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Demonstrating Low Temperature Grids: ATES as Flexibility for E-grid

J.T. Riederer[1]*, S. Sarshar[1] , P.J. Vardon[1], I. Pothof[2], A. Medema[1], M. Bloemendal[1,3].

Delft University of Technology[1], Deltares[2] , TNO[3]

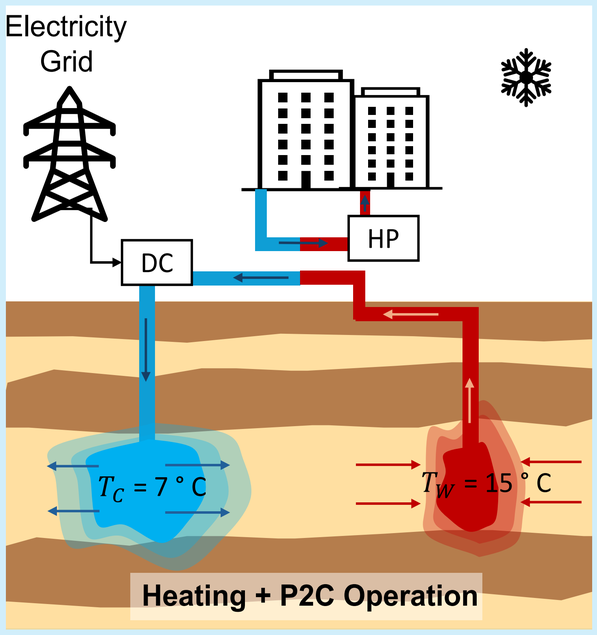
J.T.Riederer@tudelft.nl

SUMMARY

Aquifer Thermal Energy Storage (ATES) with P2C and P2H can become a flexibility for electricity grids. A Python based modflow 6 model simulates 5 years of operation of an ATES system within a cooling dominated district heating and cooling network. The case study results show that P2C operation leads to:

- Lower extraction temperatures in cooling mode
- Larger thermal radii in the subsurface
- Lower costs for regeneration of the cold well and cooling with ATES

INTRODUCTION



The electrification of the heating sector increases the congestion risk in electricity grids worldwide. Power-to-X technologies can act as flexibilities to reduce the stress on these grids. Currently, Power-to-heat (P2H) or Power-to-cooling (P2C) applications are operated demand driven. However, periods of high demand may not align with high supply. This can be addressed by combining supply-driven P2H and P2C with ATES. Generating and storing thermal energy in times of excess electricity, shifts demand for electricity to off-peak hours. The high potential of ATES in urban areas in Europe, Asia and North America makes this an promising solution for the Energy Transition.

