**AGENDA ITEM 5A**
**PPT Presentation**

# Lithium Resources Beneath The Salton Sea: Opportunities and Challenges


Michael A. McKibben, Ph.D.
Research Professor (Economic Geology & Geochemistry)
Department of Earth and Planetary Sciences
University of California, Riverside
michael.mckibben@ucr.edu


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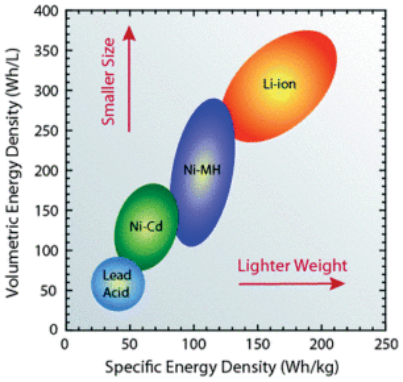
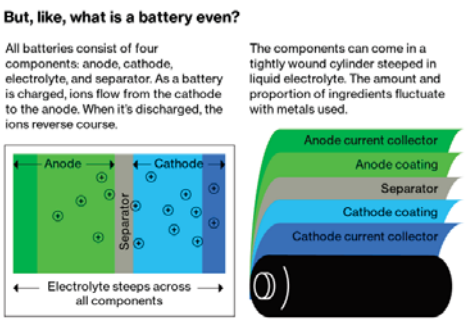
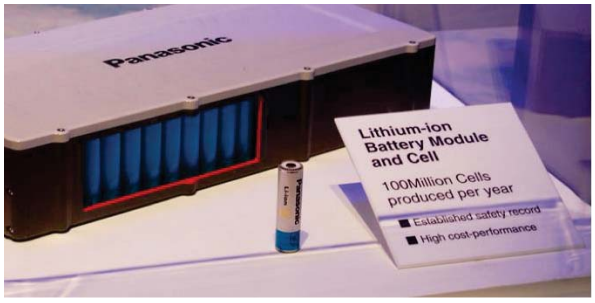
## What is Lithium and why is it so valuable?

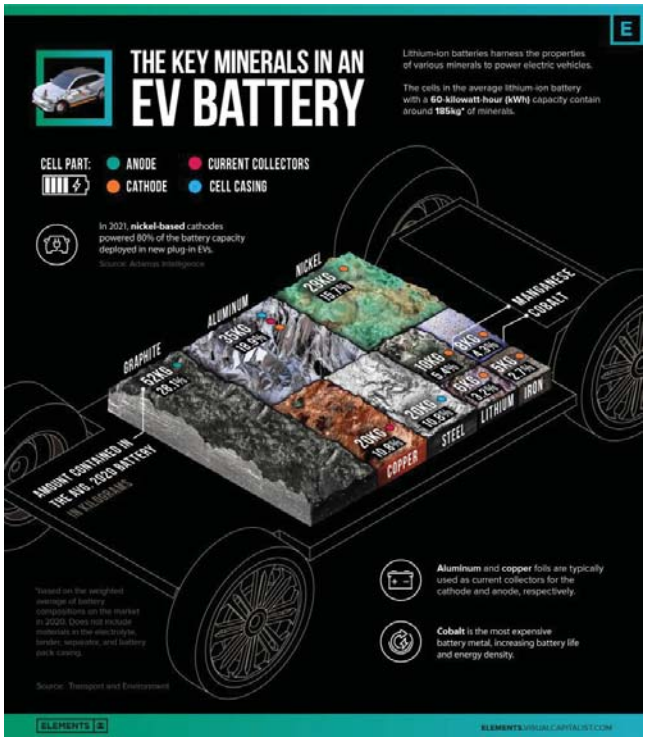
Atomic number 3 on the periodic table of the elements:
the lightest of the metals
Can store more energy per weight than other metals
So, lithium is ideal for powering mobile electrical devices
Smart phones, Laptops/Tablets, Earbuds/Airpods,
Weedwhackers, Power drills, Electric vehicles



