Detailed Axial Symmetrical Model of Large-Scale Underground Thermal Energy Storage

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INTRODUCTION:

- Large-scale thermal energy storage (TES) is a key component for transition to sustainable energy utilization in urban centers. Consequently, research has been ongoing to address TES modelling.
- However, the influence of TES on the surroundings is poorly investigated in literature.
- This paper describes the development of an axial symmetrical model for circular TES systems with its surrounding environment.

COMPUTATIONAL METHODS:

A numerical model consists of two component-level models is developed. One is TES model, which is developed as 1-D model, whereas the other one is an axial symmetrical 2-D model that is used to represent the surroundings. Extension of the model to 3D is in progress.

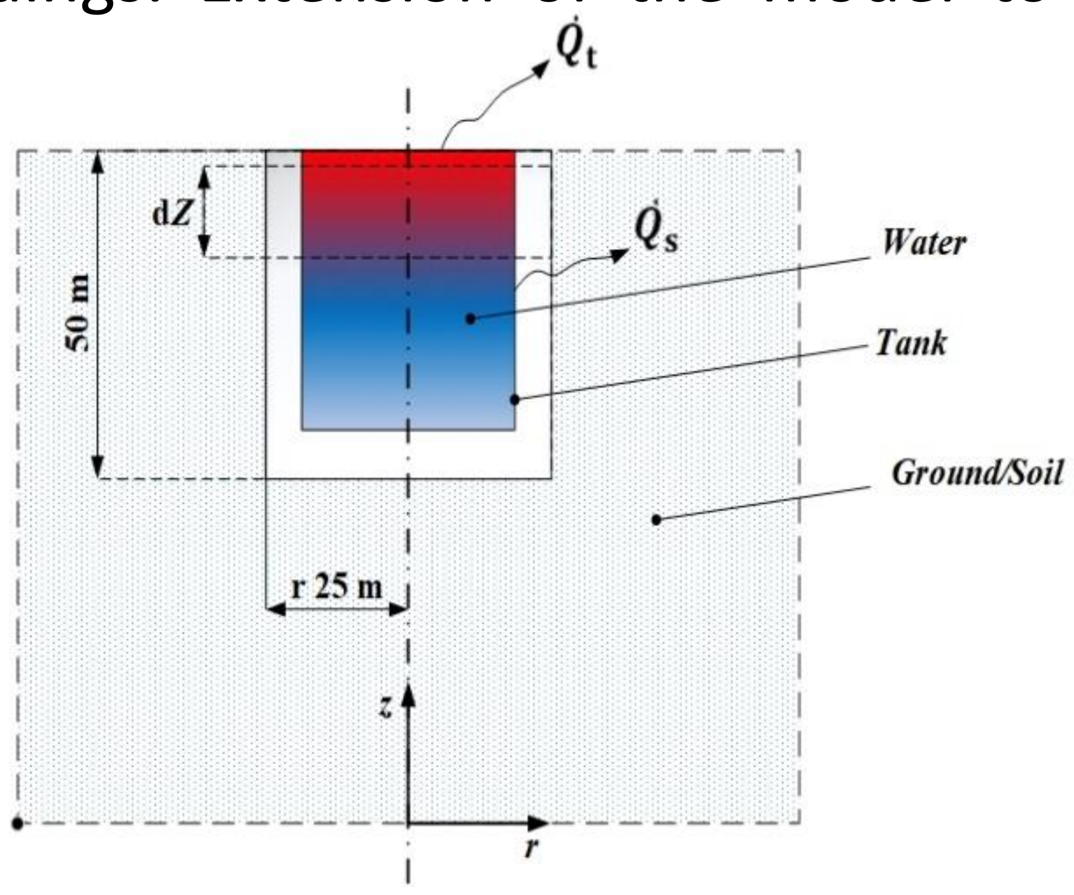

Figure 1. Schematic overview of an underground tank with its surroundings.