METHODOLOGY

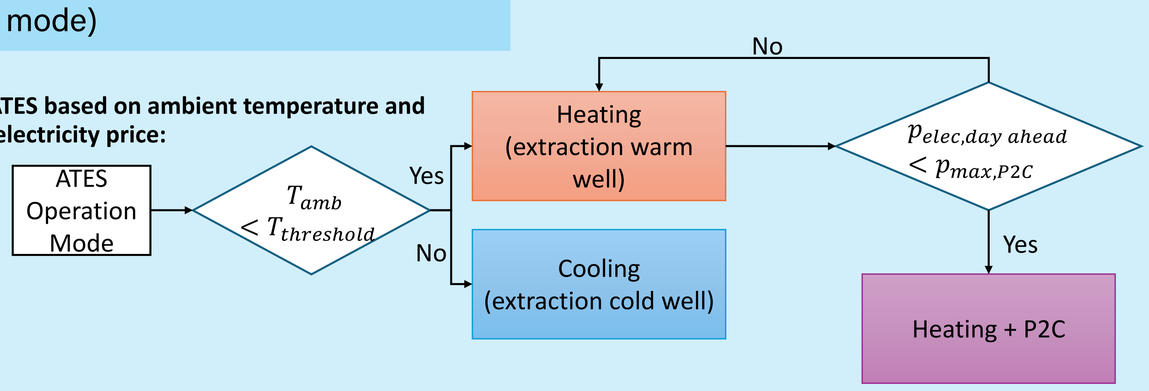
P2C and P2H with ATES

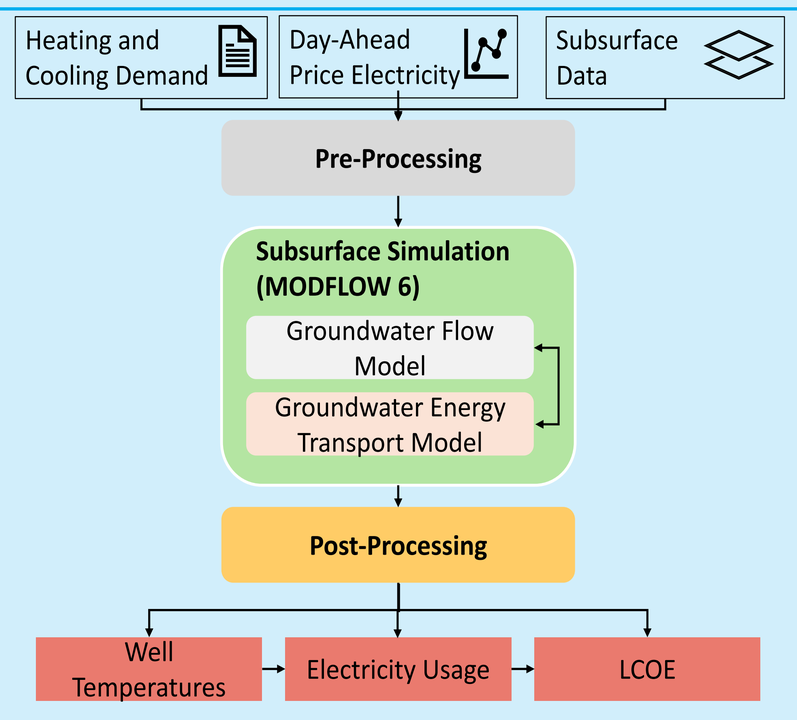
- generate thermal energy with Heat Pumps (HP) or Dry Coolers (DC) and store in ATES
- P2C: injection in cold well, extraction warm well (ATES in heating mode)
- P2H: injection in warm well, extraction cold well (ATES in cooling mode)

Case study: Delft Campus South

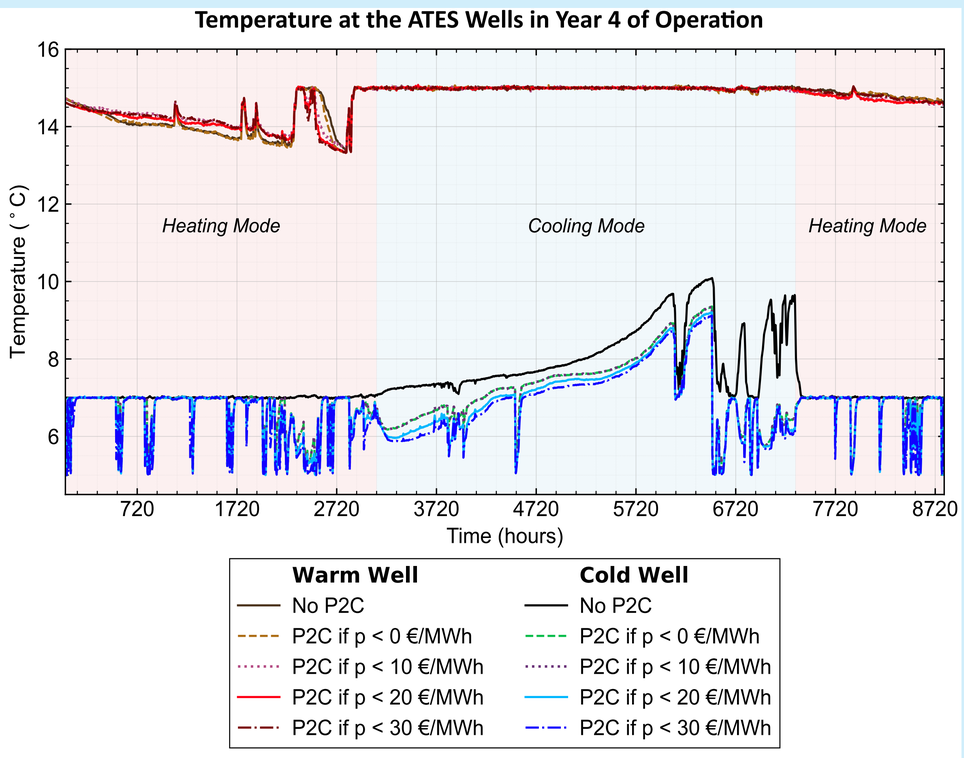
- space cooling > space heating
- Regeneration with Dry Coolers (DC)
- Heat Pumps (HP) needed for space heating
- Scenarios: different price thresholds for P2C

Operation mode of the ATES based on ambient temperature and electricity price:



