Chair of Renewable and Sustainable Energy Systems
TUM School of Engineering and Design
Technical University of Munich

Master’s Thesis / Research Internship

Optimization of vertical closed-loop geothermal systems using analytical models

Background

Domestic heating and cooling represent a significant part of the overall energy consumption. In order to reduce CO2 emissions, an increased share of heating and cooling has to be covered with renewable energy. One of the options being imposed are vertical ground source heat pumps (GSHPs) or closed-loop shallow geothermal systems. These systems can operate in single mode, for heating or cooling, or as seasonal storage, i.e. borehole thermal energy storage (BTES) (see Fig.1). In both cases, the efficiency of the system depends on its operation and the design of the borehole heat exchanger (BHE) field. Therefore, to maximize the efficiency of the system, the spatial design of the BHE field and the operation of the system should be optimized. The underlying physics of the resulting optimization problem is subsurface heat transport, which can be simulated with numerical or approximate analytical models. In several research studies [1-4], analytical models have already been used for the optimization of BHE fields.

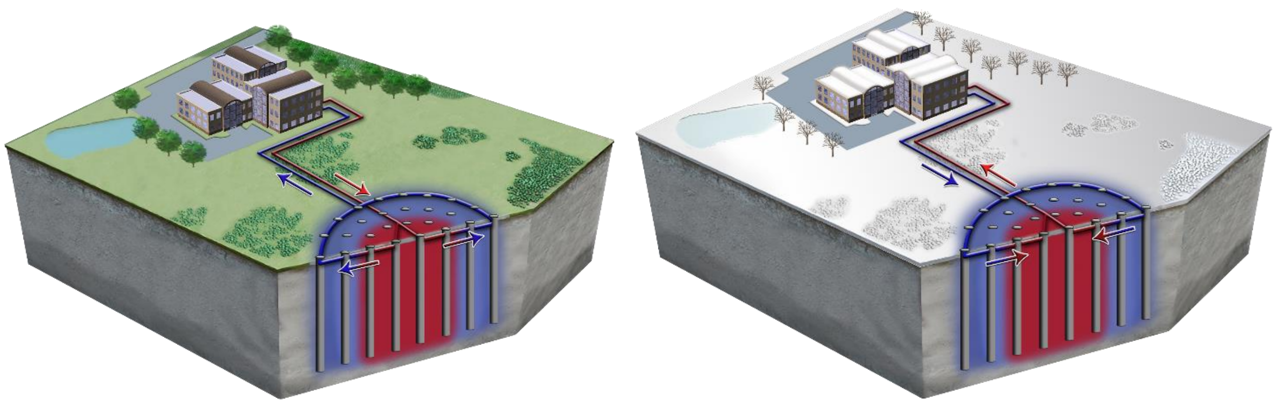

Fig.1. BTES operation in summer (left) and winter (right) [5].

Goals

The goal of this work is to develop and implement a new optimization approach for BHE fields based on analytical models of subsurface heat transport. In the first phase, the student will implement and test the existing optimization approaches. In the second phase, the student will implement and test an improved new optimization approach for BHE fields. If the previous phases are successful, there is the possibility of writing a publication, i.e. a paper-based final thesis report. The following tasks are included:

- Familiarizing with the functionality of GSHP/BTES and heat transport in subsurface (analytical models)
- Literature review on the existing optimization approaches of BHE fields
- Implementing and testing (some) existing optimization approaches
- Developing and implementing the new optimization approach
- Comparing the new and existing optimization approaches on a case study

Requirements

- Enrolled student in one of the master programs at TUM
- Interest in mathematical modeling and numerical optimization
- Programming skills: Python (other languages might be considered)
- Experience in numerical optimization (is a plus)
- Knowledge of GSHP/BTES or subsurface heat transport (is a plus)
- CV and current grade report (above average GPA)

What we offer

- Exposure to state of the art research topics
- An international and multidisciplinary working environment
- Opportunity to publish in international journals
- Possibility of paper-based thesis

Contact

Smajil Halilovic, M.Sc.
Lichtenbergstr. 4a, 85748 Garching b. München, Raum 2016
E-Mail smajil.halilovic@tum.de

Literature

[1] Beck, M., Bayer, P., de Paly, M., Hecht-Méndez, J., & Zell, A. (2013). Geometric arrangement and operation mode adjustment in low-enthalpy geothermal borehole fields for heating. *Energy*, *49*, 434-443.
[2] de Paly, M., Hecht-Méndez, J., Beck, M., Blum, P., Zell, A., & Bayer, P. (2012). Optimization of energy extraction for closed shallow geothermal systems using linear programming. *Geothermics*, *43*, 57-65.
[3] Hecht-Méndez, J., De Paly, M., Beck, M., & Bayer, P. (2013). Optimization of energy extraction for vertical closed-loop geothermal systems considering groundwater flow. *Energy Conversion and Management*, *66*, 1-10.
[4] Bayer, P., de Paly, M., & Beck, M. (2014). Strategic optimization of borehole heat exchanger field for seasonal geothermal heating and cooling. *Applied Energy*, *136*, 445-453.
[5] https://underground-energy.com/our-technology/btes/