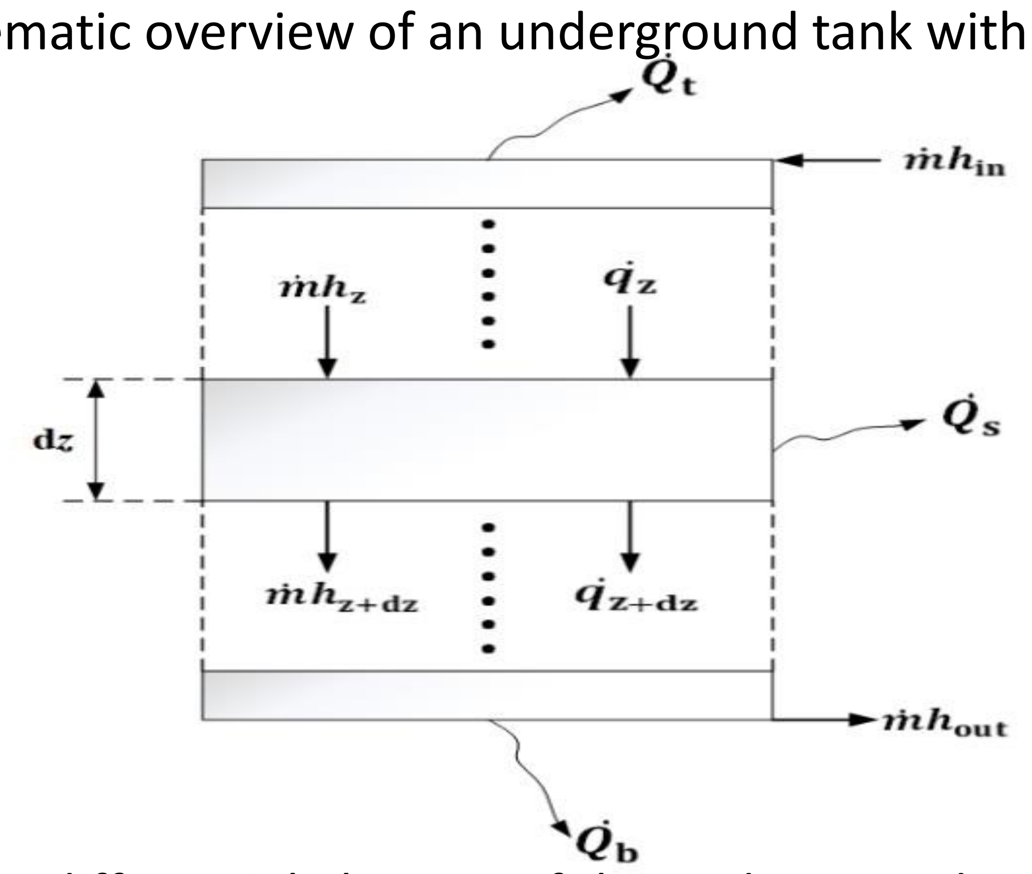

Figure 2. Finite differential element of the underground tank TES.

- Energy balance equation for TES is implemented using PDE interface.

$$d_a \frac{\partial T(t)}{\partial t} + \nabla \cdot (-c\nabla T) + \beta \cdot \nabla T = f$$

$$(\rho A c_p) \frac{\partial T(t)}{\partial t} = -(\rho A c_p v) \frac{\partial T(t)}{\partial z} + A\nabla \cdot (\lambda_w \nabla T)$$
$$-U \cdot (\pi d) \cdot (T(t) - T_{ground}(t))$$

RESULTS:

