# Aquifer Thermal Energy Storage: A Seasonal Storage System*

**Vahab Rostampour*, Martin Bloemendal°, Tamás Keviczky***

## Main Objective

Refinement of the ATES system in [1] to allow well depletion and startup phase for new installations

## Building Climate Comfort Control: Imbalance Error Dynamics

Status of Energy Content of Warm Well

$$\eta^h_k := \begin{cases} 1 & s^h_{a,k} \leq 0 \\ 0 & s^h_{a,k} > 0 \end{cases}$$

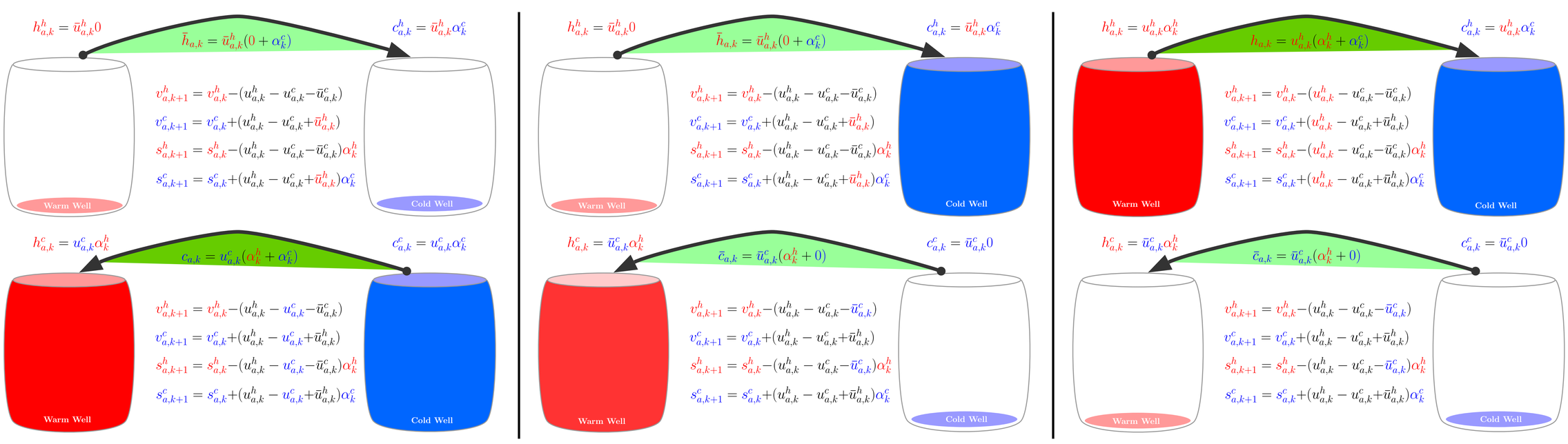
$$x^h_{k+1} = x^h_k + h_{b,k} + (1-\eta^h_k)h_{a,k} + \eta^h_k \bar{h}_{a,k} - w_{h,k}$$

$$x^c_{k+1} = x^c_k + h_{c,k} + (1-\eta^c_k)c_{a,k} + \eta^c_k \bar{c}_{a,k} - w_{c,k}$$

Status of Energy Content of Cold Well

$$\eta^c_k := \begin{cases} 1 & s^c_{a,k} \leq 0 \\ 0 & s^c_{a,k} > 0 \end{cases}$$