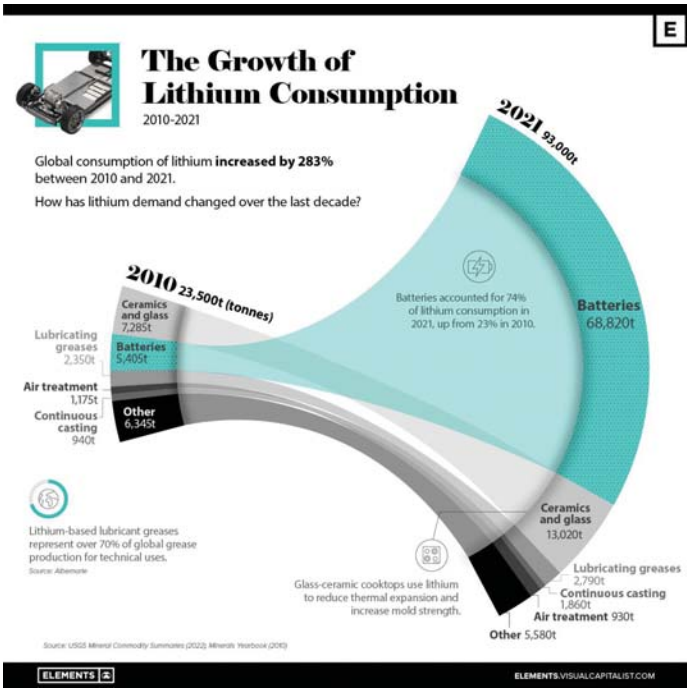



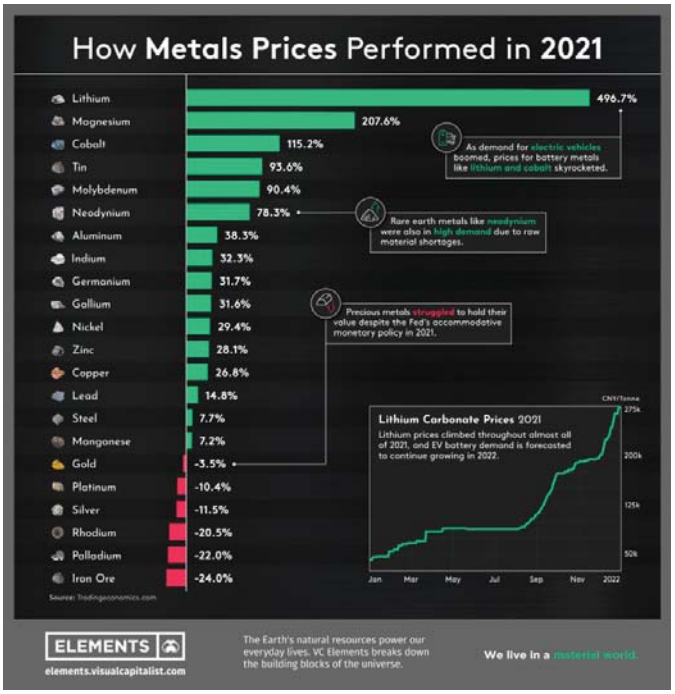
# Metals in battery cells for electric vehicles come from minerals and brines




~ 6 kg of lithium (13.2 pounds)

## Growth in demand = growth in price



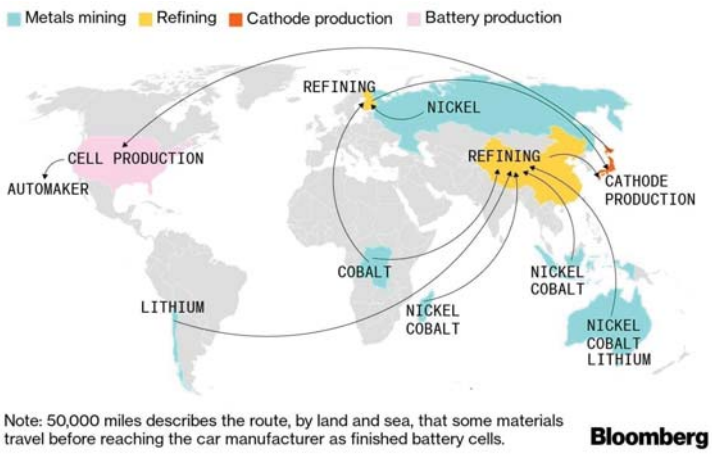

This is the reason for all the sudden interest in the geothermal Li far beneath the Salton Sea!

