New Charter Housing Trust Limited

# Evaluation of Flue Gas Heat Recovery, insulation of hard to treat cavity walls and heating controls

## Technical Evaluation Report

**Kathy New, Marvin Beckett, Paul Cartwright, Michael Hamer September 2017**

# CP749
# Energy Efficient Solutions in the North West
# New Charter Housing Trust Limited

| | |
|---|---|
| Number of households assisted | 53 |
| Number of households monitored | 16 |

# 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 to fund the installation and evaluation of technologies costing up to a maximum £7,400 per household, and a smaller measures programme with 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 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.

## 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 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.

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## Legal limitations and disclaimer

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# Executive summary

## Project overview

This project was delivered by New Charter Housing Trust Ltd and involved installing measures in 53 properties in both the social and private housing sectors. 17 properties received a new boiler with flue gas heat recovery system fitted and heating controls, 17 received hard to treat cavity wall insulation, and 19 properties received all measures. The aims of the project were;

- To provide evidence on the relative effects of each technology functioning on an individual basis in comparison to a whole house retrofit approach in fuel poor homes.
- To apply energy usage data to provide evidence of the most effective combinations of technology in various property types.
- To assess if householders benefit by having more control over their heating systems.

The technologies installed were: Ideal Code boilers with built-in Flue Gas Heat Recovery (FGHR); Honeywell programmable wireless room thermostats; Honeywell and Warwick in-house Thermostatic Radiator Valves (TRVs); and Isothane's Technitherm hard to treat cavity insulation.

## Context

Around 1.65m households in England live in local authority owned housing and a further 2.28m live in properties owned by housing associations. Many of these properties will currently only have a basic thermostat and programmer. In 2010, 38% of homes with a boiler did not have a room thermostat and 45% had no thermostatic radiator valves[1].

It has been claimed that smart thermostats can reduce bills by 20-30%; however, heating controls have received limited funding from Government schemes in the past. Boiler replacement schemes or funding for new central heating systems have usually only involved the installation of basic thermostats and programmers, and while smart heating controls were included in the Green Deal and Green Deal Cashback schemes these, closed in 2015.

Fuel poverty in Tameside Metropolitan Borough Council is estimated to be 11.9%, which is slightly higher than the England average of 11%[2].

Many of those in fuel poverty live in hard to treat properties – those which have solid or non-standard cavity walls, and/or do not have access to mains gas. These households are also likely to be in deeper fuel poverty.

Additionally, most households within this study were working but on low incomes and fuel poverty figures in England show that a high percentage of households living in fuel poverty are under the

[1] Smarter heating controls research program (DECC, 2012) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/254877/smarter_heating_controls_research_programme_overview.pdf (Accessed 23 May 2017)

[2] Sub-regional fuel poverty data 2015 https://www.gov.uk/government/statistics/sub-regional-fuel-poverty-data-2017 (Accessed 3rd July 2017)

age of 60. The energy performance bands of the properties in the study were below band C, the target minimum standard the Government has set for the homes of fuel poor households.

## The technology

The technologies being trialled were: Ideal Code boilers with built-in FGHR; Honeywell programmable wireless room thermostats; Honeywell and Warwick in-house TRVs; and Isothane's Technitherm hard to treat cavity insulation.

FGHR systems take advantage of heat within waste flue gases resulting from the combustion of gas in the boiler. This recovered heat is used to preheat the cold water entering the boiler, thereby lowering the amount of energy needed to warm the water up to the required level.

Wireless room thermostats provide automatic time and temperature control of the home, by transmitting time and temperature data to the receiver box with no need for hard-wiring.

TRVs are self-regulating valves fitted to hot water heating system radiators, to control the temperature of a room by changing the flow of hot water to the radiator. This enables bespoke temperature control on a radiator-by-radiator basis.

Isothane's Technitherm hard to treat cavity wall insulation is an injected polyurethane foam which, when injected into the cavity, expands to fill the cavity adhering to both the inner and outer wall forming an air tight layer of insulation.

## The project

New Charter Group is a social landlord with 19,500 homes in Manchester, Nottingham and Oldham. New Charter worked with contractor Warm Front Limited to install measures in 53 properties in the Tameside area of North West England, which were a mixture of social housing and private tenure domestic properties. The properties selected for improvements in this project were previously uninsulated and/or had old non-condensing boilers without FHGR.

17 properties received new boilers and heating controls, 17 received hard to treat cavity insulation and 19 received this combination of measures.

Of these, NEA monitored 16 properties, 5 with new boilers and heating controls, 6 with insulation, and 5 with the combination of measures. A control group of 6 properties was also adopted, where no measures were installed. This was used as a comparator, as energy data from before the installations took place was sparse.

40% of the residents in the monitored group had health conditions, all of which were worsened by the cold.

## Findings and insights from the study

### The majority of residents with measures saved energy

- 86% of the residents with the installed measures said that they had felt they had saved on their energy bills.

- By combining meter reading data and 20 year average degree days data, it was shown that residents who received both the insulation and heating improvements made an estimated annual average saving on their energy bill of 45%.
- In comparison to the control group, lower gas consumption averaging 27% was seen where the heating system and controls were fitted, and 21% where the hard to treat cavity wall insulation was installed. However the control group recorded higher average indoor temperatures and were likely to have had longer than average heating periods.
- The only property (T-20) that provided meter reading data both pre and post-installation of the full combination of measures showed an estimated average annual saving of 34.54% (£170.25) on their gas bill and an estimated average annual saving of 18.7% (£68.49) on their electricity bill.

### The majority of residents felt warmer and more comfortable

- 71% of all residents surveyed said they felt warmer and more comfortable as a result of the measures. The residents with the all of the measures showed the most significant change in satisfaction levels.
- Temperatures indicate that properties with installed measures achieved the recommended living room warm and healthy temperatures of 18-21°C during a winter period for peak heating times of 6-8am and 5-9pm.
- A large proportion (69%) of residents that felt they had reduced the need for supplementary heating.
- The measures had a clear positive impact on the home energy efficiency levels as seen by the before and after Standard Assessment Procedure (for assessing home energy efficiency) (SAP) ratings, with 62% of properties moving up from band D to band C.
- Overall the combination of FGHR built-in boiler coupled with HTTC insulation appears to have had the biggest impact on energy bill reduction. This equated to an annual estimated average saving of 44.72% (£329.53) on gas bills in comparison to the control group during the 2016-2017 winter period.
- 92% of participants felt they had more control over their energy bills as a result of combination of the new integrated FGHR measures, the controls (TRVs and programmable thermostat) and energy advice received. However, the high temperature recordings taken from some living rooms and bedrooms may indicate that further cost savings could be achieved through more effective use of the thermostat and TRVs (unless these higher temperatures were as a result of residents taking benefit in comfort not cost).
- 78% of residents felt the measures had helped to ease their money worries somewhat.

### Conclusions and recommendations

- Unsurprisingly the biggest savings achieved were where there was a combination of efficient heating, controls and insulation fitted. Residents satisfaction rates were highest in these households
- The combination of measures can be effective in helping reach EPC band C lifting properties in band D up to this higher level which is the government target for fuel poor households; however more analysis needed on the impact on SAP bands.
- There are huge variations in temperatures recorded in the different properties in this study and further work is needed to establish how we can help people achieve healthy heating regimes which can also achieve cost savings

- Resident engagement is vital to ensure a comprehensive data set for analysis (both in terms of obtaining regular meter readings and the qualitative feedback via the social evaluation questionnaires).
- In a future study it would be valuable to commence the monitoring period the winter before measures are installed, so that a comparison can be made pre and post-installation for all properties. This would confirm the accuracy of the findings of this study, and remove the need to compare with similar control properties.

# 1. Project overview

## 1.1 Introduction

New Charter Group is a social landlord with 19,500 homes covering Manchester, Nottingham and Oldham. As well as operating a number of housing associations including New Charter Homes Limited, the New Charter Group also owns an academies education trust and a building company. New Charter Homes Limited manages in the North West of England, including the Tameside area.

Figure 1.1 location of Tameside

The project modelled three scenarios:

1. Properties that received new boilers with built-in Flue Gas Hear Recovery, and heating controls.
2. Properties that received hard to treat cavity wall insulation.
3. Properties that received both measures.

The new boilers installed were Ideal Code boilers, chosen because they had the FGHR functionality built in. The executive summary provides more detail about this technology and the other products used in the trial. The heating controls installed were Honeywell programmable wireless room thermostats, together with either Honeywell or Warwick TRVs.

The Isothane Technitherm cavity foam solution was chosen as this product presented a number of benefits over standard Cavity fill insulation. These benefits include:

- The product can be used in cavities that would be too narrow or uneven to use conventional cavity fill insulation.
- The material bonds to the surfaces inside the cavity and provides additional stabilisation to the construction.
- The product has higher insulation performance than tradition cavity wall insulation which can more than offset the reduced thickness often used.
- The product provides a moisture barrier and therefore protect from penetration of wind driven rain.

Warm Front Limited completed all works on this project on behalf of New Charter, and 30% of the properties assisted were privately owned to gain experience of resident benefits and views in both sectors.

### 1.2 Aims

The aims of the project were;

- To provide evidence on the relative effects of each technology functioning on an individual basis on comparison to a whole house retrofit approach in fuel poor homes.
- To apply energy usage data to provide evidence of the most effective combinations of technology in various property types.
- To assess if householders benefit by having more control over their heating systems.

### 1.3 Project timeline

Figure 1.2 shows the original timeline for the project but the monitoring equipment installation was delayed until after the measures were fitted.

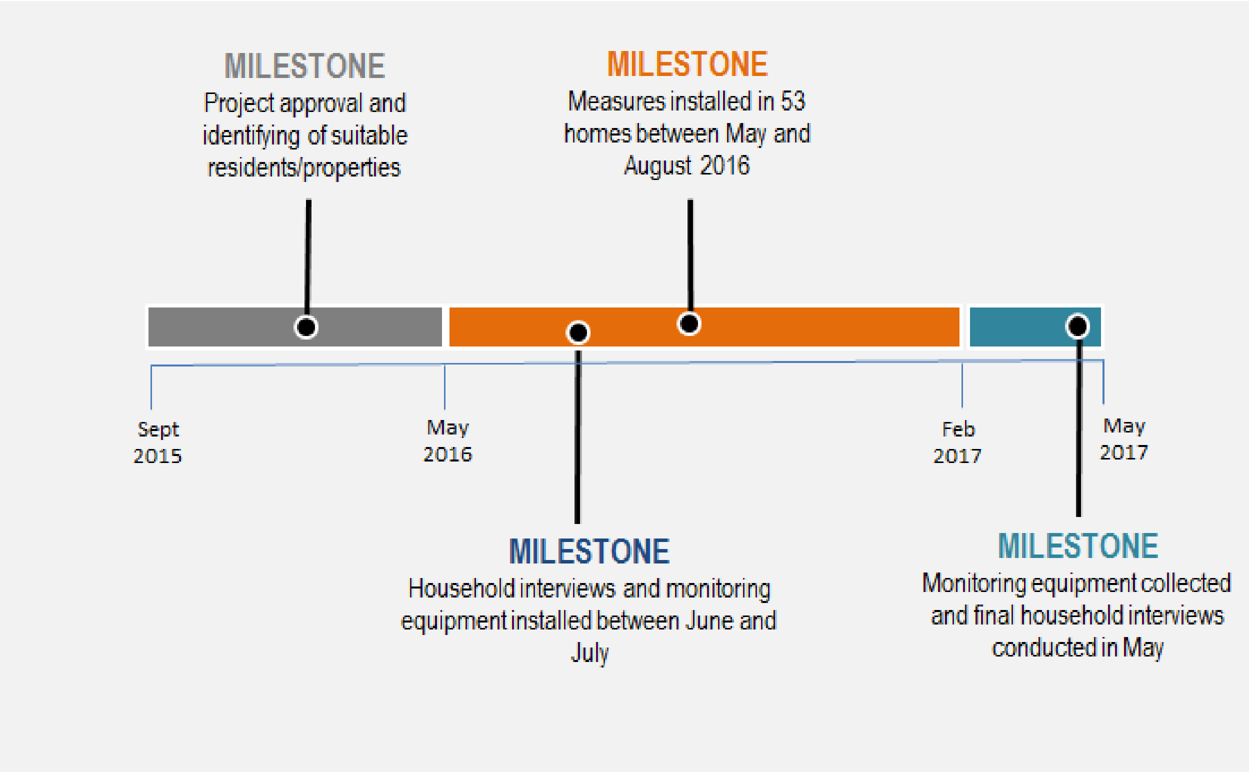


Figure 1.2 Project timeline

### 1.4 Attracting beneficiaries and establishing the monitored group

Warm Front Ltd identified the residents to benefit and who agreed to be part of the monitoring and evaluation exercise. This included both New Charter residents and private tenants, all of whom were expected to be on lower than average incomes or living in, or at risk of, fuel poverty. They also identified control properties and visited the residents to secure data-sharing consent.

Additionally New Charter elected to carry out repointing works to their properties where:

- Existing pointing had failed
- In some cases existing cavity wall insulation had failed
- There was evidence of rainwater leaks
- The properties suffered from high exposure to weather

This is necessary before any cavity wall insulation is to be fitted. The New Charter beneficiaries for this project were selected from the list of properties scheduled for works on the repointing scheme, which provides a suitable selection of varying property and occupancy types. Combining the previous planned re-pointing scheme with this project allowed New Charter to minimise tenant disruption by completing all building and repair works in one go.

The privately owned properties were in the same area to the New Charter repointing list and provided the largest possible mix of property and occupancy types in the local area. New Charter, working with Warm Front Ltd, also helped to provide the greatest amount of data available for NEA's technical team to evaluate.

# 2. Technical evaluation methodology

## 2.1 Introduction

FGHR boilers, heating controls and HTTC were installed in 53 properties in Tameside by Warmfront Ltd, on behalf of New Charter Housing Trust Ltd.

