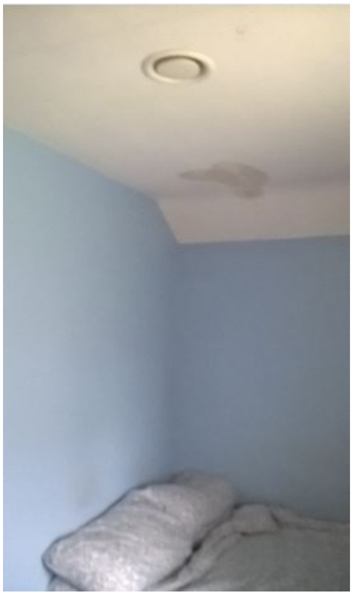
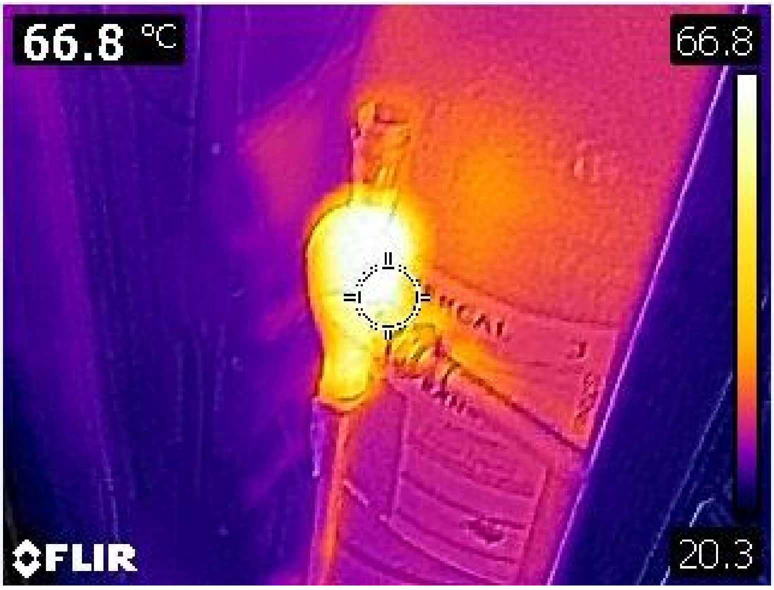
NEA Action for Warm Homes

TECHNICAL INNOVATION FUND

Passive ventilation with heat recovery and Oxypod.
Royal Borough of Greenwich

Technical Evaluation Report





Jamie Barnes, David Crookes and Michael Hamer
September 2017

CP763
Passive Ventilation with Heat Recovery and Oxypod.
Lead Partner: London Borough of Greenwich

Number of households assisted	50
Number of households monitored	7

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.

Acknowledgements

With grateful thanks to our project partners:

Royal Borough of Greenwich

NEA team:

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Executive summary

Project overview

This project was delivered by the Royal Borough of Greenwich. It involved installing a combination of two technologies - the Oxypod device, which removes dissolved gases from water-based central heating systems, reputedly improving efficiency of the system and reducing running costs; and the Ventive S passive ventilation and heat recovery system, which is intended to improve relative humidity levels and human comfort in interior spaces.

The project had the following aims;

- To establish whether households experience a reduction in heating costs as a consequence of installed systems.
- To establish whether Oxypod enables a more efficient gas central heating system.
- To establish whether the Ventive system reduces relative humidity and improves human comfort within dwellings.
- To establish whether Ventive S reduces obvious signs of excess moisture within buildings, such as organic growth or failure of internal decoration due to damp.
- To examine ease of installation, ease of use and resident satisfaction for installed systems.
- To contribute towards a body of evidence that will enable landlords and householders to assess contribution of installed systems to energy efficiency and suitability of systems in older, hard-to-treat housing stock where residents experience fuel poverty.

Context

Around 2.5 million households in England are estimated to be in fuel poverty[1] representing 11% of all English households. The main drivers are the price of energy, the level of household income, the physical quality and energy efficiency characteristics of the dwelling, and the degree of vulnerability of the occupants.

Improving a household's energy efficiency can make a difference to heating costs and thermal comfort, however there are particular challenges in assisting those who live in 'hard-to-treat' properties, such as buildings constructed with solid walls, older and large buildings, households with no boiler or using other (non-mains gas) heating appliances. As well as these properties being difficult and/or expensive to heat, cold indoor temperatures and inadequate ventilation can also cause instances of damp. This in turn can impact human health, damage the fabric of the building and make a dwelling more difficult and costly to heat.

[1] ANNUAL FUEL POVERTY STATISTICS REPORT, 2017 (2015 DATA) Published June 2017 Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/639118/Fuel_Poverty_Statistics_Report_2017_revised_August.pdf [Accessed 25/08/2017]

The technology

Oxypod

According to the manufacturer, Oxypod is a 'de-aerator' which removes air from water and is designed to be installed in water-based central heating (and cooling) systems. In a normal heating system (without Oxypod), air can form into bubbles which can create cold spots in radiators, reduce heat transfer in the boilers heat exchanger, thereby reducing heating performance leading to increased energy usage and higher bills. The manufacturer claims that the system provides "significant savings on your central heating bills and a healthier heating system"[2]. It claims to not only save on heating bills for householders but reduces unscheduled maintenance on heating systems. It may also have a positive environmental impact by reducing CO_2 emissions (from reducing heating fuel use).

Ventive

Ventive S is an innovative system developed by Ventive for trial through this project in the Greenwich Borough Councils housing stock, before being released to market. At the time of evaluation (August 2017), the product was available for purchase[3]. It uses roof-mounted vents and a patented heat exchanger to introduce passive ventilation and heat recovery (PVHR) to a property's interior. This is intended to reduce humidity and consequently improve human comfort and instances of damp. Ventive S uses no electricity to run, recovers the heat energy from outgoing air, and can be integrated into existing chimneys.

The project

The project involved installing Oxypod units and Ventive S systems in 50 properties owned by the Royal Borough of Greenwich. Properties chosen for installation were 3-bedroom semi-detached hard-to-treat properties constructed in the mid-20th century; with residents who had reported fuel poverty, difficulty in paying for energy bills and/or problems with damp. All had gas central heating, and immediately prior to interventions had received external wall insulation.

Installations began in February 2016 and were completed in April 2016. The Oxypod was relatively straightforward to install, while some challenges were encountered with the installation of the Ventive systems which impacted on the performance and subsequent evaluation. Properties selected had generally been subject to piecemeal measures to improve energy efficiency and human comfort. The measures implemented and assessed by this report did not include removal of any previous or historic interventions.

Energy Performance Certificates (EPCs) were obtained for the 7 monitored homes prior to the installation of the measures; these had very variable Reduced Standard Assessment Procedure (RdSAP) ratings of 54-72. It is noted however that EPCs for 2 properties had not identified installation of external wall insulation to properties and had not been updated to reflect that improvement. This will impact the validity of the findings. 1 property was reported to have an EPC

[2] http://www.oxypod.me/benefits [Accessed 25/08/2017]
[3] http://www.ventive.co.uk/wp-content/uploads/Ventive-S-Datasheet-v1.31.pdf [Accessed 23/08/2017]

rating of E, 5 have EPC ratings of D, and 1 of C.

