EGU22-5401
https://doi.org/10.5194/egusphere-egu22-5401
EGU General Assembly 2022


# Life-span economic and environmental analysis of deep borehole heat exchanger coupled geothermal heat pump heating system with different drilling depths

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Geothermal energy stored in the 1~2 km depth, which has advantages in terms of its continuity and sustainability, has attracted more attention in recent decades in the building heating industry. To meet the carbon-neutral prospect in the building sector, a new-type deep borehole heat exchanger (DBHE) is proposed to extract geothermal energy and has been utilized in Europe and northern China. The DBHE is typically drilled to more than 2000 m depth, and it is usually coupled with a heat pump to supply heat to the buildings. In this work, a dual-continuum finite element method was implemented in the open-source software OpenGeoSys to mimic the heat transfer process between the DBHE and the surrounding subsurface. After validating against in-situ experimental data of the pilot DBHE heating project in Xi’an, a heat pump model was also included in the OpenGeoSys model so that the entire heating system can be simulated over the long-term operation. Results show that the circulation temperatures of the DBHE have a decreasing trend during the long-term operation. Through the energy analysis, the amount of heat extracted by the DBHE was found to be mainly supplied by the energy stored within the surrounding soil. With different drilling depths of the DBHE, long-term simulation results illustrate that the heat extraction rate increases with deeper depth. After considering the electricity consumption of the heat pump and circulation pump, the Levelized cost of heating (LCOH) of the DBHE heating system was evaluated over its life-span cycle, and the optimal drilling depth of the DBHE was found to be 2600 m based on the specific geological properties of Weihe Basin, Xi’an. The proposing evaluation method provides a reference for decision-makers when designing the DBHE heating system.