Coupled Heat Transfer in Borehole Heat Exchangers and Long Time Predictions of Solar Rechargeable Geothermal Systems

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An increased share of renewable energies is regarded as an integral part of a strategy towards a sustainable future.

Within the project Geo-Solar-WP we want to have a detailed look at the development of a system of three borehole heat exchangers (BHEs) in a triangular arrangement. We built COMSOL models to calculate the heat transfer between the BHEs and the thermal development of the system considering different subsurface flow conditions and the possibility of thermal recharging by solar heat collectors in summer.

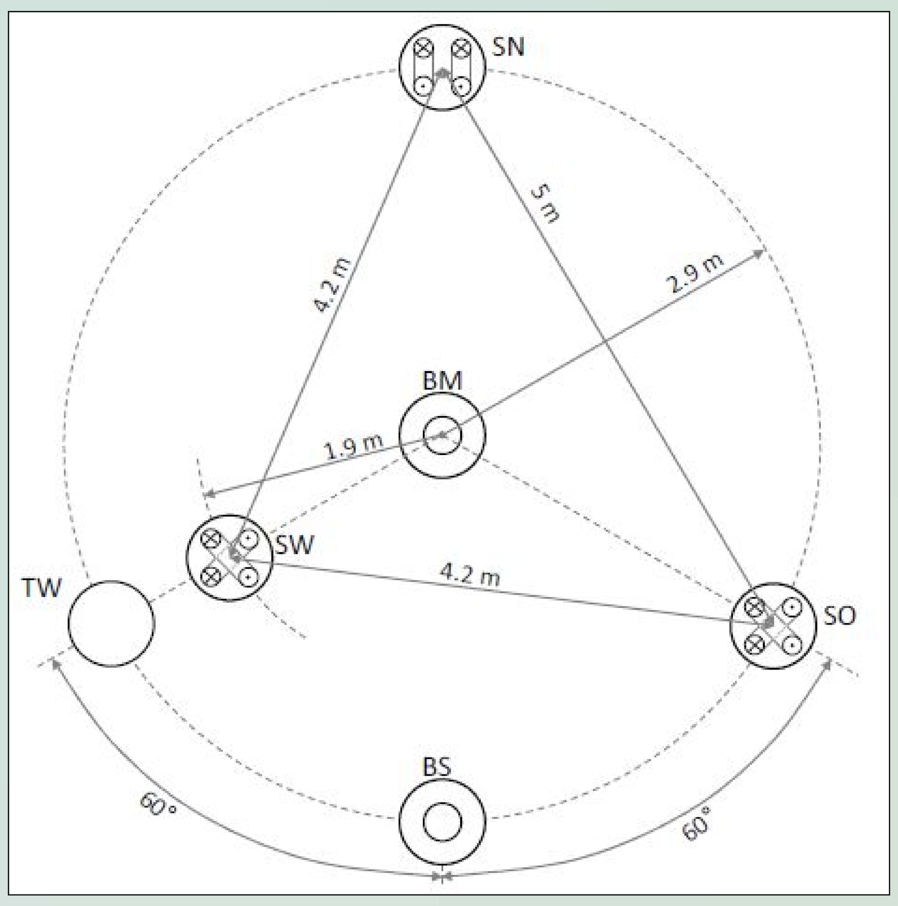


Figure 1. Top view on the test site at the ISFH

Governing Equations: Heat equation inside the pipes and outside in porous media:

$$(\rho C_p)_{eq}\frac{\partial T}{\partial t} + \rho C_p \vec{u}\cdot\nabla T = \nabla\cdot(k_{eq}\nabla T) + Q$$

The heat flow between the BHEs and the subsurface is calculated by introducing an effective thermal conductivity:

$$k_{eff}^{-1} = k_{pipe}^{-1} + k_{transition}^{-1} = \frac{1}{k_{pipe}} + \frac{1}{h\cdot r_i\cdot\log\left(\frac{r_o}{r_i}\right)}$$

Model Validation: Experimental test runs are used to validate the models. The results promise accuracy for further investigations.

