Fraunhofer Institution for Energy Infrastructures and Geothermal IEG

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Mine Thermal Energy Storage (MTES)

2nd European Underground Energy Storage Workshop

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Paris, 24th May 2023

Mine Thermal Energy Storage (MTES)

Case studies North Rhine Westphalia

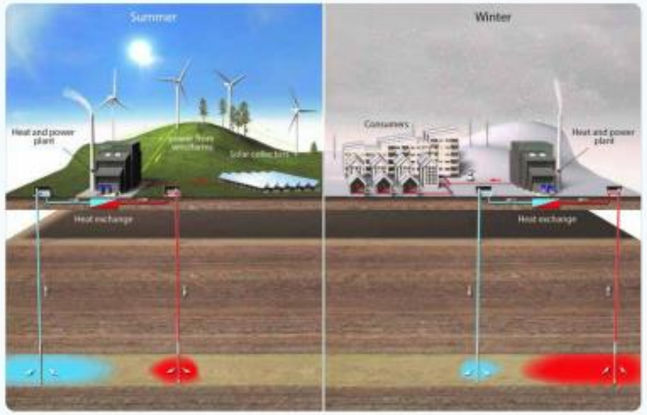
1. HEATSTORE Project Bochum

2. 5G DHC Mine Water Project Mark 51°7 Bochum

3. Outlook Mine Water Potential in NRW

Mine Thermal Energy Storage (MTES)

HEATSTORE Project Bochum

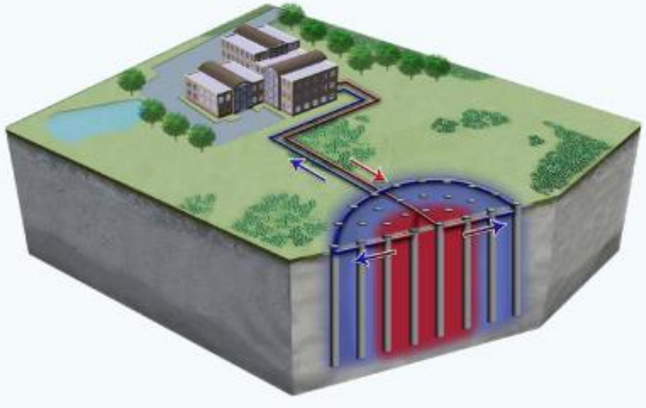


Aquifer Thermal Energy Storage

ATES can take place by injection and later re-production of hot water in aquifers in both shallow and deep geological formations. The aquifers can be both unconsolidated sand units, porous rocks like sandstones or limestone or fractured rock formations. It is an open system using geothermal or water wells and storing the heat in the groundwater and in the formation around it.

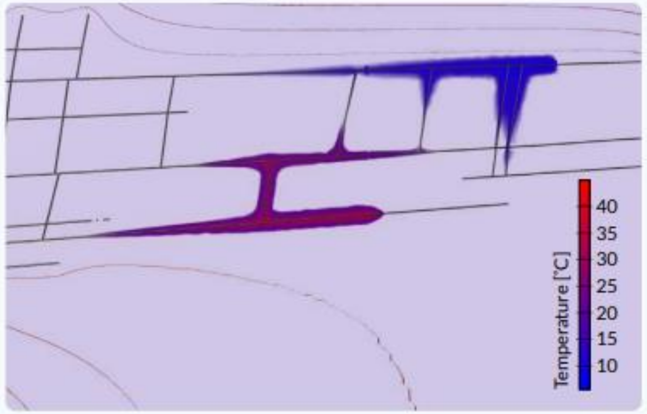
Pit Thermal Energy Storage

Hot water is stored in very large (multiple) excavated basins with an insulated lid. Sides and bottom are typically covered by a polymer-liner, but can also be made of concrete.



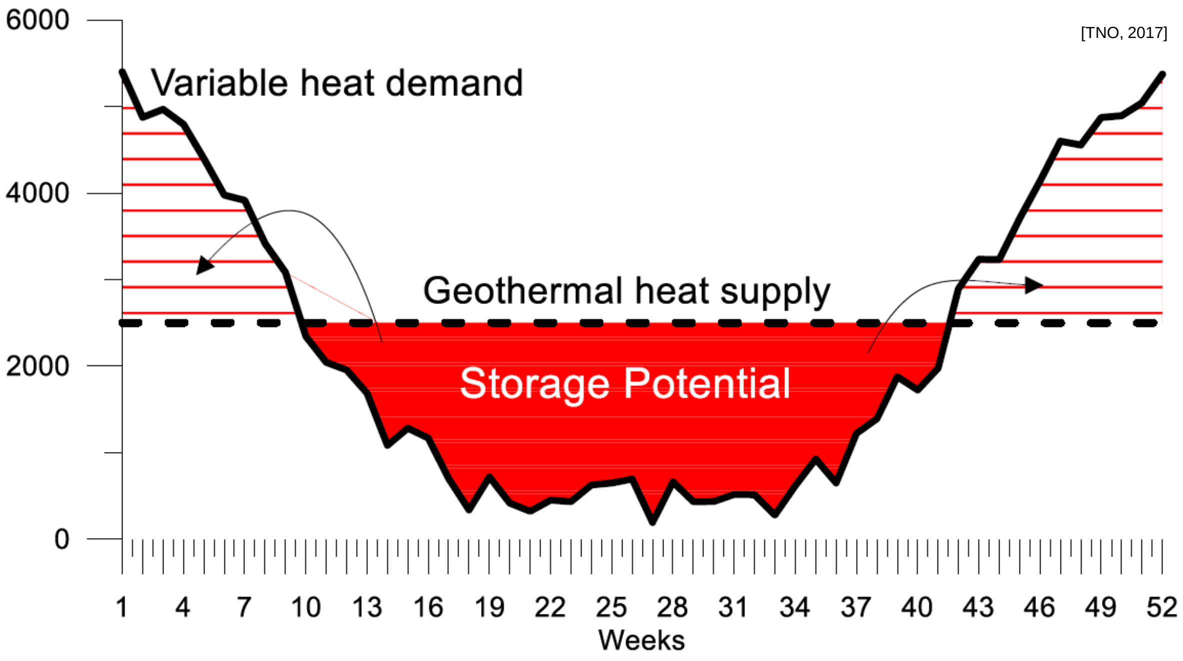
Borehole Thermal Energy Storage

The natural heat capacity in a large volume of underground (unconsolidated) soil or rock is used to store thermal energy with or without groundwater as the storage medium. It typically has several closely spaced boreholes, between 50 and 200 m deep; they act as heat exchangers to the underground, usually in U-pipe form.



Mine Thermal Energy Storage

Mine water of abandoned and flooded mines is used as a storage medium for high temperature storage. The mine water can also be used as an ambient energy source in combination with heat pumps.



How are we going to meet the heating demand with a distinct seasonal profile without fossil fuels but with the same security of supply?

HEATSTORE

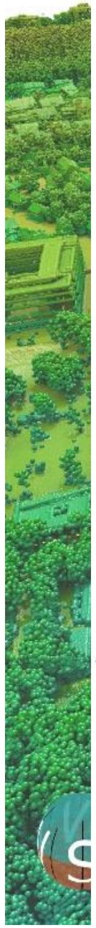
IEG Colliery

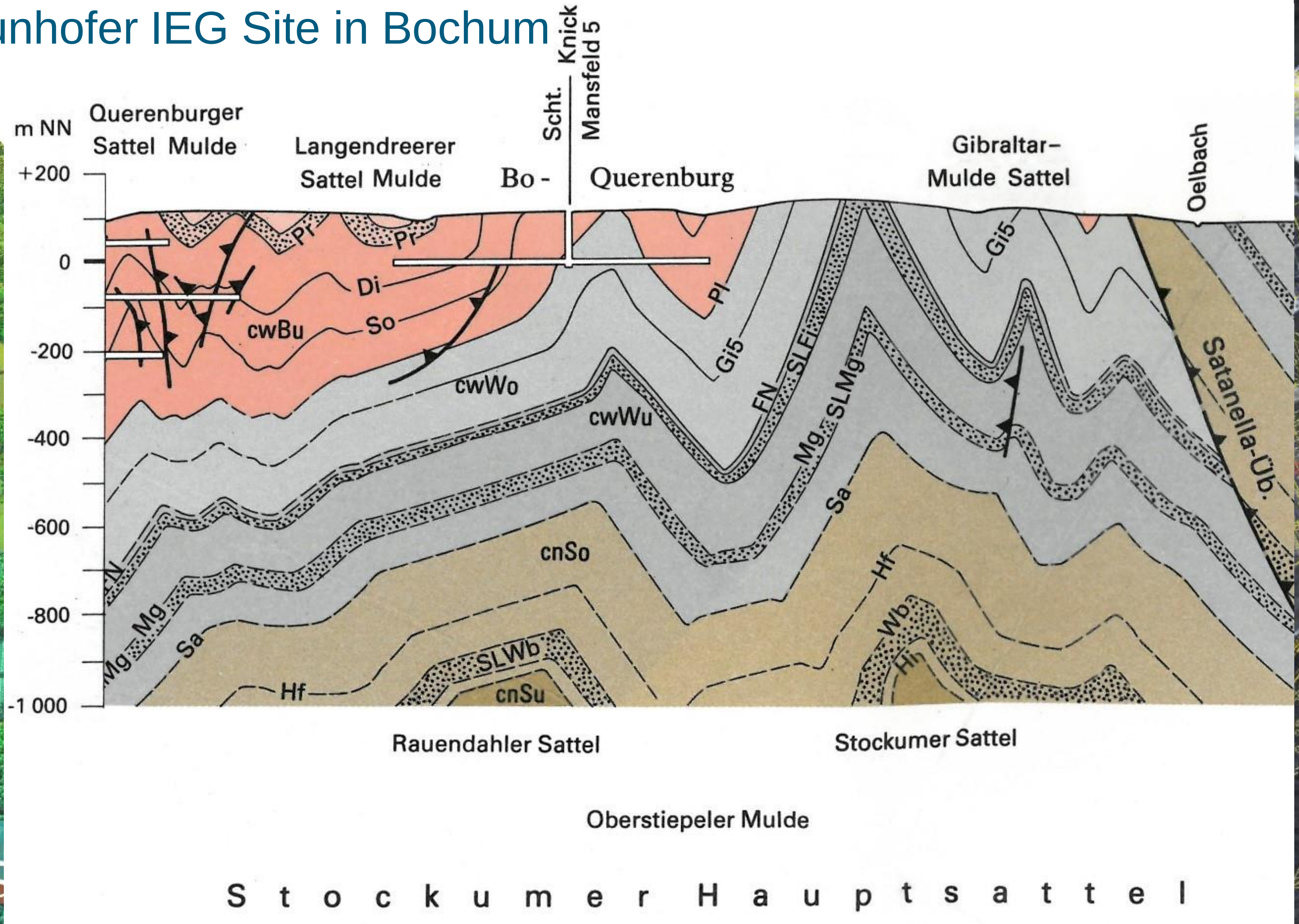
Former main shaft (1954)