The 16 households in the monitoring exercise were assigned a unique reference number (prefix T) to maintain anonymity of the households involved.

| Property | SAP (Standard Assessment Procedure) rating before measures. | SAP band before. | SAP rating after measures | SAP band after | Measures | Additional Controls |
|---|---|---|---|---|---|---|
| T-01 | 68 | D | 74 | C | Both measures | Honeywell programmable wireless room thermostats, TRVs: Honeywell. |
| T-02 | 62 | D | 68 | D | HTTC (Hard to treat cavity wall insulation) | N/A |
| T-05 | 66 | D | 70 | C | HTTC (Hard to treat cavity wall insulation) | N/A |
| T-07 | 51 | E | 68 | D | FGHR (Flue gas heat recovery) built in boiler | Honeywell programmable wireless room thermostats, TRVs: Honeywell. |
| T-08 | 44 | E | 63 | D | FGHR (Flue gas heat recovery) built in boiler | Honeywell programmable wireless room thermostats, TRVs: Honeywell. |
| T-10 | 64 | D | 72 | C | HTTC (Hard to treat cavity wall insulation) | N/A |
| T-12 | 57 | D | 70 | C | FGHR (Flue gas heat recovery) built in boiler | Honeywell programmable wireless room thermostats, TRVs: Honeywell. |
| T-15 | 64 | D | 71 | C | Both measures | Honeywell programmable wireless room thermostats, TRVs: Honeywell. |
| T-16 | 68 | D | 73 | C | Both measures | Honeywell programmable wireless room thermostats, TRVs: Honeywell. |
| T-17 | 68 | D | 71 | C | HTTC (Hard to treat cavity wall insulation) | N/A |
| T-20 | 55 | D | 65 | D | Both measures | Honeywell programmable wireless room thermostats, TRVs: Honeywell. |
| T-24 | 67 | D | 73 | C | HTTC (Hard to treat cavity wall insulation) | N/A |
| T-26 | 68 | D | 73 | C | Both measures | Honeywell programmable |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | wireless room thermostats, TRVs: Honeywell. |
| T-29 | 65 | D | 73 | C | FGHR (Flue gas heat recovery) built in boiler | Honeywell programmable wireless room thermostats, TRVs: Honeywell. |
| T-36 | 66 | D | N/A① | D | FGHR (Flue gas heat recovery) built in boiler | Honeywell programmable wireless room thermostats, TRVs: Honeywell. |
| T-37 | 64 | D | 66 | D | HTTC (Hard to treat cavity wall insulation) | N/A |

① - The most current EPC was issued prior to the new boiler with FGHR being installed

Table 2.1 Showing details of the homes, their home efficiency rating (SAP) and their measures installed during the study.

The table below shows the various SAP bands and ratings for reference purposes

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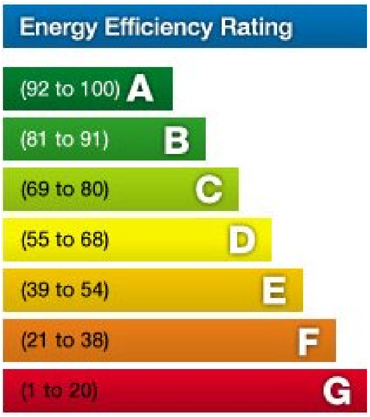



## 2.2 Technical monitoring

Of the 53 households involved in the project, 17 originally agreed to participate in the technical monitoring however 1 was not suitable which left 16. Monitoring of their properties began in May 2016, at the same time as the FGHR boilers; heating controls and HTTC insulation were installed. Each monitored property had 2 different types of monitoring equipment installed. These were Lascar Thermal & Humidity Loggers USB-2[3] and Lascar USB Thermal probes[4].

No temperature data was available prior to the measures being fitted. As well as the fitting of monitoring equipment, back-billing/meter read data was also requested from the residents in order to be able to compare their energy use pre- and post-installation of the measures. However, the vast majority of the residents were unable to provide adequate meter reading data for a period before the measures were installed to provide a clear picture of previous consumption. The table

[3] Lascar Thermal and Humidity logger. https://www.lascarelectronics.com/easylog-data-logger-el-usb-2/ Accessed June 2017.
[4] Lascar Thermal Probe. https://www.lascarelectronics.com/easylog-data-logger-el-usb-1/ Accessed June 2017.

below (Table 2.2) shows a breakdown of the properties supplying adequate data after the measures were installed which was also less than had been hoped for but 11 of the 16 households did provide reliable records. Additionally a control group of 5 households, similar in size and occupancy levels which did not have any measures installed were monitored over the same period and allowed comparisons in usage to be made between those with older boilers and unfilled cavities.

| Property | Provided adequate meter reading data after the measures were installed. |
|---|---|
| T-01 | No |
| T-02 | Yes |
| T-05 | No |
| T-07 | Yes |
| T-08 | Yes |
| T-10 | Yes |
| T-12 | Yes |
| T-15 | Yes |
| T-16 | No |
| T-17 | Yes |
| T-20 | Yes |
| T-24 | No |
| T-26 | Yes |
| T-29 | Yes |
| T-36 | No |
| T-37 | Yes |

Table 2.2, chart showing complete and incomplete data sets.

Households taking part in the study were asked to regularly record gas and electricity meter readings in a pre-printed log book. Meter readings were obtained from energy bills and by contacting their energy supplier (with residents' consent) wherever possible. These were used to assess the gas consumption after the installation of the measures. Householders were also reminded on a weekly basis through SMS text messages to their mobile telephones, to record their meter readings.

## Monitoring equipment

The following monitoring equipment was used on the project.

## Thermal & Humidity loggers


Figure 2.3 Lascar EL-USB-2 temperature and humidity logger (left) and thermal probe (right)

Temperature and humidity in the monitored properties was recorded every hour using a Lascar EL-USB-2 temperature and humidity logger[5]. These were placed in the living room and main bedroom of the monitored properties around the time of the installations of the measures.

### Thermal Probes

USB-TP loggers were used to monitor the surface temperature of the radiator that they were placed on. These were placed on bedroom and living room radiators in 11 of the monitored properties. These were not required where there had only been cavity wall insulation installed.

| Property Type | Monitoring Equipment | Number of properties |
|---|---|---|
| Monitored | USB-2 Thermal and humidity data loggers – two for each monitored property | 16 |
| Monitored | USB Thermal probe | 11 |
| Control | USB Thermal data loggers – two for each control property | 5 |
| Control | USB Thermal probe | 1 |

Table 2.4 Summary of monitoring equipment used.

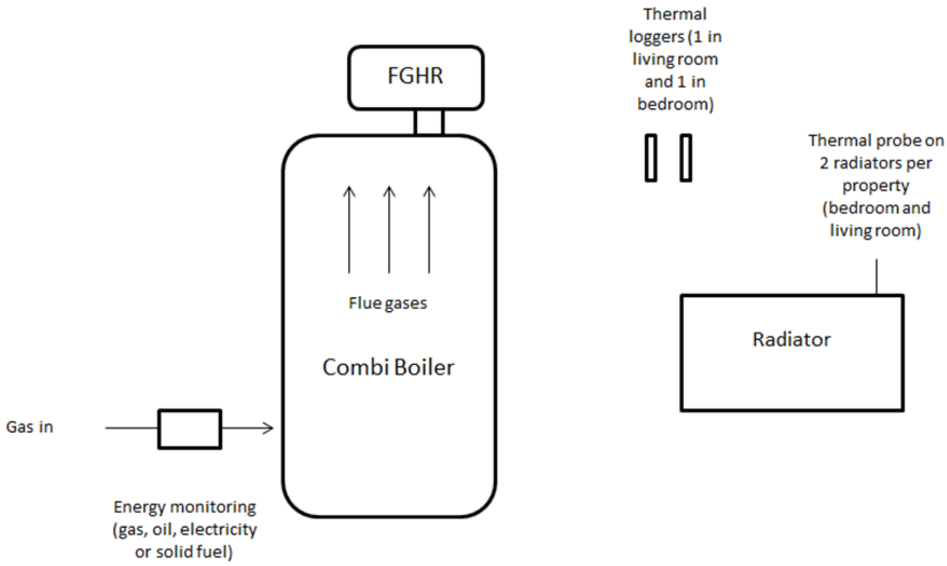



Figure 2.5 (a) Schematic diagram of logger placement for Flue gas heat recovery built-in boiler properties.

5 Lascar EL-USB-2 datasheet https://www.lascarelectronics.com/media/2925/easylog-data-logger_el-usb-2.pdf (Accessed 12 May 2017)

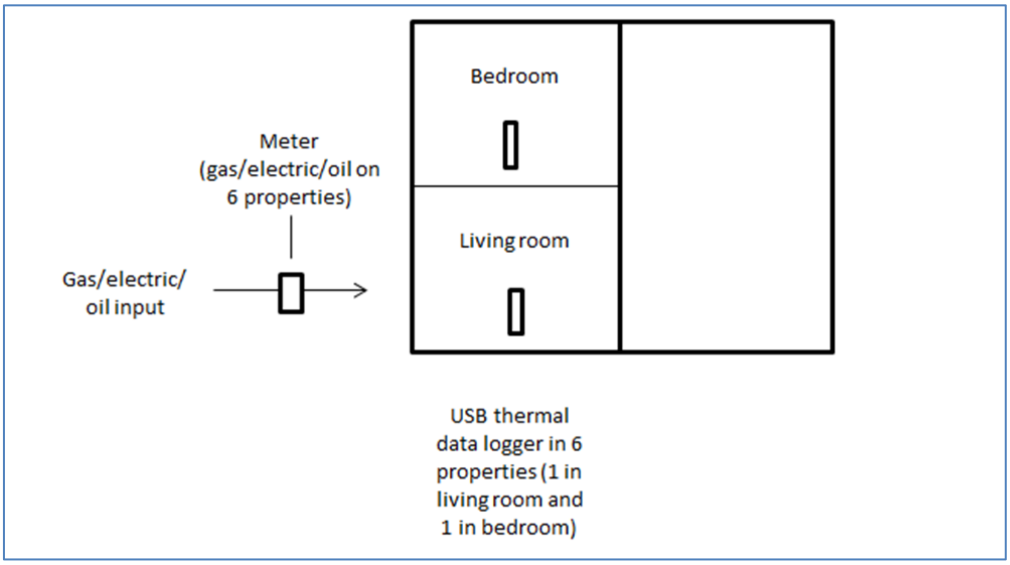



Figure 2.5 (b) Schematic diagram of logger placement within properties with HTTC insulation.

## 2.3 Factors affecting the evaluation methodology

| Issue | Description and mitigation |
|---|---|
| **Delays with installation of measures** | Measures were not installed until May 2016, there was no pre-installation energy data available. A control group therefore had to be identified and amendments made to the evaluation methodology. |
| **Engagement with the monitored group** | Initial questionnaires were completed with just 13 of 16 households and only 14 completed the end questionnaire. (However data loggers were retrieved from all16 properties). |
| **Identification of control group** | The control group households were identified later in the project, and a full winter data set was not available for all properties for comparison with the main group of monitored properties. |
| **Optipulse loggers were not installed as specified by the partner** | When NEA visited the properties to conduct the final householder interviews and collect the monitoring equipment, the majority of the Optipulse loggers were not installed in the position indicated by the partner (and supported by photographs). The data that these loggers would have contained is not therefore available for analysis. |
| **Resident moving home** | 1 of the residents in a control property moved out during the course of the study, however there was enough data gathered over the winter to use in the analysis. |
| **Meter readings** | Unfortunately 5 of the 16 households did not diligently take meter readings, so there is limited pre- and post-installation energy |

consumption data available from their properties.

# 3. Social impacts

A semi-structured questionnaire was conducted with 13 of the 16 monitored households at the beginning of the study, around the time the installations took place. A final questionnaire was conducted with 14 of the 16 monitored households at the end of the study. The control group households also answered a combined beginning/end questionnaire when the study concluded. Personal details such as age, work status and health conditions affecting residents were collected along with household attitudes and feelings towards saving energy, worrying about paying energy bills, and staying warm. Structural details of the home such as the number of rooms, insulation levels and boiler age were also collected along with energy bill data such as supplier, tariff and method of payment.

## 3.1 Householder demographic details

The age range of the household members taking part in the study is shown in Figure 3.1(a). 51% were aged 16-59, and the results indicate that the majority of households were of working age and in full time employment (60%).

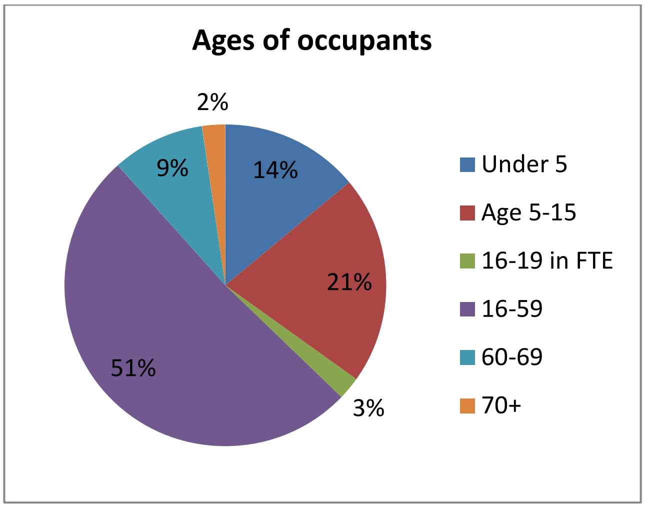



Figure 3.1 (a) Household ages

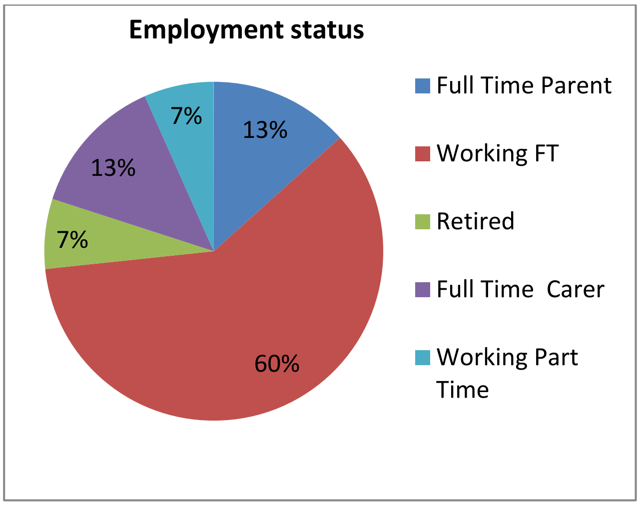
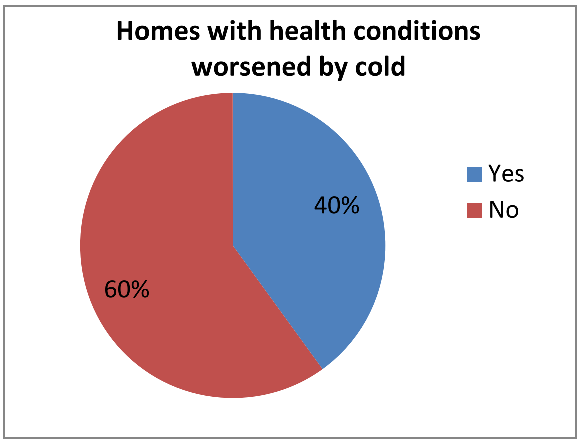



Figure 3.1 (b) Employment status

40% of households studied had someone living in the property with a health condition which is negatively impacted by living in a cold home, see Figure 3.2. These health conditions included diabetes, high or low blood pressure, osteoarthritis, arthritis, poor circulation and asthma.

Figure 3.2
Health conditions



All monitored properties had gas central heating (GCH) as the main heating source, and were fairly evenly split between 2 (53%) and 3 (47%) bedroom properties (Figure 3.3). 27% of the households were semi-detached properties and 73% were mid-terrace properties, as shown in Figure 3.4, which impacts on the property's heating needs and heat loss.

