

Lithium from geothermal resources in Germany

The joint project UnLimited
GW-SDG, May 2022, Paris

EnBW Energie Baden-Württemberg AG

Research and Development

Department of applied Geology, Geothermal energy

M.Eng. Elif Kaymakci, Dr. Thomas Kölbel

Hydrosion GmbH

Dr. Lena Kölbel

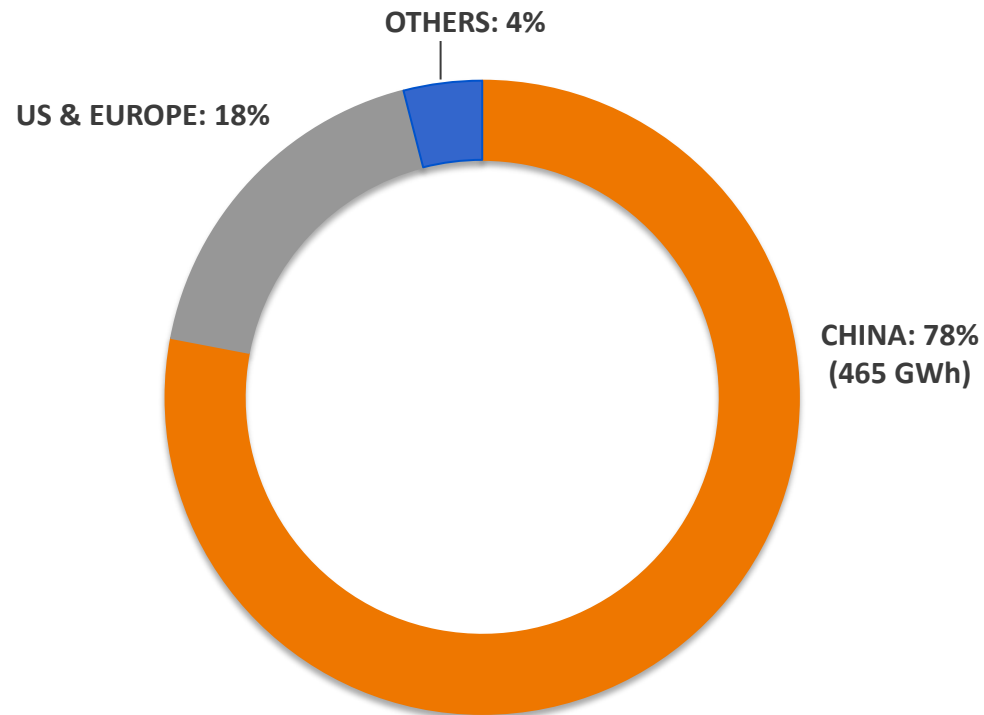
19.05.2022



Lithium – fast increasing importance

Battery Production

- EU to target 30 million electric cars by 2030

