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Thermal Impact of High Temperature Aquifer Thermal Energy Storage on Overlying Layers

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High temperature Aquifer Thermal Energy Storage (HT-ATES) is one option to compensate for the seasonal mismatch between supply and demand in a renewable dominated heating sector. The thermal impacts to be expected by a planned HT-ATES plant can be predicted by numerical modelling, which is necessary for the development of monitoring concepts, legal authorization and economical assessments. One aspect of numerical pre-investigations, which was mostly disregarded by previous studies, is the assessment of thermal impacts in layers above the storage formation, which are heated conductively by the warm well. Furthermore, a quantification of the related heat losses and the implications on storage efficiency need to be considered.

The thermohydraulic processes induced by the HT-ATES are numerically simulated by a radially symmetric model neglecting ambient groundwater flow. The model includes the discretised warm ATES well, which reaches to a depth of ≈250 m and the surrounding geological layers. The geology and the operational scheme are based on a typical setting representative for northern Germany. The simplified operational scheme consists of half a year injection and half a year extraction, repeated for 50 years, with an injection temperature of 85 °C, varying return flow temperatures and an initial subsurface temperature of 13 °C. The thermal properties of the well casing are varied in a sensitivity study to estimate the influence of different material choices.

The model results show, that a temperature increase of 5 °C propagates 7 m radially in cohesive layers around the well in the first year of operation. After 50 years, temperature increases of 5 °C or more are found within a distance of about 40 m, 30 °C within about 13 m and 50 °C within about 2 m. Density-driven buoyancy flow is observed in cohesionless layers, leading to heat accumulation near the top of these layers. The heat consequently propagates significantly further there than in the cohesive formations, e.g. a temperature increase of 5 °C propagates maximally 121 m from the well in 50 years. The conductive heat loss to the overlaying formations through the well casing is 2 % of the injected heat. The such derived estimation of thermal impacts in overlaying formations is conservative, since ambient groundwater flow is neglected, which would result in lower temperatures due to advective heat transport away from the well. The heat loss, however, would be larger with groundwater flow, since this would reduce temperatures around the well and thus increase the temperature gradients and the conductive heat transport. Material choices of the well material may increase or decrease the heat losses and thus the thermal

impacts.