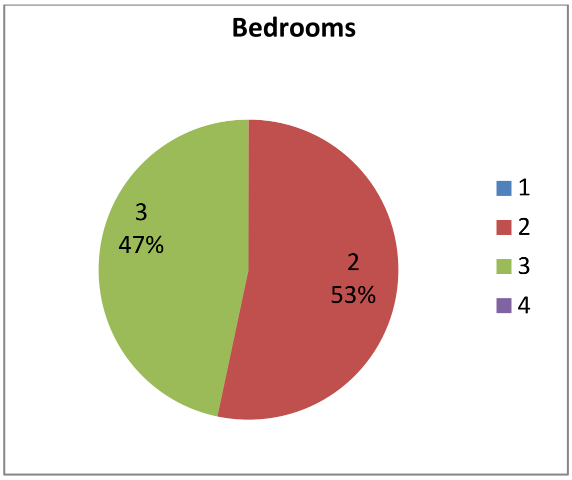



Figure 3.3 Number of bedrooms

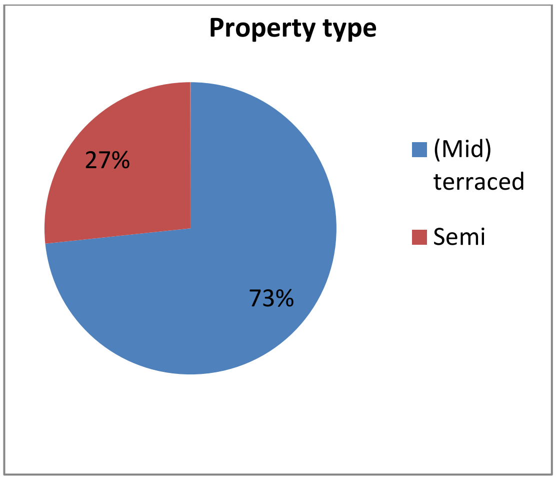



Figure 3.4 Property type

### 3.2 Qualitative feedback given pre-installation of the technologies

The original main home heating system for all properties had been gas central heating from a variation of combi boilers, Baxi Bermuda back boiler, or standard boilers. These boilers were then replaced with Ideal Code boilers with an integral FGHR system. Those properties receiving HTTC measures already had a condensing combi boiler. A large proportion (31%) of residents reported that they use additional supplementary heating at times throughout the year. Residents' main method of controlling their heating had been by using room thermostats or programmable timers.

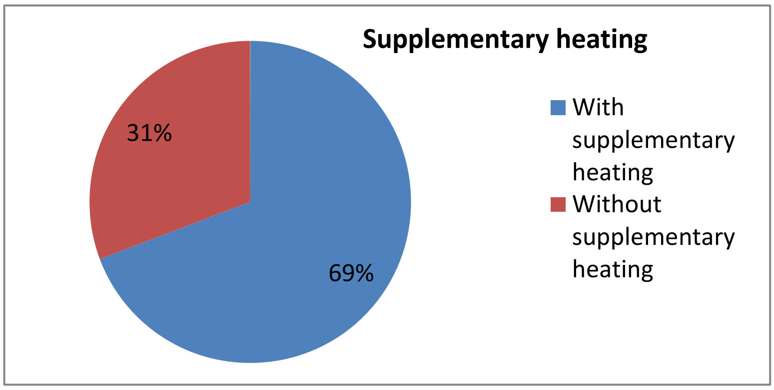



Figure 3.5 Supplementary heating.

All properties had double glazed windows although some residents said they were still draughty and suffered window condensation. Residents reported that 77% of the properties had cavity wall construction and 8% of properties had solid walls (and 15% of residents didn't know). 73% of the residents interviewed knew that they had the full standard 250-270mm loft insulation, 9% had 5-156cm loft insulation and 18% had either 'some' or none. 23% of households also felt their main external door/s were draughty when answering the initial questionnaire.

46% of households Figure (3.6) reported some concerns about damp and condensation with mould growth in various rooms; needing window sealant replacement; or gaps in loft insulation.

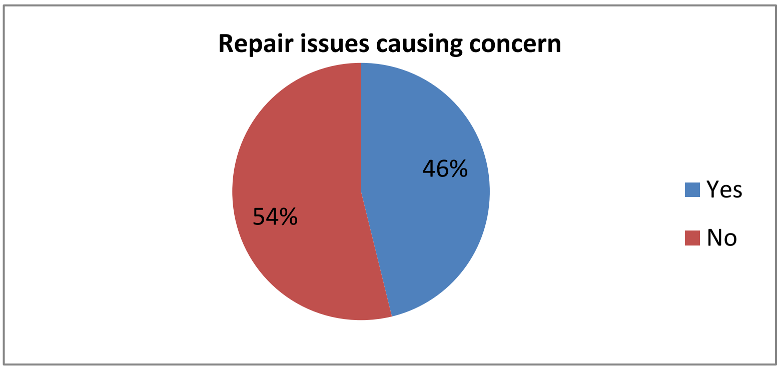



Figure 3.6 Repair issues causing concern.

82% of householders reported that their normal evening living room temperature was in the recommended 18-21°C range, whereas 9% was normally between 16-18°C and 9% said they normally had the living room thermostat set at 16°C, which is lower than suggested for periods when residents are occupying the room (Figure 3.7). 80% of residents heated the whole house but 20% heated selected rooms.

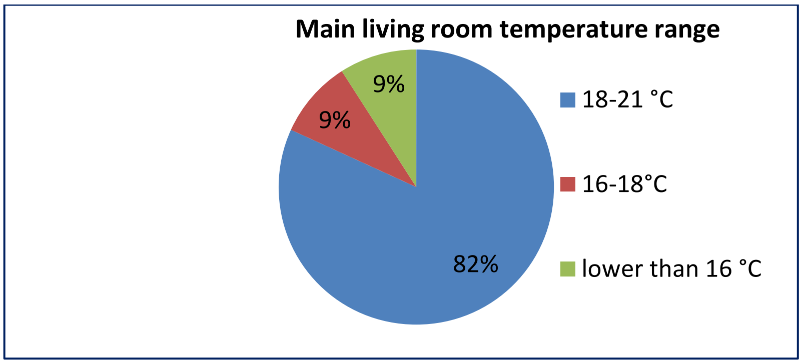



Figure 3.7 main living room temperature during preferred evening heating period (5-9pm)

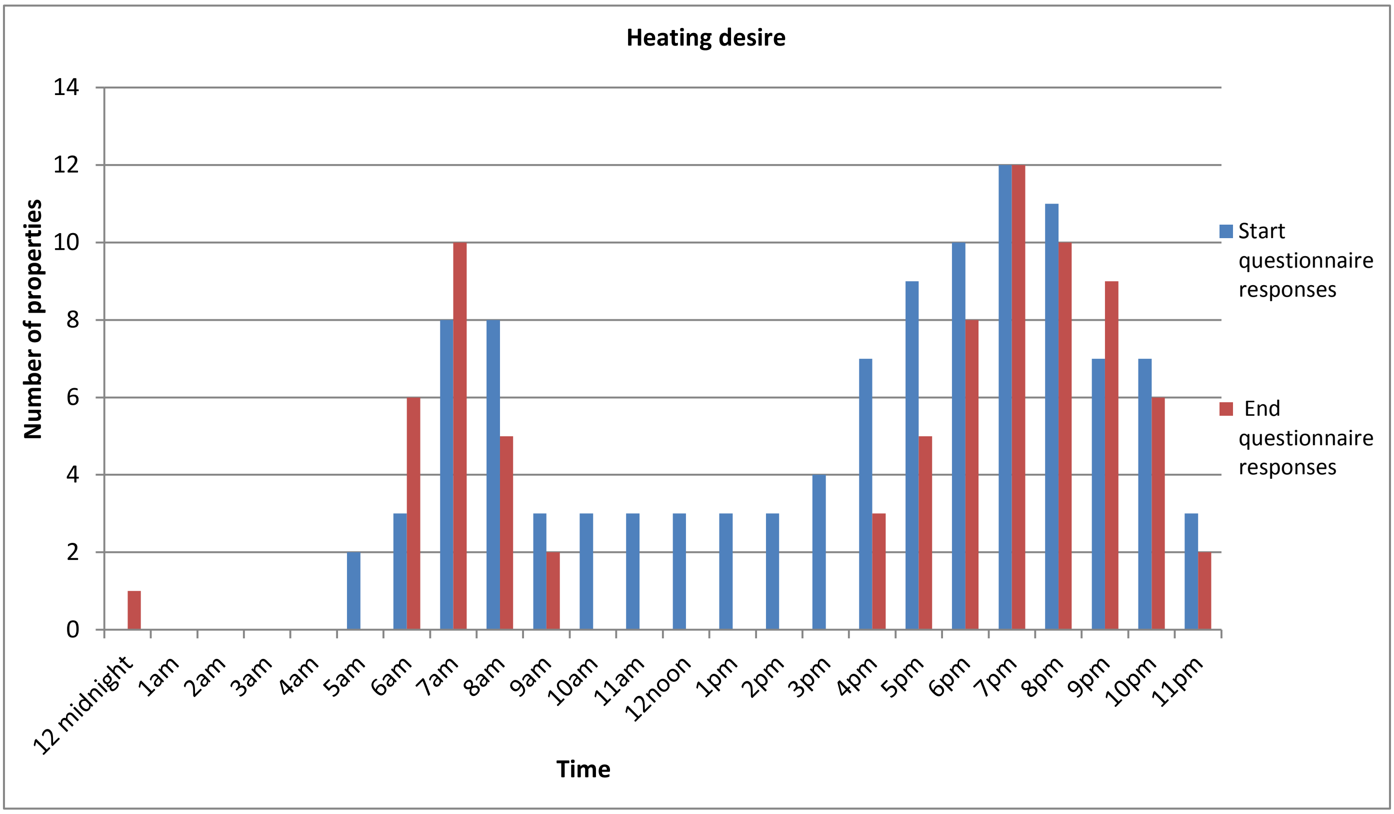



Figure 3.8 Times when it was important for the residents to have a warm home.

Residents were asked when it was important to have a warm home and responses varied between each individual with some reporting intervals as long as 15 hours per day, and others reporting intervals as short as just 1 hour per day. The period of 5-9pm was seen as the most desired time for heating the home and was used as the “evening heated period” in our analyses of thermal comfort.

It is clear from Figure 3.8 that there was also a desire for higher heating levels during the morning period between 6am-8am. Between 8am and 4pm this decreased significantly, possibly because a high proportion of the monitored households were in full or part time employment (67%).

### 3.3 Qualitative feedback given post-installation

As previously shown in Figure 3.6 46% of the residents noted concerns about their building, which had an impact on the comfort and heating of the home. By the end of the monitoring period only 18% of the properties still required any repairs. It is not clear whether the improvements were a result of the installation of the measures or other repair woks had been undertaken. There were no changes in occupancy levels during the monitoring period, but one household reported a change in occupation and another reported a change in health conditions.

After the monitoring period, 86% of the residents felt that they had seen a reduction in their energy bills as a result of the measures installed and 71% said their homes felt more comfortable as a result of the measures.

### 3.4 Resident acceptance and satisfaction

Residents were asked to rate their satisfaction with their heating systems using the following responses: ‘very dissatisfied’, ‘dissatisfied’, ‘neither’, ‘satisfied’ or ‘very satisfied’. Each response was assigned a score between 0 and 100. An average (mean) score between 0 and 100 was then calculated was then calculated across the sample.

Figure 3.9 below shows the results of the households’ receiving only HTTC insulation perceived comforts and benefits before and after it was installed.

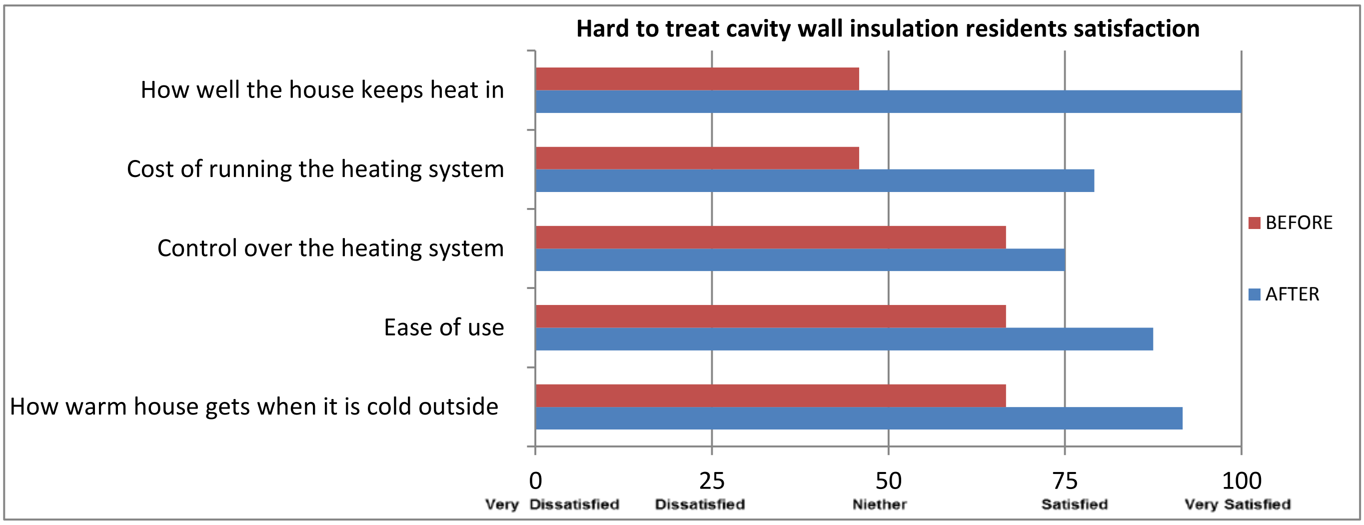



Figure 3.9 Residents with only HTTC satisfaction

There is a significant improvement in satisfaction with how well homes kept heat in, and good improvement on the cost of running the heating systems. This result is to be expected as HTTC insulation is designed to keep more heat within the property which is likely to mean residents will need to use less heating to warm their homes[6].

Satisfaction has increased across all questions asked. The reasoning for the improvement on the ease of use in this particular measure is unclear as there was no change to the heating system. However, it may have been a result of energy saving advice from NEA advisors.

