Geoserv

GRUOUND LOOP SIZING REPORT

‘Irish Ground Thermal Properties Project 2'

Client Ref: RDD/00045

SUSTAINABLE ENERGY AUTHORITY OF IRELAND

ENERGY RESEARCH, DEVELOPMENT & DEMONSTRATION PROGRAMME 2015

APRIL - 2016

GROUND LOOP SIZING TABLES

The ground loop sizing tables completed as part of this project are an initial means of using the tested laboratory data and thermal response test data as part of the IGTP and IGTP2 projects, to provide guidelines values, based on a set of assumptions, of the possible heat extraction rates from vertical closed loop collectors.

The data obtained from lab tests and TRT tests from both projects was used as reference and the operational data from operating systems used to model the heat extraction rate that can be expected given different ground conditions in Ireland.

Similar guidelines values published in the VDI 4640 in Germany, the MIS 3005 Ground Loop Sizing tables in the UK and the Geotrainet training manual are commonly used by professionals in Ireland to size ground source collectors. The thermal conductivity database developed as part of this project has highlighted some considerable differences in thermal conductivity values for references lithologies compared to these guidelines. Table 2 below presents average heat extraction rates for Irish geological conditions based on different rock thermal conductivity values, an average full load equivalent hours of operation of a heat pump and an average annual ground temperatures over a 25 year period.

Table 3 – Guideline Heat Extraction Rates for Irish Ground Conditions

(1800 FLEQ – Single-U 40mm – 10kW installed capacity)

	1,800 FLEQ hours	Average Peak Extraction Rate (W/m)							
	Average Ground T (°C)	14	13	12	11	10	9	8	7
Thermal Conductivity (W/m/K)	4	58	54	51	48	45	42	39	36
	3.8	56	53	50	47	44	41	38	36
	3.6	54	51	49	46	43	40	37	35
	3.4	53	50	47	44	42	39	36	34
	3.2	51	48	45	43	40	38	35	33
	3	49	46	44	41	39	36	34	31
	2.8	47	45	42	40	37	35	33	30
	2.6	45	43	40	38	36	34	31	29
	2.4	45	41	39	36	34	32	30	28
	2.2	43	39	37	35	33	31	29	27
	2	41	36	35	33	31	29	27	26
	1.8	38	34	33	31	29	28	26	24
	1.6	36	32	30	29	27	26	24	23
	1.4	31	30	28	27	25	24	23	22
	1.2	28	27	26	25	23	22	21	20
	1	26	24	23	22	22	21	20	19

A series of three tables (refer to appendix A) were completed simulating 1,200 hours, 1,800 hours and 2,400 hours of operation of a heat pump.

The tables allow the user to reference the thermal conductivity values on the IGTP website for a given formation or lithology and estimate an average peak extraction rate of a geothermal closed loop vertical collector based on a local average ground temperatures. The values highlighted in orange represent potential typical values for ground conditions in Ireland.

It is important that the tables completed in this project provide indicative values only. The table cannot substitute for any site-specific assessment, site-specific information on the local ground conditions or for any thermal response test data that should be obtained in the case of large scale collectors.

The heat extraction rate values given in the IGTP sizing tables are only applicable in the case of small scale residential systems and have been compiled considering systems between 8kW to 12kW installed capacity ranges only.

Larger systems, especially where these exceed 18-20kW, should not be sized using these tables and more site-specific values should be sought at the specific location where the system is planned.

Assumptions:

The assumptions listed in table 4 have been made for the purposes of modelling and compilation of the heat extraction rates identified.

Table 4 – Heat Extraction Rate Modelling Assumptions

ASSUMPTIONS	
FLEQ hours	**1200, 1800 or 2400**
Collector Type	Single-U
Pipe Size (mm)	40
Pipe Material	PE100
Pipe Thermal Conductivity (W/m/K)	0.42
Pipe Wall Thickness (mm)	3
Shank Spacing (mm)	60
Backfill - Thermally Enhanced Grout (W/m/K)	2
Fluid Type	Monoethylene Glycol
Fluid Concentration (%)	33
Borehole therm. res. internal	0.52 (m·K)/W
Reynolds number	1.052E4
Thermal resistance fluid/pipe	0.004731 (m·K)/W
Thermal resistance pipe material	0.06159 (m·K)/W
Contact resistance pipe/filling	0.1 (m·K)/W
Borehole therm. res. fluid/ground	0.1476 (m·K)/W
Effective borehole thermal res.	0.1477 (m·K)/W
Heat Pump Operation	Heating Mode only

Methodology

Heat Extraction rates were modelled based on considering each combination of the following parameters:

- Ground temperatures – between 7^{o}C and 14^{o}C at 1^{o}C intervals;
- Thermal conductivity 16 values at increments of 0.2 w/m/K between 1 and 4 W/m/K;
- Three full load equivalent hour scenarios:
    - 1,200 hours;

    - 1,800 hours;
    - 2,400 hours;
- Heat Pump Installed capacities – 8kW, 10kW and 12kW for each of the above conditions;
- 2 No. Collector Types including Single-U 40mm pipe diameter and Double-U 32mm pipe collectors – both SDR11 (PE100) material for each scenario.

