Project code CP742
Gas Absorption Heat Pump for a Sheltered Housing Scheme
Colchester Borough Homes

Technical Evaluation Report

Tom Shepherd
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Background

About National Energy Action

National Energy Action is the national fuel poverty charity working across England, Wales and Northern Ireland, and with sister charity Energy Action Scotland (EAS), to ensure that everyone can afford to live in a warm, dry home. In partnership with central and local government, fuel utilities, housing providers, consumer groups and voluntary organisations, it undertakes a range of activities to address the causes and treat the symptoms of fuel poverty. Its work encompasses all aspects of fuel poverty, but in particular emphasises the importance of greater investment in domestic energy efficiency.

About the Technical Innovation Fund

NEA believes that there is huge potential for new technologies to provide solutions for some of the 4 million UK households currently living in fuel poverty, particularly those residing in properties which have traditionally been considered too difficult or expensive to include in mandated fuel poverty and energy efficiency schemes. However, more robust monitoring and evaluation is needed to understand the application of these technologies and assess their suitability for inclusion in future schemes.

The Technical Innovation Fund (TIF) which was designed and administered by NEA, formed part of the larger £26.2m Health and Innovation Programme along with the Warm Zone Fund and Warm and Healthy Homes Fund.

TIF facilitated a number of trials to identify the suitability of a range of technologies in different household and property types and had two strands: a large measures programme, providing funding of up to £7,400 per household, and a smaller measures programme providing up to the value of £1,000 per household. It launched in May 2015, with expressions of interest sought from local authorities, housing associations, community organisations and charities wishing to deliver innovative projects in England and Wales.

Over 200 initial expressions of interest were received and NEA invited 75 organisations to submit full proposals. Applications were assessed by a Technical Oversight Group, chaired by Chris Underwood, Professor of Energy Modelling in the Mechanical and Construction Engineering Department at Northumbria University who is also a trustee of NEA. In total, 44 projects were awarded funding to trial 19 different types of technologies and around 70 products (although this number reduced slightly as some products proved not to be suitable and were withdrawn).

More than 2,100 households have received some form of intervention under this programme that has resulted in a positive impact on either their warmth and wellbeing, or on energy bill savings. Of course, the amount of benefit varies depending on the household make up and the measures installed. In a small number of instances we removed the measures and took remedial action to remedy the situation and protect residents from increased energy costs or other detrimental effects.

Technical monitoring and evaluation

NEA has been working with grant recipients to monitor the application of these technologies and assess performance, as well as understand householder experiences and impacts.

A sample of households from each TIF project was selected for monitoring purposes. Participation was entirely voluntary, and householders were free to withdraw at any time. This involved the installation of various monitoring devices within the home which collected data for analysis by NEA's technical team. Some residents were also asked to take regular meter readings. In some instances, a control group of properties that had not received interventions under TIF were also recruited and monitored.

The technical product evaluation was conducted alongside a social impact evaluation to inform our understanding of actual energy behaviour changes, perceived comfort levels and energy bill savings, as well as any other reported benefits. Householders were asked to complete a questionnaire both before and after the installation of the measures which captured resident demographic data including any health conditions. Small incentives in the form of shopping vouchers were offered to maintain engagement over the course of the evaluation period.

The HIP fund was principally designed to fund capital measures to be installed into fuel poor households. A small proportion of the funding enabled NEA to conduct limited research and monitoring of products installed and was restricted to ensure that the majority of funds were spent on the products. All products included in the trials were deemed to offer costs savings and energy efficient solutions as proposed by the delivery partners. The research and monitoring aimed to provide insights to inform future programme design and interested parties of the applicability of the product to a fuel poor household. We recognise that due to the limited number of households involved in the monitoring exercises, the variability seen within those households and the limited period we were able to monitor a product's performance, we may recommend that further research is needed to better understand the application of these products in a wider range of circumstances over a longer period of time.

The research was conducted according to NEA's ethics policy, which adopts best practice as recommended by the Social Research Association (SRA) Ethical Guidelines 2002.

An accompanying programme of training and outreach work was also delivered to 292 frontline workers to increase local skills and capacity.

Individual project reports are being compiled and will be made available publicly on NEA's website from September 2017, along with a full Technical Innovation Fund Impact Report.

Acknowledgements

With grateful thanks to our project partners:

Colchester Borough Homes

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Legal limitations and disclaimer

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Executive summary

Project overview

This project part-funded the installation of a Gas Absorption Heat Pump (GAHP) into a sheltered housing scheme that was undergoing major refurbishment. Project partners Colchester Borough Homes had already installed one GAHP into a sheltered housing scheme with positive feedback. However, they wanted more information about the efficiency and cost effectiveness of the GAHP.

As part of the refurbishment the building also received insulation upgrades and renewable generation technology. The housing scheme was remodelled with the 48 existing properties – a mixture of studio, one and two-bedroom flats being reduced to 36 one- and two-bed flats.

The project had the following aims;

- Improve the energy performance of the building
- Reduce running costs for residents
- Monitor and understand the energy use of the GAHP
- Accurately calculate the savings attributable to the GAHP

Context

Air and ground source heat pumps are becoming increasingly popular in areas off the mains gas network because of their efficiency and generation of renewable energy. Running costs of air and ground source heat pumps are similar to condensing gas boilers. However, installation costs are relatively high and although the domestic Renewable Heat Incentive[1] (RHI) is available to offset extra investment needed, there is currently little overall financial benefit to install them in areas where gas is available. Gas absorption heat pumps run on a refrigeration cycle and can improve on the efficiency of modern condensing gas boilers. The heat energy output per kWh input of gas can be as high as 1.64. They represent an opportunity to cut running costs and improve environmental performance using gas as the input fuel.

The technology

Gas Absorption Heat Pump (GAHP)

Like their electric counterparts, gas absorption heat pumps are able to extract heat from the air. However, unlike electric heat pumps, there is no requirement for an electrical compressor. Instead, the system uses a generator-absorber heat exchange cycle powered by natural gas or LPG. All heat pumps use the refrigeration cycle and, in gas absorption heat pumps, the working fluid is an ammonia/water solution. The ammonia acts as the refrigerant and the water acts as an absorber. The components of a gas absorption heat pump include an evaporator, a generator, an absorber/regenerator and a condenser/absorber.

GAHPs improve on the amount of heat energy that is produced over a condensing gas boiler from the same amount of gas input. The advertised COP of the GAHP installed on this project is up to 1.64 (air 7 ^{0}C, flow 35 ^{0}C), and the manufacturer's claim that over a heating season the SCOP for a unit with flow temperature of 55 ^{0}C is 1.12.

[1] https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi [Accessed 22/11/2018]

The project

The project was to install and monitor a gas absorption heat pump in a sheltered housing block of 36 one and two-bedroom flats. The building was completely refurbished, including changing the size and number of properties. The old heating had been with individual gas boilers in each property with a communal hot water system. It had upgraded insulation, a solar PV array, and a new communal heating and hot water system comprising: 2 new GAHPs, a solar thermal array and 3 back-up gas boilers.

A mixture of tenants was chosen for monitoring the internal temperature and heat use of their properties. The project bridged the time during which the housing scheme was being refurbished. Some of the tenants who were selected for monitoring had temperature sensors installed in their old flat and then moved into their new flat, while some tenants had already moved into their new flat when monitoring began.

The refurbishment and installation of the heating system was over the period February to June 2016. Monitoring was for 2 years from January 2016 to July 2018.

Summary of findings

Energy costs

Individual gas usage was not measured before the start of the project, so it is not known how much gas each tenant was using for their heating. As part of the project heat meters were installed on the heating circuit of each flat to measure how much heat each tenant was using. Calculations showed that on average the tenants were using approximately 5,540 kWh of heat over a year to heat each flat.

The cost of heating, hot water and electricity is all included in the service charge for each flat, so tenants do not see the actual cost of their own heating use.

Damp and humidity

- Nobody identified damp as an issue either before or after the refurbishment.
- Following refurbishment, the level of humidity in each flat increased. This was due to a measured decrease in average temperature, probably linked to controllability, and also a likely decrease in ventilation due to improved insulation, new windows and draught reduction in the properties.
- The average internal humidity measured in the monitored properties was 40% RH in the lounge and 42 % RH in the bedroom. The maximum measured humidity was 59 % RH in a bedroom, which is not a concern for damp.

Thermal comfort and resident satisfaction

- Internal temperatures reduced by an average of just over 1 ^{0}C following refurbishment.
- The internal temperature was much more consistent with a reduced range between maximum and minimum temperature.
- Residents reported increased satisfaction with their heating after refurbishment
- Residents felt they had less control over the heating, but this did not worry them because the temperature was all pre-set to what they needed.

Conclusions and recommendations

The new heating system had a BMS with associated meters to record inputs and outputs from the GAHP. However, the BMS suffered major delays in being commissioned, and did not collate sufficient useable data to enable the team to draw any conclusions about the running cost and efficiency of the GAHP.

Householders thought that their new heating system was a big improvement on the old system

Following installation of the new heating system average internal temperatures decreased on average by just over 1 ^{0}C.

The average temperature range in each property reduced from 8.3 ^{0}C to 5.7 ^{0}C suggesting that the control system was more effective at controlling the heating.

Humidity increased on average by 7.7% but was not at a level to cause problems with health or condensation and damp.

Future monitoring projects should check the data that is being provided from the monitoring equipment at an early stage, is commissioned on time, and designed to capture the data required by the interested parties and store it for later analysis. If there are problems, such as a heat meter being located in the wrong place, then this could be identified, and remedial action taken in a timely manner. Analysis of the data collected by the BMS gave concern that the data was inaccurate. It was suggested that this could have been rectified by upgrading the controller to one that would write to a web-based “dashboard” of important information, but this was not pursued.

Regular manual readings of all the important meters could have provided sufficient data to calculate system performance over the heating season or over a period of a year.

1. Project overview

1.1 Introduction

This project centred on a sheltered housing accommodation complex with 48 units spread across 4 blocks managed by Colchester Borough Homes (CBH). The scheme houses elderly and infirm residents in one and two-bedroom flats spread over two floors. The building was constructed in 1967 with hard-to-treat cavity walls and had poor levels of energy efficiency. It was initially refurbished in 1998.

The building was renovated at the start of the project in 2016. The renovation changed the layout of the building, including number and size of the flats. It improved the insulation, lighting and energy efficiency of the building. The old individual gas fired boilers (one per accommodation unit) provided space heating and communal domestic hot water for the complex. These were replaced with a new gas absorption heat pump (GAHP), together with a solar thermal system and three new back-up gas boilers. In addition, a solar PV system was installed to complement the measures.

A gas absorption heat pump had previously been installed at another of CBH's sheltered housing schemes and proven successful, although no monitoring of the system had been installed. A grant from the Technical Innovation Fund went towards providing two GAHPs allowing CBH to monitor to demonstrate the running costs of GAHPs in the complex. It was planned that the monitoring would be largely completed through a comprehensive Building Management System (BMS) to log energy and heat variables at regular intervals.

Figure 1.1 Picture of the exterior South elevation showing part of the PV array

1.2 Aims

The project had the following aims:

- Improve the energy performance of the building
- Reduce running costs for residents
- Monitor and understand the energy use of the GAHP
- Accurately calculate the savings attributable to the GAHP

1.3 Context

The sheltered housing scheme was constructed with hard-to-treat cavity walls, had poor levels of energy efficiency and houses elderly and infirm residents.

The accommodation blocks were constructed in 1967, were poorly insulated and were designed during a period where energy efficiency was of less concern than ease and speed of construction. The average SAP score at the start of the project was 66 (EPC band D).

The existing fabric of the building is traditional 3 leaf construction with 100 mm cavity with Woodwool insulation in places, with a blockwork internal leaf and a fletton brick external façade. There are pitched roofs with Concrete Marley Wessex interlocking roof tiles and areas of flat roofing with felt cover, which have a poor thermal performance. Each flat and all communal laundry areas were serviced by individual gas fired wall mounted boilers (12 kW) for heating and hot water. The communal areas were serviced by an independent gas fired boiler. Each flat was naturally ventilated through the use of windows.

The external walls which had been hard-to-treat cavity walls were upgraded to have a thermal transmittance (U value) of 0.25 W/m^2K. The floor was also well insulated to have a U value of 0.14 W/m^2K. New triple-glazed windows were installed.