[6] Which. Cavity Wall insulation. Accessed June 2017. http://www.which.co.uk/reviews/insulation/article/cavity-wall-insulation/cavity-wall-insulation-costs-and-savings

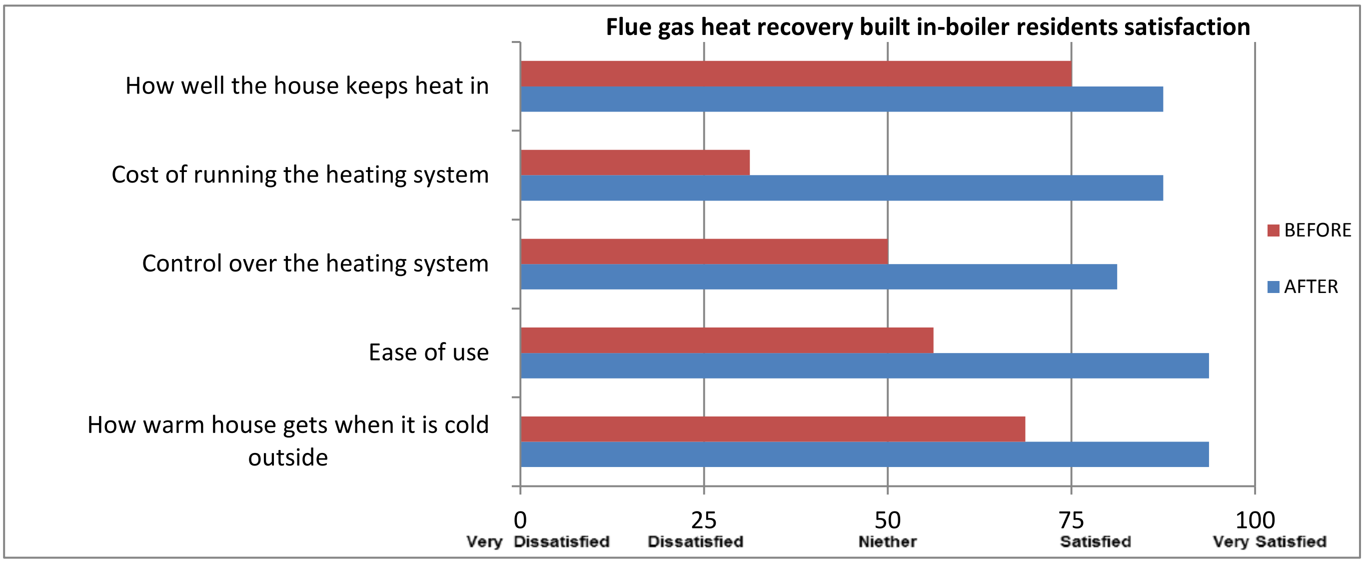



Figure 3.10 Residents with only FGHR boiler satisfaction with their heating system.

Figure 3.10 shows the results of the households' receiving only the boiler/FGHR and controls and their perceived comforts and benefits before and after the new heating system was installed. The clearest increase in satisfaction is in the cost of running the heating system. The nature of FGHR integrated system is essentially to increase the efficiency of the boiler by recycling the heat from waste flue gases, which is normally lost as a result of boiler gas combustion[7].

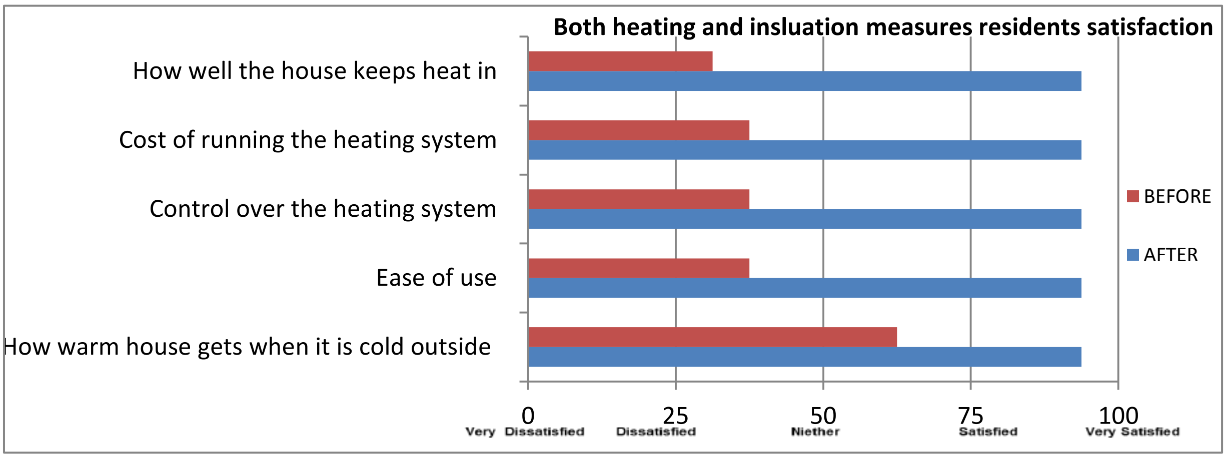



Figure 3.11 Residents satisfaction with both HTTC and FGHR measures installed

Figure 3.11 shows significant improvements in all areas of satisfaction. The combination of the measures complement each other by the FGHR increasing the efficiency of the heating system whilst the HTTC insulation increases the homes ability to keep heat in the home and increase the efficiency of the actual home as well[8].

[7] The Green Age. Flue gas heat recovery systems. Accessed June 2017. https://www.thegreenage.co.uk/tech/flue-gas-heat-recovery-systems/

[8] Energy Saving Trust. Home Insulation, 2017. Accessed June 2017. http://www.energysavingtrust.org.uk/home-insulation

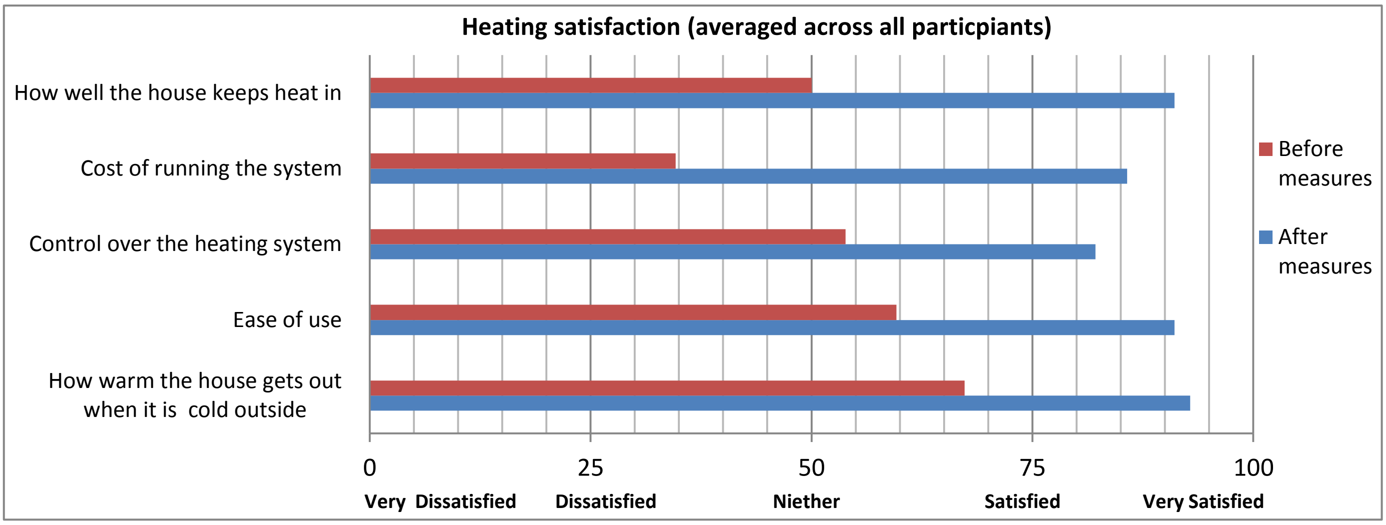


Figure 3.12 Overall residents' satisfaction with their heating system.

Figure 3.12 shows a clear positive difference in satisfaction across all residents since the measures were installed, particularly the cost of running the heating system and how well the home kept heat in.

### 3.5 Perceived cost

The measures installed will have the biggest impact on gas bills as all of the properties heating systems were, and are, gas powered.

As shown in Figure 3.12 above, on average, regardless of which technology was installed, residents felt the measures had a positive impact on their energy bills. 86% of residents said they felt they had cheaper energy bills as a result of the measures, however 14% said they felt their bills had not changed. None said their energy bills had increased as a result of the installed measures (See Figure 3.13(a) below).

In a breakdown of the different measures:

- 83% of the residents with HTTC insulation said they felt they had saved money.
- 100% of those with FGHR measures said they felt they had saved money (although 1 resident did not answer this question).
- 75% of residents with both measures said they had seen a saving on their energy bills – which is the most surprising result as we would have expected all of these residents to have seen savings.

As shown in Figure 3.13(b) below, 92% of participants felt they had more control over their energy bills as a result of the FGHR measures, the controls (TRVs and programmable thermostat) and energy advice received.

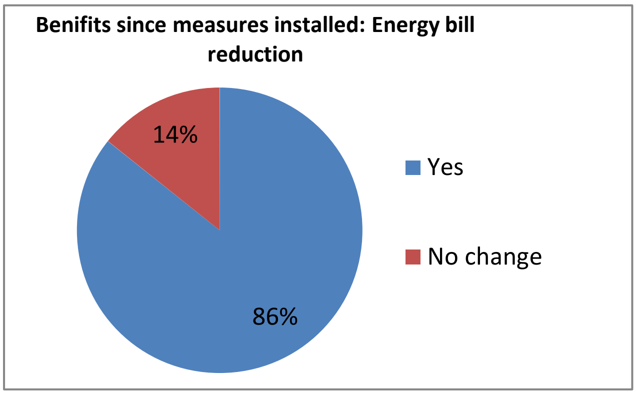



Figure 3.13 (a) Resident response on energy bill benefits of the measures.

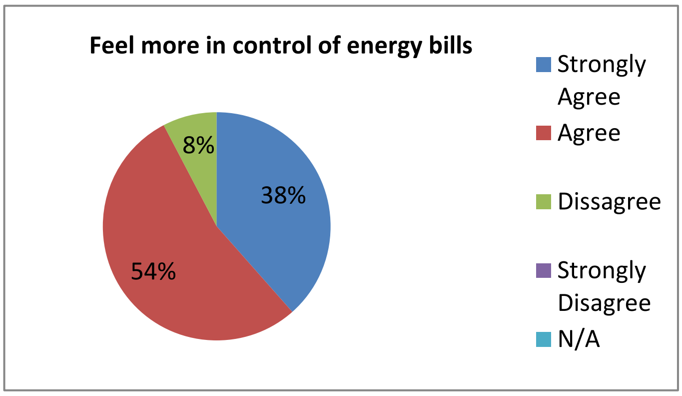



Figure 3.13 (b) Residents response to how they felt about the control they have on their energy bills after the measures had been installed.

## 3.6 Perceived comfort and benefits

Residents were asked if their homes were warmer and more comfortable as a result of the measure installed. 71% (Figure 3.14(a)) said they felt warmer and more comfortable, and 78% of residents (Figure 3.14(b)) felt the measures had helped to ease their money worries somewhat.

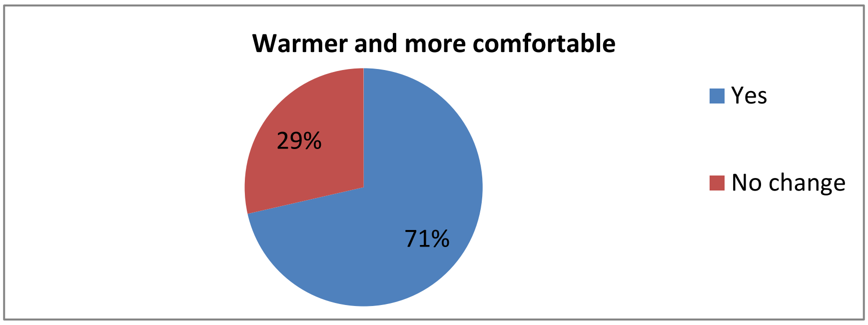



Figure 3.14(a) Perceived comforts of residents after measures installation.

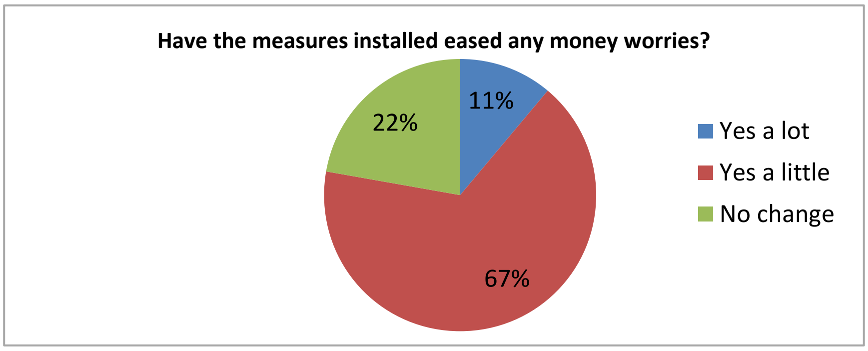



Figure 3.14(b). All residents' responses on how the measure impacted money worries.

A large proportion (69%) of residents that felt they had reduced the need for supplementary heating in their homes since the project began. As well as the measures installed, it was shown in responses from residents that NEA's input had certainly been a factor in increasing energy saving awareness (Figure 3.14 (c) below).

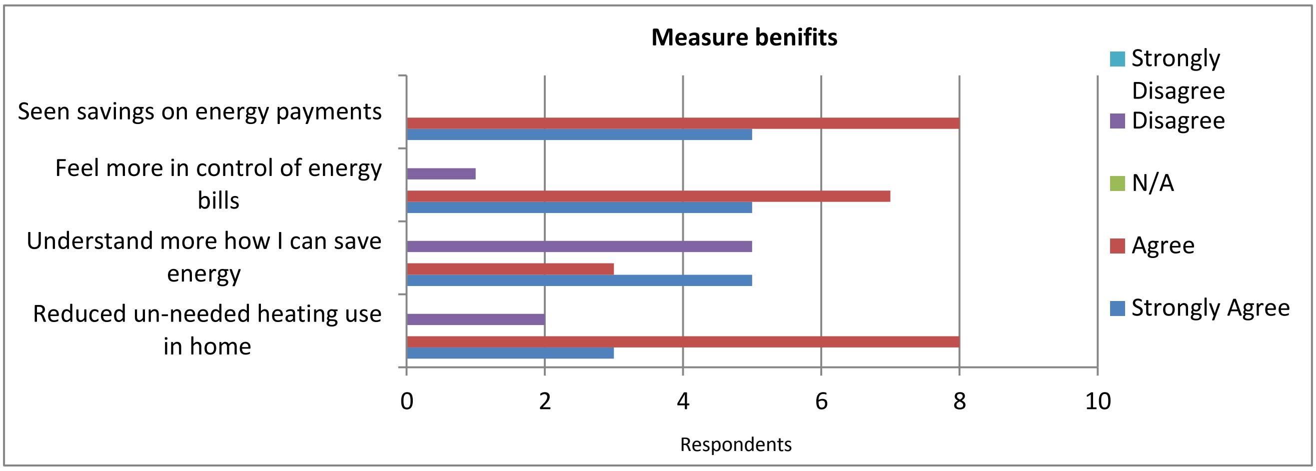



Figure 3.14(c). All residents' responses to statements about some of the benefits of the measures installed.

# 4. Technical evaluation

## 4.1 Cost analysis using meter readings and energy bills

Gas and electricity meter readings were recorded by households during the monitoring period and used to work out the energy consumption data.

