EGU25-5644, updated on 14 May 2025
https://doi.org/10.5194/egusphere-egu25-5644
EGU General Assembly 2025

Recycling of subsurface heat loss from thermal energy storage basins through geothermal trenches

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Seasonal thermal energy storage (sTES) is elementary for decarbonizing district heating systems in urban areas. To overcome related land use conflicts, the re-use of idle infrastructure or industrial facilities is proposed. Existing infrastructure and basins can be refurbished as large-scale heat storage devices. This avoids demolition efforts and construction costs for new concrete structures or the application of costly components (e.g., insulation layers). However, structures not specifically designed for sTES may experience notable challenges that compromise efficiency, including suboptimal geometries or interactions with shallow groundwater conditions.

Our study presents an innovative approach for dealing with increased heat losses of poorly insulated Reno-sTES facilities installed in shallow aquifers. In the groundwater downstream, we propose and test the installation of a geothermal trench that is connected via a geothermal heat pump with the same energy system. The objective is to optimize the technical performance and robustness of the sTES by integrating the ambient ground as an additional storage medium, and by “recycling” ambient heat loss. Using a further development of the previously presented STORE model [1,2]. For simulating water-gravel thermal energy storage, the effects of various (e.g., geometrical) geothermal trench setups are analyzed, revealing thermal impacts, ideal configurations, and optimal operation modes. Based on a synthetic study, we focus on both the performance of the geothermal trench and the Reno-sTES. The scenario analysis with generalized parameter settings (e.g., different groundwater regimes, geothermal trench operation schemes) reveals the applicability of this innovative approach for optimizing closed-loop, ground-based sTES implementations in practice.

References:

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