Air and ground source heat pumps are becoming increasingly popular in areas off the mains gas network because of their efficiency and generation of renewable energy. Running costs of air and ground source heat pumps are not much difference to condensing gas boilers. However, installation costs are relatively high and although the domestic RHI is available to offset extra investment needed, there is currently little overall financial benefit to install them in areas where gas is available. Gas absorption heat pumps run on a refrigeration cycle and can improve on the efficiency of modern condensing gas boilers. The heat energy output per kWh input of gas can be as high as 1.64. They represent an opportunity to cut running costs and improve environmental performance using gas as the input fuel. This project aimed to evaluate the savings available, and hence evaluate the potential reduction in rental charges to the residents, as a result of efficiency improvements to the landlord.

1.4 Project timeline

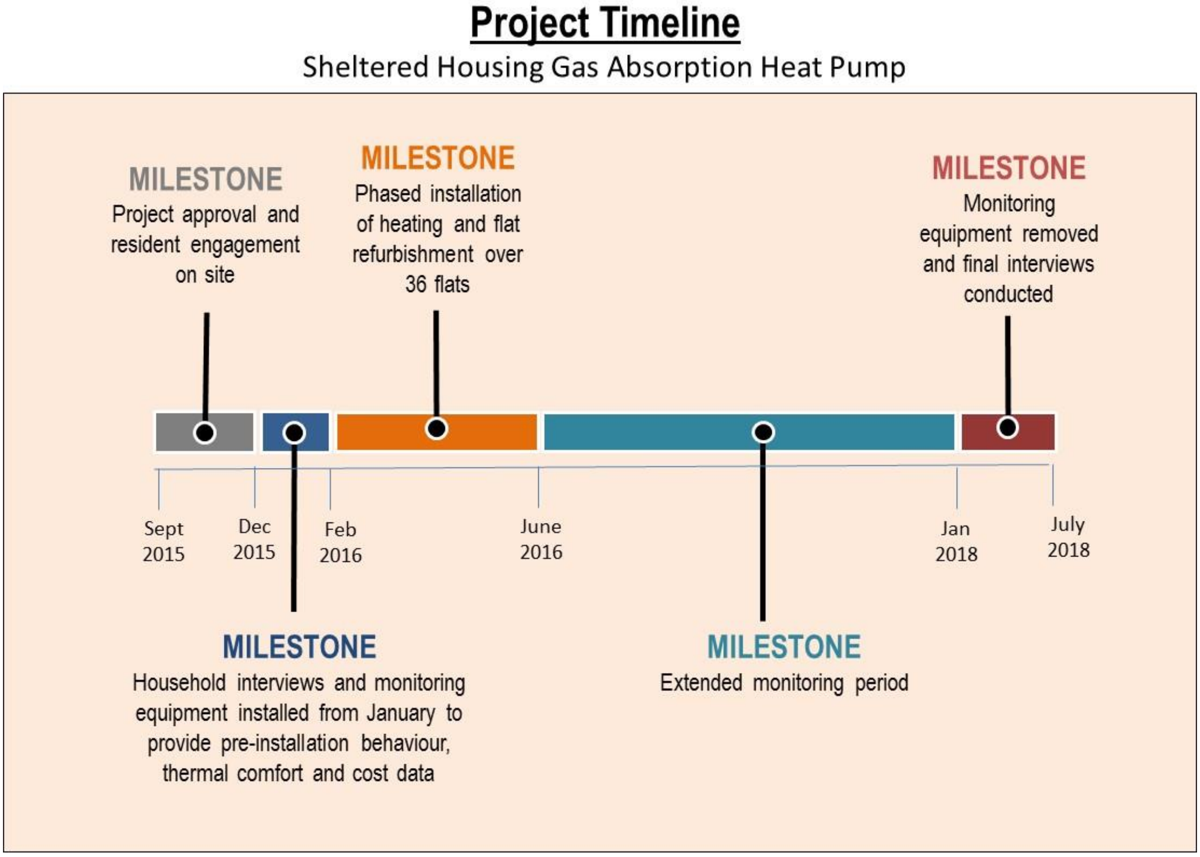


Figure 1.2 Project timeline

Colchester Borough Homes (CBH) is an Arms Length Management Organisation (ALMO) set up and owned by Colchester Borough Council to provide housing and property services to the local community. CBH manages over 7,000 residential, commercial and public buildings including 6,100 homes and 21 sheltered housing schemes.

The selected installers,

- Designers of the heating system: Flamestone Ltd
- Building contractors: N.D Smith
- Mechanical contractors: Cooper & Brome
- Electrical contractors: C J Electrical

1.5 Attracting beneficiaries and establishing a monitored group

The sheltered housing scheme that was the focus of this project was selected because it was due for refurbishment and required a new heating system. The works involved were substantial and included remodelling of the building. The original building included 48 dwellings (studio, 1-bedroom and 2-bedroom flats), which was reduced to 36 (1 and 2-bedroom flats) following the refurbishment. 12 tenants were selected for monitoring, with the aim that temperature loggers would be fitted in the old flat and follow these tenants into their new flat. Some of the tenants had already moved into their newly refurbished flats by the time monitoring started, meaning that pre-improvement data was not available for all of the sample properties.

Trial properties for monitoring were selected at random, checking with tenants that they were happy for the temperature loggers to be kept in their homes for the duration of the study.

Householders who agreed to take part in the monitoring study were interviewed at the start and again at the end of the project by NEA. This was a comprehensive semi-structured interview, asking questions about their personal circumstances, health, opinion of existing heating, how they use it, their bills, their view of the new heating and how it compared to the previous heating.

CBH managed the refurbishment process throughout, directly managing the contractors working on the project, and assisting NEA with tenant liaison, data collection and obtaining utility meter readings.

	Before refurbishment		After refurbishment	
Resident ref	SAP score of flat	Flat type	SAP score of flat	Flat type
T-01			78	top floor flat
T-02			80	top floor flat
T-03	67	top floor flat	81	top floor flat
T-06	71	ground floor flat	80	top floor flat
T-07	64	top floor flat	78	top floor flat
T-08	60	ground floor flat	79	top floor flat
T-09	70	ground floor bedsit	78	ground floor flat
T-12	71	ground floor flat	78	ground floor flat
T-18	68	ground floor flat	79	ground floor flat
T-25			81	top floor flat
T-26			78	ground floor flat
T-27			81	ground floor flat
T-28			81	ground floor flat
T-29			81	top floor flat
Average of those monitored	67.3		79.5	
Average of all flats	66.3		79.2	

Table 1.2 properties selected for monitoring

Note that at the start of the monitoring period some properties had already been upgraded, so there was no previous flat to compare with.

Average SAP Improvement of those monitored = 12.2
Average SAP improvement of all flats = 12.9

1.6 Factors affecting the planned evaluation methodology

Issue	Description and mitigation
Size of monitoring group	A total of 12 properties were monitored but, as the renovation was underway when the monitoring started, only 6 old properties has temperature loggers installed before they were refurbished. 4 newly refurbished properties were monitored from the project start. 2 others were included from later in the project.
Identification of the monitored group and control group	It was not possible to compare the heating performance of the properties from before with the properties occupied by the same tenant afterwards, because the size of the properties changed, as well as their insulation and heat load.
Start of monitoring	At the start of monitoring a report was commissioned on the status of the BMS system. This determined that it had not been commissioned at that stage and that no readings could be taken. It was recommended that the interface which provided a means of reading the outputs from the various meters should be upgraded to one which could be monitored via a web-based system. This was not implemented during the timescale of the project and had a significant impact on the report and conclusions which could be drawn.
Monitored group	The sheltered housing block was refurbished with residents in situ. The building was worked on in stages with residents moving from their old property to a new one as properties were completed. The idea was that temperature loggers would move with tenants. However, when a tenant moved out of a flat, the loggers were collected up, and did not necessarily move with the same tenant. This means that there are some gaps in data, and not all data from the original properties was useful. At the end of the first year, new temperature/humidity loggers were installed ensuring that a full set of temperature and humidity data was available for the second year. The second year's monitoring in the new flats was more consistent.
System performance	It was not possible to evaluate the performance of the GAHPs due to the poor data collection, and absence of a robust BMS system. Meter readings of the gas and electric meters supplying the GAHPs were only taken twice during the project, and on one of these dates the heat meter for the GAHPs was showing an error. Unfortunately, this means that it has not been possible to evaluate the coefficient of performance of the GAHPs.

Issue	Description and mitigation
Meter readings	Data from heat meters in individual flats were downloaded at intervals, enabling an analysis of internal temperature against heat usage in each flat. The solar thermal heat meter was installed in the pipework after the buffer tank, rather than before, so heat cannot be directly attributed to the solar thermal system. In addition, this heat meter failed during the project.
Monitoring equipment	The BMS system that was installed at the start of the project stored data for 3 weeks at a time before being overwritten. Data was downloaded intermittently, so there was not a continuous set of data for the full monitoring period.
Billing	Households have a single bill for their property which includes heating, water, electricity consumption, as well as a contribution towards maintenance of the property. The usage of energy does not affect the bills, so high heat users pay the same as low heat users. CBH calculates the service charge based on costs from 2 years previously, so savings in heating costs are not passed on to residents until after the project was concluded.

2. Social evaluation and impacts

2.1 Qualitative feedback from initial questionnaire

At the start of the project, those households who had been selected for monitoring had an initial visit from NEA, during which a comprehensive semi structured questionnaire was undertaken. The questionnaire covered household demographics, existing heating system, heat requirements, use and control of existing heating, existing running costs, using and saving energy in the home.

Householders who were bieng monitored had one further data gathering visit from NEA at the end of the project to ask about customer experience of the new heating system in comparison to the old.

This section includes information and graphs showing detail of the responses the monitored households gave to questions at the start and the end of the project.

At least one member of each household was over the age of 60. All households identified as being retired or not working due to health or disability.

All householders questioned said that they were able to keep warm with both their existing heating and with the new heating. There was no change following installation of the new heating.

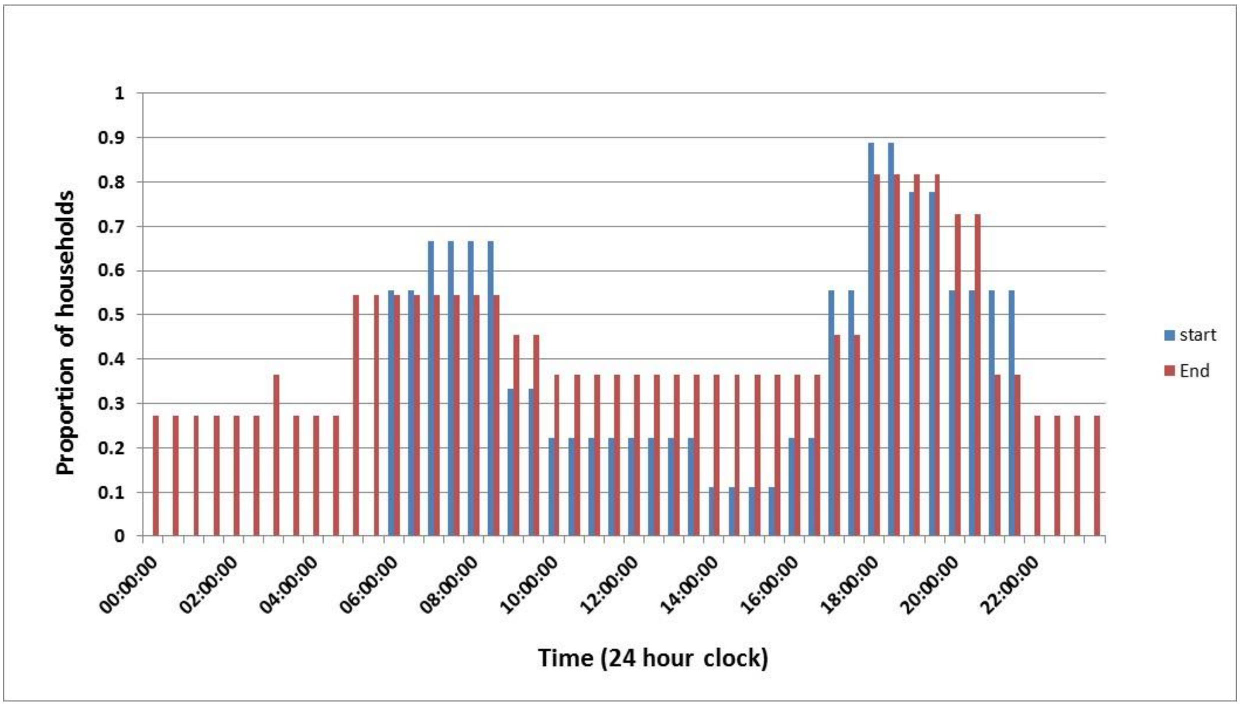


Figure 2.1 Times when residents stated it was important for them to have a warm home

At the start and the end of the project households were asked at what time of day it was important for them to have a warm home. The results to this question are shown in figure 2.1 above. 8 households answered the question at the start of the project and 11 at the end, so to enable comparison, the number of households is shown as a proportion of the total. It can be seen that at the end the requirements were for a more balanced heating period, spread over a longer period of the day.

