Geothermal Energy & Lithium Production›

The „UnLimited Project“

EnBW Energie Baden-Württemberg AG
Research & Development
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UnLimited

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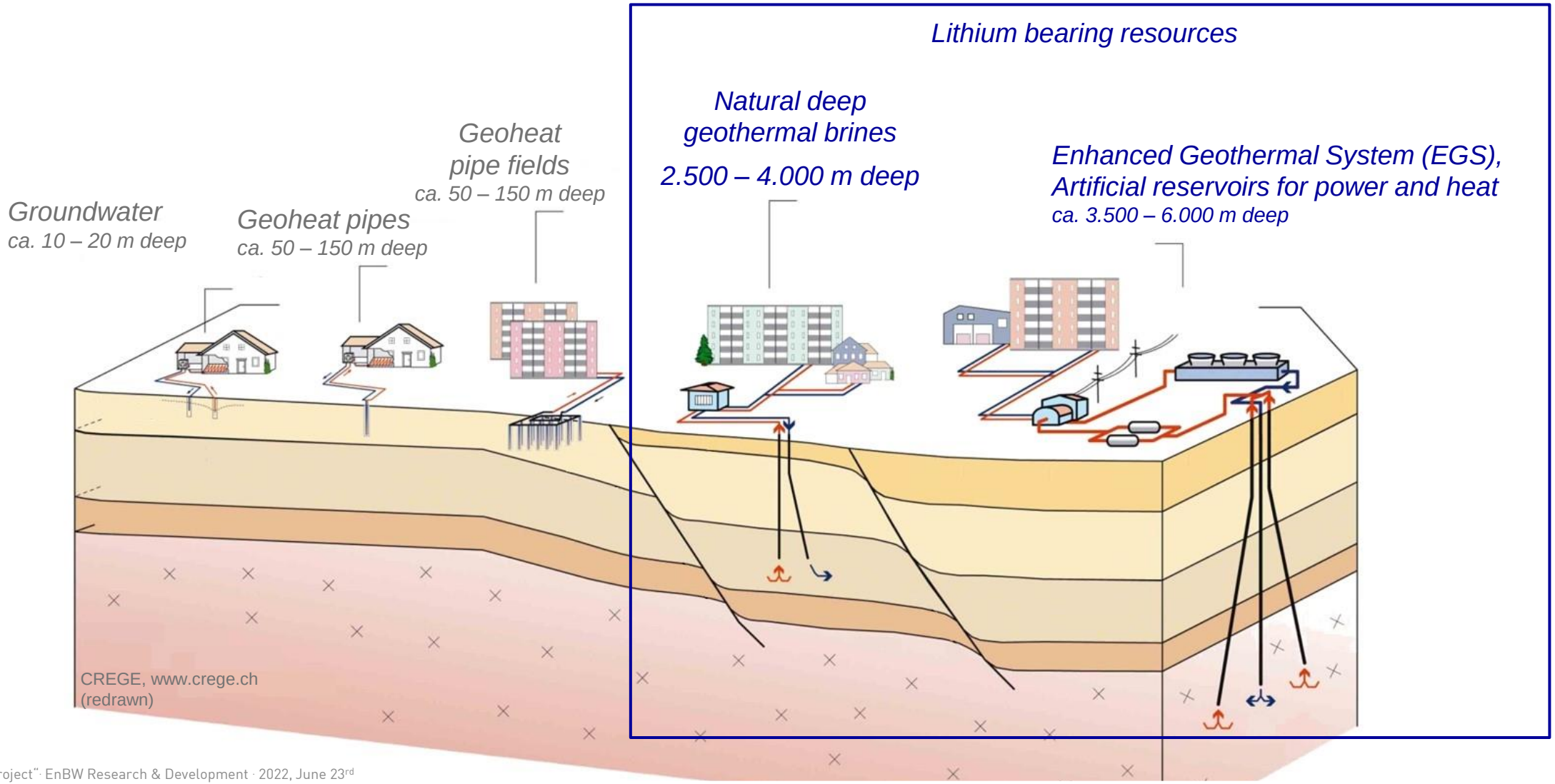
Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