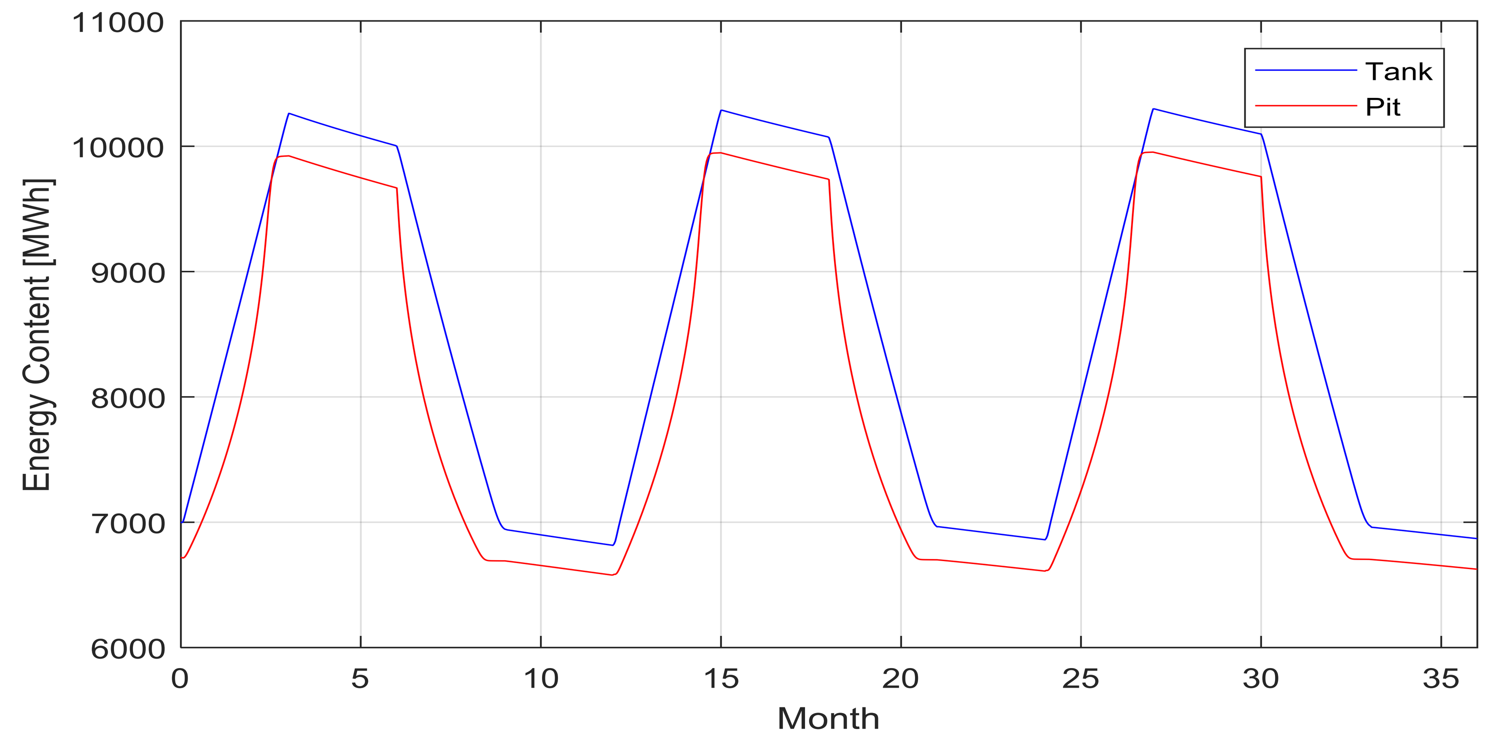

Figure 3. Energy stored in the underground storage over 36 months.

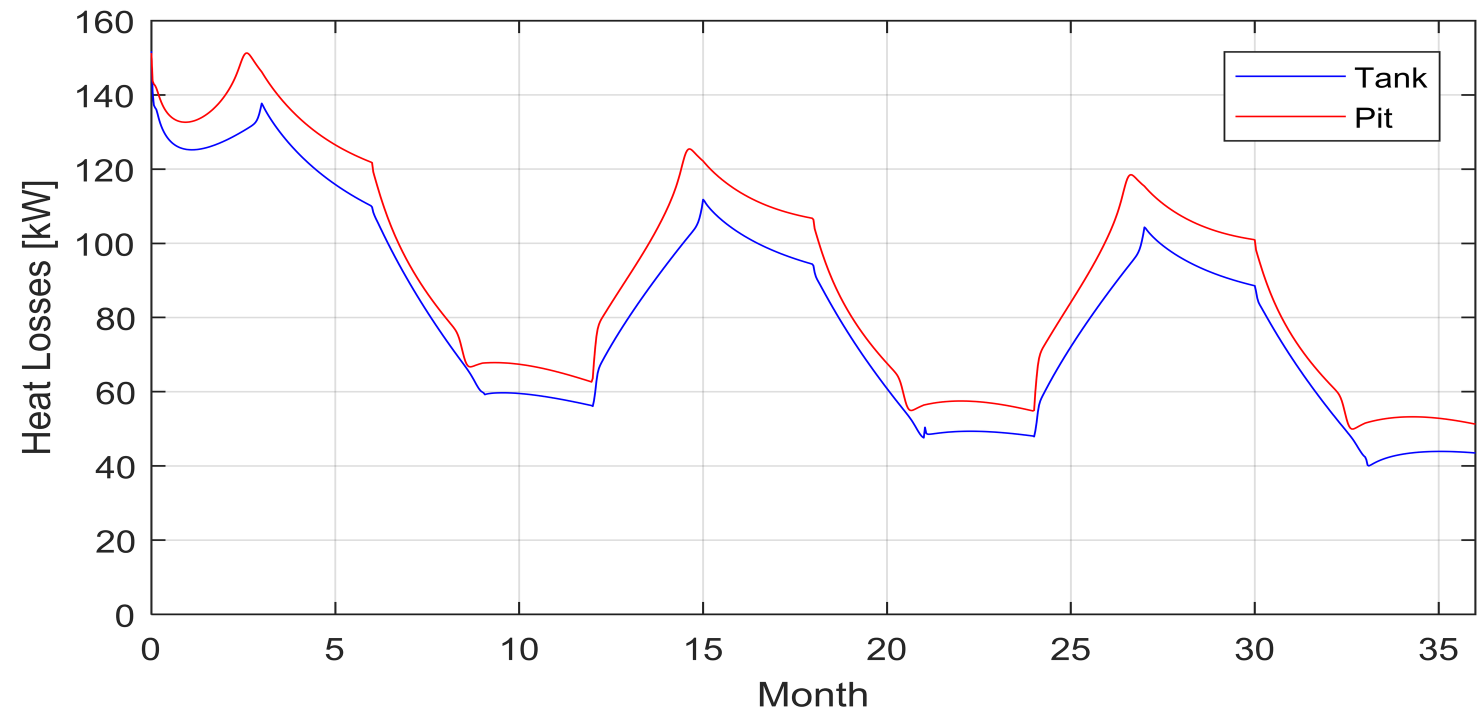

Figure 4. Heat lost from the underground storage over 36 months.

