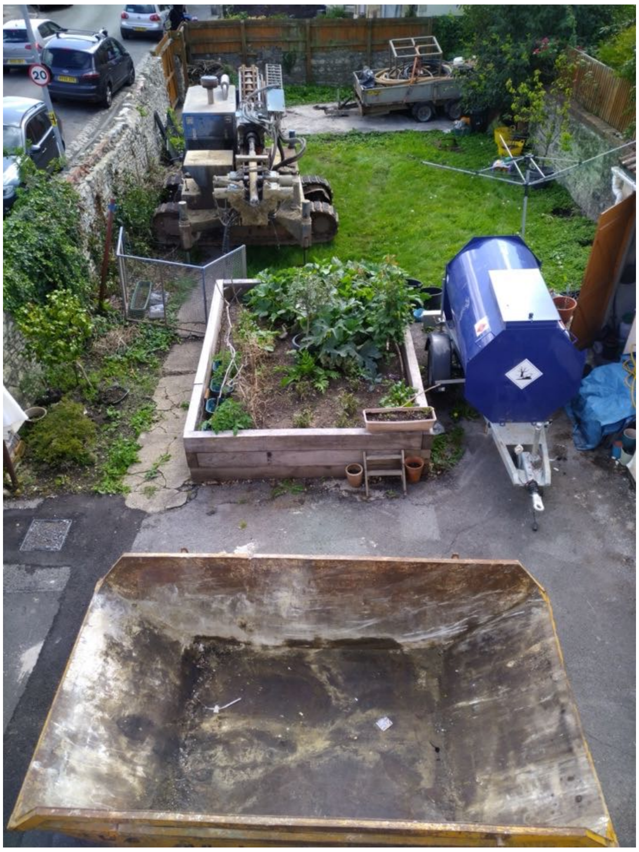
SOAP
RETROFIT

Ground Source Heat Pump Sizing Using SmartHTC

Case Study Application of SmartHTC

20 October 2021

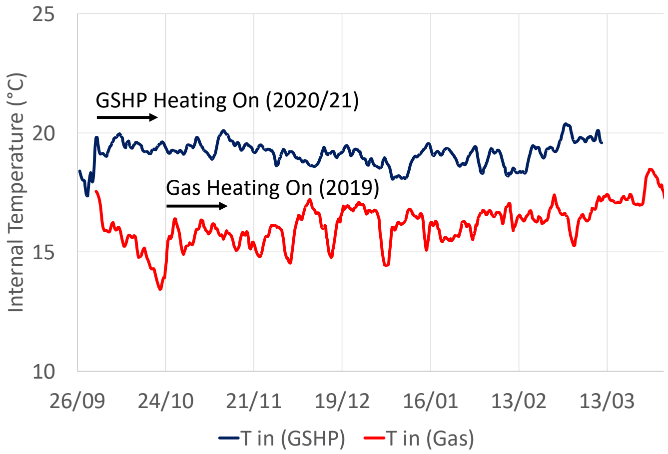


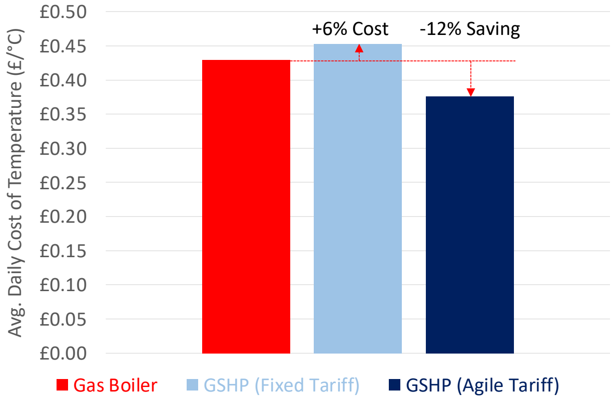
1 Executive Summary

SOAP Retrofit undertook a low energy retrofit project of a large semi-detached Victorian property in Bristol which included the installation of a GSHP system using closed-loop vertical boreholes. The GSHP replaced a gas combi boiler and the existing radiators were retained

To accurately size and specify the system, SmartHTC[1] was used to measure the actual thermal performance of the dwelling rather than relying solely on design calculations. The measured Heat Transfer Coefficient (HTC) of the property was approximately 400 W/K compared to design estimates of > 700 W/K. The measured HTC allowed the GSHP to utilise only 3 boreholes (rather than 4). Correspondingly, a 5-15kW inverter-driven MasterTherm heat pump was selected for the installation. A larger unit would have been required if based on the design estimate. Furthermore, this sizing exercise provided confidence in retaining the existing radiators

The operational performance of the gas and GSHP systems were monitored and analysed by SOAP Retrofit throughout 2019 to 2021. The GSHP achieved comfortable internal temperatures (averaging ~19°C) across the monitoring period. These were notably higher than the occupants previous use of the gas boiler system (~16°C). The GSHP was demonstrably able to meet the temperature demand of the occupants whilst external temperatures varied from 14.7°C to -2.9°C





In terms of energy efficiency and cost effectiveness, the GSHP performed better than the gas boiler. On average, the daily energy cost, normalised by temperature, using the GSHP system was 38p/°C; 12% cheaper than compared to the gas boiler (43p/°C). This was aided using a time-of-use tariff (Octopus Agile). If a traditional fixed electricity tariff was used, the daily normalised cost would be 6% higher than gas (45p/°C)[2]

Overall, the GSHP system delivers internal temperatures very cost effectively, with significantly lower total energy consumption (and environmental impact). Utilising the Renewable Heat Incentive, the system has a simple payback period of 6.14 years before accounting for any energy cost savings

[1] https://buildtestsolutions.com/thermal-performance/smarthtc/

[2] Note that these values include non-heating costs but represents the actual savings achieved in total running costs due to the GSHP system (which was the only change between monitoring periods)

2 Introduction

A low energy retrofit project of a large semi-detached Victorian property in Bristol was undertaken by SOAP Retrofit. The project involved design and installation of;

- 270mm mineral wool loft insulation (including loft legs and boarding)
- 100mm mineral wool suspended timber floor insulation throughout the ground floor
- 5.25 kW_p Solar PV array to the East and South facing roof pitches
- Smart heating controls
- LED lighting throughout
- Smart meters and energy monitoring systems
- Extensive draughtproofing and air tightness works
- Vertical borehole Ground Source Heat Pump (GSHP) system, installed following the above works

Future works being developed include;

- Improved ventilation with decentralised MHVR in bathrooms
- External wall insulation (mineral wool or wood fibre) to the East and South facing solid brick rendered façades
- Internal wall insulation (wood fibre) to the North facing solid stone façade
- Waste-water heat recovery

This report provides further information on the GSHP system design and installation which was informed by the SmartHTC[3] tool, provided by Build Test Solutions and administered by (and developed in conjunction with) SOAP Retrofit Ltd. Utilising the SmartHTC system enabled the system to be sized appropriately and reduce capital requirements by approximately 15% (as an additional borehole was calculated to not be required and a smaller heat pump could be utilised). This is particularly important as when wall insulation is installed in the future, the GSHP could have been oversized. Optimal sizing now, permits reduced flow temperatures and therefore maximised performance of the system in the future

SmartHTC is an algorithm that measures the whole house Heat Transfer Coefficient (HTC) by utilising smart meter (or simple meter readings) and internal temperature data. It is designed to be an accurate, repeatable, unobtrusive, and low cost in-situ measurement tool, with results comparable to those that would be found via a co-heating test (which is by no means low cost or unobtrusive)

[3] https://buildtestsolutions.com/thermal-performance/smarthtc/

3 Property Details

The property undergoing retrofit was built in 1905, is of solid wall construction with suspended timber floors and has a pitched tiled roof. The ground floor has been retrofitted with with 100mm semi-rigid Rockwool insulation throughout. The lofts have also been retrofitted with 270mm of cross-laid Rockwool insulation throughout. There is a room in the roof which requires further insulation at the walls, pitches, and flat roof. Loft and floor insulation and the addition of Solar PV were conducted before the gas monitoring period documented in this report

The property is semi-detached and the side and rear of the property are solid rendered brick (~425mm), whereas the front is solid stone (~400mm). All walls are plastered internally with gypsum plaster. The small utility room to the rear of the property is constructed from single skin solid brick (~150mm) with flagstone flooring directly laid onto the soil. It has double glazed windows throughout, retrofitted in 2014. It is naturally ventilated (with a continuous and humidity controlled extract vent in the kitchen) and there are 2 original fireplaces which have been temporarily sealed with mineral wool. Retrofit of a Mechanical Ventilation Heat Recovery (MVHR) system is planned to extract humid air from the main bathroom and en-suite and supply pre-heated fresh air to the main bedroom, second bedroom and loft. These areas currently suffer from excessive relative humidity due to lack of bathroom ventilation