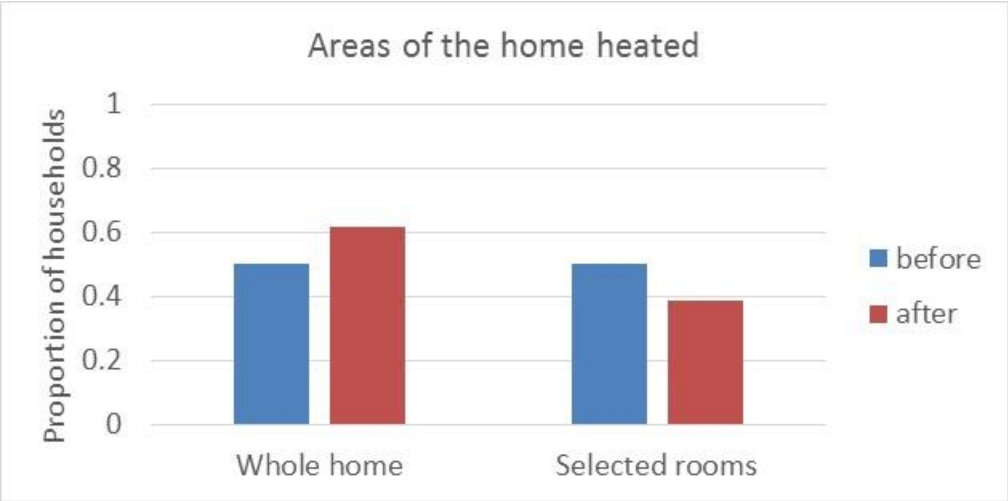


Figure 2.2 Areas of the home that residents said they heated before and after the refurbishment.

There was an increase in the proportion of households who heated the whole property after refurbishment and installation of the new heating. In most cases the rooms not heated were bedrooms because residents said that they didn't like their bedrooms heated.

2.2 Affordability of energy bills

Residents pay a service charge which includes heating, electricity, water and a contribution towards maintenance of the property. The cost of the service charge is calculated based on the costs 2 years in arrears. As the project only considered the 2 years within the monitoring period, any savings made in reduced energy use due to the new heating had not filtered through to reduced bills for residents. Households pay a fixed sum per month, which is not based on the amount of energy they use – people who use a lot of energy pay the same as those who seldom use the heating. Consequently, as shown in figure 2.3 below, when asked at the end of the project whether the upgrade had reduced money worries, the vast majority of respondents said there was no change. All properties had a heat meter installed as part of the refurbishment and CBH intend to introduce a charge for the heat that people use in the future.

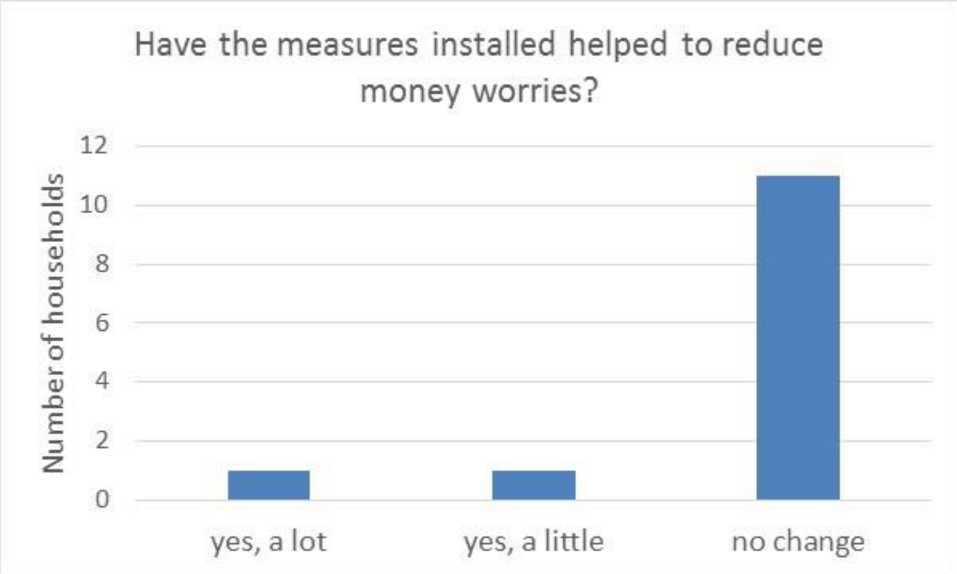


Figure 2.3 Number of households whose money worries have changed following installation of the new heating.

2.3 Resident acceptance and satisfaction

During the final interviews, householders were asked about their satisfaction with various aspects of their new heating system. They could choose from 'very dissatisfied', 'dissatisfied', 'neither', 'satisfied' or 'very satisfied'. Each of the responses was assigned a score where 'very dissatisfied' scored 0, ranging to 'very satisfied' which scored 100. An average (mean) score of between 0 and 100 was calculated for each question. Graph 2.4 below shows a chart with the response scores to the statements listed.

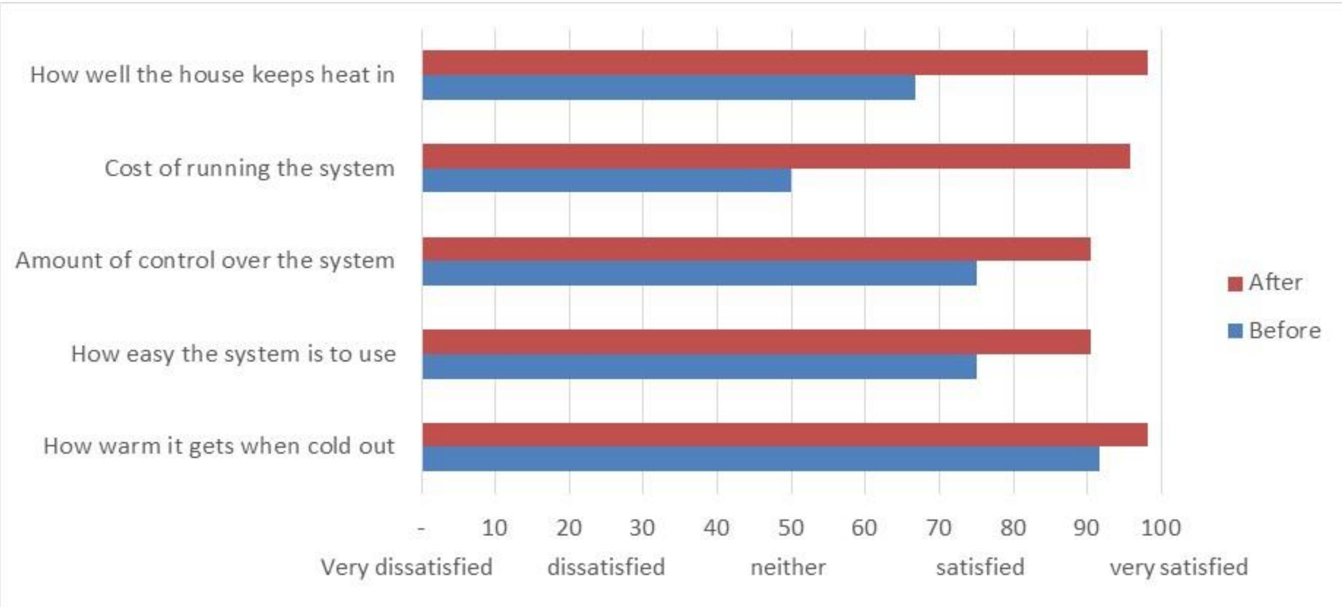


Figure 2.4 levels of satisfaction with various aspects of the new heating

Satisfaction levels with the new heating systems were generally high, with most households responding that they were satisfied or very satisfied with the warmth, cost, controllability, and ease of use. For all categories households were, on average, happier with the new system than the old. Interestingly, although the cost was unchanged, there was a big increase in the satisfaction rating of the cost of running the system. Presumably, residents were happier to pay the same for a better performing system.

2.4 Ease of use and reliability

There have been problems with the hot water system – either not being warm enough, no hot water at all, and taking a long time to come through hot. These appear to have been resolved.

One person said that the bathroom isn't warm enough because the radiator is too small.

One householder didn't like the new digital controller and preferred the old dial thermostat. However, there were several comments about how good it is to have a system that doesn't need to be adjusted and that keeps the flat at the right temperature, and that it is much better than before.

2.5 Perceived comfort and benefits

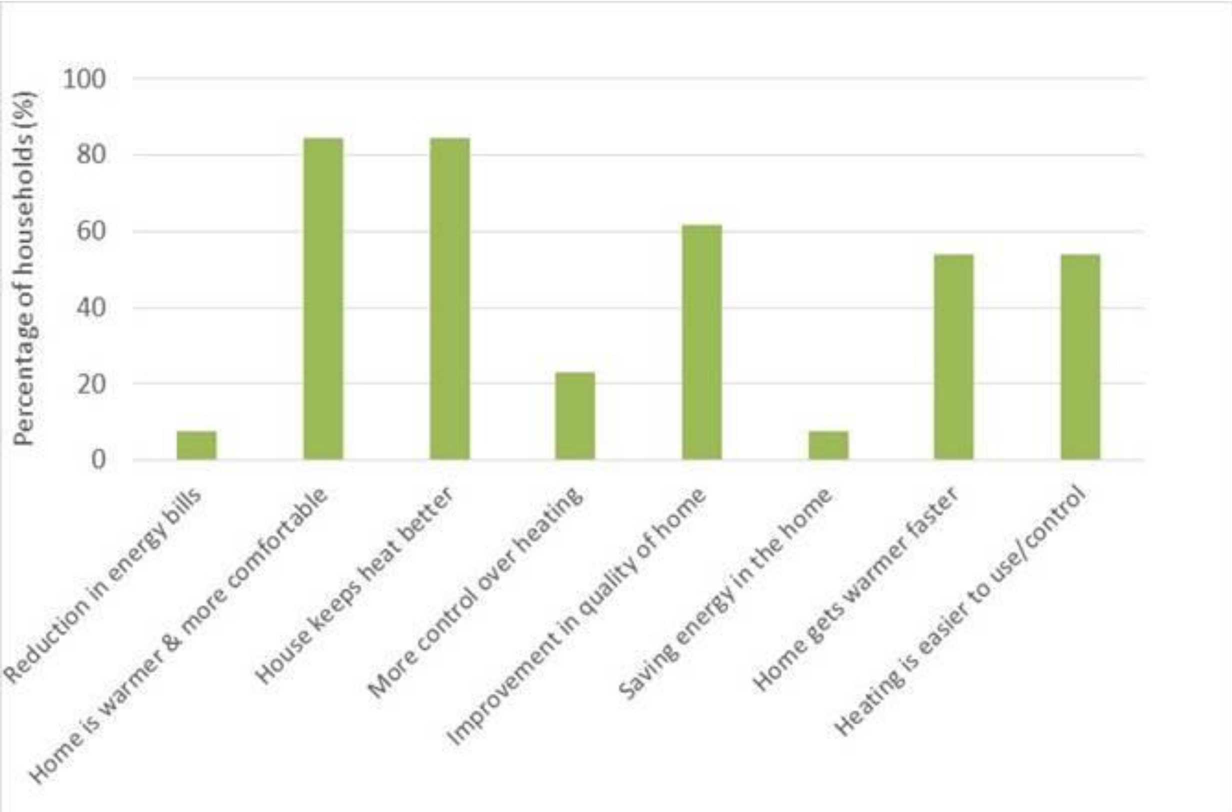


Figure 2.5 Benefits perceived by residents after installation of the GAHP

Figure 2.5 above shows the percentage of householders agreeing with statements about various aspects of their new heating system.

Reduction in Energy Bills

Only one household thought that they had had a reduction in energy bills, but any changes wouldn't be seen until two years after the installation when savings filter through to the service charge. It is unsurprising that the vast majority didn't report any savings.

Warmer and more comfortable?

10 out of 12 households thought that their home was warmer and more comfortable than it had been previously, and that it keeps the heat better than before.

