GSHP Association

MCS (MIS 3005) Important Changes;
what will need doing.... *(a very brief précis)*

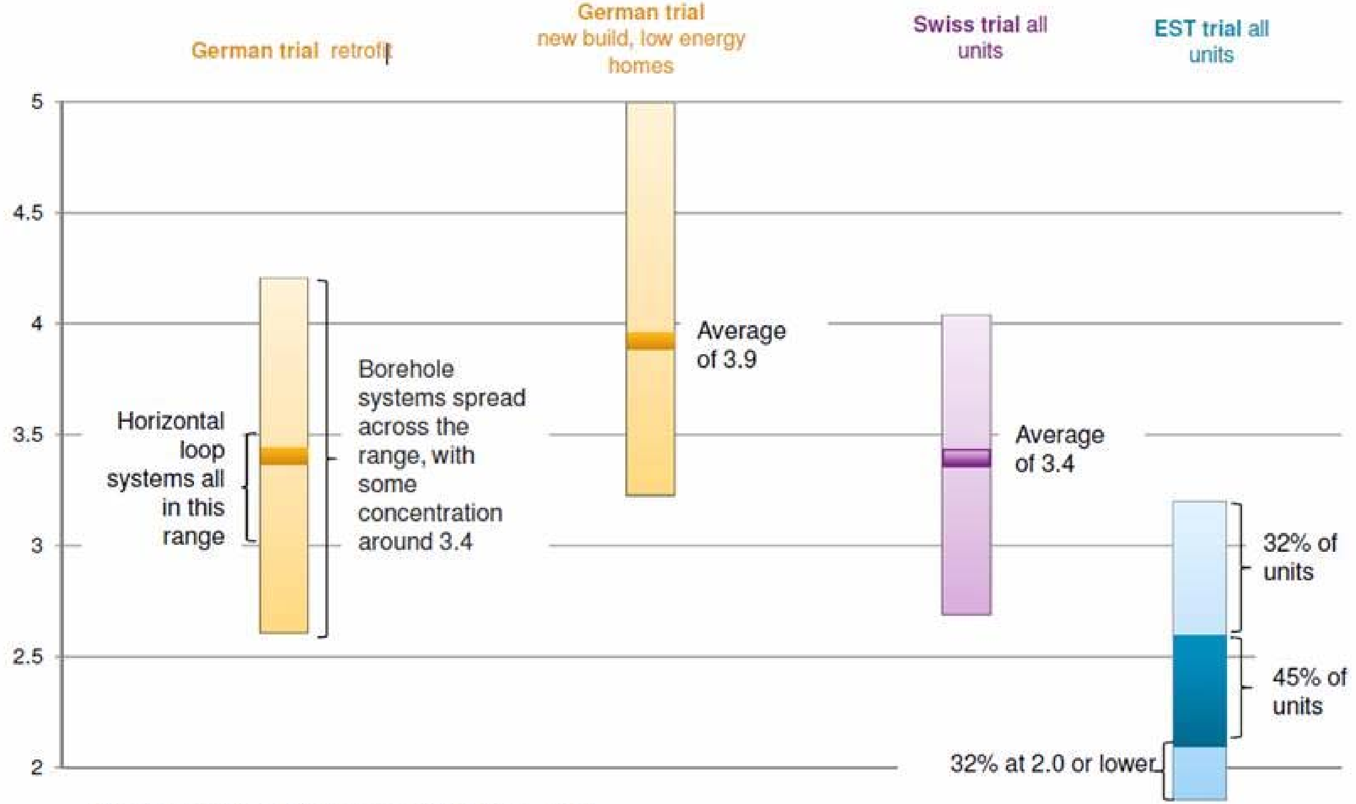
David Matthews, Chief Executive
Ground Source Heat Pump Association

16th September 2011, Geological Society, London

EST trial results compared to Switzerland & Germany

DELTA Energy & Environment

GSHP



SFOE, 2010; Fraunhofer ISE, 2010, EST, 2010

GSHP Association

Getting it wrong

Air Collector Systems:

- Noise
- Location (good air flow & connection)
- Defrost cycles
- Undersizing
- Oversizing
- Inaccurate heat loss calculation
- Poor heat distribution design or install
- Inadequate control strategy
- Commissioning, Handover & Maintenance

Getting it wrong

Ground Collector Systems:

- Undersizing
- Oversizing
- Inaccurate heat loss calculation
- Poor heat distribution design or install
- Inadequate control strategy
- Commissioning, Handover & Maintenance
- Inadequate collector design
- Inadequate collector install

it's expensive to put right

Some Ground Collector Faults:

- Not enough surface area/depth or proximity
- Overlapping pipework
- Poor materials (pipes, antifreeze etc)
- Poor hydraulic design (massive pumps)
- Poor backfilling or grouting
- Poor drilling/trenching practice
- No capping off
- Poor purging and filling
- Inadequate joints

Heat Loss Calculation (HLC) complies BS EN 12831 software compliant BS EN 12831. *i.e. good HLC*

ROOM	KITCHEN/DINING		JOB	Dom Heat Des Guide		Amount	Air	Design	Heat Loss	Variation from DHDG
Design Room Temp	21	No of air				air heated	change	Temp		
Outside Design Temp	-1.8	changes				per hour	factor	Difference		Design temp was -3 C
Design Temp Diff	22.8	per hour	Length m	Width m	Height m	m3/hour	w/m3K	°C	Watts	
VENTILATION HEAT LOSS		2	4.9	2.7	2.4	63.50	0.33	22.8	478	
Fabric Heat Loss						Area m2	U-Value			
FLOOR			4.9	2.7		13.23	0.79	22.8	238	
EXT WALL (gross area)			7.6		2.4	18.24				
WINDOW GLAZING				1.1	1.05	1.16	4.8	22.8	126	Single Glazing
DOOR				1.75	2.1	3.68	4.8	22.8	402	Single Glazing
EXT WALL (net area)	Subtract glazing & door from gross ext wall area					13.41	0.68	22.8	208	
CEILING or ROOF (gross area)			2.33	1.92		4.47	Heat gain from bathroom			
ROOF GLAZING				0	0	0.00	0	0	0	
CEILING or ROOF (net area)	Subtract roof glazing from gross roof area					4.47	1.41	-1	-6	
INTERNAL WALL 1			0		0	0	0	0	0	
INTERNAL WALL 2			0		0	0	0	0	0	
PARTY WALL			2.7		2.4	6.48	1.02	11	73	
OTHER			0	0	0	0	0	0	0	
DESIGN HEAT LOSS FOR ROOM (Sum of Watts for all elements)									1519	
EXPOSED LOCATION	Yes	If YES, add		10	% to DESIGN HEAT LOSS				152	
HIGH CEILING	No	If YES, add		0	% to DESIGN HEAT LOSS				0	
INTERMITTENT HEATING		Add		0	% to DESIGN HEAT LOSS				0	No intermittent heating
TOTAL ROOM HEAT LOSS									1671	

GSHP Association

Heat Loss Calculation (HLC) complies BS EN 12831 software compliant BS EN 12831. *i.e. good HLC*

ROOM	KITCHEN/DINING		JOB	Dom Heat Des Guide		Amount	Air	Design	Heat Loss	Change
Design Room Temp	21	No of air				air heated	change	Temp		
Outside Design Temp	-1.8	changes				per hour	factor	Difference		
Design Temp Diff	22.8	per hour	Length m	Width m	Height m	m3/hour	w/m3K	°C	Watts	
VENTILATION HEAT LOSS		1.5	4.9	2.7	2.4	47.63	0.33	22.8	358	Draft proof
Fabric Heat Loss						Area m2	U-Value			
FLOOR			4.9	2.7		13.23	0.37	22.8	112	50 mm U/F insulate
EXT WALL (gross area)			7.6		2.4	18.24				
WINDOW GLAZING				1.1	1.05	1.16	2.1	22.8	55	Low E glass door
DOOR				1.75	2.1	3.68	2.1	22.8	176	Low E glass door
EXT WALL (net area)	Subtract glazing & door from gross ext wall area					13.41	0.39	22.8	119	Cavity wall insulate
CEILING or ROOF (gross area)			2.33	1.92		4.47	*Heat gain from bathroom*			
ROOF GLAZING				0	0	0.00	0	0	0	
CEILING or ROOF (net area)		Subtract roof glazing from gross roof area				4.47	1.41	-1	-6	
INTERNAL WALL 1			0		0	0	0	0	0	
INTERNAL WALL 2			0		0	0	0	0	0	
PARTY WALL			2.7		2.4	6.48	1.02	11	73	
OTHER			0	0	0	0	0	0	0	
DESIGN HEAT LOSS FOR ROOM (Sum of Watts for all elements)									887	
EXPOSED LOCATION	Yes	If YES, add		10	% to DESIGN HEAT LOSS				89	
HIGH CEILING	No	If YES, add		0	% to DESIGN HEAT LOSS				0	
INTERMITTENT HEATING		Add		0	% to DESIGN HEAT LOSS				0	
TOTAL ROOM HEAT LOSS									976	

Internal and external temperatures recommended in CIBSE Guide A: Environmental Design

Room	Internal design temperatures (°C) from the UK national annex to BS EN 12831
Living room	21
Dining room	21
Bedsitting room	21
Bedroom	18
Hall and landing	18
Kitchen	18
Bathroom	22
Toilet	18

Floor Heat Loss - local annual average external air temperature.