The property areas are as follows:

- Gross internal floor area = 231m^2
    - *Ground Floor = 111m^2*
    - *First Floor = 98m^2*
    - *Room in Roof = 22m^2*
- External wall area = 239m^2
    - *Of which, windows = 39m^2*
    - *Wall = 200m^2*
- Party wall area = 130m^2

Figure 1: As-Built Property Façades; Front (North), Side (East) and Rear (South)

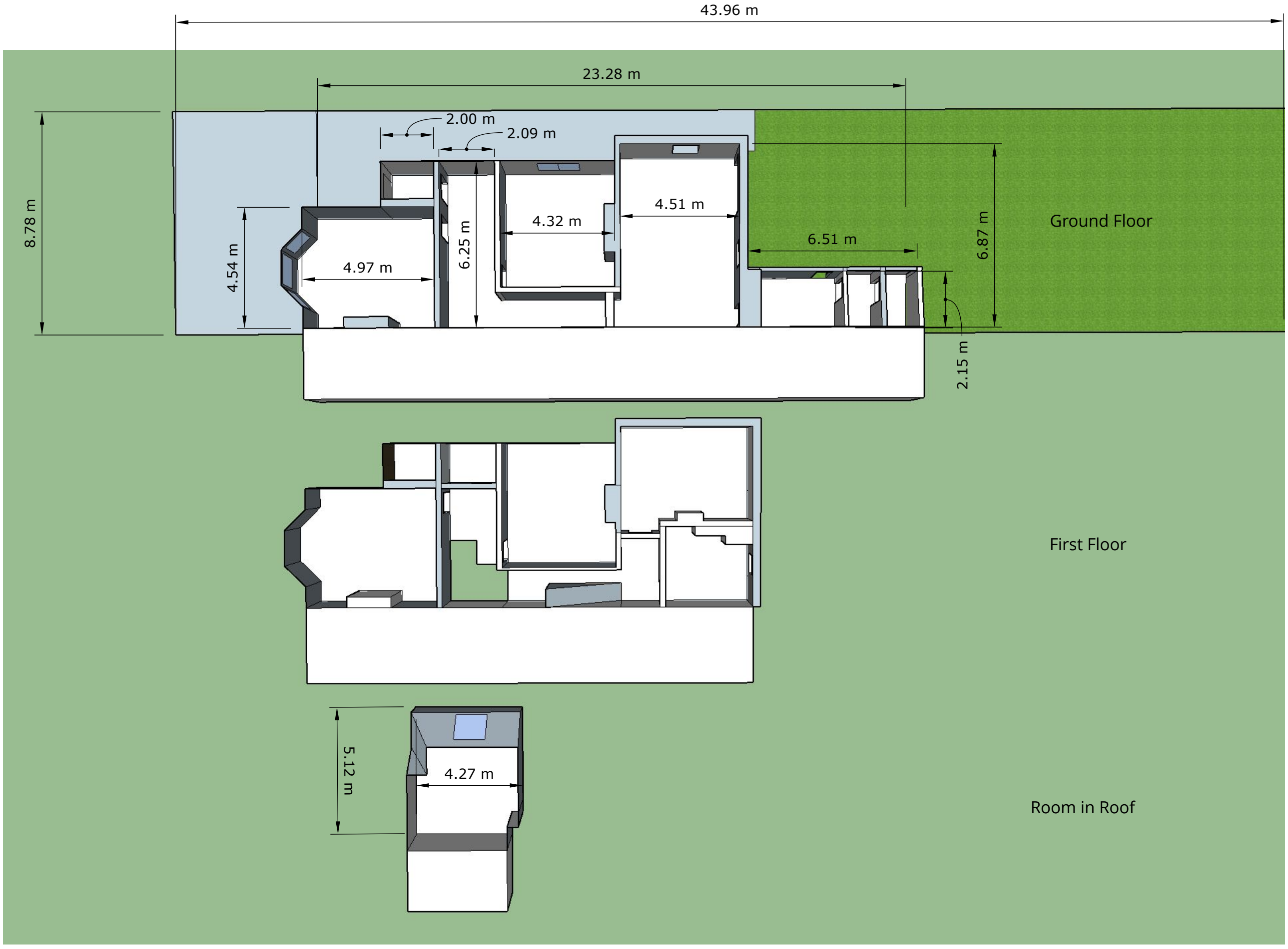


Figure 2: As-Built Floor Plan

4 Heat Transfer Coefficient - SmartHTC vs. SAP

To inform the heat pump sizing process, SmartHTC was utilised to measure the HTC which can be used to estimate the peak heat load requirement of the property[4]. The value measured by SmartHTC (based on real operational data) was compared to the value that would be calculated using a full SAP calculation and from the initial (unadjusted) heat loss model

Figure 3 and Table 1 below show the results from the SmartHTC measurement. SmartHTC uses a 3-week period to calculate the HTC of the property. The graph shows consecutive calculations of the HTC throughout the winter period to provide additional confidence in the results. The table shows the average HTC measured across the whole winter period (including confidence intervals). Results showed excellent repeatability throughout the period, improving confidence in the result

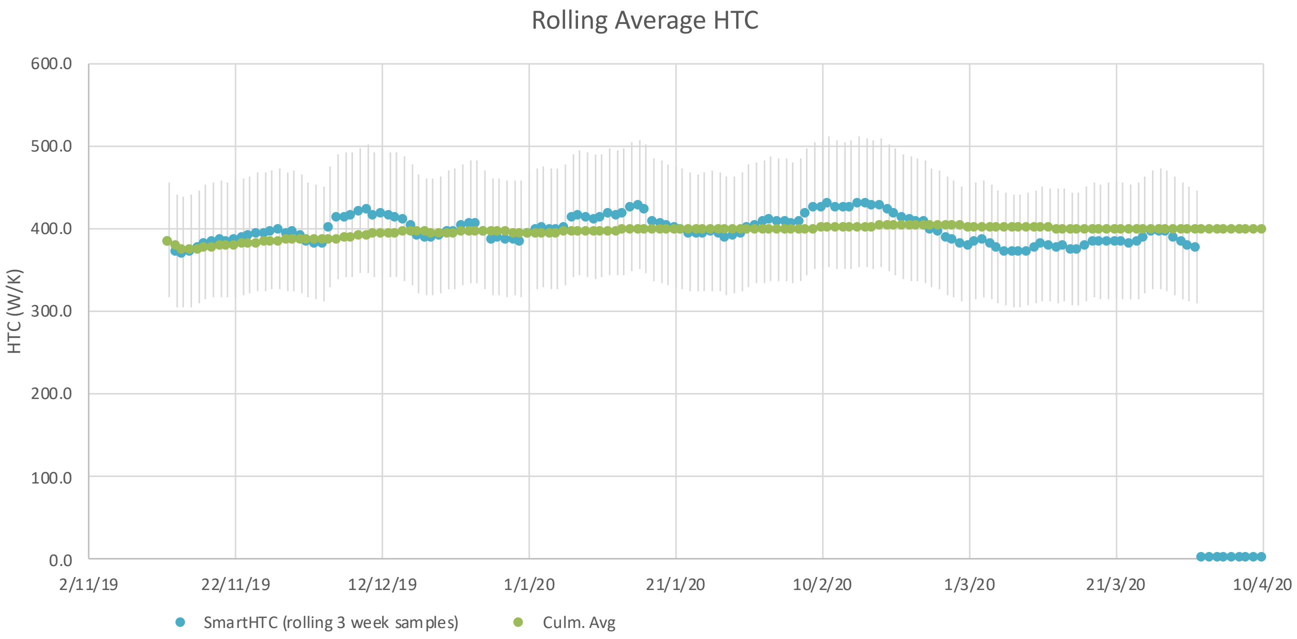


Figure 3: SmartHTC 3-Week Rolling Samples and Cumulative Average from 24/11/19 to 01/04/20

	HTC (W/K)	-ve CI	+ve CI
SmartHTC	392	-67	+72

Table 1: Winter HTC Measurement from SmartHTC (23 Weeks Data Total)

Table 2 below shows the SAP calculation of the HTC, based on as-built construction details (rather than default assumptions) to accurately represent the actual building performance. There is a significant discrepancy between the calculated and the measured HTC of approximately 80% (SAP calculated HTC > measured HTC)

[4] Note that MCS accredited calculations were also performed by the supplier. However, the construction details were adjusted based on the findings of the SmartHTC measurement to more accurately calculate the actual peak heat load

Heat Loss (W/K)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fabric	463	463	463	463	463	463	463	463	463	463	463	463
Thermal Bridges	69	69	69	69	69	69	69	69	69	69	69	69
Ventilation	195	183	187	183	187	169	172	165	162	169	169	179
HTC	727	715	719	715	719	701	704	697	694	701	701	711
Average HTC	**709 W/K**											