EnBW

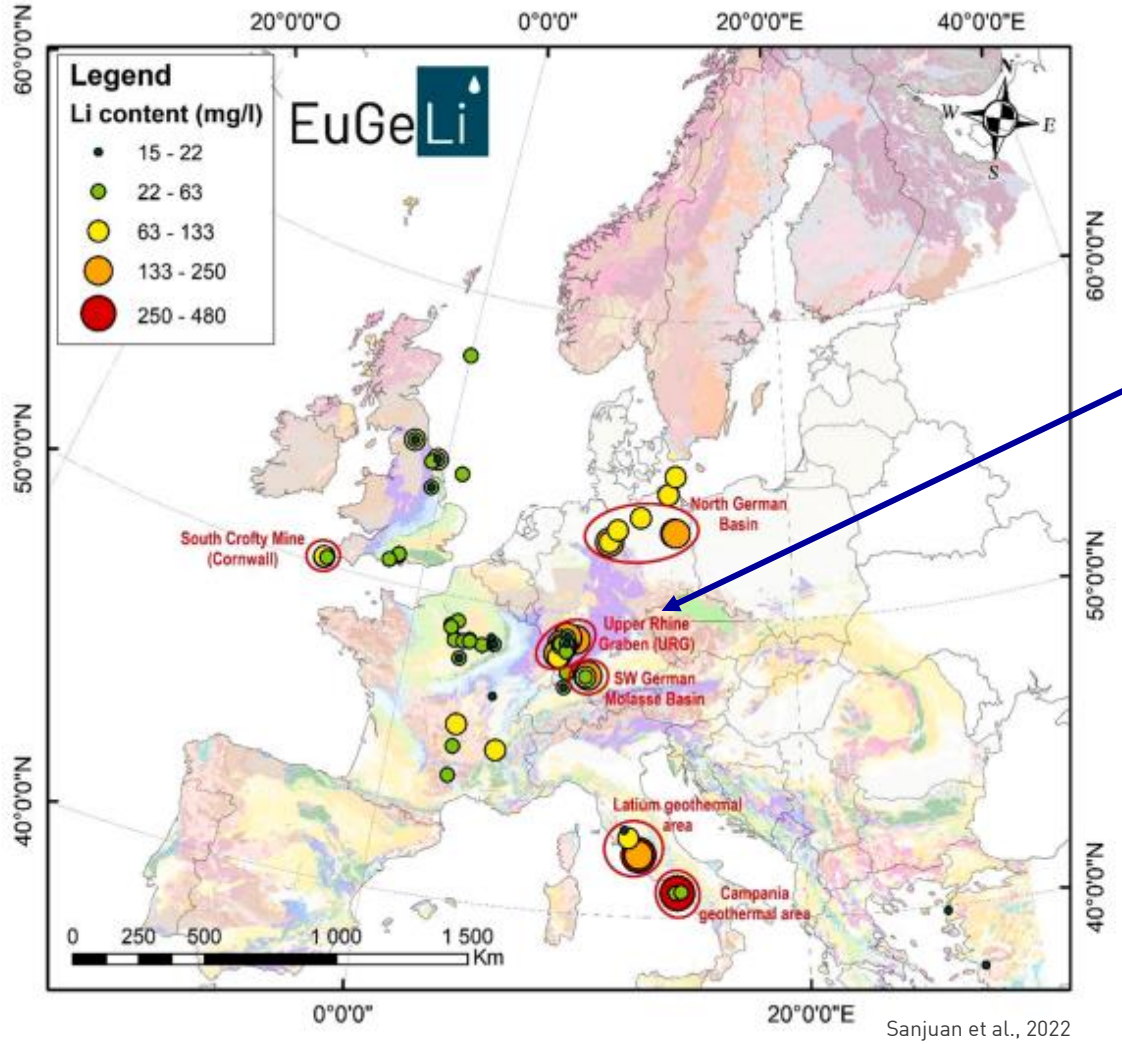
Utilisation of geothermal power & heat

Shallow and deep geothermal systems

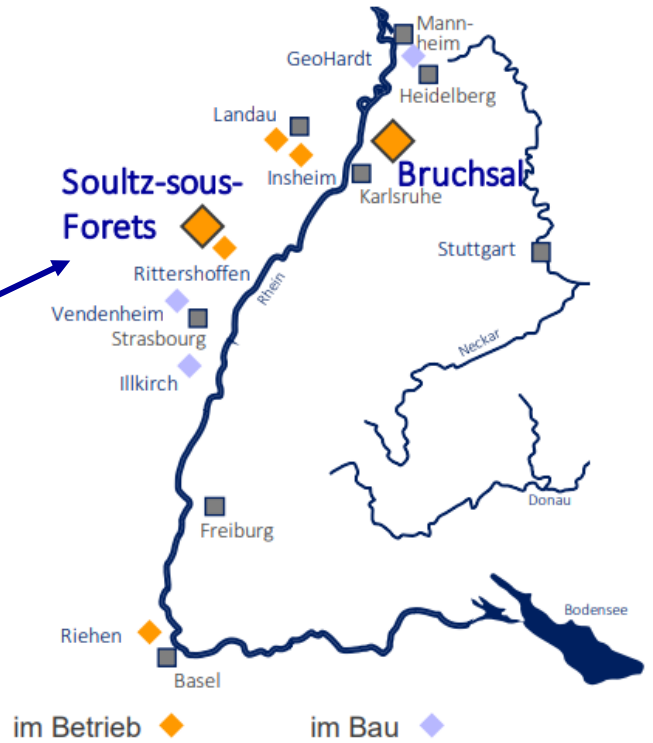


Lithium from geothermal brines

European resources and Upper Rhine Graben



Sanjuan et al., 2022



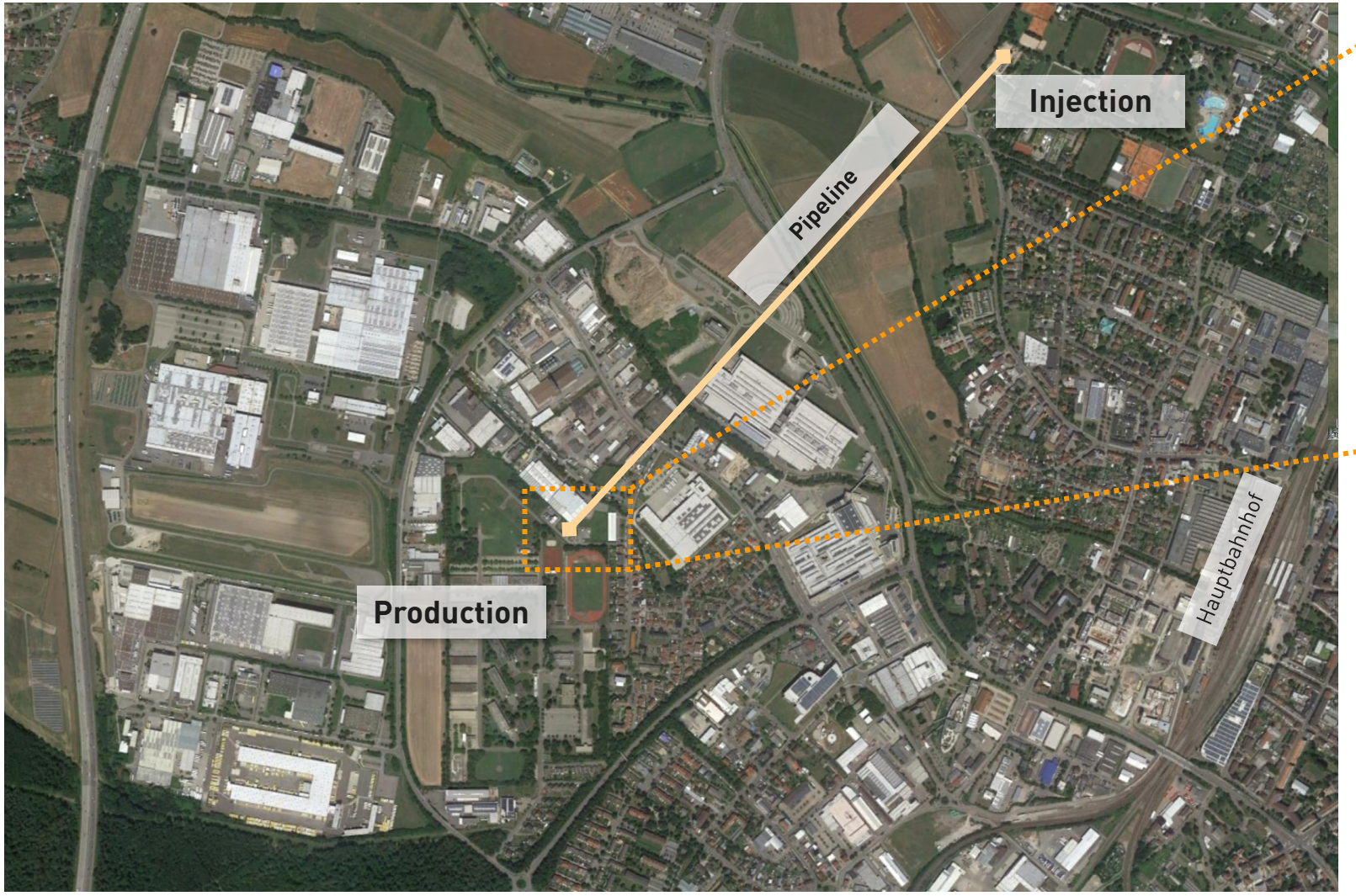
Li Conc. at geothermal site	Potential LCE production p.a.
Bruchsal 163 ppm	~ 6.500 t
Soultz 173 ppm	
Rittershoffen 190 ppm	
Insheim 168 ppm	
Landau 168 ppm	

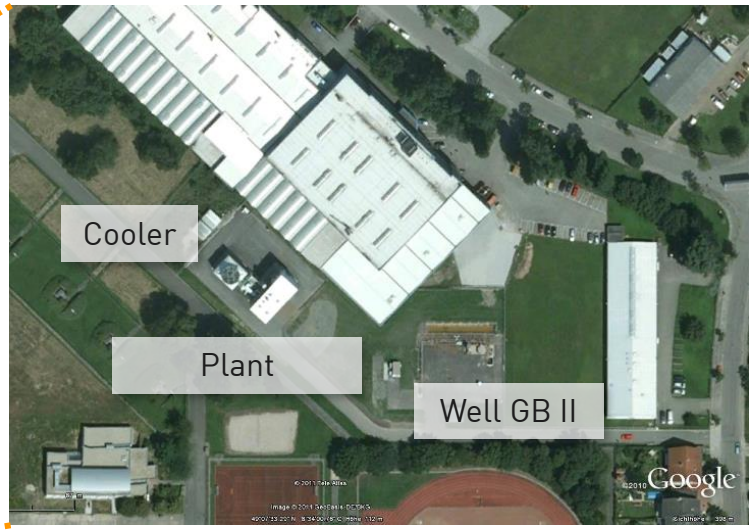
* 90% recovery rate and 90% operation time

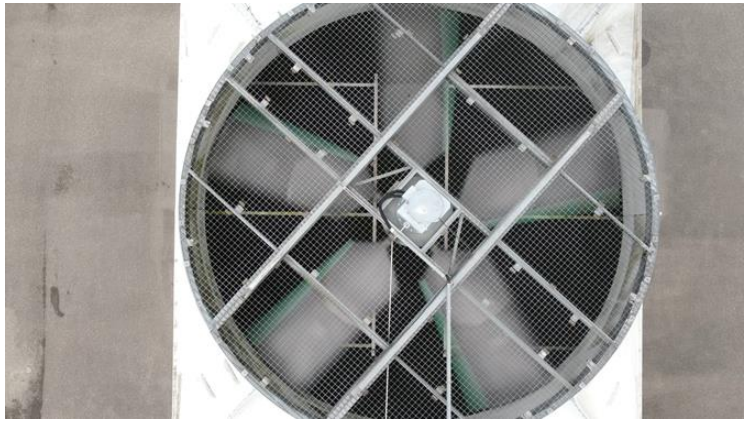
~ 5 % of lithium carbonate required for European Battery Alliance battery production target

