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

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.
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-feasibility
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

Summer 2020
Winter 2020
Spring 2021
Summer 2021
HEATSTORE

Bochum Research and Drilling Rig (BoReX)
HEATSTORE
IN SITU TEST

- Steady state (flow and heat transport)
  - MI1 cool site Ort 4
  - MO1 hot site Ort 4 (max. 60 °C)
- 1.234 m³; 5.8 m³/h; 50 MWh

Heat injection test/Dec. 2020 (MP1)

Graph: Measured temperature (MP1) vs. Modelled temperature (MP1) over time [days].
HEATSTORE
Proof of Concept

\[ \Delta T \left[ ^\circ C \right] \]

- \( \Delta T_{\text{CSP}} \)
- \( \Delta T_{\text{MTES}} \)

22-Nov 12:30 to 22-Nov 13:30
22-Nov 13:30 to 22-Nov 14:00
22-Nov 14:00 to 22-Nov 14:30
22-Nov 14:30 to 22-Nov 15:00
22-Nov 15:00 to 22-Nov 15:30
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-Laar
   - 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 Wärmennetzsysteme 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

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
- 85% of cold demand by heat pumps
- 33% during exchange
- 67% by minewater
Project Mark 51°7 Bochum
Access mine water use

Drilling concept:
- Singular drilling location
- Cold well vertical drilling
- Hot well directional drilling

Minewater level 230 mBGL

Cold reservoir 4th level 340 mBGL (19 - 22°C)

Hot reservoir 8th level 816 mBGL (30 - 34°C)

Ships filled

Minewater drainage Ruhr Friedlicher Nachbar

Prinz Regent 5,900,000 m³/y

Dannenbaum

Friedlicher Nachbar
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 N₂-driven
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
Project Mark 51°7 Bochum
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
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Eternity benefits from eternity burdens!
Thank you for your attention

Questions?

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