Seasonal Crystalline Borehole Thermal Energy Storage (BTES), Darmstadt

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Seasonal Crystalline Borehole Thermal Energy Storage, Darmstadt

TECHNISCHE UNIVERSITÄT DARMSTADT

Graduate School of Energy Science and Engineering

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Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz

aufgrund eines Beschlusses des Deutschen Bundestages

FKZ: 03EE4030A

ANGER seit 1863

Handke Brunnenbau

Geotechnik Lehr
Am Taubenbaum 25 a
61231 Bad Nauheim

STEP OILTOOLS

LIAG Leibniz-Institut für Angewandte Geophysik

HLNUG Für eine lebenswerte Zukunft

LUNA

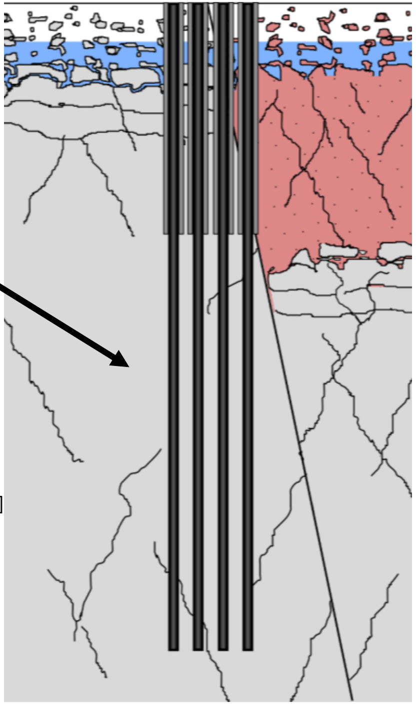
FRANK

HEIDELBERGCEMENT

SKEWs – TU-DA Demo-site and goals

Location

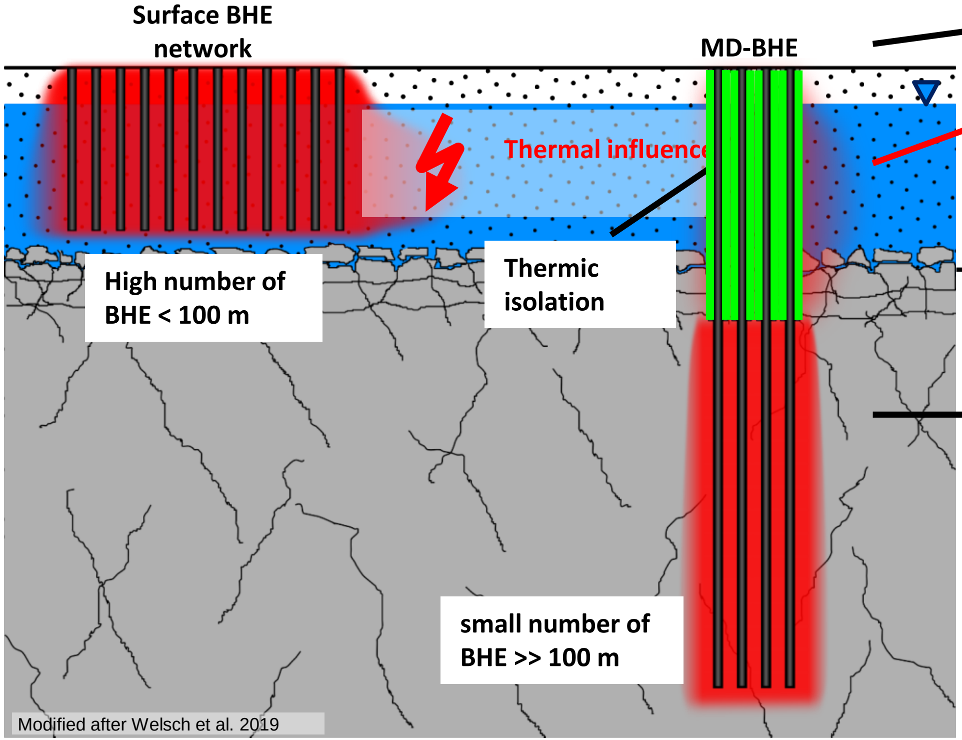
Connect to the heating system



Medium deep boreholes

- **Construction of a MD-BTES as a demonstrator on a technical scale (3 x 750 m deep borehole heat exchangers, spacing approx. 8,7 m)**
- **Demonstration of the hydraulic down-the-hole-hammer drilling method for MD-BTES**
- **Experimental characterization of the operation of MD-BTES**
- **Validation and calibration of numerical models on real measured data**
- **Economic and emission prediction for planning of highly scaled plants**
- **Evaluation of the integration of the MD-BTES into the energy concept of the TU Darmstadt**

Concept – Medium deep borehole thermal energy storage



- Less surface occupancy
- Reduced thermal influence in near-surface aquifers

Aquifer
Porous rock

Hard Basement rock

Low permeability

- Conductive heatflow
- Low convective losses due to min. flowing groundwater

BHE : Borehole Heat Exchanger

SKEWs – TU-Darmstadt Demo-site and goals

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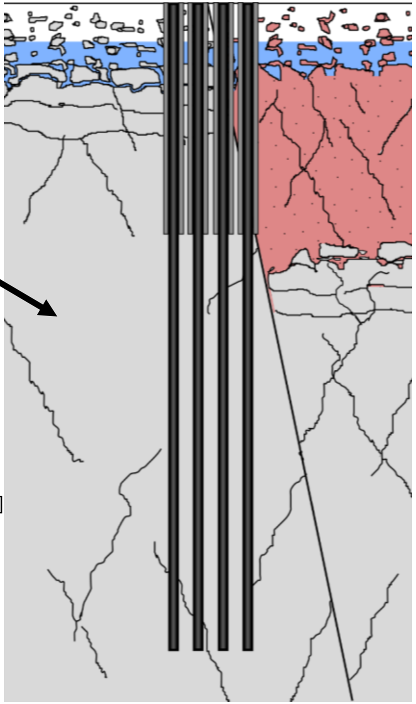