Location	Altitude (/m)	Hourly dry-bulb temperature (°C) equal to or exceeded for 99% of the hours in a year
Belfast	68	-1.2
Birmingham	96	-3.4
Cardiff	67	-1.6
Edinburgh	35	-3.4
Glasgow	5	-3.9
London	25	-1.8
Manchester	75	-2.2
Plymouth	27	-1.2

In the absence of more localised info, data from the closest location decreased by 0.6 °C for every 100m height above sea level - may be used,

i.e. take account of local internal and external conditions

Heat Loss Calculation (HLC) complies BS EN 12831 software compliant BS EN 12831. *i.e. good HLC*

ROOM	KITCHEN/DINING		JOB	Dom Heat Des Guide		Amount	Air	Design	Heat Loss	Change
Design Room Temp	21	No of air				air heated	change	Temp		
Outside Design Temp	-1.8	changes				per hour	factor	Difference		
Design Temp Diff	22.8	per hour	Length m	Width m	Height m	m3/hour	w/m3K	°C	Watts	
VENTILATION HEAT LOSS		1.5	4.9	2.7	2.4	47.63	0.33	22.8	358	Draft proof
Fabric Heat Loss						Area m2	U-Value			
FLOOR			4.9	2.7		13.23	0.37	22.8	112	50 mm U/F insulate
EXT WALL (gross area)			7.6		2.4	18.24				
WINDOW GLAZING				1.1	1.05	1.16	2.1	22.8	55	Low E glass door
DOOR				1.75	2.1	3.68	2.1	22.8	176	Low E glass door
EXT WALL (net area)	Subtract glazing & door from gross ext wall area					13.41	0.39	22.8	119	Cavity wall insulate
CEILING or ROOF (gross area)			2.33	1.92		4.47	*Heat gain from bathroom*			
ROOF GLAZING				0	0	0.00	0	0	0	
CEILING or ROOF (net area)	Subtract roof glazing from gross roof area					4.47	1.41	-1	-6	
INTERNAL WALL 1			0		0	0	0	0	0	
INTERNAL WALL 2			0		0	0	0	0	0	
PARTY WALL			2.7		2.4	6.48	1.02	11	73	
OTHER			0	0	0	0	0	0	0	
DESIGN HEAT LOSS FOR ROOM (Sum of Watts for all elements)									887	
EXPOSED LOCATION	Yes	If YES, add		10	% to DESIGN HEAT LOSS				89	
HIGH CEILING	No	If YES, add		0	% to DESIGN HEAT LOSS				0	
INTERMITTENT HEATING		Add		0	% to DESIGN HEAT LOSS				0	
TOTAL ROOM HEAT LOSS									976	

GSHP association

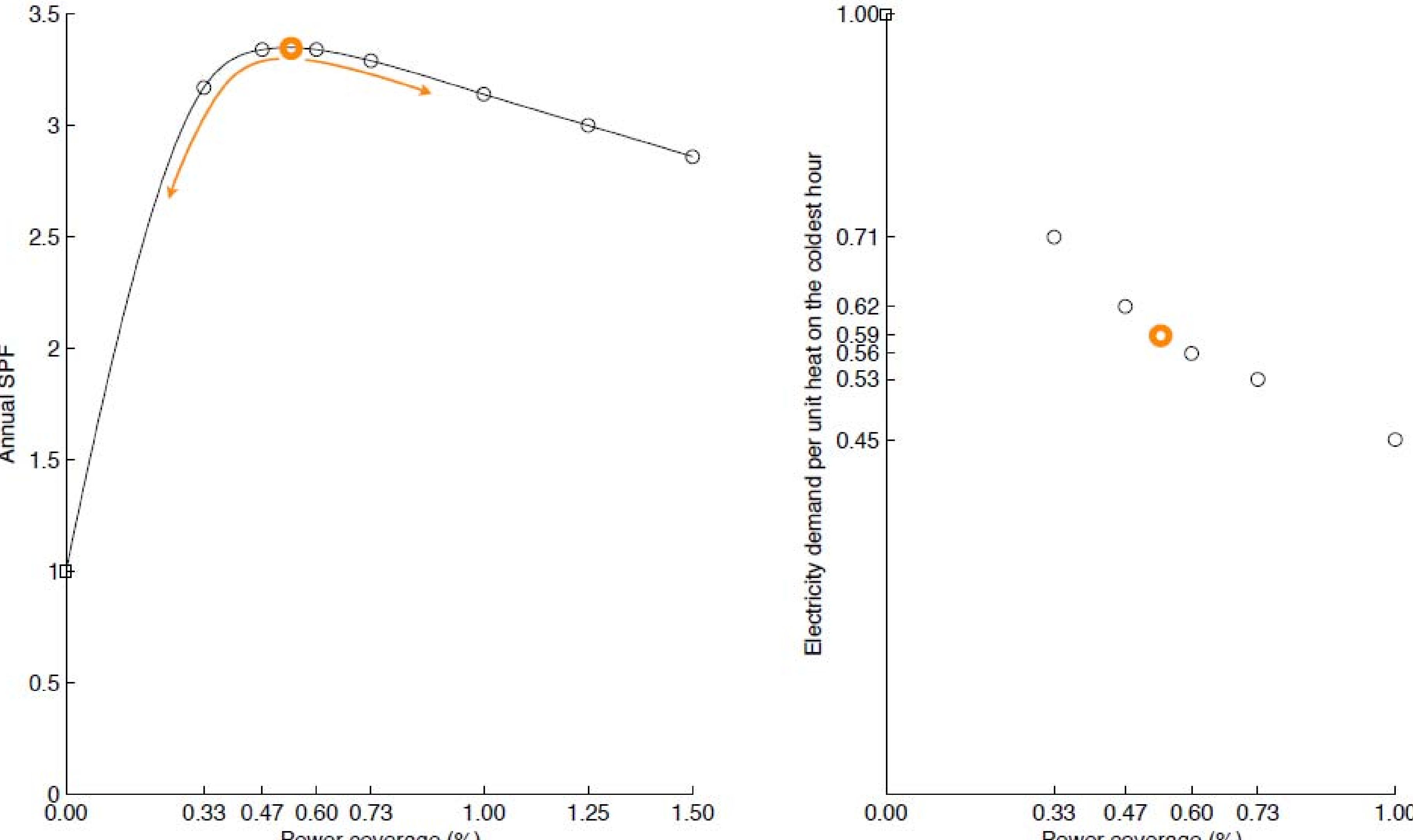
Heat Loss Calculation (HLC) complies BS EN 12831 software compliant BS EN 12831. *i.e. good HLC*

ROOM	KITCHEN/DINING		JOB	Dom Heat Des Guide		Amount	Air	Design	Heat Loss	Change
Design Room Temp	21	No of air				air heated	change	Temp		
Outside Design Temp	-1.8	changes				per hour	factor	Difference		
Design Temp Diff	22.8	per hour	Length m	Width m	Height m	m3/hour	w/m3K	°C	Watts	
VENTILATION HEAT LOSS		1.5	4.9	2.7	2.4	47.63	0.33	22.8	358	Draft proof
Fabric Heat Loss						Area m2	U-Value			
FLOOR			4.9	2.7		13.23	0.23	11	33	screed U/F; 100mm
EXT WALL (gross area)			7.6		2.4	18.24				
WINDOW GLAZING				1.1	1.05	1.16	2.1	22.8	55	Low E glass door
DOOR				1.75	2.1	3.68	2.1	22.8	176	Low E glass door
EXT WALL (net area)	Subtract glazing & door from gross ext wall area					13.41	0.39	22.8	119	Cavity wall insulate
CEILING or ROOF (gross area)			2.33	1.92		4.47	*Heat gain from bathroom*			
ROOF GLAZING				0	0	0.00	0	0	0	
CEILING or ROOF (net area)	Subtract roof glazing from gross roof area					4.47	1.41	-1	-6	
INTERNAL WALL 1			0		0	0	0	0	0	
INTERNAL WALL 2			0		0	0	0	0	0	
PARTY WALL			2.7		2.4	6.48	1.02	11	73	
OTHER			0	0	0	0	0	0	0	
DESIGN HEAT LOSS FOR ROOM (Sum of Watts for all elements)									809	
EXPOSED LOCATION	Yes	If YES, add		10	% to DESIGN HEAT LOSS				81	
HIGH CEILING	No	If YES, add		0	% to DESIGN HEAT LOSS				0	
INTERMITTENT HEATING		Add		0	% to DESIGN HEAT LOSS				0	
TOTAL ROOM HEAT LOSS									890	