Bruchsal geothermal plant

In operation since 2009







Plant design

Operated by Bruchsal Municipality and EnBW R & D

Geothermal brine cycle

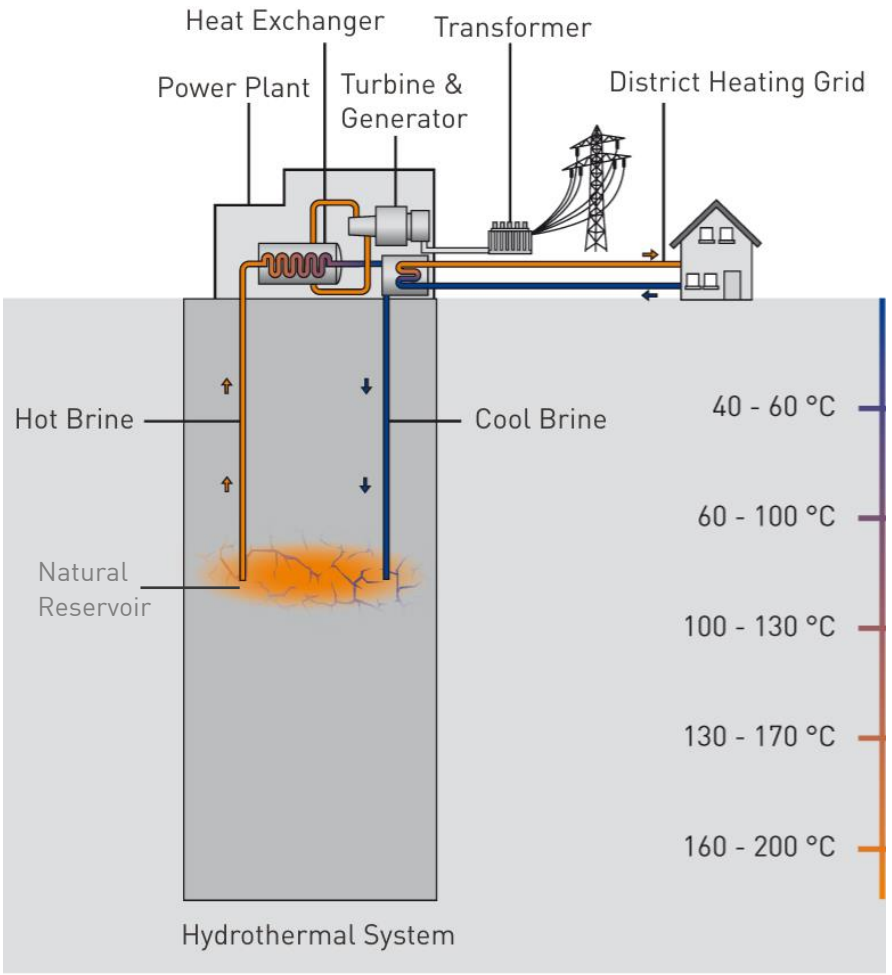
- Production rate: 28 l/s
- Inlet temperature: 126 °C
- Outlet temperature: 60 °C
- Operational pressure: 22 bar

Power production

- Working media: ammonia/water
- Capacity: 550 kW
- Cooling: wet cooling tower
- Heat exchanger: 2x plate exchanger