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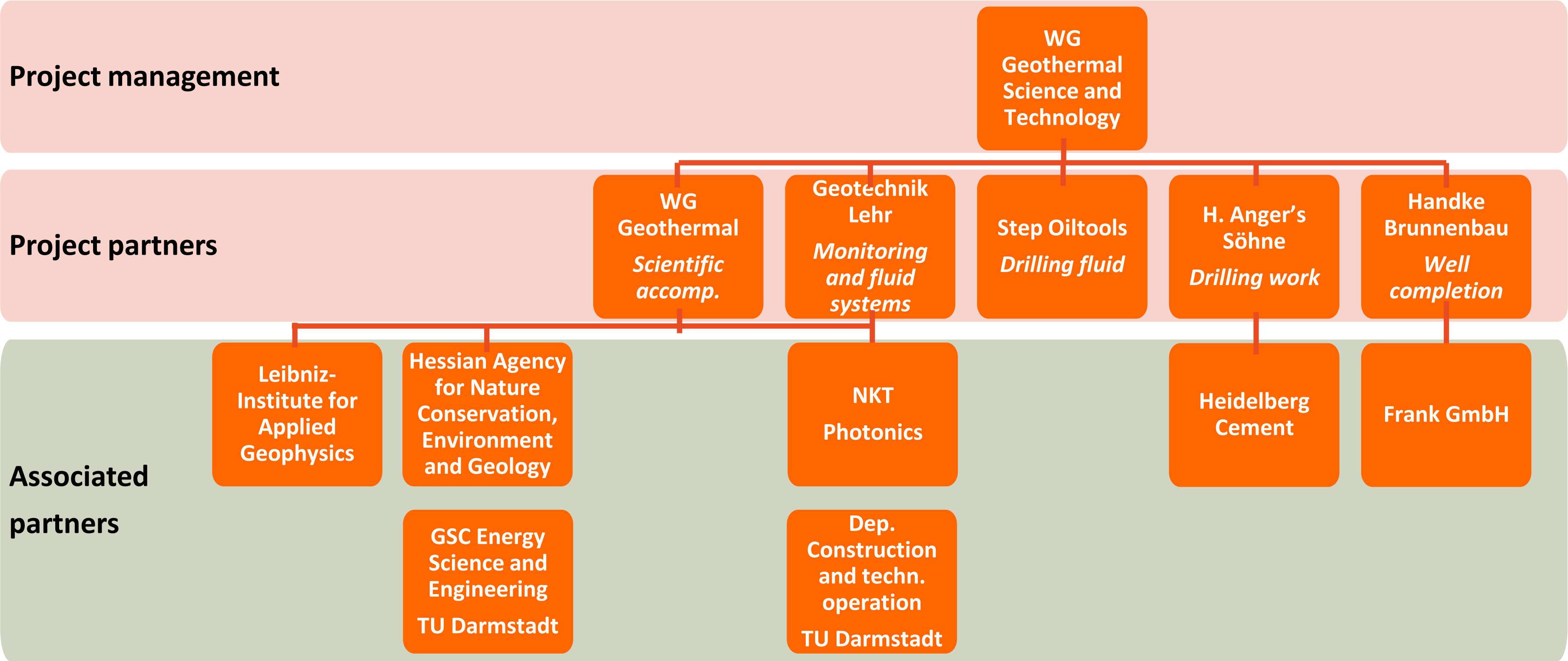
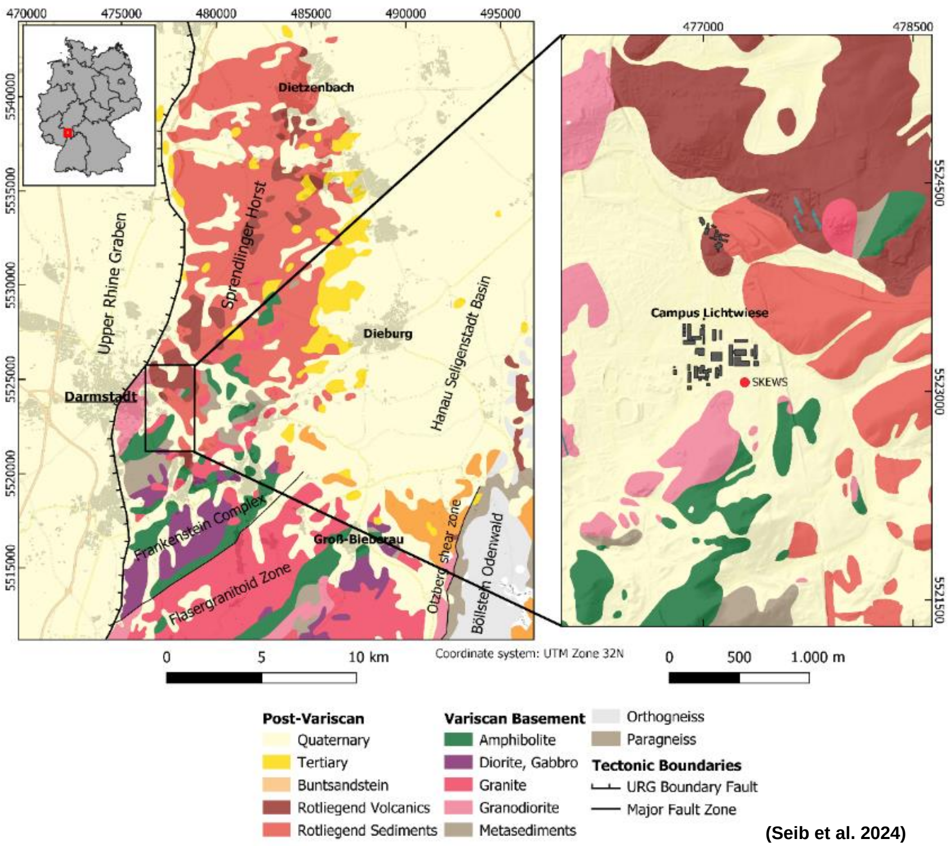
SKEWs – Project partners



