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The foreseen Mine thermal energy storage (MTES) system within the PUSH-IT project

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ABSTRACT

The European Union aims to achieve a net-zero greenhouse gas (GHG) economy by 2050, with a 55% reduction from 1990 levels by 2030. Currently, heating and cooling account for over 50% of Germany's final energy demand, predominantly supplied by fossil fuels (BMWK, 2022). A major challenge in decarbonizing heat systems is the seasonal mismatch between heat supply and demand. The full potential of intermittent renewable thermal energy sources can only be harnessed through flexible heat network management and diverse storage technologies. Mine Thermal Energy Storage (MTES) systems offer a replicable and intelligent solution to balance seasonal fluctuations in heating and cooling demand. One of six demonstration sites in the PUSH-IT (Piloting Underground Storage of Heat In GeoThermal reservoirs) project is located in Bochum, North Rhine-Westphalia (NRW), Germany, where an abandoned hard coal mine is being repurposed into an MTES system.

1 THE PUSH-IT PROJECT

PUSH-IT demonstrates full-scale high-temperature heat storage (up to 90°C) in geothermal reservoirs using three technologies: aquifers, boreholes, and mines, across six European sites. These technologies are tailored to diverse geological conditions prevalent across Europe. The project will develop, deploy and test our technologies for a variety of configurations of heat sources, heat storage technologies, geological conditions, distribution systems, stakeholder populations and market and legal conditions.

PUSH-IT aims to reduce environmental impact, levelized cost of energy, and operational risks while enhancing performance and resilience. This is achieved through the development and demonstration of enabling technologies, including advanced monitoring systems, water quality control, innovative drilling and completion methods, and smart control systems. Societal engagement is integral, involving citizen participation, analysis of public perceptions, and exploration of governance models that promote inclusive decision-making in urban heating systems. The consortium includes heat suppliers, drilling companies, public planning authorities, and academic institutions. Through transdisciplinary collaboration, PUSH-IT will deliver operational projects and generate transferable solutions applicable across Europe. All activities are systematically monitored and documented, resulting in a comprehensive dataset on technical and social performance.

2 SITE DESCRIPTION

Up to this point, only one high temperature MTES pilot plant (Bochum, Germany) has been established within the framework of the HEATSTORE project, in which the possibility of thermal energy storage in an abandoned colliery was explored.

The local district heating grid of the Ruhr University Bochum (RUB) is powered by two CHP modules (9 MW total) and three peak boilers (105 MW total), which are located at the university's technical centre. The Mansfeld colliery, situated approximately 120 m below ground level (bgl), is being tested as a possible heat storage reservoir (Figure 1) within the project framework.

The PUSH-IT demonstration site will utilize surplus summer heat from a data center (peak load: 700 kW) and store it in the colliery via four wells drilled into the first stone drift. Depending on pump test results, these wells will function as production/injection or monitoring well. The geothermal gradient (Leonhardt, 1983) suggests a natural rock temperature of approximately 11 °C at this depth. The site is located just 300 m northeast of the HEATSTORE pilot, allowing reutilization of geological, hydrogeological, and modelling data for the next phase of RUB's district heating transformation.