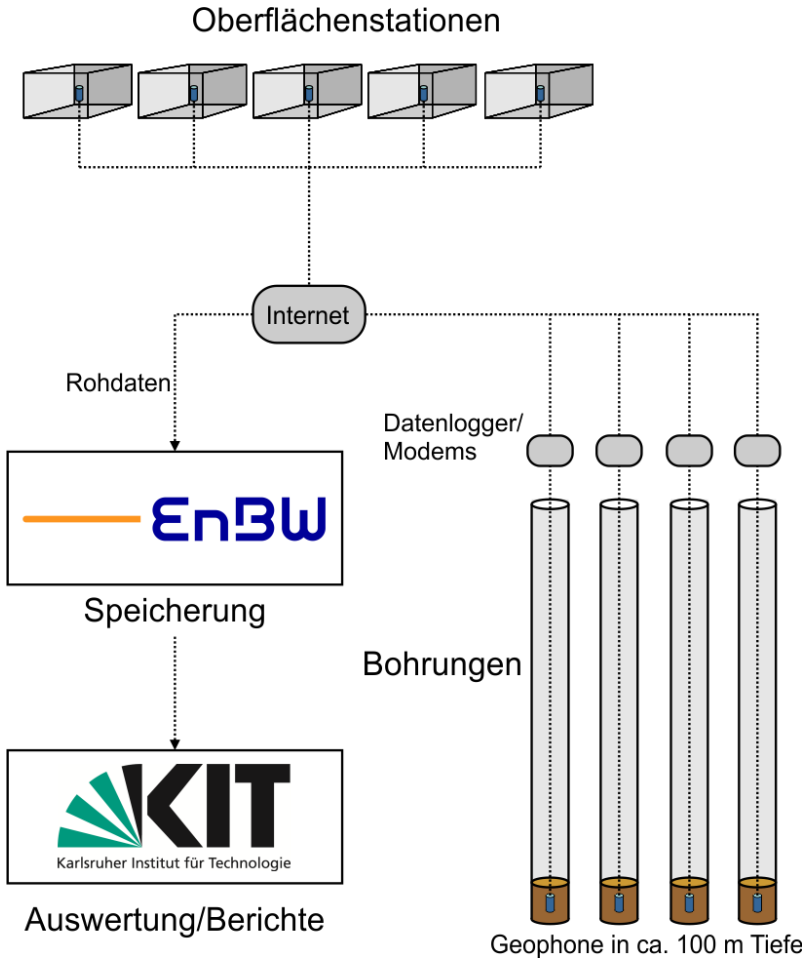
Heat supply

- Flow rate: 6,25 l/s
- Inlet temperature: 95 °C
- Thermal capacity: 1.200 kW

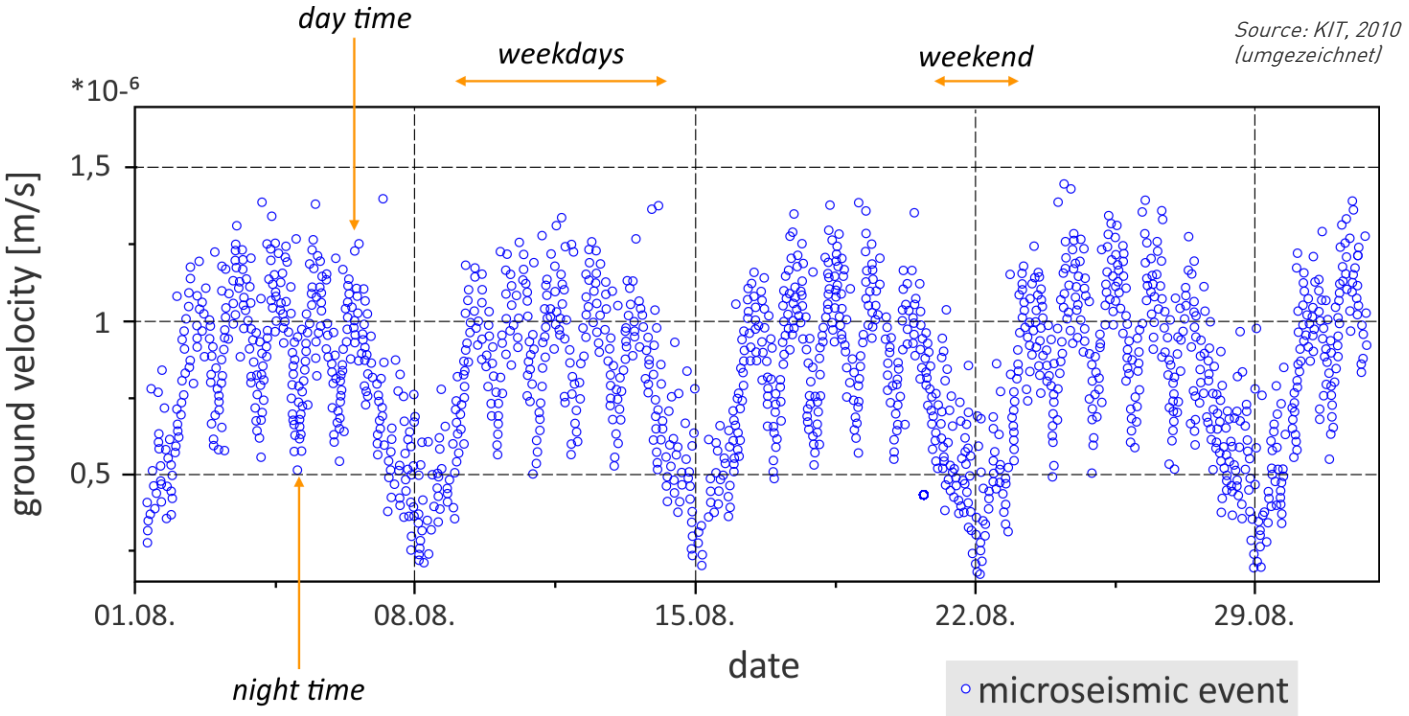


Seismic Monitoring

No seismicity since start of operation

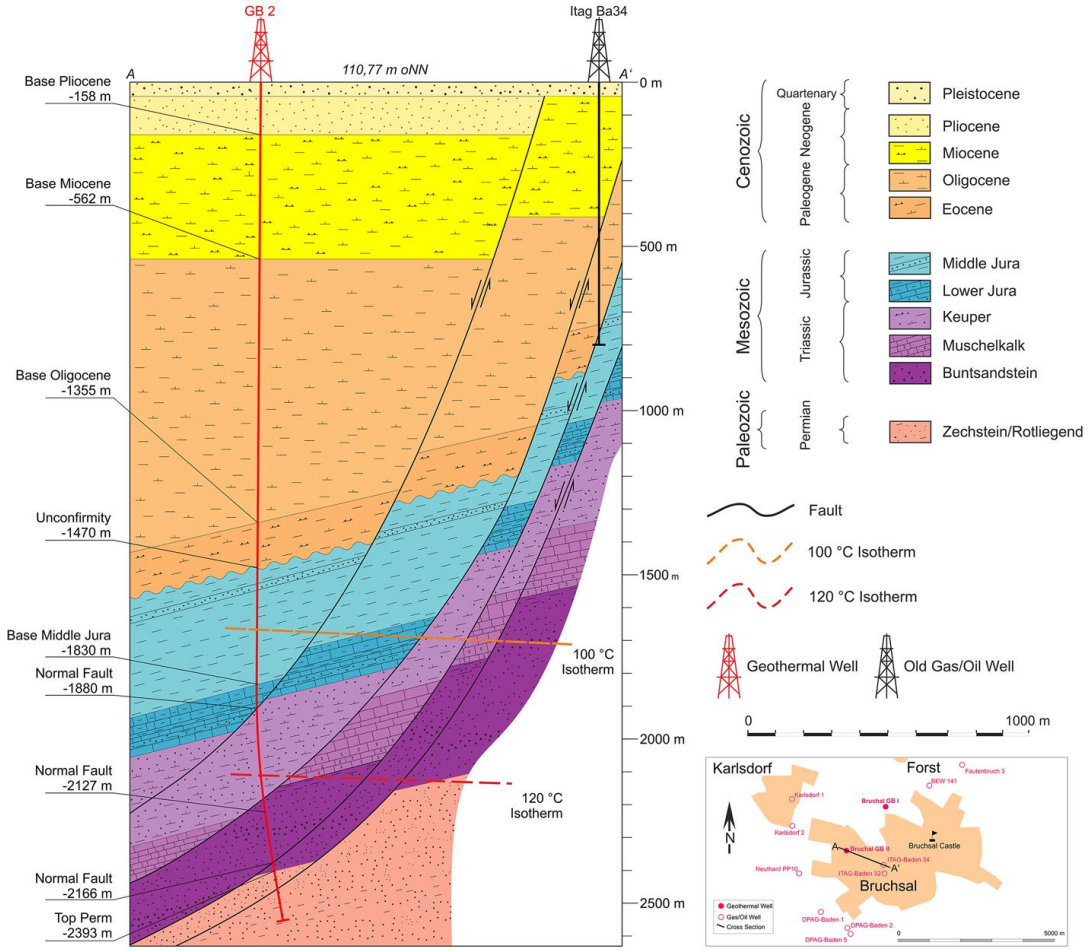


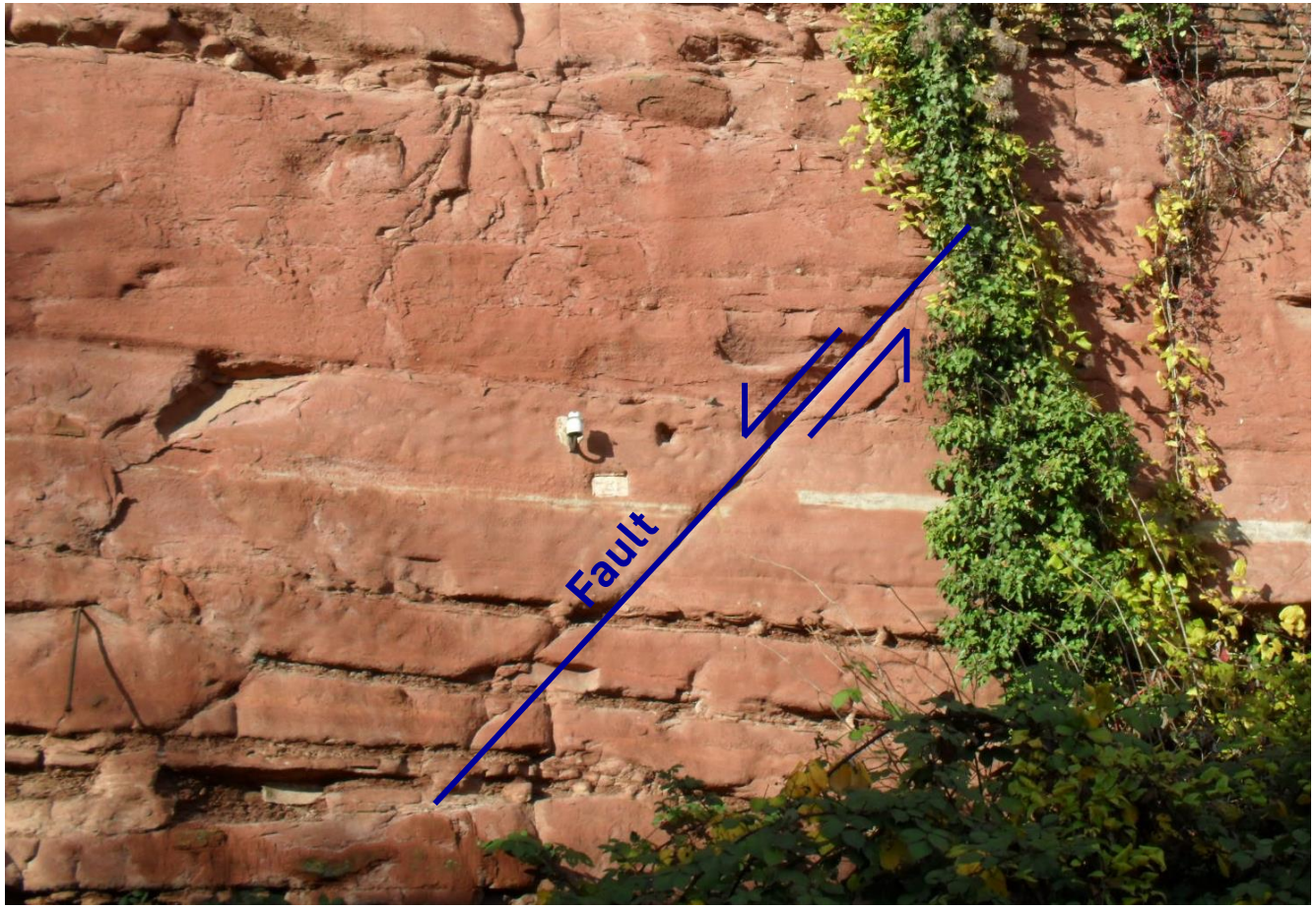
- In operation since 2010
- Up to four seismic stations in boreholes, in addition five surface stations Oberflächenstationen
- Measurements still active



