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Planning ATES systems under uncertainty

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Abstract

Aquifer Thermal Energy Storage (ATES) can contribute to significant reductions in energy use within the built environment, by providing seasonal energy storage in aquifers for the heating and cooling of buildings. ATES systems have experienced a rapid uptake over the last two decades; however, despite successful experiments at the individual level, the overall performance of ATES systems remains below expectations – largely due to suboptimal practices for the planning and operation of systems in urban areas.

The interaction between ATES systems and underground aquifers can be interpreted as a common-pool resource problem, in which thermal imbalances or interference could eventually degrade the storage potential of the subsurface. Current planning approaches for ATES systems thus typically follow the precautionary principle. For instance, the permitting process in the Netherlands is intended to minimize thermal interference between ATES systems. However, as shown in recent studies (Bakr, van Oostrom, & Sommer, 2013; Sommer et al., 2015) a controlled amount of interference may benefit the collective performance of ATES systems. An overly restrictive approach to permitting is instead likely to create an artificial scarcity of available space, limiting the potential of the technology in urban areas.

Master plans – which take into account the collective arrangement of multiple systems – have therefore emerged as an increasingly popular alternative. However, permits and master plans both take a static, ex ante view of ATES governance, making it difficult to predict the effect of evolving ATES use or climatic conditions on overall performance. In particular, the adoption of new systems by building operators is likely to be driven by the available subsurface space and by the performance of existing systems; these outcomes are themselves a function of planning parameters. From this perspective, the interactions between planning authorities, ATES operators, and subsurface conditions form a complex adaptive system, for which agent-based modelling provides a useful analysis framework.

As a first step towards better understanding these interactions, this study presents preliminary results from a hybrid simulation environment which couples an agent-based ATES adoption model and a hydrologic model of the subsurface. The models are parameterized to simulate typical operating conditions for ATES systems in a dense urban area. Furthermore, uncertainties relating to planning parameters and adoption processes are explicitly considered using exploratory modelling techniques.

References

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