The initial intention was to recruit 12 households to the monitoring group, however this was reduced to 8 households due to difficulties installing the monitoring equipment; and then later to 7 when 1 withdrew due to ill health. Householder feedback was gathered to assess the ease of use, reliability and impact of the technology, and monitoring equipment was installed to record temperature and humidity.

Summary of findings

Energy costs

- Overall, evaluation of data and householder feedback indicates that the majority of monitored households did experience a reduction in energy costs during the trial period, with savings ranging widely from between 1.22% and 23.57%. 1 householder experienced a 19.29% increase in energy costs over the period however there may be a number of factors which led to this including some evidence of under occupancy of the property before the measures were fitted. Oxypod state that significant savings can be made to heating costs after installation of the device, and while the majority of households did experience a saving, none achieved the stated 'up to' figure[4], and there would have been a contribution to these savings from the Ventive system installed at the same time. Ventive S and Oxypod are separate technologies with no adverse impact on one another's operation.

- 12.8% average reduction in gas consumption was observed. This figure compares favourably with another project undertaken with just Oxypod installed, where an average reduction in gas consumption was found to be 7.3%[5]. This indicates Ventive S may have had a further positive contributory impact upon reduction in gas consumption, despite some issues with incorrect installation and operation.

- Heating costs (corrected for differences in the before install and after install weather conditions) varied between a saving of £13.95 and £244, with one household experiencing an increase in heating costs of £89. The average saving amounted to £89.

Damp and humidity

- There were installation problems with the Ventive system which may have impeded proper evaluation of the system. Despite this, improvement was observed by some householders such as a reduction in the presence of mould in bedrooms and absence of condensation on window glass. Others reported no appreciable change since installation of the system. Humidity data is inconclusive with regards to efficacy of Ventive S in improving levels of humidity in properties.

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[5] TIF Project CP770, p. 18….it is important to consider monitored properties of this group may be of a different plan, age, and construction type to those of CP763. Also degree day data will be relevant to the region concerned; all factors that may influence data and findings.

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Thermal comfort and resident satisfaction

- The majority of householders felt their homes were warmer after installation of measures.
- Recorded thermal levels were all within the recommended range for a healthy home.
- There is some, but limited, evidence to suggest heating controllability and performance improved following installation of measures. This is observed in data that shows internal temperatures became more closely correlated with degree days.
- Householder satisfaction with installed systems is mixed. Responses regarding operation of systems are generally neutral (as might be expected with ‘fit and forget’ systems). Some negative feedback was expressed regarding product installation issues and the identification and rectification of faulty systems.

Conclusions and recommendations

With 1 exception, all householders made savings on heating costs; compared to the period prior to installation (the exception was due to other issues and household changes not attributable to the products). Interventions also appear to have caused greater household interaction with their existing heating controls, such as using TRVs and room thermostats.

Most householders were happy with the interventions once installation issues had been overcome and the technology was functioning correctly. Responses regarding perceived comfort after installation were also positive, however it must be considered that all homes within the monitored group had recently received external wall insulation prior to the beginning of the monitoring period and this may have impacted on perceived levels of comfort.

Oxypod was demonstrated to be a relatively simple intervention that does not require installation by a specialist engineer. Once installed it was maintenance free. The Ventive S proved to be most effective when installed by an experienced contractor familiar with the system. The overall benefits of the Ventive system have been difficult to conclusively evaluate due to incorrect and faulty installations which impacted the trial period. A holistic approach to analysis of data and householder feedback indicates there may be significant benefits, however further evaluation is needed to substantiate this. It is recommended that future Ventive systems are installed by a single experienced contractor familiar with the system. This will ensure a housing provider can maintain more rigorous control over a scheme, and issues can be addressed promptly.

It is recommended that where a package of measures such as Oxypod and Ventive S are installed these are accompanied by loft insulation top ups and draught-excluders, fitted to doors and windows where necessary. A whole house support would lead to greater benefits and household satisfaction. It is also important that when any behaviour change is needed to maximise the benefits of the measures installed, the residents are given appropriate advice and support.

1. Project overview

1.1 Introduction

This project was delivered by the Royal Borough of Greenwich. It involved installing 2 technologies in 50 properties. These were the Oxypod device, which removes dissolved gases from water-based central heating systems, reputedly improving efficiency of the system and reducing running costs; and the Ventive S passive ventilation and heat recovery system, which is intended to improve relative humidity (RH) levels and human comfort in interior spaces.

1.2 Aims

The project had the following aims;

- To establish whether households experience a reduction in heating costs as a consequence of installed systems.
- To establish whether Oxypod enables a more efficient gas central heating system.
- To establish whether the Ventive system reduces relative humidity and improves human comfort within dwellings.
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- To contribute towards a body of evidence that will enable landlords and householders to assess contribution of installed systems to energy efficiency and suitability of systems in older, hard-to-treat housing stock where residents experience fuel poverty.

1.3 Context

Around 2.5 million households in England are estimated to be in fuel poverty representing 11% of all English households. The main drivers are the price of energy, the level of household income, the physical quality and energy efficiency characteristics of the dwelling, and the degree of vulnerability of the occupants.

Improving a household's energy efficiency can make a difference to heating costs and thermal comfort, however there are particular challenges in assisting those who live in 'hard-to-treat' properties, such as buildings constructed with solid walls, older and large buildings, households with no boiler or using other (non-mains gas) heating appliances. As well as these properties being difficult and/or expensive to heat, cold indoor temperatures and inadequate ventilation can also cause instances of damp. This in turn can impact human health, damage the fabric of the building and make a dwelling more difficult and costly to heat.

1.4 Project timeline

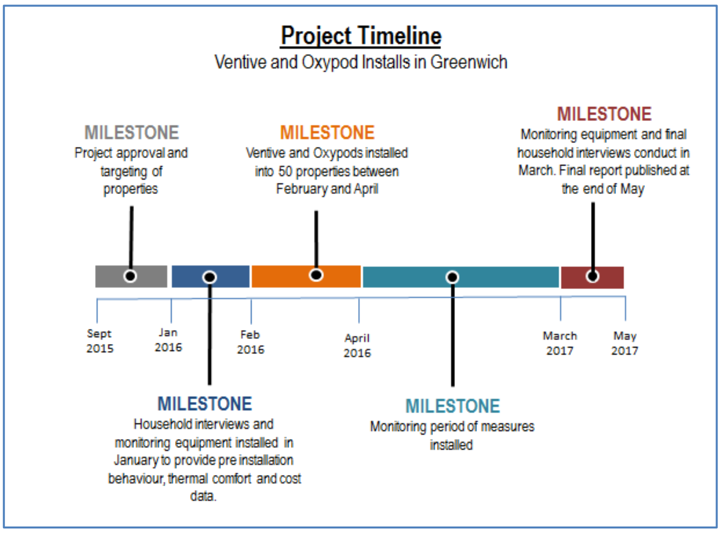

Figure 1.1 Project timeline

The lead partner in the project was Royal Borough of Greenwich which owns a large number of properties within the Borough. At the start of the project Greenwich only had 1 contractor trained in the installation of Ventive, but the council was able to recruit an additional 2 contractors to ensure the project would meet its deadline. An early release of a new product (Ventive S) was installed, installations typically taking 3–5 days. Ventive S is now released as a mainstream product within the evolving Ventive range[6]. The installation of Oxypod was a relatively straightforward process and it was found that it could be added to 5-6 heating systems by a single contractor per day. Installations to 50 properties of both Oxypod and Ventive S began in February 2016 and completed in April 2016.