As a result of some missing or incomplete data, not all properties could be included in this part of the evaluation. Comparisons made are between the control group and the properties which supplied adequate post-installation figures. It must be noted that 80% of the control group were either, full time carers, full time parents, or unemployed, which differs from the monitored group where 60% of the residents were in full time work.

Because of the types of measures installed in this trial and the fact that all properties have gas central heating, the intention was to gauge the impact of the installed technologies on heating as opposed to other household appliance use. Therefore the electricity data is less relevant. However, it is worth mentioning that the residents that had received measures made noticeable savings on their electricity bills in comparison to the residents in the control group.

Estimated average electricity bill saving of:

- 23.57% across all residents in comparison to residents in the control group.
- 26.87% with the FGHR boiler in comparison to residents the control group.
- 21.17% with HTTC insulation in comparison to residents in the control group.
- 44.72% with both measures in comparison to the residents in the control group.

A theoretical price of 16p per KWh for a standard tariff was used to calculate the electricity costs (as used across other NEA projects).

For gas, a theoretical price of 5p per KWh was used for all cost calculations. This may be slightly higher than current rates but aims to take into account standing charges, and the proportion of householders likely to be using prepayment meters or on standard tariffs. In most cases, the first meter reading available was within one month of installation. This meant that the key period of analysis and comparison of both the monitored residents and the control group was the winter period November 2016 - February 2017.

To properly analyse energy use for indoor space heating, account must be taken of the weather. An external temperature of 15.5°C is accepted by energy professionals as the outside temperature below which indoor heating will be required. When the outdoor temperature is above 15.5°C then no indoor heating is deemed necessary.

Degree days (DD) represent the heating requirement i.e. the number of degrees below 15.5°C that the average temperature is on each day during a given period. For example, when the average outside temperature drops to 14.5°C, this is classed as 1 DD and if the average outside temperature drops to 13.5°C in one day, that is classed as 2 DD and so on. Degree days are added together for the given period of time to give the total number of degree days for that period.

Different periods can then be compared to view energy consumption and the results used to predict energy consumption are on a normalised basis taking into account the outside temperature for those different periods[9]. Degree day data was obtained from the weather station at Manchester Airport (2.27W, 53.35N) EGCC. This is close to the Greater Manchester area where the properties are located, and has produced good quality data for many years. Twenty year average degree day values were available.

| 20 year average degree-day comparison of savings | | | | | | | | Region | Greater Manchester | | | 20 year average | | | 2,224 | Overview |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONTROLS | "Before" period | | | | | | | MAINS | "After" period | | | | | | | Comparison |
| Tech Ref | Period | Days | Total Period (kWh) | Cost per 30 days | Degree days | kWh per Degree Day | Estimated annual cost# | Tech Ref | Period | Days | Total Period (kWh) | Cost per 30 days | Degree days | kWh per Degree Day | Estimated annual cost# | Estimated Comparison/ Saving# |
| T-33 | 22/9/16 to 31/3/17 | 190 | 17,470.5 | £137.93 | 1,554.70 | 11.237 | £1,249.36 | T-12 | 25/5/16 to 9/5/17 | 349 | 12,701.8 | £54.59 | 1,932.10 | 6.574 | £730.91 | |
| T-14 | 15/7/15 to 8/12/16 | 512 | 13,397.4 | £39.25 | 2,668.10 | 5.021 | £558.27 | T-17 | 27/5/16 to 9/5/17 | 347 | 10,435.2 | £45.11 | 1,920.60 | 5.433 | £604.07 | |
| T-06 | 12/9/16 to 10/5/17 | 240 | 10,542.5 | £65.89 | 1,811.40 | 5.820 | £647.08 | T-08 | 12/7/16 to 1/2/17 | 173 | 2,371.4 | £20.56 | 807.30 | 2.937 | £326.59 | |
| T-20 | 23/8/15 to 27/2/16 | 184 | 5,271.2 | £42.97 | 1,188.80 | 4.434 | £492.98 | T-20 | 8/6/16 to 28/3/17 | 211 | 4,540.8 | £32.28 | 1,564.30 | 2.903 | £322.73 | 34.54% |
| | | | | | | | | T-26 | 25/5/16 to 24/5/17 | 364 | 10,603.5 | £43.70 | 1,979.30 | 5.357 | £595.61 | |
| | | | | | | | | T-07 | 1/6/16 to 9/5/17 | 342 | 11,916.3 | £52.26 | 1,909.00 | 6.242 | £694.01 | |
| | | | | | | | | T-02 | 22/5/16 to 24/5/17 | 367 | 8,718.4 | £35.63 | 1,990.90 | 4.379 | £486.87 | |
| | | | | | | | | T-37 | 27/5/16 to 24/5/17 | 362 | 16,287.0 | £67.49 | 1,967.80 | 8.277 | £920.21 | |
| | | | | | | | | T-10 | 25/6/16 to 9/5/17 | 318 | 9,616.1 | £45.36 | 1,879.40 | 5.117 | £568.86 | |
| | | | | | | | | T-29 | 17/11/16 to 10/5/17 | 174 | 8,583.8 | £74.00 | 1,486.50 | 5.774 | £642.01 | |
| | | | | | | | | T-15 | 13/7/16 to 31/5/17 | 322 | 5,195.2 | £24.20 | 1,901.00 | 2.733 | £303.84 | |
| Average | | 282 | 11,670 | 72 | 1,806 | 6.628 | 736.922 | | | 303 | 9,179 | 45 | 1,758 | 5.066 | 563.247 | 23.57% |
| | # 12 month estimated costs based on 20 year degree-day value for the region stated | | | | | | | | | | | | | | | |

Table 4.1(a) Overview results across all residents' analysis of gas costs of the control group and monitored group with measures. T-20 provided detailed data to allow full confidence in the analysis of their usage prior to and after measures were installed.

The primary observation that can be made from Table 4.1(a) is that over one winter period, the annual estimated gas bill of those without the measures (control group) is higher than those with the measures, (£736.922 per annum compared to £563.247 per year average normalised estimated cost) suggesting that the measures have reduced the gas bills, although this group also had potentially longer home heating periods as they were likely to spend more time at home?. This is further supported by the residents' responses on perceived savings shown in Figures 3.13 (a) and (b), and 3.14 (a). The estimated gas bill saving of the monitored group is 23.57% (£173.68) compared to the control group.

[9] Carbon Trust March 2012. Degree Days Accessed June 2017 https://www.carbontrust.com/resources/guides/energy-efficiency/degree-days/

TECHNICAL INNOVATION FUND

## 4.2 FGHR technical evaluation

Table 4.1(b) Properties with **FGHR measures** installed compared with control properties.

| 20 year average degree-day comparison of savings | | | | | | | | Region | Greater Manchester | | | 20 year average | | | 2,224 | FGHR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONTROLS | "Before" period | | | | | | | MAINS | "After" period | | | | | | | Comparison |
| Tech Ref | Period | Days | Total Period (kWh) | Cost per 30 days | Degree days | kWh per Degree Day | Estimated annual cost# | Tech Ref | Period | Days | Total Period (kWh) | Cost per 30 days | Degree days | kWh per Degree Day | Estimated annual cost# | Estimated Comparison/ Saving# |
| T-33 | 22/9/16 to 31/3/17 | 190 | 17,470.5 | £137.93 | 1,554.70 | 11.237 | £1,249.36 | T-12 | 25/5/16 to 9/5/17 | 349 | 12,701.8 | £54.59 | 1,932.10 | 6.574 | £730.91 | |
| T-14 | 15/7/15 to 8/12/16 | 512 | 13,397.4 | £39.25 | 2,668.10 | 5.021 | £558.27 | T-08 | 12/7/16 to 1/1/17 | 173 | 2,371.4 | £20.56 | 807.30 | 2.937 | £326.59 | |
| T-06 | 12/9/16 to 10/5/17 | 240 | 10,542.5 | £65.89 | 1,811.40 | 5.820 | £647.08 | T-07 | 1/6/16 to 9/5/17 | 342 | 11,916.3 | £52.26 | 1,909.00 | 6.242 | £694.01 | |
| | | | | | | | | T-29 | 1/6/16 to 9/5/17 | 174 | 8,583.8 | £74.00 | 1,486.50 | 5.774 | £642.01 | |
| Average | | 314 | 13,803 | 81 | 2,011 | 7.360 | 818.236 | | | 260 | 8,893 | 50 | 1,534 | 5.382 | 598.378 | 26.87% |
| | # 12 month estimated costs based on 20 year degree-day value for the region stated | | | | | | | | | | | | | | | |

Table 4.1(b) shows that the residents with FGHR measures have a slightly lower average consumption than the control group. Those with measures consume between 2.9-6.5 kWh per degree day whilst the control group consumes between 5.0-11.2 kWh per degree day. The average cost per 30 days for the monitored group (£50) is also lower than the control group (£81), potentially attributable to the efficiency of the new boilers with built-in FGHR when compared to the standard combi boilers in the control properties. Overall the estimated annual gas bill saving was 26.87% (£219.86) when compared to the control group. This shows a reduction in energy bills and is reflected in the responses of the monitored residents to the social evaluation shown in Figures 3.10 and 3.11.

### FGHR measures performance graphs

Where there were sufficient meter readings during the winter heating period, it was possible to plot a graph of gas consumption (kWh) against number of degree days i.e. the heating requirement. The performance graphs show how well the residents are controlling the use of their FGHR heating system measure. Ideally this was to be compared against their previous heating system, but is only possible where residents have supplied adequate data.

The graphs use gas consumption (kWh) gained through the supplied meter readings and the degree days to form a gradient of energy use for a given amount of degree days. The line of best fit indicates if residents are using their heating efficiently, i.e. when the outside temperature is below 15.5°C is when heating is required. Good lines of best fit show efficient use or control of the heating system. A poor line of best fit indicates over use (over heating) or under heating, which could be poor efficiency of the property or not heating the property enough.

Figure 4.2(a) shows performance lines of the control group and (b) shows the performance lines of the monitored residents with FGHR measures installed. Graph (a) for property T-14 shows a good line of best fit. The line of best fit shows the relationship between gas consumption and degree days, a better line of best fit would show that heating is being used when required i.e. when the outside temperature falls below 15.5°C. A strong line of best fit would indicate good control over the heating system, although still indicates that the property is still being under heated as shown by the Y value (-185.62), suggesting that the property could be heated more to maintain a comfortable temperature, possibly as result of poor insulation allowing heat to escape. Property T-06 appears to show the best line of best fit from the control group, however the house also appears to be under-heated as shown by the Y value (-129.16). This could be due to poorer efficiency of the property or different heating patterns.

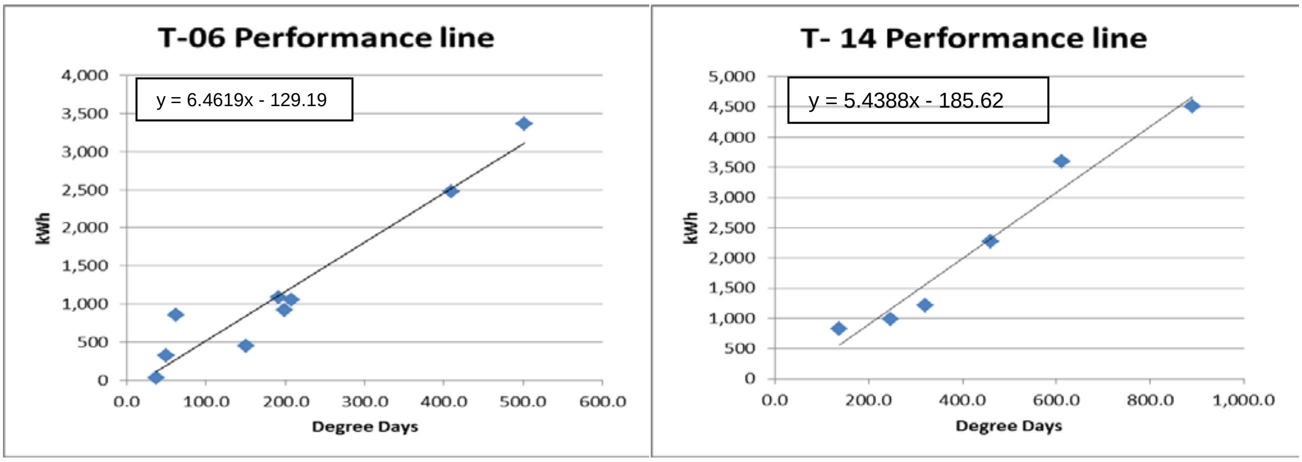



Figure 4.2(a) Control properties performance line indicating how well the residents controlled their heating systems.

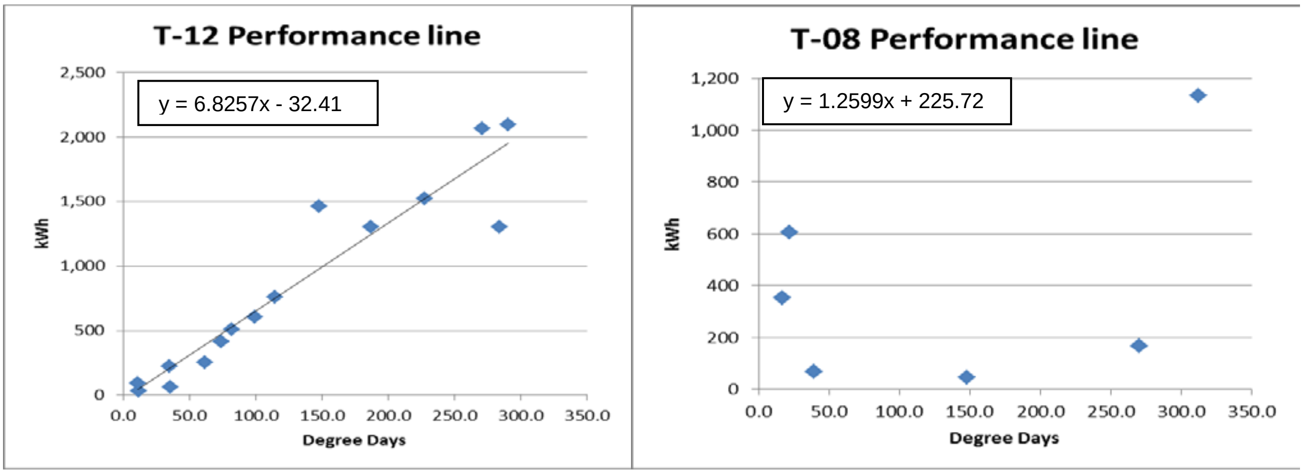



Figure 4.2(b) Main residents with FGHR performance line indicating how well the residents controlled their heating systems.

When looking at the monitored residents with measures, only 2 with FGHR measures installed had provided enough data to analyse performance. Property T-08 shows fairly poor heating control even with the measures installed. The Y value (225.72) shows that property T-08 is generally overheating their property as the ideal Y value would be between 30 and -30. T-12 shows a fantastic line of best fit with a Y value that indicates slight under-heating (-32.41). The social evaluation data at Figure 3.10 also indicates that the FGHR boiler did have a generally positive impact on the heating control for the monitored residents with FGHR measures.