As part of this methodology over 1,500 permutations of above parameters were tested using Blocon Earth Energy Designer (EED) software to obtain the peak extraction rate based on an averaged MWh heat demand throughout the winter months.

The peak extraction rates were given by the heat extracted in W/m at the coldest time of the year in January and averaged over a 25 year period. This is considered comparable to the expected lifetime of a heat pump using a geothermal collector.

The following findings were observed as part of the permutations tested:

- A variance of approximately 2 W/m extraction rate was observed for 8kW with higher rates and 12kW heat pumps with lower rates from the median value reported which represents a 10kW system. This was mostly true of any given ground temperature modelled;
- A variance of approximately 1 W/m extraction rate was observed between single-U 40mm collectors and double-U 32mm collectors;
- Ground conditions with thermal conductivity lower than 1.4 W/m/K have significantly lower heat extraction rates potentially requiring doublet the collector surface area than those with higher TC values;
- Where average ground temperatures are lower than 9^{o}C, the decrease in the extraction rate can exceed 15% to 20% of the 11^{o}C ground temperature value.
- Peak average extraction values can be derived for each temperature scenario with a variance of ± 2 W/m extraction rate. These values are given in Table 3 and in appendix A.

Further modelling over the averaged heat extraction values observed was performed using Ground Loop Design to ascertain that the modelled values were consistent with other modelling tools.

The sizing tables that illustrate average peak ground extraction rates have been circulated to installers, drillers and engineers that are actively involved or have participated in the design and testing of ground source systems. Feedback on the proposed values based on known heat pump operating conditions of heat pump not considered in this project or known to the authors is as expected.

APPENDIX A

Average Peak Heat Extraction Rates

1,200 FLEQ hours	Average Peak Extraction Rate (W/m)							
Thermal Conductivity (W/m/K) \ Average Ground T (°C)	14	13	12	11	10	9	8	7
4	59	55	52	49	46	43	40	37
3.8	57	54	51	48	45	42	39	36
3.6	55	52	49	46	44	40	38	35
3.4	54	51	48	45	42	39	36	34
3.2	52	49	46	43	41	38	35	33
3	50	47	44	42	39	37	34	31
2.8	48	45	43	40	38	35	33	30
2.6	46	43	41	38	36	34	31	29
2.4	43	41	39	37	34	32	30	28
2.2	41	39	37	35	33	30	28	26
2	39	37	35	33	31	29	27	25
1.8	36	34	32	31	29	27	25	24
1.6	33	32	30	28	27	25	24	22
1.4	31	29	28	26	25	23	22	21
1.2	28	26	25	24	23	21	20	19
1	25	24	23	21	20	19	18	17

1,800 FLEQ hours	Average Peak Extraction Rate (W/m)							
Thermal Conductivity (W/m/K) \ Average Ground T (°C)	14	13	12	11	10	9	8	7
4	58	54	51	48	45	42	39	36
3.8	56	53	50	47	44	41	38	36
3.6	54	51	49	46	43	40	37	35
3.4	53	50	47	44	42	39	36	34
3.2	51	48	45	43	40	38	35	33
3	49	46	44	41	39	36	34	31
2.8	47	45	42	40	37	35	33	30
2.6	45	43	40	38	36	34	31	29
2.4	45	41	39	36	34	32	30	28
2.2	43	39	37	35	33	31	29	27
2	41	36	35	33	31	29	27	26
1.8	38	34	33	31	29	28	26	24
1.6	36	32	30	29	27	26	24	23
1.4	31	30	28	27	25	24	23	22
1.2	28	27	26	25	23	22	21	20
1	26	24	23	22	22	21	20	19

Thermal Conductivity (W/m/K)	2,400 FLEQ hours	Average Peak Extraction Rate (W/m)							
	Average Ground T (°C)	14	13	12	11	10	9	8	7
	4	57	54	51	48	45	42	39	37
	3.8	55	53	50	47	44	41	38	36
	3.6	54	51	48	45	43	40	37	35
	3.4	52	49	47	44	42	39	36	34
	3.2	50	48	45	43	40	38	35	33
	3	49	46	44	41	39	37	34	32
	2.8	47	44	42	40	37	35	33	31
	2.6	45	43	40	38	36	34	32	30
	2.4	43	41	39	37	35	33	31	29
	2.2	41	39	37	35	33	31	29	27
	2	39	37	35	33	31	30	28	26
	1.8	36	35	33	31	30	28	27	25
	1.6	34	32	31	29	28	27	25	24
	1.4	32	30	29	28	26	25	24	23
	1.2	29	28	27	26	24	23	22	21
	1	26	25	24	24	23	22	21	20