Table 2: Extract from SAP – Heat Loss and Heat Transfer Coefficient (HTC)

4.1 Heat Pump Sizing

To calculate the peak heat load used to determine the GSHP and borehole requirements, SmartHTC, SAP, and Heat Engineer calculated outputs were analysed using a ΔT of 22ºC[5] (Table 3 below)

	HTC	Peak Heat Load
SAP	709 W/K	15.6 kW[6]
Heat Engineer (unadjusted)	*931 W/K*[6]	20.5 kW
SmartHTC	392 W/K (-67, +72)	7.2 to 10.2 kW

Table 3: Estimated Peak Heat Load (ΔT = 22ºC)

The heat load using the measured (SmartHTC) value was significantly lower than either (unadjusted) calculated value (~40% to 60% lower) which resulted in a more appropriately sized system to be designed and installed. The optimised design utilises 3x 100m vertical boreholes, with peak heat output of approximately 5kW each. The heat pump selected was the MasterTherm AQ37i1, single phase, inverter driven unit with an output ranging from 5-15kW[7]. Additionally, a 290l hot water cylinder with integrated 90l heating buffer was installed

To satisfy the calculated heat load, a fourth borehole would be required, and a larger heat pump to be installed (and buffer vessel) which would have increased capital costs significantly and introduced inefficiency into the system during operation due to an oversized heat pump, unable to modulate down to lower heat loads sufficiently. Figure 4 below shows the locations of the vertical boreholes in the rear garden. A fourth borehole would have potentially been feasible, but it is desirable to size the GSHP optimally and reduce capital cost to maximise the contribution (and payback) from the Renewable Heat Incentive. Furthermore, when wall insulation is installed in the future, there is potential for the GSHP to be oversized. However, by optimising the current design (using a reasonably high peak flow temperature of 55ºC) and using an inverter driven heat pump, the system can be continually optimised by simply adjusting flow temperatures. This maximises the cost-effectiveness of the project, which is reliant on the RHI[8]. Overall, the optimisation exercise using the SmartHTC measurement enabled an optimal GSHP design to be conducted

[5] Average internal temperature = 20ºC. External temperature = -2ºC
[6] Not directly calculated in model. Estimated based on 22°C ΔT
[7] Note that the initial Heat Engineer model recommended a 7 – 22kW MasterTherm GSHP
[8] It is a separate issue as to the appropriateness of current funding which could have been better spent on deep insulation works and subsequent installation of a smaller heat pump system

Note that the boreholes are drilled approximately 6m apart at the surface and drilled at approximately 5° off-vertical ("toe-out"), meaning the base of the boreholes are approximately 14m apart. This ensures the maximum thermal capacity of each borehole and ensures that the ground does not become over-cooled between boreholes. This spacing was the maximum permissible given the dimensions and obstructions in the garden

Figure 4: Locations for Boreholes (red), Manifold (orange) and Lateral Pipework (red-dash) in Rear Garden[9]

4.2 Radiator Sizing

To confirm the compatibility of the GSHP with the existing radiators, a per-room heat loss analysis was conducted using Heat Engineer. The majority of the radiators throughout the house are Stelrad type K2 (2x radiator panels with 2x convertor fins) and have high output to balance the original construction of the property. However, with the retrofit insulation and air tightness measures, the heat loss has reduced significantly and therefore the existing radiators are "oversized", and so can be operated at lower flow temperatures. Note that the measured HTC could not be entered into Heat Engineer and so the values derived from this calculation are slightly higher than measured. However, any oversizing of the heat emitters permits the GSHP to be operated at lower temperatures for periods of the year which will improve its overall Seasonal Coefficient of Performance

Table 4 below shows the calculated radiator outputs and individual room heat losses calculated in Heat Engineer. The under/oversize is also tabulated. Note that some rooms do not have any radiators (i.e. hallways) and so rely on adjacent spaces to maintain temperature. Most bedroom and living space radiators are significantly oversized, and this additional output will help to balance

[9] Note that the hedge row has been removed to facilitate installation of GSHP

heat loss from untreated spaces. The towel rails in both bathrooms are planned for replacement with dedicated radiators due to the significant under-sizing. The office is currently unheated but houses the hot water cylinder (290l + 90l central heating buffer). A radiator will be fitted in the future if the temperatures are determined to be insufficient. The utility room houses the GSHP and is also only intermittently used, but a radiator has been added (1.2m x 0.6m K2 unit) to improve the heating. A 0.8m x 0.5m K2 unit has also been retrofitted in the lobby as this was a notable cold spot

Room	Radiator Output @ 55°C (W)	Room Heat Loss (W)	Under/Oversize (W)
Kitchen	2,142	2,422	-280
Dining	1,919	1,253	+666
Living	2,548	2,013	+535
GF Hall	*(No Radiator)*	806	-806
Utility	980 *(+ Radiator Retrofitted)*	1,671	-691
Lobby	*(Radiator Retrofitted)*	463	-463
Bedroom 1	2,380	1,204	+1176
En-Suite	280	595	-315
Bathroom	336	544	-208
Bedroom 2	2,142	536	+1606
Bedroom 3	1,904	970	+934
Office	*(No Radiator)*	846	-846
Bedroom 4	1,904	323	+1581
FF Hall	*(No Radiator)*	640	-640
TOTAL	16,535	14,286	+2,248

Table 4: Individual Room Heat Loss and Radiator Sizing

In parallel to the radiator sizing, a simple exercise was also conducted to determine how appropriate the existing radiators would be for the reduced flow temperatures supplied by the GSHP. The maximum temperature supplied by the heat pump (MasterTherm AQ37i1) is 55°C, at an acceptable SCOP of 3.73[10]. Throughout the 2019 winter, the boiler flow temperature was manually set to 55°C to mimic the potential flow temperatures from the heat pump. The boiler was a Worcester Bosch 42CDi Classic combi, supplying all the heating and hot water for the property. The internal temperatures were monitored throughout the winter period via the SmartHTC sensors and via the Honeywell EvoHome smart TRVs. External conditions logged via Weatherbit.io

Internal conditions were programmed to be 20°C from 8am – 10am and 5pm – 10pm, with setback temperatures of 16°C. The loft room was typically unheated as it is only used as a spare room. Figure 5 below shows the monitored temperatures over the winter period. The whole period is shown in the top graph and a "zoomed in" period shown in the bottom graph for clarity. The temperature response achieved with the reduced flow temperature was satisfactory and each room reached and held its target temperature without fail. This simple exercise was highly beneficial to improve client confidence in adopting lower flow temperatures. Note that it would have been beneficial to reduce

[10] https://mcscertified.com/product-directory/

flow temperatures further because since its installation, the heat pump has successfully operated with a maximum weather compensated flow temperature of 45°C

