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Assessment of the effect of groundwater flow on the performance of Borehole Thermal Energy Storage systems

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In a Borehole Thermal Energy Storage (BTES) system, heat is extracted from or injected to the subsurface, taking advantage of the relatively constant temperatures of the underground. Such systems have very high thermal efficiency and contribute significantly to the reduction of primary energy use and greenhouse gas emissions. Both thermal conduction and advection can influence the efficiency, but thermal advection is often neglected in the design of BTES systems. However, in areas with strong groundwater flow the heat exchange and BTES systems' overall efficiency can be significantly affected, as heat is transported towards or away from the borehole along with the flow. The goal of this project is to gain insight in the influence of groundwater flow on the efficiency of a BTES system. Two case studies of systems in the Netherlands are presented, together with design measures to improve BTES efficiency. The first case study examines a BTES system in an area with strong groundwater flow, while the second case study is of an area where no groundwater flow is present. A numerical model using MODFLOW/MT3D is created to simulate coupled groundwater flow and heat transport under various conditions. The numerical model is first tested with a two-dimensional analytical solution, after which it is used to compute the influence of groundwater flow on the efficiency of the BTES system.