Ease of use

Only 3 of the 12 households thought that they had more control over their heating than they had previously. However, they were happy with the heating and commented that they were able to let it get on with heating their home without the need to make adjustments. Half of them thought that it was easier to use or control.

Saving energy in the home

Although there are likely to be significant energy savings due to the insulation upgrades, new heating system and energy generation measures following the refurbishment, households didn't see energy savings in the home as one of the benefits of the new heating system. Only one out of the 12 mentioned it as a benefit.

Speed to heat up

Half of those questioned thought that their home warmed up more quickly with the new heating system.

Ease of use of hot water system

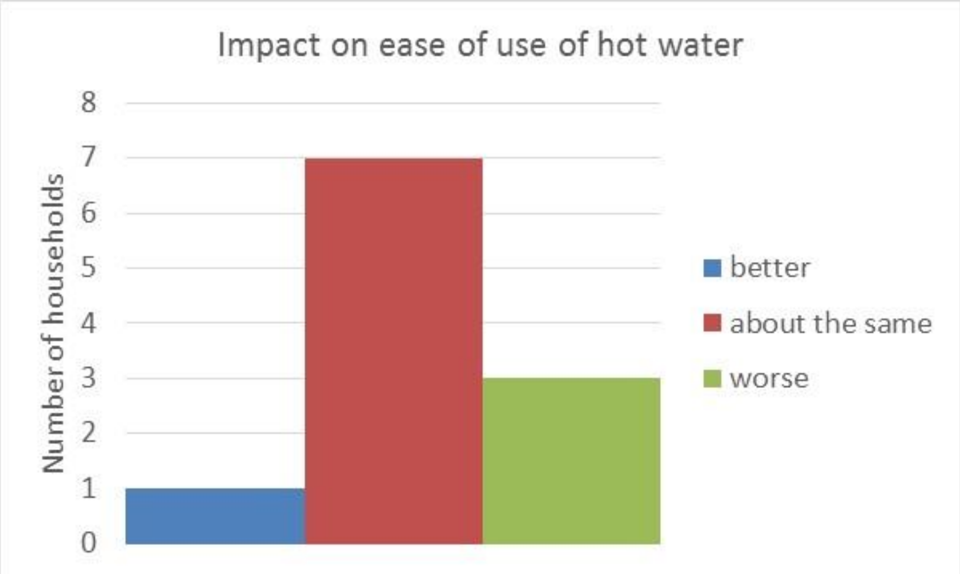


Figure 2.6 The impact on ease of use of hot water after installation of the GAHP

Only one household thought that the new hot water system was better than the old one. The reason this householder gave for the improvement was that there was a new shower in the flat, whereas previously there had only been a bath. There were some initial problems with the hot water not coming through warm enough, which seem to have tainted some residents' opinion about the hot water, even though these seem to have been resolved. A couple of residents also said that it takes a long time for the water to come through hot.

3. Technical evaluation and results

3.1 Overview of technology

Like their electrically-powered counterparts, gas absorption heat pumps are able to extract heat from the air. However, unlike electric heat pumps, there is no requirement for an electrical compressor. Instead, the system uses a generator-absorber heat exchange cycle powered by natural gas or LPG. All heat pumps use the refrigeration cycle and, in gas absorption heat pumps, the working fluid is an ammonia/water solution. The ammonia acts as the refrigerant and the water acts as an absorber. The components of a gas absorption heat pump include an evaporator, a generator, an absorber/regenerator and a condenser/absorber.

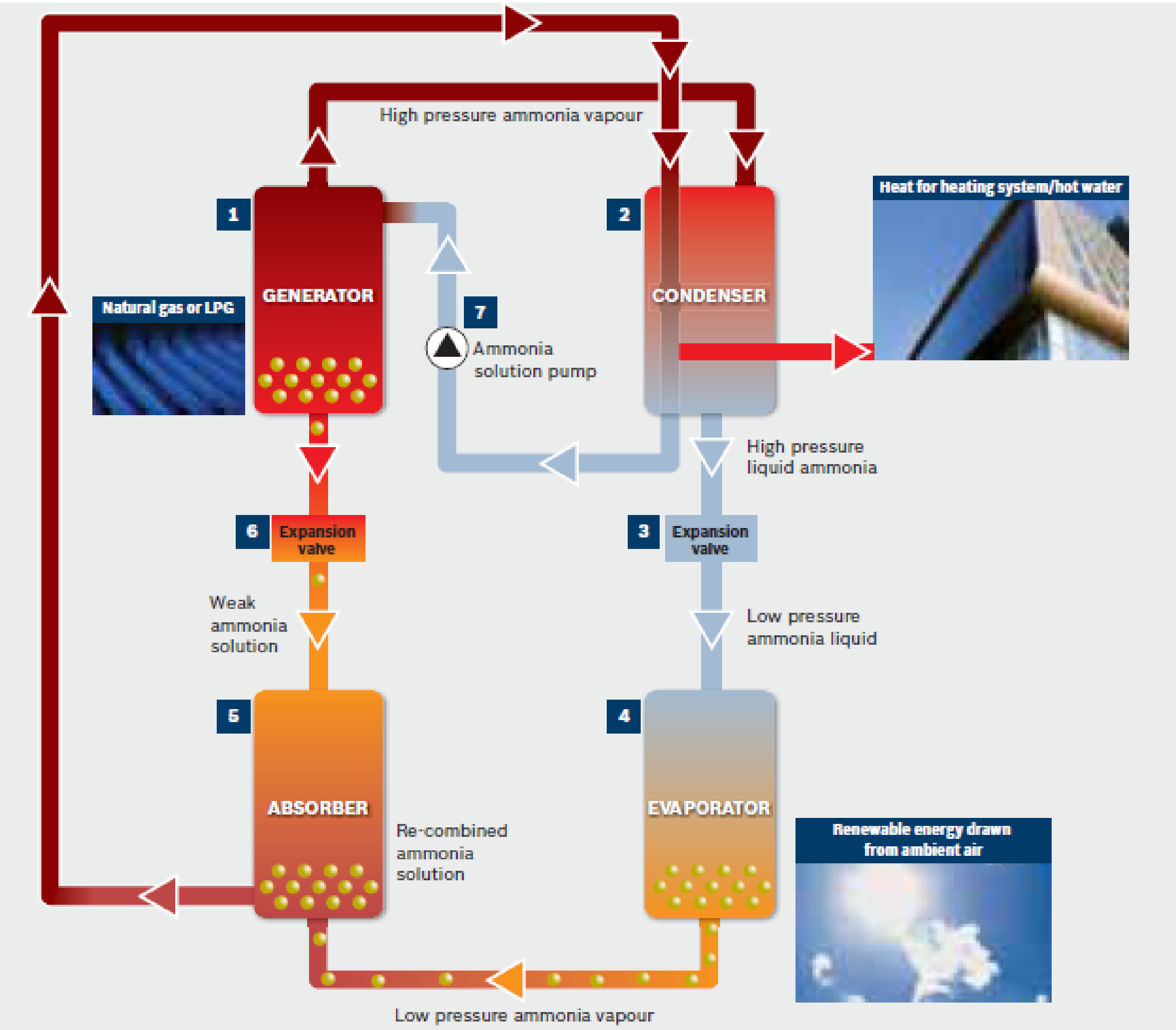


Figure 3.1 diagram of the operating cycle of a gas absorption heat pump

Figure 3.1 above and description below are taken from the Worcester Bosch GAHP brochure. (http://www.bosch-industrial.co.uk/files/Bosch_GAHP_brochure_UK.pdf)

1 Generator
Within the Generator, the low NOx gas-fired burner heats the ammonia/water solution via a heat exchanger, increasing the temperature and pressure. This causes it to separate into ammonia vapour and a weak ammonia solution. The ammonia vapour travels to the Condenser (2) whilst the weak ammonia solution is circulated to the Absorber (5).

2 Condenser
The now high temperature, high pressure ammonia vapour releases its heat into the heating system in the condenser. In doing so, the vapour changes state, becoming a liquid. This liquid travels to the expansion valve (3) on its way to the Evaporator (4).

3 Expansion valve
The ammonia liquid, still at high pressure, passes through the expansion valve where the pressure falls. Due to reduced pressure, partial evaporation of ammonia liquid takes place, then the mixture moves to the evaporator (4).

4 Evaporator
A fully modulating fan draws ambient air through the fins of the Evaporator. The ambient air contains a high amount of free, renewable energy from the air. This energy is captured by the ammonia and causes it to evaporate. The now-heated, low pressure vapour passes on to the Absorber (5).

5 Absorber
In the absorber, the weak ammonia solution from the Generator (1) recombines with the heated vapour from the Evaporator (4), having first passed through a second expansion valve (6). As the vapour re-merges with the weak ammonia solution, the vapour changes state into a liquid, releasing further heat to the heating system in the second pass of the condenser. The now-reformed ammonia solution is pumped (7) back to the generator.

6 Second expansion valve
As described above, this second valve controls the flow of the weak solution between the Generator (1) and the Absorber (5).

7 Ammonia solution pump
The ammonia solution pump moves the ammonia solution from the Absorber (5) back to the Generator (1) via condenser (2) where the process starts again.

The gas absorption heat pump selected for this project is the Worcester Bosch AWO 38L2. The manufacturer's product brochure states that the heat pump has a Gas Utilisation Efficiency (GUE) of up to 164% efficiency, at air temperature of 7 ^{0}C and flow temp of 35 ^{0}C.
This reduces to 150% with external temperature of 7 ^{0}C and flow temp of 50 ^{0}C and reduces further to 119% at the same external temp and flow temp of 65 ^{0}C.

At a flow temp of 55 ^{0}C over the heating season, with an average external temperature of 7 ^{0}C, the average efficiency is advertised as 112%.

The system is designed with a flow temperature of 55 ^{0}C. At this temperature the rated output of the GAHP is about 35.5 kW. Two Worcester Bosch AWO 38 L2 heat pumps were installed, with a total rated capacity of 71.1 kW.

As part of the refurbishment of the building, the heating system was given a complete overhaul. In addition to the 2 GAHPs, the following was installed:

- three new Worcester Bosch model GB162 condensing gas boilers rated at 100 kW each
- a solar thermal system consisting 12 panels, each of area 2.9 m^2., giving a total area of 34.8 m^2. A solar PV array of 39 kWp on the south facing elevation.

The gas boilers operate in rotation. Up to three of the gas boilers would work depending on load requirement. The design heat load is 135 kW, so the GAHPs only provide just over half load at design conditions.

When the solar thermal system is generating heat, this has priority and is used to meet or contribute to the building heat demand. Once the solar is unable to maintain the minimum setpoint, the gas absorption units are enabled, and finally if the gas absorption units can't satisfy the heat demand then the gas boilers are introduced one at a time in order to ensure that the building heat loads are met.

As the external temperature increases or the internal heat demand reduces, the gas boilers are removed, followed by the GAHPs and finally the system reverts back to solar when it is able to do so.

The following photographs show the main system components in situ (Figures 3.2 – 3.5).

Figure 3.2 view of the two Worcester Bosch GAHPs

Figure 3.3 Worcester Bosch GAHPs in their compound


Figure 3.4: two 1500 litre buffer tanks in the plant room

Figure 3.5: three Worcester Bosch back up boilers

3.2 Technological monitoring

In order to effectively monitor the efficiency of the gas absorption heat pump, a number of different monitoring equipment was installed across the sheltered housing scheme. 12 properties had temperature and humidity loggers installed. Two of these were installed per property (1 in living room and 1 in bedroom) to regularly record temperature and humidity inside the property every hour.

BMS System;

The following meters were installed as part of the building management system (BMS):

- gas meter measuring gas input to the GAHP
- heat meter for the output from the GAHP
- heat meter for output from the solar thermal system
- electricity in to the GAHP
- All flats have individual heat meters, linked to the BMS system.

In addition, the following meters were also on site:

- gas meter measuring total gas usage at the sheltered housing scheme
- main electric meter for the property
- electricity generated by the solar PV system

The aim was for the BMS system to provide performance data with remote access via a PC at CBH, but at the end of the monitoring period this had not been implemented.