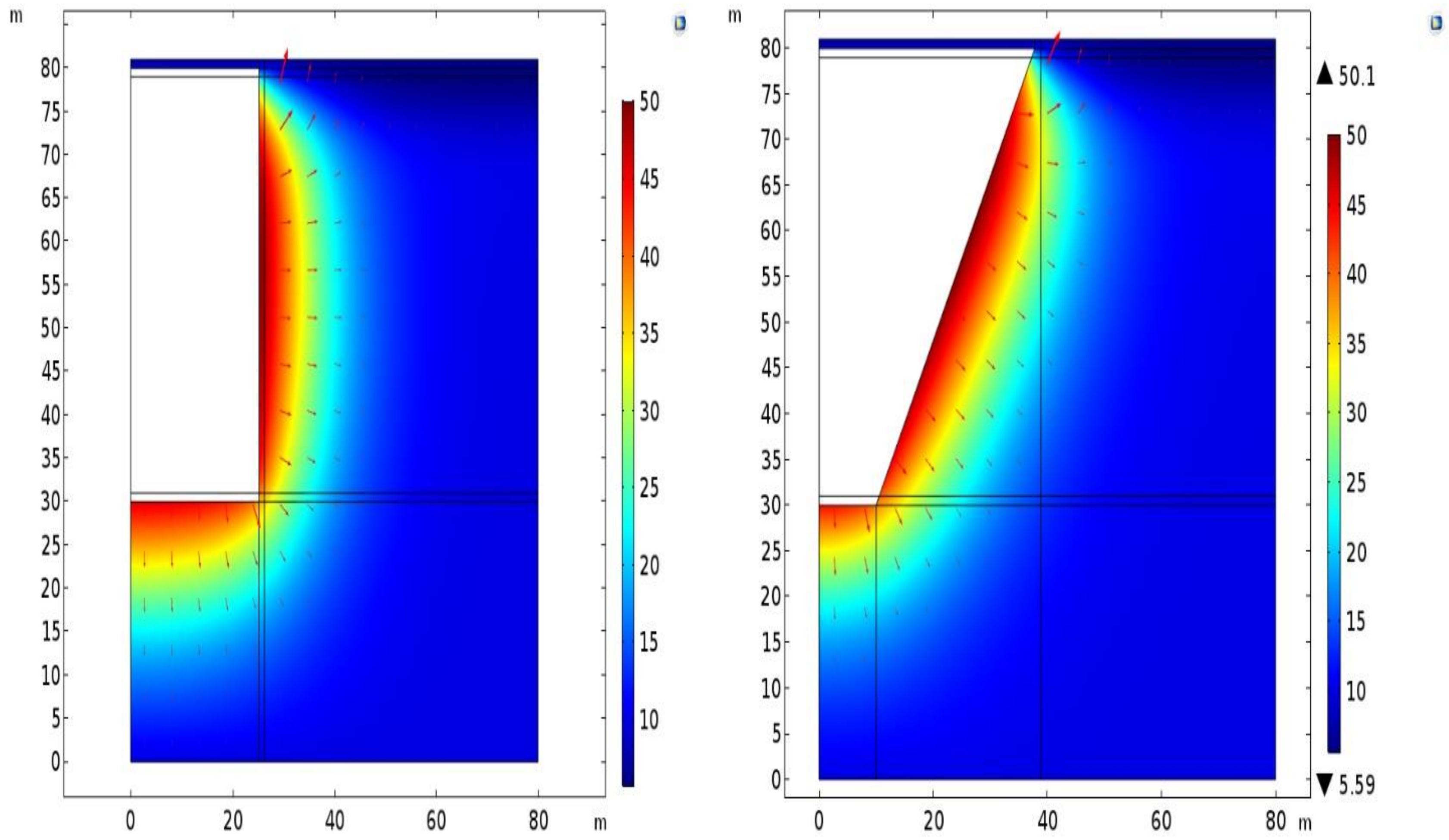

Figure 5. Contour plots for the surroundings of the tank (left) and the pit (right) TES at the end of the 3rd year.

CONCLUSION:

- The thermo-hydraulic behavior of the storage medium is correctly implemented and delivers qualitatively correct results. Validation of the model is ongoing.
- The ground is, depending on the level of insulation, highly influenced with surroundings temperature exceeds 40 ° C.

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