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Heat recovery of ATES systems in aquifers with a vertical density gradient

Martin Bloemendal (1,2) and Theo Olsthoorn (1)
(1) Delft University of Technology, (2) KWR watercycle research institute

Aquifer Thermal Energy Storage Systems (ATES) are often placed in aquifers in which salinity increases with depth. This is the case in coastal areas where also the demand for ATES application is high due to high degrees of urbanization in those areas. The seasonally alternating extraction and re-injection between ATES wells disturbs the preexisting ambient salinity gradient causing horizontal density gradients, which trigger buoyancy flow, which in turn affects the recovery efficiency of the stored thermal energy.

This research uses analytical and numerical methods to understand and explain the impact of buoyancy flow on the efficiency of ATES in such situations, and to quantify the magnitude of this impact relative to other thermal energy losses. The results of this research show that losses due to buoyancy flow may become considerable at relatively large ambient density gradients of over 0.5 kg/m3/m in combination with a vertical hydraulic conductivity of more than 5 m/d. Monowell systems suffer more from buoyancy losses than do doublet systems under similar conditions.