Geology and local reservoir rocks

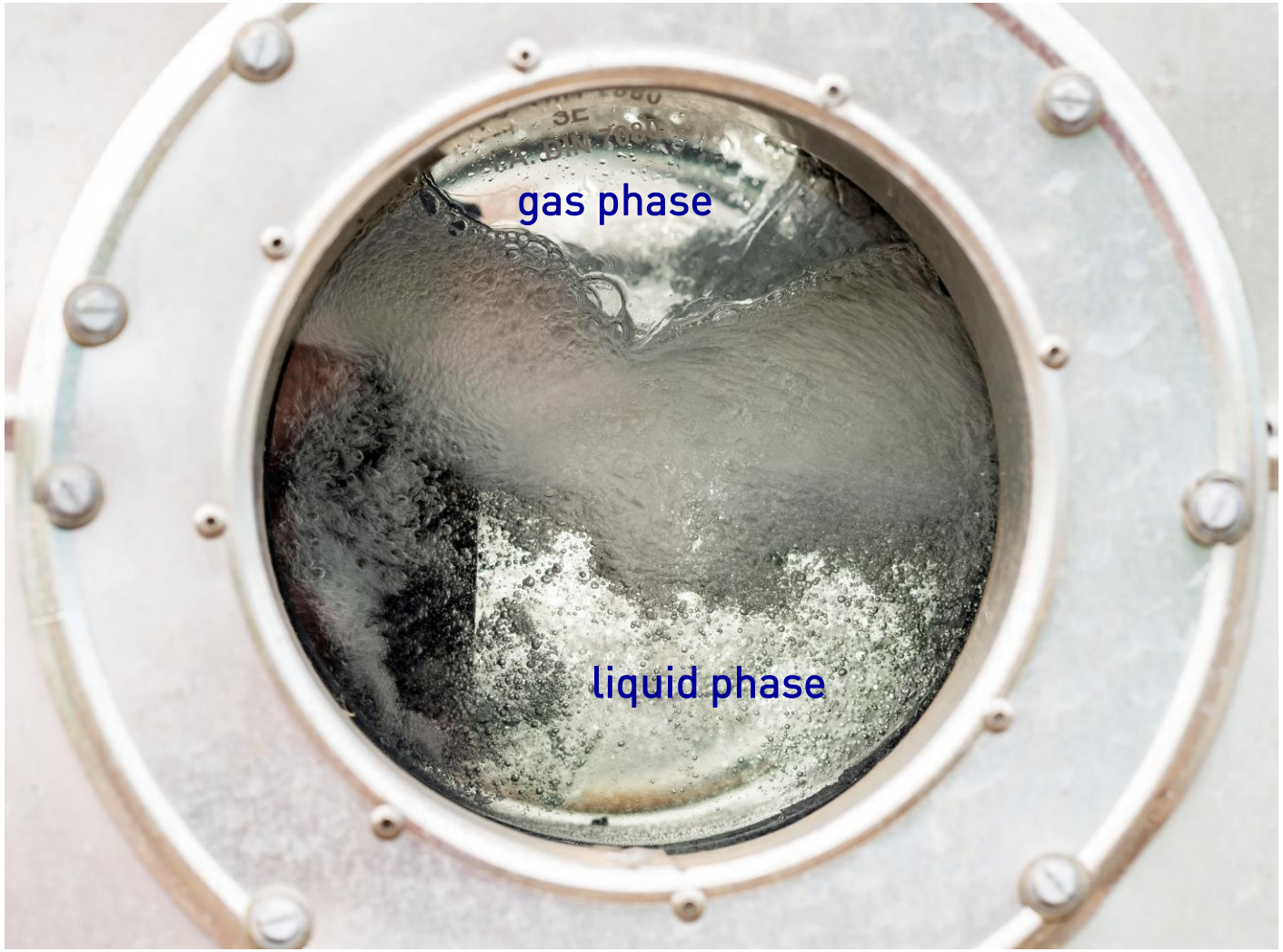
Origin of Li in geothermal brine is still unknown