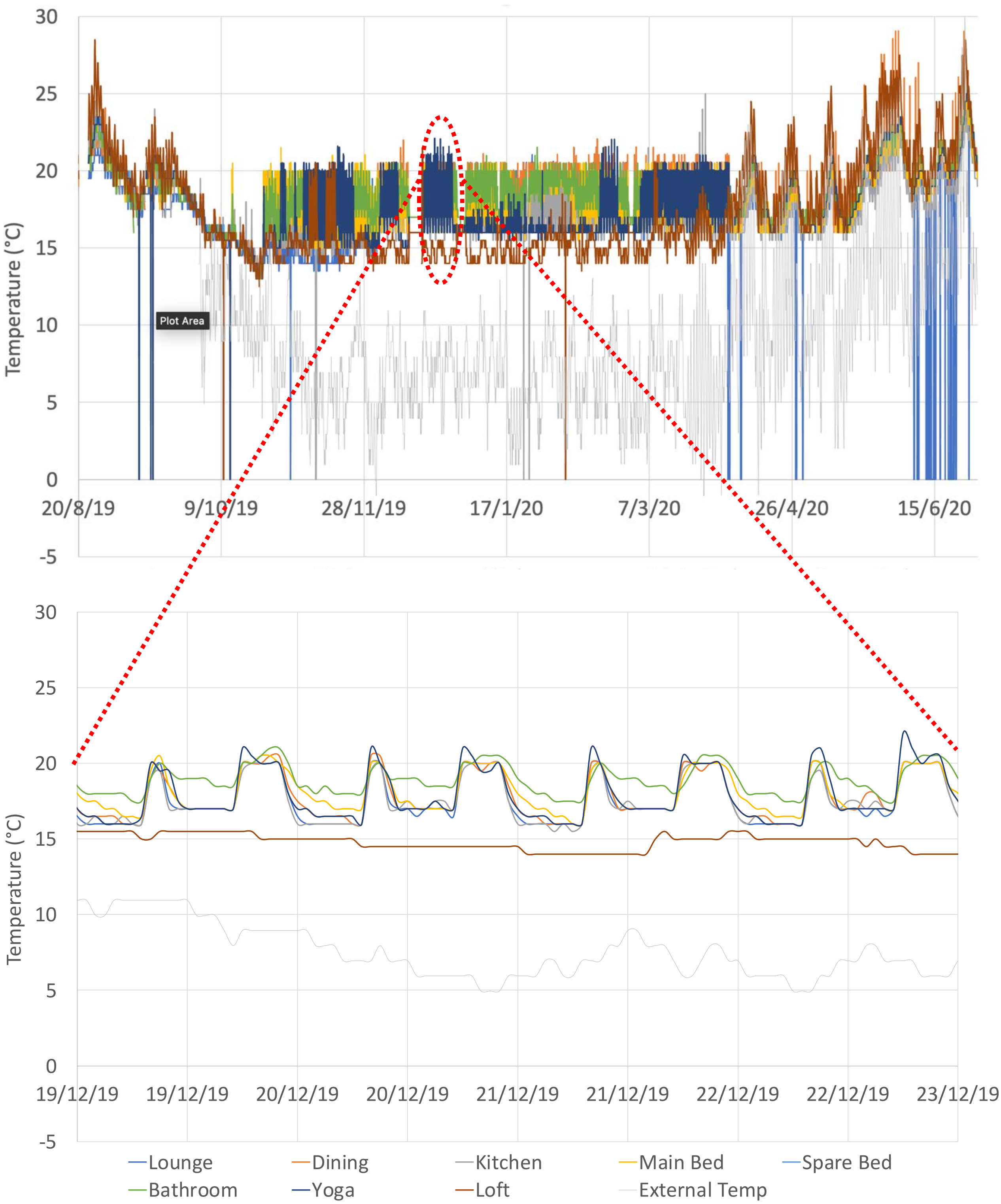


Figure 5: Internal Temperatures – Whole Winter (top) and Sample Period (bottom)

5 Installation and Payback

The installation of the GSHP system was completed by Thermal Earth Ltd throughout the summer in 2020. Figure 6 below shows the MasterTherm AQ37i1 GSHP in-situ in the utility room and the Joule combined DHW (290l) and buffer (90l) cylinder in the office (first floor). The cylinder was fitted in the location of the gas boiler and so no additional space within the house was lost. The utility room area was the closest location to the garden where the boreholes and manifold were installed and so minimise the risk of condensation on the brine loop pipes within the house. Note that the photos were taken before pipe insulation was installed on the GSHP pipework

A simple hot water diverter (Solic 200) was also installed as part of the works to divert excess PV generation to the immersion in the DHW cylinder. This also provides some additional protection against legionella (alongside a weekly timer on the immersion) as this can raise the temperature of the cylinder to 60°C, whereas the GSHP is programmed to provide 48°C

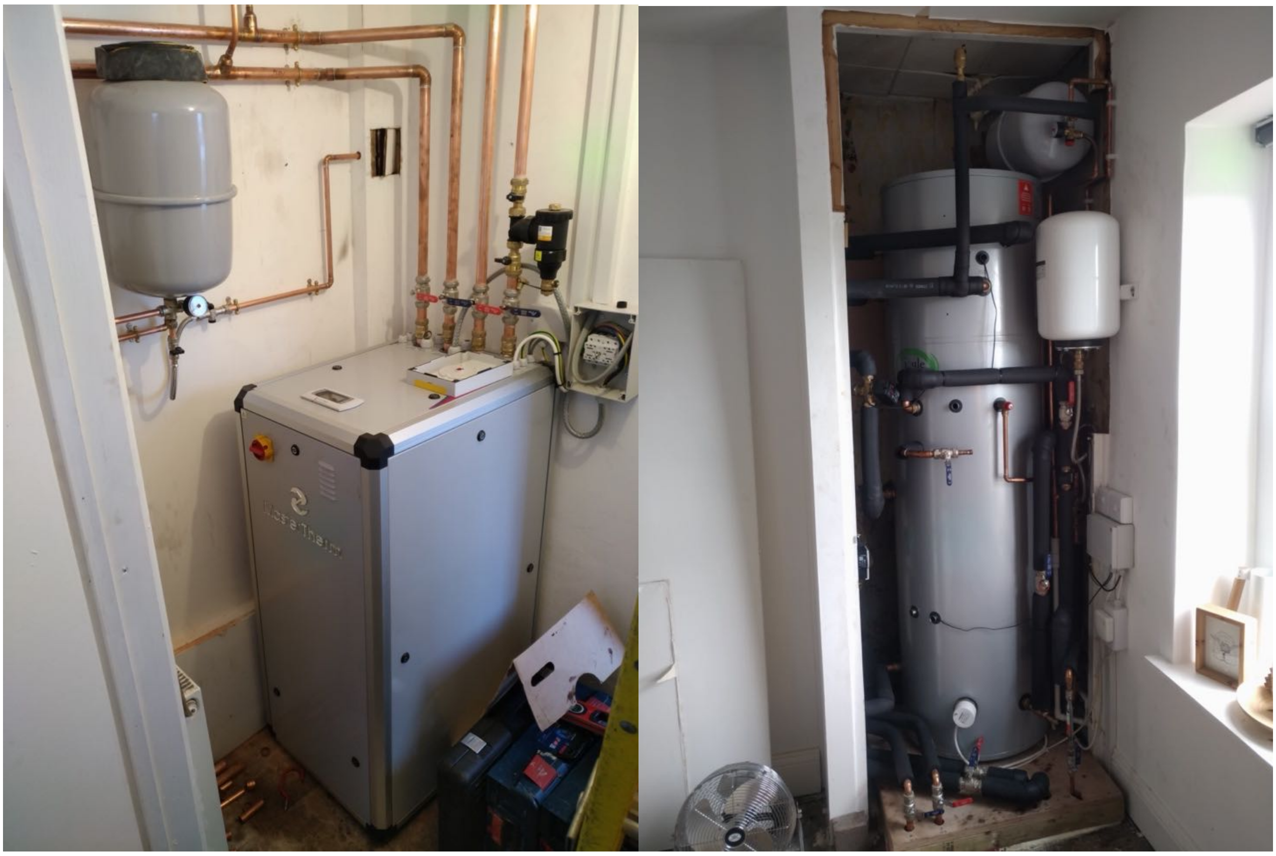


Figure 6: MasterTherm AQ37i1 GSHP (left) and Joule 300l DHW + 90l buffer cylinder (right) in-situ

The total installation cost of the system was £32,500 inc. VAT (@5%). The Renewable Heat Incentive (RHI) funding will provide £37,054 over the 7-year period (exc. any CPI increase). The system therefore has a simple payback period of 6.14 years before accounting for any operational cost savings

6 GSHP Operational Performance

The GSHP system was commissioned on 30th September 2020 and the first full day of operation was 1st October 2020. It was not possible to include an MMSP (Metering and Monitoring Service Package) as part of the install as there are no commercially available systems for GSHPs. Therefore, precise determination of the Coefficient of Performance (COP) is not possible. However, in the following section, detailed monitoring data from comparable winter periods with each system (gas combi boiler in 2019 and GSHP in 2020) have been analysed to compare the overall efficacy[11] of the heating system

The period compared is from 1st Oct until 10th Mar 2021 for the GSHP system and from 23rd Oct 2019 to 10th Feb 2020 for the gas boiler system. Figure 7 below compares the average internal[12] and external temperatures during these periods, also highlighting when each system was switched on for the winter. For both systems, daily average external temperatures in the monitoring period varied similarly, between 14.7°C and -2.9°C for the GSHP and 14.4°C and 1.7°C for the gas boiler

