IWG DG Support Unit
Platform for research-industry exchange

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Topics

• DG IWG Support Unit
• EERA Geothermal
• Cryogenic energy storage: Pilsworth Grid Scale Demonstrator Plant
• Geothermal research at Karlsruhe Institute of Technology (KIT)
  • DeepStor
  • Messenger Nanoparticles
  • Li-extraction
  • Wellbore flow simulator (Jia Wang)
DG IWG Support Unit

provides the DG-IWG with relevant data about the execution of the IP, from stakeholder groups and provide strategy support for the DG-IWG in their decision-making process and action

promotes and organises initiatives to mobilise the geothermal community to implement the actions identified in the implementation plan, e.g.: workshops, brokerages, consortium building and exploitation of RD&I results.

provides a secretariat for the DG-IWG to assist on administrative issues and to support strategy development
WP 3: input from research community

• To identify relevant ongoing national and European research actions supporting the implementation of the Deep Geothermal IPs RD&I actions by universities and research organisations.
• To investigate and promote cross-cutting RD&I actions between different IPWGs and other relevant research initiatives (Mission Innovation Challenge, FET-Flagships).
• To explore and implement supporting measures to enhance the knowledge transfer to industry.

WP Leader: KIT  
Partner: EERA
EERA in EU & globally

50,000+ Experts

250+ Organisations

30 Countries

All 10 SET Key Actions

17 Joint Programmes

All 9 ETIPS and other platforms

35% Cross-cutting & societal challenges

6 out of 8 Mission Innovation Challenges … so far

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EERA Joint Programmes

- JP AMPEA
- JP Bioenergy
- JP Carbon Capture and Storage (JP CCS)
- JP Economic, Environmental and Social Impacts (JP E3S)

- JP Nuclear Materials (JP NM)
- JP Smart Cities (JP SC)
- JP Smart Grids (JP SG)
- JP Wind Energy (JP Wind)

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EERA Geothermal

- Established in 2010
- 28 Participants, 7 associate participants
- Common endeavour to coordinate European geothermal energy research
- Approximately 40% of European research capacity
Pilsworth Grid Scale Demonstrator Plant

Air turns to liquid when cooled down to -196°C (-320°F), and can then be stored very efficiently in insulated, low pressure vessels. Exposure to ambient temperatures causes rapid re-gasification and a 700-fold expansion in volume, which is then used to drive a turbine and create electricity without combustion.

The process

- Charge
- Store
- Recover

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Storage capacity comparison
When deployed in optimum circumstances, a 100MW plant could store enough power to generate electricity for 100,000 homes. This is the best option for mid-to-large-scale storage which can be located at the point of demand.
Pilsworth Grid Scale Demonstrator Plant

What is beneficial about Cryogenic Storage?

<table>
<thead>
<tr>
<th></th>
<th>Response</th>
<th>Expandability</th>
<th>Black Start</th>
<th>Renewable curtailment avoidance</th>
<th>Efficiency (%)</th>
<th>Lifespan (years)</th>
<th>Scalability (MW) 4 hour +</th>
<th>Sustainability</th>
<th>Locatability</th>
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<tbody>
<tr>
<td>Highview CRYO</td>
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<td>80</td>
<td>50</td>
<td><img src="image5" alt="Circle" /></td>
<td><img src="image6" alt="Circle" /></td>
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# Geothermal research at KIT

From basic research to demonstration projects

<table>
<thead>
<tr>
<th>DEEPSTOR</th>
<th>Intelligent nano particles</th>
<th>Mineral extraction &amp; co-usage</th>
<th>WellboreKit</th>
</tr>
</thead>
</table>
| • Demonstration project for the environmentally friendly utilisation of geothermal heat and „high temperature“ heat storage towards an autonomous Campus district heating system at KIT | • Novel exploration technology with nano tracers to retrieve quantitative physical and chemical information from the reservoir | • Li extraction: testing of filter and adsorption technologies  
• BrineMine: Membrane distillation for desalination and mineral recovery from geothermal brines by use of geothermal heat | • Numerical two-phase, multi-component wellbore flow simulator |