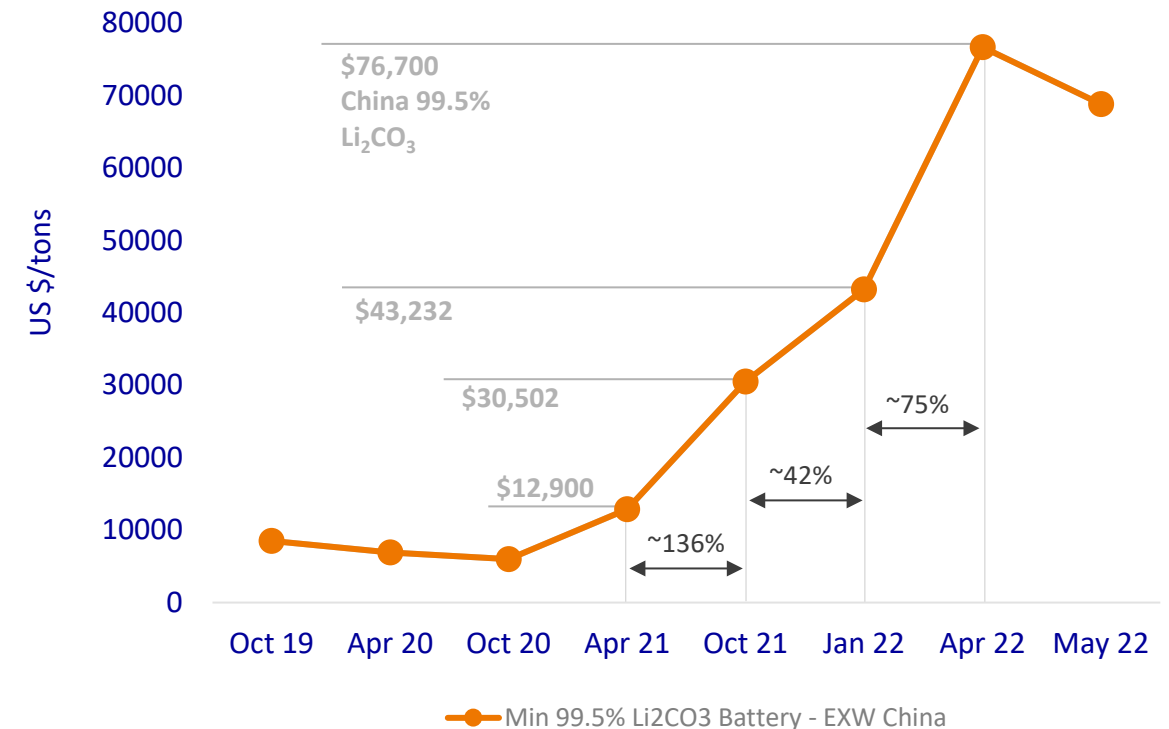


Battery Production Capacity

Source: CEPA, 2022

Li Prices from 2019 to 2022

Price rising by about **800 %** over the past 2 years

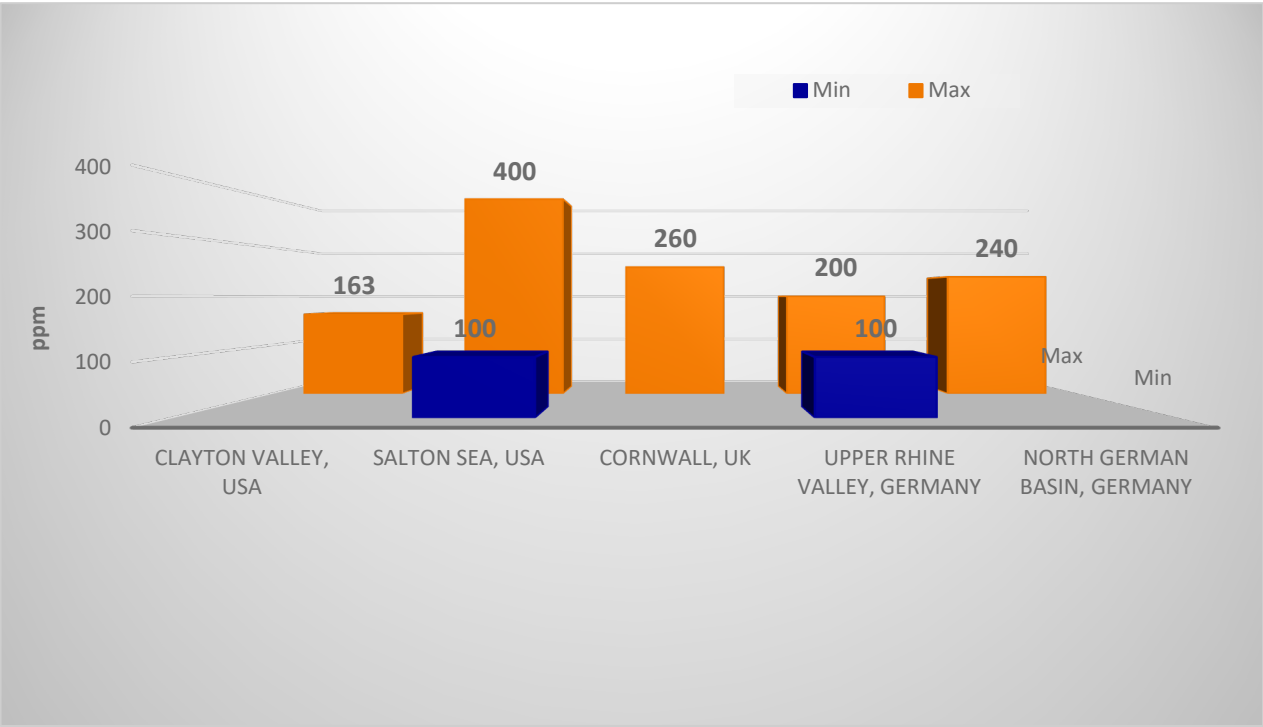


Source: Benchmark Mineral Intelligence, 2022

Lithium Occurrence in Geothermal Brines

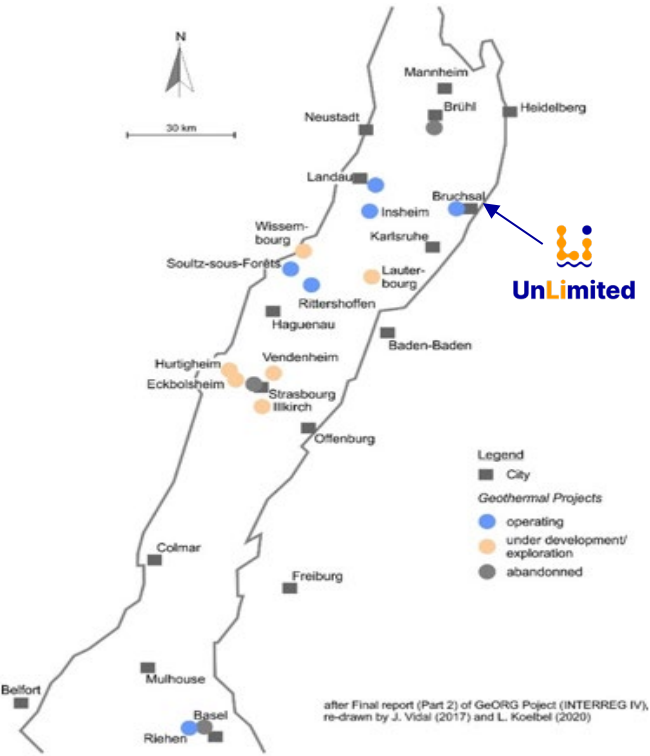
URV Potential Li - Extraction

Lithium concentration in geothermal brines



Source: Gruber et al. (2011), Sanjuan et al. (2016), Cornish Lithium (2020)

