LITHIUM EXTRACTION AND PURIFICATION FROM GEOTHERMAL BRINE

ACTOR NETWORK THEORY APPLICATIONS TO UNITED STATES GEOTHERMAL DEVELOPMENT: PARALLELS FROM THE 1970'S-1980'S TO PRESENT

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SOCIOTECHNICAL SYNTHESIS

The following STS and technical work considers lithium extraction from geothermal brine. Projections estimate that current lithium supplies, largely sourced through water-intensive processes in South America, fail to meet half of the anticipated 2030 demand; therefore, there is large political motivation to establish a stable, domestic lithium source. The technical work engineers unit operations surrounding a novel sorbent for selective lithium capture from highly saline underground brines in the Salton Sea, California. The process can be retrofitted to existing geothermal power plants in the Salton Sea region and produces battery-grade lithium hydroxide monohydrate ($LiOH \cdot H_2O$) solid. The STS work investigates American geothermal mineral extraction project development between 1970 and 1989 with the intent to inform future and current geothermal project development. The STS and technical work are tightly coupled in that they both center American geothermal mineral extraction project development.

Geothermal brines are typically highly acidic and highly saline; thus, geothermal lithium extraction processes have historically been hindered by equipment corrosion, mineral scaling, and low selectivity for lithium versus other minerals present in solution. The technical work utilizes a novel sorbent designed by UVa professors Geise, Koenig, and Giri for selective lithium capture. The project uses a 6,000 gallon per minute brine flow rate and 50 MW geothermal plant basis with brine composition provided by industry partner specifications. OLI Studio and Aspen v.11. Software are used to design units in conjunction with literature empirical correlations and manual calculations.

The designed process with iron (III) phosphate sorbent achieves 99% overall process recovery for lithium and 99 mol% purity, satisfying battery standards. Based on discounted cash flow analysis with a 7-year straight-line depreciation schedule, a plant lifetime of 20 years, and a battery-grade lithium hydroxide monohydrate sale price of $65/kg, the project IRR is 569%. This indicates an extremely attractive investment opportunity. The return on investment (ROI) is determined to be 12,236% over 20 years with a final cumulative cash position of 13 billion USD. Further work should be done to finalize chemical and scale specifications, but the overall profitability suggests the process and plant should be strongly considered as a candidate for addition to existing Salton Sea geothermal plants.

The following STS work applies an Actor Network Theory (ANT) framework to study changes in American mineral property management, land management policy, and natural resource law from the 1970s to the 1980s. By grouping specific organizations into three categories of macro-actors–federal, state, and private–larger socio-political trends may be observed than by relational study between individual agencies, organizations, or companies. The following STS work is completed to elucidate framing and power dynamic shifts among American technical and political mineral interests.

In the early development period, state and private actors developed framing independent of federal actors in the absence of federal regulatory structure. In the 1970s, increasing federal dominion in natural resource and land management led to discontinuities between state and federal policy. In the 1980s, federal expansionism exerted sufficient force on state and private framing such that state and private actors began to resist federal expansionism. The U.S. D.O.E. Geothermal Technologies Program Annual Budget demonstrates parallels between geothermal

project development motivation during the 1970s energy crisis and today. Developmental trends between the 1970s and 1980s may thus inform future geothermal project framing.

Lithium mining processes with sufficient technological feasibility are likely to be heavily subsidized by either private or public actors, or both. Increasing competition for mineral extraction process knowledge, geochemical data, and mineral technologies disincentivizes collaboration within a complicated geo-political and technical regulatory space. Coordination between actors operating at the federal, state, local, and private levels is essential for rapid and equitable geothermal exploration.

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