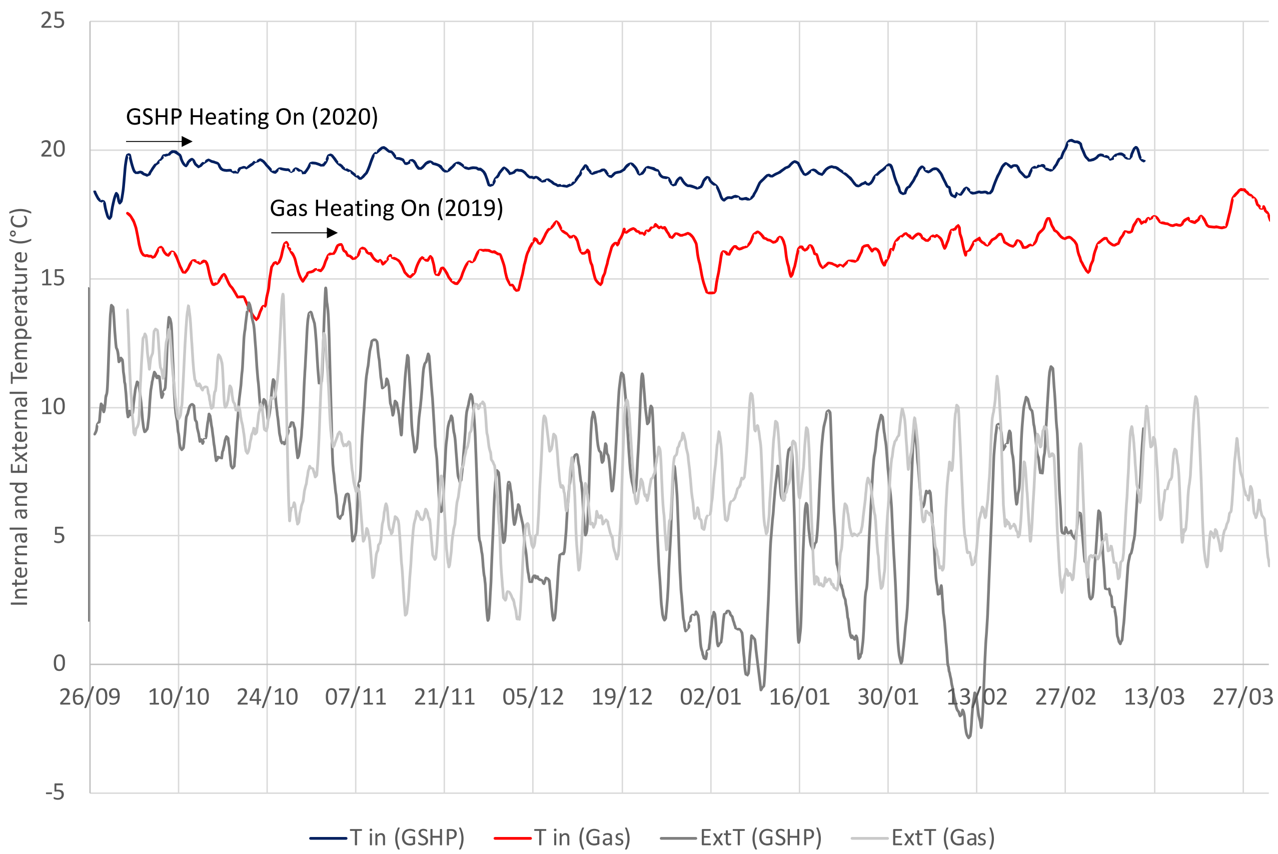


Figure 7: Comparison between Internal and External Temperature During Winter Periods with Gas and GSHP system

[11] Efficacy is defined here as the useful system output, which in the case of a heating system is the ΔT between internal and external temperatures, per unit of consumption of energy (gas or electricity). The units are °C/kWh

[12] Derived from 5 sensors for 2019 and 7 for 2020 (two additional, otherwise same locations)

It is clear that the internal temperatures achieved with the GSHP are significantly higher (and more comfortable) than when the gas boiler was used. The operating procedures are considerably different with the GSHP programmed to achieve 20-21°C for the majority of the day (19.5°C average) compared to two peaks (7 hrs total) of 20°C and a setback temperature of 16°C (17.2°C average). The setpoint profiles are shown in Figure 8. It is intuitive therefore that the GSHP system is achieving significantly higher internal temperatures rather than this being conclusive of its relative performance. However, it is important to note that internal temperatures near 20°C were easily achieved with the GSHP system and so the overall system sizing appears demonstrably sufficient

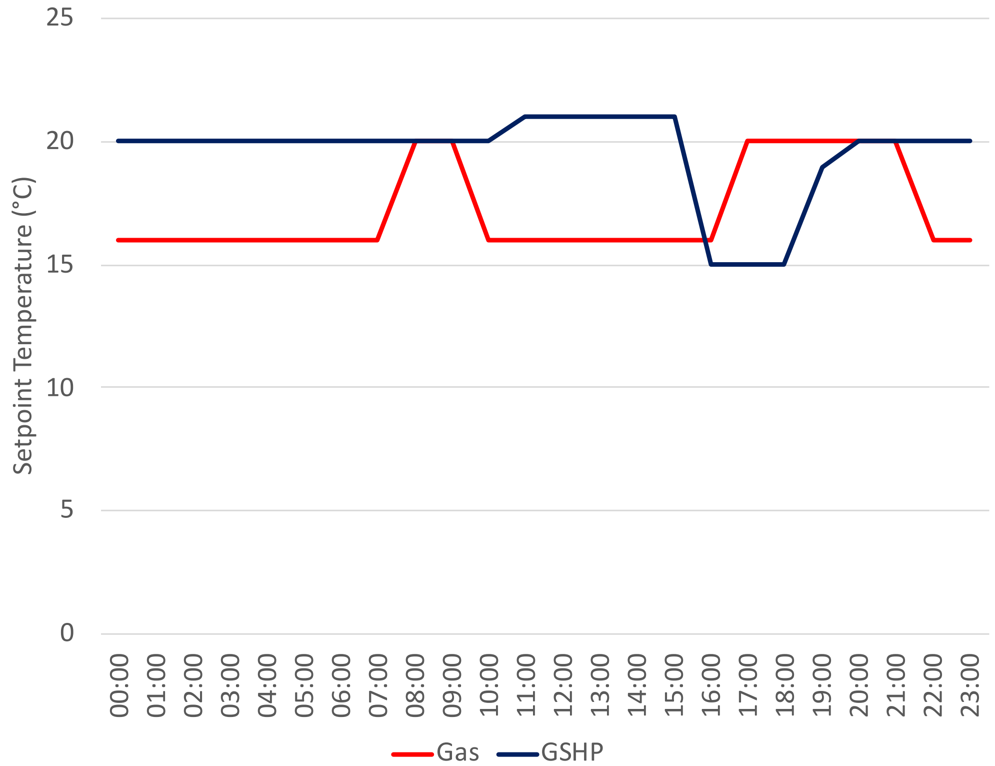


Figure 8: Temperature Setpoints for Gas Boiler (2019) and GSHP (2020) Systems

To analyse the relative performance of the systems, the total energy consumption across the monitoring periods was recorded and used to calculate the efficacy of the systems. For the gas boiler system, this relied on periodic manual gas meter readings taken throughout the winter period. For the electrical consumption, half-hourly data was accessed via the SMETS2 smart electricity meter direct from the utility supplier (Octopus Energy). The solar PV system also includes dedicated monitoring which reports generation, export and self-consumption (in 15 min intervals) and so this data was also used in the analysis. It is not possible to disaggregate domestic electrical consumption (i.e. for plug loads, cooking etc.) or space heating and hot water. It is therefore assumed that hot water and domestic electrical consumption is comparable between the two winter periods. Note that there was no change of occupancy between the two monitoring periods and so this is a reasonable assumption

Figure 9 below compares the efficacy of the gas boiler and GSHP system during their respective winter periods. The internal temperatures are also presented to highlight the improved internal conditions. The daily system efficacy was calculated for periods when the heating system was operating as per the following equation:

$$System\ Efficacy\ (°C/kWh) = \frac{Daily\ Average\ \Delta T\ (°C)}{Daily\ Total\ Energy\ Consumption\ (kWh)}$$

where;

$$Daily\ Average\ \Delta T = Daily\ Average\ Internal\ Temp.(°C) - Daily\ Average\ External\ Temp.(°C)$$

$$Daily\ Total\ Energy\ Consumption\ (kWh) = \\ Daily\ Gas\ (kWh) + Daily\ Import\ Elec.(kWh) + Daily\ Self\ Consumption\ from\ PV\ (kWh)$$

