A modular approach to inverse modelling of a district heating facility with seasonal thermal energy storage

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Publication date: 2017

Citation for published version (APA):
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Introduction

We develop a TRNSYS model for a district heating plant in Brædstrup, Denmark (see Fig. 1). Model parameters for the renewable components are estimated by applying inverse modelling to one year of operational data. Each component is calibrated separately as exemplified below for the borehole thermal energy storage (BTES). For the analysis of the remaining components please refer to our full paper in the conference proceedings.

Inverse modelling example - BTES

Model parameters for the BTES are the storage heat capacity (C) and borehole thermal resistance (Rb). Optimum parameters are identified by minimising the objective function

\[ \varphi = \sum (T_{\text{out}}(s) - T_{\text{out}}(m))^2 \]  

It is important to preheat the BTES in TRNSYS so that for simulation time \( t < 0 \) the storage average temperature is

\[ T_{\text{BTES}} = \frac{T_{\text{max}} + T_{\text{min}}}{2} + \frac{T_{\text{max}} - T_{\text{min}}}{2} \sin(\omega(t + \theta)) \]  

We estimate \( T_{\text{max}} \), \( T_{\text{min}} \) and the phase \( \theta \) based on historical data before minimising the objective function in Eq. (1) to obtain a storage specific heat of 2.00 MJ/m³/K and borehole thermal resistance of 0.018 m·K/W.

The simulated energy is compared to observations in Fig. 2.

Fig. 2: Simulated and observed energy injected and extracted from the storage. Simulation start time is January 1st 2014. The first approximately 80 days corresponds to energy extraction.

Conclusion

We have developed a TRNSYS model for a district heating facility by applying inverse modelling to one year of operational data for each component in the system.

We collect the optimised components in a single model of the full system using the tanks as a central hub. The full model yields a simulation error of 7.1 % for the delivered energy.