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Mathematical optimization of borehole heat exchanger fields for heating, cooling and seasonal storage

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In our work, we employ mathematical optimization and control techniques to strategically operate and arrange borehole heat exchangers (BHE) in such fields. Linear programming and evolutionary algorithms are applied in combination with numerical and analytical equations, and with data-based models, to solve hypothetical and realistic problems. The studied scenarios represent variable environmental conditions, such as with and without groundwater flow, as well as homogeneous and heterogeneous hydrogeological conditions. We inspect BHE fields of different size, with seasonally variable heating and cooling energy demands, and for a range of total system lifetimes. As objective, efficient heat or cold supply or the maximum temperature decline in the ground is specified. It is demonstrated that the BHE field performance can be improved both by case-specific ideal arrangement and time-dependently regulated individual BHE operation. It is found that instead of standard lattice arrangements, optimized geometries are favourable, with BHEs concentrated along the fringe of a field. Groundwater flow means additional energy provision by advection from a given direction towards the field. Optimized operation under such conditions adopts a seasonally variable loading of individual BHEs that is oriented at the groundwater flow direction.