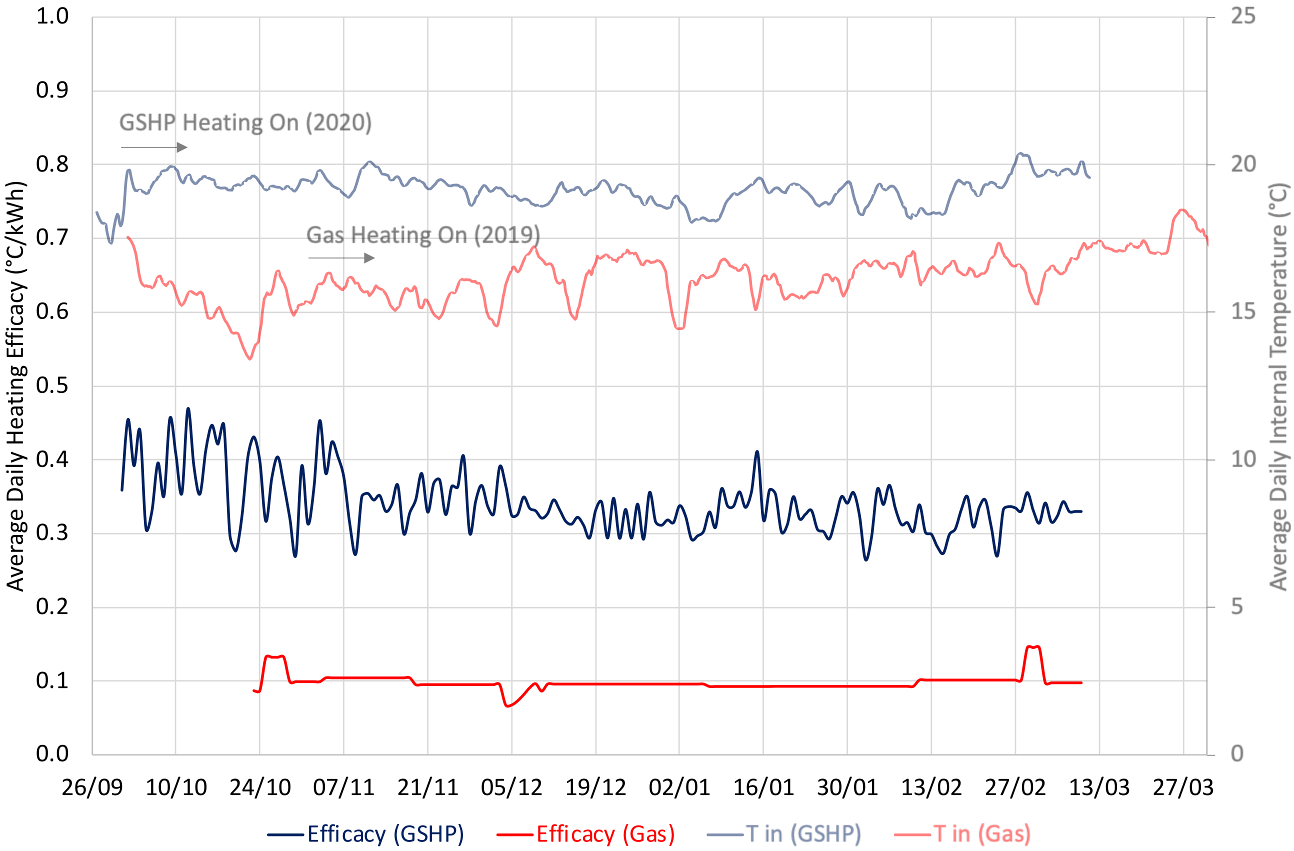


Figure 9: Comparison Between Internal Temperature and System Efficacy for Gas and GSHP Systems

Figure 10 below shows the correlation between the measured ΔT and energy consumption for each system across the monitoring periods. Figure 11 compares the average efficacy of the gas boiler and GSHP systems across their relative monitoring periods. The gas boiler produces approximately 0.10°C of internal temperature increase per kWh of energy consumed compared to 0.34 °C per kWh for the GSHP. In energy terms, this is approximately a four-fold improvement. Both figures highlight the stark contrast in energy performance of the two systems across a wide range of ΔT's

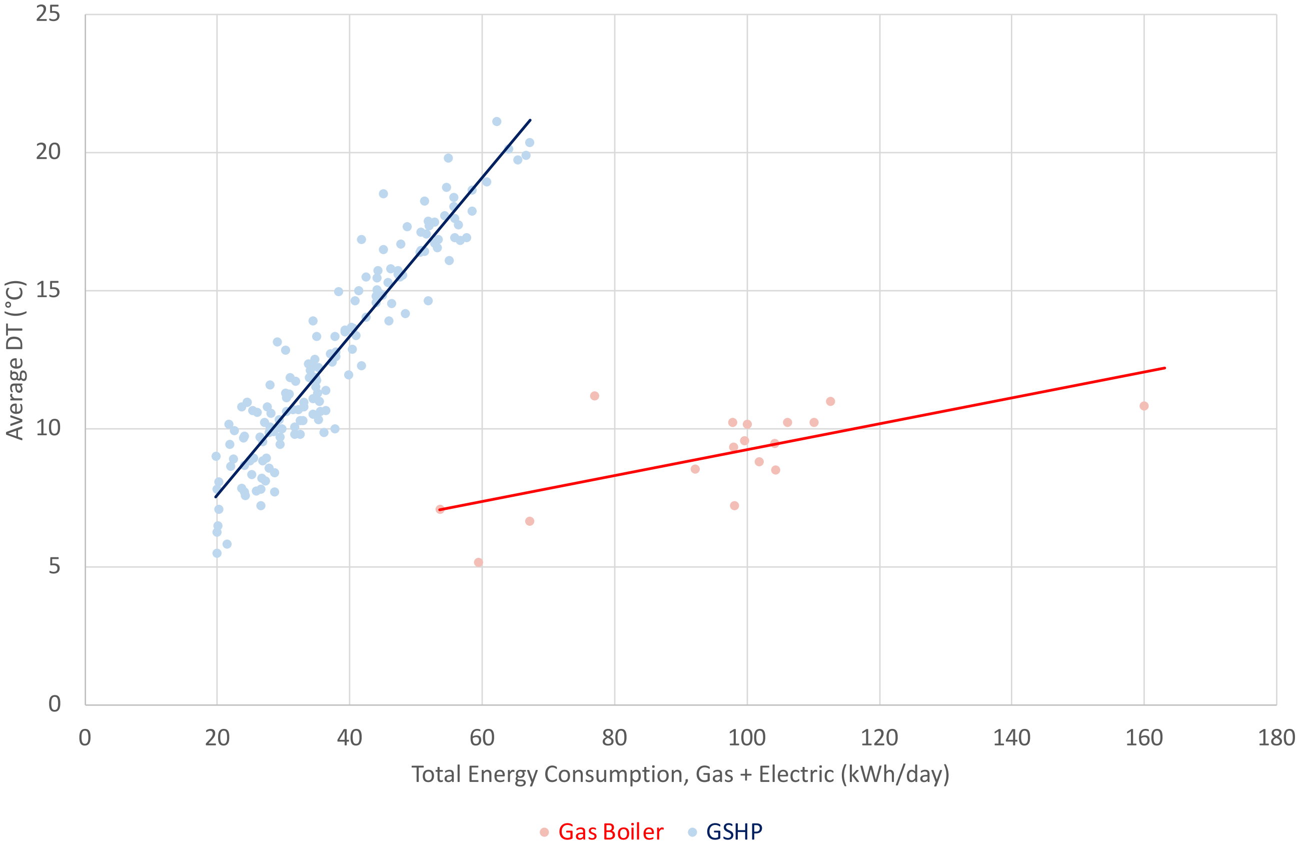


Figure 10: Correlation Between ΔT and Total Energy Consumption for Gas and GSHP Systems

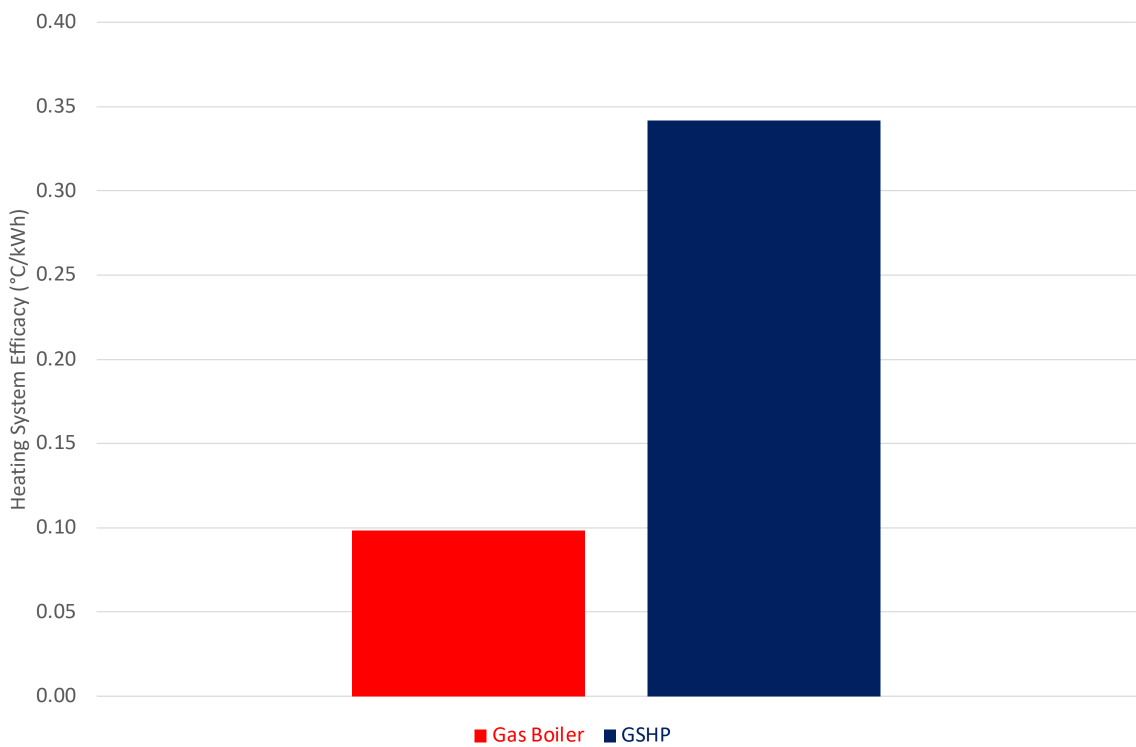


Figure 11: Comparison Between System Efficacy (°C/kWh) of Gas Boiler and GSHP Systems

The energy performance of the GSHP is clearly a significant improvement upon the original gas boiler system. However, this is intuitive given that a boiler efficiency might be 90% at best (i.e. 0.9), whereas the heat pump coefficient of performance is documented as 4.3 (i.e. 430%) at 45°C. Therefore, an assessment of the cost effectiveness of each system was also made to account for the difference in price between gas and electricity.