SKEWS – Project location

Geological context

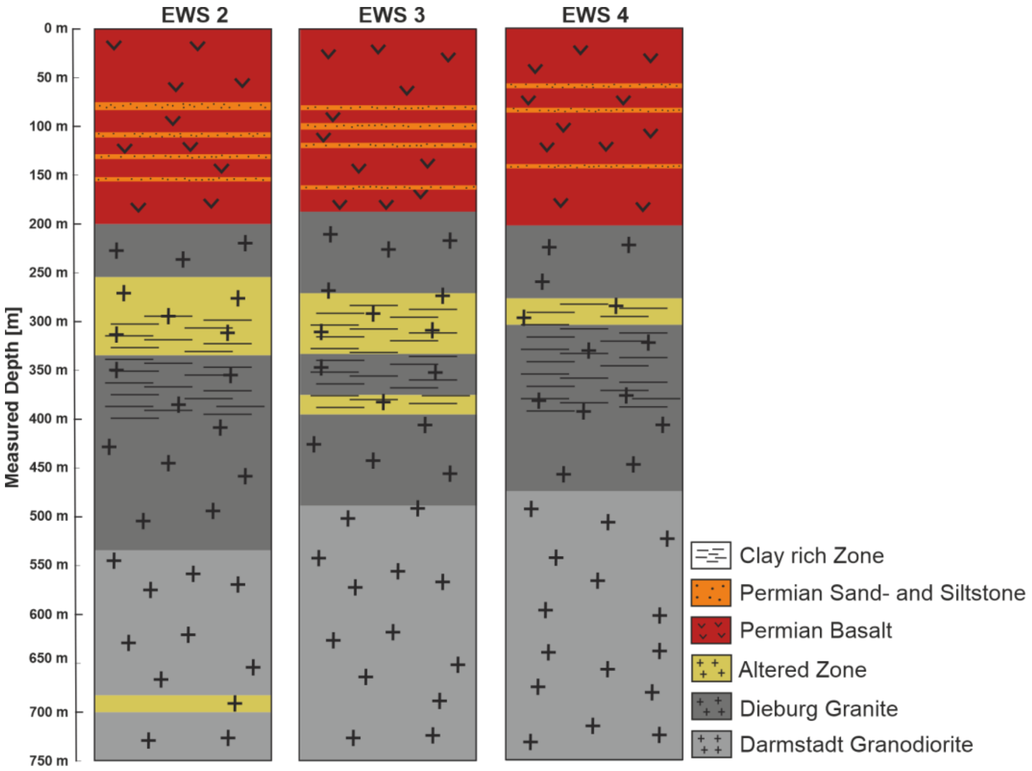
- The project site is located in the northern Odenwald crystalline complex
- The Odenwald is dominated by variscan plutonic complexes
- Locally, the site is characterized by variscan plutonic rocks and Permian sedimentary and volcanic rocks



(Seib et al. 2024)

Geological interpretation

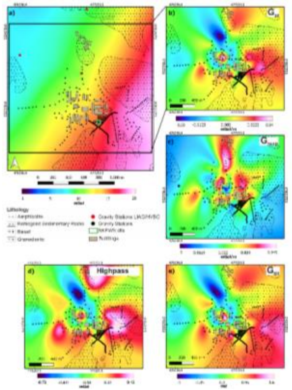
- **Cutting samples taken continiously every three meter interval**
- **Thick unexpected permian basalt deposit with total thickness of up to 200 m**
- **Below that two plutonic units with varying degrees of alteration**



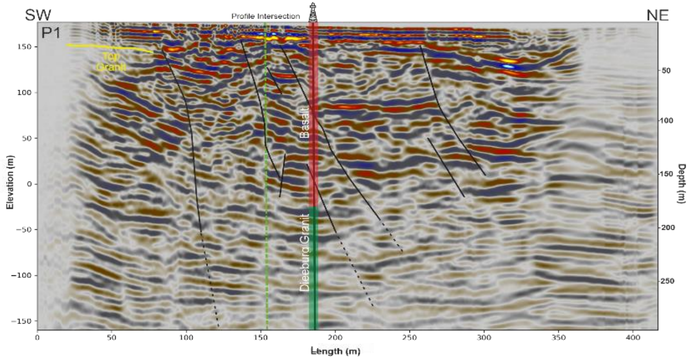
Geophysical study

Before:
- **Geologic and geophysical investigations**
- **Gravimetry**
- **2D-Seismic**
- **Electrical resistivity tomography**
- **Outcrop analogue studies**

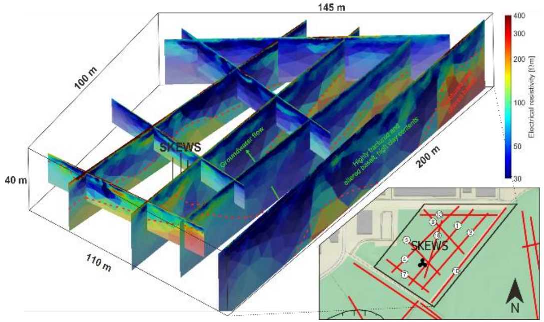
During drilling:
- **Geophysical logging**