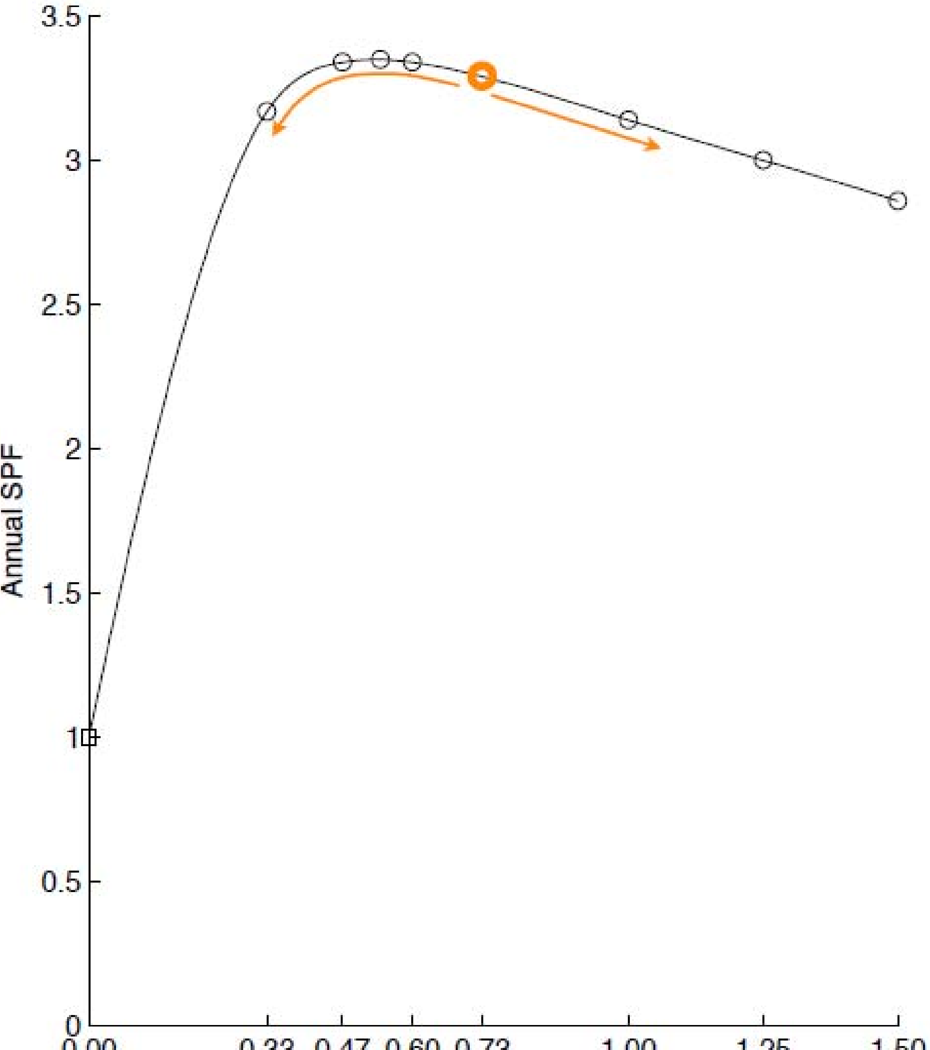
provide at least ***100%*** of the calculated design ***space heating power*** requirement at the selected internal and external temperatures, the selection being made after taking into consideration the space heating ***flow temperature*** assumed in the heat emitter circuit and any variation in heat pump performance that may result.

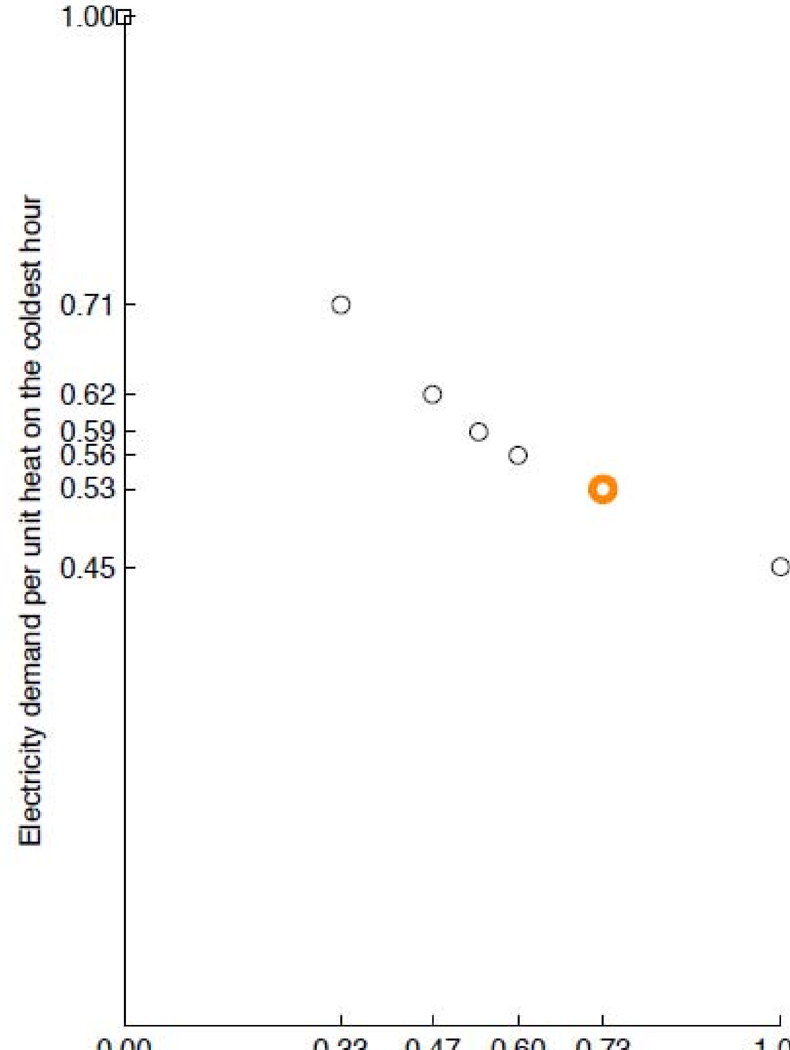
Please note*:-100% includes defrost cycles and no immersion heater within space heating design zone*

mpact of power coverage on SPF and electricity demand on coldest hour



npact of power coverage on SPF and electricity demand on coldest hour





Bivalent fossil-fuel & HP heat sources must be fully integrated into single CH control circuits. CH = Space & HW

For bivalent fossil-fuel & HP heating circuits, the percentage fossil-fuel and HP contribution must be clearly stated in the quote

For DHW design purposes, use BS 6700 and take into account the number and type of points of use

There is a comment about HW cylinders needing larger HX with HPs

Legionella and other bacteria management with HP and HW circuits

e.g. pasteurised for 60 °C for 60 minutes every 24 hours

GSHP association

Domestic selection guide

hese recommendations are based on the guidelines in BS 6700.

uidance should be sought for unusual applications. Eg: High flow-rate showers, large baths etc.

Hot Water Demand	Bedrooms	Indirect units	Direct units
1 Standard Bath	Bedsit / 1 Bed	60/90	150
or Shower	2 – 3 Bed	120	180
	3 – 4 Bed	150	210
1 Standard Bath	2 – 3 Bed	120	180
	3 – 4 Bed	150	210
1 Bath and En-suite	2 – 3 Bed	150	210
	3 – 4 Bed	150	210
	4 – 5 Bed	180	250
2 Standard Baths	2 – 3 Bed	180	210
	3 – 4 Bed	180	210
	4 – 5 Bed	210	250
3 Bathrooms	3 – 4 Bed	250	300
	4 – 5 Bed	250	300

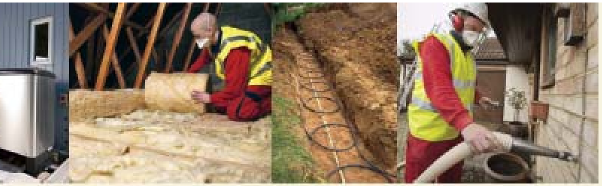
Contractor shall communicate to the customer the running cost of the system under normal design conditions including:

- *Estimated annual HP electricity cost*
- *Electricity cost of CH & GL pumps, especially any 24/7 pumps*
- *HL associated with storage vessels (Part L cyl & pipework insulation)*
- *Electricity cost of any HW immersion heater usage*

<u>Heat Emitter Guide</u> *Customer aware and see*

- *Room Heat Loss*
- *Emitter type and emitter temperature (worst room)*
- *Temperature Star Rating and possible improvement*
- *Flow temperature*
- *SPF*

GSHP association



Heat Emitter Guide for Domestic Heat Pumps

Heat pumps can provide high-efficiency low-carbon heat for dwellings. Their performance is optimised if low-temperature heat emitters are used for heat distribution in the house, so this guide aims to help you select an emitter type and operating temperature which will result in high efficiency and low running costs.

The guide uses a Temperature Star Rating to indicate how efficient the proposed system is likely to be. More efficient systems are given a higher number of stars. The maximum is 6 stars. More stars are given when lower heat emitter temperatures are used because the heat pump is able to operate more efficiently.

