ATES-SG: Aquifer Thermal Energy Storage Smart Grids

with Plus Project in Amsterdam

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Partners

Delft University of Technology ▪ Waternet ▪ Tauw ▪ Priva ▪ KWR ▪ DWA ▪ Provincie Noord-Holland

Period

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Improving the use of seasonal thermal energy storage

Aquifer thermal energy storage (ATES) plays a crucial role in the energy saving objectives of the Netherlands when considering the heating and cooling of buildings. The researchers have investigated how ATES control configurations and planning policies affect the adoption of ATES in urban areas, and how this development in turn will affect the sustainable use of the subsurface as a resource for thermal storage. The result is a proof-of-concept for interdependent ATES/building control systems which can significantly improve the current operational performance of ATES, with a focus on distributed model-based predictive control (DMPC) approaches.

✱ Agent-based modelling and analysis

An improved methodological toolkit was developed for the agent-based modelling of ATES systems, which could suitably simulate interactions between the operation of ATES and subsurface conditions, as well as their inherent uncertainties. It was applied in case-studies in Utrecht and Amsterdam, resulting in a better understanding of the implications of spatial planning, operational uncertainties, and ATES control configurations towards the performance and adoption of urban ATES systems.

✱ A distributed control framework

In order to improve the operational control of such systems, new models and control approaches were developed for single ATES system dynamics integrated into an uncertain building climate comfort system. Also a distributed control framework was created to avoid unwanted overlap between neighbouring ATES systems while taking into consideration their shared uncertainty sources. The data-driven framework handles both local and network-wide uncertain constraints.

✱ Multi-disciplinary modelling, analysis and design

The two PhD students have integrated their data and findings in order to connect the technical insights with the current legal framework for ATES planning and governance. Results were translated to directly implementable recommendations and necessary steps for further development and adoption of the ATES Smart Grid concept.

Read more

1 M. Bloemendal, M. Jaxa-Rozen, T. Olsthoorn (2018): *Methods for planning of ATES systems*, Applied Energy

2 V. Rostampour, T. Keviczky (2019): *Probabilistic Energy Management for Building Climate Comfort in Smart Thermal Grids with Seasonal Storage Systems*, IEEE Transactions on Smart Grid

3 V. Rostampour, W. Ananduta, T. Keviczky (2019): *Distributed Stochastic Thermal Energy management in Smart Thermal Grids*, In Intelligent Integrated Energy Systems

4 M. Jaxa-Rozen (2019): *Methods for planning, simulation, and operation of Aquifer Thermal Energy Storage under deep uncertainty*. PhD thesis, TU Delft

5 V. Rostampour (2018): *Distributed Data-Driven Decision Making in Uncertain Networked Systems with Applications in Smart Energy Systems*. PhD thesis, TU Delft

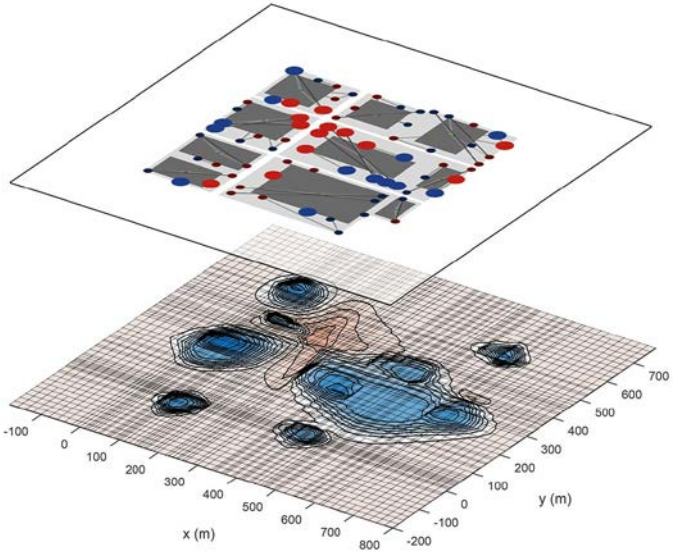
6 J. Bloemendal (2018): *The hidden side of cities: Methods for governance, planning and design for optimal use of subsurface space with ATES*. PhD Thesis, TU Delft

Insights & recommendations

[1] The case studies led to an improvement in specific greenhouse gas emission savings by 75% for the idealized case, and by 38% for the Utrecht case. These results indicate that the coordinated operation of ATES systems could lead to a win-win for policymakers and operators, by enabling further adoption of the technology in a given area and increasing greenhouse gas emission savings, without penalizing economic performance. However, this requires denser layout guidelines for ATES systems, and the exchange of information among participating ATES operators.

[2] Significant energy and greenhouse gas emission savings can be achieved by coordination among nearby buildings using the developed distributed data-driven energy management framework for building climate comfort systems that are interconnected via ATES. This can be used as a basis for Smart Thermal Grids that can keep the energy balance between uncertain thermal energy demand and production units of individual buildings. A key ingredient for this solution turned out to be a technique to decompose a large-scale robust optimal control problem, while guaranteeing the robustness of the resulting distributed solutions.

[3] The results of this project are also applicable in many cities in other countries with ATES potential. Fundamental insights were obtained into the processes that affect energy losses in the subsurface and we developed design methods and operational guidelines to limit those. The developed assessment methods can be used to optimize well placements, and determine thresholds that indicate a need for ATES planning/governance and below which self-organization is possible.



The research programme Uncertainty Reduction in Smart Energy Systems (**URSES**) aims to make a quick transition to a reliable, affordable and sustainable energy system possible. It is a joint initiative of several departments of NWO, Shell, AMS and the TKI Urban Energy.

NWO Netherlands Organisation for Scientific Research

AMS AMSTERDAM INSTITUTE FOR ADVANCED METROPOLITAN SOLUTIONS

TKI URBAN ENERGY Topsector Energie