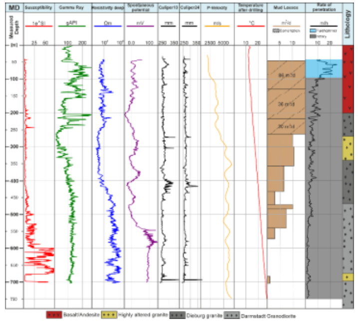
Gravimetry



Seismic



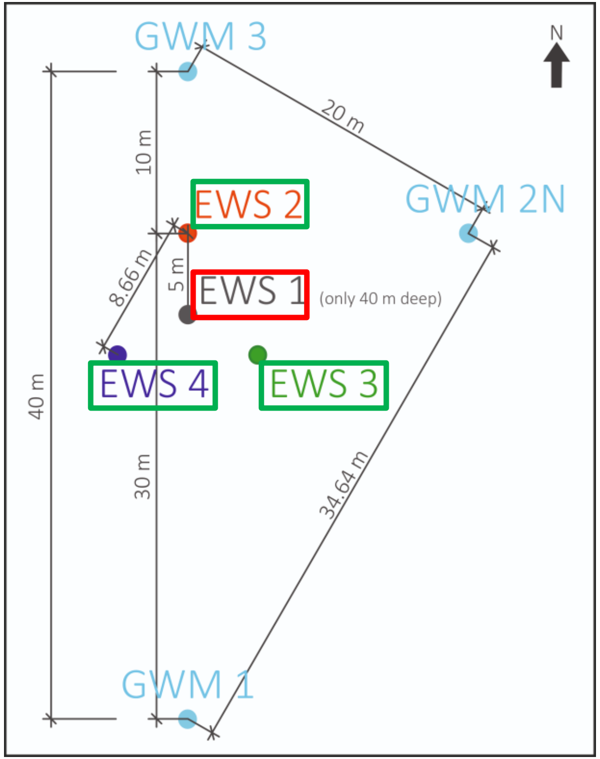
Geoelectric

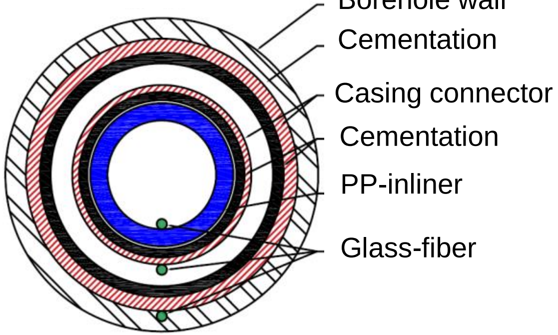


Borehole geophysics

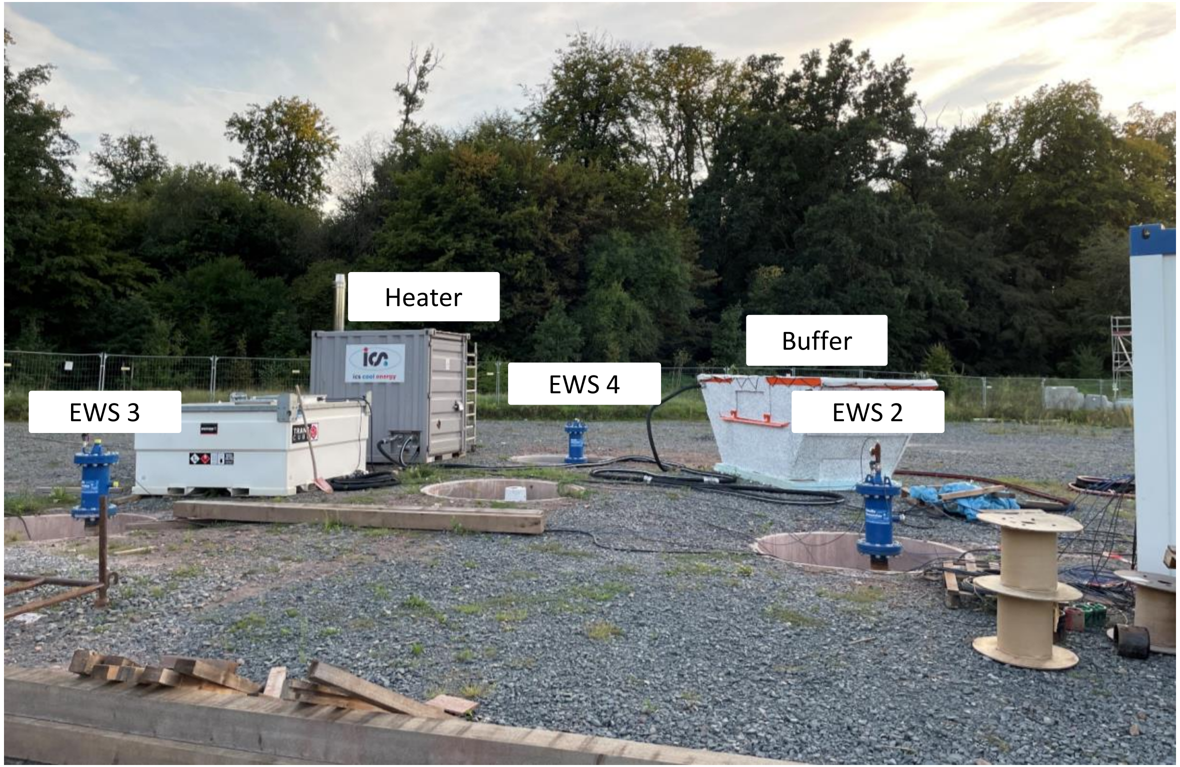
Storage layout

- **Three coaxial borehole heat exchangers**
- **Each 750 m depth**
- **9“ drilling diameter at TVD**
- **7“ Steel Casing**
- **5.5“ Central Liner pipe with PP-inliner for thermal insulation**
- **Three groundwater monitoring wells**