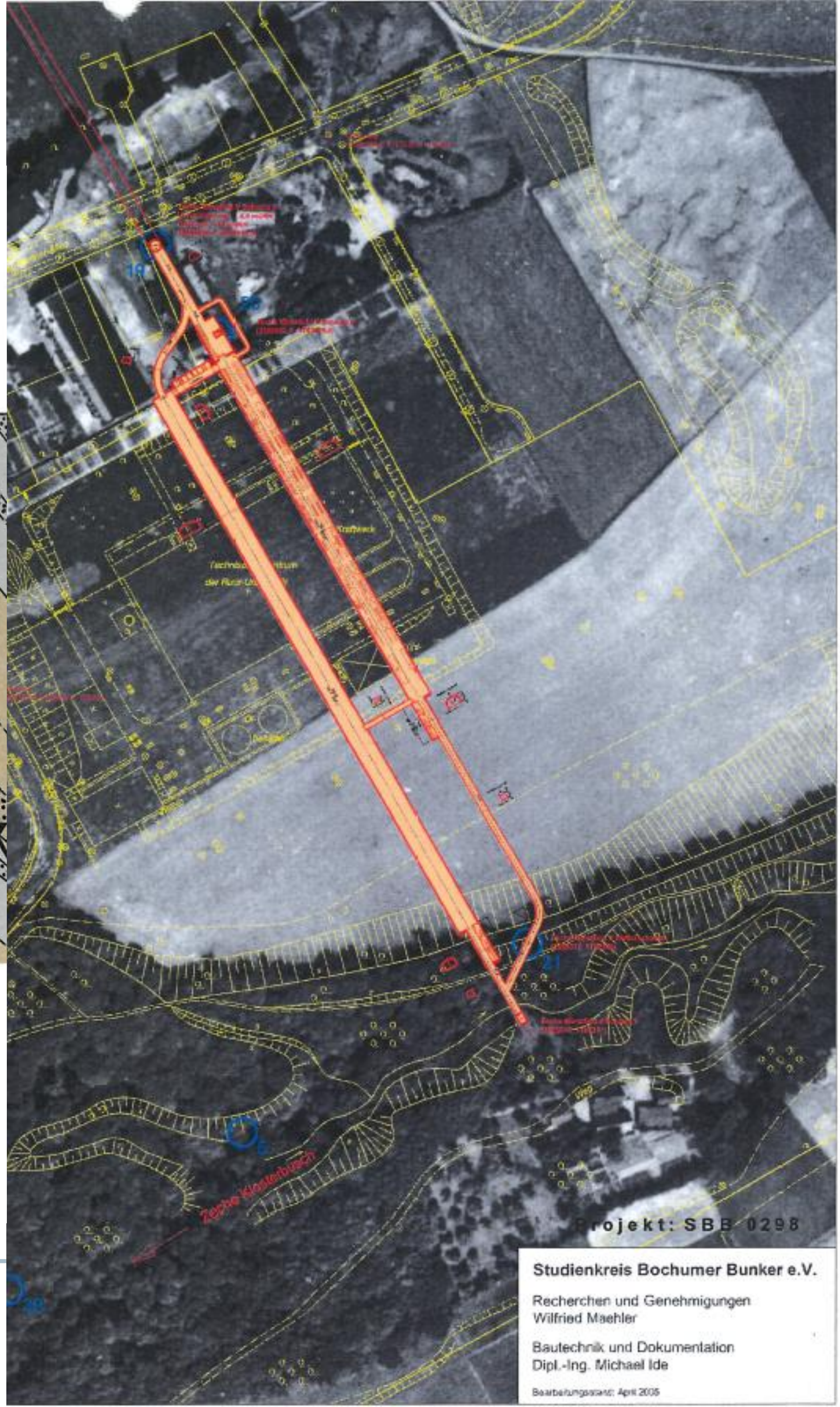
Nightingale visitation colliery in Witten, Germany (wooden beam construction)