## 4.3 HTTC technical evaluation

| 20 year average degree-day comparison of savings | | | | | | | | Region | Greater Manchester | | | 20 year average | | | 2,224 | HTTC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONTROLS | "Before" period | | | | | | | MAIN | "After" period | | | | | | | Comparison |
| Tech Ref | Period | Days | Total Period (kWh) | Cost per 30 days | Degree days | kWh per Degree Day | Estimated annual cost# | Tech Ref | Period | Days | Total Period (kWh) | Cost per 30 days | Degree days | kWh per Degree Day | Estimated annual cost# | Estimated Comparison/ Saving# |
| T-33 | 22/9/17 to 31/3/17 | 190 | 17,470.5 | £137.93 | 1,554.70 | 11.237 | £1,249.36 | T-17 | 27/5/16 to 9/5/17 | 347 | 10,435.2 | £45.11 | 1,920.60 | 5.433 | £604.07 | |
| T-14 | 15/7/15 to 8/12/16 | 512 | 13,397.4 | £39.25 | 2,668.10 | 5.021 | £558.27 | T-02 | 22/5/16 to 24/5/17 | 367 | 8,718.4 | £35.63 | 1,990.90 | 4.379 | £486.87 | |
| T-06 | 12/9/16 to 10/5/17 | 240 | 10,542.5 | £65.89 | 1,811.40 | 5.820 | £647.08 | T-37 | 27/5/16 to 24/5/17 | 362 | 16,287.0 | £67.49 | 1,967.80 | 8.277 | £920.21 | |
| | | | | | | | | T-10 | 25/6/16 to 9/5/17 | 318 | 9,616.1 | £45.36 | 1,879.40 | 5.117 | £568.86 | |
| Average | | 314 | 13,803 | 81 | 2,011 | 7.360 | 818.236 | | | 349 | 11,264 | 48 | 1,940 | 5.801 | 645.005 | 21.17% |
| | # 12 month estimated costs based on 20 year degree-day value for the region stated | | | | | | | | | | | | | | | |

Table 4.3 Properties with **HTTC measures** installed compared with control properties.

Table 4.3 shows the properties with HTTC insulation have a lower average consumption than the control group. Those with measures were consuming between 5.1-8.2kWh per degree day whereas the control group consumed between 5-11.2kWh per degree day. The households with the insulation fitted had a much lower average cost per 30 days; again summer periods need to be kept in mind here. When looking at the estimated annual costs there is a clear difference of £173 between the control group and the monitored group which is an estimated saving of 21.17% (£173.23) on the gas bill per year in comparison to the control group as a result of the HTTC measure being installed. This indication is reflected in the responses of the residents shown in Figure 3.9.

## 4.4 Dual technical evaluation

| 20 year average degree-day comparison of savings | | | | | | | | Region | Greater Manchester | | | 20 year average | | | 2,224 | DUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONTROLS | "Before" period | | | | | | | MAINS | "After" period | | | | | | | Comparison |
| Tech Ref | Period | Days | Total Period (kWh) | Cost per 30 days | Degree days | kWh per Degree Day | Estimated annual cost# | Tech Ref | Period | Days | Total Period (kWh) | Cost per 30 days | Degree days | kWh per Degree Day | Estimated annual cost# | Estimated Comparison/ Saving# |
| T-33 | 22/9/16 to 31/3/17 | 190 | 17,470.5 | £137.93 | 1,554.70 | 11.237 | £1,249.36 | T-26 | 25/5/16 to 24/5/17 | 364 | 10,603.5 | £43.70 | 1,979.30 | 5.357 | £595.61 | |
| T-14 | 15/7/15 to 8/12/16 | 512 | 13,397.4 | £39.25 | 2,668.10 | 5.021 | £558.27 | T-15 | 13/7/16 to 31/5/17 | 322 | 5,195.2 | £24.20 | 1,901.00 | 2.733 | £303.84 | |
| T-20 | 23/8/15 to 27/2/16 | 184 | 5,271.2 | £42.97 | 1,188.80 | 4.434 | £492.98 | T-20 | 8/6/16 to 28/3/17 | 211 | 4,540.8 | £32.28 | 1,564.30 | 2.903 | £322.73 | 34.54% |
| T-06 | 12/9/16 to 10/5/17 | 240 | 10,542.5 | £65.89 | 1,811.40 | 5.820 | £647.08 | | | | | | | | | |
| Average | | 282 | 11,670 | 72 | 1,806 | 6.628 | 736.922 | | | 299 | 6,780 | 33 | 1,815 | 3.664 | 407.394 | 44.72% |
| | # 12 month estimated costs based on 20 year degree-day value for the region stated | | | | | | | | | | | | | | | |

Table 4.4 Properties with **Dual measures** installed compared with control properties

Table 4.4 shows the properties with both measures (FGHR integrated boiler & HTTC) installed. One property (T-20) gave enough data to compare the pre- and post-installation periods. As can be seen T-20 spent 34.54% (£170.25) less on gas after the measures were installed. There were no changes in circumstances recorded since the project began, so there is no obvious separate factor that has impacted on the bill change. Furthermore, in the pre-installation period there were fewer degree days than in the post-installation period. Property T-20 also made an 18.7% (£68.49) saving on their electricity bill after the measures were installed, which may indicate a decrease in use of any electric powered supplementary heating.

Overall those with both measures have lower average consumption rates than the control group. The monitored group consumed between 2.7-5.3KWh whilst the control group consumed between 4.4-11.2KWh. Again the average cost per 30 days is lower than the control group but summer periods must also be considered. The estimated savings where both measures were installed demonstrated the best results of all 3 of the monitored groups, with an estimated average annual saving of 44.72% (£329.53) on gas bills in comparison to the control group.

## 4.5 Dual measures performance

It is possible to plot a graph of gas consumption (kWh) against number of degree days i.e. predicted heating requirement. Figure 4.5 below, shows the performance lines of the monitored group with both measures installed. Figure 4.6 below shows performance lines of the control group properties (exactly the same as Figure 4.2(a)).

The performance graphs show how well the residents are controlling the use of their FGHR heating system measure. The graphs use gas consumption (kWh) gained through the supplied meter readings and the degree days to form a gradient of energy use for a given amount of degree days. The line of best fit indicates if residents are using their heating efficiently, i.e. when the outside temperature is below 15.5°C is when heating is required. Good lines of best fit show efficient use or control of the heating system. A poor line of best fit indicates over use (over heating) or under heating, which could be poor efficiency of the property or not heating the property enough.

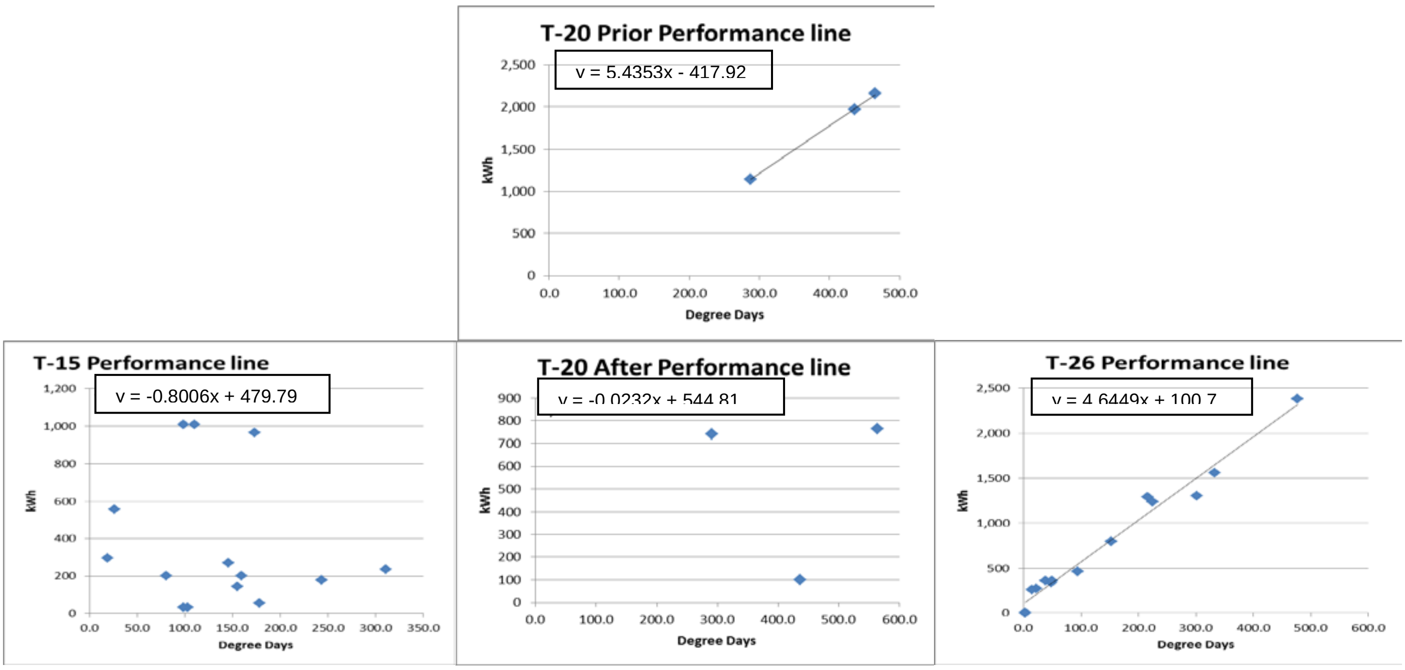
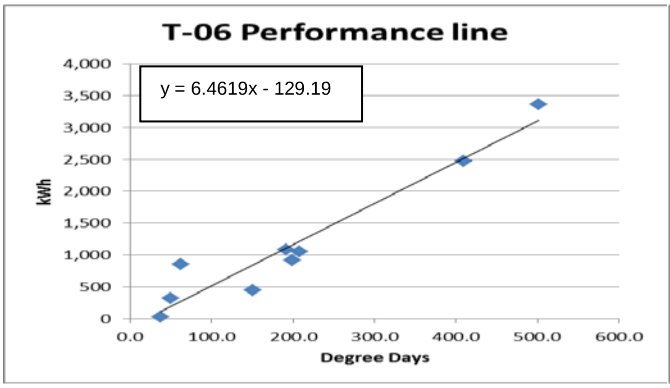



Figure 4.5 Monitored Group properties with both heating and insulation measures - performance line indicating how well the residents controlled their heating systems. Some lines of best fit have been left out because of scattering of results.



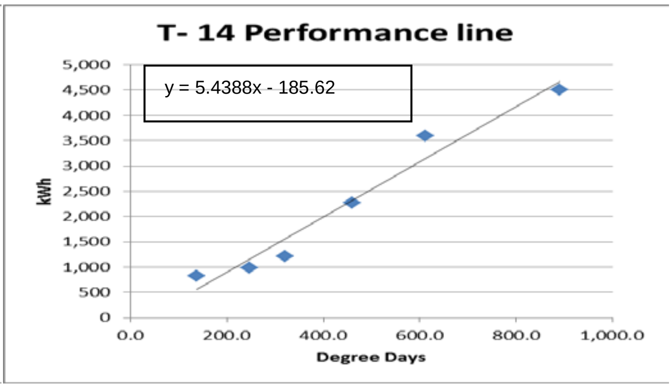




Figure 4.6 Control properties performance line indicating how well the residents controlled their heating systems.

All of the monitored residents in the dual measures group provided adequate data to analyse performance, including T-20 which also provided some pre-installation data.

The Y value (-417.92) shows that T-20 was under-heating to some degree before the measures were installed. Once the measures were installed there is no evidence here that there has been an improvement in control of heating, despite this particular resident saying that they had felt an improvement on their control over the heating system in the second survey questionnaire. The Y value has drastically changed to +544.81 which shows the property has been heated a lot more compared with the prior measures period. This might indicate that the household is heating their property more than needed but this would require further analysis. Property T-15 has a slightly lower Y value indicating they could have a slightly better level of control of the heating system than T-20. Property T-26 shows clear control of the heating system as can be seen in the strong line of best fit, where the other 2 properties results were too scatted to place a line of best fit indicating T-20 and T-15 had poor control over their heating systems. All of the properties have shown to be over heating to some degree – many dramatically so, however as 40% of residents reported health issues it is possible that higher heating levels were preferred or required.in some properties. But because of the scattering of the results it is difficult to define a specific reason.

## 4.6 Temperature and thermal comfort

Temperature and humidity loggers were placed in each of the monitored homes during the study. One was located in the living room and a second was placed in the main bedroom. Loggers were not placed until after the installations had taken place so it is not possible to compare temperature and thermal comfort before and after installations took place. We therefore had to rely on anecdotal feedback from householders about their perceptions of temperature and thermal comfort prior to the measures being installed.