Upper Rhine Valley Potential Lithium Extraction



- Bruchsal
~ 810 t LCE p.a. (30 l/s)
- Soultz sous Forets
~ 900 t LCE p.a. (30 l/s)
- Rittershoffen
~ 1800 t LCE p.a. (70 l/s)
- Landau
~ 1300 t LCE p.a. (50 l/s)
- Insheim
~ 1300 t LCE p.a. (50 l/s)

*90% recovery rate



~ Total Battery Production in URV: 150.000 batteries p.a. (*60 kWh battery capacity)

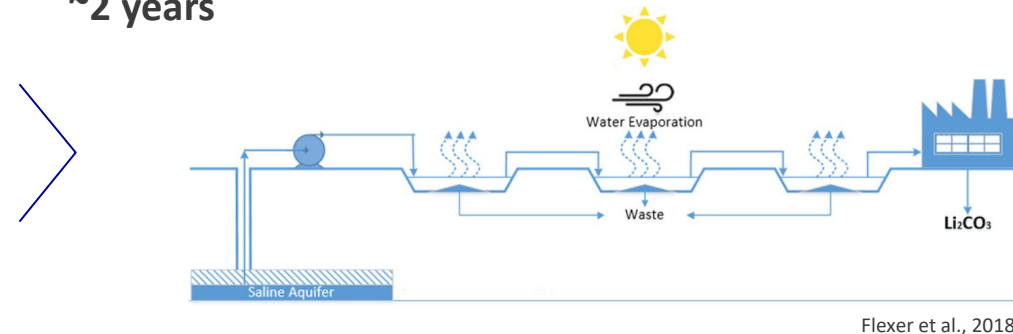
Lithium Extraction and Recovery from Brines

