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GEOthermal Technology for economic Cooling and Heating

GEOTeCH

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Collaborative Project

Optimal operation of the systems

Executive Summary

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1. PUBLISHABLE EXECUTIVE SUMMARY

This document is the deliverable D4.7 "Optimal operation of the P&P dual-source heat pump systems" which describes the dynamical simulation models used for the analysis of control strategies, optimization of control strategies and parametric sensitivity analysis of key system operational and design parameters.

One of the key aims of the GEOTeCH project is to develop a 'Plug and Play' (P&P) small scale heat pump system solution that is adaptable to a wide range of small buildings in a range of climatic and ground conditions. This is possible because of the hybrid nature of the heat pump that is being developed and also because of the control system being developed. Development of a robust control system depends on firstly modelling whole system operation in a wide range of conditions.

Three different model approaches have been developed:

- UPVLC
- GROENHOLLAND
- KUL

These models were described in detail in deliverable D4,6, Global system model of plug & play installations. This report, deliverable D4.7, describes the results obtained with these models and summarizes the most promising candidates for the control algorithms and associated parameter settings.

After validation of the models based on a comparison between the models using a few selected benchmark cases, the models have been used to optimize different control implementations and analyze the sensitivity for different parameters. The results are used for the implementation in the central systems controller and also in the development of the design methodologies.

With the UPVLC model a detailed analysis has been made for the coupled behavior of the heat pump compressor and fan operation. With the Groenholland model, that performs a single calculation of one complete year in less than 30 seconds, more extensive optimizations and sensitivity analysis is possible. With the KUL model the coupled interactions between the P&P heat pump system and building is possible.

Main results achieved are:

1) The selection of air or ground as a source for the heat pump depends on the actual climatic and load conditions of the system. Therefore, the selection of an optimal offset in the P&P controller is needed. Also, the dead band around the offset is an important control parameters. In both cases the ground is favored as a source, due to the difference in pump and fan energy.

2) Optimal temperature differences on the source and user pump have been calculated.

3) Sensitivity analysis on the heating set point shows a significant effect on performance. For the control system it is important to be able to assess the lowest flow temperature at which comfort in the building is achieved.

4) Sensitivity analysis on the cooling set point shows a much smaller effect, even in a climate which has a significant amount of cooling.

5) Sensitivity analysis on the user and DWH tank volumes shows a significant effect of the user tank volume on overall performance. This may have to do with the on/off cycling of the heat

pump and may therefore be related to the frequency below which the system switches to on/off control.

6) The analysis of the effect of a variable temperature set point for frost limit (forced use of ground source) as a function of compressor frequency and/or fan speed. There turns out to be very little effect of varying the fan speed on the SPF, but varying the fan speed will result in more use of the ground as at lower fan-speeds the frosting limit is higher.

The work in this task has been mainly been accomplished by three partners: Groenholland, UPVLC and KUL. The distribution of work has been as follows:

GROENHOLLAND: task leader, coordination of the task and development of the reduced order model that will be implemented in the actual controller hardware. Groenholland has also developed a building model to calculate the thermal loads for the controller simulation (an office space with workshops).

UPVLC: developing a detailed model of the demo site control system and building thermal response, based on the B2G ground source model. Adaptation of the B2G model to the new heat exchangers developed in the project.

KUL: Will develop a detailed model for the control system based on another approach, mainly incorporating a RC-network approach for the borehole system modelling. This model will also be coupled to a dynamical building model of a standard house.

The relations to other activities in the GEOTeCH project:

Inputs:

- From WP3, T3.4 the spiral heat exchanger model and detailed validation data. (D3.2, numerical analysis of heat exchanger performance and D3.3 validation test results and heat exchanger performance data.)
- From WP4, T4.1.3 the heat pump prototype characterization (D4.5, Experimental results of prototype 1 and 3).

Outputs:

- The output of the global system model will be used in T4.2.3 to evaluate the control system performance.
- In T4.3, the results will be used to implement the control strategy in the supervisor controller hardware.
- In T4.4 the models and results will be used to define the systems design framework.