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High Temperature ATES in combination with power-to-heat: maximizing renewable energy use for a local energy system

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To reduce worldwide greenhouse gas (GHG) emissions, fossil fuels are being replaced by renewable energy in a rapid tempo. As a result, the energy system becomes more decentralized with e.g. PV systems as a source for local multi-energy systems, with aim to become as self-sustainable as possible. This is challenging because these systems often rely on an intermittent energy source (production mainly in summer), which is not aligned with energy demand (mainly in winter). One solution for this problem is the combination of power-to-heat (PtH) with High Temperature Aquifer Thermal Energy Storage (HT-ATES), which allows for flexible and effective utilisation and storage of available green electricity to match the availability and demand of sustainable electricity. Currently, insights in the practical potential of this solution and methods for effective integration of PtH and HT-ATES in multi-energy systems are lacking. Therefore, we assessed methods to improve the integration and control of a HT-ATES system and tested varying ways of integration for a local decentralized multi-energy system. To this end, we expanded and integrated a multi-energy system model with a numerical hydro-thermal model to dynamically simulate the functioning of the integrated HT-ATES. The impact of key design parameters (heat pump size, storage

temperature, cut-off temperature) on overall energy performance and the effect of different methods for integration of the local energy system were simulated and analysed.

Results show that the integration of HT-ATES with PtH allows for providing the local energy system with 100% of the yearly heat demand with a 25% smaller heat pump than without HT-ATES. Also, compared to Pth without storage, the yearly energy use pattern changes dramatically to match the availability of renewable electricity. An inventive mode of operation was designed which allows for lowering the threshold temperature of the HT-ATES by an innovative integration of the heat pump. This mode of operation increases the HT-ATES performance and decreases the overall costs of heat production. Overall, this study shows that the integration of HT-ATES in a multi-energy system is suitable to cost-effectively match annual heat demand and supply, and to increase local sustainable energy use. Solutions like these show high potential to decentralize energy production/use, to decrease pressure on the power grid and to increase total renewable energy use.

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