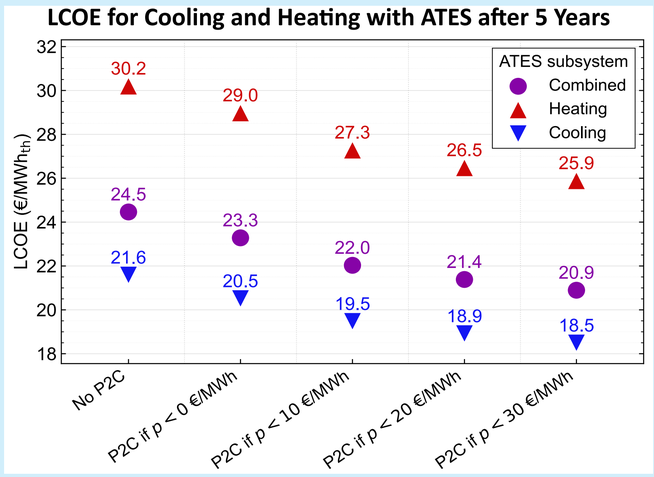


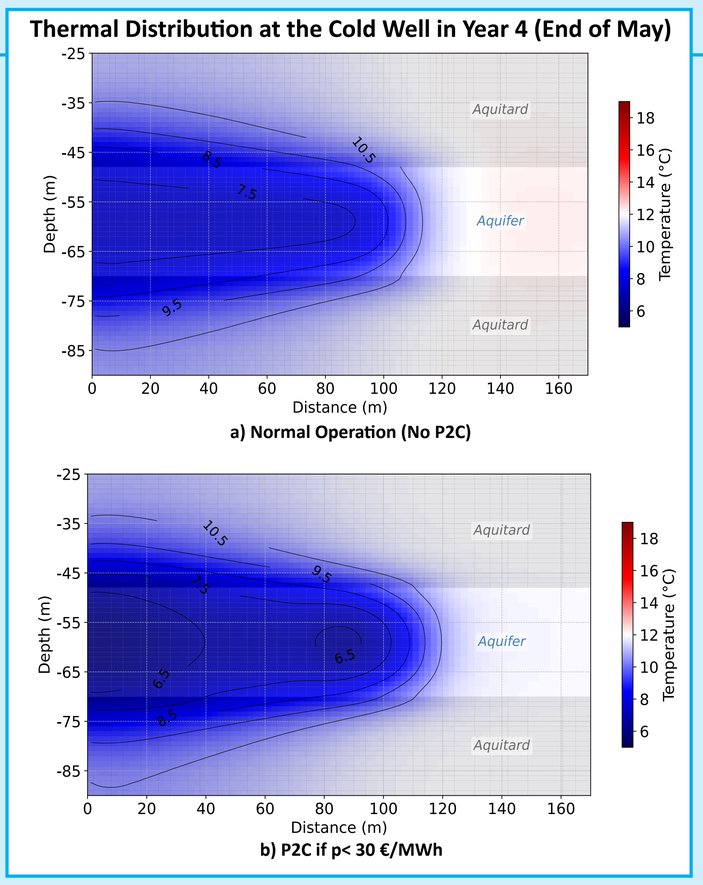
RESULTS



P2C Effect on ATES Operation:

- Increase in maximal thermal radius
- Lower extraction temperatures cold well
- Regeneration shifted to times with excess electricity
- Lower costs for cooling
- Lower costs for heating in P2C scenarios because of production increase in off-peak hours





DISCUSSION

Higher price thresholds increase the application of P2C and thus increase the effect on the temperature at the cold well. The price threshold can be optimized to minimize costs for a given time frame based on predictions of electrictiy prices. However, deviations from predictions cause uncertainty for the application of P2C. Additionally, fluctuations in heating and cooling demand impact the performance of ATES as a flexibility. To apply P2C operation of ATES in real world systems these uncertainties need to be evaluated. The case study shows daily switches between P2C and regular operation. Short switches between operation modes may have drawbacks that outweigh the benefits of P2C.

CONCLUSION

ATES with Power-to-cooling (P2C) can shift the electricity demand for cooling towards off-peak hours in cooling dominated systems. This reduces the stress on the electricity grid and leads to lower operational costs for cooling with ATES. Key uncertainties are the electricity prices and the demand for heating and cooling. The combination of P2H and P2C in the same system may offer additional opportunities for ATES as a flexibility for electricity grids. Therefore, next steps highlight different balanced and unbalanced systems and their suitability for supply-driven P2H and P2C with ATES.

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