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Optimization of Borehole Thermal Energy Storage System Design Using Comprehensive Coupled Simulation Models

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Large-scale borehole thermal energy storage (BTES) is a promising technology in the development of sustainable, renewable and low-emission district heating concepts. Such systems consist of several components and assemblies like the borehole heat exchangers (BHE), other heat sources (e.g. solarthermics, combined heat and power plants, peak load boilers, heat pumps), distribution networks and heating installations. The complexity of these systems necessitates numerical simulations in the design and planning phase. Generally, the subsurface components are simulated separately from the above ground components of the district heating system. However, as fluid and heat are exchanged, the subsystems interact with each other and thereby mutually affect their performances. For a proper design of the overall system, it is therefore imperative to take into account the interdependencies of the subsystems.
Based on a TCP/IP communication we have developed an interface for the coupling of a simulation package for heating installations with a finite element software for the modeling of the heat flow in the subsurface and the underground installations. This allows for a co-simulation of all system components, whereby the interaction of the different subsystems is considered. Furthermore, the concept allows for a mathematical optimization of the components and the operational parameters. Consequently, a finer adjustment of the system can be ensured and a more precise prognosis of the system's performance can be realized.