HEATSTORE

Fraunhofer IEG Site in Bochum

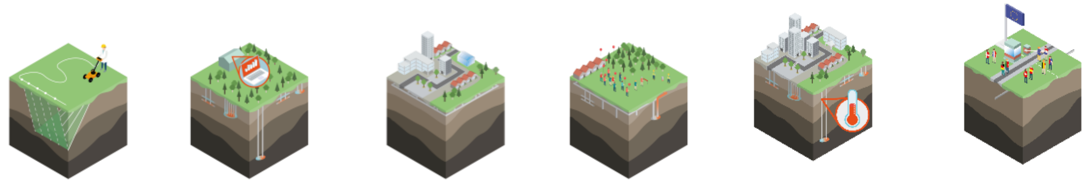




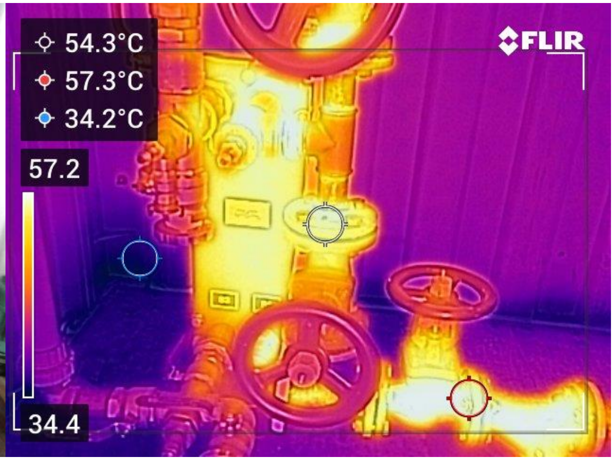


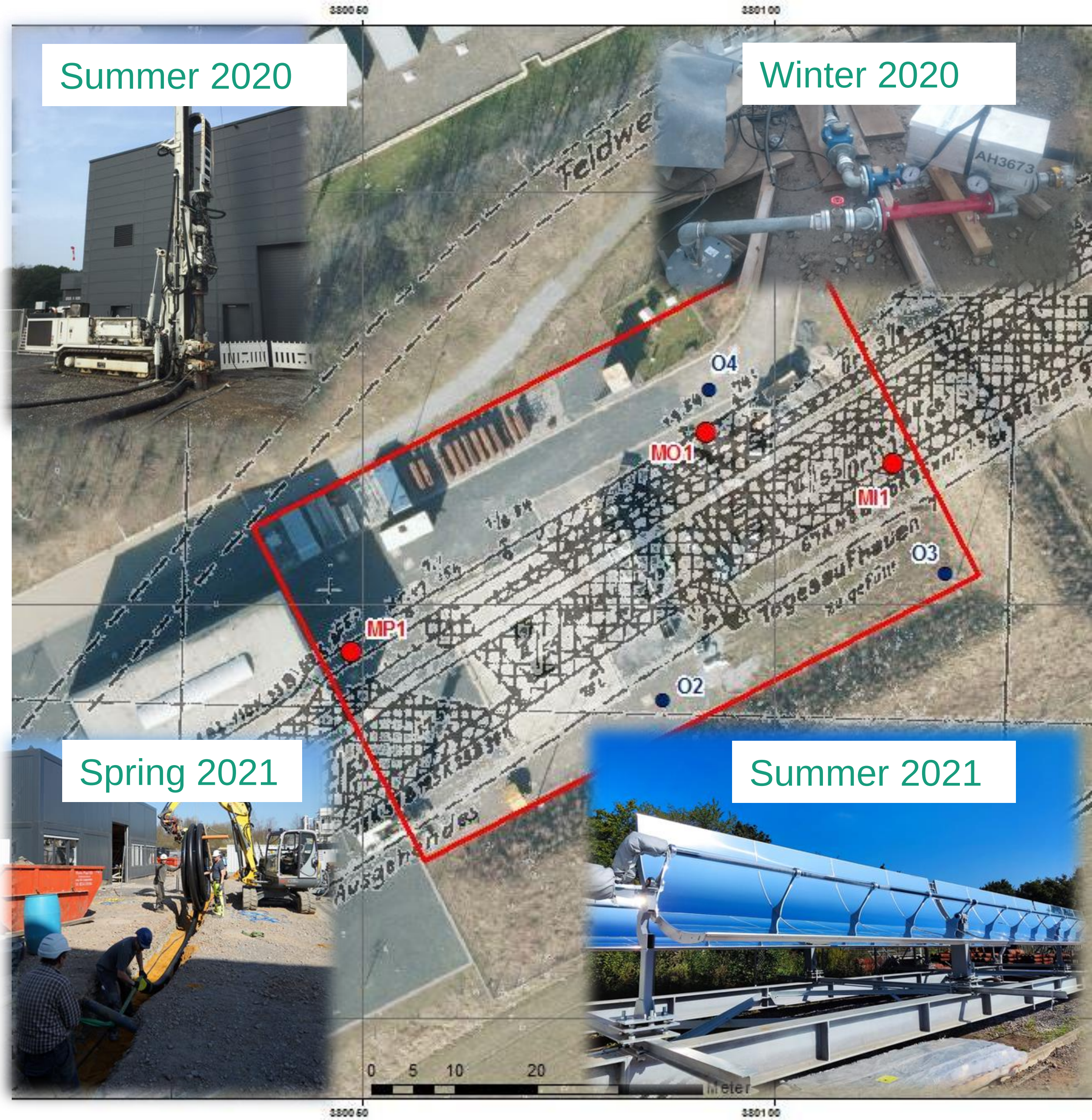
HEATSTORE

Work packages



WP1: Legal Framework and pre-feasabilty	WP2: Numerical Modeling of the subsurface	WP3: Integration of a Power Plant with surplus heat	WP4: Establishment of Underground Storage	WP5: Proof of Concept	WP6: Market Uptake and Dissemination

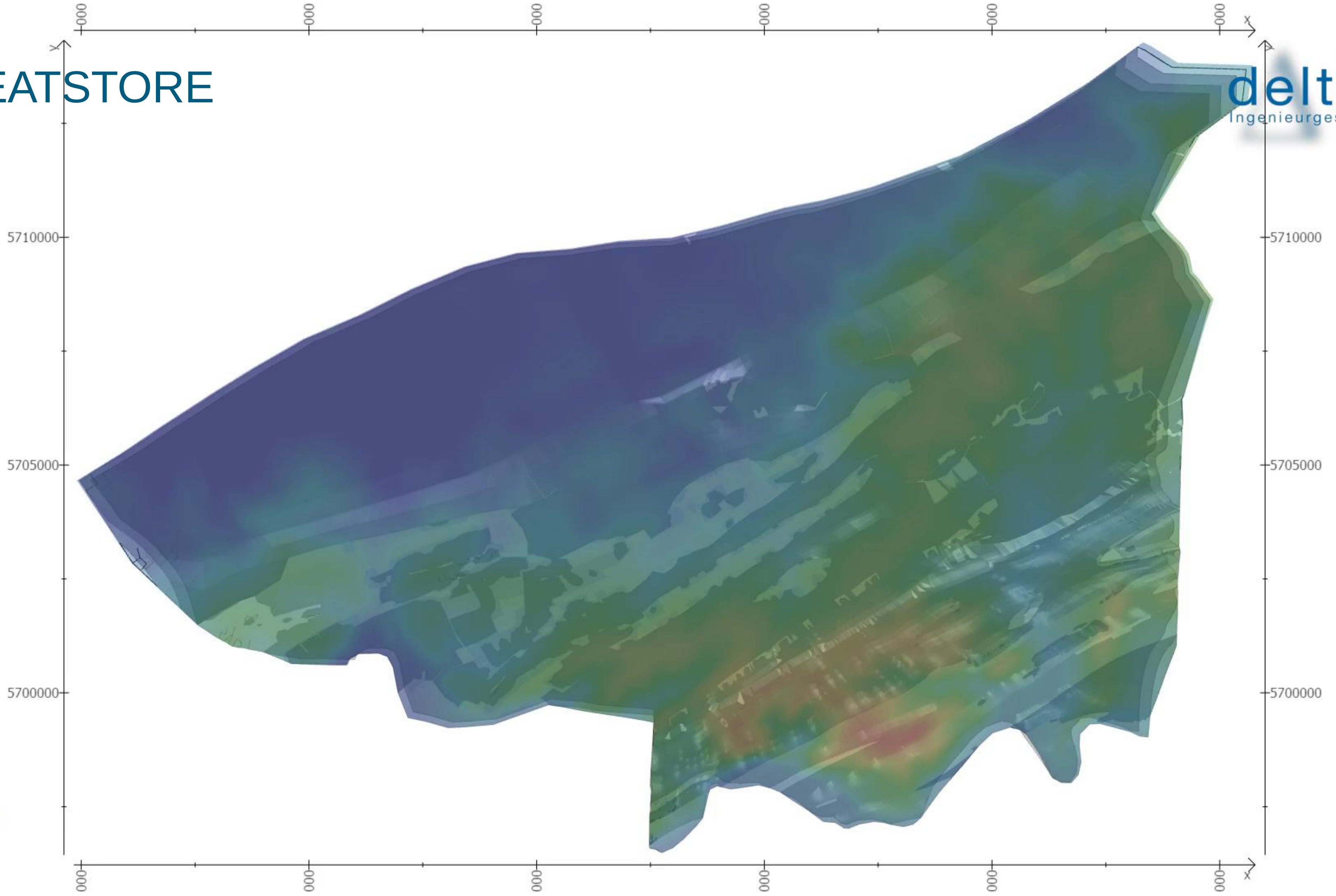




HEATSTORE

Bochum Research and Drilling Rig (BoReX)

