of South America or Australia which are notoriously damaging to the environment. Still, many questions remain about the possible environmental impacts.

Dr. Patrick Dobson is co-leading a team of researchers at Berkeley Lab and UC Riverside to evaluate the environmental impacts of lithium extraction at the Salton Sea.

Key environmental questions include:

- How much water is required?
- How much energy is required?
- What waste will be generated?
- How will the waste be disposed?
- What air pollution will be created and how effectively can it be mitigated?

Community Impacts

Communities near the Salton Sea have experienced decades of environmental injustices. The receding Salton Sea has introduced toxic contaminants into the air, and residents there have some of the highest rates of asthma in California. While lithium extraction has the potential to economically revitalize the area, benefits to community members are not guaranteed, nor have communities and Indigenous Tribes had all their questions sufficiently addressed. **Dr. James Blair** at Cal Poly Pomona is one of several researchers supporting community organizations in their pursuit of just and equitable community benefit agreements.

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