A dynamic building and aquifer co-simulation method for thermal imbalance investigation

Due to their favorable supply temperature, aquifer thermal energy storage (ATES) systems perform as an efficient heating/cooling energy storage facility for buildings. ATES systems consist of a warm and cold well. They are designed to operate with a temperature difference of at least 8°C between wells, whereas the existing installations operate in practice with an average temperature difference of 4°C. The ATES supply temperature is influenced by heat losses to the surroundings and the yearly balance of total heat exchange of heating and cooling between a building and the groundwater. Previous studies mainly focused on the investigation of heat losses to the environment. This paper explored the influence of thermal imbalance of a building load on the temperature of the aquifer and the heating/cooling system performance for the building. Due to the lack of tools capable of simulating the system that connects ATES with the buildings, we develop a co-simulation method that combines COMSOL, MATLAB and TRNSYS. In this method, COMSOL was used to model ATES, TRNSYS to simulate buildings and heating, ventilation and air conditioning (HVAC) systems and MATLAB as a mediator to exchange information between the simulation tools. The developed method was applied to a case study with three different insulation parameters to present different thermal load profiles. The results indicated that a thermally balanced building load achieved a 2.5°C higher temperature difference between the sources for cooling than a case with a thermal imbalance ratio of 79%, which resulted in a 13.7% and 6% higher system coefficient of performance (COP) higher than the case with 79% thermal imbalance ratio and 51% thermal imbalance ratio, respectively.