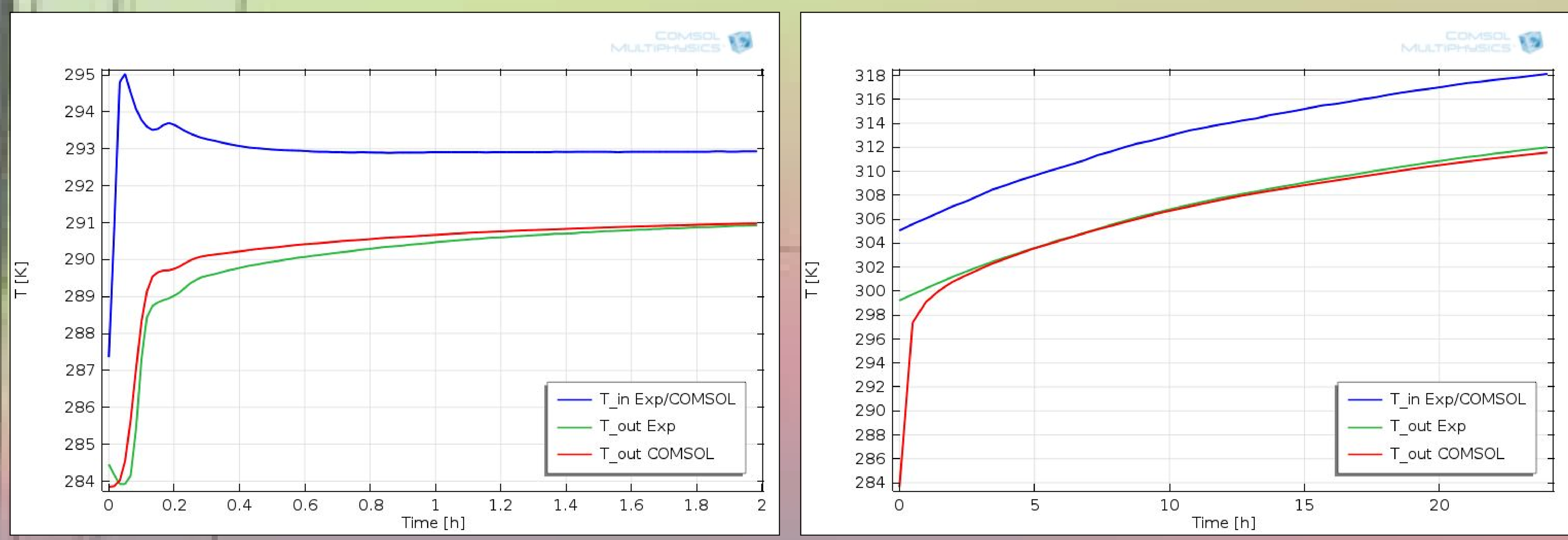


Figure 2a+b. Results of two experimental test runs and dedicated model results. The experimental inlet temperature and flowrate is taken as model input data. The outlet temperature is compared.

Thermal Recharging: Simulations show the influence of groundwater flow on the storability of heat in the subsurface.

