Predicting interactions between three neighbor open-loop Aquifer Thermal Energy Storage (ATES) systems in two overlaying aquifers in Brussels (Belgium)

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Shallow open-loop Aquifer Thermal Energy Storage (ATES) systems have been adopted by three large adjacent buildings in the centre of Brussels. The doublets of pumping and reinjection wells of two administrative buildings are located in a shallow aquifer made of Cenozoic mixed sandy and silty sublayers and operations started in 2014 and 2017. A third ATES system located in the underlying deep aquifer made of Palaeozoic fractured phyllites and quartzites, was started recently (2020) to provide the needed heating and cooling power to a large multi-service building. Groundwater levels variations in these two aquifer systems are different and pumping tests performed in the upper aquifer system have shown no impact on the groundwater levels in the Palaeozoic bedrock aquifer. After being calibrated on groundwater flow conditions in both aquifers, a 3D hydrogeological model using Feflow© was developed to simulate the cumulative effect of the three geothermal installations in the two exploited aquifers.

In terms of heat interactions, a previous model has shown how the thermal imbalance of the ATES system started in 2014 was jeopardising the thermal state of the upper aquifer (Bulté *et al.* 2021). Here, interactions with the third ATES system located in the deep aquifer are studied and modelled with different operational scenarios. Even though hydraulic interactions between the two aquifers are very limited, heat exchanges occur between the two aquifers, through an aquitard formed by low permeability Cretaceous base deposits and the weathered top of the bedrock.

The simulation results show that despite the unbalanced ATES system affecting mainly the shallow groundwater conditions, an adjacent but deeper ATES system can operate without significant interactions. Acquisition of additional measured data (i.e., piezometric heads, groundwater temperatures, detailed pumping, injection flow rate, etc.) will be crucial to improve the reliability of the simulated results for different operational scenarios. This will be particularly useful for the future management of the three ATES systems in order to avoid losses in both efficiency and durability.

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