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An Extended Numerical Model for the Simulation of large Borehole Heat Exchanger Array

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Abstract

Utilizing shallow geothermal energy for heating and cooling buildings has received increasing interest in recent years. For large commercial buildings or energy storage applications, a typical system will include hundreds of Borehole Heat Exchangers (BHEs) that were connected with each other through a pipe network laid on top of them. Depending on the different arrangements of BHEs (connected in a serial or parallel way), the heat exchange rate of BHEs may vary.

In the analytical approach, the heat extraction rate on each BHE is imposed as a Neumann type of boundary condition, and the temperature distribution of the subsurface is calculated by super-imposing the individual temperature field from each BHE. This approach is not capable of predicting the interaction and influence from the pipe network, which the performance of each BHE is heavily dependent on. In this study a numerical model has been extended to explicitly couple the BHE and pipe network. The model is based on two open-source softwares, a finite element simulator OpenGeoSys (OGS, www.opengeosys.org) and the Thermal Engineering Systems in Python (TESPy, https://github.com/oemof/tespy). These two softwares are linked together through specification of an interface. This model allows a dynamic heat extraction rate of each BHE that is determined by the thermal-hydro processes in the pipe network.

The modeling results showed that after a certain operation period, the BHE in the center of the array was experiencing a lower heat extraction rate. Through the long-term operation, the thermal load was gradually shifted towards those BHEs located at the outer boundary of the array. It is estimated that the newly developed model can provide more reasonable prediction in the subsurface temperature evolution and predict the actual dynamic performance of a large BHE array.