It was initially proposed that 12 households would be recruited for monitoring purposes although only 8 households were eventually recruited. Of these, 1 resident withdrew from the study due to ill health. This report provides insights from those 7 households.

1.5 Attracting beneficiaries and establishing a monitored group

- As the social landlord, Royal Borough of Greenwich had access to property and tenant data which enabled easy targeting of suitable properties. Using this data, they had identified 50 suitable properties quickly which allowed works to begin as soon as the grant agreement was reached.
- Properties chosen for installations were selected from a hard-to-treat group of mid-20th century construction. Households had reported problems with damp and had been living in fuel poverty. The properties selected were all to have received external wall insulation during the summer of 2014 (subject to their suitability for the trial products).
- Greenwich provided NEA with a list of 12 households for the monitoring purposes and NEA made contact with the residents and had a 100% success rate in signing up residents for the monitoring procedures.

[6] http://www.ventive.co.uk/products/ventive-s/ [Accessed 25/08/2017]

- Monitoring equipment was only suitable for 7 of the 12 properties but these were all installed by the end of May 2016. NEA later visited residents and completed the first part of a simple questionnaire and collected historic meter readings and billing information. The questionnaires were completed at the end of the monitoring period.

1.6 Factors affecting the planned evaluation methodology

Issue	Description and mitigation
Size of monitoring group	The size of monitoring group was originally planned to be 12 households. This was reduced to 8 due to difficulties installing monitoring equipment in some properties prior to installation of measures. This was later reduced to 7 households, 1 withdrawing due to ill health.
Identification of the monitored group and control group	The group of residents was successfully selected and initial visits carried out to distribute temperature data-loggers in February 2016.
Start of monitoring	Monitoring equipment was placed into the properties taking part in the study during February 2016. Oxypod and Ventive S were installed into 7 of the 12 properties between February and April 2016. This left only a limited pre-installation period for the temperature and humidity loggers to record prior to installation.
Monitored group	Recruitment of the monitored group was relatively straightforward. Some within the group remained highly engaged with the process throughout the study and others to a lesser extent but in general data sets and questionnaire responses have allowed NEA to draw out some helpful findings and insights.
System performance	Ventive S involves a more complex and invasive installation process. Incorrect installation has, in some cases, caused the system to operate inefficiently. Consequently, in some cases poor householder satisfaction is experienced. It is unclear to what extent inefficient functioning of a system has impacted data. This report will view data as a whole, in an attempt to draw evidence-based conclusions that may provide an insight into benefits of the system.
Meter readings	It was assumed that all of the monitored households received EWI installations during the summer of 2014. There is some evidence that EWI installations may have spilled over to summer of 2015. Due to the installation company entering receivership, there is no available data to indicate precise installation dates. As a precaution, data has been adjusted to take account of that uncertainty. This will help to ensure validity of data, with regards to installed measures relevant to this report.
Monitoring equipment	Temperature and humidity data was collected from the living room

	and main bedroom. For 2 households comfort levels data was only retrieved from a single room.

2. Technical evaluation

2.1 Introduction

Oxypod and Ventive S were installed into 50 properties owned by Royal Borough of Greenwich. Installations were focused upon older solid wall properties constructed during the mid-20th century.

The monitored properties were allocated a property reference to ensure the anonymity of householders.

Figure 2.1 An example of a property similar to those in the monitored group with Ventive S installed, note external wall insulation.

Property type and External Wall Insulation (EWI) install dates

Figure 2.2 shows all properties subject to monitoring are semi-detached. Evidence shows they are of mid-twentieth century construction and are of a 'system built' form generally considered 'hard-to-treat' in terms of appropriate interventions to improve energy efficiency. It was suggested by Greenwich Borough Council that all properties received external wall insulation during the summer of 2014, however as Table 2.2 identifies, the SAP assessments (conducted October 2014 – June 2017) failed to identify EWI installations applied to 2 properties. Unfortunately the company responsible for installing EWI in monitored properties has gone out of business and it was not possible to determine when the EWI was fitted. Note the floor space size of the properties varied significantly.

Tech Ref	House type	SAP rating	Floor area m2	EPC Space and water heating demand	EWI noted on EPC
T-03	Semi-detached	63	69	12968	Yes
T-04	Semi-detached	66	68	7727	Yes
T-05	Semi-detached	64	70	11523	No
T-09	Semi-detached	64	85	14143	No
T-16	Semi-detached	72	68	8029	Yes
T-20	Semi-detached	56	95	15513	Yes
T-21	Semi-detached	54	73	14387	Yes
Average		62.71	75.43	12041	

Table 2.2 Table showing details of homes included in monitored group

2.2 Technical monitoring

Temperature and humidity was recorded every 30 minutes using a Lascar EL-USB-2 temperature and humidity logger[7]. Temperature and humidity loggers were placed, 1 per room, in the living room and a bedroom.

Following installation of Oxypod, comparable thermal imaging pictures were taken of specific radiators within 3 properties of the monitored group to measure whether an increase in radiator temperature had been achieved.

The energy efficiency or SAP rating ranged between 54 and 72. It is noted that in 2 cases the installation of EWI had not been recognised by the assessor, therefore in those 2 cases ratings may not reflect an accurate reflection of building energy efficiency performance.

Households taking part in the study were asked to regularly record gas and electricity meter readings in a simple log book. Recent and historic meter readings were obtained from energy bills and by contacting their energy supplier. These were used to assess gas consumption before and after installation of measures relevant to this study.