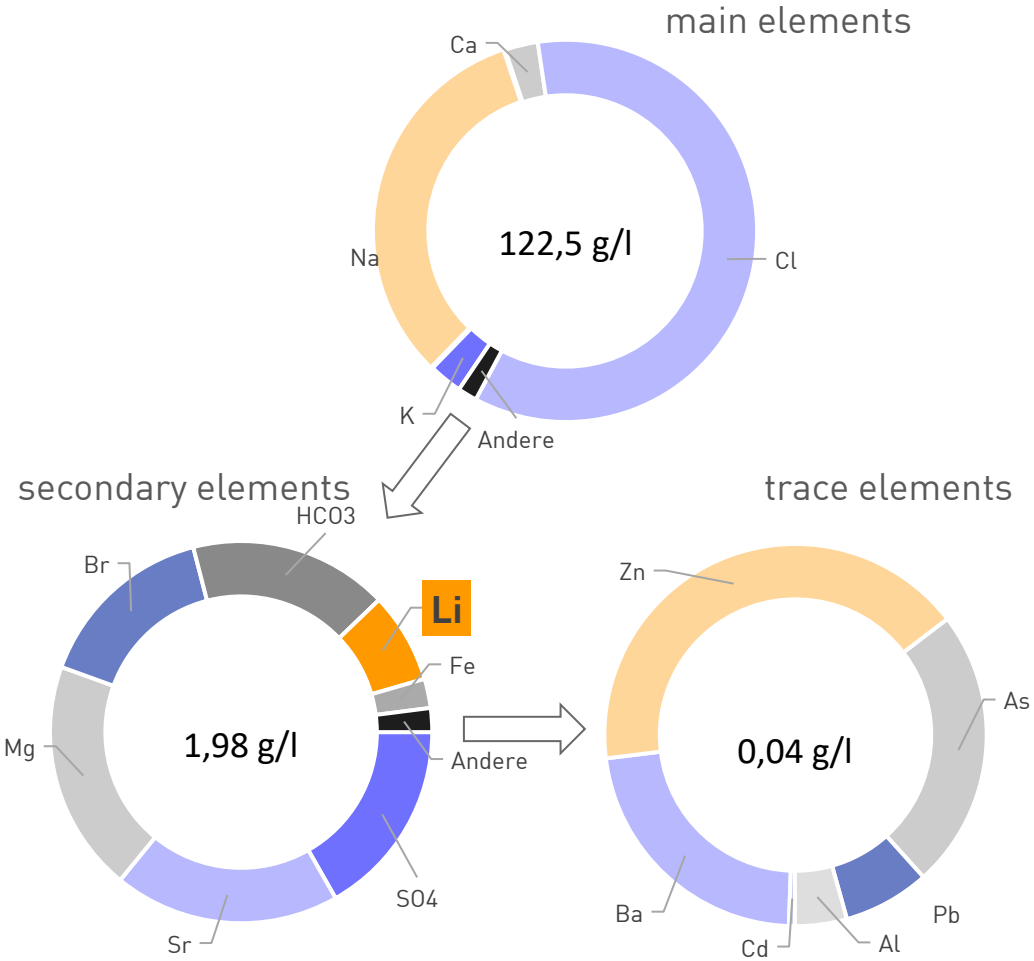




Geothermal brine at Bruchsal

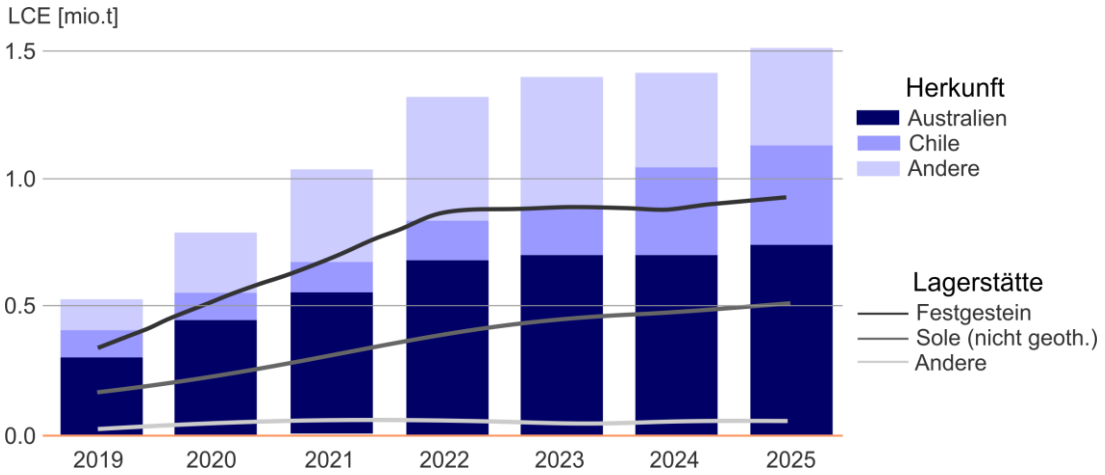
4x more saline than ocean water





Lithium demand and recent production

Increasing demand mainly caused by e-mobility

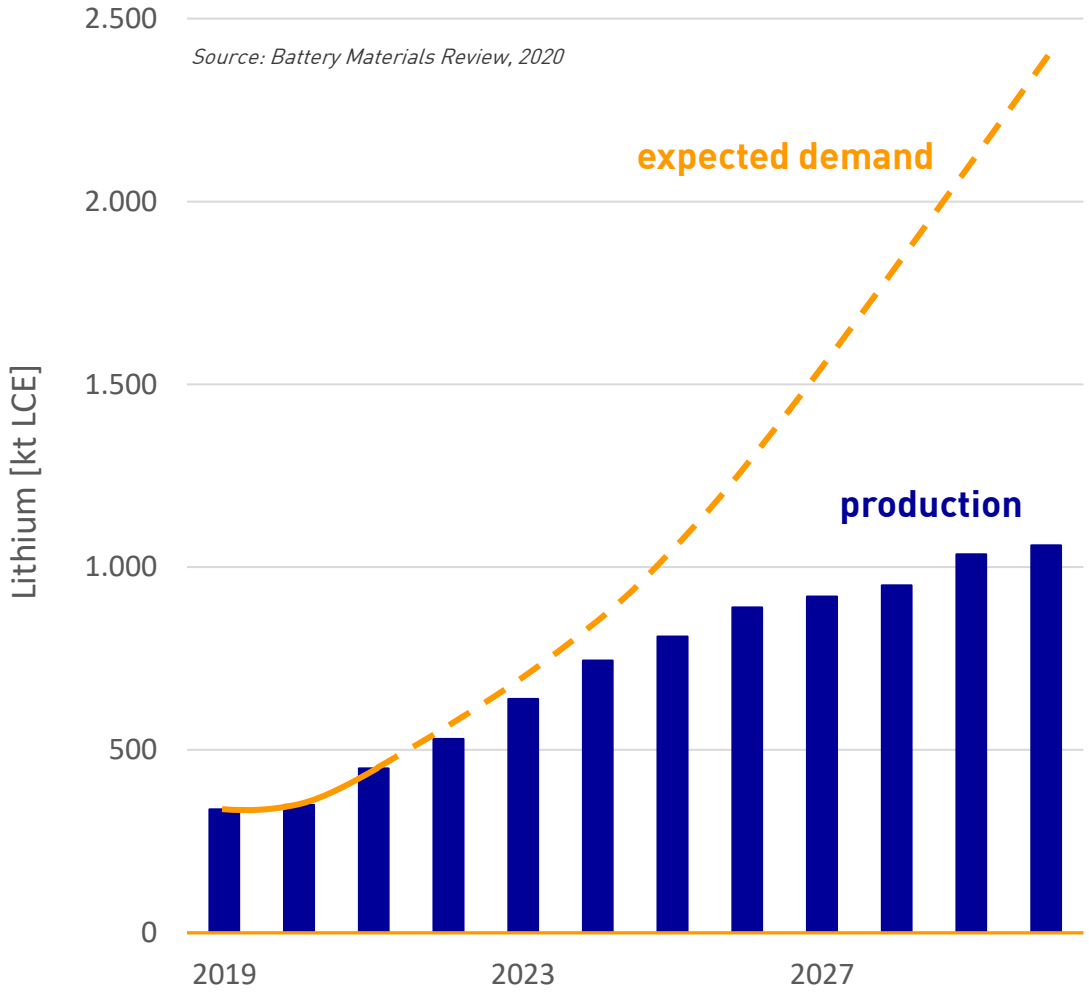


Source: S&P Global Market Intelligence, S&P Global Platts , 2020

Top 5 companies in Lithium production worldwide

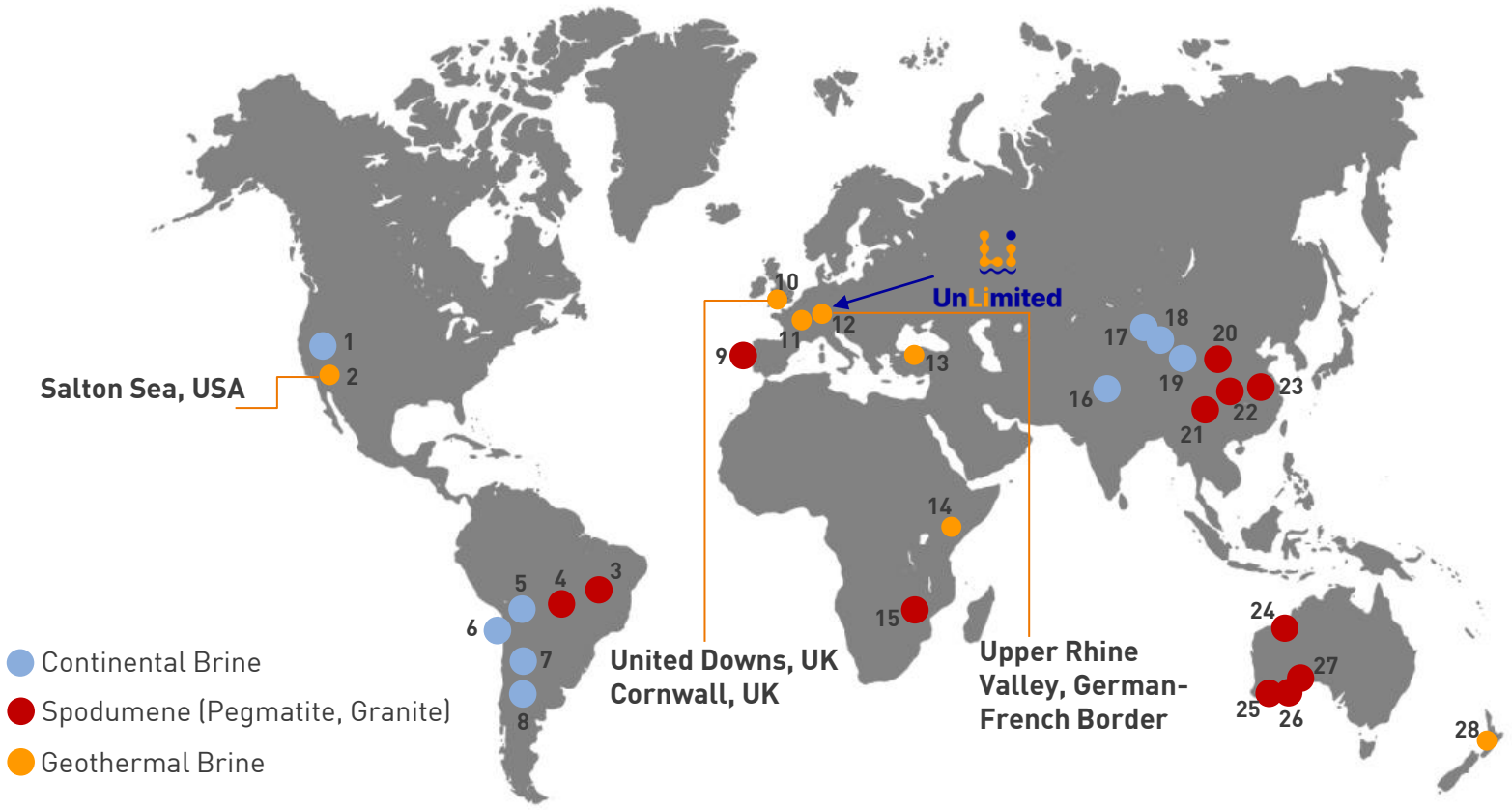
- Albemarle (USA)
- Mineral Resources Limited (Australia)
- Jiangxi Ganfeng Lithium (China, Australia, Argentina, Mexico)
- Tianqi Lithium (China, Chile, Australia)
- Sociedad Química y Minera –SQM- (Chile)