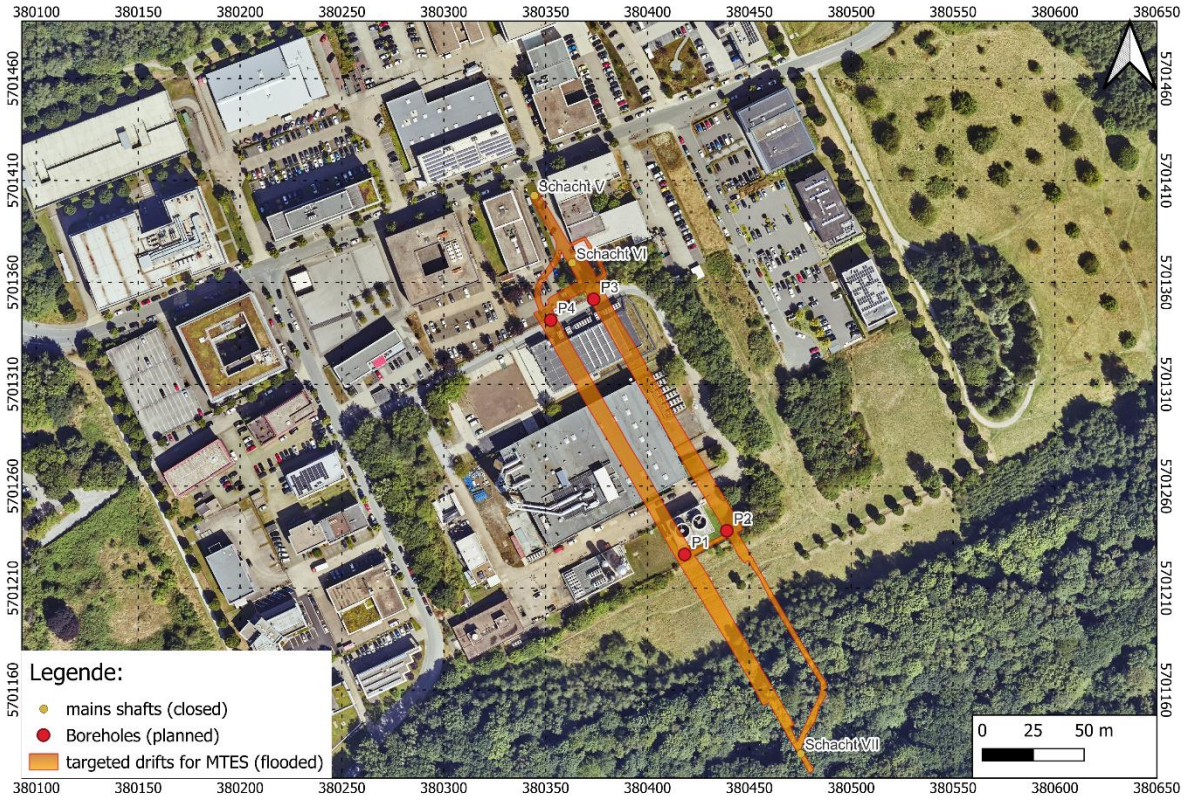


Figure 1: Aerial view on the Bochum demo site showing the targeted former galleries of the abandoned Mansfeld colliery at a depth of 120 m bgl (modified after Maehler & Ide 2005)

3 LOCATION

The MTES site is integrated into the RUB's technical centre and connected to the existing District Heating Network (DHN), which supplies heat to the RUB campus (5,700 employees, 43,000 students; Figure 2) and the Fernwärme Universitätsstadt (FUW) grid (4,800 rental units, 760 homes, 115 other customers). The energy provider, Unique Wärme GmbH—a joint venture between RUB and Stadtwerke Bochum Holding—was founded in 2018. The technical centre hosts 100 MW of heating and 10 MW of cooling capacity.



Figure 2: Aerial view on the entire RUB campus with circa 30 different buildings of age, size and energy demand as well as adjacent rental apartments, domiciles and further customers on the left part of the aerial photograph.

An overview of the district heating tracks is illustrated in Figure 3. The combined heat and power unit (CHP) is the main power plant for both electricity and heat supplementing the RUB power grid as well as the external district heating grid owned by FUW.

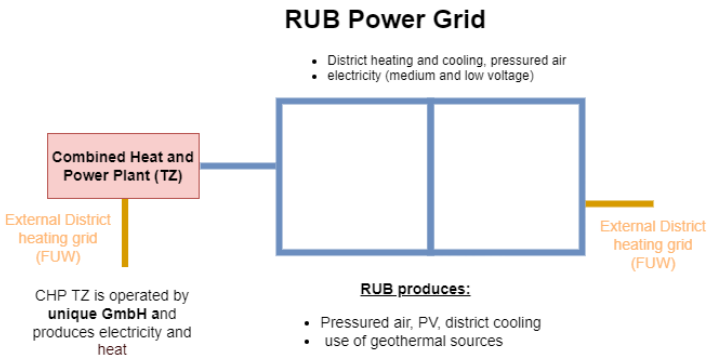


Figure 3: Overview of the district heating network tracks at the Bochum campus fed by energy of a combined heat and power plant connected to the RUB power grid (blue) and the external FUW district heating grid (orange)

4 DRILLING AND COMPLETION

The drilling and completion works are realized with the IEG own drilling rig *Hütte HBR 207 GT* (Figure 4). In order to accommodate 9 5/8" casings for the wells, large conductor pipes with accessories had to be purchased for the IEG drilling rig within the PUSH-IT project.

The new conductor pipes have a diameter of 14", so that drilling with a 12 ¾" diameter is now possible. This enables the installation of 9 5/8" casings and henceforward up to 8" electrical submersible pumps for high productions rates.

All four boreholes are to be drilled with a diameter of 323,9 mm to a depth of approximately 120 m bgl and will be secured after completion by a well cap.

The rig will be moved to the points indicated on the site map in

Figure 1 before drilling mud, separator and container for the borehole cuttings are connected via high-pressure hoses. In order to secure the first meters of loose rock against dislodging, a conductor pipe is temporarily installed and removed again before cementation.