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Geothermal research at KIT

DEEPSTOR

Existing Heat Sources @ KIT - CN

- Autonomous heat supply
- Heat production currently 100% from fossil: gas (Backup: oil)
  - CHP base load heat supply (heating demand summer)
    \[ \rightarrow 2 \text{ MW}_{e/t} \]
  - Temporary 2 CHP units for scientific purposes
    \[ \rightarrow 2 \times 4.5 \text{ MW}_{e/t} \]
  - 3 hot-water boilers for peak load
    \[ \rightarrow 49 \text{ MW}_t \]
Geothermal research at KIT

DEEPSTOR

- **Existing:**
  - Largest known thermal anomaly of Germany at Campus North of KIT: up to 170°C in 3 km depth
  - District heating system coupled with gas-fired cogeneration unit

- **Goal:**
  - Intermediate heat storage in exploited reservoirs
  - Geothermal heat production envisaged
  - Applied acceptability studies
  - Scientific test operation towards autonomous campus heat management
  - Complementing infrastructures MoNiKa (Modular Low Temperature Power Plant 100kW installed) and EnergyLaB 2.0 (https://www.elab2.kit.edu/downloads/Broschure_EL2_2018.pdf)

Construction: 01/2021-09/2024
Operation: 09/2024-12/2027
Vision: "Heat Lab" at KIT-CN

\[ CH_4(g) \rightarrow C(s) + 2H_2(g) \]
Geothermal research at KIT

**Messenger Particles: A Novel Approach**

Intelligent nanoparticles reporting from places which are inaccessible

1) **Injection**
- Intelligent (nano)particles with quantitative memory function
- Flowing to the remote places of interest

2) **Reaction**
- Chemical and physical environment in the borehole
- Experienced conditions induce irreversible changes of the particles ("Memory")

3) **Detection**
- Analysis of the induced changes after return of the particles
- Quantitative information from reservoir

E-mail: thomas.schimmel@kit.edu

DG-IWG Support Unit, Brussels 5th February 2020
Lithium extraction
in geothermal powerplants

Jens C. Grimmer & Florencia Saravia
Lithium global demand

6Li: 7.4%
7Li: 92.6%

Short notes:
Production of Tritium from 6Li: H-bombs, nuclear fusion
Pharmacy: psychotropic drugs / antidepressiva

Source: Robert Baylis, Roskill, 9th Lithium Supply, and Markets Conference, 31st May 2017
New emerging technologies put pressure on raw materials supply

Sources: Roskill, Peteves et al., World Resource Forum 2017, European Commission
Price development of lithium

Example: lithium producer in Argentina

from presentation for investors of Orocobre (07/2018)
Geothermal sites in the Upper Rhine Graben

actually:
Bruchsal
Landau
Insheim
Soultz-sous-Forêts
Rittershoffen

potentially:
Brühl?
Graben-Neudorf?
Neuried?
...

Li⁺-concentrations
seawater: 0,18±0,07 mg/l
geothermal waters: ≤ 300 mg/l
salt lake brines: 100 – 4000 mg/l
Lithium potentials in the URG

URG total (six geothermal sites):
2,220 t Li / year
11,820 t LCE / year
→ ca. 120 Mio. US$ / year

Compare to Orocobre Ltd.
2018: 11,837 t LCE
average price:
US$12,578 / t (2018)
Li-extraction in geothermal plants: potentials and chances

- improving profitability
- development of a smart, environmentally neutral, economic process
- supplementary contribution to energy transformation
  - e-mobility, energy storage
  - important raw material for Li-ionen accumulators (+cobalt, nickel, aluminium)
- national economics: no (political) country risk, no costs for importing („money remains in the country“)
- job opportunities
- infrastructure situation: existing plant operation (no risks of finding, no costs for drilling), lithium distribution (railway, highway, water transport network), close to market (Europe)
## SWOT-Analysis

<table>
<thead>
<tr>
<th><strong>Strengths</strong></th>
<th><strong>Weaknesses</strong></th>
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<tbody>
<tr>
<td>- use of existing geothermal power plants</td>
<td>- No established technology</td>
</tr>
<tr>
<td>- no country risk</td>
<td>- site specific peculiarities (water chemistry....)</td>
</tr>
<tr>
<td>- ideal infrastructure and close to market</td>
<td></td>
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<tr>
<td>- contribution to energy transformation</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Chances &amp; Potentials</strong></th>
<th><strong>Threats &amp; Risks</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Improving profitability</td>
<td>- waste disposal</td>
</tr>
<tr>
<td>- Increase life time of geothermal power plants</td>
<td>- economic-technical efforts needed are too much</td>
</tr>
<tr>
<td><strong>potential for other elements</strong></td>
<td>- market risks: excess supply of lithium → falling prices</td>
</tr>
<tr>
<td></td>
<td>- new technologies</td>
</tr>
</tbody>
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now: „cradle-to-grave“

