Modeling of Borehole Thermal Energy Storage Systems (BTES) for integration in grid simulations to investigate flexibility options

Timea Kostner[a] , Kai Zosseder[a]

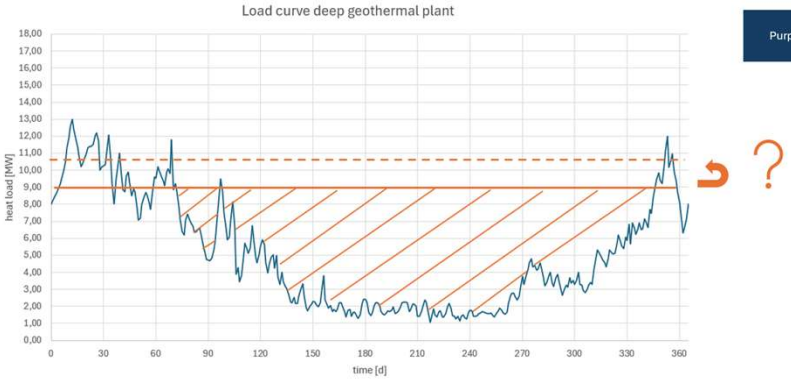
[a]Chair of Hydrogeology, Geothermal Energy Group, Technical University of Munich, Arcisstr. 21, 80333 Munich, Germany

Introduction

- FlexGeo project integrates geothermal energy with underground thermal energy storage (UTES) for enhancing the flexibility
- Coupling HT-BTES (High Temperature-Borehole Thermal Energy Storage) with grid simulations needed to quantify flexibility potential

Research aims

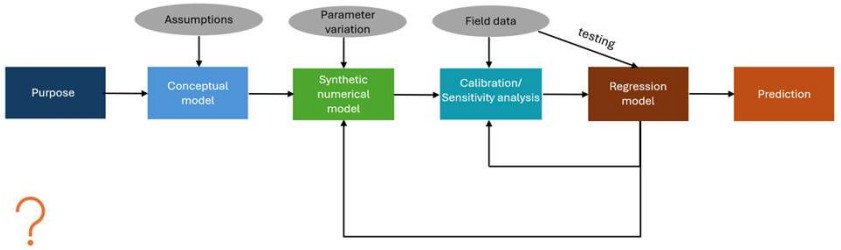
- Regression model provides general formula for multiple scenarios
- Model can be coupled with grid simulations
- Focus: improving district heating system flexibility at different sites
- Workflow predicts efficiency & thermal output of HT-BTES storages over time
- Enhances confidence in renewable energy meeting future energy needs



Methods

- Develop conceptual & calibrated numerical BTES models
- Perform sensitivity analysis to identify key influencing parameters
- Vary geological parameters, source temperatures, load curves, and operational constraints
- Analysis of parameter matrix to create a regression model
- Use predictions from numerical models in grid models to evaluate flexibility options

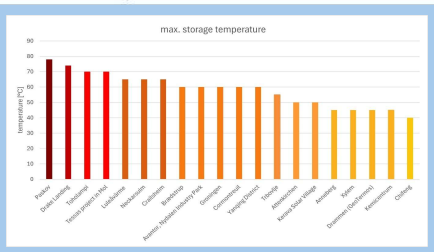
Workflow



Knowledge

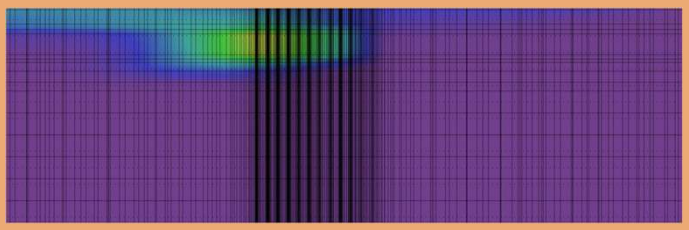
Literature review results

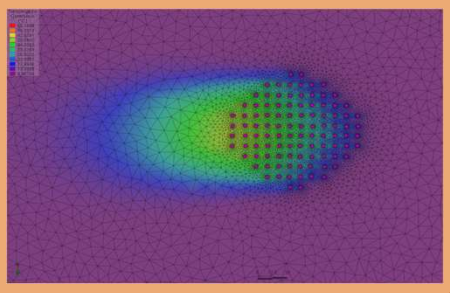
- Comprehensive literature review of 21 HT-BTES worldwide
- derive parameter ranges which reflex the use of HT-BTES at the moment
- HT-BTES with storage temperatures above 40°C up to 80°C
- Storage efficiency up to 66%
- Heat sources: industrial waste heat, solar collectors, biomass
- Systems depth: 20-280 m
- Probe spacing: 2-7 m
- Thermal conductivity of underground: 1.1-3.6 [W/mK]
- Volumetric heat capacity: 1.9-2.85 [MJ/(m^3/K)]

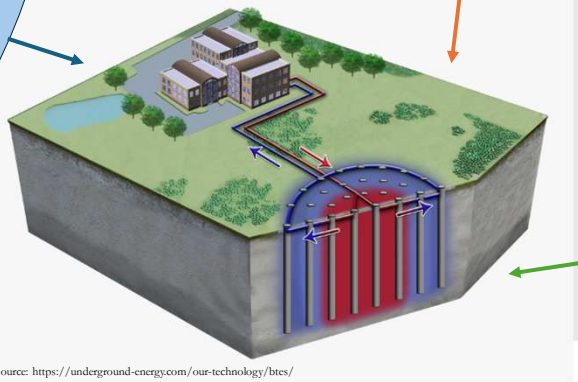


Modeling in Feflow

- Slow reaction for fluctuations
- Grid data must be smoothened
- Very sensitive to hydrogeological parameters as groundwater flow







Source: https://underground-energy.com/our-technology/btes/

Needed data

- Reservoir parameters
- Technical parameters
- Operational parameters

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Timea Kostner
timea.kostner@tum.de