Current Practice:

Evaporative Concentration

- › Salar Brines
- › Product: Li_2CO_3 and LiCl

~2 years



- ✓ Low recovery rate (20-40%)
- ✓ Eco-unfriendly
- ✓ High CO_2 emissions
- ✓ Long Running Process

Future Practice:

Direct Lithium Extraction (DLE)

- › Geothermal & Salar brines
- › Product: Li_2CO_3 and LiOH
- › Main technologies
 - Adsorption & Ion Exchange
 - Solvent Extraction
 - Membranes

~2 hours



- ✓ High recovery rate (>90%)
- ✓ Eco-friendly
- ✓ Minimal CO_2 emissions
- ✓ Fast Running Process

Adsorption/Ion Exchange

- ✓ High adsorption capacity
- ✓ High technology readiness level

Solvent Extraction

- ✓ Expensive, potentially larger CAPEX

Membranes

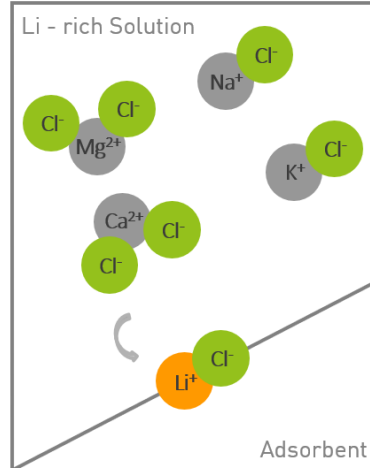
- ✓ Low technology readiness level

Adsorption / Ion Exchange – a promising DLE Technology

1

Various aluminum hydroxides (AlOH) & aluminum oxides (AlOx) (Adsorption)

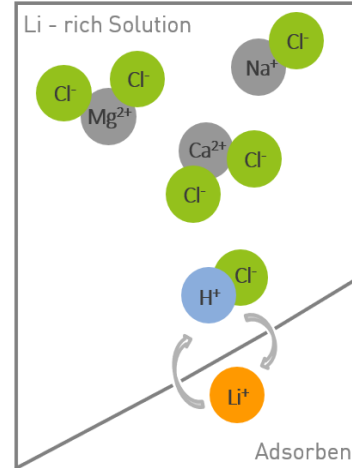
- Highly selective for lithium
- Number of pilot plants from salar and geothermal brines
- Full scale DLE from salar brines
- No acid requirement
- Slow degradation of the media
- Lower concentration in Li-solution



2

Manganese oxides (MnOx) (Ion-Exchange)

- High exchange capacity and high selectivity for lithium ions
- Needs big amounts of base and acid, increases OPEX
- Degradation of sorbent due to acidic conditions, Challenge: Stability of sorbent
- Promising for full-scale application



3

Titanium oxides (TiOx) (Ion-Exchange)

- High exchange capacity and high selectivity for lithium ions
- Needs big amounts of base and acid, increases OPEX
- Does not dissolve in acid
- Promising for full-scale application

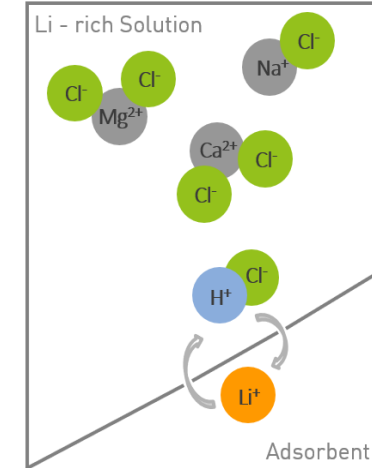


Illustration: Adapted from Jade Cove Partners, 2021

- ✓ Superior selectivity towards lithium
- ✓ Environmentally friendly and cost effective
- ✓ High technology readiness level