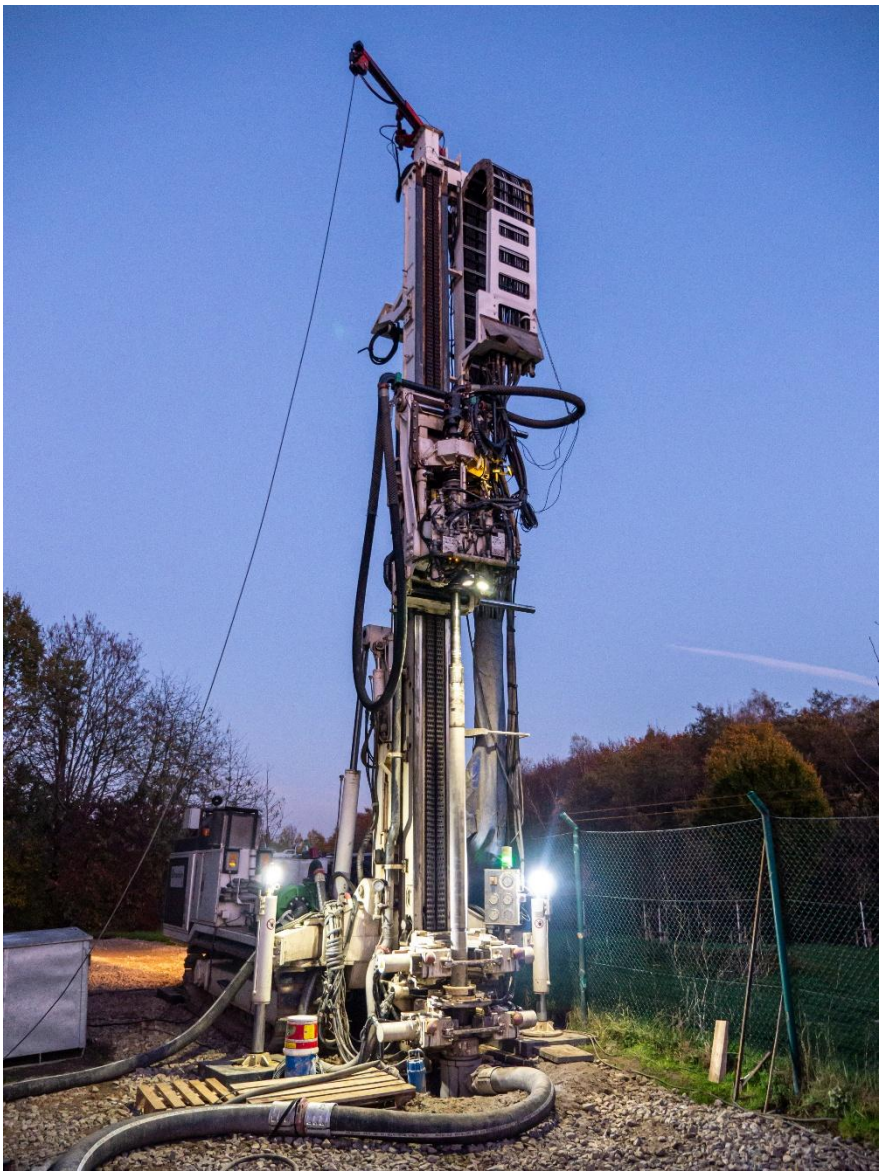


Figure 4: IEG drilling rig

5 CONCLUSION

The possible seasonal input and output of surplus heat into a MTES within the former Mansfeld colliery has to be considered more closely, taking into account the framework parameters of the district heating network of the FUW district heating grid. The different temperature levels in the seasonal heat storage and in the district heating network are likely to be problematic. While a maximum storage temperature of up to 90 °C seems possible within the MTES, the district heating network is operated with a weather-compensated flow temperature. In order to be able to provide the required heat output, the flow temperature is raised linearly from 80 °C below an outside temperature of 8 °C to 120 °C at an outside temperature of -10 °C.

If surplus heat potentials with a corresponding temperature level are available, the MTES could be charged with up to 90 °C. Due to the weather-compensated adjustment of the flow temperature of the grid, the heat could only be utilized up to an outside temperature of about 8 °C. Since the heat demand of the connected customers is rather low in this time period (summer and transitional phases spring / autumn), a withdrawal would only be necessary in winter when the heat demand is high. Due to the described temperature differences in the MTES and in the grid, heat withdrawal in times of high heat demand is not possible without further system technology.

This problem can be tackled by implementing a smart district heating control system (increased geothermal base load) and additionally utilizing high temperature heat pumps. The heat pump system could raise the heat to be dissipated to the weather-controlled temperature required in the flow of the network.

The foreseen MTES system at the technical centre of the RUB could increase the amount of renewable energy sources (e.g. integration of surplus heat from a data center) and help to decrease the peak loads within the district heating grid. This would lead to a reduction in operating costs and CO_2 emissions.

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