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Integrating Geohydrological Models In ATES-Systems Control

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1) Purpose.
Accomplish optimal and sustainable use of subsurface for Aquifer Thermal Energy Storage (ATES).

2) Scope.
A heat pump in combination with an ATES system can efficiently and sustainably provide heating and cooling for user comfort within buildings. ATES systems are popular in moderate climate in which ATES systems are exploited as they are able to save primary energy. While storing warm and cold groundwater, ATES systems occupy a significant amount of the subsurface space, making that the space in the aquifers below cities is becoming scarce [1]. With the rapid growth of the number of ATES systems, the use of the subsurface intensifies, which raises additional questions regarding its sustainability and the long term profitability of the individual systems. In practice considerable difficulties regarding A) the performance of these installations and B) optimal and sustainable use of the subsurface are met.

3) Approach.
Recently it was confirmed [2] that ATES systems can be placed closer to each other with limited effect on their energy efficiency. By placing them closer together we introduce the risk of a tragedy of the commons [3]. Therefore it is of importance to know where the warm and cold zones are over time and enable ATES-controllers to use the subsurface optimal and sustainably. From the field of multi agent systems and complex adaptive systems we use approaches and techniques to make an operation and control system that enables to adapt their control not only based on current demand, but also on current aquifer status and expected future demand.

We are developing a numerical groundwater model structure which is fed with operational data of different ATES-systems. While doing this we run into challenges and opportunities like; spatial and temporal scale issues, sustaining the storage with balancing thermal storage and extraction at area level, dynamics and relation between hydrological and thermal influence and consequences for spreading of contaminants, using thermal energy storage for “peak-shaving” of wind/solar power production etc.. I will address the following two topics;
- Balancing of stored heating and cooling capacity. To sustain an ATES-system heating and cooling capacity storage must more or less balance. Buildings often do not have a similar heating and cooling demand. Placing ATES-well closer to each other offers the opportunity to exchange energy between different buildings in the subsurface to balance heating and cooling capacity. To be able to do so, thorough understanding of the interaction between thermal influence area resulting from highly dynamic and uncertain energy demand from buildings is required.
- The hydrological influence area of ATES wells is much bigger than the thermal influence area. Placing wells closer to each other therefor has a significant effect on the mixing of water and spreading of contaminants (which are often present in shallow aquifers under (old) city centers).
We use both analytical and numerical approaches to gain insight in patterns of thermal and contaminant spreading and to find solutions in managing these effects.

4) Results and conclusions
The subsurface is of crucial importance for intended energy savings. A control system working towards a global optimum for both the subsurface and buildings, instead of a local optimum for an individual building and local ATES will increase the overall efficiency. What is needed for that is insight in the spatial temperature distribution in the subsurface, in combination with adaptive and robust operational rules. We want to prove that a groundwater model simulating active ATES-systems can provide insight in the subsurface temperature distribution to adjust their control strategy in accordance with up-to-date information. Step by step we are solving the problems on this path, I would like to share and discuss my results, solutions and challenges.

References

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