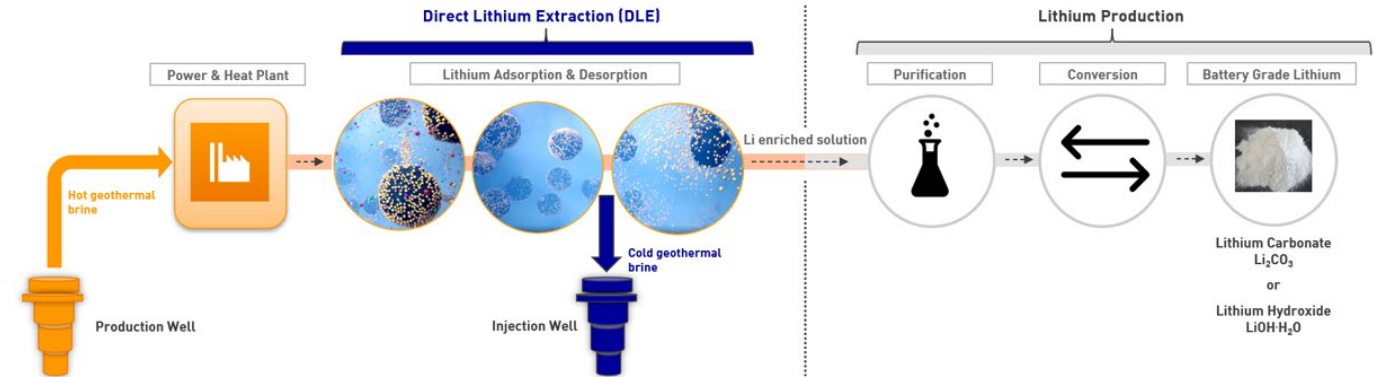
UnLimited's DLE Process

Co-production of Lithium at the geothermal power plant in Bruchsal, Germany



Li extraction from geothermal brines (DLE)

Partners	EnBW, KIT, UGOE, Hydrosion, BESTEC
Duration	2020-2024
Funding	BMWK, 2.7 Mio. €
Technology	DLE – Ion Exchange
Scope / Goals	Testing multiple sorbents Pilot plant in Bruchsal Resource Analysis

