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Thermal recycling assessment for Groundwater Heat Pumps (GWHPs) with time-varying flow rates

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Groundwater Heat Pumps (GWHPs) are gaining an increasing interest for the heating and cooling of buildings, due to their economic convenience and their low carbon intensity. They are usually composed of abstraction and injection well(s); reinjection is usually performed in order to avoid the depletion of the aquifer as large flow rates (i.e. tens of liter per second), and it takes place into the same aquifer to avoid geochemical alterations. This practice, however, may result in the return of part of the injected thermally altered groundwater to the abstraction well. Milnes and Perrochet [1] distinguish between thermal feedback (when the reinjection temperature is set) and thermal recycling (when a temperature difference between abstraction and reinjection is set). While thermal feedback has been studied for a long time [2-4], thermal recycling has been addressed more recently [5] due to a higher mathematical complexity of its modelling.
In this work, we present the development of an explicit formula for the calculation of the maximum thermal alteration of abstracted water, occurring in the long term in a GWHP under typical operating conditions. A sinusoidal trend of the thermal power - and hence of the abstracted flow rate – with a yearly cycle was assumed, which mimics the typical trends of energy demands in buildings.
The formula was derived based on a large number of numerical simulations with FEFLOW, and validated comparing to analytical formulae available in the literature [5, 6]. It considers a single use of the heating/cooling system; however, if both uses are foreseen, the prevailing one should be used, which is a conservative assumption. In this way it is possible to quickly assess, with a good approximation, the operational sustainability of a GWHP well doublet layout.

References

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