The guide can be used for systems with existing radiators or to design a new heat emitter system. A flow chart has been designed to help you through the process for an individual room. This process should be repeated for all of the heated rooms in the dwelling; the heat pump operating SPF will be limited by the worst performing room.

The **Guidance Table** over the page is annotated to help you achieve the most suitable design for the room/dwelling. Several examples are also included in the guide to illustrate the advantages of improving the energy efficiency by reducing fabric and ventilation heat loss and achieving lower emitter temperatures.

The emitter guide is not a detailed design tool, but is intended to stimulate a proper review of the dwelling-specific heat load and heat emitter design, leading to optimised performance and low running costs.

Who produced this guide?

Trade Associations representing heat pumps and heat distribution technologies have worked together to produce this useful guide which is supported by DECC and EST. Participating members are:

energy saving trust
beama
GSHP association
HPA
HHIC
UHMA

Start → Calculate the heat loss for each room (in W). Heat loss calculations according to BS EN 12831 are recommended.

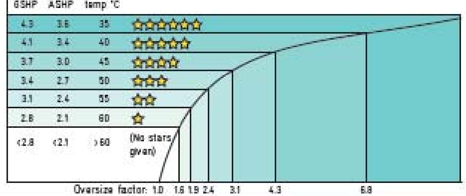
Are you designing a new heating system or looking to use the existing one?

- New → Use the Guidance Table over the page to design a new system
- Existing → You need to work out the Temperature Star Rating. **Does the system have radiators?**
  - No → Use the Guidance Table over the page to determine the Temperature Star Rating
  - Yes → Determine the rated output of the existing radiators at a mean water to air temperature difference of 50°C using manufacturers' tables. See note.

Note: Manufacturers' rated output tables before the year 2000 were based on a mean water to air temperature difference of 60°C. Later tables are based on a 50°C temperature difference (MW-AT = 50°C). To convert rated outputs based on a 60°C temperature difference to 50°C temperature difference, multiply by 0.825.

Divide the rated output by the room heat loss to determine the Oversize Factor.

Use the chart and the calculated Oversize Factor to determine the Temperature Star Rating for that room:



Likely space heating SPF GSHP	ASHP	Heating circuit flow temp °C	Temperature Star Rating
4.3	3.6	35	☆☆☆☆☆☆
4.1	3.4	40	☆☆☆☆☆
3.7	3.0	45	☆☆☆☆
3.4	2.7	50	☆☆☆
3.1	2.4	55	☆☆
2.8	2.1	60	☆
<2.8	<2.1	>60	(No stars given)

Oversize factor: 1.0 1.6 1.9 2.4 3.1 4.3 6.8

Would you like a higher Temperature Star Rating?

- No → **Proceed with installation**
- Yes → The Temperature Star Rating can be improved by: reducing the room's fabric and ventilation heat loss; increasing the rated output of the heat emitter by adding or replacing radiators; or by switching to a different emitter type. **Do you want to redesign the heat emitter system?**
  - No → Use the existing radiator examples on this page to demonstrate the impact of reducing heat loss and increasing radiator output
  - Yes → Use the Guidance Table and examples over the page to investigate reducing the fabric and ventilation heat loss and switching emitter type and specification

EXAMPLES for EXISTING RADIATOR SYSTEMS

Calculating the Temperature Star Rating of an existing radiator system

An example of a poorly-insulated room has been adapted from CIBSE's Domestic Heating Design Guide. The room is assumed to be in London (design outside air temperature = -1.8°C) and initially has single glazing. The heating is assumed to be used continuously.

Room heat loss: 1671W
Size of existing radiator: 1600mm L, 700mm H, 103mm D (double panel)
Existing radiator rated output at MW-AT = 60°C: 2349W
Existing radiator rated output at MW-AT = 50°C: 2349 x 0.825 = 1938W

Calculate the Oversize Factor and look up the Temperature Star Rating on the chart.

Oversize factor: 1938/1671 = 1.2
Temperature Star Rating: (no stars) ☆☆☆☆☆☆
Radiator flow temperature: > 60°C

To operate at these temperatures, a specialist heat pump would be required. **You must therefore take action to ensure satisfactory operation.**

The examples on this page demonstrate the impact of reducing heat losses and increasing radiator output. Use the Guidance Table over the page to redesign the emitter system.

REDUCING FABRIC AND VENTILATION HEAT LOSSES

Reducing the fabric and ventilation heat loss is an efficient way of increasing the Temperature Star Rating because it reduces energy consumption and improves the system efficiency – always consider reducing heat losses when making changes to a house.

If the external walls have cavity wall insulation adde[illegible] windows are replaced with A-rated double glazing, 5[illegible] of underfloor insulation is added, and the room is ca[illegible] draught-proofed, the example room's Temperature Sta[illegible] Rating is improved:

Improved room heat loss: 976W
New oversize factor: 1938/976 = 2.0
New Temperature Star Rating: 2 stars
Radiator flow temperature: 55°C
Likely GSHP heating SPF: 3.1
Likely ASHP heating SPF: 2.4

UPGRADING THE EXISTING RADIATORS

Upgrading the existing radiator to one that has a high[illegible] rated output is another way of increasing the Temper[illegible] Star Rating:

Size of new radiator: 1600mm L, 700mm H, 135mm [illegible] is a double convector with the same frontal area as t[illegible] existing radiator)
New radiator rated output: 3269W
New oversize factor: 3269/1671 = 2.0
New Temperature Star Rating: 2 stars

Radiator flow temperature: 55°C
Likely GSHP heating SPF: 3.1
Likely ASHP heating SPF: 2.4

REDUCING FABRIC AND VENTILATION HEAT LOSSES A[illegible] UPGRADING THE EXISTING RADIATORS

The two previous examples can be combined to produ[illegible] more efficient installation:

Improved room heat loss: 976W
New radiator rated output: 3269W
New oversize factor: 3269/976 = 3.4
New Temperature Star Rating: 4 stars

Radiator flow temperature: 45°C
Likely GSHP heating SPF: 3.7
Likely ASHP heating SPF: 3.0

Notes and assumptions used to create this guide

Heat pump Likely Seasonal Performance Factor (SPF) is calculated for space heating only in accordance with the following notes and assumptions[illegible]

(a) Leeds is used for weather data. (b) Provision of domestic hot water is not included. (c) Room temperature is based on European Winter sta[illegible] 21°C operative temperature per BS EN ISO 7730. (d) The heat pump is sized to meet 100% of the space heating load and is the only heat source [illegible] in the dwelling. (e) GSHP SPF is the SCOP calculated in accordance with prEN 14825. (f) GSHP 0/35 COP – 3.5 (MCS minimum thresholds). (g) [illegible] flow temperature in heat emitter guide is at peak design conditions (i.e. at the lowest external design temperature). (h) The temperature differe[illegible] across the heat emitters is fixed at 1/7th of the emitter circuit flow temperature. (i) Weather compensation is used. (j) 100W has been added [illegible] the electrical consumption of heating circulation pumps. (k) The heat emitter control system meets current building regulation requirements. [illegible] allowance has been made for losses from cycling, buffer vessels, or associated water pumps. (m) The GSHP ground array is designed with a m[illegible] heat pump entry water temperature of 0°C. (n) A ground circulation pump is included. (o) The SPF values for ASHP are 0.7 less than for GSHP, w[illegible] is consistent with SAP. (p) Installation of screed UFH has floor insulation to BS EN 1264 or building regulations, – whichever is the greater – wi[illegible] and finishing floor laid over. (q) Installation of Al-plated UFH has floor insulation to BS EN 1264 or building regulations, whichever is the great[illegible] UFH pipework laid on top of a proprietary aluminium plate system with no air gaps between the aluminium plates, chipboard flooring and finish[illegible] floor. (r) Performance of UFH is calculated according to BS EN 1264 and is shown using differing floor coverings with resistance values of: Car[illegible] – 0.15m²K/W (or 1.5 TOG), Wood – 0.10m²K/W, Tile – 0.00m²K/W. (s) Required performance of Fan Coils, Fan Convectors and Radiators is expre[illegible] as an Oversize Factor or heat transfer multiplier to determine the required manufacturers' catalogued output per BSEN442 at a mean water to a[illegible] temperature difference of 50°C. The exponents used in the heat transfer equation to calculate the heat transfer multipliers are 1.3 for Standard Radiators, 1.1 for Fan Coils and 1.0 for Fan Convectors. The room temperature used to calculate the heat transfer multipliers is fixed at 21°C.

GSHP association

…vide the room heat loss by the room floor area to …ntify the **room specific heat loss** band on the far left …he table that should be used in the design process.

…Use the colour coding (which identifies suitable …ptions) and different emitter types, together with …e Temperature Star Rating, the heating circuit flow …mperatures and the likely space heating SPFs to …ect an emitter type and specification that achieves the desired operating conditions.

Is the emitter an underfloor heating system?