In 2019, the gas and electricity tariffs that applied to the property were 3.125 p/kWh and 15.73 p/kWh (inc. VAT) respectively. To coincide with the heat pump installation, the electricity tariff was changed to a time-of-use tariff (Octopus Agile). This tariff utilises a variable half hourly rate, defined daily and published at 4pm the previous day. The tariff is most expensive between 4 – 7pm, hence programming the thermostat to minimise heat consumption during this period. Figure 12 below shows the average Agile tariff (and range of prices) that applied during the GSHP monitoring period

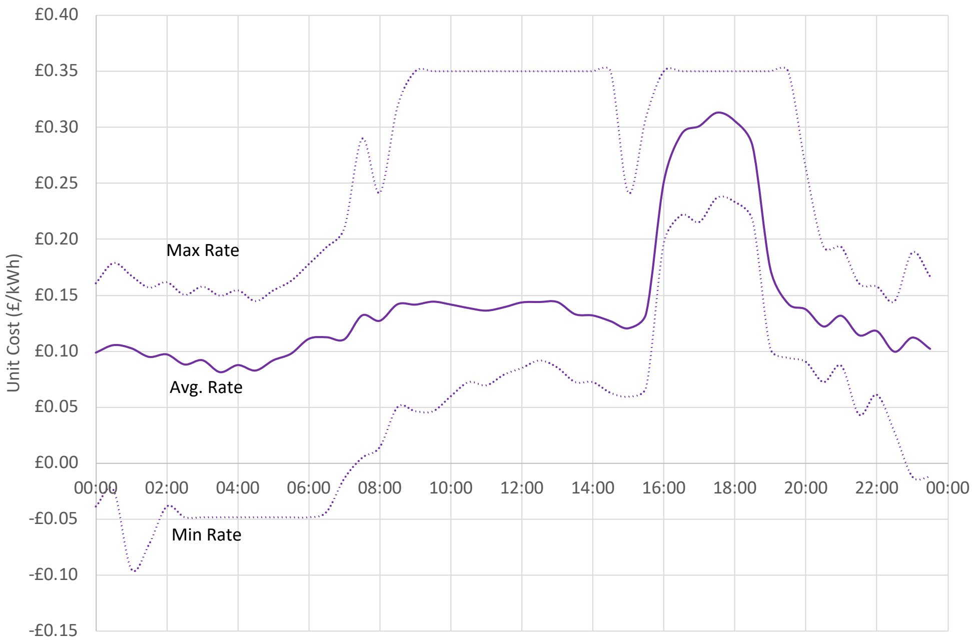


Figure 12: Max., Min. and Avg. Octopus Agile Electricity Tariffs (£/kWh) During GSHP Monitoring Period

Figure 13 below shows the correlation between the total daily cost of energy (gas + electricity[13]) and the average ΔT achieved by the gas boiler and the GSHP system. Two correlations are provided for the GSHP system; one using the agile tariff (which was the actual prices paid) and one using a comparative fixed tariff (set at 15.73 p/kWh as per the 2019 period). Figure 14 shows the average cost effectiveness of each system derived from the correlations. It shows that even when the additional cost of electricity is accounted for, the GSHP system saves on average 12% compared to the prior gas boiler system to achieve the same internal temperatures. If a fixed tariff was used however, it would be approximately 6% more expensive to operate than the gas boiler. The sensitivity of gas vs. electric systems will always depend on prevailing utility costs, but these results show that, like-for-like the heat pump is achieving satisfactory performance

[13] Including addition of solar energy self-consumed from the PV system at the equivalent daily energy rate (fixed or Agile)

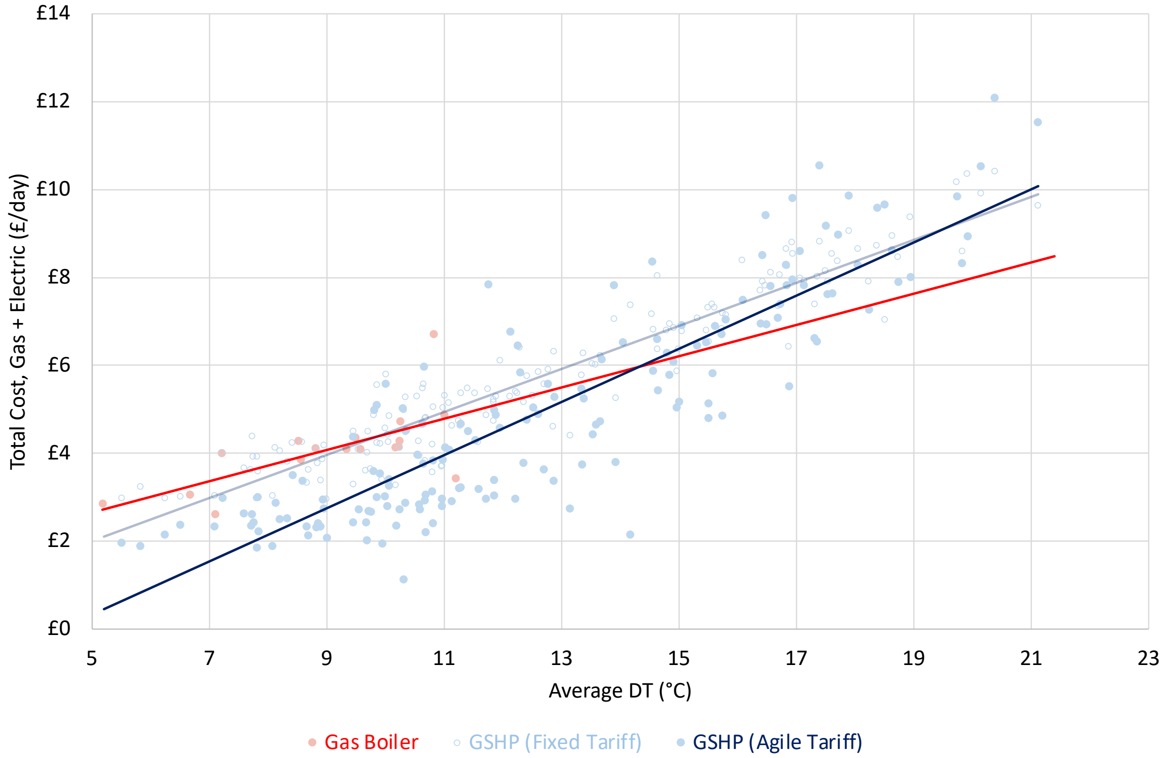


Figure 13: Correlation Between Total Daily Cost for Gas and GSHP (Agile and Fixed Tariff) Systems and ΔT

