EGU24-16828, updated on 07 Dec 2024
https://doi.org/10.5194/egusphere-egu24-16828
EGU General Assembly 2024
© Author(s) 2024. This work is distributed under
the Creative Commons Attribution 4.0 License.

A case study on the use of AI methods towards bridging the gap between design and operation of ground-source heat pump systems.

Nikolas Makasis[1,2], Monika Kreitmair[1,2], Chaoqun Zhuang[3], Kathrin Menberg[4], Wonjun Choi[5], and Ruchi Choudhary[2,3]
[1]The University of Surrey, United Kingdom of Great Britain – England, Scotland, Wales (n.makasis@surrey.ac.uk)
[2]The University of Cambridge, United Kingdom of Great Britain – England, Scotland, Wales
[3]The Alan Turing Institute, United Kingdom of Great Britain – England, Scotland, Wales
[4]Karlsruhe Institute of Technology, Germany
[5]Chonnam National University, South Korea

Shallow geothermal energy technologies have seen significant development over past decades and the number of ground-source heat pump (GSHP) installations has seen an increasing trend worldwide. Importantly, a plethora of scientific research has explored performance, mechanical stability, optimisation, and innovative approaches to utilise the ground as a source or sink of thermal energy. Despite this, however, there is often a gap between the designed performance of a system and the realised in-situ operation. Such a gap can result from a lack of information, such as imprecise ground profile/thermal properties, changes in the environment and conditions, such as in building usage due to changes in behavioural patterns, as well as the fact that GSHP design is typically undertaken in isolation of other system elements, e.g., by using only estimates of the heating and cooling demands.

Real-time monitoring and appropriate smart control methods can help bridge this discrepancy, alleviating potential issues. Heat pumps and building management systems typically record useful data, such as the temperature of the fluid in the ground loop, constituting valuable sources of information on the current system performance at a given moment. However, using these data to predict how the system will perform in the future, and thus inform system operation, is not trivial. A field that can help tackle this problem is data science, which uses data-driven artificial intelligence (AI) approaches to provide useful insights from data and has had tremendous advancements in recent years. It is therefore expected that statistical AI approaches can be used with data from GSHP systems meaningfully, to inform the efficient operation of the system.

This research focuses on a case study in Cambridge, UK, where a GSHP system, with capacity of 320 kW and a ground loop with 24 160-m deep boreholes, provides heating and cooling for a recently constructed university building. The data recorded from this system is utilised together with a combination of AI methods, such as gradient boosting and deep neural network predictive models, and finite element modelling to assess how well the ground loop performance can be

predicted in real time and the implications this can have on the performance of the system. Thus, this work demonstrates how GSHP data can be leveraged to make useful decisions based on updated information and thereby ensure that a GSHP system performs efficiently throughout its lifetime.