Data from the loggers was analysed for the winter period between 1st November 2016 and 22nd February 2017, comparing the monitored residents' properties and the control group. These were averaged to provide overall winter temperature performance shown in Tables 4.7(a), (b), (c), (d), (e).

| HTTC | 24hr Average °C | 5-9pm Average °C |
|---|---|---|
| T-37 | 20.56 | 21.17 |
| T-02 | 19.59 | 19.90 |
| T-05 | 17.07 | 17.31 |
| T-10 | 18.62 | 18.03 |
| T-24 | 21.30 | 21.63 |
| Maximum | 21.30 | 21.63 |
| Minimum | 17.07 | 17.31 |
| Average | 19.43 | 19.61 |
| Std Dev | 1.66 | 1.90 |

| FGHR | 24hr Average °C | 5-9pm Average °C |
|---|---|---|
| T-07 | 17.53 | 17.91 |
| T-12 | 20.31 | 21.47 |
| T-29 | 21.30 | 21.63 |
| T-36 | 14.18 | 14.28 |
| Maximum | 21.30 | 21.63 |
| Minimum | 14.18 | 14.28 |
| Average | 18.33 | 18.82 |
| Std Dev | 3.19 | 3.48 |

| Dual | 24hr Average °C | 5-9pm Average °C |
|---|---|---|
| T-26 | 18.76 | 20.33 |
| T-16 | 19.39 | 19.70 |
| T-01 | 17.08 | 17.68 |
| T-20 | 18.30 | 18.44 |
| Maximum | 19.39 | 20.33 |
| Minimum | 17.08 | 17.68 |
| Average | 18.38 | 19.04 |
| Std Dev | 0.98 | 1.20 |

Table 4.7 (a), (b) and (c). Average evening living room temperatures of the HTTC residents, FGHR residents and the residents that received both measures. The data is for the winter period of November 2016 - February 2017 using thermal USB-2 logger data.

| HTTC | 24hr Average °C | 5-9pm Average °C |
|---|---|---|
| T-37 | 22.49 | 22.56 |
| T-02 | 17.09 | 17.20 |
| T-05 | 11.68 | 11.56 |
| T-10 | 17.02 | 15.52 |
| Maximum | 22.49 | 22.56 |
| Minimum | 11.68 | 11.56 |
| Average | 17.07 | 16.71 |
| Std Dev | 4.41 | 4.56 |

| FGHR | 24hr Average °C | 5-9pm Average °C |
|---|---|---|
| T-08 | 19.40 | 19.08 |
| T-07 | 19.72 | 19.84 |
| T-12 | 19.75 | 20.15 |
| T-29 | 15.97 | 15.81 |
| T-36 | 14.33 | 14.48 |
| Maximum | 19.75 | 20.15 |
| Minimum | 14.33 | 14.48 |
| Average | 17.83 | 17.87 |
| Std Dev | 2.52 | 2.56 |

| Dual | 24hr Average °C | 5-9pm Average °C |
|---|---|---|
| T-26 | 17.65 | 18.57 |
| T-16 | 18.27 | 17.88 |
| T-20 | 16.67 | 16.91 |
| T-15 | 16.53 | 16.64 |
| Maximum | 18.27 | 18.57 |
| Minimum | 16.53 | 16.64 |
| Average | 17.28 | 17.50 |
| Std Dev | 0.83 | 0.89 |

Table 4.7 (d), (e) and (f). Average bedroom temperatures of the HTTC residents FGHR residents and the residents that received both measures the data is for the winter period of November 2016 - February 2017 using thermal USB-2 logger data.

| Living Room Property | 24hr average °C | 5pm-9pm average °C |
|---|---|---|
| T-03 | 18.22 | 18.58 |
| T21 | 17.39 | 18.88 |
| T-28 | 16.90 | 17.42 |
| T-06 | 18.26 | 17.97 |
| T-14 | 16.21 | 18.90 |
| Maximum | 18.26 | 18.88 |
| Minimum | 16.21 | 16.90 |
| Average | 17.40 | 17.95 |
| Std Dev | 0.88 | 0.81 |

| Bedroom Property | 24hr average °C | 5pm-9pm average °C |
|---|---|---|
| T21 | 20.33 | 21.72 |
| T-03 | 19.62 | 19.72 |
| T-28 | 16.90 | 17.42 |
| T-14 | 16.29 | 17.00 |
| Maximum | 20.33 | 21.72 |
| Minimum | 16.29 | 17.00 |
| Average | 18.29 | 18.97 |
| Std Dev | 1.99 | 2.19 |

Table 4.7(g) and (h) Average Living Room and Bedroom temperature of control group properties.

Note: The date range for the above figures in the control group properties is 1st February 2017 to 22nd February 2017. A problem was identified during January 2017 where the temperature loggers in these properties had been placed on the radiator and not away from any direct heat. This was rectified at the end of January and loggers placed where they would record room temperature and humidly only.

Recorded living room temperatures varied greatly as seen in Table 4.7 (a), (b), (c) which could indicate preferences and or lack of adequate control. All of these properties have one or two rooms in the house which they do not heat. Additionally, property T-16 reported repair issues of concern and it is not clear whether these were addressed or were still impacting on the heating of that home.

The living room temperature of property T-36 (Table 4.7 (b)) was lowest, with the resident reporting that they only use the heating system for an hour in the morning and two hours the evening (6pm-8pm) during winter. The average temperature over 24 hours was 18.8°C overall and 19.2°C during the period highlighted by participants as being important to be warm (5-9pm).

The control group living room temperatures (Table 4.7 (g) were in the range 16.9 to 18.58°C during the 4hour evening period, an average of 17.95°C. The 24 hour period was very similar at 17.4°C. On average bedroom temperatures in the control group properties was approximately 1°C higher at 18.97°C during the 4hour evening period and 18.29°C during the 24hour period.

Overall, residents with the HTTC measures had the highest average living room temperature after the measures were installed and FGHR had the lowest. Property T-33 had to be discounted from the analysis as the logger had been incorrectly located for a prolonged period of time. Property T-14 (Table 4.7 (d)) was recorded as having a good level of insulation. It also has a higher average temperature. T-05 (Table 4.7 (e)) had the lowest heating levels recorded and this resident reported setting the temperature below an average of 15.5°C across the whole house. As expected the bedrooms temperatures are on average lower than the living room average. Additionally, properties T10, T-02 (Table 4.7 (e)), T-16 and T-15 (Table 4.7 (g)) all said that they do not heat spare bedroom/s within their properties. Overall, residents with FGHR measures had the highest average bedroom temperature and those with HTTC had the lowest after the measures were installed; which is a contrast to the living room averages. This difference may be down to bedroom heating preferences or the lack of TRVs being used to control room temperatures more effectively.

The living rooms in control group properties were slightly cooler (1°C – 2°C on average) than the monitored properties but the bedroom were slightly warmer on average (approximately 1°C on average)

| Average Temperature Nov 2016 - Feb 2017 | | | | |
|---|---|---|---|---|
| Measure | 24hr LR | 5-9pm LR | 24hr BR | 5-9pm BR |
| HTTC | 19.43 | 19.61 | 17.08 | 16.94 |
| FGHR | 18.33 | 18.82 | 17.3 | 17.5 |
| Dual | 18.38 | 19.04 | 17.36 | 17.57 |
| Control * | 17.4 | 17.95 | 18.29 | 18.97 |
| *February 1st 2017 - 22nd February 2017 | | | | |

Table 4.8 Average temperatures during the winter period of the different groups of residents (LR= Living room. BR= Bedroom).

Table 4.8 shows the difference in average temperature between the residents with different measures and the control group. The results are surprising, as it could be thought that those with the HTTC and multiple measures would have recorded higher temperatures due to the insulation making the properties more efficient at holding heat. This could be due to different heating habits (for example T-05 kept their house below 15.5°C across the whole house which will impact the average for the HTTC group). However, this expectation cannot be confirmed due to the fact there is no prior data.

## 4.7 Thermal probe analysis

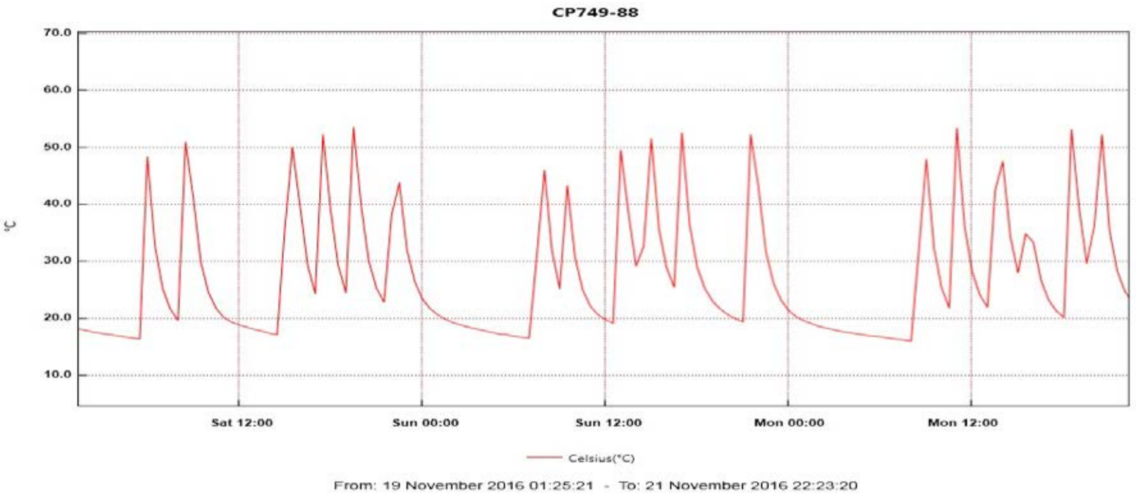



Figure 4.9 (a) Property T-26 (dual measures) living room thermal probe data 19th Nov-21st Nov 2016.

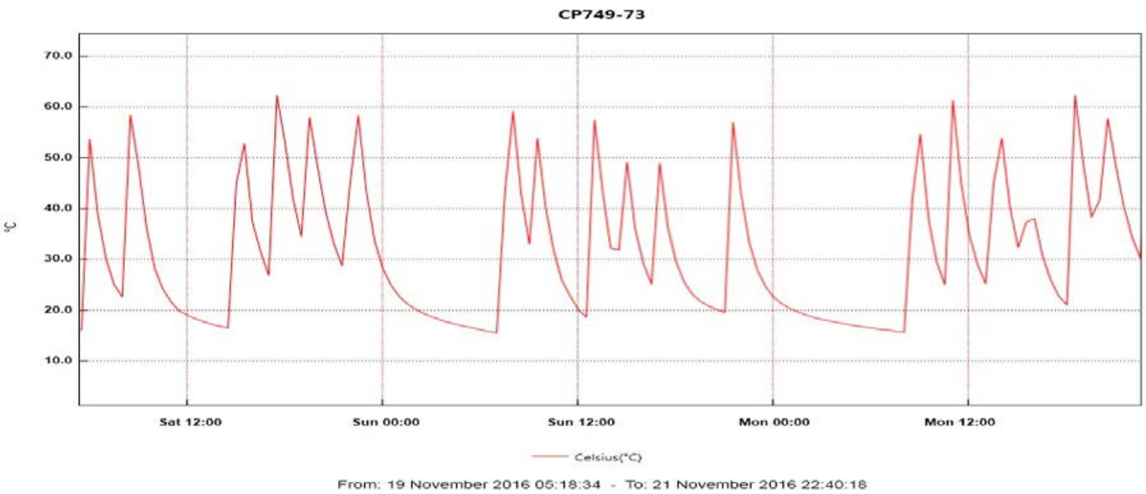



Figure 4.9 (b) Property T-26 (dual measures) bedroom thermal probe data 19th Nov-21st Nov 2016.

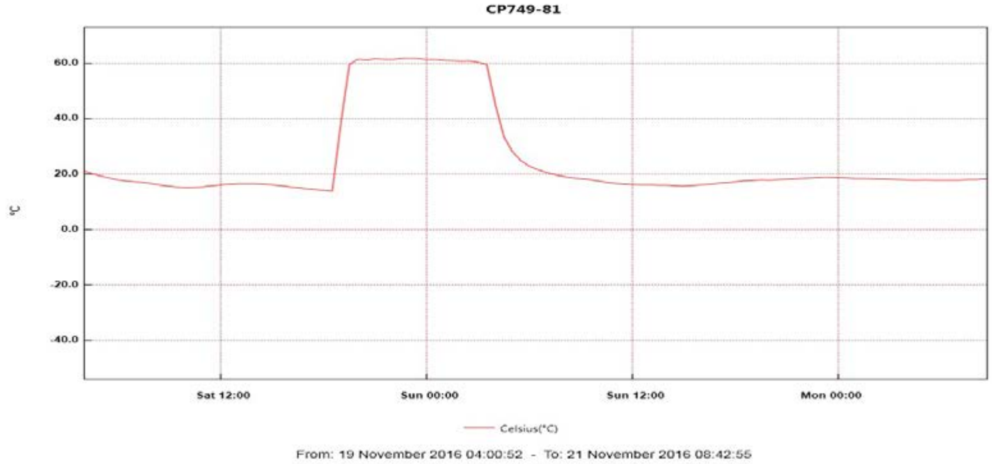



Figure 4.9 (c) Property T-08 (FGHR measures) bedroom thermal probe data 19th Nov- 21st Nov.

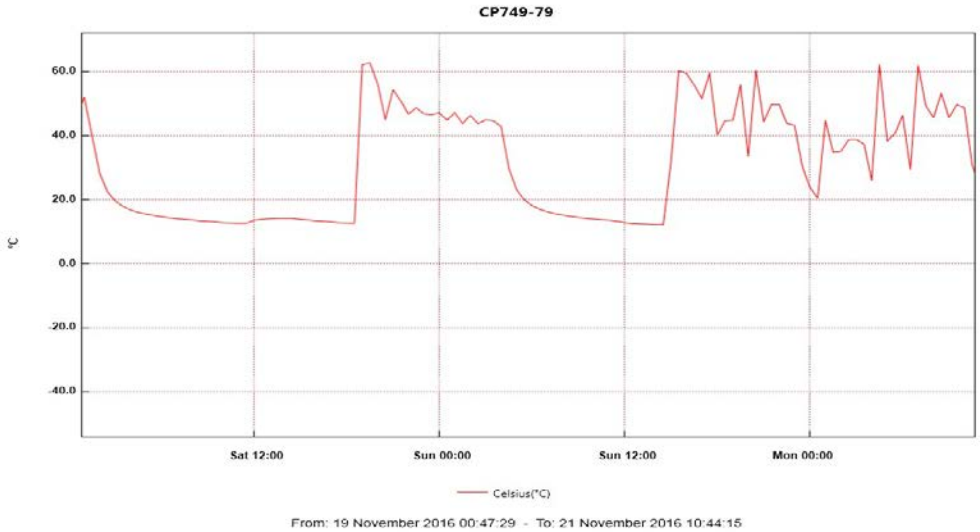



Figure 4.9 (d) Property T-08 (FGHR measures) living room thermal probe data 19th Nov- 21st Nov.

The thermal probes were placed on radiators to collect data on the radiator temperature in order to see if there was evidence of greater control over the heating system. Unfortunately data for some properties had not been recorded fully, possibly because of uncharged batteries and a malfunction/interference on many thermal probes caused by the wire coming lose on the probe which can be a common issue. Therefore, only 2 properties have been used in this analysis where we can see what impact the TRVs and programmable thermostats had on zonal temperature control.

Figures 4.9(b) and (c) shows property T-26 has an element of control over their zonal heating as they have different radiator temperatures in the living room and bedroom, choosing a slightly cooler temperature in the bedroom than in the living room. Referring back to Figure 4.5 T-26 showed a great performance line indicating good control of the heating system overall, whereas this analysis indicates the zonal control of the heating within the property. A potential reason for this could be that T-26 set only slightly different temperatures for the bedroom and living room and only used the boiler when needed which could be represented by the sharp peaks on the Figures 4.9 (b) & (c) graphs. The usage data from the Honeywell programmable wireless thermostats and TRVs would have helped determine this but unfortunately we were unable to obtain this from Honeywell due to connectivity issues to the internet from the properties concerned.

Tables 4.7 (d) and (e) show that property T-08 demonstrated a greater level of control over their zonal heating. This is very visible when comparing between Sunday 12:00 and Mon 00:00 (furthest to the right) in the bedroom and living room. The living room radiator reached 60°C while the bedroom stays around 20°C, this type of control might be one of the reasons this property had the lowest estimated annual cost of all of the properties with both measures (Table 4.7 (b)). In contrast to property T-26, property T-08 is showing a very clear difference in zonal control of the living room and bedroom, but a poor performance line. A potential explanation is that the resident in T-08 had two different heating settings for the living room and bedroom, but used the boiler over longer periods of time on higher temperatures as shown by the consistent lines in the thermal data graphs (Figure 4.9 (d) & (e)) particularly the bedroom graph (Figure 4.9 (d)) between Saturday night and Sunday morning. Again this is only a potential scenario and the usage data from the wireless thermostats and TRVs would help determine this if it becomes available from the manufacturer.