[7] Lascar EL-USB-2 Datasheet https://www.lascarelectronics.com/media/1572/easylog-data-logger_el-usb-2.pdf [Accessed June 2017]

Figure 2.3 Lascar EL USB-2 Data Logger

Property Type	Monitoring Equipment	Number of properties
Monitored	**Thermal Data Logger:** These were used to record temperature and humidity inside the property every hour.	7
Monitored	**Record of gas meter readings** before and after installation of measures relevant to this study.	7

Table 2.4 Summary of monitoring equipment/information

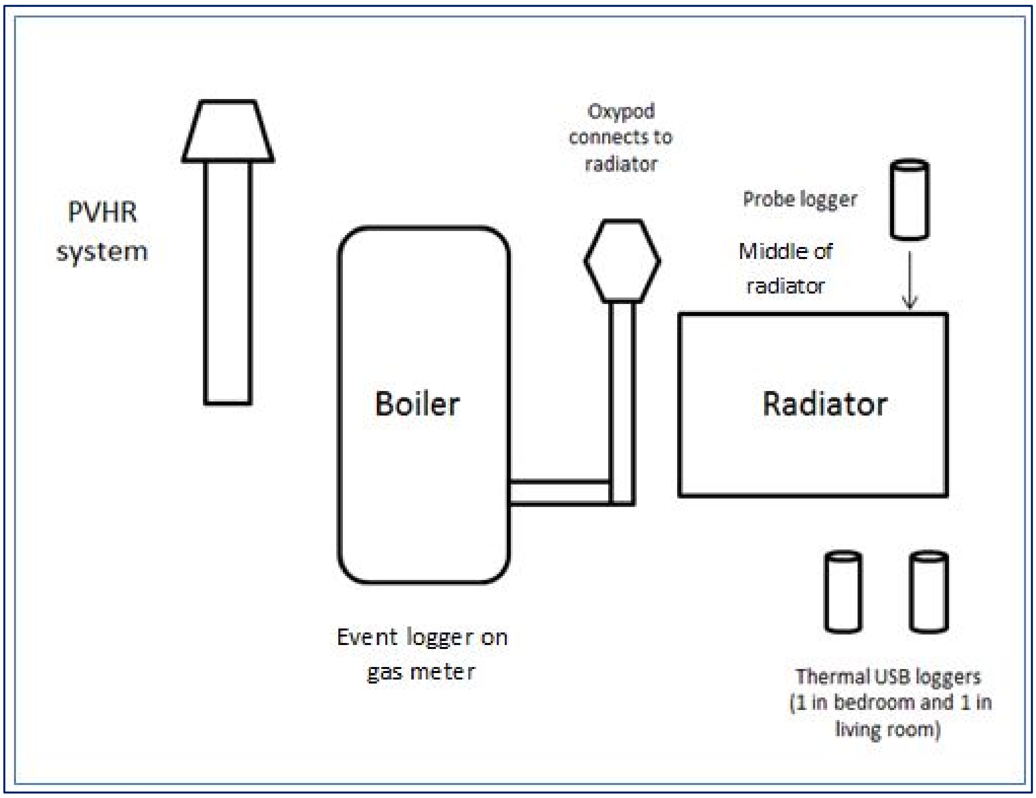

Figure 2.5 Schematic showing installed measures and methods of recording

Measures Installed

Figure 2.6a Oxypod device Figure 2.6b Installed Oxypod

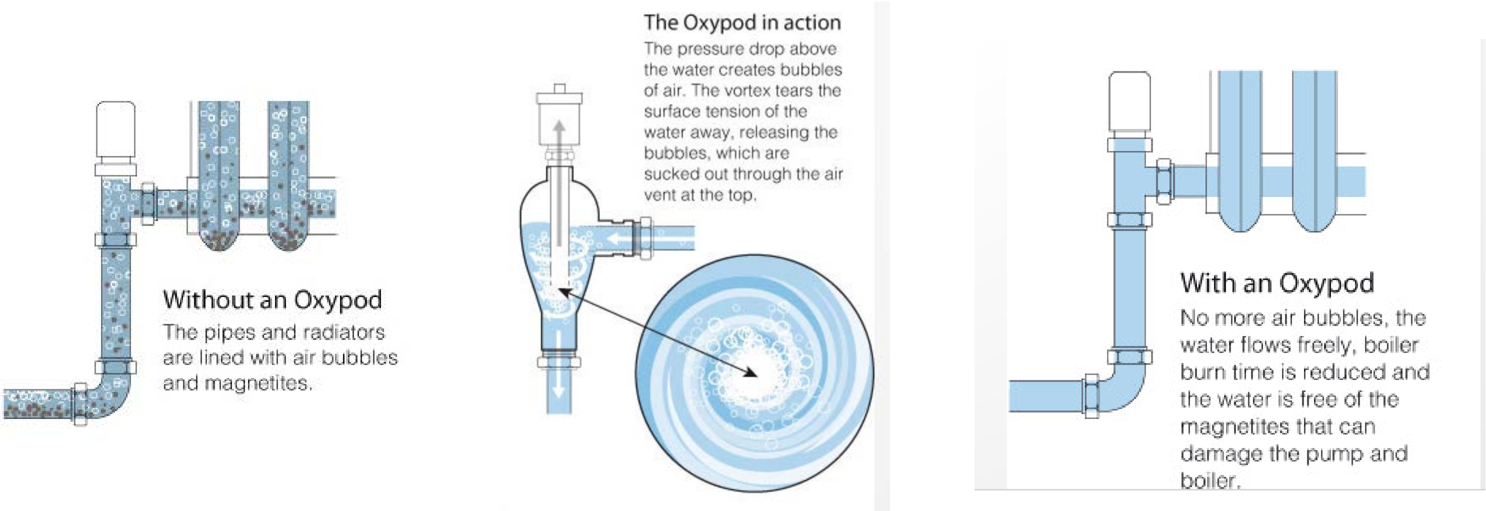

Figure 2.6c: How Oxypod works

According to the manufacturer, Oxypod[8] is a 'de-aerator' which removes air from water and is designed to be installed in water-based central heating (& cooling) systems. The heating system can be a traditional gas/oil boiler, a biomass system, or a ground/air-source heat pump.

Oxypod is egg-shaped and has been designed so that, as water passes through it and begins to spin, it cannot form a vortex because of the shape of the body. The water implodes in on itself, stripping away the surface tension. This helps in the release of dissolved air, see Figure 2.6c[2].

In a normal heating system (without Oxypod) when water passes through the boiler its temperature rises thereby reducing the fluid's capacity to hold dissolved air. This air (mainly nitrogen & oxygen) forms into bubbles which may gather in the top of radiators, in boiler heat exchangers and within pipes and radiators causing a thermal barrier. The air bubbles also increase surface friction, which adversely affects the flow of water running through the pipes and radiators. This can create cold spots in radiators, which then need to be bled using a radiator key (or other method) to allow air to escape. The build-up of air results in impaired heating performance leading to increased energy usage and higher bills, as well as an increase in wear and tear on the boiler and pumps.

Oxypod state that "You can expect significant savings on your central heating bills and a healthier heating system"[9], depending on the system and fuel source. It claims to not only save on heating bills for householders but reduces unscheduled maintenance on heating systems. It may also have a positive environmental impact by reducing CO_2 emissions (from reducing heating fuel use).

Ventive

Ventive S is an innovative system developed by Ventive and trialled by Royal Borough of Greenwich. It uses roof-mounted vents and a patented heat exchanger to introduce passive ventilation and heat recovery (PVHR) to a property interior. This is intended to remove humidity and consequently improve human comfort and reduce instances of damp. Damp within properties can impact human health, the building fabric, and can make a dwelling more difficult and costly to heat.

The installation of Ventive S takes on average 3 to 5 days depending on difficulty and property type. For householders, the majority of work will take place on roofs and within the roof-space, allowing disruption to be kept to a minimum. Once installed the system is cost-free in operation and requires no ongoing input from the householder.