HEATSTORE



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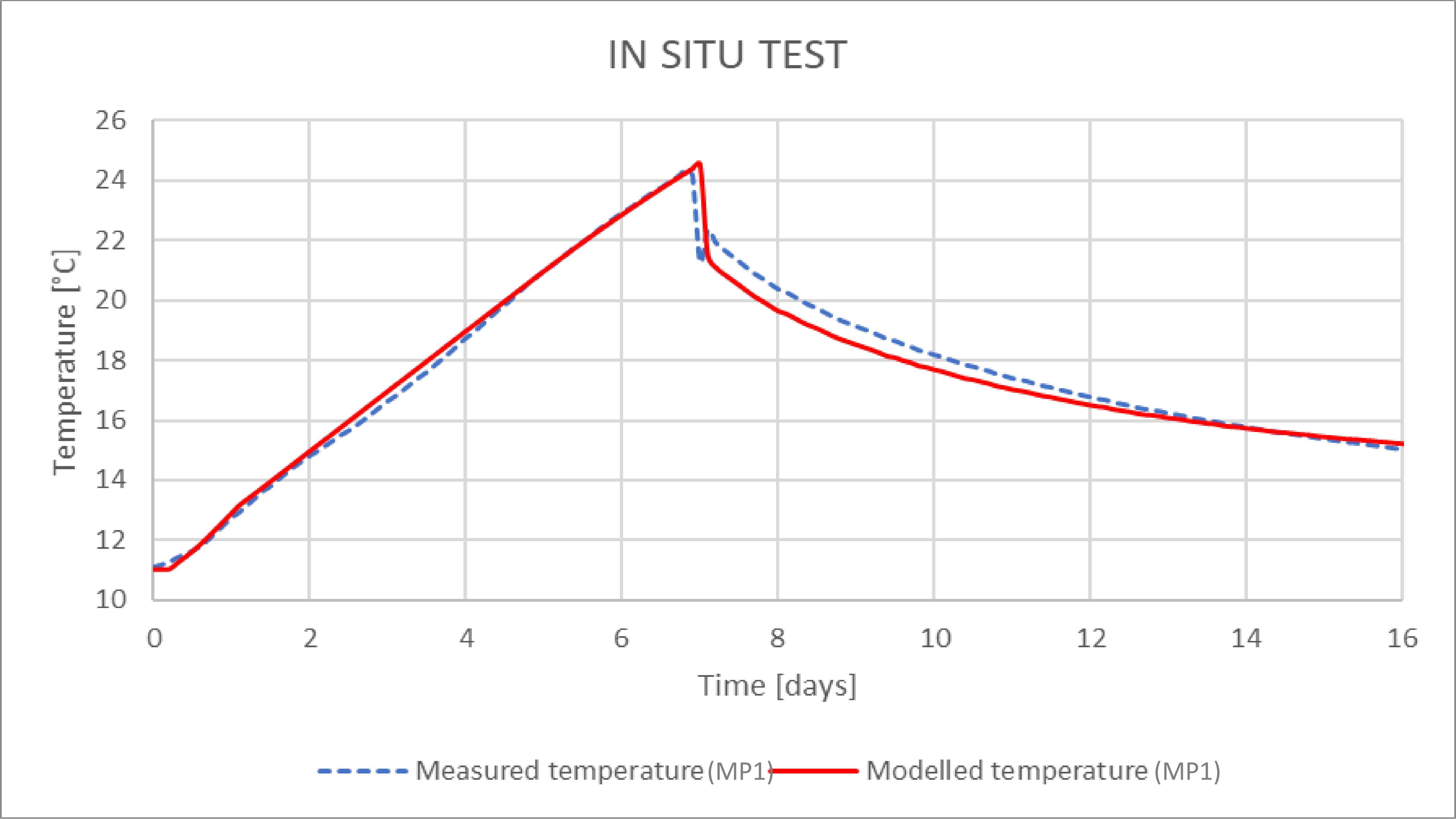
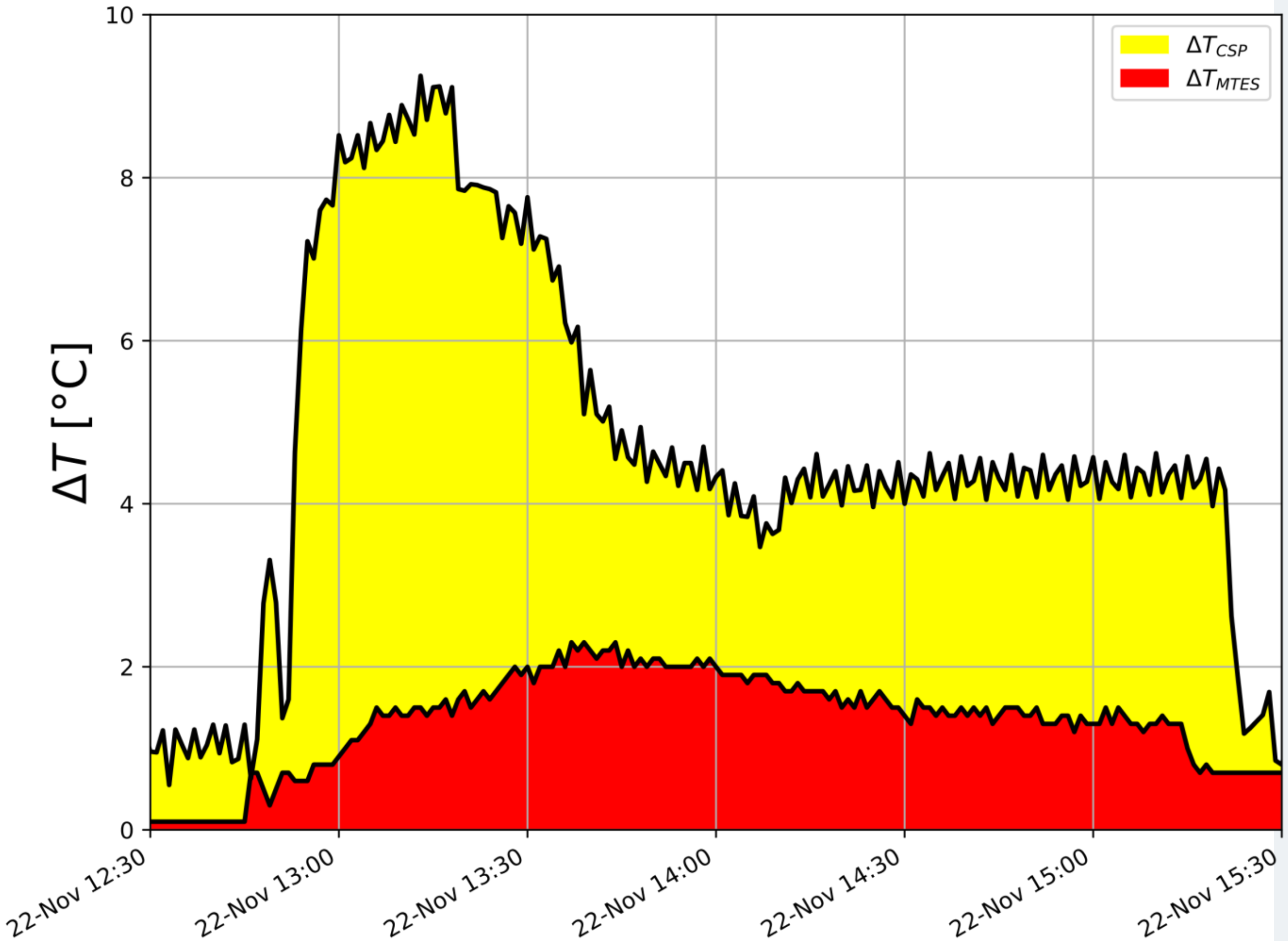
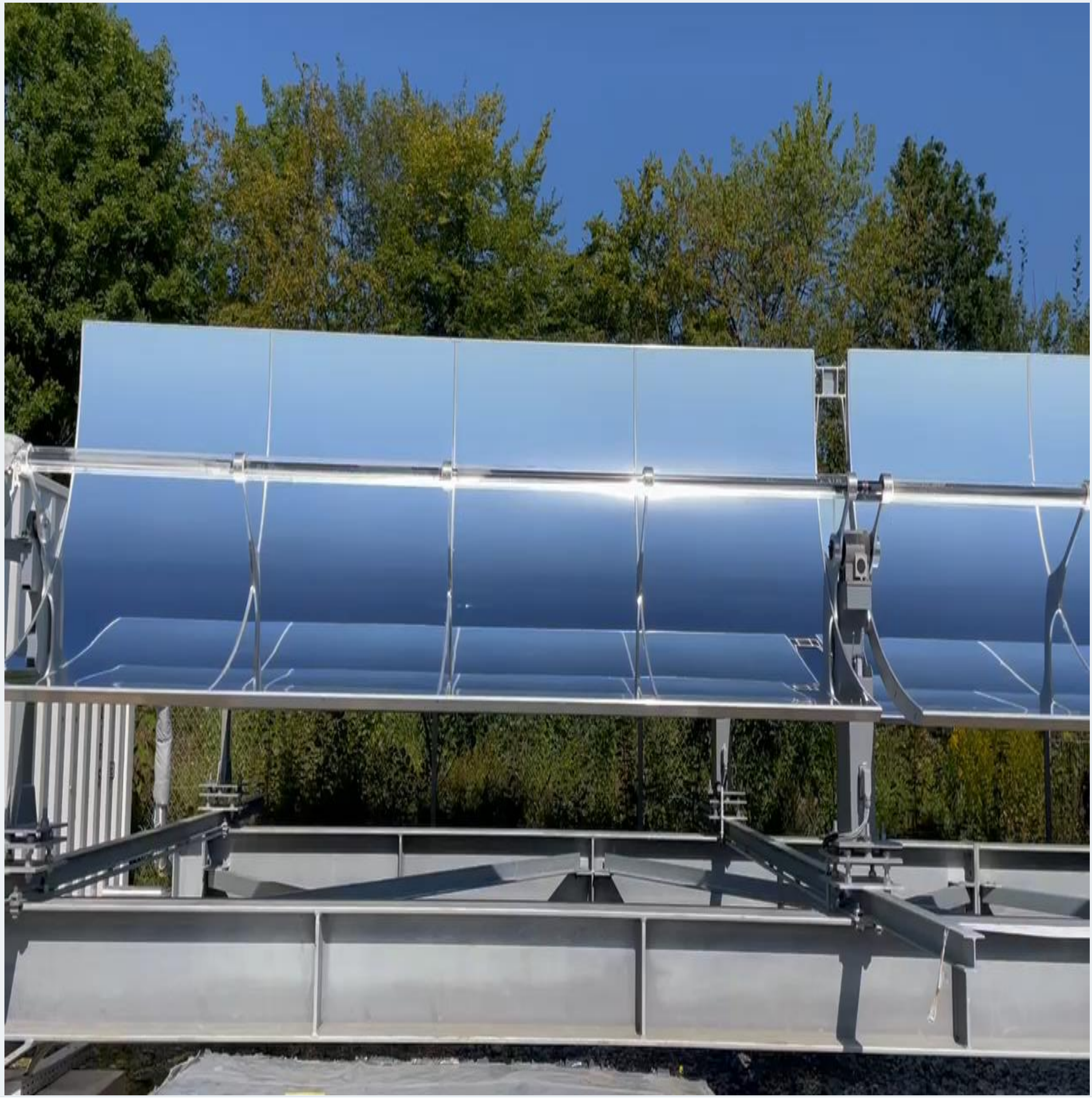

IN SITU TEST
Temperature [°C]
26
24
22
20
18
16
14
12
10
0
2
4
6
8
10
12
14
16
Time [days]
Measured temperature (MP1)
Modelled temperature (MP1)

HEATSTORE

Proof of Concept





HEATSTORE

Lessons Learned

Partners:
delta h

Duration:
2018 – 2021

Goal:
Development of a Mine Thermal Energy Storage (MTES) Pilot Plant for the energetic reuse of an abandoned colliery

1. Production well(s) need to be drilled into non-backfilled fully flooded parts, in order to achieve high flow rates.
2. Temperature of the surface heat-source has to be minimum 10-15 °C higher than the desired downhole heat injection temperatures for depths <100 m.
3. Prevention of intake of oxygen into the mine water system is a key for a durable operation of the storage system. Otherwise a rapid precipitation of iron minerals (i.e. ferrihydrite) may occur.
4. Shallow well can be drilled vertical without the guidance of a rotary steerable system, but the implementation of heavy drill-collars and (slightly oversized) stabilizers is highly recommended.