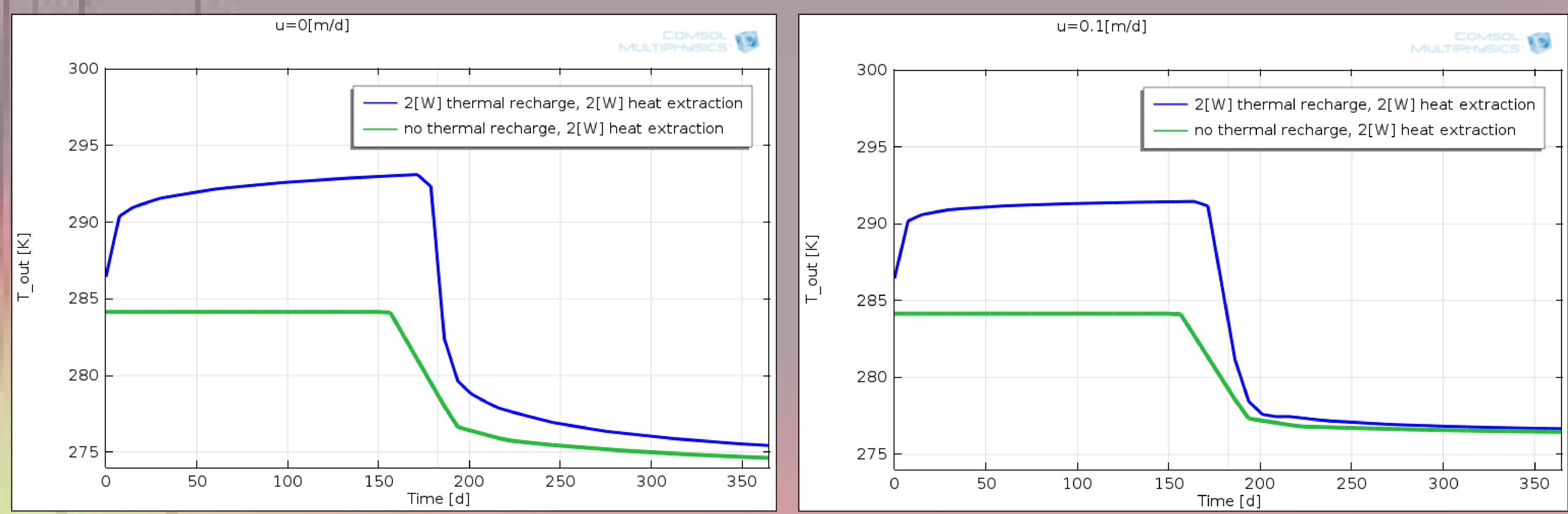
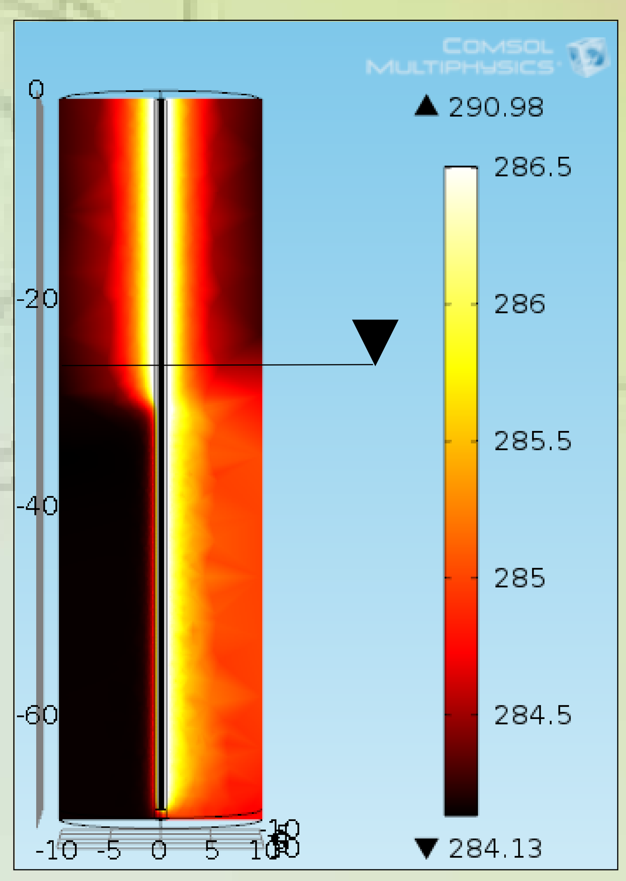
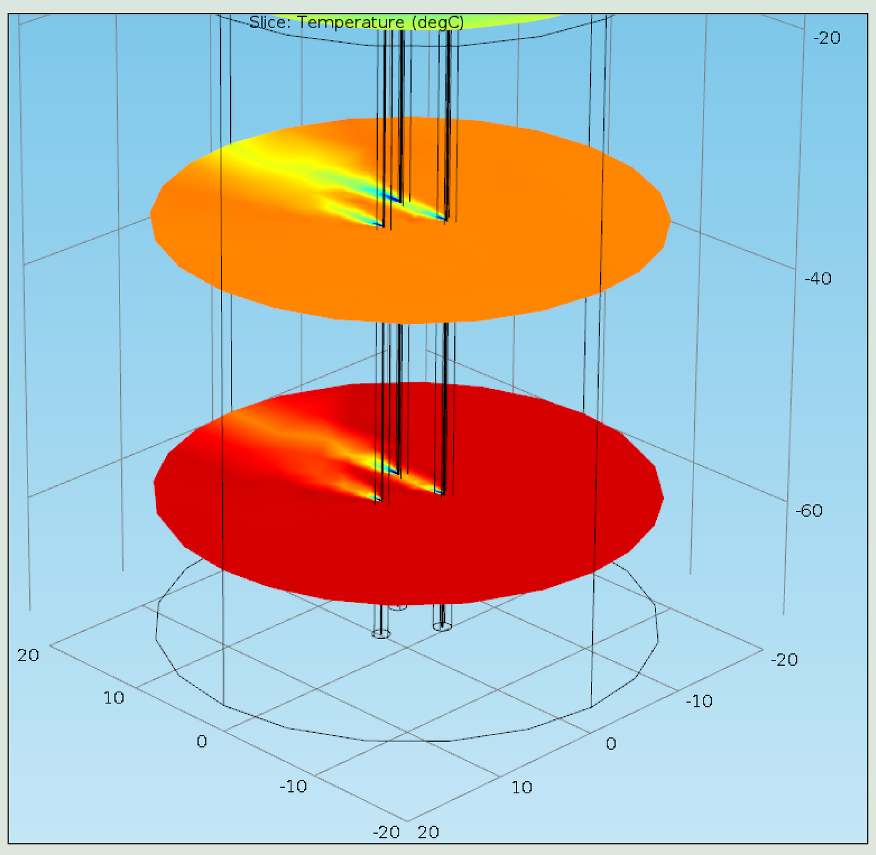


Figure 3a+b. Comparison of outlet temperatures for a one year simulation with and without previous thermal charging.
a: u=0[m/d], **b:** u=0.1[m/d]



The benefit of thermal heat storage gets partly lost when groundwater flow is a significant heat transport mechanism. Stored head is transported downstream and becomes unavailable for the BHE system.



Outlook: Since the models work promising we intend to add all three BHEs and to investigate the influence of thermal heat exchange between them. We will also try to use and compare the new *Pipe Flow Module* for the BHE simulation.

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