[9] Available from http://www.oxypod.me/benefits [Accessed 11/05/2017]

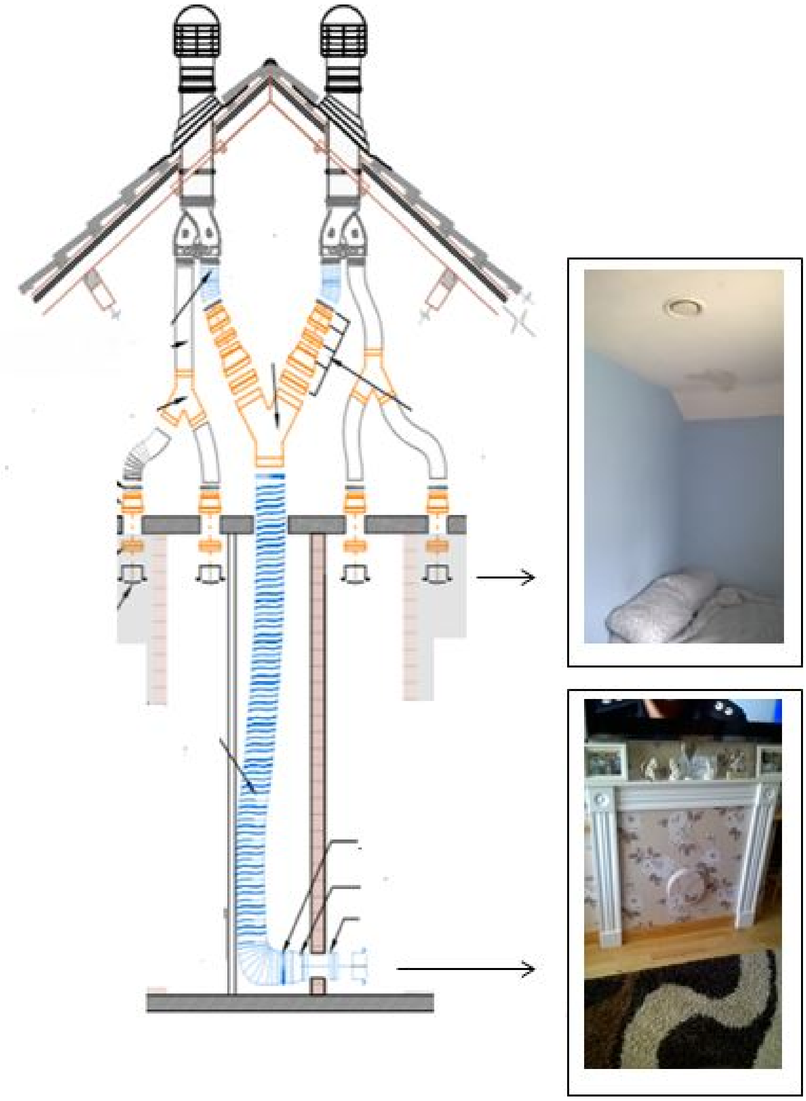

Figure 2.7 Schematic and examples of internal vents

3. Social evaluation and impacts

3.1 Qualitative feedback from initial questionnaire

The age range of householders who were interviewed for the study is shown in Figure 3.1a. The largest proportion, 86% were in the age range 30-59 followed by 14% who were in the age range 60-69. None of the residents were 70 years of age or more at the time of interview.

57% of households had a member who was working part time at the time of interview. 14% of households had a member who was retired; the same percentage applies to households where a member was unemployed. 15% of households had a member who was not working due to ill health. Of the households taking part in the survey, just over a quarter were sole occupation. 43% had 2 residents with 14% respectively for households with 3 and 4 residents. No households taking part in the study had more than four residents.

The majority of households taking part in the study had a member working part time, unemployed, retired, or not working due to ill health. At the time of interview, 29% of households had a member with a health condition, 71% of households had no members with health conditions.

Residents were asked if there was a specific time of day when they felt it was important to have a warm home. This might be when they are least active e.g. sitting watching TV in the evening or when washing/drying first thing in the morning. Figure 3.2 shows the responses aggregated from all respondents.

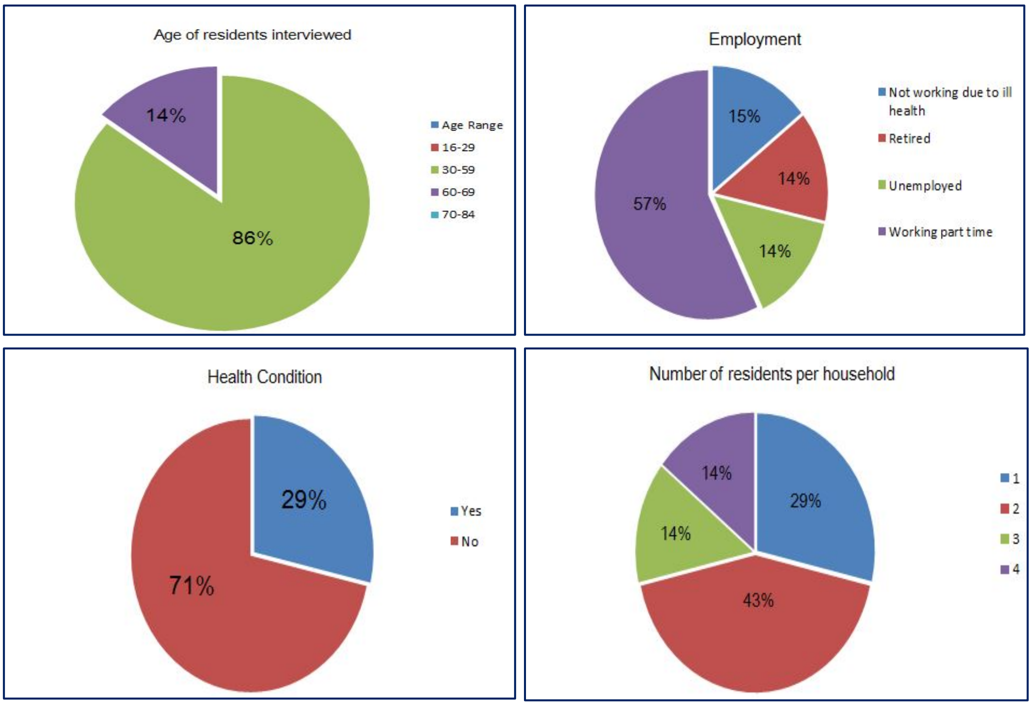

Figure 3.1 (a) Age of residents interviewed (b) Employment (c) Health condition (d) Number of residents per household