Mine Thermal Energy Storage (MTES)

5G DHC Mine Water Project Mark 51°7 Bochum

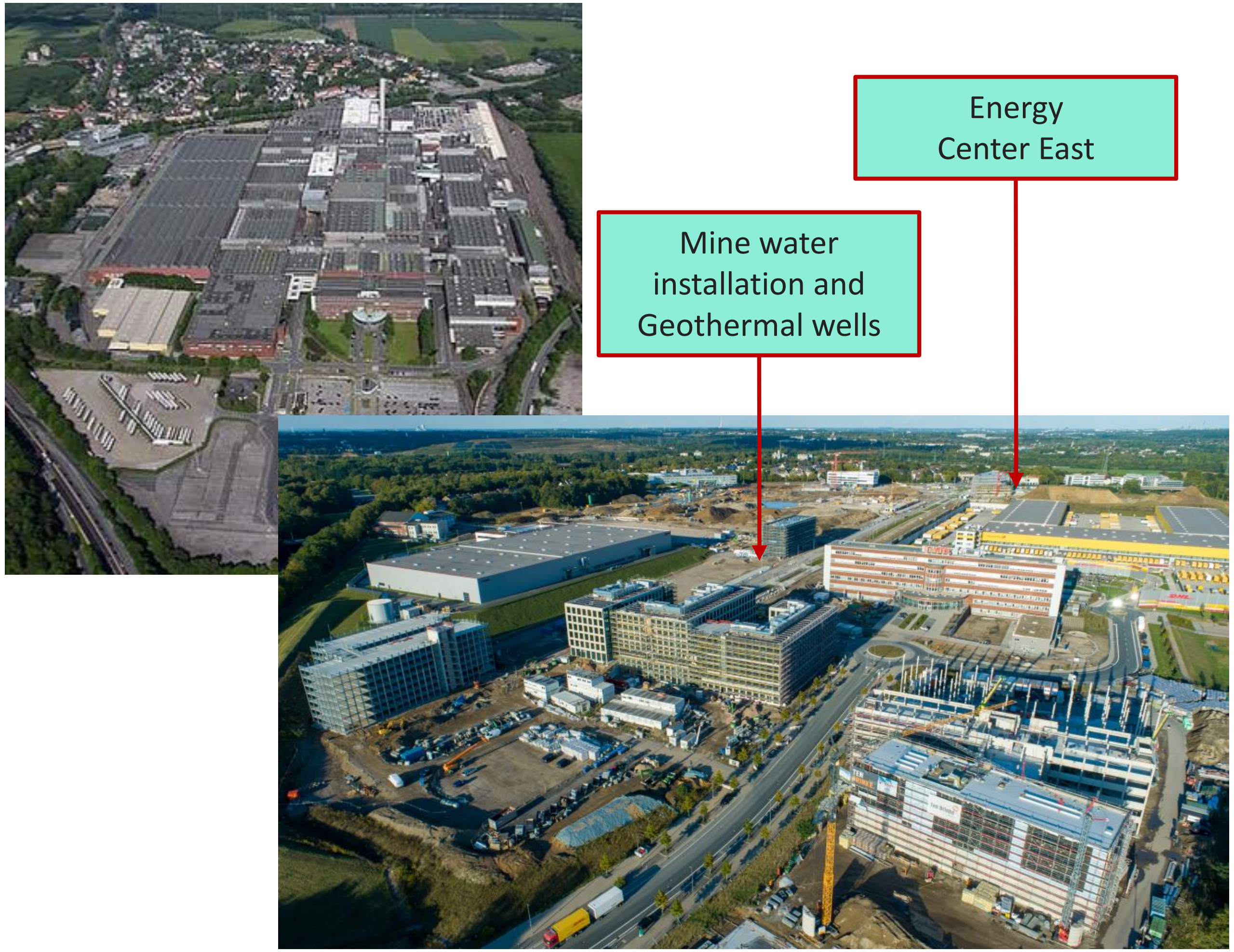
Project Mark 51°7 Bochum

5G DHC with mine water

1. Area
   - 68 ha – Area in Bochum-Laer
   - 1859-1958: Colliery Dannenbaum
   - 1958-2014: Auto production Opel
   - Now: Redevelopment industrial, technology and knowledge campus Mark 51°7
   - Floor area approx. 210,000 m2

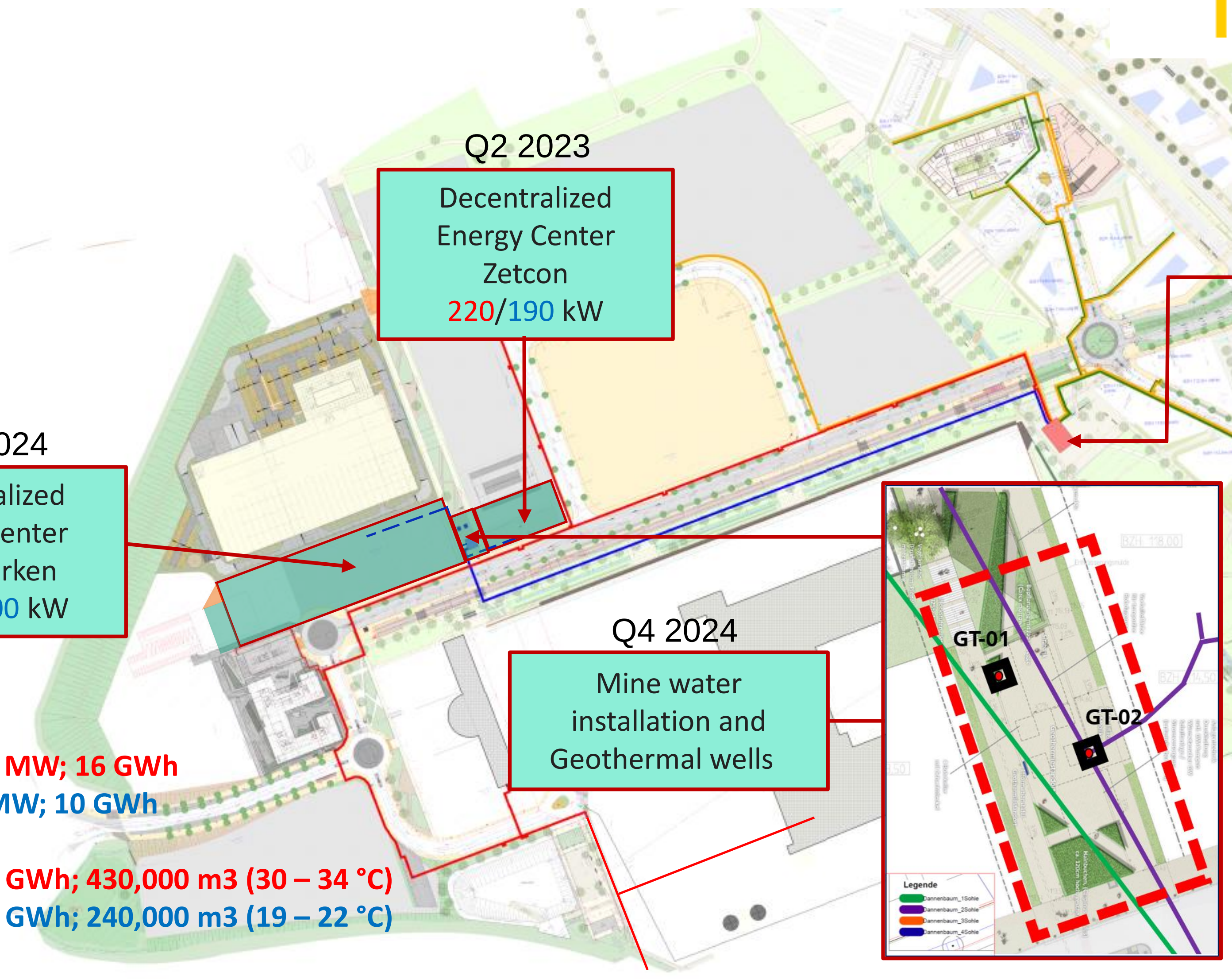
2. 5G DHC
   - National Funding Program Wärmenetzsysteme 4.0
   - 35% of Investment
   - Grids and Energy Center East

3. Minewater
   - Funding Interreg D2Grids
   - 60% of Investment
   - Minewater installation and wells
   - Demonstrator Energy Center of Zetcon



Project Mark 51°7 Bochum

Scope



Q4 2024

Decentralized Energy Center East (LowEx DHC grid)
11,500/8,500 kW

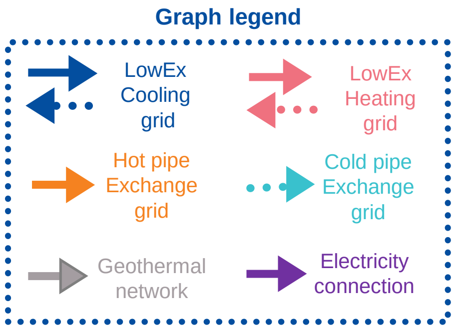
- District heating grid (HT) 90/40°C
- Exchange grid 10/25 – 27/45 °C
- Heating grid (LowEx) 48/33°C
- Cooling grid (LowEx) 10/16 °C

