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Aquifer Thermal Energy Storage for Seasonal Thermal Energy Balance

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Aquifer Thermal Energy Storage (ATES) systems allow storing large quantities of thermal energy in subsurface aquifers enabling significant energy savings and greenhouse gas reductions. This is achieved by injection and extraction of water into and from saturated underground aquifers, simultaneously. An ATES system consists of two wells and operates in a seasonal mode. One well is used for the storage of cold water, the other one for the storage of heat. In warm seasons, cold water is extracted from the cold well to provide cooling to a building. The temperature of the extracted cold water increases as it passes through the building climate control systems and then gets simultaneously, injected back into the warm well. This procedure is reversed during cold seasons where the flow direction is reversed such that the warmer water is extracted from the warm well to provide heating to a building.

From the perspective of building climate comfort systems, an ATES system is considered as a seasonal storage system that can be a heat source or sink, or as a storage for thermal energy. This leads to an interesting and challenging optimal control problem of the building climate comfort system that can be used to develop a seasonal-based energy management strategy. In [1] we develop a control-oriented model to predict thermal energy balance in a building climate control system integrated with ATES. Such a model however cannot cope with off-nominal but realistic situations such as when the wells are completely depleted, or the start-up phase of newly installed wells, etc., leading to direct usage of aquifer ambient temperature.

Building upon our previous work in [1], we here extend the mathematical model for ATES system to handle the above mentioned more realistic situations. Using our improved models, one can more precisely predict system behavior and apply optimal control strategies to manage the building climate comfort along with energy savings and greenhouse gas reductions.

[1] V. Rostampour and T. Keviczky, “Probabilistic Energy Management for Building Climate Comfort in Smart Thermal Grids with Seasonal Storage Systems,” arXiv [math.OC], 10-Nov-2016.