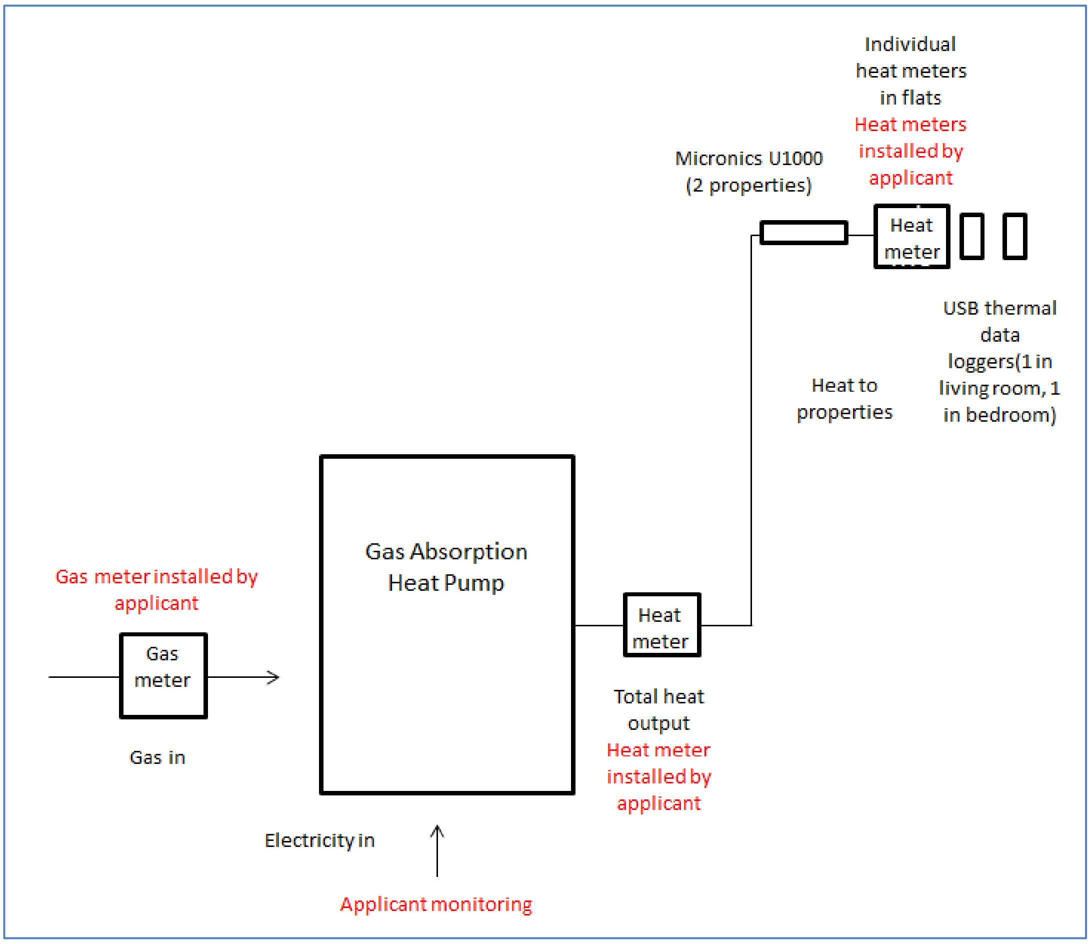


Figure 3.6 – Schematic diagram of monitoring equipment placed in the plant room and in the monitored properties

The original plan was for the BMS to take regular readings from the various meters installed and store the data for later analysis. However, the data collected was not sufficiently detailed to be able to analyse. Data also appeared suspicious, with sudden jumps in meter readings after prolonged periods with no explainable cause. Readings from the heat meters in each flat were recorded for

21 days before being overwritten. The data from the BMS (including the data from the heat meters) was available through CBH secure networks and consequently had to be downloaded by CBH staff periodically. For various reasons, data was only downloaded intermittently, meaning that there were large gaps in the data. Useful information on the heat used in each property was able to be analysed during some of these 21-day periods during the winter.

The electricity and gas meters for the site were not linked to the BMS as originally specified, so were manually read. The dates that the gas and electric meters were read did not always coincide with the date of the BMS download, which meant it was not possible to analyse a full dataset over any period.

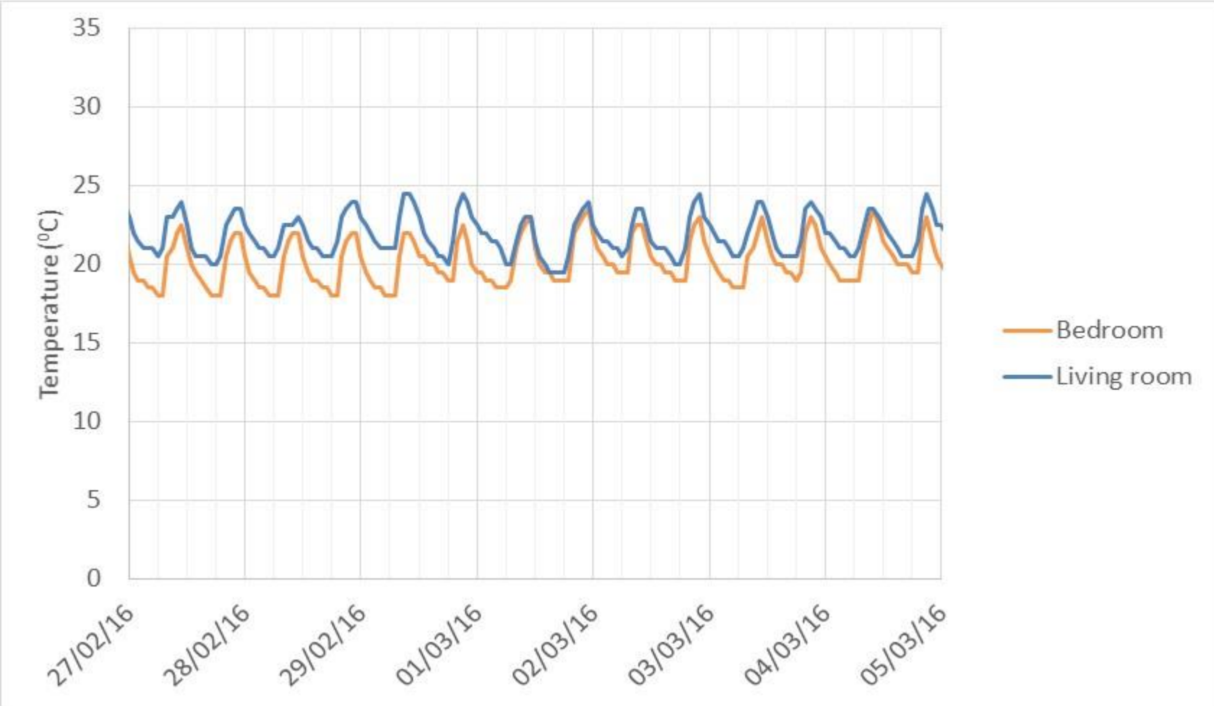
Although detailed analysis of the meter readings has not been possible, there is sufficient data to suspect that the back-up boilers are contributing more to the heat load of the building than the GAHPs.

Meter	Reading date 1	Reading date 2	Difference in readings	kWh	No of days	Degree days	kWh / day	kWh / dd
Main gas meter	3/6/17	25/1/18	26,937	302,249	236	1,052	1,281	287
GAHP gas meter	25/10/16	23/7/18	13,308	149,324	636	3,795	235	39
GAHP heat meter	8/3/17	25/1/8	37,478	37,478	323	1,456	116	26

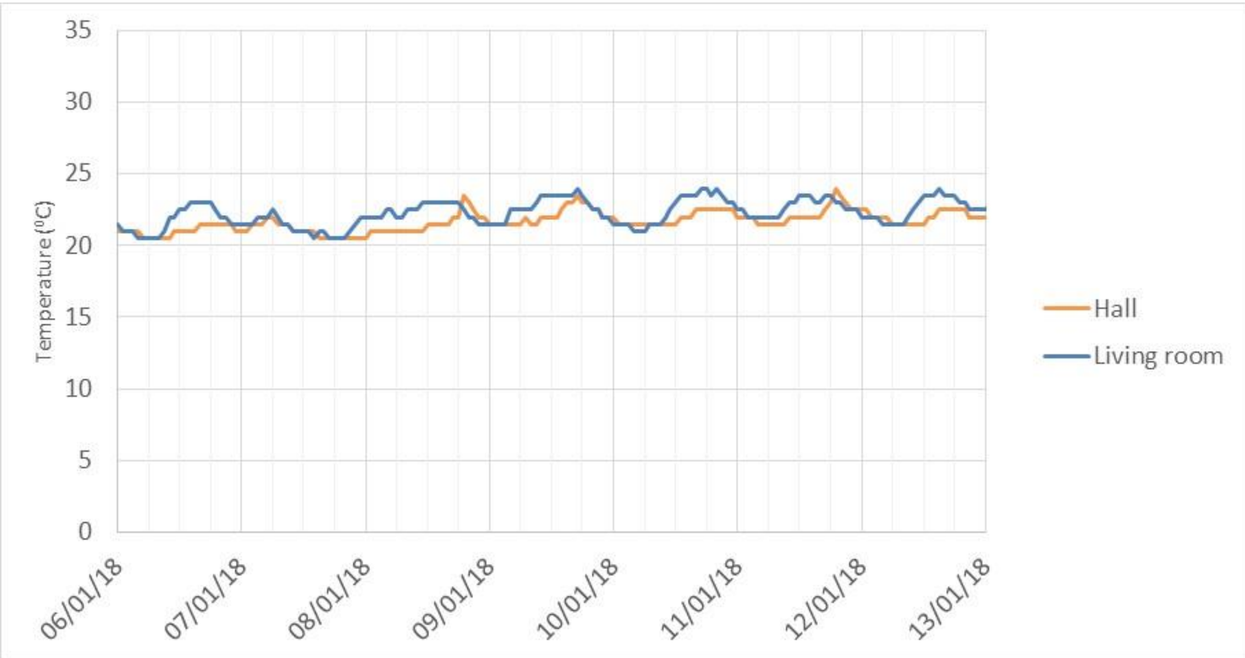
Table 3.7 various meter readings

From Table 3.7 above, it can be seen that the measured gas input to the GAHPs over 636 days was approximately half that of the gas used on the site over only 236 days. The site gas usage was more than 5 times the GAHP per day over the different periods measured, and over 7 times when corrected for external temperatures (degree days). Over different dates again, the heat output from the GAHP is of a similar order to the GAHP input, so suggests that the readings are reasonable. Due to the difference in dates, no firm conclusions can be drawn, but it appears that the GAHP does not provide the anticipated level of heat to the building (significantly less than half of the building heat demand).

Temperature graphs

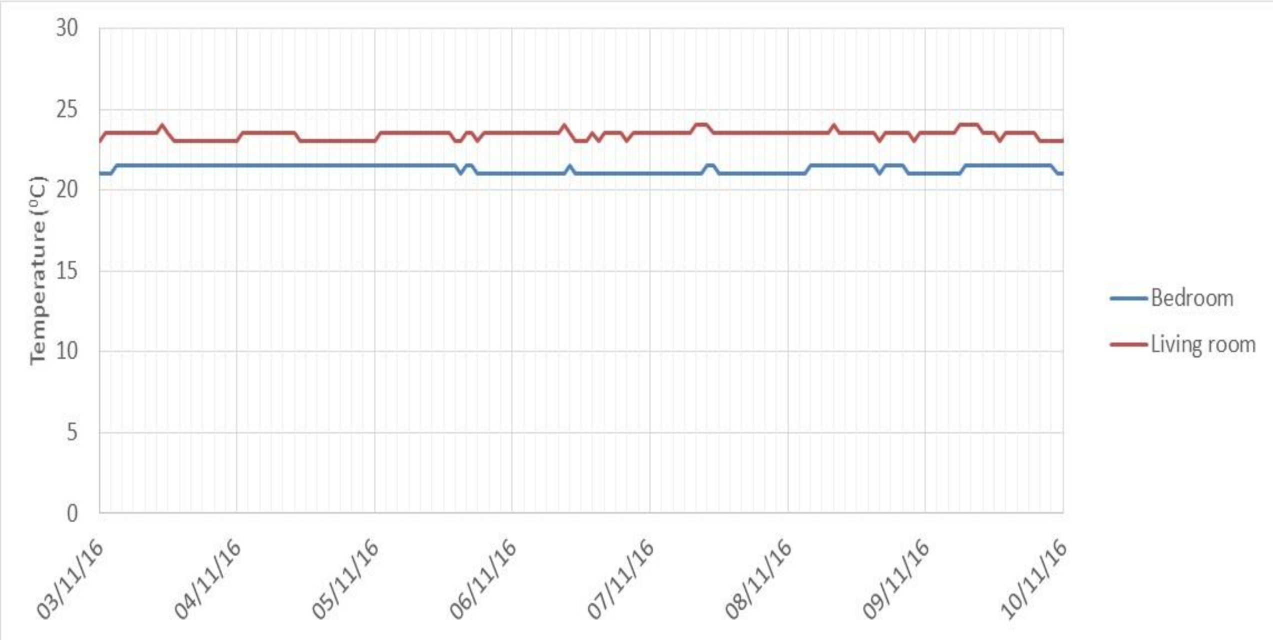


Graph 3.8 bedroom and living room temperatures at property T-08 with old heating system.