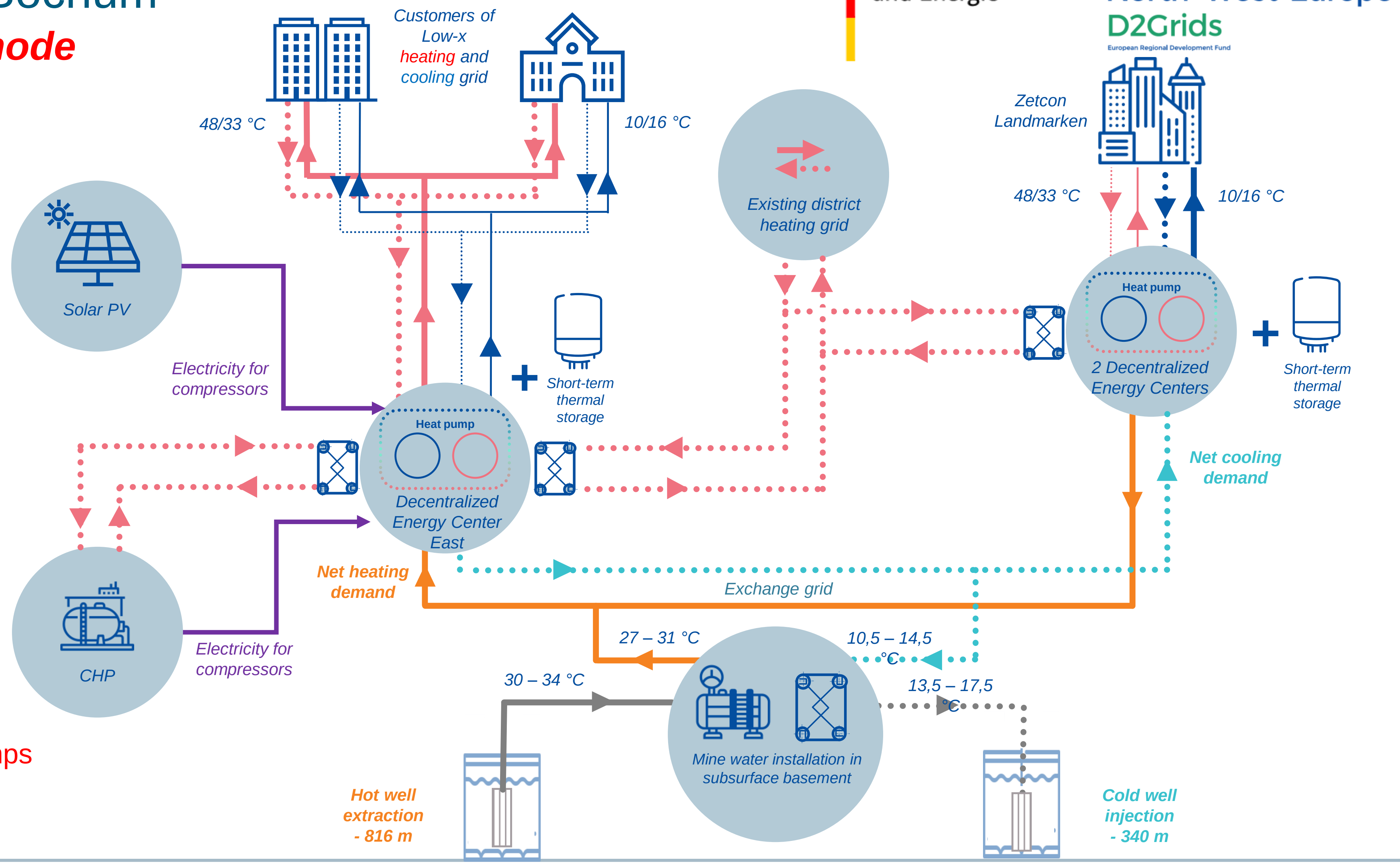
Total heat demand: 12,8 MW; 16 GWh
Total cold demand: 9,6 MW; 10 GWh

Minewater: 2.9 MW; 8.3 GWh; 430,000 m3 (30 – 34 °C)
Minewater: 3.5 MW; 5.6 GWh; 240,000 m3 (19 – 22 °C)

Project Mark 51°7 Bochum

Scheme ***net heating mode***





- 85% heat demand by heat pumps
- 30% during exchange
- 70% by minewater

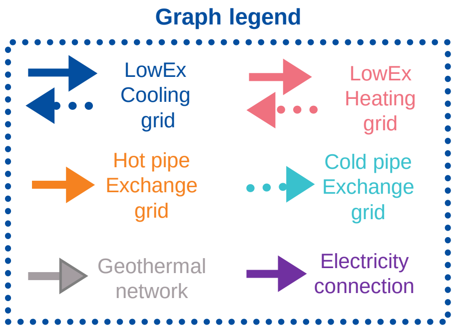
Bundesministerium für Wirtschaft und Energie

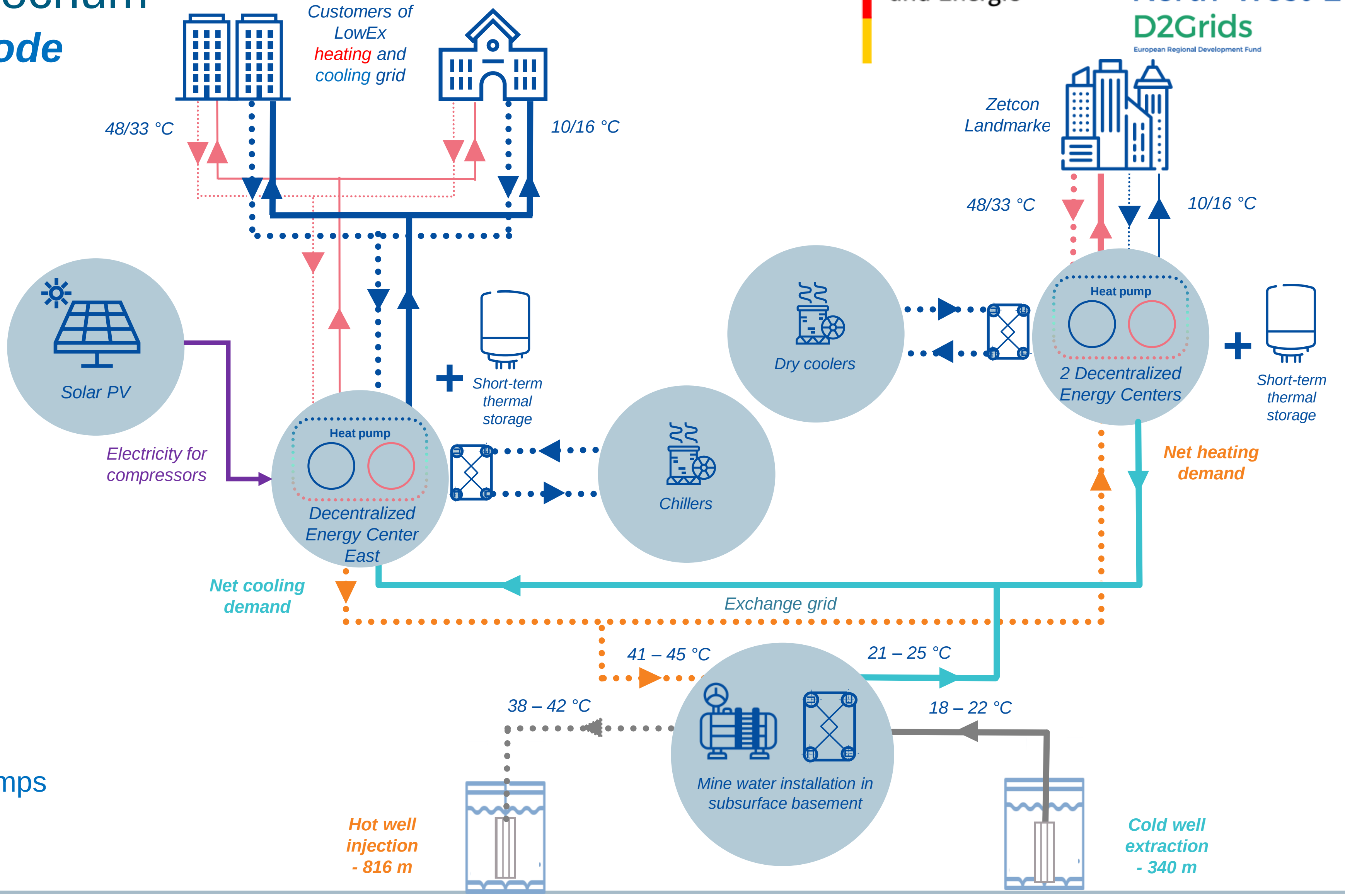
Interreg North-West Europe D2Grids

European Regional Development Fund

Project Mark 51°7 Bochum

Scheme ***net cooling mode***





- 85% of cold demand by heat pumps
- 33% during exchange
- 67% by minewater

GEOTHERMAL DHC Towards Decarbonized Heating and Cooling! FUW Unternehmensgruppe STADTWERKE BOCHUM STADTWERKE BOCHUM Fraunhofer IEG

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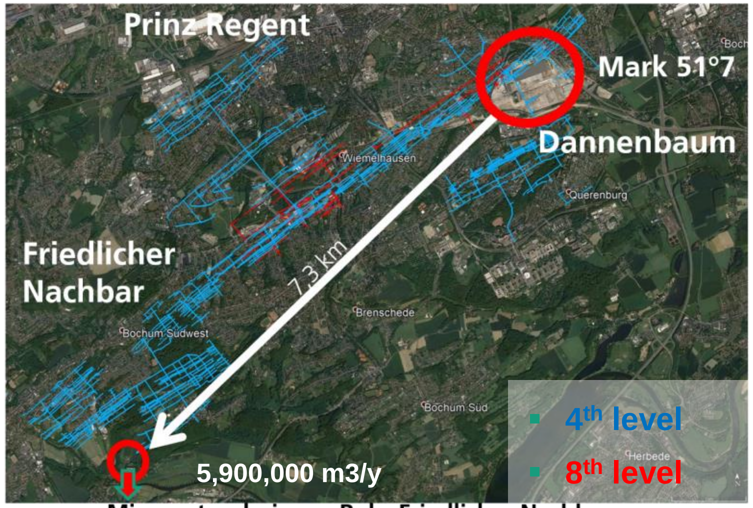
Access mine water use