### 4.8 Humidity

Humidity is the percentage of water vapour held by the air compared to the saturation level. Water vapour is generally not usually considered to be an indoor contaminant or a cause of health problems. In fact, some level of humidity is necessary for comfort. On the other hand, the relative humidity (RH) 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 on physiological processes, whereas the indirect effects result from the impact of humidity on pathogenic organisms or chemicals. This may be of concern to some of the control property residents that have shown to exceed the range of normal indoor temperatures (Figure .4.7 (b)).

Figure 4.10 illustrates the optimum humidity levels as cited by Anthony Arundel et al (1986)[10]. The study concludes that maintaining relative humidity levels between 40% and 60% would minimise adverse health effects relating to relative humidity. The indirect health effects of relative humidity may be growing in importance as a result of the continuing construction of energy efficient sealed buildings with low fresh air ventilation rates, but this subject is outside of the scope of this study.

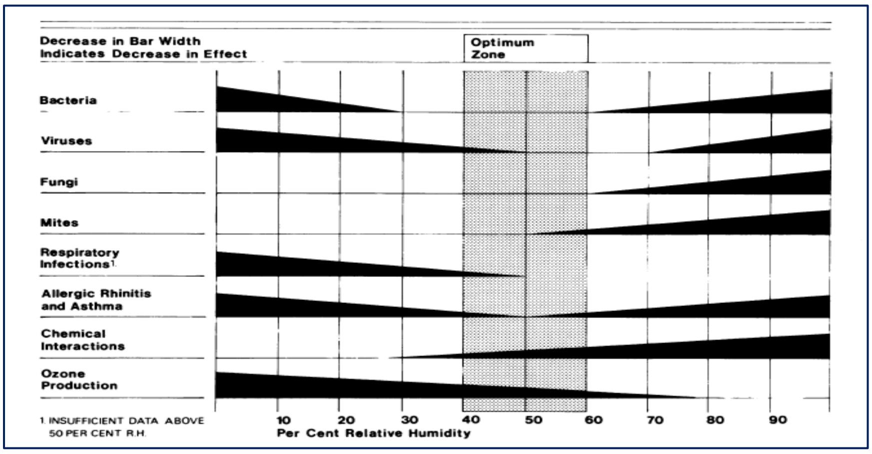



Figure 4.10 Optimum humidity levels to reduce indirect effects from pathogenic organisms or chemicals.

[10] Anthony V. Arundel,* Elia M. Sterling, Judith H. Biggin, and Theodor D. Sterling. March 1986. Indirect Health Effects of Relative Humidity in Indoor Environments. Accessed June 2017. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1474709/

| FGHR Living room | 24hr | 5-9pm | Bedroom | 24hr | 5-9pm |
|---|---|---|---|---|---|
| T-07 | 65.69 | 65.69 | T-07 | 60.60 | 59.92 |
| T-12 | 43.16 | 43.72 | T-12 | 51.68 | 52.40 |
| T-29 | 51.09 | 52.73 | T-29 | 69.98 | 68.92 |
| | | | T-36 | 69.73 | 69.42 |
| | | | T-08 | 45.48 | 45.23 |
| Average | 53.31 | 54.04 | | 59.49 | 59.18 |

Table 4.11 (a) Nov16-Feb17 Humidity data for residents with FGHR measures installed.

| HTTC Living room | 24hr | 5-9pm | Bedroom | 24hr | 5-9pm |
|---|---|---|---|---|---|
| T-37 | 58.82 | 59.25 | T-37 | 57.95 | 58.75 |
| T-02 | 56.00 | 54.22 | T-02 | 40.17 | 40.58 |
| T-05 | 74.80 | 74.91 | T-05 | 69.82 | 72.84 |
| T-10 | 66.06 | 65.58 | T-10 | 57.33 | 57.37 |
| | | | T-24 | 51.09 | 52.73 |
| Average | 63.92 | 63.49 | | 55.27 | 56.45 |

Table 4.11 (b) Nov16-Feb17 Humidity data for residents with HTTC measures installed.

| Dual Living room | 24hr | 5-9pm | Bedroom | 24hr | 5-9pm |
|---|---|---|---|---|---|
| T-26 | 52.35 | 51.25 | T-26 | 60.97 | 60.41 |
| T-16 | 57.84 | 58.53 | T-16 | 69.70 | 69.60 |
| T-01 | 63.04 | 64.44 | T-01 | 63.73 | 62.21 |
| T-20 | 49.51 | 50.40 | T-20 | 59.29 | 59.39 |
| Average | 55.69 | 56.15 | Average | 63.42 | 62.90 |

Table 4.11 (c) Nov16-Feb17 Humidity data for residents with Dual measures installed.

| Controls Living room | 24hr | 5-9pm | Bedroom | 24hr | 5-9pm |
|---|---|---|---|---|---|
| T-03 | 49.72 | 49.14 | T-03 | 50.07 | 48.11 |
| T-21 | 38.95 | 32.49 | T-21 | 37.15 | 30.37 |
| T-28 | 40.73 | 38.24 | T-28 | 40.73 | 38.24 |
| T-14 | 36.64 | 31.21 | T-14 | 44.55 | 38.84 |
| T-06 | 32.08 | 29.79 | | | |
| Average | 39.63 | 36.18 | | 43.12 | 38.89 |

Table 4.11 (d) Nov16-Feb17 Humidity data for control group residents.

| Living room | 24hr Average | 5-9pm | Bedroom | 24hr Average | 5-9pm |
|---|---|---|---|---|---|
| Dual | 55.69 | 56.15 | Dual | 63.42 | 62.90 |
| FGHR | 53.31 | 54.04 | FGHR | 59.49 | 59.18 |
| HTTC | 63.92 | 63.49 | HTTC | 55.27 | 56.45 |
| Controls | 39.63 | 36.18 | Controls | 43.12 | 38.89 |

Table 4.11 (e) Average humidity in the monitored and control properties with readings taken between 1st November – 22nd Febuary 2017.

The loggers were also able to monitor humidity of the properties. Relative humidity (RH) is reliant on temperature and moisture level; the higher the RH the more water moisture is in the air. Cooler temperatures will often mean higher RH because the air has a lower capacity to hold moisture; warmer temperatures increase the capacity to hold moisture. High levels of RH can be damaging to the interior of the property and potentially harmful to health. The Building Regulations part F[11] state that the suggested average monthly maximum humidity levels for domestic dwellings during

[11] Building regulations. 2010. The Building Regulations 2010. Accssesed June 2017. Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/468871/ADF_LOCKED.pdf.

the heating season is 65%. As mentioned above the recommended humidity levels are between 40-60%. As can be seen in Tables 4.7 (a), (b), (c) and (d) the majority of the main properties are within this recommendation after the measures were installed. Before the new heating and insulation a number of the residents complained of dampness, condensation and even mould growth.

However, there are still some properties (e.g. T-05) that exceed the recommended humidity levels which can lead to these problems (in this instance it is likely due to this particular household maintaining a lower internal temperature).

Control group properties on the other hand appear to be mostly below the RH recommendation which can lead to dry skin and risk of colds, flu and other infections[12]. Table 4.11 (e) indicates the overall averages for RH of each type of measure installed. Factors that increase humidity to unwanted levels include; more people in the home at once, cooking, washing or drying clothes in the home with inadequate ventilation. This can lead to mould and trigger allergies as humidity can have a direct and indirect effect on the population growth and survival of infectious or allergenic organisms such as fungi, protozoans, mites, bacteria and viruses[13]. In the final questionnaire when asked if the residents felt the measures had improved the mould or damp in their properties, two of the monitored residents T-26 (Dual) and T-05 (HTTC) said it had improved the situation, whilst all other resident said there was no change, which might indicate other behaviour issues such as drying clothes indoors.

[12] NHS September 2014. Sick Building syndrome. Accssesed June 2017. http://www.nhs.uk/Conditions/Sick-building-syndrome/Pages/Introduction.aspx

[13] Anthony V. Arundel,* Elia M. Sterling, Judith H. Biggin, and Theodor D. Sterling. March 1986. Indirect Health Effects of Relative Humidity in Indoor Environments. Accessed June 2017. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1474709/

# 5. Conclusions and recommendations

## 5.1 Conclusions

The original aims of the project were;

- To provide evidence on the relative effects of each technology functioning on an individual basis in comparison to a whole house retrofit approach in fuel poor homes.

- To apply energy usage data to provide evidence of the most effective combinations of technology in various property types.

- To assess if householders benefit by having more control over their heating systems.

### All measures resulted in energy savings

- 86% of the residents who had measures installed said that they had felt they had saved on their energy bills as a result of the measures. 83% of the residents with HTTC insulation said they felt they had saved money. All of those with FGHR measures said that they had felt they had saved, although 1 resident did not answer this question. 75% of residents with dual measures said they felt a saving on their energy bills, although 1 resident did not answer this question.

- With the meter readings provided, and the 20 year average degree days data from Manchester Airport weather station, it was shown that the dual measures made an estimated annual average 45 % saving, FGHR a 27% saving and HTTC with a 21% saving on their estimated average gas bills in comparison to the control group.

- The only property (T-20) that gave before and after meter readings showed an estimated average annual saving of 34.54% (£170.25) on their gas energy bills and an estimated average annual saving of 18.7% (£68.49) on electricity bills since the dual measures were installed in this property.

### The majority of residents said they were warmer and more comfortable as a result of the project

- 71% of all the residents felt that they were warmer and more comfortable as a result of the measures. The residents with the dual measures showed the most significant change in their satisfaction with their home as a result of the measures (Figure 3.11).

- Although the residents said they felt more comfortable in their homes, there was no recorded improvement on damp or mould as a result of the measures installed.

- The 24hr average living room temperatures during Nov 2016-Feb 2017 winter period for the residents with measures ranged between 18.19 - 19.62°C and during the 5-9pm heating period it raised to 18.6 – 19.89°C. HTTC residents had the highest average living room temperature Nov 2016-Feb 2017. FGHR had the lowest.

- The 24 hr average bedroom temperatures during Nov 2016-Feb 2017 winter period for the residents with measures ranged between 17.08 – 17.36°C and during the 5-9pm heating period lowered slightly to16.94 – 17.57°C. FGHR residents had the highest and HTTC had the lowest.

- On average the residents with FGHR measures were the warmest of the monitored residents, although there was a variation in heating habits of all residents. The control group was noticeably warmer than any of the measures groups. There are several potential reasons for this such as members of the household with health issues impacted by the cold and the majority of the control residents being either full time carers or parents.

- The dual measures combination of heating and insulation improvements appear to have had the biggest impact on energy bill reduction. This had an annual estimated average saving of 44.72% (£329.53) on gas bills in comparison to the control group with combi boiler heating systems during the 2016-2017 winter period.

**There was some evidence of increased control over the heating system and improvements in energy efficiency**

- There was evidence of increased control over the heating system as residents were able to program their thermostats (an example is shown in Figure 3.2(d), (e)). However, as shown in Figure 3.2(b) and (c) residents did not always do this. The extent to which these devices aid control is dependent on the extent to which residents engage with this functionality.

- The measures had a clear positive impact on the residents home efficiency as seen by the before and after SAP ratings, with 62% properties moving up to band C across all properties. After installation 80% of residents with dual measures achieved band C. 67% of HTTC residents achieved band C and 40% of FGHR residents achieved band C.

### 5.2 Impact on fuel poverty energy efficiency targets

The SAP levels of a number of properties were increased due to the installation of these measures. In a number of instances these increased the EPC band of the property up to band C but in other instances there was movement from band E to D ( in line with the 2020 milestone the Government set for England), but in some cases the properties assisted saw just a couple of SAP point improvements. Households were selected as they were in or at risk of fuel poverty and these increased SAP levels and corresponding needed energy expenditure will have reduced the fuel poverty gap.

The FGHR built-in boilers are promoted being more efficient than standard combi boilers[14][15]. The products installed in this project have reduced energy bills for all of the residents who completed the survey questionnaires. It was also shown in Table 4.1(b) that on average residents made an

[14] The Green Age. Flue gas heat recovery systems. Accessed June 2017. https://www.thegreenage.co.uk/tech/flue-gas-heat-recovery-systems/

[15] Ideal. 2017. Logic code combi esp1. Accessed June 2017. **http://idealboilers.com/installer/boilers/combi-boilers/logic-code-combi-esp1/**

estimated 26.8% saving on gas energy bills in comparison to the control group who all had standard combi boilers. The boilers installed in the control group properties are approximately 4-7 years old; boiler efficiency is broadly comparable to the monitored group excluding the effect of the FGHR unit.

The HTTC insulation also appeared to reduce heating bills as the majority of residents said their energy bills had decreased since the measure was installed (two reported bills stayed the same). The reduction in energy bills was supported by data as seen in Table 4.3 which showed an estimated average annual saving of 21.17% (£173.23) in comparison to the control group.

All except one of those receiving both heating and insulation measures (who did not answer the final questionnaire) said that they had felt their energy bills had reduced after the measures were installed. The reduction was supported in the Table 4.4 with an average estimated 44.72% (£329.53) annual saving on the gas bill in comparison to the control groups. Table 4.1 (b) also included the property (T-20) which provided detailed meter reading data for the period prior to the study. Property T-20 made an overall estimated saving of 34.54% (£170.25) on their annual gas bill and an estimated 18.7% (£68.49) on their annual electricity bill after the measures were installed.

## Appendix 1: Glossary of Terms

| | |
|---|---|
| **DD** | Degree Days |
| **EPC** | Energy Performance Certificate |
| **FGHR** | Flue Gas Heat Recovery |
| **FPNES** | Fuel Poor Network Extension Scheme |
| **GCH** | Gas Central Heating |
| **HIP** | Health and Innovation Programme |
| **HTTC** | Hard to-treat cavity wall insulation |
| **NEA** | National Energy Action – the National Fuel Poverty Charity |
| **RH** | Relative Humidity |
| **SAP** | Standard Assessment Procedure (for assessing home energy efficiency) |
| **TIF** | Technical Innovation Fund |
| **TRV** | Thermostatic radiator valve |

## Appendix 2: Case study

Ms H lives in a semi-detached house which had its heating supplied by a back boiler unit that was very expensive to run and in very poor condition. Due to its age and state of disrepair Ms H lived in constant fear that the unit would break down as installers had informed her that many of the parts were obsolete and could no longer be obtained, making a boiler repair impossible and a replacement with a new unit the only option.

Ms H could not afford to run the heating and hot water system during the winter as costs were escalating. During the survey with the Technical Innovation Fund team it was found that Ms H's income was £10 above the pension limit however, the team assured her that she would still be eligible to participate in the scheme.

An Ideal Code 33kw Flue Gas Heat Recovery boiler was installed in Ms H's home and she is now delighted with how quickly her heating comes on, the fact that she no longer has a large hot water tank to heat up and how the controls are so easy to use and are saving her money because there is a timer setting on the new boiler. Ms H's money now goes a lot further because of her decreased gas bills and her quality of life has improved as a result of being included in the scheme.

## Appendix 3 - 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](http://www.nea.org.uk/hip)**