Goal(?): „cradle-to-cradle“ (recycling may become attractive in the future)
Li Extraktion Methods

- pyro- and hydrometallurgical processes
- chromatographic processes
- capacitive / electrophoreetic processes
- Microorganisms
- Precipitation
- Liquid-liquid extraction
- Membrane technology
- Ion exchange / absorption
- combined processes

TRL 4
patent process
started: Jens Grimmer

E-mail: jens.grimmer@kit.edu
Aims:
• Extracting raw materials and drinking water from geothermal waters
• Process development: membrane technology, the heat of the water shall power a technical process, which separates the mineral raw materials and the water in a closed loop.

Steps:
1. A pilot plant will be developed in Germany
2. In parallel, a sampling campaign in northern Chile will be conducted to estimate the raw material potential of geothermal waters and to select an ideal site for extracting raw materials.
3. In a final step, the developed pilot plant will be transferred and installed in Chile.
Contact

• DeepStor  thomas.kohl@kit.edu
• Messenger Paticles  thomas.schimmel@kit.edu
• Li-extraction (URG)  jens.grimmer@kit.edu
• BrineMine  valentin.goldberg@kit.edu
Please contact us:

• If you are looking for research expertise.
• If you are looking for project partners.
• If you are looking for new innovative ideas.
• If you are looking for students to offer them an internship.
• If you would like to know what the research is working on.

olga.suminska-ebersoldt@kit.edu
holger.ihssen@helmholtz.de
WellKit - A Coupled Wellbore Simulator for Geothermal Application

Maziar Gholami Korzani, Sebastian Held, Fabian Nitschke, Jia Wang and Thomas Kohl
Tiefstes Loch in Hannover wird ein Problemfall

Am tiefsten Loch Hannovers gibt es Schwierigkeiten: Das „GeneSys“-Projekt zur Beheizung der Bundesanstalt für Geowissenschaften mit umweltfreundlicher Erdwärme muss wegen technischer Probleme vorerst gestoppt werden.

Von Bärbel Hassa

Noch ist unsicher, wie es auf dem Bild der Rohrleitung in der Geschossen-Sozialwohnung in Hannover endet. Quelle: Marion Erckan
Wellbore simulator (MOSKITO)

- Pipe Hydraulics
  - Two-phase flow
- Transient
  - Highly dynamic problems
- Fully Coupled
  - Strong interaction of system parameters
- Multi-Component
  - Dissolved solids and gases
- Coupling Wellbore – Reservoir (TIGER)
  - Large scale problems, field operations
Validation: Thermal system

- Against analytical solution of Satman et al. (2016)
  - 2500 m deep vertical well
  - 2x injection (20°C and 90°C)
  - 1x production (245°C)

- Against analytical solution of Bobok and Szarka (2012)
  - 2500 m deep well
  - Counterflow circulation scheme
  - Injection in string, production from annulus
Application: Two-phase hydraulics

- Multiple-inclined well + changing pipe diameter
- Production flow rate at top: 15 L/s
- Ambient pressure at top
- Complete 2-phase flow
Reservoir simulator (TIGER)

- Anisotropic heterogeneous porous media
  - 3D flow

- Discrete embedded features
  - Fractures and openhole well paths

- Fully coupled
  - Thermo-Hydro-Solute processes

- Massive Parallel FE-Solver
  - Computational efficiency

- Mesh adaptivity
Coupling MOSKITO-TIGER

- Multi-app simulation
  - Transfer data at each time step
  - Picard iteration for convergence
  - Loosely coupled

- Modelling methodology
  - One reservoir model
  - Several well model

- Technical notes
  - Standalone models
  - Executable separately
Example: T-H simulation (MOSKITO&TIGER)
Example: Simulations on the RN-15/IDDP-2 well in Iceland

