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Modeling Neighborhood-Scale Shallow Geothermal Energy Utilization - A Case Study in Berlin

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Nowadays, utilizing shallow geothermal energy for heating and cooling buildings has received increased interest in the energy market. Among different technologies, large borehole heat exchanger (BHE) arrays are widely employed to supply heat to various types of buildings and districts. Recently, a 16-BHE array was constructed to extract shallow geothermal energy to provide heat to the newly-developed public building in Berlin. According to the previous geological survey, different non-homogeneous sedimentary layers exist in the subsurface, with variating groundwater permeabilities and thermal parameters. To estimate the performance of the BHE array system, and its sensitivity to different subsurface conditions, as well as to determine its thermal impact to the surrounding area, a comprehensive 3D numerical model has been set up according to the Berlin BHE array project. The model is simulated for 25 years with two finite element simulators, the open source code software OpenGeoSys (OGS) and the well-known commercial software FEFLOW. In the model, an annual thermal load curve is assigned to each BHE according to the real monthly heating demand. Although the way of the implementing parameters in the two programs differs from each other and some assumptions had to be made in the model comparison, the comparison result shows that both OpenGeoSys and FEFLOW produce in good agreement. Different parameters, e.g. the Darcy velocity, the thermal dispersivity of the aquifer, the surface temperature and the geothermal heat flux are investigated with respect to their impact on the underground and BHE circulation temperature. At last, the computed underground temperature and the brine fluid temperature evolution from OGS is benchmarked with the results from the model simulated in FEFLOW. The numerical experiments show that the the ground water field has the strongest influence on the brine fluid temperature within the BHEs. When the thermal dispersivity of the aquifer is considered, the mixing effect in the aquifer leads to a higher brine fluid temperature in the BHE, indicating a better thermal recharge of the system.