Mine thermal energy storage (MTES) systems in abandoned collieries within the Ruhr area

Florian Hahn[1], Stefan Klein[1], Kevin Mannke[1], René Verhoeven[1], Jonas Güldenhaupt[1], Torsten Seidel[2], Timo König[2]

[1]*Fraunhofer IEG, Bochum, NRW, Germany, florian.hahn@ig.fraunhofer.de*

[2]*delta h, Witten, Germany, ts@delta-h.de*

Extended Abstract

The EU aims to have a net-zero greenhouse gas (GHG) economy by 2050, with 55% reduction on 1990 levels by 2030. At present, heating and cooling represent over 50% of the final energy demand in Germany and are mainly supplied by fossil fuel derived energy (BMWK, 2022). A challenge for decarbonizing heat systems is the gap of the seasonal mismatch between supply and demand for heat and heat generation from sustainable sources. The potential of volatile renewable thermal energy sources can only be fully exploited through a flexible management of heat supply networks and a wide range of different storage technologies. Mine thermal energy storage (MTES) systems could provide such a replicable and smart solution to counterbalance the seasonal dip and peak in the heating and cooling demand.

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 successfully tested.

The local district heating grid of the Ruhr University (RUB) is currently operated by two CHP modules with a total capacity of 9 MW and three gas peak boilers with a total thermal output of 105 MW. These are located within the RUB's technical centre. The abandoned Mansfeld colliery at a depth of approx. 120 m bgl is located directly below the premises of the power plant and is planned to be used as a reservoir for heat storage. The Bochum MTES demo site within the PUSH-IT project will be established in conjunction with the RUB on the premises of their technical centre. This project will supplement surplus heat during the summer from a data centre with a peak load of 700 kW. In order to utilize this surplus heat during the winter, the abandoned Mansfeld colliery will be developed as a MTES via four wells (planned for Q3/2024) into the first stone drift of the colliery. Based on the results of the foreseen pump tests, the wells will either serve as production/injection or monitoring wells.

Fig. 1 reveals the mine workings (1st level) of the abandoned Mansfeld colliery at a depth of approx. 120 mbgl, which are directly located below the premises of the power plant of the "technical centre". Based on the geothermal gradient postulated by Leonhardt (1983), the first level should have a natural rock mass temperature of approx. 11 °C. The power plant of the FUW grid is situated only 300 m Northeast of the previously developed HEATSTORE MTES pilot site, so that the existing results (e.g. geology, hydrogeology, regional numerical model) can be utilized for the next transformation phase of the FUW district heating network.

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 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 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.

Keywords: Underground, mine, thermal, energy, storage

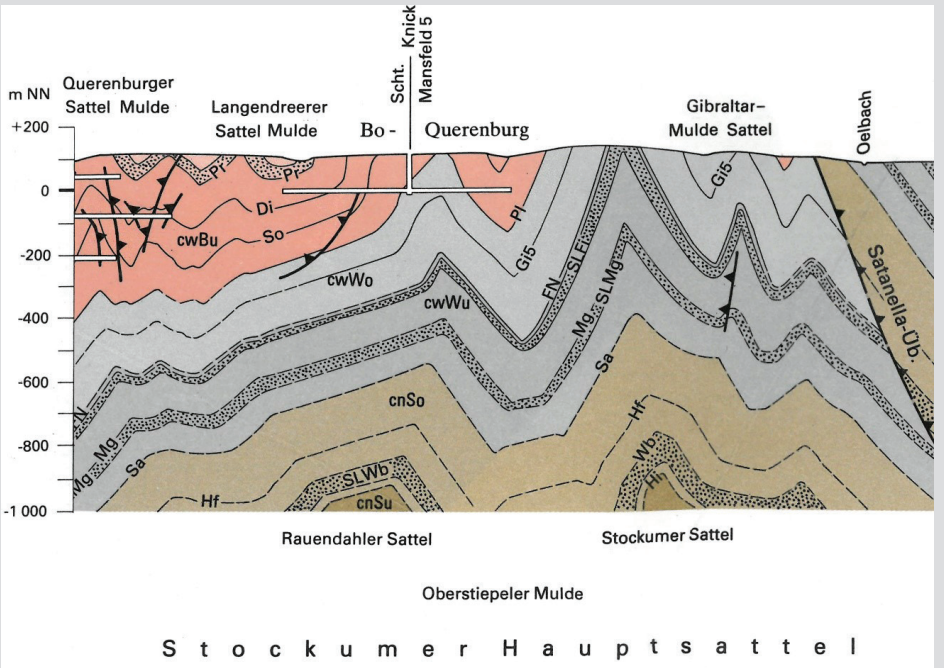

Figure 1 *Mansfeld colliery (Stehn, 1988)*

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