

Accepted Manuscript

An improved method for upscaling borehole thermal energy storage using inverse finite element modelling

K.W. Tordrup, S.E. Poulsen, H. Bjørn



PII: S0960-1481(16)31060-6

DOI: [10.1016/j.renene.2016.12.011](https://doi.org/10.1016/j.renene.2016.12.011)

Reference: RENE 8348

To appear in: *Renewable Energy*

Received Date: 21 December 2015

Revised Date: 2 December 2016

Accepted Date: 5 December 2016

Please cite this article as: Tordrup KW, Poulsen SE, Bjørn H, An improved method for upscaling borehole thermal energy storage using inverse finite element modelling, *Renewable Energy* (2017), doi: 10.1016/j.renene.2016.12.011.

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

1 An improved method for upscaling borehole thermal energy 2 storage using inverse finite element modelling

3 K. W. Tordrup*, S. E. Poulsen and H. Bjørn.

4 Centre of Applied Research and Development in Building, Energy & Environment, VIA University College,
5 8700 Horsens, Denmark

6 *Corresponding author: kart@via.dk (K. W. Tordrup)

7 **Abstract**

8 Dimensioning of large-scale borehole thermal energy storage (BTES) is inherently uncertain due to the
9 natural variability of thermal conductivity and heat capacity in the storage volume. We present an improved
10 method for upscaling a pilot BTES to full scale and apply the method to an operational storage in Brødstrup,
11 Denmark. The procedure utilizes inverse 3D finite element method (FEM) modelling of distributed
12 temperature measurements inside the BTES for inferring the thermal properties of the subsurface. We find
13 that individual geological layers can be distinguished in terms of their heat capacities and thermal
14 conductivities using inverse modelling. The depth integrated estimate of thermal conductivity differs
15 significantly from that obtained from a single thermal response test (TRT) at the site. As such, we find
16 significant scaling effects in terms of the subsurface thermal conductivity distribution which are expected to
17 be further amplified in an expansion of the pilot BTES to full scale. The methodology presented in this paper
18 therefore provides an improved basis for upscaling pilot BTES systems. The operational data and BTES
19 temperature measurements are published with the present paper in the supplementary material.

20 **Keywords:** borehole thermal energy storage, numerical modelling, inverse modelling, model validation,
21 thermal conductivity, dimensioning

22 **1. Introduction**

23 Large-scale thermal solar collector arrays are currently being integrated into the district heating networks in
24 Denmark in order to increase the fraction of renewable energy of total heat consumption. Since solar energy
25 production peaks in the summer when heat consumption is low, storage is required for effective balancing of
26 seasonal fluctuations in energy demand and consumption. In addition, the increased production of wind
27 power makes it economically feasible to produce heat by means of heat pumps or electrical boilers when the
28 price of electricity is low, which further increases the need for heat load balancing. In Denmark, district
29 heating networks with large solar collector arrays are typically balanced by a combination of accumulation
30 tanks and hot water pit storage. Currently, the district heating networks in Denmark incorporate more than
31 80, large-scale solar thermal arrays with either pit or tank storage systems [1].

Download English Version:

<https://daneshyari.com/en/article/4926412>

Download Persian Version:

<https://daneshyari.com/article/4926412>

[Daneshyari.com](https://daneshyari.com)