Graph 3.9 hall and living temperatures at property T-08 with the new heating system

Graphs 3.8 and 3.9 show internal temperatures in the flats T-08, occupied by the same resident before and after refurbishment. There is a marked reduction in the range of temperatures measured.



Graph 3.10 bedroom and living room temperatures at property T-01 with new heating system.

Graph 3.10 above shows the stable internal temperatures achieved in one property following installation of the new heating system.

3.3 Cost

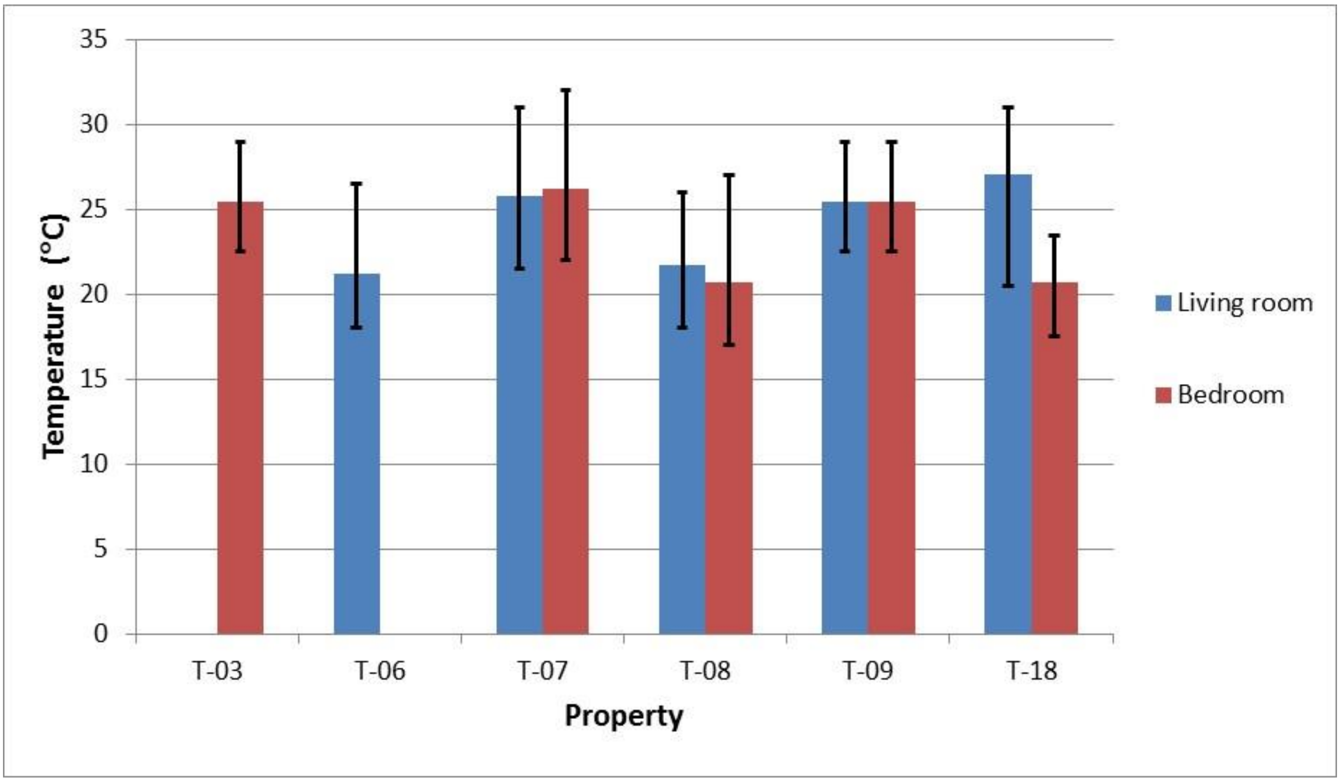
As people were living in different flats at the end of the project from those where they started, and the flats were far better insulated after the works, it is not possible to make any comment about the change to anyone's bills for heating. The change in property and insulation are likely to have as big an impact as any reduction in heating costs through an improved, more efficient, heating system. Due to the billing mechanism previously discussed, residents did not see any changes in their bills during the monitoring period.

3.4 Temperature and thermal comfort

Temperature readings were taken at hourly intervals throughout the monitoring period in the lounge and bedroom. The data in table 3.11 and graph 3.12 below shows the recorded temperatures in flats that were monitored before the refurbishment. Data in table 3.13 and graph 3.14 show the recorded temperatures in flats that were monitored after the refurbishment.

Tech Ref	Living room temperatures 10 February to 31 March 2016				Bedroom temperatures 10 February to 31 March 2016			
	Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Average Temp (°C) 5pm-10pm	Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Average Temp (°C) 5pm-10pm
T-03					25.5	29.0	22.5	24.9
T-06	21.2	26.5	18.0	21.9				
T-07	25.8	31.0	21.5	27.2	26.2	32.0	22.0	28.0
T-08	21.7	26.0	18.0	21.9	20.7	27.0	17.0	21.9
T-09	25.5	29.0	22.5	25.3	25.5	25.5	17.0	25.3
T-18	27.1	31.0	20.5	27.0	20.7	23.5	17.5	21.0
Maximum	27.1	31.0	22.5	27.2	26.2	32.0	22.5	28.0
Minimum	21.2	26.0	18.0	21.9	20.7	23.5	17.0	21.0
Average (Mean)	24.3	28.7	20.1	24.7	23.3	27.0	18.4	24.1

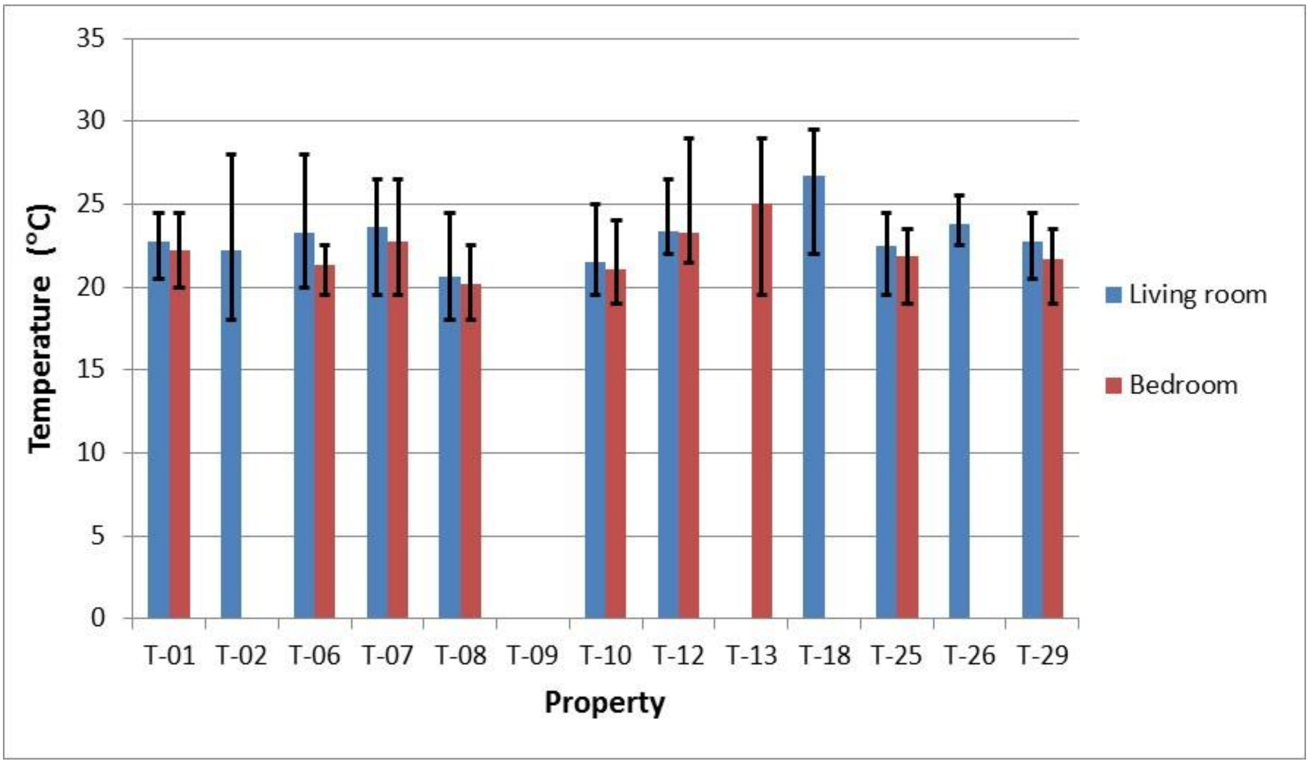
Table 3.11 living room and bedroom temperatures in properties before renovation for the period 10 Feb to 31 March 2016



Graph 3.12 showing the data from table 3.10 above.

Tech Ref	Living room temperatures 10 February to 31 March 2017				Bedroom temperatures 10 February to 31 March 2017			
	Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Average Temp (°C) 5pm-10pm	Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Average Temp (°C) 5pm-10pm
T-01	22.7	24.5	20.5	23.1	22.2	24.5	20.0	22.2
T-02	22.2	28.0	18.0	22.8				
T-06	23.3	28.0	20.0	23.6	21.3	22.5	19.5	21.2
T-07	23.6	26.5	19.5	24.3	22.7	26.5	19.5	23.4
T-08	20.6	24.5	18.0	20.8	20.2	22.5	18.0	20.4
T-10	21.5	25.0	19.5	22.3	21.1	24.0	19.0	21.8
T-12	23.4	26.5	22.0	24.1	23.3	29.0	21.5	22.9
T-13					25.0	29.0	19.5	24.6
T-18	26.7	29.5	22.0	26.8				
T-25	22.5	24.5	19.5	23.1	21.9	23.5	19.0	22.4
T-26	23.8	25.5	22.5	23.7				
T-29	22.7	24.5	20.5	23.1	21.7	23.5	19.0	21.7
Maximum	26.7	29.5	22.5	26.8	25.0	29.0	21.5	24.6
Minimum	20.6	24.5	18.0	20.8	20.2	22.5	18.0	20.4
Average	23.0	26.1	20.2	23.4	22.2	25.0	19.4	22.3

Table 3.13 living room and bedroom temperatures in properties after renovation for the period 10 Feb to 31 March 2017



Graph 3.14 showing the data from table 3.12 above

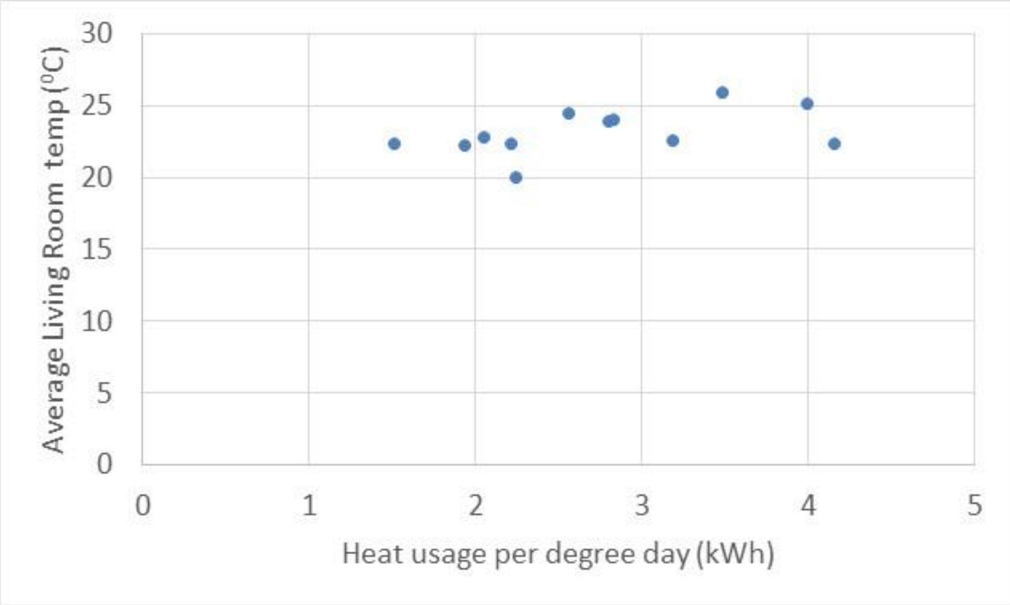
Following renovation of the sheltered housing scheme, over the selected periods in the graphs above, the average internal temperature in the monitored properties reduced from 24.3 ^{0}C to 23.0 ^{0}C in the living rooms and from 23.3 ^{0}C to 22.2 ^{0}C in the bedrooms.