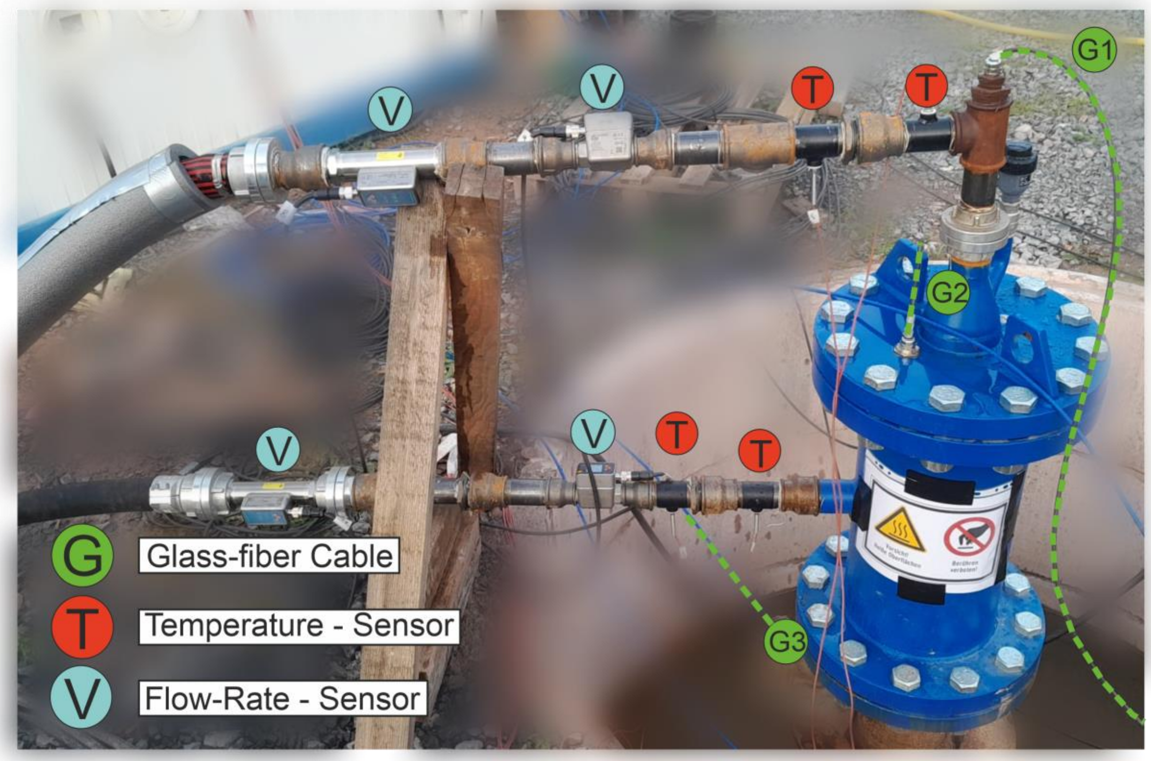




On site



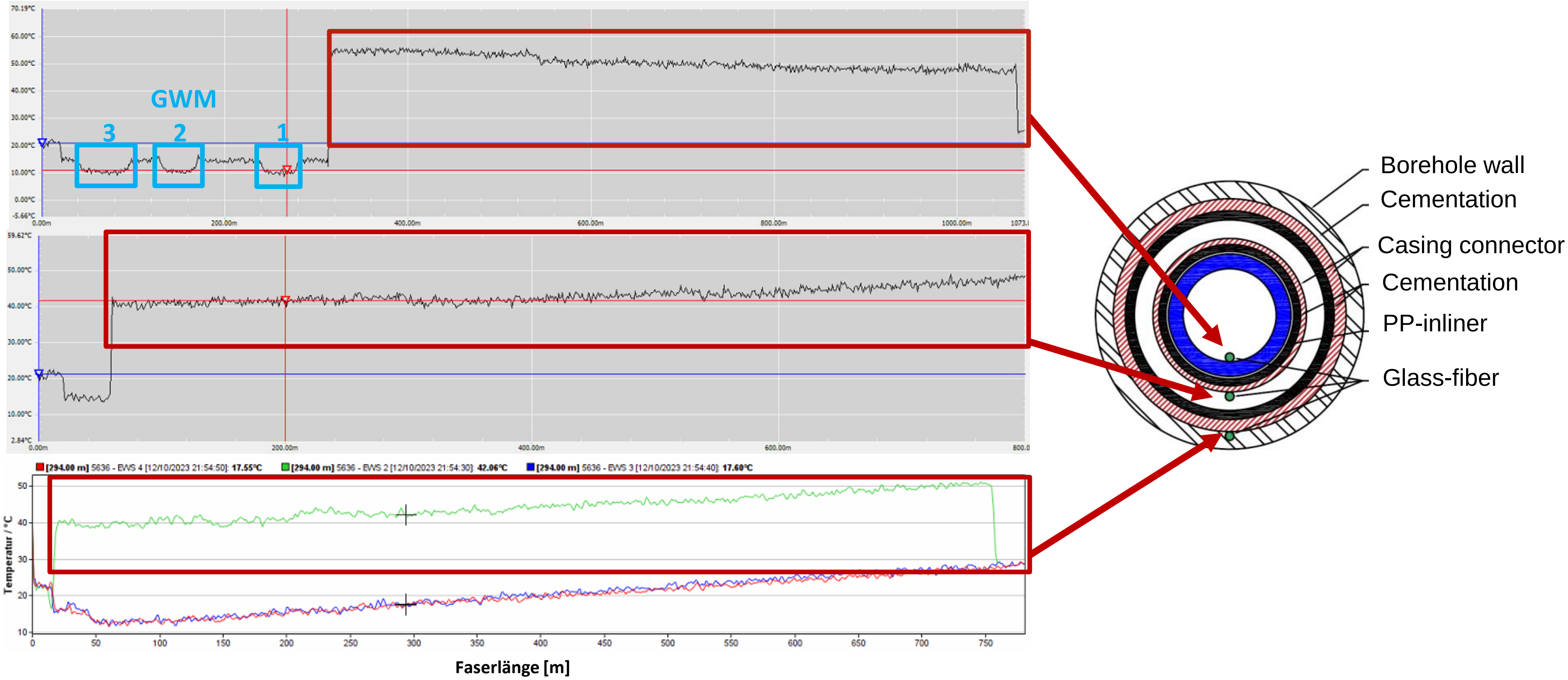
Flow and temperature monitoring



Flow-sensor

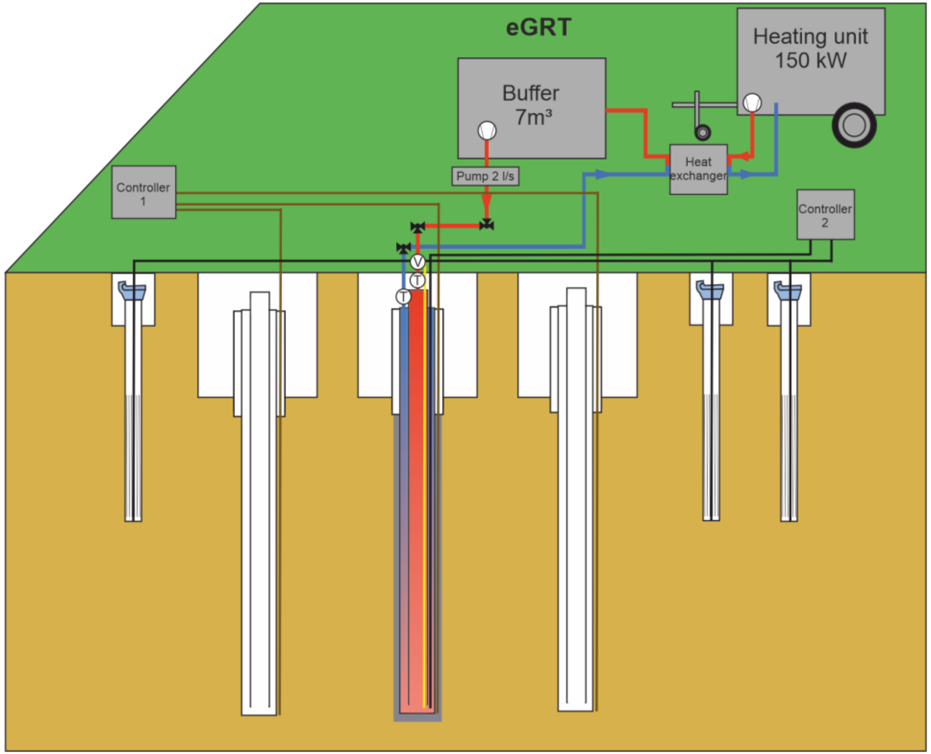
Temperature-sensor

First results– Start GRT 05.10.23 in BHE 2

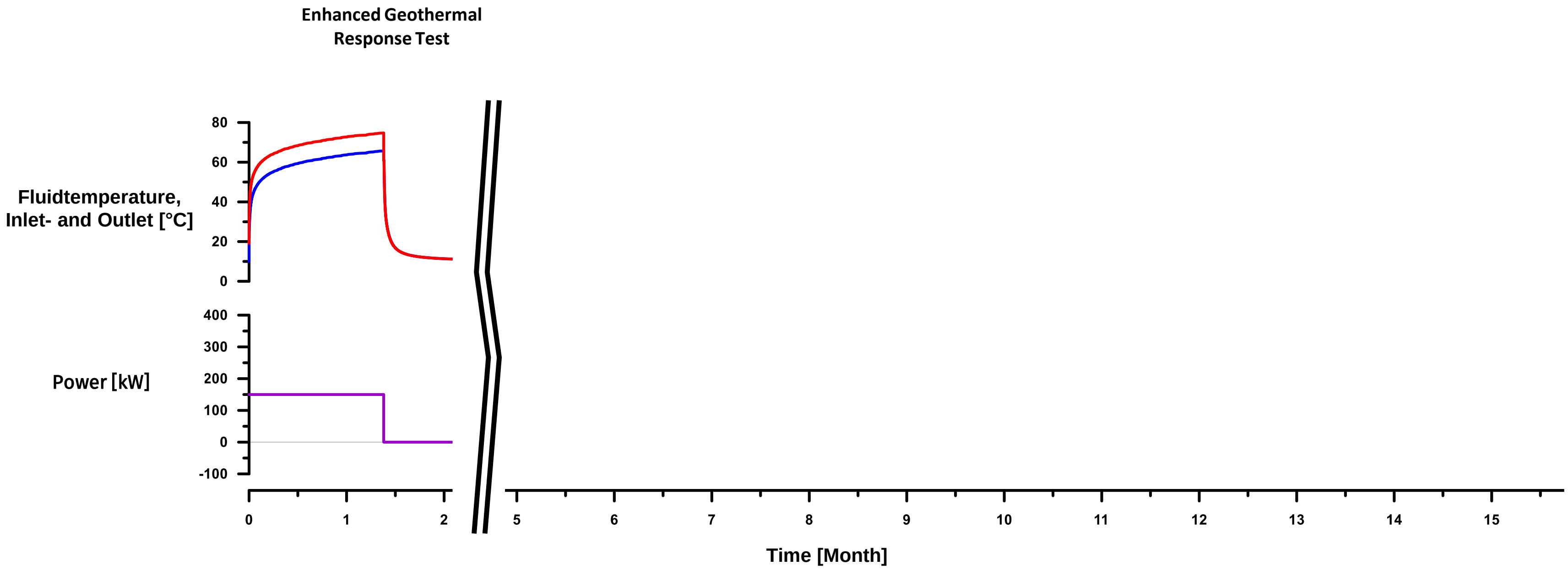


Geothermal Response Test: Sep - Nov 2023

- **Depth-resolved determination of the thermal properties of the borehole and the rock formation**
- **Defined heating of a borehole heat exchanger with heating units**
- **Temperature monitoring with fiber optic cables and temperature sensors**
- **Flow measurement at the well head**