Source: NS Energy, 2021



Lithium deposits worldwide

No relevant resources in Europe



Source: Adapted from Jade Cove Partners

Lithium production (realised & planned)

1. Silver Peak, USA
2. Salton Sea, USA,
3. Mina da Cachoeria, Brazil
4. Mibra, Brazil
5. Salar de Uyuni, Bolivia
6. Salar de Atacama, Chile
7. Salar de Olaroz, Argentina
8. Salar de Hombre Muerto, Argentina
9. Alijó, Portugal
10. United Downs, United Kingdom
11. Rittershofen, Rion, Puy-de-Dome, France
12. Upper Rhine Valley, Germany
13. Denizli, Turkey
14. Olkaria Geothermal Field
15. Bikita, Zimbabwe
16. Zhabuye Salt Lake, China
17. West Taiji Nai'er, China
18. East Taiji Nai'er, China
19. Qinghai Salt Lake, China
20. Sichuan Aba, China
21. Jiajika, China
22. Maerkang, China
23. Ningdu, China
24. Pilgangoora, Australia
25. Greenbushes, Australia
26. Mount Cattlin, Australia
27. Mount Marion, Australia
28. Ohaaki, New Zealand

UnLimited r&d project

Co-production from deep geothermal brines

Objectives

- Sustainability of the resource
- Transfer from lab scale to on site operation
- Design and testing of an emission free technology
- Techno-economic analysis

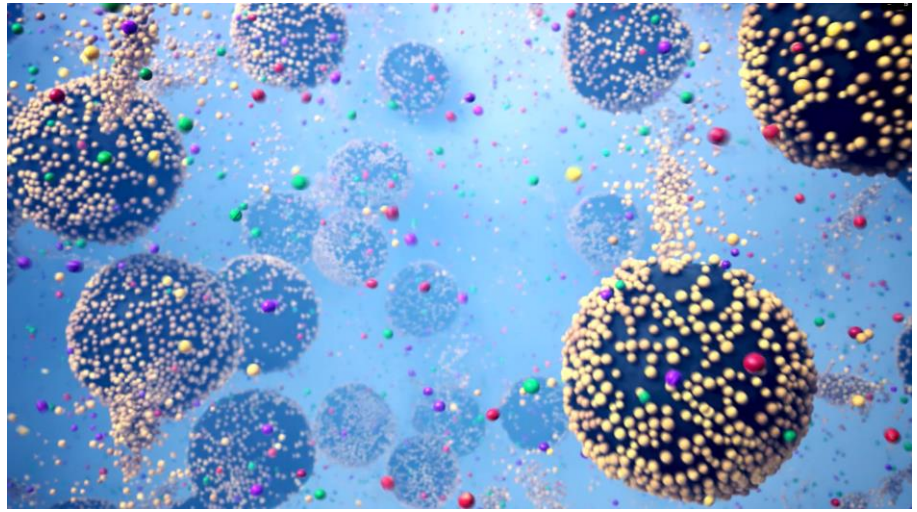
Project data

- Partner: BESTEC, Universität Göttingen (UGOE), Hydrosion, Karlsruher Institut für Technologie (KIT-AGW), EnBW F & E
- Duration: Dec. 2020 until Dec. 2024
- Total cost: ca. 3,4 Mio. €
- Funding: ca. 2,7 Mio. €

Supported by:

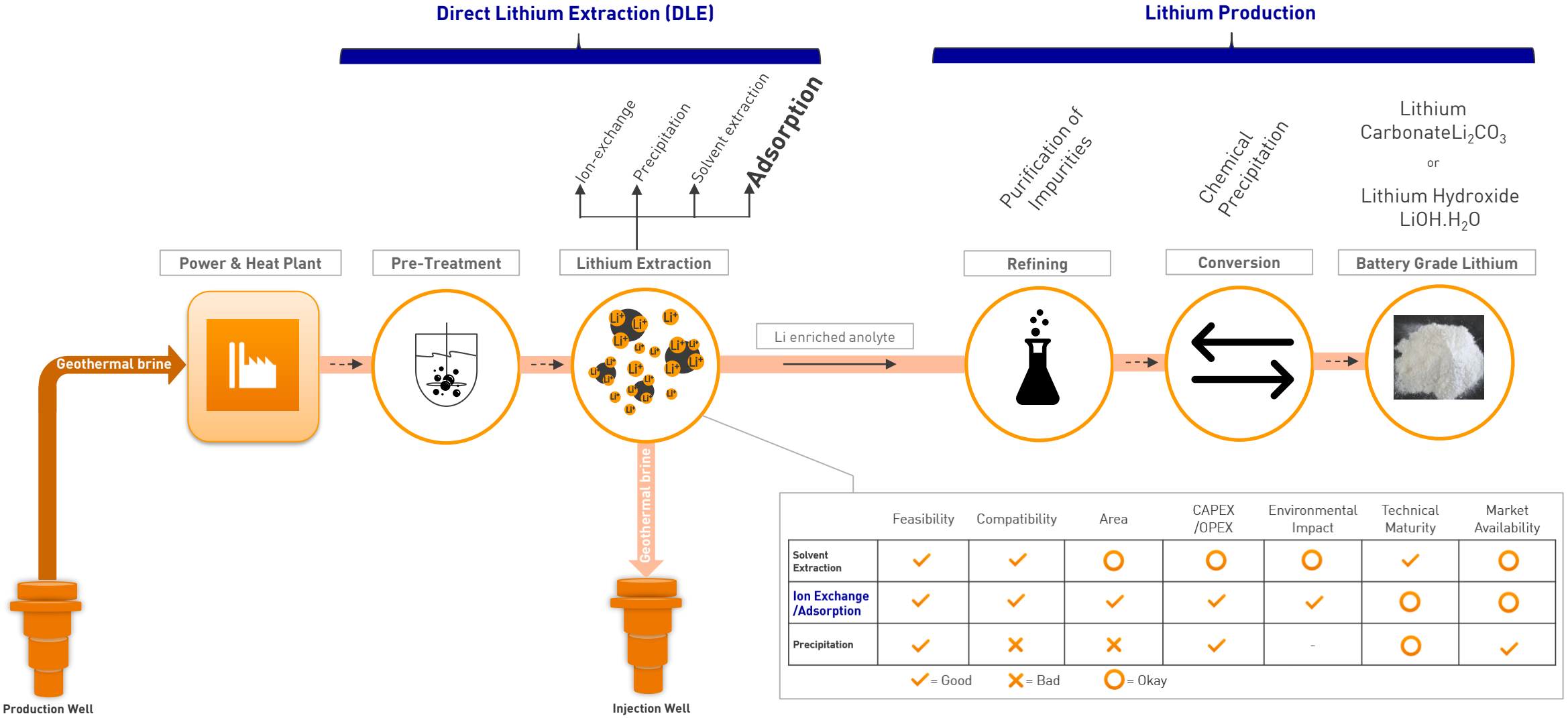
Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag



General production design

Pre-selection from various option

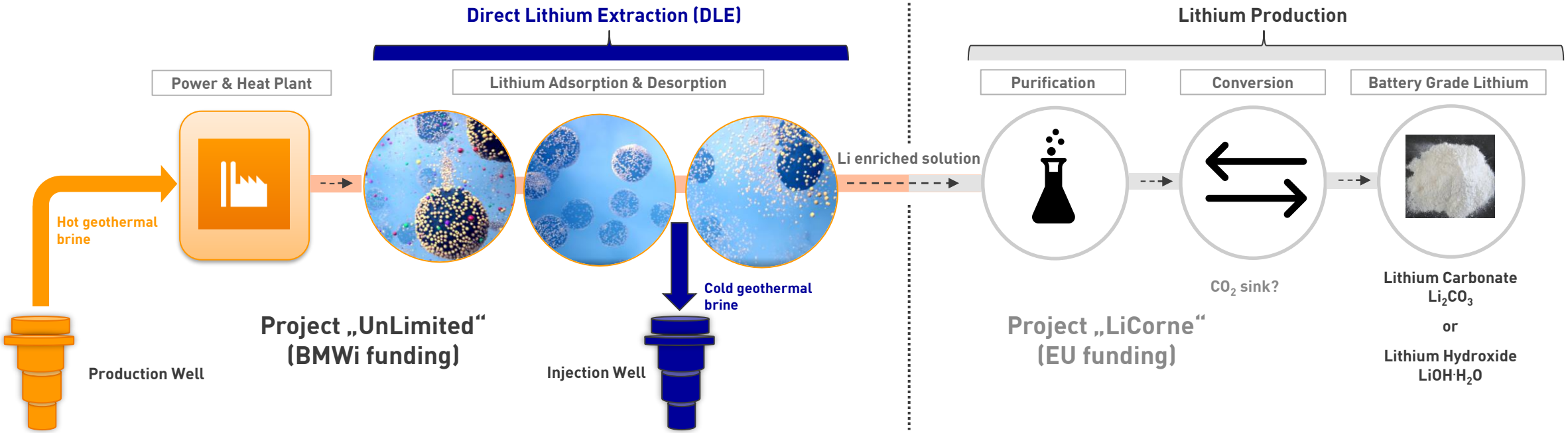


	Feasibility	Compatibility	Area	CAPEX /OPEX	Environmental Impact	Technical Maturity	Market Availability
Solvent Extraction	✓	✓	○	○	○	✓	○
Ion Exchange /Adsorption	✓	✓	✓	✓	✓	○	○
Precipitation	✓	✗	✗	✓	-	○	✓

✓ = Good ✗ = Bad ○ = Okay

Adsorption technology

Complex design with high requirements



Direct Lithium Extraction (DLE)

Adsorption and desorption

1. step

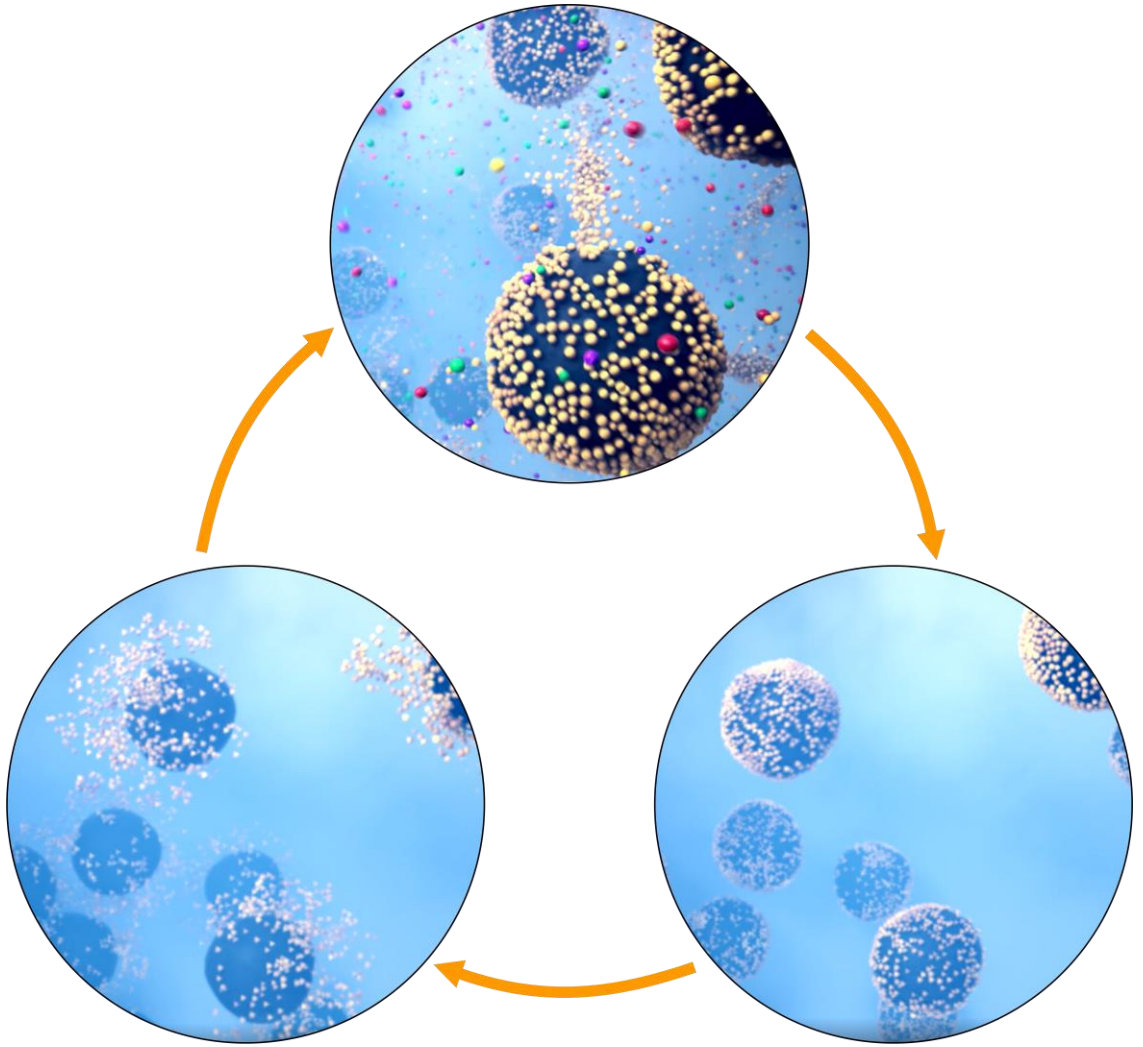
Lithium adsorption

adsorbent and geothermal brine

2. step

Lithium desorption

adsorbent and acidic solution

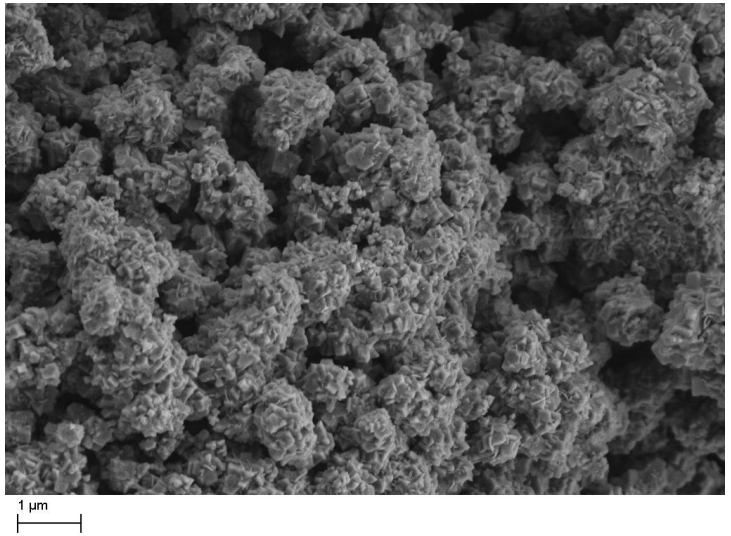


Status Quo and next steps

Tests on site and tecno-cost analysis

Recent status

- Lab tests secured the very good characteristics of manganese oxide
  - High adsorption capacity and selectivity
  - Sufficient stability of the adsorbent during operation (several hundred cycles tested)
  - Very good kinetics
- Tracer test started in January 2022
- Prototype design completed, installation on site in recent days
- /demonstrator tests scheduled in June 2022
- Geochemical process monitoring under design



Next Steps

- Tests with various adsorbents using a prototype/demonstrator
- Process optimisation
- Cost evaluation

Lithium from geothermal brine at Bruchsal

Summary & Outlook

Summary

- Germany is one of the biggest importer of lithium worldwide
- Today no relevant lithium deposit exists in Europe
- Lithium from hot geothermal brines might be an option
- The Bruchsal geothermal plant could provide an 800 t LCE per year, sufficient for appr. 20.000 e-mobility batteries

Open topics

- The sustainability of the reservoir needs to be secured
- The technology transfer from lab scale to a profitable on site facility needs to be mastered
- Zero carbon emission is an requirement
- The lithium production needs to meet commercial criteria

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