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ATES with Power-to-Cooling and Power-to-Heat as Flexibility in the Energy Transition

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

INTRODUCTION

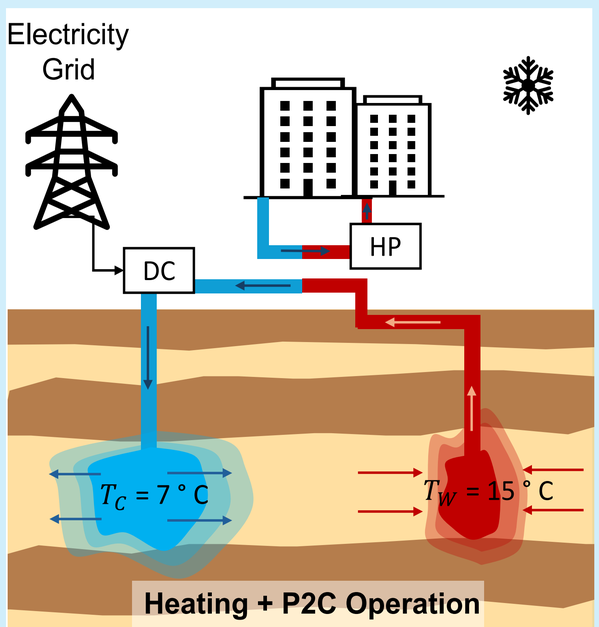
The electrification of the heating sector within the Energy Transition increases the congestion risk in electricity grids worldwide. Power-to-X technologies can act as additional flexibilities to reduce the stress on these grids. Power-to-heat (P2H) or Power-to-cooling (P2C) applications are currently operated demand driven. However, periods of high demand may not align with high supply. Therefore, supply-driven P2H and P2C in combination with Aquifer Thermal Energy Storage (ATES) is promising to reduce the stress on the electricity grid and decouple heating and cooling demands from the electricity demand. This can also reduce the costs for heating and cooling. The high potential of ATES in urban areas in Europe, Asia and North America makes this an attractive solution to address key challenges in the Energy Transition.

Power-to-Cooling and Power-to-Heat with ATES

- Using excess electricity to generate thermal energy with Heat Pumps (HP) or Dry Coolers (DC)
- P2C: injection in cold well, extraction warm well (heating)
- P2H: injection in warm well, extraction cold well (cooling)
- Unbalanced systems: contribution to ATES regeneration

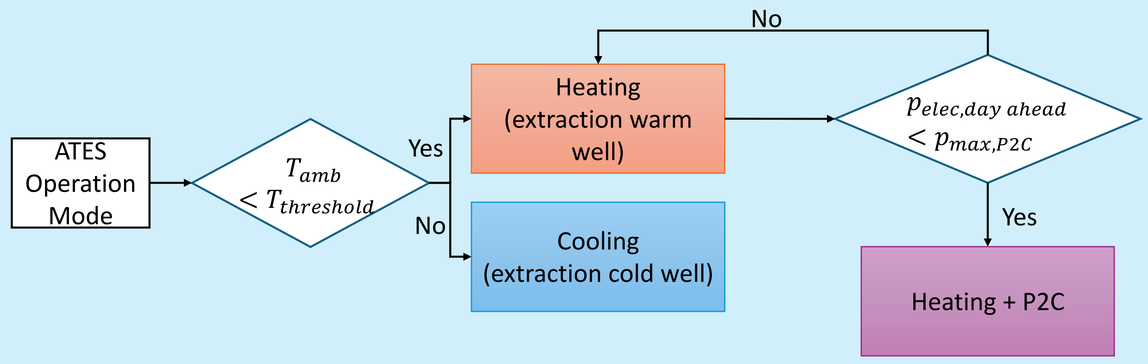
Case study: **Delft Campus South**

- Demand space cooling > demand space heating
- Heat pumps (HP) needed for space heating
- Excess electricity available + ATES in heating mode
  ➡ P2C Operation

