Geothermal Heat Pump System Operational Data: high frequency monitoring of a large university building

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Date: 29 September 2017.

This document provides commentry on the data made available from the PhD project "*Performance Analysis of a Large-scale Ground Source Heat Pump System" by S.Naiker.* This data was collected from the system operating in the Hugh Aston Building at De Montfort University, Leicester, UK. A Schematic of the system is shown below in Fig.1.

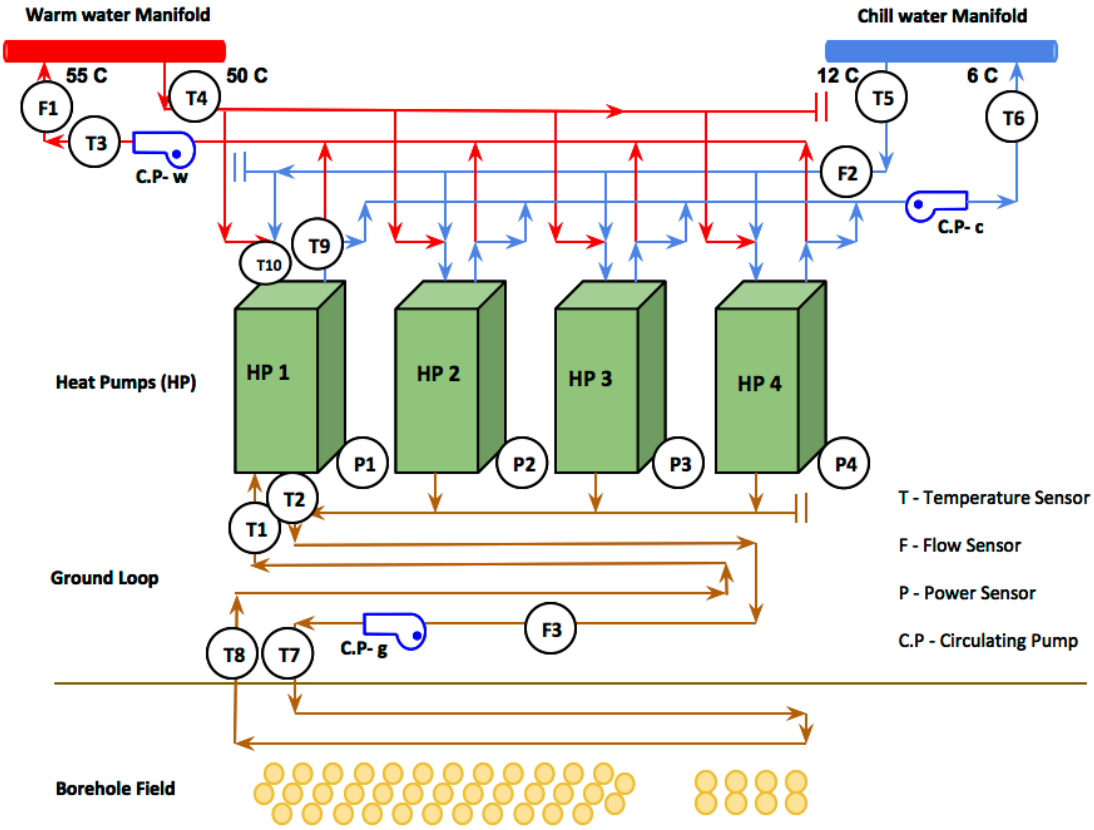

Figure 1. System schematic and monitoring points.

Ground Loop Data.

Data-set includes minutely measurement of flow temperature (°C), return temperature (°C), and flow rate (L/s) of the ground loop circulating fluid for the period of 3 years, 1 month, 1 day starting from 12/01/2010 17:12 to 13/02/2013 20:58. These data correspond to monitoring sensors T7 and &8 and F3 in the schematic. Due to size of the data-set, data-set is split into three separate files covering each individual year. Namely,

DMU_BHE_2010.xlsx
DMU_BHE_2011.xlsx
DMU_BHE_2012_2013.xlsx

The initial data-set included missing data due to various reasons. But some of the missing data were estimated and filled-in, and some were left unknown. Orange shade in the cell indicates the unknown values are estimated & filled-in, and the value -99.00000 indicates the unknown values are left unknown.

Key to read the data	
Measured Data (Temperature, Flow rate)	Measured Value
Data filled-in	Estimated Value
Data left unknown	-99.00000

The fluid properties of the circulating fluid vary with the temperature and concentration of the propylene glycol mixture, and its impact on the energy calculation is considered as minimum for the operating temperature range (10 – 20°C). The density of the circulating fluid is 1020 kg/m^3 for 20% propylene glycol mixture at 15°C, and the same value has been used in the validation exercise carried out by Naicker (2015). For more details on the parameters of the borehole and circulating fluid, please refer the thesis of Naicker (2015).