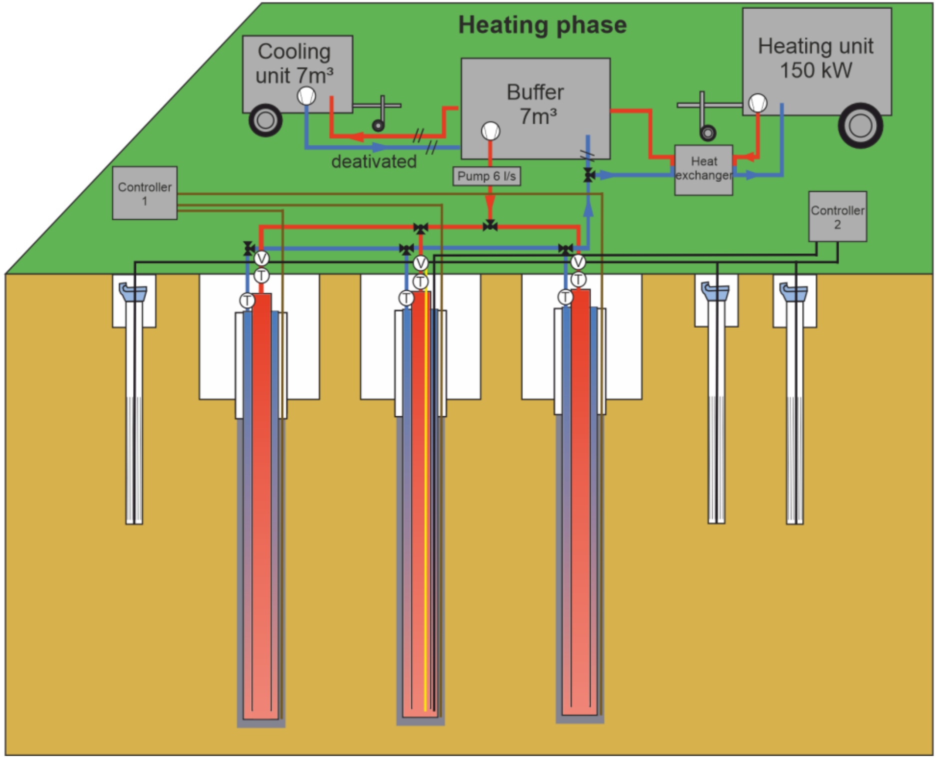


Concept dGRT

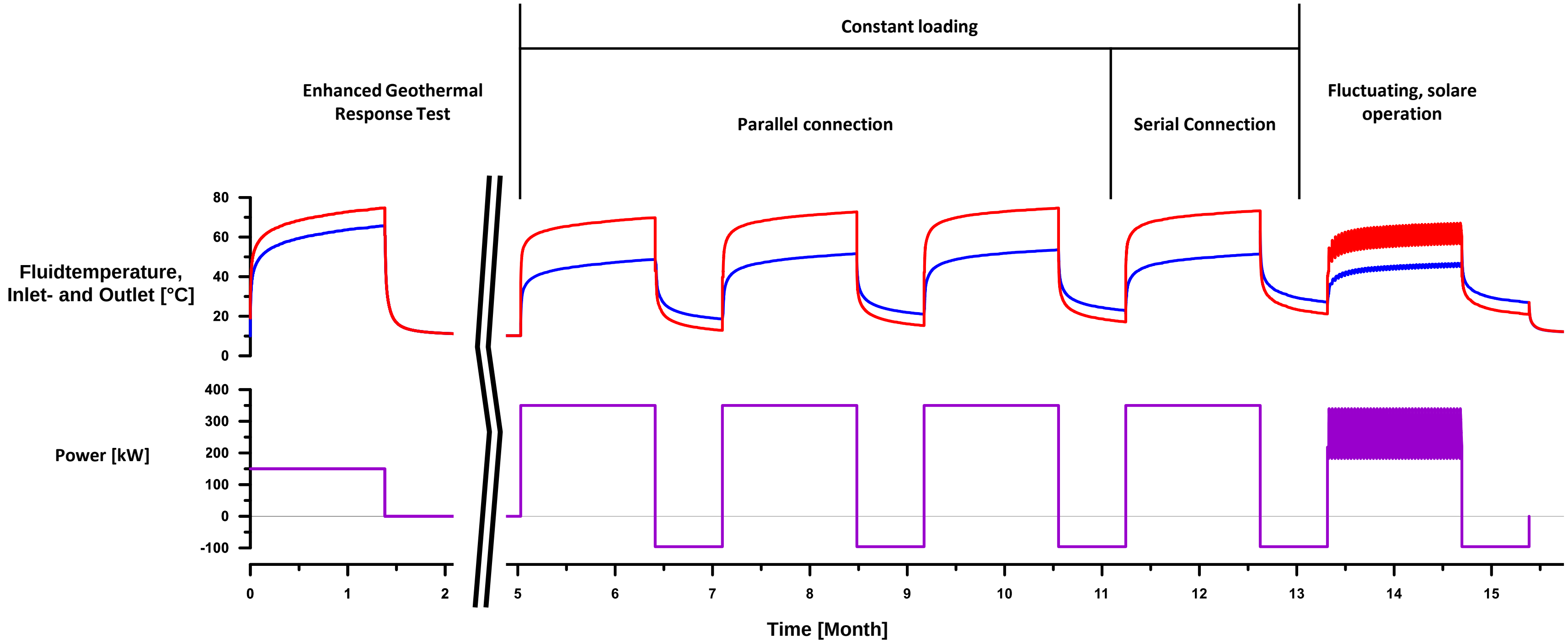


Testphase – Start December / January

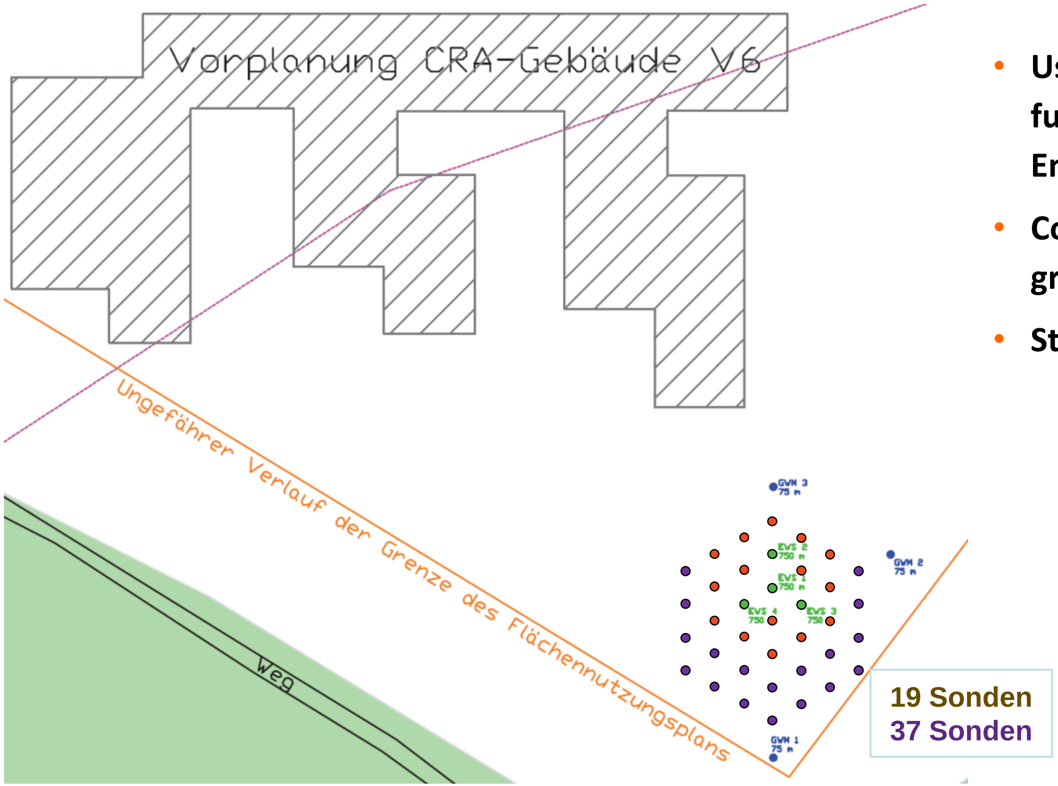
- Defined heating of a borehole heat exchanger with heating units
- Temperature monitoring with fiber optic cables and temperature sensors
- Flow measurement at the well head



Testphase


Constant loading
Enhanced Geothermal Response Test
Parallel connection
Serial Connection
Fluctuating, solare operation
Fluidtemperature, Inlet- and Outlet [°C]
80
60
40
20
0
Power [kW]
400
300
200
100
0
-100
0
1
2
5
6
7
8
9
10
11
12
13
14
15
Time [Month]

System development after SKEWS



- Usage as demonstrator for further experiments (Push-It, Eneff-Campus)
- Connection to district heating grid
- Storage extension

Thank you for your attention!

Funders of studies about MD-BTES

HESSEN Hessisches Ministerium für Wirtschaft, Energie, Verkehr und Landesentwicklung

Graduate School of Energy Science and Engineering

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

FKZ: 03EE4030A

FORUM INTERDISZIPLINÄRE FORSCHUNG

Interreg North-West Europe DGE-ROLLOUT

Upcoming development of the SKEWS site is funded by EU Horizon project:

PUSH IT

Literature originating from SKEWS and pre-runner research

- Welsch B (2019): Technical, Economical and Environmental Assessment of Medium Deep Borehole Thermal Energy Storage Systems. Dissertation, TU Darmstadt