No: …d off the Oversize …tor and multiply it …he room heat loss …V) to determine the …uired rated output. → …manufacturers' data …select an emitter …ble of achieving the …uired rated output. → **Proceed with installation**

Yes: Read off the **maximum pipe spacing** (PS) to be used in the design. → **Proceed with installation**

…tant notes:

…tables are presented as a generic aid to ensure that …rrect information is being provided within the heat …r design. Competent heating system designers will be …o provide site-specific solutions to meet your exact …ements.

…tables cover space heating only – domestic hot water …included.

…y for GUIDANCE TABLE

- (red) **REDUCE FABRIC AND VENTILATION HEAT LOSS** – System cannot perform at the design parameters stated; consider reducing heat loss and/or load-sharing design with other emitter types.
- (orange) **CONSIDER MEASURES TO REDUCE FABRIC AND VENTILATION HEAT LOSS** – System can perform at these design conditions but emitter sizes are likely to be excessive
- (light orange) **CAUTION** – System can perform at these design conditions with extra consideration on the emitter and heat pump design
- (green) **GO AHEAD** – System can perform at the stated efficiencies with the selected emitter design.
- …5 **Underfloor Pipe Spacing** – PS≤150 means UFH pipes should be spaced at 150mm or less to achieve the design condition.
- …4 **Oversize Factor** – multiply the room heat loss (in W) by the Oversize Factor to determine the required emitter output with a mean water to air temperature difference of 50ºC. Oversize Factor is the same as a Heat Transfer Multiplier

GUIDANCE TABLE

	Temperature Star Rating	Heating circuit flow temperature °C	Likely space heating SPF: GSHP	Likely space heating SPF: ASHP	Oversize factors for other emitters: Domestic Fan Convector/Fan-assisted Radiator	Oversize factors: Standard Radiator	Oversize factors: Fan Coil Unit	Underfloor heating: screed: with TILE	Screed: with WOOD	Screed: with CARPET	Underfloor heating: Aluminium panel: with TILE	Alu panel: with WOOD	Alu panel: with CARPET
Room heat loss less than 30 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0	PS≤300	PS≤300	PS≤200	PS≤200	PS≤200	PS≤150
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤200
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
	★☆☆☆☆☆	60	2.8	2.1	1.4	1.6	1.5	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
Room specific heat loss 30 to 50 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0	PS≤300	PS≤100		PS≤100	Reduce heat loss	
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5	PS≤300	PS≤200	PS≤150	PS≤200		
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6	PS≤300	PS≤300	PS≤300	PS≤200	PS≤200	PS≤150
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	PS≤300	PS≤300	PS≤300	PS≤300	PS≤200	PS≤200
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
	★☆☆☆☆☆	60	2.8	2.1	1.4	1.6	1.5	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
Room specific heat loss 50 to 80 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0	PS≤100	Reduce heat loss				
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5	PS≤200				Reduce heat loss	
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6	PS≤300	PS≤100	PS≤100	PS≤150		
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	PS≤300	PS≤200	PS≤150	PS≤200	PS≤100	
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7	PS≤300	PS≤300	PS≤200	PS≤200	PS≤150	PS≤100
	★☆☆☆☆☆	60	2.8	2.1	1.4	1.6	1.5	PS≤300	PS≤300	PS≤300	PS≤300	PS≤200	PS≤150
Room specific heat loss 80 to 100 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0						
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5	PS≤150	Reduce heat loss				
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6	PS≤200			PS≤100	Reduce heat loss	
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	PS≤250	PS≤100	PS≤100	PS≤150		
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7	PS≤300	PS≤200	PS≤150	PS≤200	PS≤100	
	★☆☆☆☆☆	60	2.8	2.1	2.1	1.6	1.5	PS≤300	PS≤250	PS≤250	PS≤200	PS≤150	PS≤100
Room specific heat loss 100 to 120 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0						
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5						
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6						
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	Reduce heat loss			Reduce heat loss		
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7						
	★☆☆☆☆☆	60	2.8	2.1	1.4	1.6	1.5						
Room specific heat loss 120 to 150 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0						
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5						
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6						
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	Reduce heat loss			Reduce heat loss		
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7						
	★☆☆☆☆☆	60	2.8	2.1	1.4	1.6	1.5						

Reducing fabric and/or ventilation heat losses can move a room up to the next specific heat loss band, making it easier to achieve a good SPF.

Changing the emitter type can enable the emitter to operate at a lower temperature.

Changing the floor covering on UFH can reduce the required emitter temperature.

Changing the emitter specification can reduce the flow temperature and therefore increase SPF.

EXAMPLES of systems designed using the GUIDANCE TABLE

Benefits of reducing fabric and ventilation heat losses

The poorly-insulated example room introduced on the front page has the following heat loss and dimensions:

Original room heat loss: 1671W
Room size: 4.9m x 2.7m = 13.2m²
Room specific heat loss: 1671/13.2 = 126 W/m²
Room specific heat loss band: 120 to 150 W/m²

A higher Temperature Star Rating can be achieved if the room specific heat loss (in W/m²) is reduced. This is indicated in the Design Table by the different colour coding for different specific heat loss bands. Reducing the room heat loss as in the example on the first page, moves the room into a lower room specific heat loss band.

Improved room heat loss: 976W
Room specific heat loss: 976/13.2 = 74W/m²
Room specific heat loss band: 50 to 80 W/m²

These examples design standard radiator, fan-assisted radiator and underfloor heat distribution systems that achieve the maximum recommended Temperature Star Rating for this improved room.

Standard radiators

The Oversize Factor required to achieve the maximum recommended Temperature Star Rating is circled on the Guidance Table for a radiator system in a room with a specific heat loss in the 50 to 80 W/m² band.

Room specific heat loss band: 50 to 80 W/m²
Emitter type: Radiators
Design Temperature Star Rating: 4 stars ★★★★☆☆
Design Radiator Flow Temperature: 45ºC
Likely GSHP heating SPF: 3.7
Likely ASHP heating SPF: 3.0

Required Oversize Factor: 3.1
Required rated output: 976 x 3.1 = 3024W

Manufacturer: Myson Select SD 70 160 (or equivalent)
Size: 1600mm L, 700mm H, 135mm D
Manufacturer's Rating : 3269W

OR

Manufacturer: Myson Select SX 70 100 (or equivalent)
Size: 2 No. 1000 mm L, 700mm H, 97mm D
Manufacturer's Rating: 2 x 1583 = 3166W

Fan-assisted radiators

A fan-assisted radiator will have a higher heat output than a standard radiator the same size. You can therefore achieve a higher Temperature Star Rating without the heat emitter becoming too large for a room with a fixed specific heat loss.

The Oversize Factor required to achieve the maximu… recommended Temperature Star Rating is also circl… the Guidance Table for a fan-assisted radiator syst…

Room specific heat loss band: 50 to 80 W/m²
Emitter type: Fan-assisted radiators
Design Temperature Star Rating: 5 stars ★★★…
Design Radiator Flow Temperature: 40ºC
Likely GSHP heating SPF: 4.1
Likely ASHP heating SPF: 3.4

Required Oversize Factor: 3.1
Required radiator output: 976 x 3.1 = 3024W

Manufacturer: Jaga Strada DBE Type 11 (or equival…
Size: 400mm L, 930mm H, 118mm D
Manufacturer's Rating: 3114W

OR

Manufacturer: Jaga Strada DBE Type 11 (or equival…
Size: 2 No. 800 mm L, 650mm H, 118mm D Manufa…
Rating: 2 x 1534 = 3068W

Screed underfloor heating

Depending on the floor construction and covering, a… underfloor heat distribution system may be able to … an even lower heating circuit flow temperature- an… therefore higher Temperature Star Rating- in the sa… room specific heat loss band.

The maximum pipe spacing required to achieve the … recommended Temperature Star Rating is circled o… Guidance Table for a screed underfloor heat distrib… system with a tile covering .

Room specific heat loss band: 50 to 80 W/m²
Emitter type: Screed underfloor
Floor covering: Tile
Design Temperature Star Rating: 6 stars ★★★…
Design Radiator Flow Temperature: 35ºC
Likely GSHP heating SPF: 4.3
Likely ASHP heating SPF: 3.6
Maximum underfloor pipe spacing: 100mm

Aluminium panel underfloor heating

An aluminium panel underfloor heat distribution system with a tile covering cannot achieve such a … Temperature Star Rating. The maximum pipe spacin… required to achieve the highest recommended Temp… Star Rating is circled on the Guidance Table .