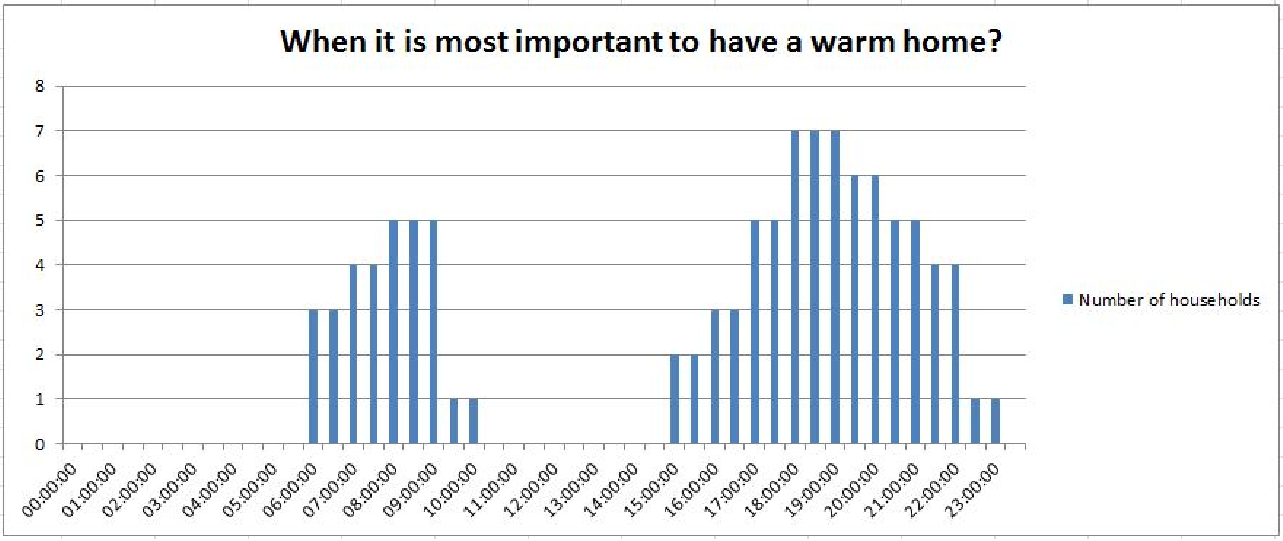

Figure 3.2 Times it is most important for residents to have a warm home

This shows a morning peak in heating requirement between 6am-10am, with none of the residents citing a heating requirement during late morning or early afternoon. Most residents required their homes to be warm in the early evening with the greatest number requiring a warm home between 5pm-10pm. 5 households typically preferred their home at a healthy 18-21°C while a single resident preferred a warmer home of over 21°C.

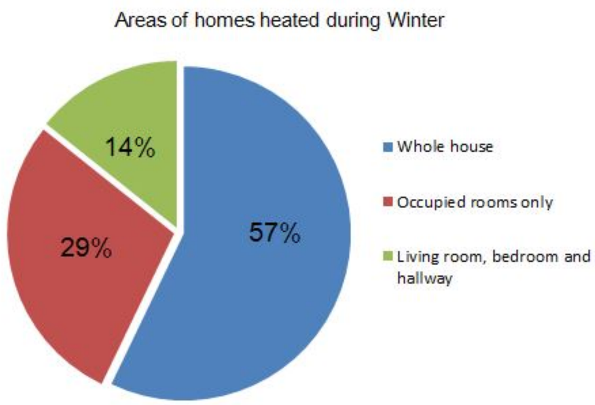

Figure 3.3 Areas of homes heated during winter

Figure 3.3 shows the heating behaviour by residents when heating homes during winter. 57% of residents heated the whole house including any rooms that may have been unoccupied or only occasionally used. 29% heated occupied rooms only with 14% heating only a living room, bedroom and hallway.

2 households had combination boilers and 5 had standard gas boilers. There was no accurate information to determine building construction type; however EPC assessments conducted on the properties do recognise they are probably system built, of unknown materials without a cavity. EPC data shows that 5 households did not have loft insulation installed, 2 households did have loft insulation, but it was not possible for NEA staff to access the lofts to verify the data entered by the domestic energy assessor who conducted the EPC, or check for subsequent loft insulation installation.

All properties had double-glazed windows and reported effective draft excluders fitted to letterboxes. 1 property, T-21 retained a wooden front door at the time of initial survey, which was ‘draughty’ according to the householder. Another householder, T-05 reported a draughty vent in a bedroom. This is probably an inherent issue with original construction and provision for air circulation within the property. Householder T-20 commented that the hallway radiator is too small and patio doors are draughty.

Evidence taken from householder surveys and EPC certificates suggests these were hard-to-treat buildings that have been subject to incremental solutions to meet a decent homes standard and address potential fuel poverty and improve comfort levels.

3.2 Resident acceptance and satisfaction

Residents were asked to rate satisfaction with their heating system using one of the following responses: ‘very dissatisfied’, ‘dissatisfied’, ‘neither’, ‘satisfied’ or ‘very satisfied’. Residents were also asked for comments on specific aspects of their experience of the installed systems and the impact they had made upon living conditions within their homes.

When residents were asked how warm their home gets when cold outside, 6 responded as satisfied, 1 responded as very satisfied. 4 residents noticed a reduction in heating bills, with 2 residents remarking they had not noticed much difference. 1 resident noted that radiators seemed hotter.

When residents were asked if any impact had been noticed on damp, condensation or mould within their homes, 2 residents considered it was better since measures were installed, 5 said it was about the same. In all, 4 households experienced dissatisfaction or problems with the Ventive product, which were attributable to incorrect installations by the contractors unfamiliar with the system, or faulty components.

When residents were asked if the measures were easy to use, 5 responded as satisfied and 2 as very satisfied. This is as would be expected since both installed measures require no direct user input when in operation.