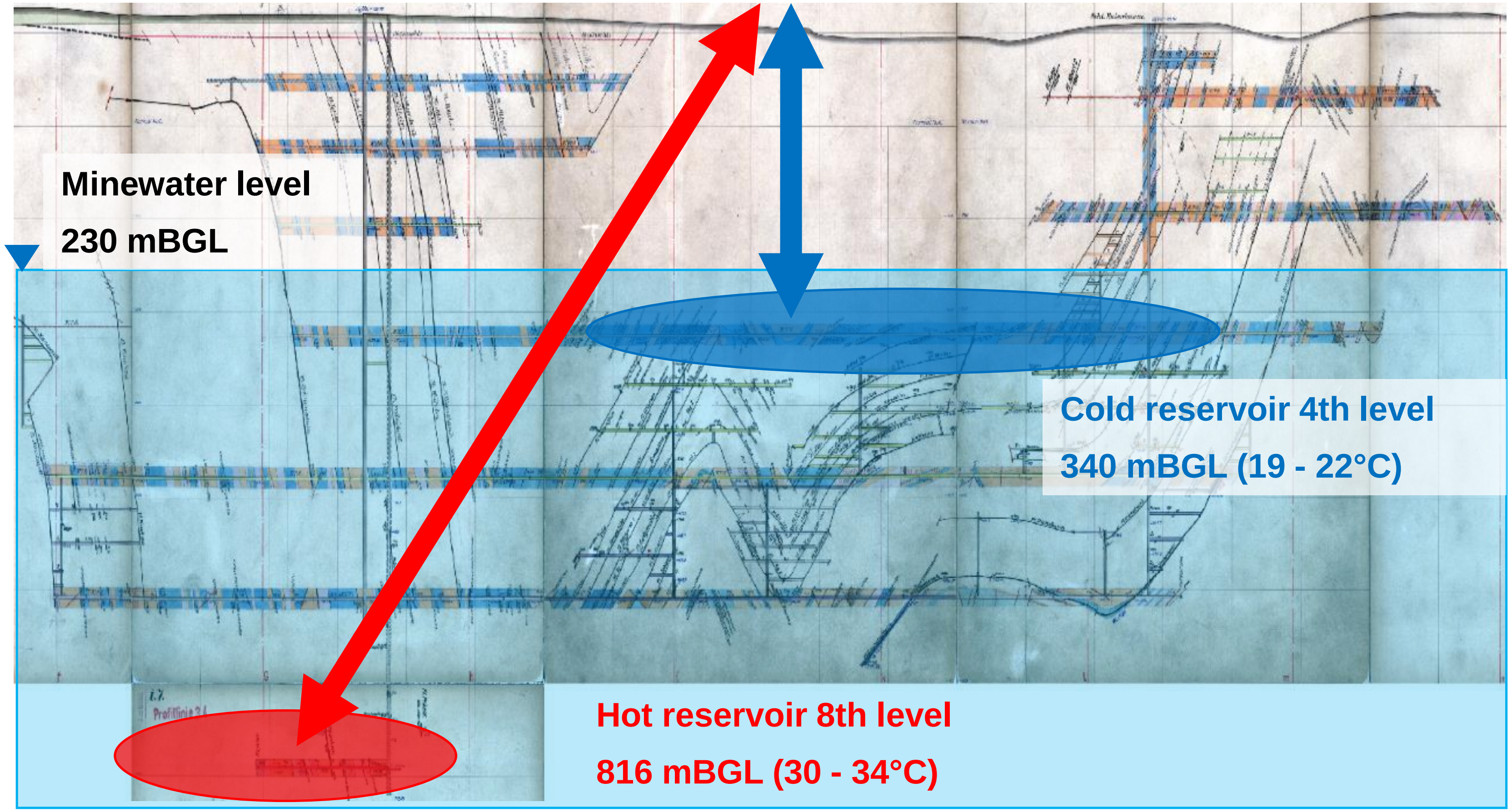
Drilling concept:

- Singular drilling location
- Cold well vertical drilling
- Hot well directional drilling



Minewater drainage Ruhr Friedlicher Nachbar

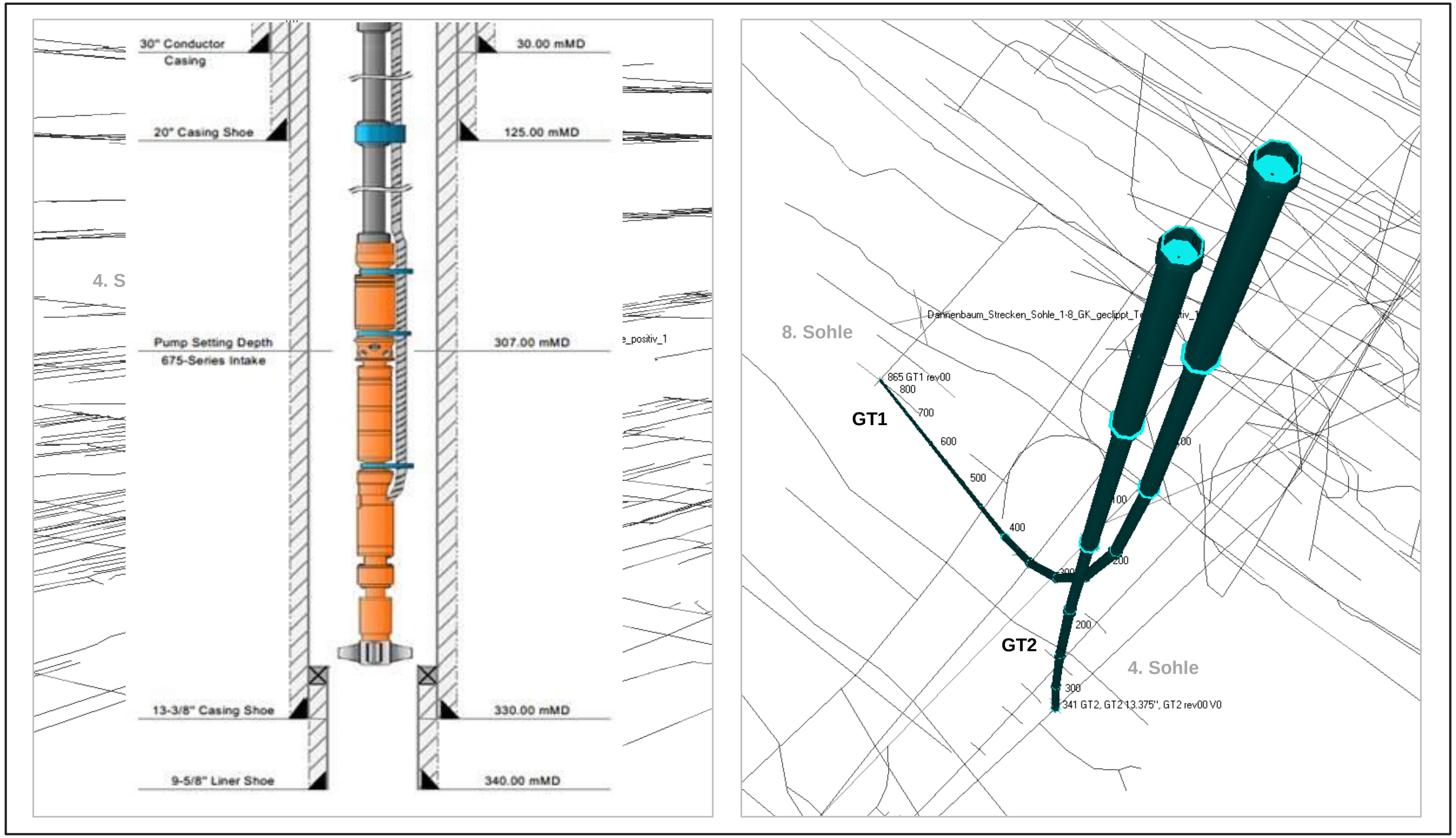
Shafts filled



Project Mark 51°7 Bochum

Borehole and pump

1. Dimensions
   - Production casing 13 3/8“
   - Production liner 9 5/8“
   - Slot liner approx. 10 m before reaching point of attack gallery
   - Inclination GT-01 approx. 20°
   - Pump OD 6,75“ (– 307 mBGL). Overall Dimension 7,29”
   - Length of the pump approx. 17m
   - Injection valve OD 8“
   - Tubing 7“
2. Operation
   - Bidirectional
   - Flowrate +150 m³/h
   - Min. prod. load 30-40 m3/h
   - Start/stop pump max 5/h
   - Pressurized buffer (2 - 8 bar)
   - Injection valve N_2-driven



Bundesministerium für Wirtschaft und Energie

Interreg North-West Europe D2Grids
European Regional Development Fund

Project Mark 51°7 Bochum

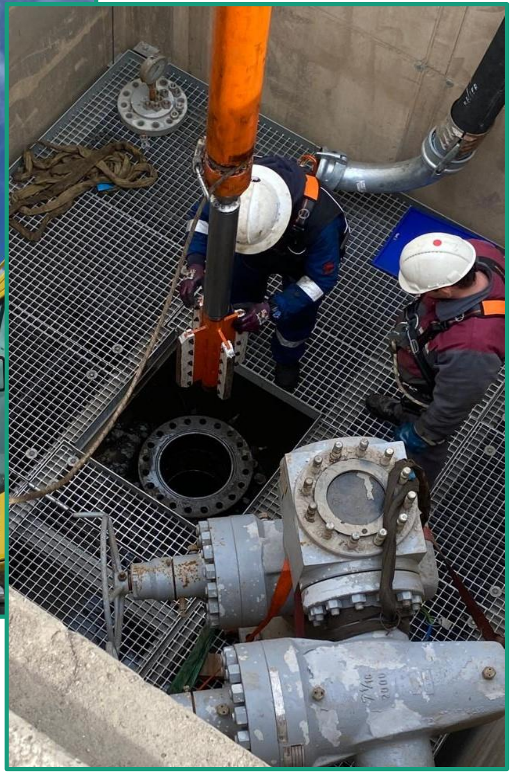
Current status and next steps

1. Geothermal wells
   - The first drilling (GT-02) was completed on 28.01.2022
   - The second drilling (GT-01) was completed on 09.03.2022
   - Pumps tests were executed in March 2023