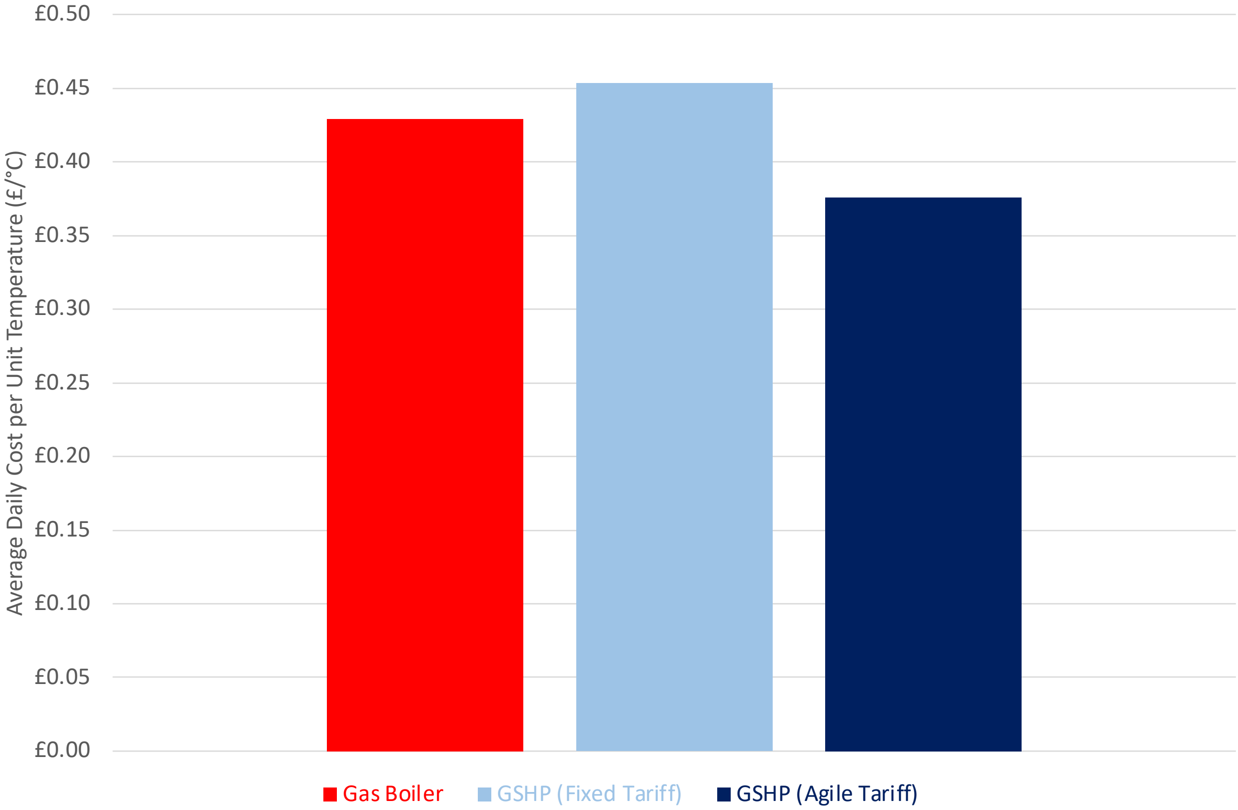


Figure 14: Average Daily Cost per °C ΔT for Gas Boiler and GSHP System (with a Fixed or Agile Tariff)

Gas boiler data was extrapolated to higher delta T's to compare to the GSHP data because the maximum average ΔT over the monitoring period was < 11°C. This was limited because of the manual gas meter readings that were taken which covered longer time periods than daily. The actual performance of the gas boiler at higher temperature differentials may therefore be different to the extrapolated correlation shown in Figure 13. However, for comparison of average running costs, it is assumed to be sufficiently accurate. The graph also shows that the heat pump may compare less favourably to the gas boiler during very low external temperatures (as might be expected for a heat pump system, albeit less-so with a GSHP). However, the relatively short duration and frequency of these periods means that across the whole heating period, the system performs efficiently overall

Also note that the costs presented in Figure 13 and Figure 14 are total daily energy costs as it was not possible to separate those costs for other uses (i.e. cooking, appliances, lighting etc.). However, the use and occupancy of the building between the gas boiler and GSHP monitoring periods remained consistent and so it was determined that this was a valid comparison

Recent spikes in gas (and subsequently electricity) prices (September / October 2021) highlight the sensitivity of any heating system to utility prices. Therefore the energy performance comparisons (outlined in Figure 9, Figure 10, and Figure 11) may be more widely applicable to represent the comparative performance between the gas boiler and the GSHP system in this case study. Since the monitoring period, the energy tariff has been changed by the resident to Octopus Go which operates at 16.26p/kWh flat rate, with a reduced cost period (5.5p/kWh) between 00:30 and 04:30 daily. Based on initial monitoring during October 2021, average daily unit costs for electricity have averaged 12.5p/kWh. During the reported monitoring period, the average electricity price achieved through the Agile tariff was 13.68p/kWh and so additional cost savings may be achieved in the 2021/22 winter period

Finally, Solar PV was installed at the property before either gas or GSHP monitoring period and this reduces the reliance of the building on grid electricity. The data presented above includes the equivalent cost of the energy that was self-consumed to present a fair comparison between the systems (since the heat pump can utilise excess PV whereas the gas boiler system could not)[14]. If the self-consumption data is excluded from the comparison (i.e. actual daily energy costs are utilised), the comparative performance of the system is more significant, saving between 4% (fixed electricity price) and 20% (Agile tariff) over the gas boiler scenario as shown below in Figure 15

[14] This is calculated based on a daily measurement of self-consumed energy multiplied by the prevailing average unit cost of energy for that day (either fixed or variable when analysing the results using the Agile tariff)

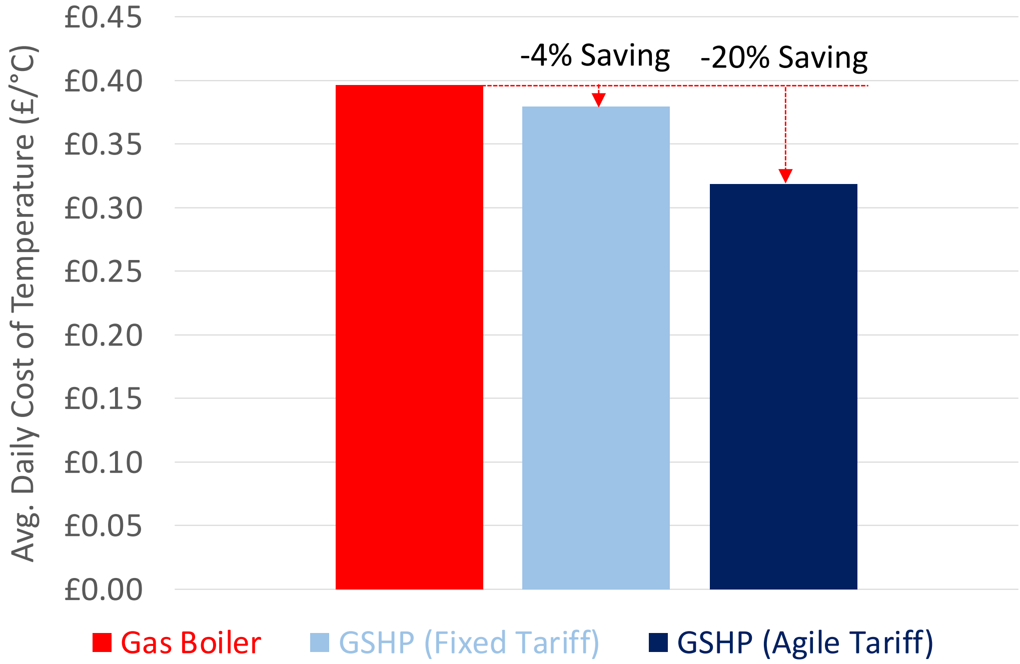


Figure 15: Average Daily Cost per °C ΔT for Gas Boiler and GSHP System (with a Fixed or Agile Tariff) excluding the equivalent energy cost of Self-Consumed PV energy

7 Conclusions

SmartHTC was utilised to inform the sizing of a Ground Source Heat Pump installation at a low energy retrofit project property in Bristol. It was used to ensure that the heat pump was sized appropriately for the actual performance of the property, in particular to avoid over-sizing (now and in the future following installation of wall insulation) which can lead to inefficiencies and additional capital cost

The SmartHTC measurement showed that the heat transfer coefficient of the property was approximately 55% of that calculated via SAP (using actual construction details). The thermal performance of the property is therefore significantly better than calculations suggest, meaning that the peak heat load is significantly smaller than anticipated

The final design utilised 3 vertical boreholes (~100m each) with a MasterTherm AQ37i1 5-15kW GSHP and a 290l DHW cylinder with 90l heating circuit buffer. Uncorrected design estimates would have required a fourth borehole and a larger heat pump to be installed, increasing capital cost significantly and introducing potential inefficiency during low/part load operating conditions

Performance monitoring shows that the GSHP system is achieving comfortable internal temperatures at a lower cost (and energy consumption) than the previous gas boiler system. Maintaining internal temperatures with the GSHP saves approximately 12% compared to the gas boiler. Some of this benefit is due to the utilisation of a time-of-use tariff (Octopus Agile). If a fixed electricity tariff had been used, the cost would have increased approximately 6%. Including the contribution of free-electricity from the Solar PV system, the GSHP system performance is improved and performs better than the previous gas boiler system regardless of using a fixed or time-of-use tariff. Both results show that the heat pump is able to perform similarly (or even better) than a gas boiler in a traditionally constructed property when it is sized appropriately and operated efficiently

When designing heat pumps (ASHP or GSHP) for retrofit, measuring the actual performance of the property using SmartHTC could maximise the cost effectiveness (reduced payback period) and also the operational performance of the system. It is logical that these systems are based on the actual performance of a building, particularly given that the performance gap exists both negatively and positively (buildings performing significantly worse or better than calculated)

8 Contact Details

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