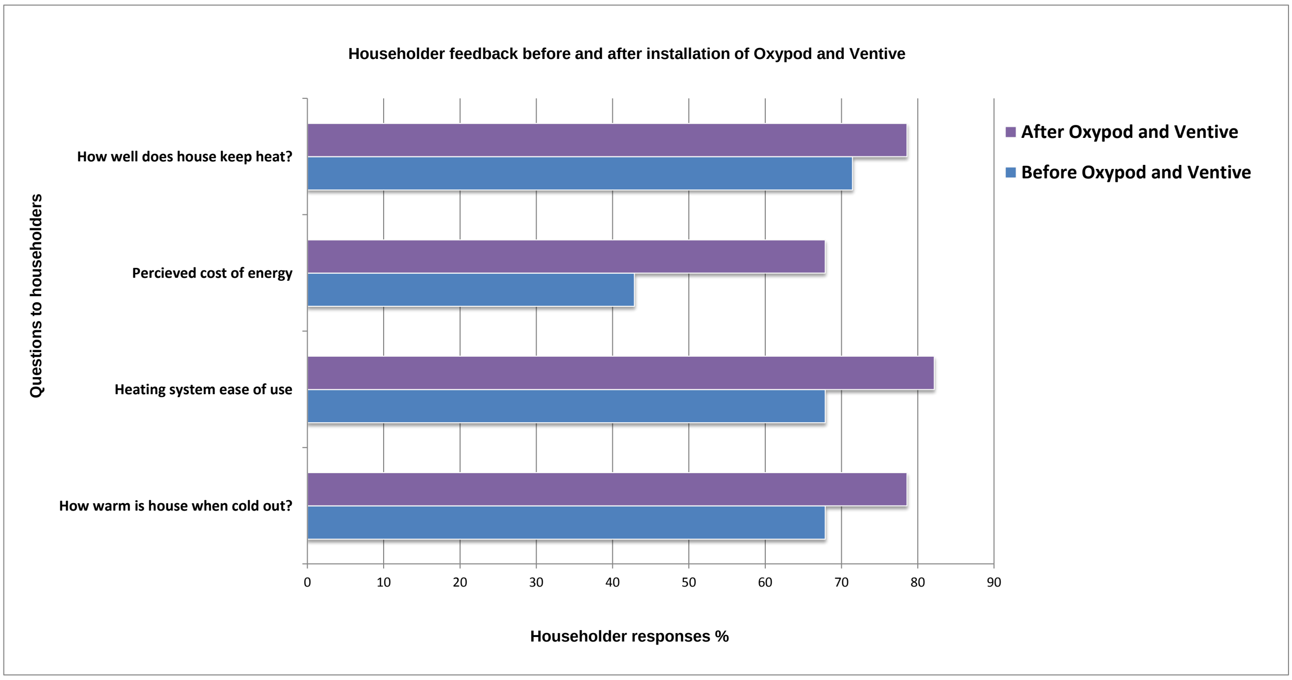

Figure 3.4 Comparison, householder feedback before and after install of measures

Residents were asked a series of statements at the end of the study about the installations. Their responses ranged from 'very satisfied', 'satisfied', 'neutral', 'dissatisfied' and 'very dissatisfied'. For purposes of statistical comparison, 'very dissatisfied' is scored as 0, and 'very satisfied' scored as 100. Figure 3.4 shows a comparison of householder feedback relating to specific relevant aspects of experience and behaviour before and after installation of Oxypod and Ventive S. The analysis indicates that the combination of the installed measures did have a positive impact upon behaviour and human comfort.

Figure 3.4 shows that householder feedback taken both before and after installation of measures does indicate an improvement in human comfort (how warm the house is, and how it retains the heat), the perceived cost of energy to households and heating system ease of use. From a superficial perspective, this suggests the products have been successful in delivering what they claim to. However, it is recognised that perceived comfort levels reported by residents may have been influenced by the addition of external wall insulation to the properties on various dates in the year preceding this project.

3.3 Ease of use, householder knowledge, and reliability

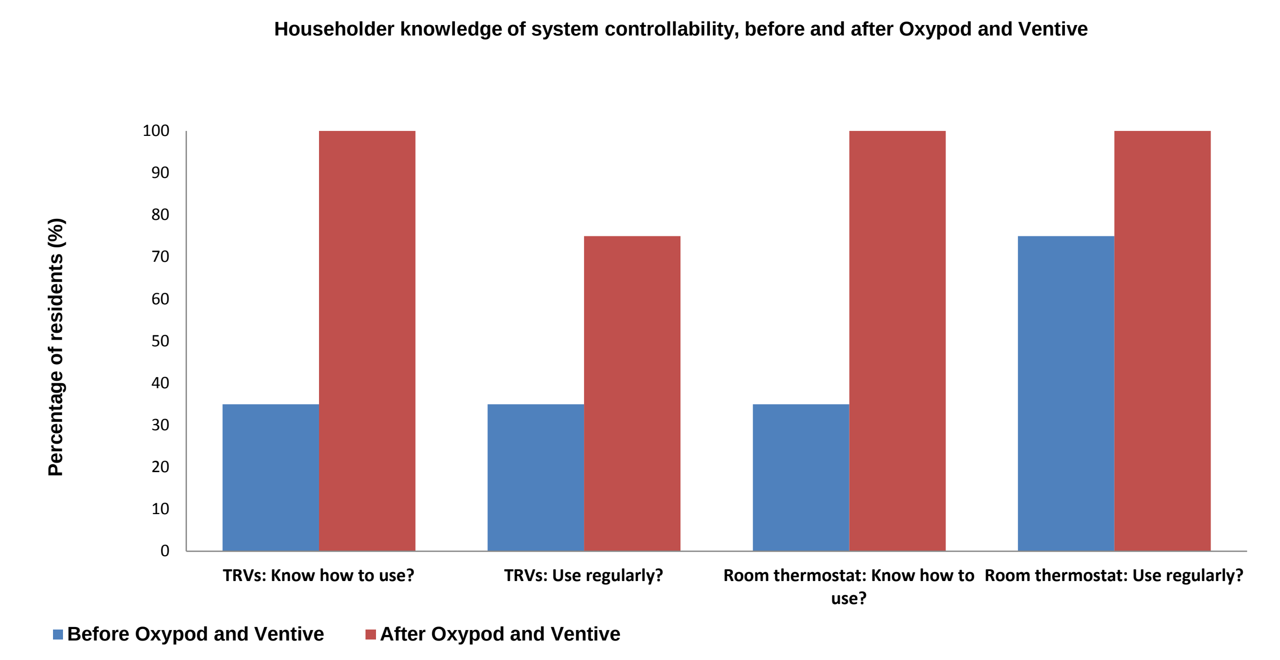

Figure 3.5 Comparison, knowledge of system controllability, before and after installation of measures

It is already noted that both Oxypod and Ventive S, once installed, require no direct user input when in operation. When asked how easy the systems are to use, 6 households responded they were satisfied and 1 household responded very satisfied. No householders had further comments to make regarding ease-of-use.

All households had existing TRVs. This device allows a majority of radiators in a household to be independently controlled with regards to temperature, or to be turned off in unused rooms. All properties also had an existing wall-mounted thermostat to control room temperature throughout the house. Figure 3.5 shows a comparison of householder knowledge of TRVs and wall-mounted thermostats, before and after installation of measures on a scale of 0-100 where 0 is the lowest score.

Oxypod is an intervention designed to improve efficiency of heating systems through better heat transfer between boiler and water, and water and radiators. This will lead to decreased load on the boiler and potentially less radiators working to achieve a desired temperature level within a household. To achieve the full energy saving potential of Oxypod, it is likely a householder will need to interact with their central heating system, that is, when a house gets too warm, rather than open a window, they need to adjust the thermostat to reduce temperature or fully/partially turn off an individual radiator using the TRV.

Figure 3.5 shows that before installation of Oxypod and Ventive S, 75% of householders did not know how to use, or regularly do use TRVs. Householder responses also show that 75% did not know how to properly use their wall-mounted thermostat, although approximately 65% did use it regularly prior to installation of measures. Following installation of Oxypod and Ventive S, engagement with existing devices within the home to save energy increased. This might also reflect some of the cost savings achieved. All householders indicated they knew how to use TRVs and wall-mounted thermostats after receiving advice at the same time as the measures were installed. 75% of households said they now regularly use TRVs as opposed to 35% prior to installation. The NEA Assessor provided some additional advice and training on energy efficiency to 4 households.

Interventions appear to have caused greater householder interaction with existing heating controls to reduce energy consumption. This may be a combination of better informed households regarding energy saving, and the beneficial impact of Oxypod and Ventive S leading to behavioural change.