# The U.S. has a very fragile Lithium Supply Chain

**World Mine Production and Reserves:** Reserves for Argentina, Australia, and "Other countries" were revised based on new information from Government and industry sources.

| | Mine production 2020 | Mine production 2021* | Reserves[6] |
|---|---|---|---|
| United States | W | W | 750,000 |
| Argentina | 5,900 | 6,200 | 2,200,000 |
| Australia | 39,700 | 55,000 | [7]5,700,000 |
| Brazil | 1,420 | 1,500 | 95,000 |
| Chile | 21,500 | 26,000 | 9,200,000 |
| China | 13,300 | 14,000 | 1,500,000 |
| Portugal | 348 | 900 | 60,000 |
| Zimbabwe | 417 | 1,200 | 220,000 |
| Other countries[8] | — | — | 2,700,000 |
| World total (rounded) | [9]82,500 | [9]100,000 | 22,000,000 |

Data in metric tons of Li metal,
USGS MCS 2022




Note: 50,000 miles describes the route, by land and sea, that some materials travel before reaching the car manufacturer as finished battery cells.

Bloomberg

This complex supply chain can be easily interrupted or broken by wars, embargoes, pandemics.

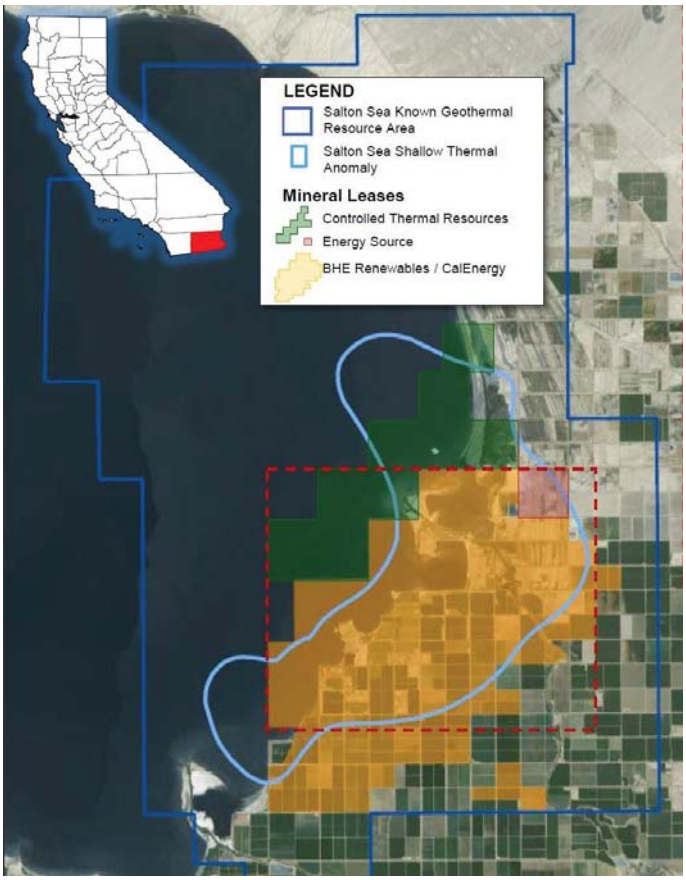
**A domestic, more environmentally-friendly approach: Direct Lithium Extraction (DLE) at the Salton Sea Geothermal Field**

Three operators generate ~400 MWe of electricity:

Berkshire Hathaway Energy Renewables (BHER)
(CalEnergy)
10 power plants

EnergySource Minerals (ESM)
(Hudson Ranch/Featherstone)
1 power plant

Controlled Thermal Resources (CTR)
(Hell's Kitchen)
Building new facilities

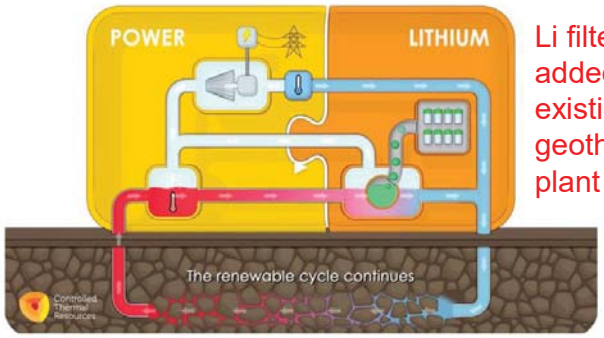



BHER

**Geothermal brine DLE: smallest footprint: closed-loop process, no huge evaporation ponds, no blasting, no pits.**

ESM

BHER




Li filter added to existing geothermal plant

CTR


Chilean salar brine: 3,100 acres

Australian hard rock: 465 acres

Geothermal lithium: 50 acres

# How much Li may be in the Salton Sea geothermal brines?

*Brine Li concentration × reservoir porosity × reservoir volume*

| | Reservoir brine volume ($km^3$) | |
|---|---|---|
| Porosity | 1990s | 2016 |
| 10% | 5.5 $km^3$ **"conservative"** | 15.5 $km^3$ |
| 20% | 11 $km^3$ | 33 $km^3$ **"optimistic"** |

| | Li in reservoir brines (metric tons of Li metal) | |
|---|---|---|
| Porosity | 1990s | 2016 |
| 10% | 1,000,000 **"conservative"** | 3,000,000 |
| 20% | 2,000,000 | 6,000,000 **"optimistic"** |

For comparison, Salar de Atacama in Chile contains 6 million metric tons of Li metal (Munk et al. 2016).

**1 ton Li metal = 5.32 tons LCE = 6.05 tons LHME**

# How much of the dissolved Li might be recovered each year?

At current brine production rates, with 90% recovery efficiency for lithium:

115,200 tons LCE/yr @ 400 MWe

**= 288 tons LCE/yr per MWe**

*Announced expansion of the geothermal field over the next several years:*

- BHER current = 345 MWe
- BHER additional = 395 MWe
- ESM current = 60 MWe
- CTR new Stage 1 = 50 MWe
- CTR new Stage 2 = 260 MWe

Total = 1,110 MWe x 288 tons LCE/MWe

**= 320,000 metric tons LCE/yr  10M EVs/yr**

= 60% of global Li production in 2021 (532,000 metric tons of LCE)

## How long might the Li production last?

For a fixed rate of 320 kt/y of LCE for the expanded geothermal field (1,110 MWe):

| "Reserves" | Annual depletion rate | Years of production |
|---|---|---|
| 5 Mt LCE (conservative) | 6.4% | 16 yrs |
| 16 Mt LCE (half optimistic) | 2.0% | 50 yrs |
| 32 Mt LCE (optimistic) | 1.0% | 100 yrs |


BHER: April 2022 – commissioned a 1/10 scale Li extraction demonstration plant. Currently designing a second demonstration plant to convert extracted Li to marketable lithium carbonate.


ESM: will start construction on commercial scale 19,000 tpy lithium hydroxide plant next to 60 MWe Cyrq power plant 4Q22/1Q23.

CTR: will start construction of commercial scale 50 MWe power plant with 20,000 tpy lithium hydroxide facility in 2023.

CTR: also plans to add additional Li extraction stages plus battery manufacturing and recycling to its Li campus:


## Water use estimates for geothermal Li extraction

ESM EIR 2021: 3,456 AFY of IID canal water for scaled-up extraction operations = 62,600 gallons of water per metric ton of Lithium Carbonate.
BHER has said it will use 50,000 gallons of water per metric ton of Lithium Carbonate, one tenth of the water needed in South American salar operations.

Potential water sources for geothermal Li extraction:

- IID canal water (but competes with ag, municipal)
- Brackish (non-potable) shallow groundwater (non-IID) - desalinated
- Imported municipal grey water (e.g., The Geysers geothermal field)
- Steam condensate (self-generated by the geothermal operators)

$CO_2$ emissions from Salton Sea geothermal power plants are published online at CARB web site: https://ww2.arb.ca.gov/mrr-data

Annual emissions data for 2019:

Annual Summary of GHG Mandatory Reporting
Non-Confidential Data for Calendar Year 2019

CALIFORNIA AIR RESOURCES BOARD

See the "Introduction" tab and the "Column Descriptions" tab for important information about the data shown.