2. Well-test
   - Approval procedure for the pumping tests were postponed.

Results of long term pump tests (48 hours):

- ***Hydraulic capacity + 150 m3/h***
- ***Low drop & rise of water level during extraction & injection***
- ***Hot mine water 27 °C; Cold mine water 17 °C***



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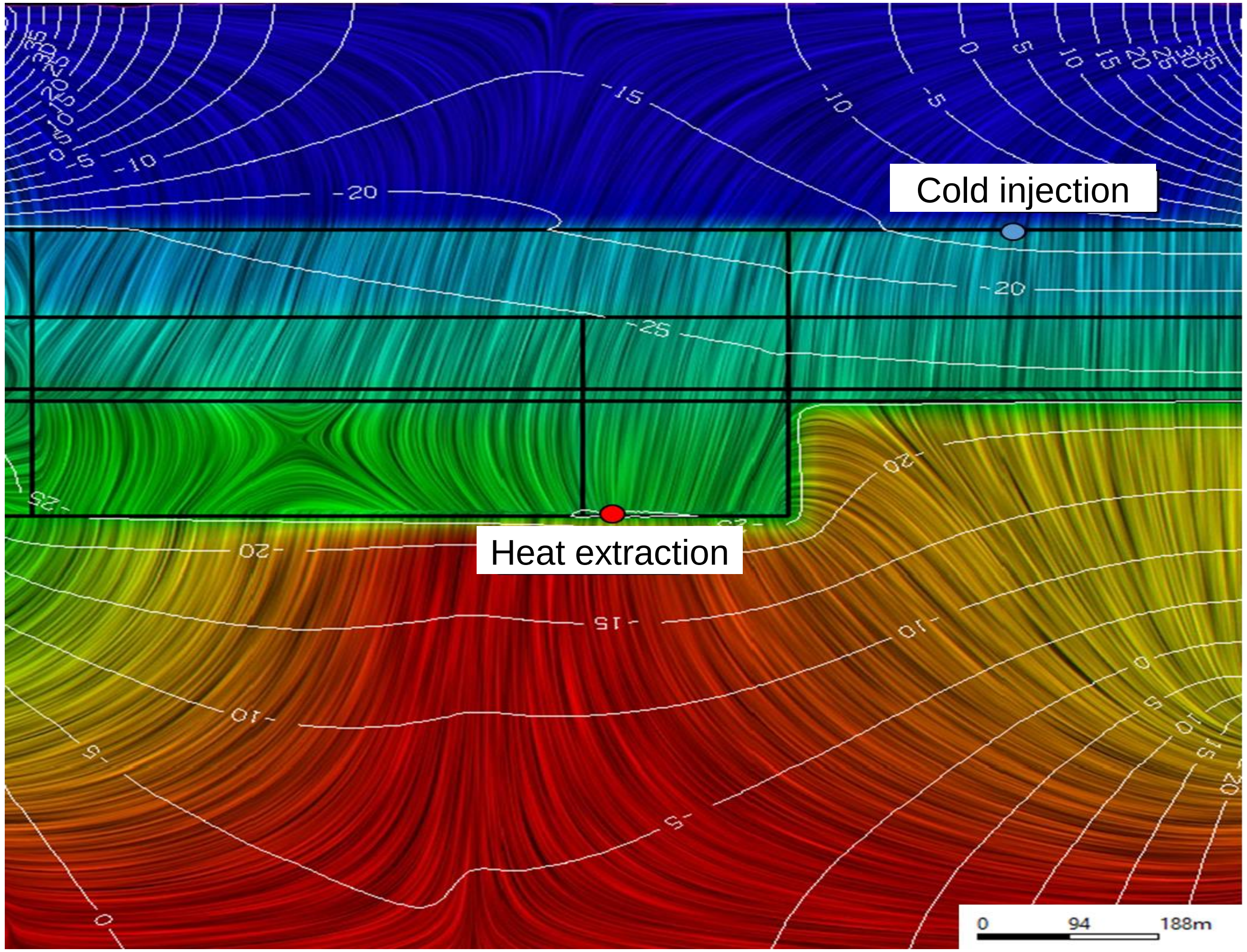
Density-dependent flow and heat transfer calculations



Conclusions

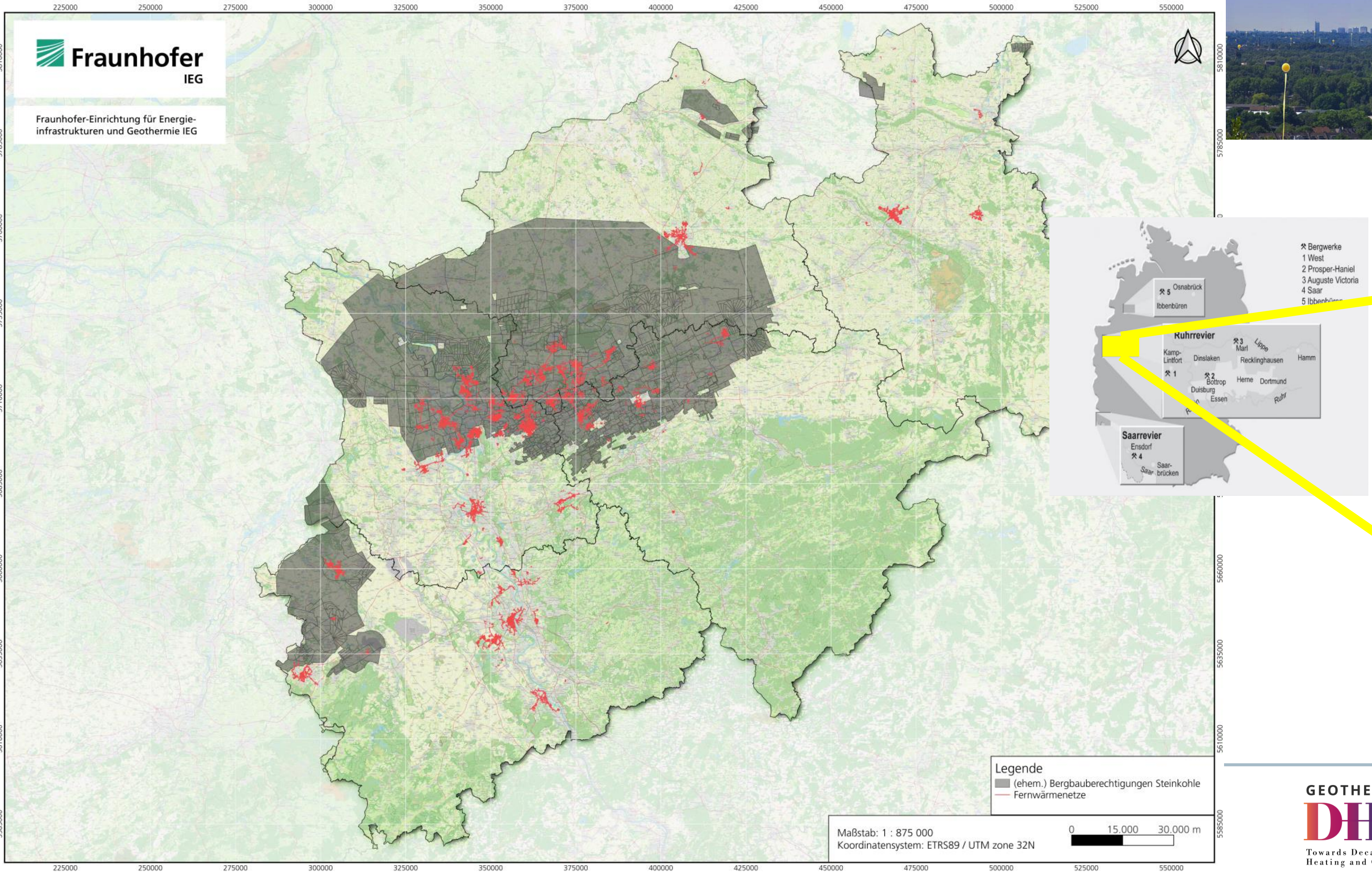
- No direct bypass between the injection and extraction.
- No significant salination of 4th level and drainage over reinjected (saline) waters from 8th level.
- Drainage effect to river Ruhr, significantly cools the temperatures compared to the natural thermal gradient.
- Depletion effect due to net heat extraction, lowers minewater temperature compared to natural temperature, especially in the 8th level.
- Depletion effect is partially compensated due to the regeneration in summer (67%)
- Depletion effect is furthermore compensated due to attraction of more geothermal heat from deeper layers.

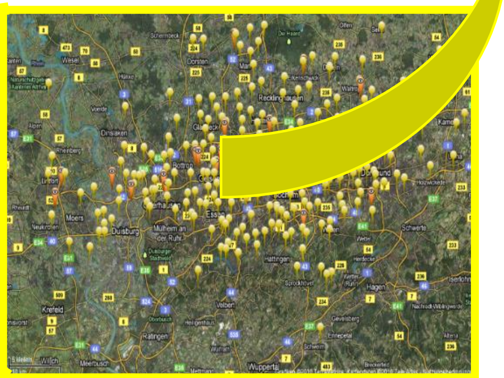
Mine Thermal Energy Storage (MTES)

Mine Water Potential in NRW

Mine Water Potential in NRW

Eternity benefits from eternity burdens!





www.schachtzeichen.de

GEOTHERMAL DHC
Towards Decarbonized Heating and Cooling!

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Thank you for your attention

Questions?

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Storage and Underground Systems
Post-mining-exploitation (lead)

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