Geophysical Research Abstracts
Vol. 19, EGU2017-14756, 2017
EGU General Assembly 2017

Coupled Simulation of Borehole Thermal Energy Storages and Solar District Heating Systems

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The temporal difference between times of high heat demands and times of high solar heat supplies can be compensated by solar district heating (SDH) with borehole thermal energy storage (BTES) systems. To achieve a good understanding of the system behavior and for optimized dimensioning of the components transient simulations are imperative. In this context the models of SDH systems and BTES pose very different requirements on their simulation environments. Taking this into account, a coupled simulation, in which both models can be realized in separate and specialized simulation environments becomes favorable. The underlying work presents a new approach for a coupled simulation of a SDH system modelled in SimulationX and a BTES system modelled in MATLAB.

A case study is performed, in which a SDH system with an annual heat demand of 1,100 MWh and a BTES is designed and dimensioned. The SDH is modelled in SimulationX and later coupled to an existing model of a BTES in MATLAB. Subsequently, a simulation over seven years is carried out to assess the performance of the designed system and the presented coupling method.

For the designed system, a storage efficiency of 56.6% and a solar fraction of 36.6% can be achieved after the final year. The implementation of a heat pump proves to be beneficial for the performance of the system. A detailed analysis of the system and component behavior is performed, which concludes in a good understanding of interdependencies between the components and the identification of potential improvements. Following this, an improvement strategy for the system is developed, in which major potentials are related to a more sophisticated control strategy.