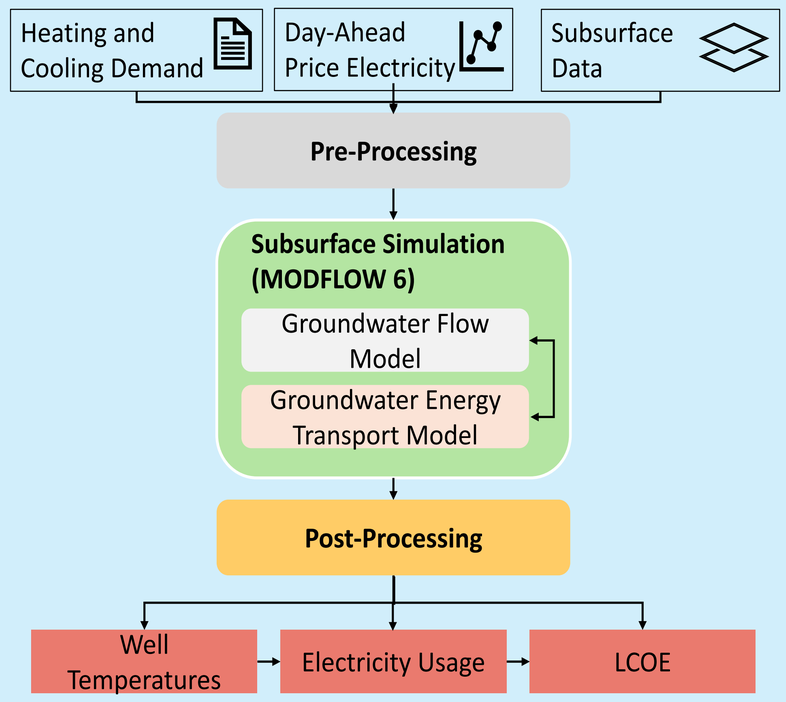


METHODOLOGY

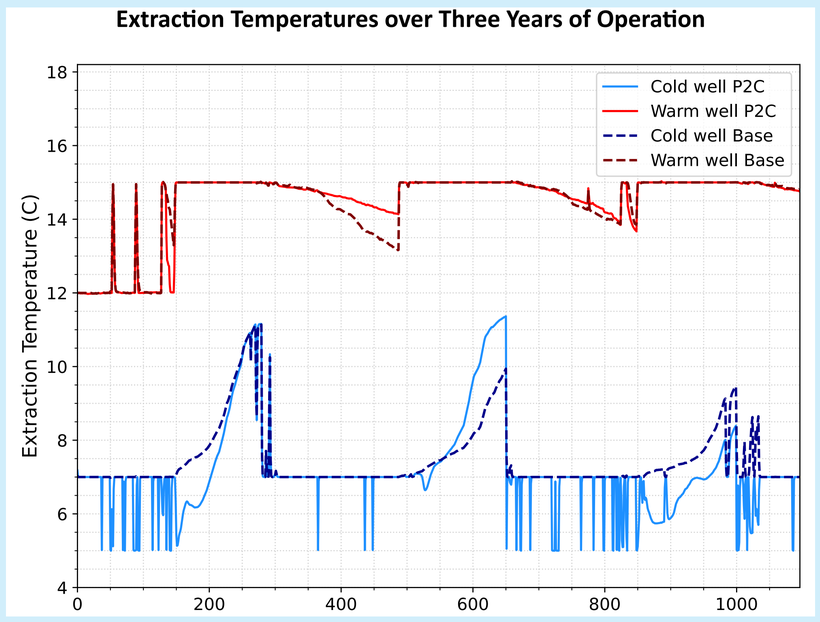
The mode of operation of the ATES depends on ambient temperature and the day-ahead price of electricity:



Scenarios consists of demand profiles generated based on yearly demands and temperature data, electricity prices and site specific subsurface data.



RESULTS



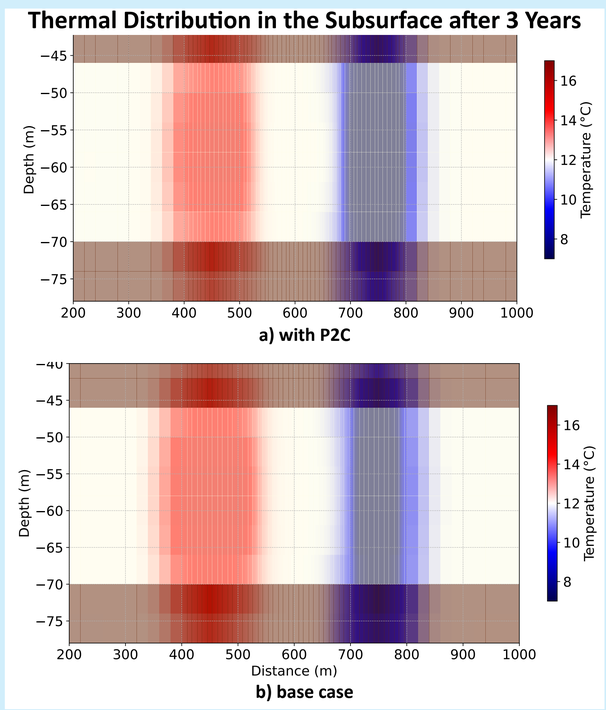
P2C Effect on Temperature Levels:

- Increase in maximal thermal radius
- **Lower extraction temperatures** cold well
- Regeneration at times with excess electricity
- **Higher thermal losses** in the aquifer and the confining layers
- Year 2 with P2C: temperature spikes at cold well
  ➡ insufficient regeneration before cooling period

because price steers regeneration

P2C Effect on Costs for Heating and Cooling:

- Peaks reduced and demand shifted to off-peak hours
- Yearly **decrease operational costs** 5%-10%
- **LCOE** for Thermal Storage with P2C: 19.19€/MWh
- Dependent on electricity price



DISCUSSION

The results strongly depend on the chosen threshold for the day-ahead price, which determines when P2C is applied. Possible deviations from predictions of electricity prices and the demand for heating and cooling create uncertainty in the performance of ATES as a flexibility. A sensitivity analysis quantifies these uncertainties and their effect on temperature levels and the costs for heating and cooling. The case study shows daily switches between P2C and regular operation. Too 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 heating and cooling towards off-peak hours in cooling dominated systems. This decouples the heating and cooling system from the electricity grid and leads to lower operational costs 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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