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Performance analysis of deep borehole heat exchangers in the Pannonian Basin

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Primarily due to the lack of production of geothermal fluids from subsurface aquifers, closed-loop geothermal systems are promising solutions for sustainable and cost-effective exploitation of geothermal energy. Compared to conventional or unconventional open-hole geothermal systems, the performance of deep borehole heat exchangers (DBHE) are relatively low. However, DBHEs may become favorable choices in certain areas due to the significantly lower exploration risks and their potential to be constructed in abandoned deep boreholes. We investigate the thermal performance of DBHEs in the Pannonian basin, exhibiting one of the hottest regions within Europe, with an average geothermal gradient of ~45 °C/km. We analyze the effect of various geological and technical parameters on the resulting outflow temperatures and output thermal powers in order to find the optimal sets of parameters for the long-term sustainable operation of DBHEs in the Pannonian basin. We approximate the performance of coaxial DBHEs through finite-element numerical modelling using the FEFLOW software. We construct the reference model in a geological environment representative for the Great Hungarian Plain based on information from well logs and literature data. The most important geological parameters we consider in the parameter tests include the geothermal gradient, lithologies, and the presence and significance of natural groundwater flows in the surroundings of the DBHE. Furthermore, we test the influence of various technical and operational parameters such as the type of working fluids, the depth of the DBHE, the thermal conductivity of the tubes, and the temperature and flow rate of the injected fluids. We predict the thermal output for the period of 10 years in order to find realistic parameter combinations that can facilitate sustainable production and reveal the most critical parameters that influence system performance in Pannonian basin settings. These results can help estimating system performance in case of actual geothermal projects and can be used as input parameters for economic calculations.