- RN-15/IDDP-2: DEEPEGS Demonstrator at Reykjanes, Iceland

- Deepening of an existing well (RN-15) of 2500 m to 4659 m (IDDP-2)
- Drilling period: August 11\textsuperscript{th}, 2016-January 25\textsuperscript{th}, 2017 (168 days)
- Several permeable zones, major fluid loss encountered
- Temperature logs conducted during the drilling
- Interpretation of these temperature data from complex borehole conditions requires sophisticated tool such as a wellbore simulator
- The objectives are to derive the static formation temperature (SFT) and fluid loss in the well
Example: Simulations on the RN15/IDDP-2 well in Iceland

- Injection flow rate over the whole drilling period

three temperature logs were simulated
Example: Simulations on the RN15/IDDP-2 well in Iceland

- prior-known Static Formation Temperature (SFT) profile of the RN-15 well

Database at ISOR (the Iceland GeoSurvey)

Friðleifsson et al., 2018
Example: Simulations on the RN15/IDDP-2 well in Iceland

- Input data for the temperature log simulations
Example: Simulations on the RN15/IDDP-2 well in Iceland

- Current approach: Stepwise inversion for the SFT
Thank you for your attention...

Robert Egert
Jia Wang
Backup
EERA Geothermal

- Established in 2010
- 30 Participants, 7 associate participants
- Common endeavour to coordinate European geothermal energy research
- Approximately 40% of European research capacity

**Sub-Programmes**

**SP1** Assessment of Geothermal Resources

**SP2** Exploration of Geothermal Reservoirs

**SP3** Constructing Geothermal Wells

**SP4** Resource Development

**SP5** Energy Conversion Systems

**SP6** Operation of Geothermal Systems

**SP7** Sustainability, Environment and Regulatory Framework

**SP8** Computing and Data Management

Coordinator/Chair: Inga Beere (Uni Bergen)

Scientific secretary: David Bruhn (GFZ/TU Delft)

SP6 Coordinator: Thomas Kohl (KIT)
Geothermal research at KIT

**Future activity: DeepStore**

- Energetic Infrastructure at KIT-CN
  - District heating with CHP (gas fired)
  - Modular Low Temperature Power Plant (MoNiKa, 100kW installed)
- EnergyLab 2.0
- Waste heat from Research Plants

- High temperature storage
  - Combining geothermal / hydrocarbon reservoirs

E-mail: thomas.kohl@kit.edu
Energy Lab 2.0

- Hydrogen from low temperature electrolysis
- Power-to-molecules
- The BIOLiQ technology
- Cathalytic methanation
- Decentralized production of liquid fuels
- Flexible heat supply
- Solar power storage park for research
- Innovative large-scale storage system (1.3MWh Li)
- Micro gas turbine
- The smart energy system control laboratory
- The energy grids simulation laboratory
- The control, monitoring and visualization center
- Power hardware in the loop
Securing raw materials supply

Legend:
- Production in tonnes (percent of total EU supply)
- Battery plant planned or under construction
- Operational battery plant
- Potential production

Source: Roskill 2018

Source: EU Criticality assessment 2017
Lithium production

- two standard processes
  - evaporation of salt lake brines and
    - precipitation of Li-carbonate / LiOH
  - pyro-/hydrometallurgic from hard rocks (pegmatite, spodumen etc.)
    - precipitation of LiOH

Lithium brine in Salinas Grandes, Andes, Argentina.

The Greenbushes mine in Western Australia.

Salt lake brines
  - large areal demand
  - aride climate conditions are needed
  - time for evaporation
  - environmental friendly???
  - relatively low costs for production

Hard rock
  - large volumes to dispose
  - energy intensive
  - relatively high costs for production
Zero Carbon Lithium Project

- Insheim, Germany

- The Exploration Target of 10.73 to 36.20 million tonnes of contained Lithium Carbonate Equivalent (LCE), is based on a range of lithium concentrations between 126 mg/L lithium and 190 mg/L lithium.

- No information about extraction process
EuGeLi Project

Extraction process developed for a brine in Argentina, now tested for the brine in Alsace
• Active solid method with fresh water to release the stored lithium
• Nanofiltration and reverse osmosis to concentrate the metal
• Purification of the lithium, then reaction with sodium carbonate to convert it to lithium carbonate. Once filtered again and washed, it achieves the chemical quality of the finished product

https://www.eramet.com/en/activities/innovate-design/eugeli-project