Evaluating thermal losses and storage capacity in high-temperature aquifer thermal energy storage (HT-ATES) systems with well operating limits: insights from a study-case in the Greater Geneva Basin, Switzerland

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High temperature aquifer thermal energy storage (HT-ATES) can play a key role for a sustainable interplay between different energy sources and in the overall reduction of CO\textsubscript{2} emission. In this study, we numerically investigate the thermo-hydraulic processes of an HT-ATES in the Greater Geneva Basin (Switzerland). The main objective is to investigate how to handle the yearly excess of heat produced by a nearby waste-to-energy plant. We consider potential aquifers located in different stratigraphic units and design the model from available geological and geophysical data. Aquifer properties, flow conditions and well strategies are successively tested to evaluate their influence on the HT-ATES economic performance and environmental impact. This was achieved using a new open-access, user-friendly and efficient code that we also introduce here as a possible tool for geothermal applications.

The results highlight the importance of thorough numerical simulations based on more realistic exploitation when designing HT-ATES systems. We show that relations between thermal performance and the shape of the injected thermal volume are generally hard to derive when complex well schedules are imposed because the injected/produced volumes may not be equal. Despite more complex storage strategies to comply with legal regulations, the shallower group of investigated aquifers in this study remains economically more suitable for storage up to 90°C. In average four well doublets will be required to store the yearly excess of energy. The deeper group of investigated aquifers, however, become interesting for storage at higher temperatures.

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