Room specific heat loss band: 50 to 80 W/m²
Emitter type: Alu panel underfloor
Floor covering: Tile
Design Temperature Star Rating: 4 stars ★★★…
Design Radiator Flow Temperature: 45ºC
Likely GSHP heating SPF: 3.7
Likely ASHP heating SPF: 3.0
Maximum underfloor pipe spacing: 150mm

GSHP association

GUIDANCE TABLE

	Temperature Star Rating	Heating circuit flow temperature °C	Likely space heating SPF: GSHP	Likely space heating SPF: ASHP	Oversize factors for other emitters: Domestic Fan Convector/Fan-assisted Radiator	Oversize factors for other emitters: Standard Radiator	Oversize factors for other emitters: Fan Coil Unit	Underfloor heating: screed: with TILE	Underfloor heating: screed: with WOOD	Underfloor heating: screed: with CARPET	Underfloor heating: Aluminium panel: with TILE	Underfloor heating: Aluminium panel: with WOOD	Underfloor heating: Aluminium panel: with CARPET
Room heat loss less than 30 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0	PS≤300	PS≤300	PS≤200	PS≤200	PS≤200	PS≤150
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤200
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
	★☆☆☆☆☆	60	2.8	2.1	1.4	1.6	1.5	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
Room specific heat loss 30 to 50 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0	PS≤300	PS≤100		PS≤100	Reduce heat loss	
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5	PS≤300	PS≤200	PS≤150	PS≤200		
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6	PS≤300	PS≤300	PS≤300	PS≤200	PS≤200	PS≤150
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	PS≤300	PS≤300	PS≤300	PS≤300	PS≤200	PS≤200
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
	★☆☆☆☆☆	60	2.8	2.1	1.4	1.6	1.5	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300	PS≤300
Room specific heat loss 50 to 80 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0	PS≤100	Reduce heat loss				
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5	PS≤200				Reduce heat loss	
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6	PS≤300	PS≤100	PS≤100	PS≤150		
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	PS≤300	PS≤200	PS≤150	PS≤200	PS≤100	
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7	PS≤300	PS≤300	PS≤200	PS≤200	PS≤150	PS≤100
	★☆☆☆☆☆	60	2.8	2.1	1.4	1.6	1.5	PS≤300	PS≤300	PS≤300	PS≤300	PS≤200	PS≤150
Room specific heat loss 80 to 100 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0						
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5	PS≤150	Reduce heat loss			Reduce heat loss	
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6	PS≤200			PS≤100		
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	PS≤250	PS≤100	PS≤100	PS≤150		
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7	PS≤300	PS≤200	PS≤150	PS≤200	PS≤100	
	★☆☆☆☆☆	60	2.8	2.1	2.1	1.6	1.5	PS≤300	PS≤250	PS≤250	PS≤200	PS≤150	PS≤100
Room specific heat loss 100 to 120 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0						
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5						
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6						
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	Reduce heat loss			Reduce heat loss		
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7						
	★☆☆☆☆☆	60	2.8	2.1	1.4	1.6	1.5						
Room specific heat loss 120 to 150 W/m²	★★★★★★	35	4.3	3.6	4.3	6.8	5.0						
	★★★★★☆	40	4.1	3.4	3.1	4.3	3.5						
	★★★★☆☆	45	3.7	3	2.4	3.1	2.6						
	★★★☆☆☆	50	3.4	2.7	2.0	2.4	2.1	Reduce heat loss			Reduce heat loss		
	★★☆☆☆☆	55	3.1	2.4	1.7	1.9	1.7						

Ground Collector

Designing ground heat exchangers is a complex engineering problem..... the installer shall adopt a conservative approach.......

≥30kW or incorporate ground loop replenishment through cooling or otherwise, the installer should undertake the design process making use of specialist recognised design tools and/or seek advice from an expert.

Software…. validated for UK use...... following parameters are used

a) Site average ground temperatures (or annual average air temperatures).

b) Site ground thermal conductivity values (in W/mK), including...water table depth

c) Accurate assessment of yearly CH energy consumption (kWh)

d) Accurate assessment-max ground power extracted (kW) (i.e. HP evap capacity)

e) Accurate assessment-temp of the thermal transfer fluid entering the heat pump.

Ground Collector

The temp of the thermal transfer fluid entering the heat pump shall be designed to be >0 °C at all times for 20 years.

Simplified design methods, (including look-up tables and nomograms)..... validated for UK ground conditions and installation practices.....

If proprietary software is not being used, systems ≤30kW without ground loop replenishment..... shall use the following procedure to designing ground HX:

Total yearly CH energy consumption (kWh) shall be estimated including

- internal heat gains,
- solar insolation heat gains
- local external air temperature
- Building heating pattern used (e.g. continuous, bi-modal, Economy10 etc.)

GSHP
ssociation

Table 3

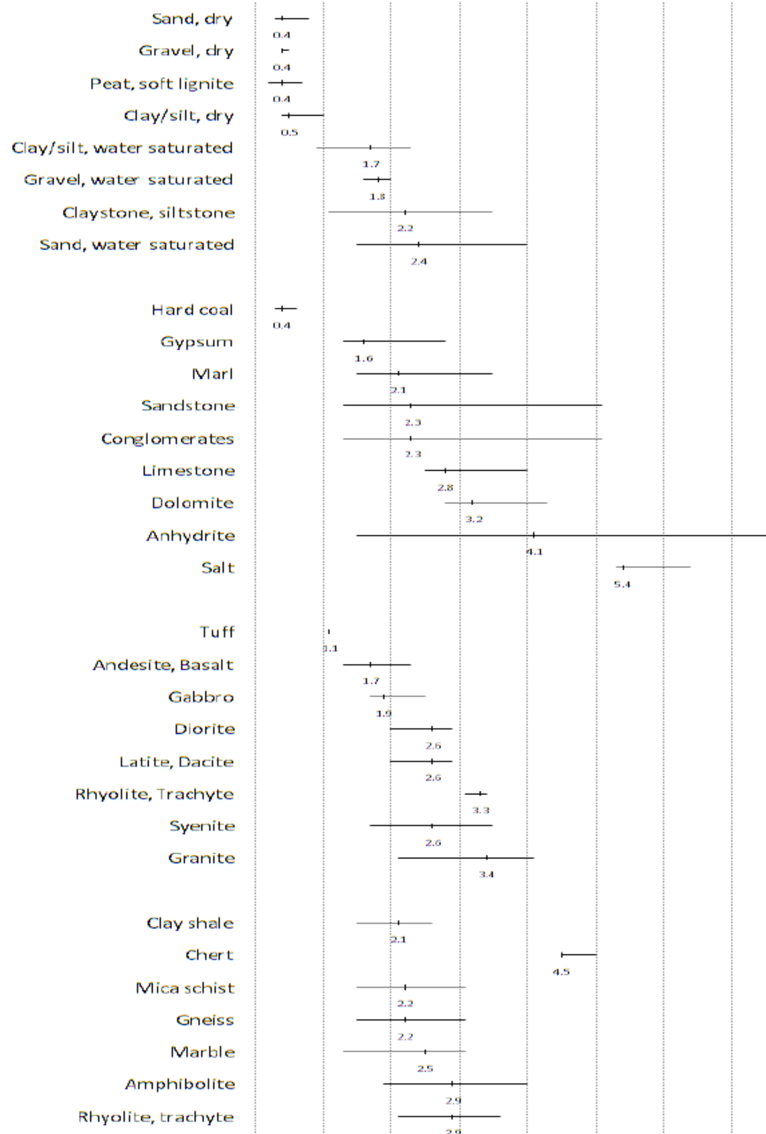
timate of total heating energy consumption er a year for space heating and domestic hot ater		kWh	[1]	
P heating capacity at 0°C ground return mperature and design emitter temperature, H		kW	[2]	
EQ run hours]/[2]	$$\text{FLEQ run hours} = \frac{\text{Total heating energy consumptic}}{\text{Heat pump capacity}}$$			
timated average ground temperature		°C	[4]	App B for Annual mean air temp
timated ground thermal conductivity		W/mK	[5]	BGS – borehole & horizontal surveys GSHPA VBS for TRT App C for rock types
aximum power to be extracted per unit length borehole, horizontal or slinky ground heat changer (from the charts and look-up tables),		W/m	[6]	

Appendix B

gion	Mean monthly and annual air temperature /°C (1981-2010)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Scotland (Dyce)	3.5	3.8	5.3	7.2	9.6	12.4	14.6	14.4	12.2	9.1	5.9	3.6	8.5
/ Scotland (Stornoway)	4.8	4.7	5.6	7.1	9.3	11.5	13.4	13.5	11.8	9.3	6.8	5.1	8.6
cotland (Leuchars)	3.6	4.0	5.7	7.5	10.0	12.9	15.0	14.8	12.7	9.5	6.1	3.6	8.8
rders (Boulmer)	4.4	4.5	5.9	7.4	9.8	12.6	14.7	14.8	12.9	10.1	6.9	4.6	9.0
Scotland (Abbotsinch)	4.0	4.2	5.9	8.0	10.9	13.5	15.4	15.0	12.6	9.4	6.2	3.8	9.1
reland (Aldergrove)	4.4	4.5	6.2	8.1	10.9	13.5	15.4	15.0	13.0	9.9	6.8	4.7	9.4
rth-eastern (Leeming)	3.8	4.1	6.1	8.1	11.0	13.9	16.2	15.9	13.5	10.0	6.5	3.9	9.4
rth-western (Carlisle)	4.3	4.5	6.2	8.2	11.1	13.7	15.7	15.4	13.2	10.1	6.8	4.2	9.4
dlands (Elmdon)	4.1	4.1	6.4	8.4	11.5	14.5	16.8	16.5	13.9	10.3	6.7	4.2	9.8
les (Aberporth)	5.3	5.1	6.6	8.2	10.9	13.4	15.2	15.3	13.7	11.0	8.0	5.9	9.9
ennines (Finningley)	4.2	4.4	6.6	8.6	11.7	14.6	16.9	16.8	14.2	10.6	6.9	4.4	10.0
Pennines (Ringway)	4.5	4.6	6.6	8.7	11.9	14.5	16.6	16.3	14.0	10.6	7.1	4.6	10.0
t Anglia (Honington)	4.1	4.1	6.5	8.6	11.9	14.8	17.3	17.2	14.6	11.0	7.0	4.4	10.1
uth-eastern (Gatwick)	4.3	4.4	6.7	8.7	12.0	14.9	17.3	17.0	14.3	10.9	7.1	4.6	10.2
uthern (Hurn)	4.9	4.9	6.8	8.7	12.1	14.8	17.0	16.8	14.4	11.2	7.6	5.2	10.4
vern Valley (Filton)	5.0	5.0	7.2	9.2	12.4	15.3	17.3	17.1	14.7	11.3	7.8	5.3	10.6
uth-western (Plymouth)	6.4	6.2	7.7	9.3	12.2	14.6	16.6	16.7	14.8	12.1	9.0	7.0	11.0
ames Valley (Heathrow)	5.2	5.2	7.6	9.9	13.3	16.4	18.7	18.4	15.6	12.0	8.0	5.5	11.3