The renovation had already begun when temperature and humidity monitoring started. This meant that some of the loggers were placed in newly refurbished properties. For these there was no comparison with the internal temperature and humidity of the old property. Because a lot more properties were monitored following refurbishment, it needs to be considered whether the 6 properties monitored before were representative of all 12. Of the 4 households whose properties were monitored both before and after, 3 out of the 4 had temperature reductions in the living room. Only two could be compared for bedrooms and both of these had temperature reductions. The average temperature change was a reduction of 0.45 ^{0}C in the living room.

The difference between the maximum and minimum recorded temperatures for each property (temperature range) also reduced following renovation. The average range of temperatures before renovation was 8.6 ^{0}C in the living room and 8.1 ^{0}C in the bedroom. After renovation the average range was 5.9 ^{0}C in the living room and 5.5 ^{0}C in the bedroom. It is likely that this is partly due to improved heating system control, and partly due to reduced heat loss (better insulation) of the building.

	Period 4 to 25 Jan 2018		
Tech Ref	Heat usage over period (kWh)	Heat usage per Degree Day (kWh)	Average Living Room temperature over period (^{0}C)
T-01	900.0	4.17	22.2
T-02	864.0	4.00	25.1
T-03	486.0	2.25	20.0
T-06	445.0	2.06	22.8
T-07	554.0	2.56	24.4
T-08	479.0	2.22	22.2
T-09	818.0	3.79	-
T-10	689.0	3.19	22.5
T-12	607.0	2.81	23.9
T-18	754.0	3.49	25.8
T-25	419.0	1.94	22.2
T-26	612.0	2.83	23.9
T-27	370.0	1.71	-
T-28	294.0	1.36	-
T-29	329.0	1.52	22.2
Maximum	900.0	4.17	25.8
Minimum	294.0	1.36	20.0
Average	574.7	2.66	23.1

Table 3.15 showing the energy measured by the heat meters at different flats over the period 4 to 25 January 2018, the energy per degree day and the average living room temperature over the same time-period



Graph 3.16 showing the average living room temperature plotted against the measured heat usage in monitored flats

Graph 3.16 above uses the data from table 3.15 to show that there is little correlation between the heat energy used and the internal temperature reached in the living room. Some properties use more than double the amount of heat energy of others, for no increase in internal temperature. This may be that some properties have a far larger heat loss than others e.g. they open their windows more, and therefore use more heat to maintain the desired internal temperature. Others may have electrical appliances which give out heat and maintain internal temperature without the need for much top-up from the heating circuit. For example, the tenants at T-06 and T-12 both had tumble dryers in their flats.

The average heat energy use for the monitored flats, as measured from the heat meters over the time period in table 3.15, was 2.66 kWh per degree day. The average for all flats was 2.60 kWh.

The average annual degree days for Colchester = 2135, so the anticipated annual heat energy use for each flat would be 5,540 kWh per year

On average the EPCs for the new flats say that the annual heat energy requirement = 59 kWh/m^2. For a flat in the scheme which was typically 54 m^2, the annual requirement = 3,068 kWh.

The actual energy use is in excess of that estimated by the EPCs. This may be partly because the average internal temperature is above that anticipated by SAP calculations in EPCs. SAP calculations assume that heating is operational for 9 hours a day during the week and 16 hours a day at weekends, with demand temperatures of 21 ^{0}C in the main living area and 18 ^{0}C elsewhere. Measured temperatures in the monitored properties were higher and the heating was operational for longer periods than that anticipated by SAP – measured internal temperatures over a 24-hour period were 23 ^{0}C in living rooms and 22.1 ^{0}C in bedrooms. Also, research shows that there is often a performance gap between what is anticipated in the design of a building and that which is achieved in practice[2].

3.5 Humidity

[2] https://www.cibse.org/getmedia/55cf31bd-d9eb-4ffa-b2e2-e567327ee45f/cb11.pdf.aspx

Water vapour in the air, usually referred to as relative humidity (RH) and quantifies the percentage of water vapour held by the air when compared to the saturation level (the highest quantity of water able to be supported by the air at a given temperature), is not usually considered to be an indoor contaminant or a cause of health problems. In fact, some level of humidity is necessary for comfort. Conversely, the relative humidity of indoor environments (over the range of normal indoor temperatures of 19 to 27°C), has both direct and indirect effects on health and comfort. The direct effects are the result of the effect of relative humidity on physiological processes, whereas the indirect effects result from the impact of humidity on pathogenic organisms or chemicals which may affect health.

Figure 3.17 illustrates the optimum humidity levels as cited by Arundel et al[3]. The study concluded that maintaining relative humidity levels between 40% and 60% would minimise adverse health effects relating to relative humidity.

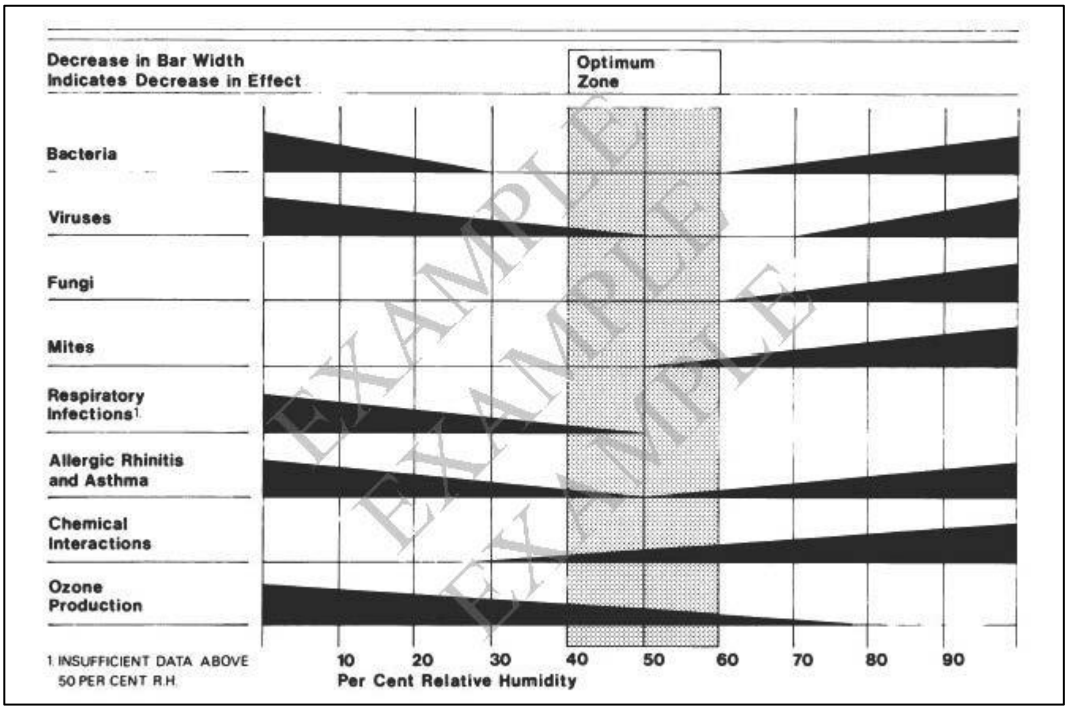


Figure 3.17 Optimum humidity levels to reduce indirect effects from pathogenic organisms or chemicals

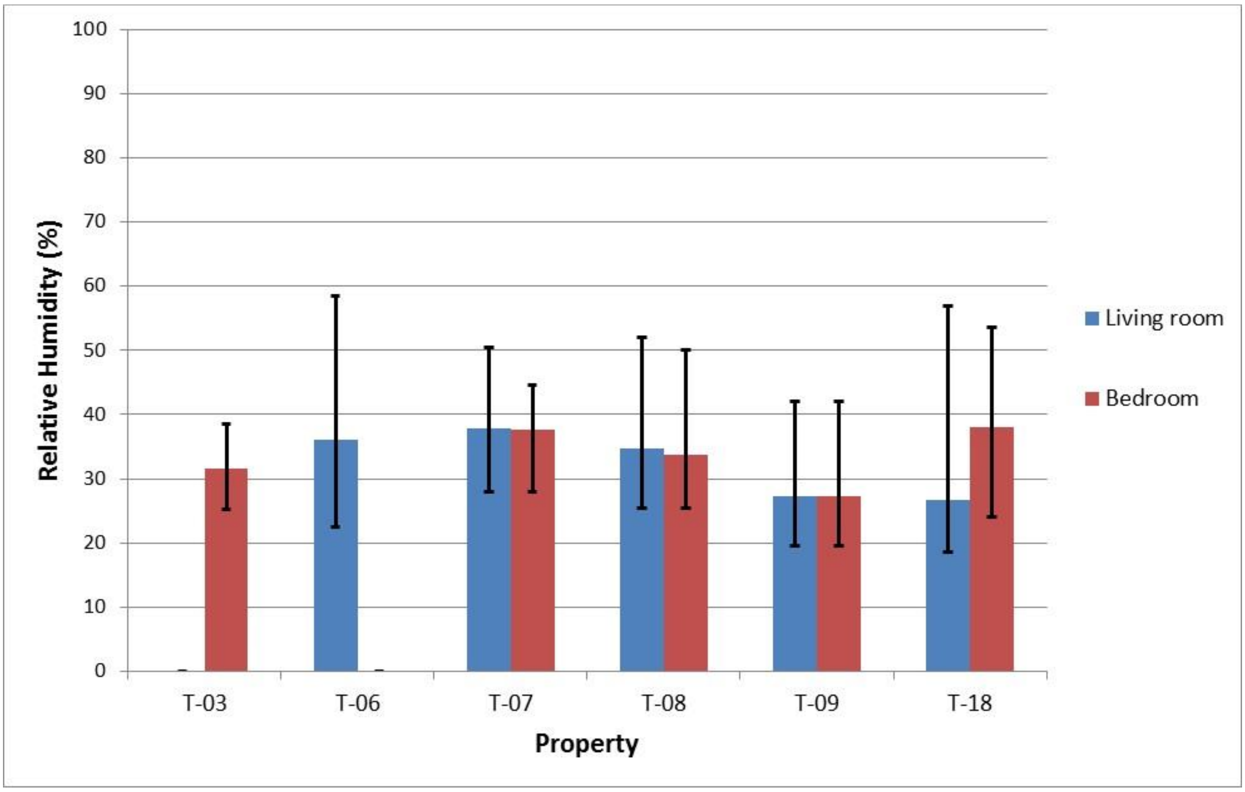
The automated data-loggers used in this project record both temperature and relative humidity (RH) at pre-determined regular intervals across the study properties. RH is a ratio (expressed as a percentage) of the amount of moisture present in the air at each logging point, relative to the amount that would be present if the air were saturated. Since the latter amount is dependent on temperature, relative humidity is a function of both moisture content and temperature. Relative Humidity is derived from the associated Temperature and Dew Point for the indicated sample. The higher the value of RH, the more water vapour is contained in the air. High values are problematic, and can cause damage to building fabric and furnishings, and can cause mould growth and cause health problems associated with this high humidity. From Approved Document F to the Building

[3] Anthony V. Arundel, Elia M. Sterling, Judith H. Biggin, and Theodor D. Sterling: Indirect Health Effects of Relative Humidity in Indoor Environments: available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1474709/ [accessed 21/03/2017]

regulations[4]; the suggested average monthly maximum humidity levels for domestic dwellings during the heating season is 65%.