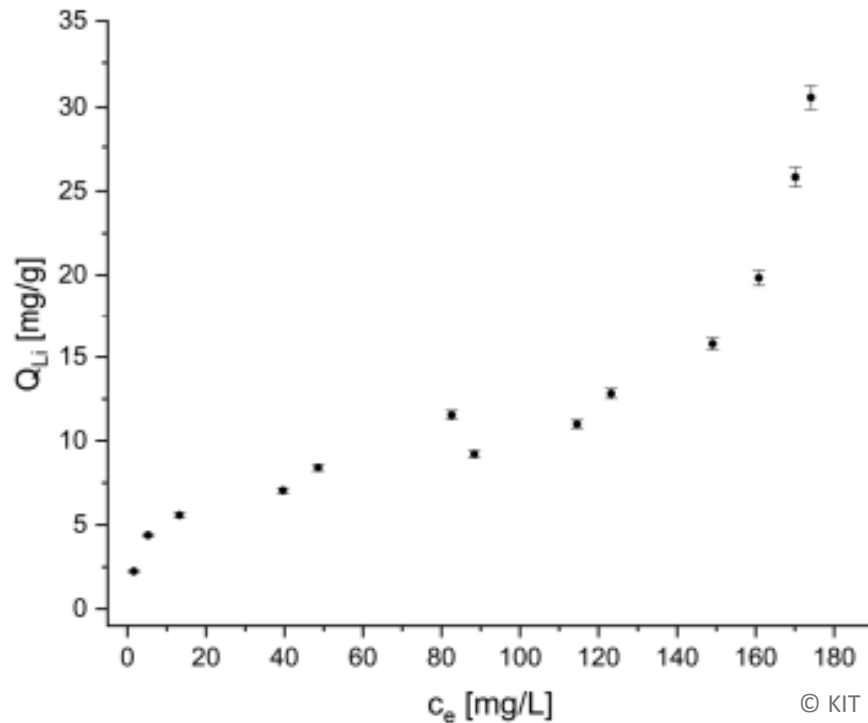


Mn-Oxide-Experiments

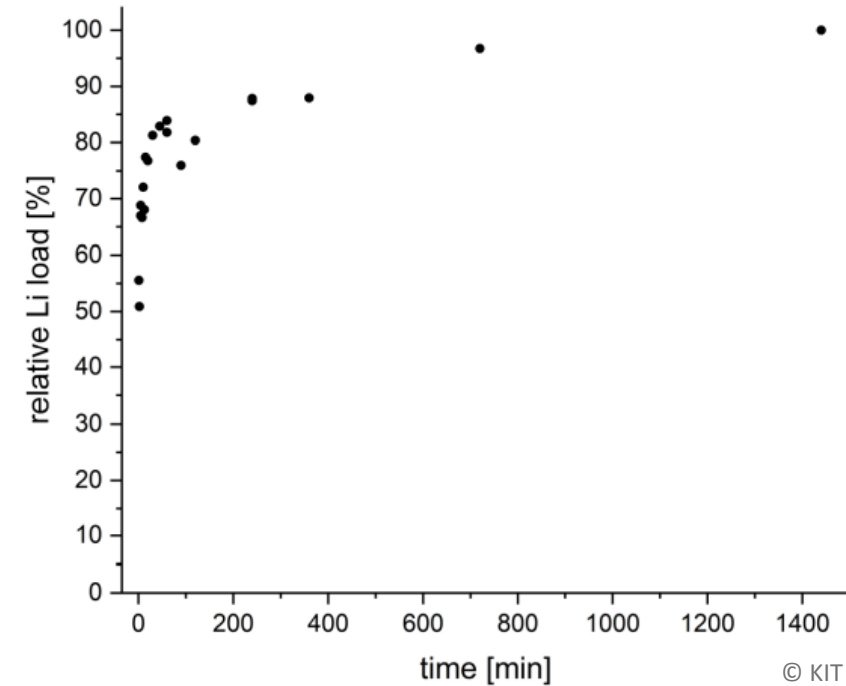
+ Fast Kinetics: Applicable for short term batch or flow extraction

+ 50% after 1 min, 65% after 5 min, 75% after 15 min

Li loading vs. equilibrium concentration after sorption



Maximum lithium loading over time



+ Sorption isotherm → high adsorption capacity

+ Q_{max} : 31 mg/g, plateau ~11 mg/g, 99% recovery rate

UnLIMITED - Project Progress Summary

2020 / 2021

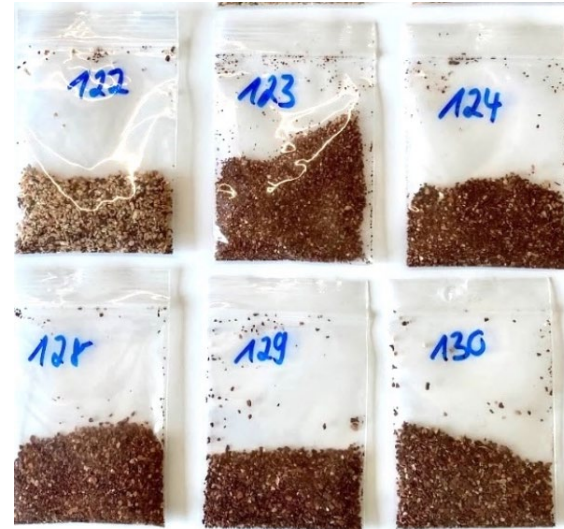
- Batch experiments with different sorbents
- Pilot Plant Design & Construction
- Continuous full geothermal brine analysis
- Drill cuttings analyzes
- Tracer Test
- Fluid monitoring Design

2022 / 2023

- Replication of experiments in lab-scale test stand
- Pilot Plant Construction
- First Production Tests
- Optimization and operation of the pilot plant
- Continuous sampling after tracer injection
- Drill cuttings analyzes data evaluation
- Fluid monitoring Set-up



© KIT



© HYDROSION



Department of Research and Development

Elif Kaymakci
Rheinhafen Dampfkraftwerk Info - E08
76185 Karlsruhe
e.kaymakci@enbw.com
+49 721 63-17932

Thank You!
Merci beaucoup!