Appendix C

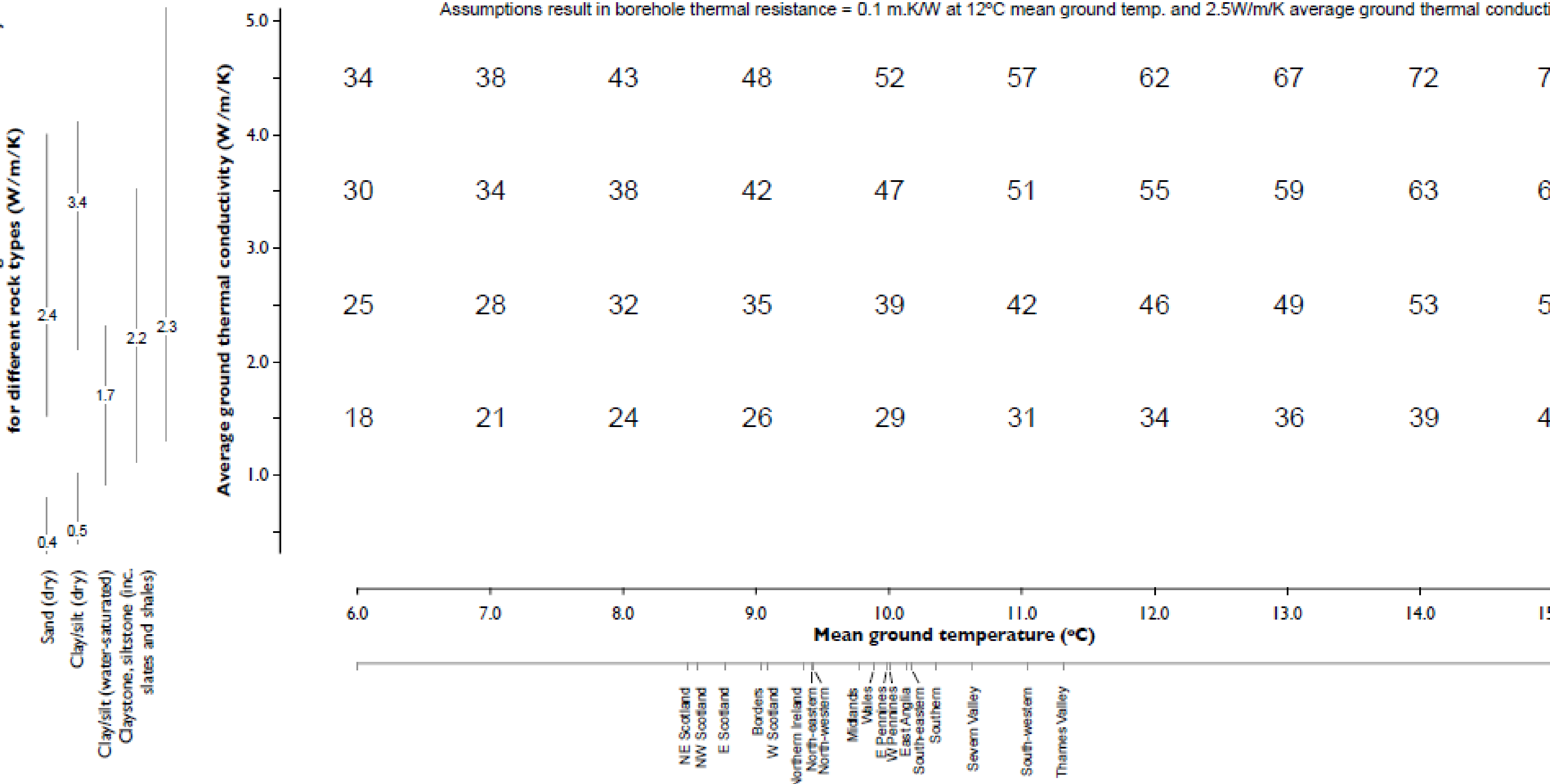
	Type of rock		Thermal conductivity (/W/mK) Min	Max	Recommended
	Sand, dry		0.3	0.8	0.4
	Gravel, dry		0.4	0.5	0.4
	Peat, soft lignite		0.2	0.7	0.4
consolidated rock	Clay/silt, dry		0.4	1.0	0.5
	Clay/silt, water saturated		0.9	2.3	1.7
	Gravel, water saturated		1.6	2.0	1.8
	Claystone, siltstone		1.1	3.5	2.2
	Sand, water saturated		1.5	4.0	2.4
	Hard coal		0.3	0.6	0.4
	Gypsum		1.3	2.8	1.6
	Marl		1.5	3.5	2.1
	Sandstone		1.3	5.1	2.3
id Sediments	Conglomerates		1.3	5.1	2.3
	Limestone		2.5	4.0	2.8
	Dolomite		2.8	4.3	3.2
	Anhydrite		1.5	7.7	4.1
	Salt		5.3	6.4	5.4
	Tuff		1.1	1.1	1.1
	Vulcanite, alkaline to ultra-alkaline	e.g. andesite, basalt	1.3	2.3	1.7
	Plutonite, alkaline to ultra-alkaline	Gabbro	1.7	2.5	1.9
gmatites		Diorite	2.0	2.9	2.6
	Vulcanite, acid to intermediate	e.g. latite, dacite	2.0	2.9	2.6
		e.g. rhyolite, trachyte	3.1	3.4	3.3
	Plutonite, acid to intermediate	Syenite	1.7	3.5	2.6
		Granite	2.1	4.1	3.4
	Slightly metamorphic	Clay shale	1.5	2.6	2.1
		Chert	4.5	5.0	4.5
		Mica schist	1.5	3.1	2.2
tamorphic rock	Moderately to highly metamorphic	Gneiss	1.5	3.1	2.2
		Marble	1.3	3.1	2.5
		Amphibolite	1.9	4.0	2.9
	Vulcanite, acid to intermediate	e.g. rhyolite, trachyte	2.1	3.6	2.9
		Quartzite	5.0	6.0	5.5



GSHP association

British Geological Survey

Maximum power to be extracted per unit length of borehole heat exchanger (W/m) wi
1800 FLEQ run hou
Conditions for us
Heat extraction only (inc. hot wa
6m minimum borehole spacing. Only valid for boreholes arranged in a line; not applicable for a large number of systems in a small a
Table created assuming: 130mm borehole diameter; single U-tube; 32mm OD SDR-11, PE100 pipe with thermal conductivity = 0.420W/m/K; 52mm pipe centre-pipe cen
shank spacing; 25% Mono Ethylene Gylcol thermal transfer fluid; Re > 2500 in the borehole active elements; thermally enhanced grout with thermal conductivity = 2.4W/n
Assumptions result in borehole thermal resistance = 0.1 m.K/W at 12°C mean ground temp. and 2.5W/m/K average ground thermal conducti



6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15
34	38	43	48	52	57	62	67	72	7
30	34	38	42	47	51	55	59	63	6
25	28	32	35	39	42	46	49	53	5
18	21	24	26	29	31	34	36	39	4

GSHP association

Maximum power to be extracted per unit length of horizontal ground heat exchanger (W/m) w

1800 FLEQ run hou

Conditions for u

Heat extraction only (inc. hot wa

0.75m minimum pipe spacing (d > 0.7

Pipe depth between 0.8m and 1

Table created assuming 25mm OD SDR 11

Table created assuming a relationship between the mean monthly temperature swing and annual mean ground tempera