	Living room humidity 10 February to 31 March 2016				Bedroom humidity 10 February to 31 March 2016			
Tech Ref	Average RH (%) 24 hours	Maximum RH (%) 24 hours	Minimum RH (%) 24 hours	Average RH (%) 5pm-10pm	Average RH (%) 24 hours	Maximum RH (%) 24 hours	Minimum RH (%) 24 hours	Average RH (%) 5pm-10pm
T-03					31.6	38.5	25.2	33.8
T-06	36.0	58.5	22.5	36.6				
T-07	37.8	50.5	28.0	38.2	37.6	44.5	28.0	38.0
T-08	34.8	52.0	25.5	35.1	33.8	50.0	25.5	32.2
T-09	27.2	42.0	19.5	27.4	27.2	42.0	19.5	27.4
T-18	26.7	57.0	18.5	27.5	38.1	53.5	24.0	39.9
Maximum	37.8	58.5	28.0	38.2	38.1	53.5	28.0	39.9
Minimum	26.7	42.0	18.5	27.4	27.2	38.5	19.5	27.4
Average (Mean)	32.5	52.0	22.8	33.0	34.2	47.5	24.3	34.4

Table 3.18 living room and bedroom relative humidities in properties before renovation for the period 10 Feb to 31 March 2016

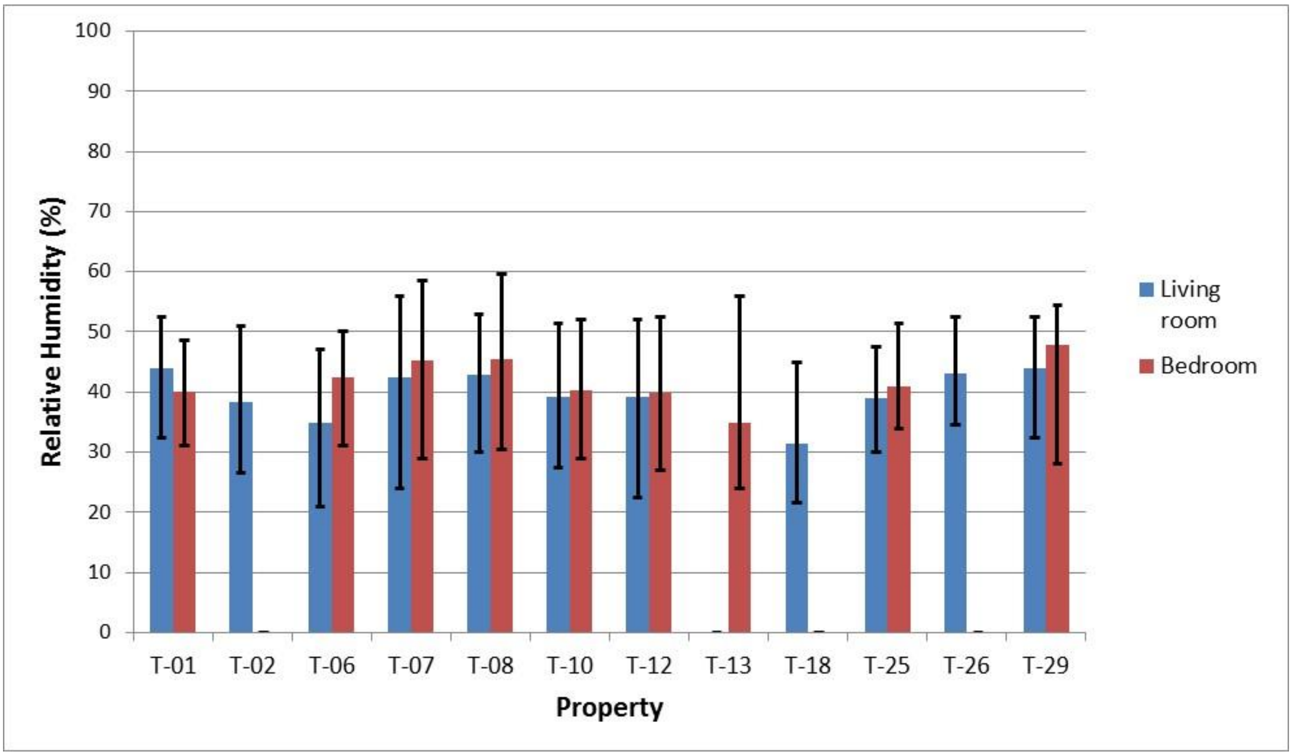


Graph 3.19 Graph based on Table 3.17 above

[4] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/468871/ADF_LOCKED.pdf [Accessed 21/03/2017]

	Living room humidity 10 February to 31 March 2017				Bedroom humidity 10 February to 31 March 2017			
Tech Ref	Average RH (%) 24 hours	Maximum RH (%) 24 hours	Minimum RH (%) 24 hours	Average RH (%) 5pm-10pm	Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Average Temp (°C) 5pm-10pm
T-01	44.0	52.5	32.5	44.1	40.0	48.5	31.0	40.2
T-02	38.3	51.0	26.5	38.0				
T-06	34.8	47.0	21.0	34.7	42.4	50.0	31.0	41.7
T-07	42.5	56.0	24.0	43.1	45.2	58.5	29.0	45.6
T-08	42.8	53.0	30.0	42.7	45.5	59.5	30.5	45.3
T-10	39.2	51.5	27.5	38.9	40.2	52.0	29.0	40.0
T-12	39.2	52.0	22.5	38.2	39.8	52.5	27.0	40.4
T-13					34.8	56.0	24.0	35.7
T-18	31.4	45.0	21.5	31.7				
T-25	39.0	47.5	30.0	39.1	40.9	51.5	34.0	41.1
T-26	43.0	52.5	34.5	43.5				
T-29	44.0	52.5	32.5	44.1	47.8	54.5	28.0	47.4
Maximum	44.0	56.0	34.5	44.1	47.8	59.5	34.0	47.4
Minimum	31.4	45.0	21.0	31.7	34.8	48.5	24.0	35.7
Average	39.8	51.0	27.5	39.8	41.8	53.7	29.3	41.9

Table 3.20 living room and bedroom relative humidities in properties after renovation for the period 10 Feb to 31 March 2017



Graph 3.21 Graph based on Table 3.19 above

The graphs and tables above show that on average there is an increase relative humidity in the flats after refurbishment when compared to before. Following renovation of the sheltered housing scheme, over the selected periods in graphs 3.19 and 3.21 above, the average internal RH in the monitored properties increased from 32.5 % to 39.8 % in the living rooms and from 33.7 ^{0}C to 41.8 % in the bedrooms.

Section 2.4 showed that the internal temperatures reduced on average following refurbishment, which for the same amount of moisture in the atmosphere will result in an increase in RH.

The difference between the maximum and minimum recorded RH for each property (RH range) reduced in the living room following renovation, while the RH range in the bedroom remained about the same. The average range of RH before renovation was 29.2 % in the living room and 18.6 % in the bedroom. After renovation the average range was 21.5 % in the living room and 18.3 % in the bedroom.

Reduced ventilation rates arising out of improved insulation, new windows, better draught-proofing could also result in increased humitidy levels, but still fall within reccomended levels.

4. Conclusions and recommendations

4.1 Conclusions

The project involved refurbishment of a sheltered housing block, including alterations which reduced the number of residences from 48 studio, one and two-bedroom flats to 36 one and two-bedroom flats. The refurbishment of the building included significantly improved insulation, reduced heat loss, and replacement of the old gas boilers (one per residence) with a new communal heating system consisting of two gas absorption heat pumps, together with solar thermal system and back up gas boilers. In addition, a solar PV array was installed.

12 individual properties had loggers installed to measure the internal temperature and humidity in the living room and bedroom. Some loggers were installed into new flats at the start of the project and some loggers followed residents as they moved from their old dwelling into their new flat.

The new heating system had a BMS with associated meters to record inputs and outputs from the GAHP. However, the monitoring equipment did not collate sufficient data to be able to make any conclusions about the running cost and efficiency of the GAHP. However, it did raise suspicions that the GAHP was not contributing as much to the overall heat demand as originally projected.

Householders thought that their new heating system was a big improvement on the old system because it required less intervention from themselves to maintain a comfortable temperature.

Following installation of the new heating system average internal temperatures decreased on average by just over 1 ^{0}C. The average temperature range in each property reduced from 8.3 ^{0}C to 5.7 ^{0}C suggesting that the control system was more effective at controlling the heating.

Humidity increased on average by 7.7% following refurbishment but was within recommended levels.

4.2 Recommendations for potential future installations

Unfortunately, the monitoring data using the BEMS has not provided sufficient data to enable any analysis of the efficiency of the GAHPs or determine future monitory savings to residents.

Future monitoring projects should check the data that is being provided from the monitoring equipment at an early stage, to ensure that it is providing the information required. If there are problems, such as heat meters being located in the wrong place, then this could be rectified early on. Analysis of the data collected by the BMS gave concern that the data was inaccurate. It was suggested that this could have been rectified by upgrading the controller to one that would write to a web-based “dashboard” of important information. However, this upgrade is only now being actioned. This will enable CBH to monitor the effectiveness of the GAHPs in future but has unfortunately come too late to be of benefit to this project.

Regular manual readings of all the important meters would have provided sufficient data to calculate system performance over the heating season or over a period of a year.

4.3 Impact on fuel poverty

There is insufficient data to be able to say whether the total energy use for the building has changed. The total bills were previously divided by 48 tenants, and after refurbishment were divided by 36 tenants.

4.4 Performance comparison against manufacturer’s claims

It has not been possible to compare the results with the manufacturer’s claims. The GAHPs have been designed with a relatively high flow temperature, and so will not achieve the higher efficiencies claimed by the manufacturer for lower flow temperatures of between 35 and 45 ^{0}C.

4.5 Economic business case for installation of measures

The building was substantially altered as part of the refurbishment, with significant improvements to insulation, energy efficiency and energy generation. The building that the new heating system was installed into was very different from that which was served by the old heating systems. Even if there was sufficient data to compare before energy use with after energy use, it would not be possible to isolate the performance of the GAHP and say how they would have performed in the old building, and any savings that would have been made by the installation of the GAHPs alone. The cost of the installation cannot therefore be compared with any energy savings to provide a business case for future projects.

Appendix 1: Glossary of Terms

BMS	*Building Management System*
CBH	*Colchester Borough Homes*
COP	*Coefficient of Performance*
DD	*Degree Days*
EPC	*Energy Performance Certificate*
EWI	*External Wall Insulation*
GAHP	*Gas Absorption Heat Pump*
GUE	*Gas Utilisation Efficiency*
HIP	*Health and innovation Programme*
LPG	*Liquified petroleum Gas*
NEA	*National Energy Action – the National Fuel Poverty Charity*
PVHR	*Passive Ventilation and Heat Recovery*
RH	*Relative Humidity*
RHI	*Renewable Heat Incentive*
SAP	*Standard Assessment Procedure (for assessing home energy efficiency)*
TIF	*Technological Innovation Fund*
TRV	*Thermostatic Radiator Valve*

Appendix 2: Health and Innovation Programme 2015 – 2017

The Health and Innovation Programme (HIP) was a £26.2 million programme to bring affordable warmth to fuel poor and vulnerable households in England, Scotland and Wales.
The programme launched in April 2015 and was designed and administered by fuel poverty charity National Energy Action as part of an agreement with Ofgem and energy companies to make redress for non-compliance of licence conditions/obligations. To date, it remains the biggest GB-wide programme implemented by a charity which puts fuel poverty alleviation at its heart.

The programme comprised 3 funds

- **Warm and Healthy Homes Fund (WHHF):** to provide heating, insulation and energy efficiency measures for households most at risk of fuel poverty or cold-related illness through health and housing partnerships and home improvement agencies

- **Technical Innovation Fund (TIF)**: to fund and investigate the impact on fuel poverty of a range of new technologies

- **Warm Zones Fund (WZF):** to install heating and insulation and provide an income maximisation service to households in or at risk of fuel poverty, delivered cost-effectively through partnership arrangements managed by NEA's not-for-profit subsidiary Warm Zones Community Interest Company

What it involved

- **Grant programmes** to facilitate the delivery of a range of heating and insulation measures and associated support. Grant recipients were encouraged to source match and/or gap funding to increase the number of households assisted and to enhance the support provided to them
- **Free training** to equip frontline workers with the skills needed to support clients in fuel poverty
- **Outreach work and community engagement** to provide direct advice to householders on how to manage their energy use and keep warm in their homes

In addition, we undertook substantial **monitoring and evaluation** work, to assess the effectiveness and measure the performance of the technologies, and to understand the social impacts of the programme. Our **communications programme** helped partners to promote their schemes locally as well as share best practice with others. The programme generated a considerable amount of **knowledge and insight** which will be made freely available to help support future policy and delivery.

Proper investment of advanced payments allowed us to generate interest which, along with efficiency savings, was reinvested back into the programme in the form of additional grants and support which helped us further exceed our targets.

For more information see www.nea.org.uk/hip

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