## ATES System Dynamics




## Simulation Results

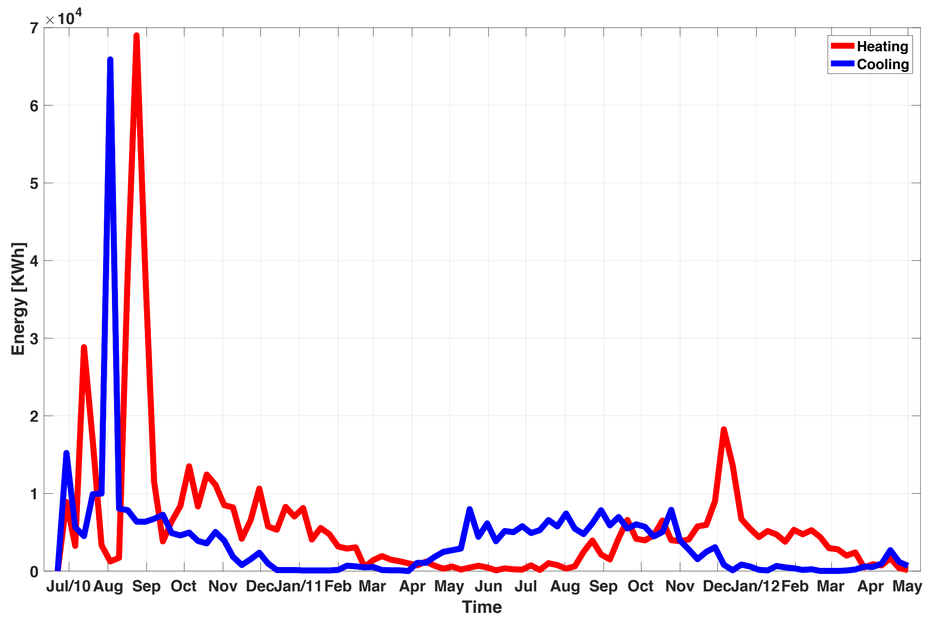



**Figure 1:** Imbalance Error Dynamics

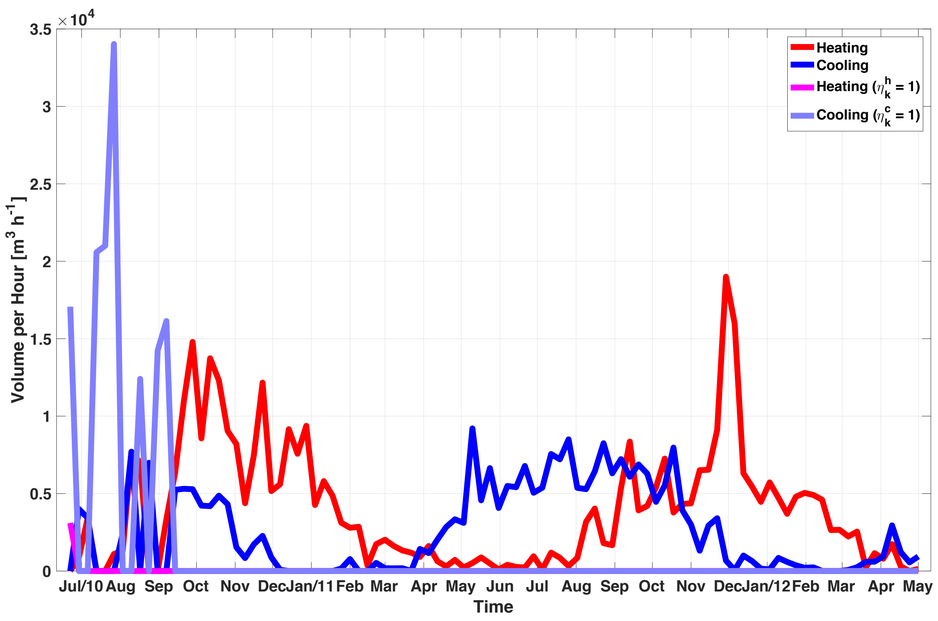



**Figure 2:** Pump Flow Rate of ATES System

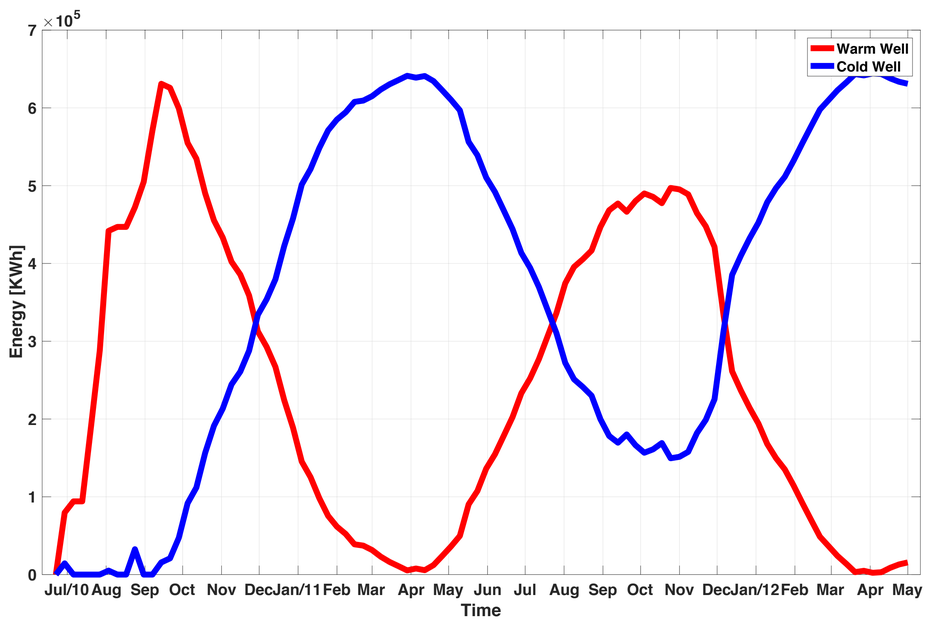



**Figure 3:** Energy Content of ATES System

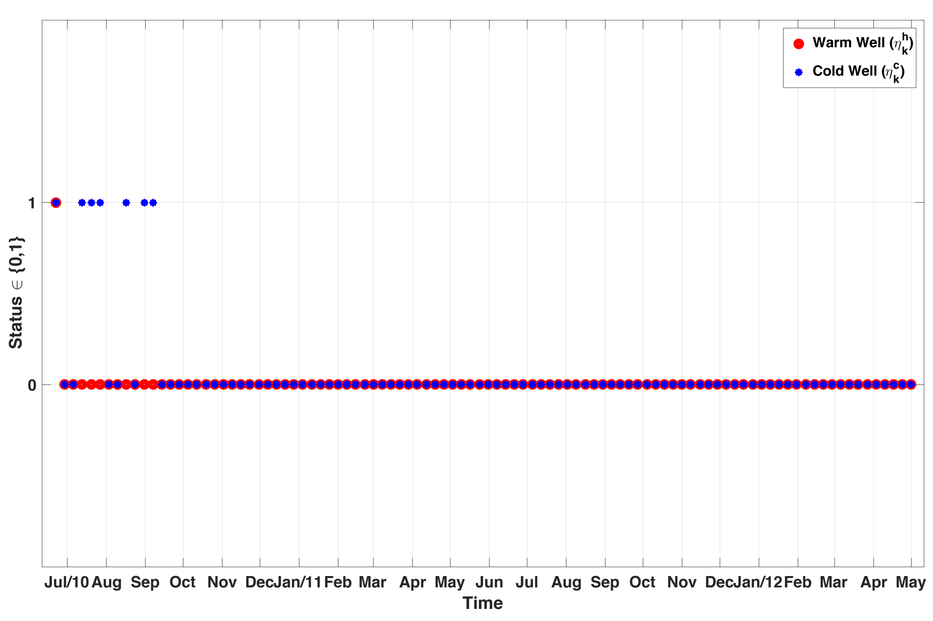



**Figure 4:** Status Change of Energy Content of ATES System

**Discussion:** Fig.1 presents the imbalance error dynamics of building climate control system. Having a positive imbalance error illustrates that we achieve the desired building comfort. In Fig.2, we show the pump flow rate of ATES system during all above situations. Fig.3 depicts the energy content of ATES system and it is specifically interesting, since it starts with empty energy content and continues to work as in the normal case. Fig.4 shows the status change of energy content of ATES system and it can be clearly seen that when wells have no energy, as it is shown in Fig.3, their status are 1.

**Conclusions:** development of a novel ATES representation using a mixed logical dynamical (MLD) system model and a stochastic model predictive control (SMPC) approach to maintenance the desired comfort for a building climate control system

**References:**

[1] V.Rostampour and T.Keviczky, Energy Management for Building Climate Comfort in Uncertain Smart Thermal Grids with Aquifer Thermal Energy Storage, Appear to IFAC World Congress 2017

* European Geosciences Union General Assembly, Vienna, Austria, 23-28 April 2017.

* Delft Center for Systems and Control, Delft University of Technology, The Netherlands.
° Faculty of Civil Engineering and Geosciences, Delft University of Technology and KWR Watercycle Research Institute, Groningenhaven, The Netherlands.