- Welsch B, Rühaak W, Schulte DO, Bär K and Sass I (2016): Characteristics of medium deep borehole thermal energy storage, International Journal of Energy Research, v. 40, no. 13, 1855–1868, doi:10.1002/er.3570.
- Welsch B, Göllner-Völker L, Schulte DO, Bär K, Sass I and Schebek L (2018): Environmental and Economic Assessment of Borehole Thermal Energy Storage in District Heating Systems, Applied Energy, v. 216, p. 73–90, doi:10.1016/j.apenergy.2018.02.011.
- Seib L, Welsch B, Bossennec C, Frey M, Sass I. Finite element simulation of permeable fault influence on a medium deep borehole thermal energy storage system. Geotherm Energy 2022; 10(1).
- Seib L., Frey M., Bossennec C., Krusemark M., Burschil T., Buness H., Weydt L., Sass, I. (2024): Assessment of a medium-deep borehole thermal energy storage site in the crystalline basement: a case study of the demo site Lichtwiese Campus, Darmstadt. Geothermics, 119
- Sass, I., Krusemark M., Seib L., Bossennec C., Pham T. H., Schedel M., Weydt L., Buness H., Homuth B. (2024): Medium-Deep Borehole Thermal Energy Storage (MD-BTES): from Exploration to District-Heating Grid Connection, Insights from SKEWS and PUSH-IT Projects. Stanford Geothermal Workshop, 12.-14.02.2024, Stanford, USA
- Krusemark M., Seib L., Ohagen M., Welsch B., Sass I. (in prep.): Influence of bore path deviations on the efficiency of a medium-depth geothermal storage system.