| ARB ID | Facility Name | Report Year | Total Emissions (metric tons $CO_2e$) Total $CO_2e$ (combustion, process, vented, and supplier) | AEL | Emitter CO2e from Non-Biogenic Sources and CH4 and N2O from Biogenic Fuels |
|---|---|---|---|---|---|
| 100692 | CalEnergy Operating Corporation - J J Elmore - Geothermal | 2019 | 7,716 | No | 7,716 |
| 100703 | CalEnergy Operating Corporation - J M Leathers - Geothermal | 2019 | 21,456 | No | 21,456 |
| 100712 | CalEnergy Operating Corporation - Region 1 - Geothermal | 2019 | 70,992 | No | 70,992 |
| 100716 | CalEnergy Operating Corporation - Region 2 - Geothermal | 2019 | 35,590 | No | 35,590 |
| 104346 | Hudson Ranch Power I - Geothermal | 2019 | 24,890 | No | 0 |

160,644 metric tons/yr for all Salton Sea power plants
= avg of 14,604 tons/yr per geothermal power plant

Compare with:

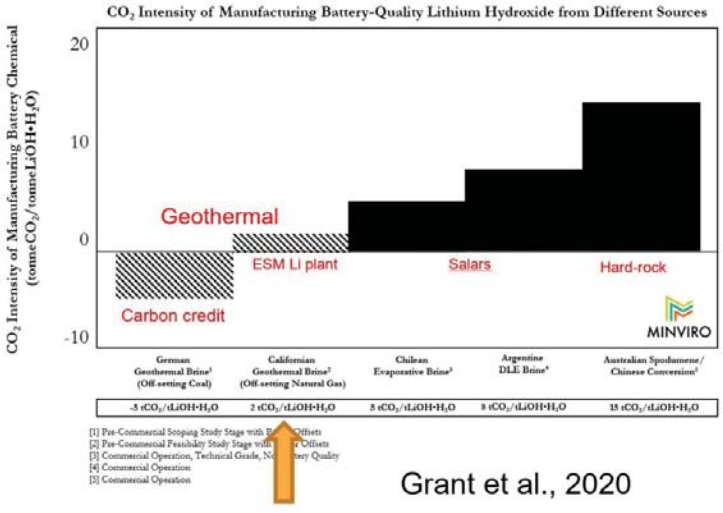
| | |
|---|---|
| Chevron's Oil Refinery, El Segundo: | 3,000,000 tons/yr |
| CalPortland Cement plant, Oro Grande: | 1,374,930 tons/yr |
| Spreckels Sugar Co. plant, Brawley: | 91,113 tons/yr |
| U.S. Gypsum Co. plant, Plaster City: | 69,943 tons/yr |
| IID Gas Turbine plant, Niland: | 57,533 tons/yr |

## Does geothermal Li extraction itself add any emissions?

Only from the added electrical energy used, when adding a Li filter to the *existing* power plant.

Most geothermal power plants generate their own electrical power to use, called the "parasitic power" load, typically 10-20% of the total power produced.

If some of this power can be used for Li extraction, it actually *reduces* $CO_2$ emissions that would otherwise be generated by using electricity generated elsewhere from fossil fuels – a carbon credit.




Grant et al., 2020

# Conclusions

- Geothermal Li extraction is the least destructive method of Li production and can help secure a stable supply chain for growing U.S. lithium needs.
- Infrastructure costs are minimized at the Salton Sea field because the bulk of the brine production and reinjection facilities already exist as geothermal power plants.
- The Salton Sea geothermal field's reservoir brines may contain up to 32 million metric tons of LCE, making it one of the largest Li deposits in the world.
- Up to 115,000 metric tons/yr of LCE could be produced from the current power plants, if Li extraction methods being piloted now are highly effective and can be scaled up to commercial production. Enough Li for 4 million electric cars per year.
- Expansion of the field over the next decade could generate over 320,000 metric tons/yr of LCE. Enough for 10 million electric cars per year.
- Lithium recovery may not add any new $CO_2$ emissions, but water use should be very carefully assessed. Many alternatives to IID canal water exist, including municipal grey water, solar-desalinated brackish groundwater, and self-generated steam condensate.