This numerical data is also available split into four ASCII files in CSV format. These are named:

Groundloop2010.csv
Groundloop2011.csv
Groundloop2012.csv
Groundloop2013.csv

Each file has a first line of comments marked with a '#' symbol. In these files, the first column is the time given in seconds. Note that times are numbered from the start of monitoring in each file. For example, the file Groundloop2011.csv has the first lines as follows:

```
# min, Ground Loop in (C), Ground Loop out (C), Flow Rate (l/s)
508729,13.873,13.850,0.000
508730,13.875,13.850,0.000
508731,13.874,13.855,0.000
```

Consequently, if these files are concatenated the times should for a correctly numbered series.

DMU Borehole array

The source side of the system is served by 56 boreholes, each with a diameter of 125 mm and depth of 100 meters. Fig. 2. shows the arrangement of borehole arrays. The average distance between two boreholes is around 5m, and the boreholes are in two arrays with 19 located outside the building and the remainder installed below the central courtyard. Each borehole has a U-tube inserted that consists of an SDR11 pipe with an outer diameter of 32 mm. The borehole is partly backfilled with drill cuttings and grouted over the top 25m. Grout thermal conductivity has been specified by the installation contractor to be 2.0 Wm^{-1}K^{-1}. The borehole heat exchanger is served by a variable-speed circulation

pump with flow rate capacity of 30 L/s. The flow is varied in four-speed steps depending on how many heat pumps are operating.

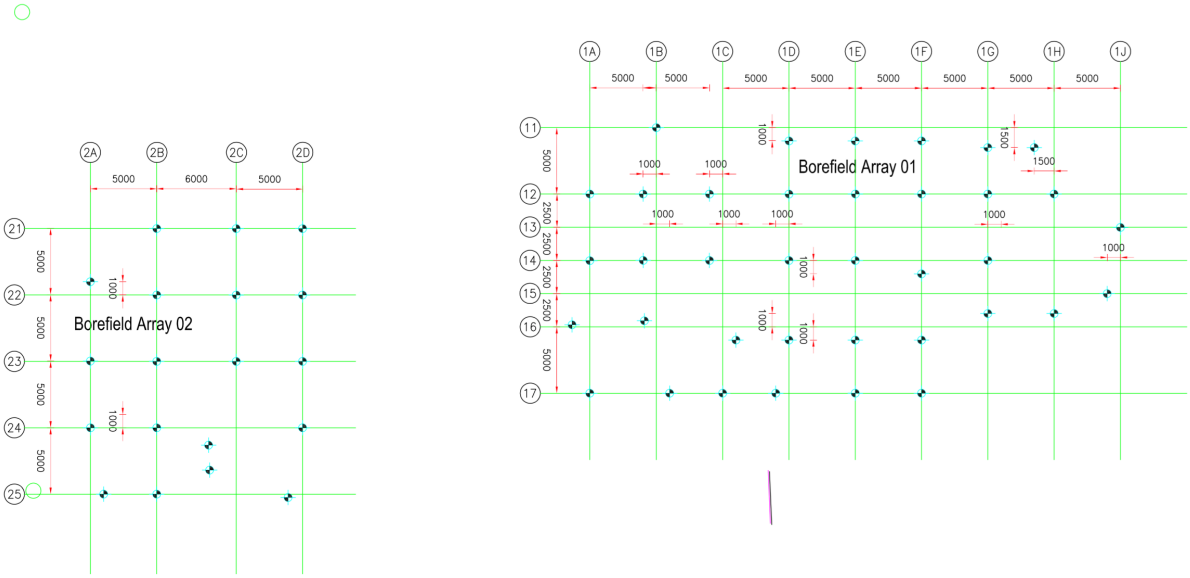

Figure 2. DMU geothermal borehole field layout (source: geothermal international, UK)

The TRT test data provided by the installation contractor (G.I.Energy) along with supplementary data is provided in the spreadsheet file: DMU_TRT.xlsx. A sheet 'key' is provided in this file with specific information about the tests and the data provided.

Heating and Cooling System Data

The following files are provided that contain data relating to heating and chilled water loops that connect the heat pumps with the distribution headers (temperature sensors T3-T6 in the schematic).

DMU_Heating_Loop.xlsx
DMU_Cooling_Loop.xlsx

Pump power calculated from the flow rate data and pump curved data (as discribed in the thesis) is provided in the following files. One column corresponds to the electrical demand and the other to the heat transferred to to fluid.

DMU_Heating_Circulating_Pump.xlsx
DMU_Cooling_Circulating_Pump.xlsx

Compressor power is recorded at half-hourly intervals. Different columns are given depending on whether the mode was cooling or heating. These data are aggregated from the four system power meters for the heat pumps.

DMU_Compressor_Power.xlsx

Missing Data

There are some short periods where it was necessary to fill-in some data or mark it as missing. How data was filled and which periods are either filled or missing is stated explicitly in Appendix C of the thesis. This is accordingly included with the data set.

For more details, please refer to the following PhD Thesis:

SS Naicker (2015) *Performance Analysis of a Large-scale Ground Source Heat Pump System*. (PhD Thesis). De Montfort University, UK. [online]. Available from: https://www.dora.dmu.ac.uk