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Temperature Distribution and Thermal Performance of an Aquifer Thermal Energy Storage System

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Energy conservation and storage has become very crucial to make use of excess energy during times of future demand. Excess thermal energy can be captured and stored in aquifers and this technique is termed as Aquifer Thermal Energy Storage (ATES). Storing seasonal thermal energy in water by injecting it into subsurface and extracting in time of demand is the principle of an ATES system. Using ATES systems leads to energy savings, reduces the dependency on fossil fuels and thus leads to reduction in greenhouse gas emission. This study numerically models an ATES system to store seasonal thermal energy and evaluates the performance of it.
A 3D thermo-hydrogeological numerical model for a confined ATES system is presented in this study. The model includes heat transport processes of advection, conduction and heat loss to confining rock media. The model also takes into account regional groundwater flow in the aquifer, geothermal gradient and anisotropy in the aquifer. Results show that thermal injection into the aquifer results in the generation of a thermal-front which grows in size with time. Premature thermal-breakthrough causes thermal interference in the system when the thermal-front reaches the production well and consequences in the fall of system performance and hence should be avoided. This study models the transient temperature distribution in the aquifer for different flow and geological conditions. This may be effectively used in designing an efficient ATES project by ensuring safety from thermal-breakthrough while catering to the energy demand. Based on the model results a safe well spacing is proposed. The thermal energy discharged by the system is determined and strategy to avoid the premature thermal-breakthrough in critical cases is discussed. The present numerical model is applied to simulate an experimental field study which is found to approximate the field results quite well.