Ground thermal conductivity (W/m/K)	6.0	7.0	8.0	9.0	10.0	11.0	12.0
4.0							
3.6							
3.2							
2.8							
2.4	9.5	13	15	18	21	23	26
2.0	8.7	11	14	16	19	20	23
1.6	7.7	10	12	14	16	18	20
1.2	6.2	7.9	9.7	11	13	15	16
0.8	4.5	5.5	6.9	8.1	9.4	11	12
0.4	2.8	3.4	4.2	4.9	5.6	6.3	6.8

Mean ground temperature (°C)

Recommended values and ranges of thermal conductivity for different rock types (W/m/K)

- Sand (dry) 0.4 – Clay/silt (water-saturated) 1.7
- Clay/silt (dry) 0.5 – Sand (water-saturated) 2.4

NE Scotland, NW Scotland, E Scotland, Borders, W Scotland, Northern Ireland, North-eastern, North-western, Midlands, Wales, E Pennines, W Pennines, East Anglia, South-eastern, Southern, Severn Valley, South-western, Thames Valley

Mean annual air temperature for UK regions (°C)

GSHP
ssociation

Maximum power to be extracted per unit length of slinky ground heat exchanger trench (W/m) w
1800 FLEQ run hou

Conditions for u

Heat extraction only (inc. hot w

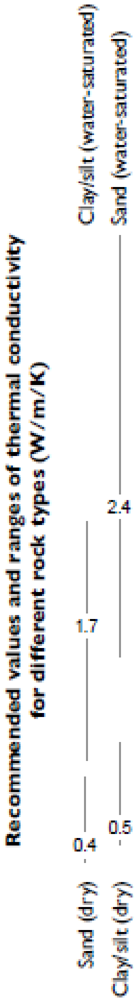
3m minimum trench spacing (d ≥

Mean slinky depth between 0.8m and

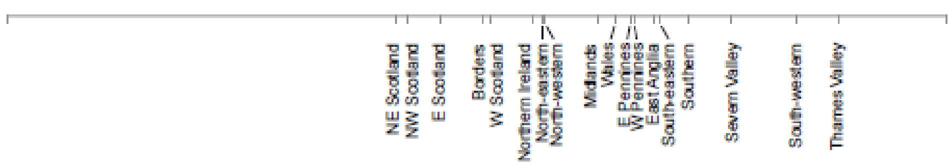
Table created assuming 32mm OD SDR 11

Pipe length to trench length ratio, $R_{pt} \geq 4$. For a 900mm slinky diameter this corresponds to a maximum 1250mm slinky

Table created assuming a relationship between the mean monthly temperature swing and annual mean ground tempera



Ground thermal conductivity (W/m/K) \ Mean ground temperature (°C)	6.0	7.0	8.0	9.0	10.0	11.0	12.0
4.0							
3.6							
3.2							
2.8							
2.4	35	45	53	61	69	76	84
2.0	32	40	47	54	61	67	73
1.6	28	34	41	47	52	58	63
1.2	22	27	32	37	42	47	51
0.8	16	19	23	26	30	34	36
0.4	9.8	11	14	16	18	20	21



Mean annual air temperature for UK regions (°C)

GSHP Association

Table 3

timate of total heating energy consumption er a year for space heating and domestic hot ater		kWh	[1]	
heating capacity at 0°C ground return mperature and design emitter temperature, H		kW	[2]	
EQ run hours]/[2]	$\text{FLEQ run hours} = \frac{\text{Total heating energy consumptio}}{\text{Heat pump capacity}}$			
timated average ground temperature		°C	[4]	App B for Annual mean air temp
timated ground thermal conductivity		W/mK	[5]	BGS – borehole & horizontal surveys GSHPA VBS for TRT App C for rock types
aximum power to be extracted per unit length borehole, horizontal or slinky ground heat changer (from the charts and look-up tables),		W/m	[6]	

GSHP Association

Table 3

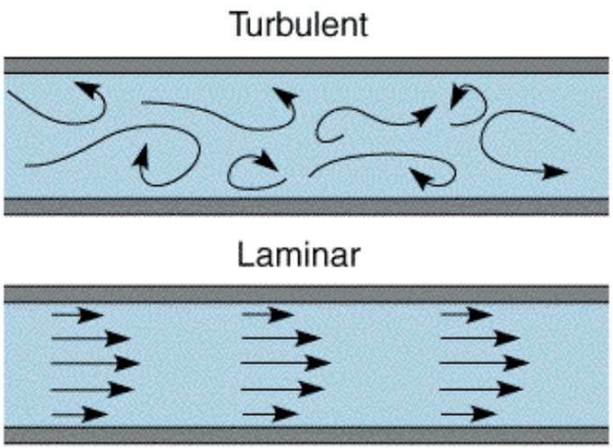
Assumed heat pump SPF (from heat emitter guide)			[7]	
Maximum power extracted from the ground (i.e. the heat pump evaporator capacity) G = [2]*1000*(1-1/[7])		W	[8]	$H\left(1-\frac{1}{SPF}\right)$
Length of ground heat exchanger calculated using the look-up tables L_b = [8]/[6]		m	[9]	$L_b = \frac{G}{g}$
Borehole, horizontal loop or slinky spacing, d		m	[10]	$A = L_b d$
Total length of ground heat exchanger active elements, L_p = [9]*R_{pt}		m	[11]	$L_p = L_b R_{pt}$
Total length of ground heat exchanger active elements installed in the ground, L_p'		m	[12]	

Rpt = 2 – boreholes,
1 - horizontal & min pipe length to trench length slink

Shall ensure.... turbulent flow.... Reynolds number…. should be ≥ 2500

Geological situation on drilling or digging show substantial deviation.... design ground HX.... recalculated

Hydraulic layout of the ground loop... pumping power... < 2.5%.... HP capacity



Site Specific Issues

HP always following manufacturer's instructions

ASHP - Avoid air recirculation......

…..........

ASHP Permitted Development rights (England and Wales) MCS 020 – comply with Planning Standards.

Commissioning

Closed-loop ground heat exchangers

The following commissioning procedure shall.......

Ground arrays (including header pipes and manifolds)....

flushed as one system to remove all debris and purged to remove all air.....

shall flush vertical and horizontal ground arrays in both directions....

should flush slinky ground arrays in both directions.....

HP (and its pipework) shall be isolated from ground HX during this process....

HP (and its pipework) shall be flushed & purged as another system, in isolation....

Once the ground array is free from debris and visible air bubbles/pockets, purging should continue on the entire system.... at least 15 minutes with a minimum flow velocity of 0.6m/s.... see Table 4

Table 4

ipe outer iameter mm	Recommended flow rate for flushing and initial purging		Minimum flow rate for purging micro air bubbles after flushing and initial
	Horizontal ground arrays (1m/s) /litres/min	Slinky ground arrays (1.5m/s) /litres/min	All ground arrays (0.6m/s) /litres/min
5	20	30	12
2	32	48	20
0	50	76	31
0	79	118	48
5	133	200	81

Table 4: Flow rates required for different pipe diameters to achieve 0.6m/s flow velocity for purging micro air bubbles; 1m/s for flushing and purging horizontal ground arrays of debris and visible air bubbles; and 1.5m/s for slinky ground arrays. Parallel loops or layouts with variable pipe geometry may require higher flow rates to achieve these flow speeds.

GSHP Association

Commissioning

Once purged.... shall.... pressure test.... entire ground source HX to BS EN 805 section 11.3.3.4

Antifreeze.... freeze protection down to -10 °C

Antifreeze quantity and type.... appropriate for the system design.... flow rate.... viscosity.... choice of ground array circulation pump.

Quantity of biocide recommended by the antifreeze manufacturer/supplier... added

2 separate, random samples.... refractometer tested.... confirm -10 °C....

Evidence should be provided to the customer that this has been achieved.

The Ground Source Heat Pump Association "Closed-loop vertical borehole design, installation and materials standard" (VBS) …. further commissioning guidance

Documentation

a comprehensive documentation pack…. Including....

- Sizing
- Domestic hot water services
- Emitter design
- Ground heat exchanger design
- System performance

GSHP ıssociation

Documentation

tem	Included	Not included	Comments
Sizing			
Details of the heat loss calculations made on the building, including the ralue of the heat loss coefficient determined for the building, the lesign internal and external air temperatures and average external air emperature used for heat loss through the floor.	☐	☐	
The heat pump power output at the design ambient temperature and lesign emitter temperature.	☐	☐	
For air-source systems, evidence that the energy requirements of the ıeat pump's defrost cycles can be met inside the design temperature ange.	☐	☐	
For installations where other heat sources are available to the same ɔuilding, what proportion of the building's space heating and domestic ıot water has been designed to be provided by the heat pump.	☐	☐	
Domestic hot water services			
Evidence for the choice of domestic hot water cylinder.	☐	☐	
Emitter design			
The heat pump power output at the design ambient temperature and lesign emitter temperature.	☐	☐	
All specific room heat losses (in W/m2);	☐	☐	

A well **designed, installed, commissioned and maintained** GSHP system is:

- Cheaper than Gas, Oil, Wood, Coal or Economy 7
- Has no Carbon Monoxide or flueing issues
- Easily achieves a 10% or much more RE target
- Can heat and cool the building
- Compatible with Domestic Solar Hot Water

Thanks for listening