3.4 Qualitative feedback given post installation of Oxypod and Ventive

1 property had additional draught exclusion fitted to the front door. 1 householder had become self-employed during the monitoring period, and while not explicitly stated, this may involve more time at home. No households stated their heating requirements had risen during the monitored period. 1 household reported problems with a hallway radiator and draughty doors, which had not been resolved when the monitoring period ended. 1 household considered their energy use had increased since installation of measures, but there is no apparent behavioural change to explain this perception and no increase in their gas bill.

3.5 Perceived comfort and benefits: reliability of installed systems

A specific reason the building form and type was selected by the landlord for installation of measures and evaluation was reported damp. The installation of Ventive S is intended to address the inherent issue of damp and excessive humidity within properties[10]. However, only a single householder complained of symptoms of excess humidity and mould in a bedroom. 2 others remarked upon excessive condensation on windows.

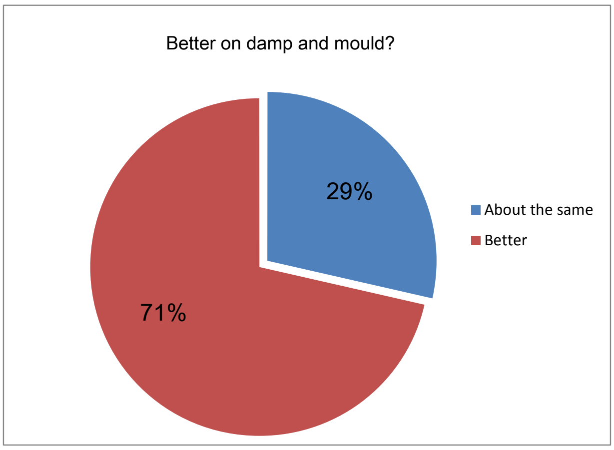

Figure 3.6: Household response to the question on the effect of the measures on dampness and mould in the property

[10] https://www.ventive.co.uk/health/damp-mould/ [Accessed 28/06/2017]

When householders were asked if installed measures have made an appreciable difference on instances of damp and mould 29% of residents observed damp and mould remained about the same. 71% of residents considered instances of damp and mould had become better since the installation of Ventive S and Oxypod. This indicates, in terms of householder perception, a qualitative improvement has been made to household interior spaces, by the addition of the Ventive system.

TechnicalRef	Householder comments: installation of Ventive
T-20	Very noisey and had to leave the house.
T-05	Had to redo works in loft, installed wrong.
T-21	Very polite and quick.
T-09	Very good and respectful of home.
T-03	First install was incorrect, reinstall in December.
T-16	Wrong extractor fan and vents are ugly.
T-04	Ok, no longer room in loft for storage.

Table 3.7 Householder feedback, Ventive S installation and general remarks

The resident feedback shown in Table 3.7 would appear to suggest that the combination of measures had an effect on perception of damp within households. There is no evidence to indicate to what extent Oxypod may have contributed to this effect.

Householder comments regarding the installation of Ventive S in their homes tended to reflect problems related to a lack of experienced installation contractors familiar with the system. While problems caused by incorrect installations have, on the whole, been addressed before the monitoring period ended, issues do appear to impact overall satisfaction. 2 households express complete satisfaction while 5 express a problem or unexpected consequence of the installation.

Better communication and interaction with householders prior to installation that firmly expresses possible long-term benefits may enable householders to anticipate and mitigate practical consequences of system installation such as a loss of loft space, or the aesthetic perception of ugly vents. Other negative feedback could be addressed by promptly diagnosing faulty components and resolving or replacing as appropriate.

TechnicalRef	Householder comments: perception
T-20	No comment
T-05	Now works complete I am happy, noticing a warmer home.
T-21	Very happy, home is warmer, noisy vent in bedroom.
T-09	Glad to have measures installed, impact is difficult to be seen, thinks bills are lower.
T-03	Distruptive with two installs, second was just before Xmas, happy with install now.
T-16	Will be happy once works complete (extractor fan). Hasn't noticed much change. Can hear wind through vents.
T-04	Hasn't noticed any changes in comfort or bills, but mould in bedroom has gone.

Table 3.8 Householder comments based upon overall experience of interventions

It is noted from Table 3.8 that most householders were happy with interventions once functioning correctly. Householder perception indicates interventions have positively impacted issues such as instances of damp and ability to keep the home warmer coupled with a reduction in heating cost. However it must be stated that householder perception of the measures was mixed, possibly due to the overall benefits being more long-term and not identified during the monitoring period of this study.

3.6 Perceived cost

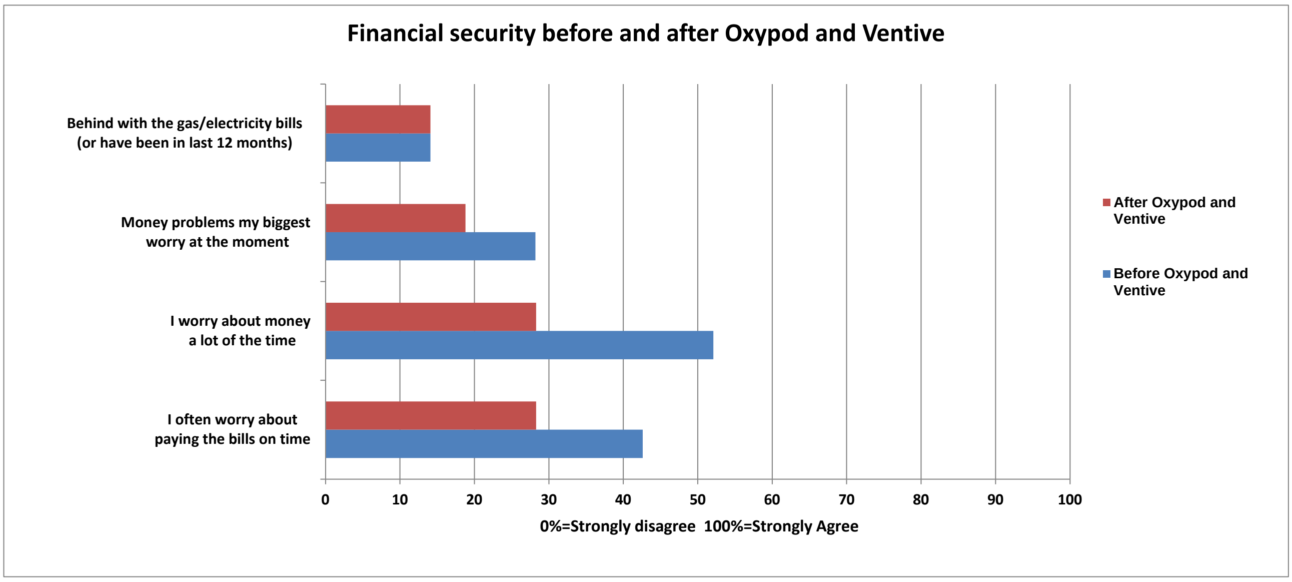

Figure 3.9 Financial security before and after measures installed

Figure 3.9 shows householders' concerns regarding paying for energy and financial security more generally. Responses were measured using 4 indicators: 'strongly disagree' is 0, 'disagree' is 33, 'agree' is 66.6 and 'strongly agree' is 100. A 'mean' score was calculated across all participants.

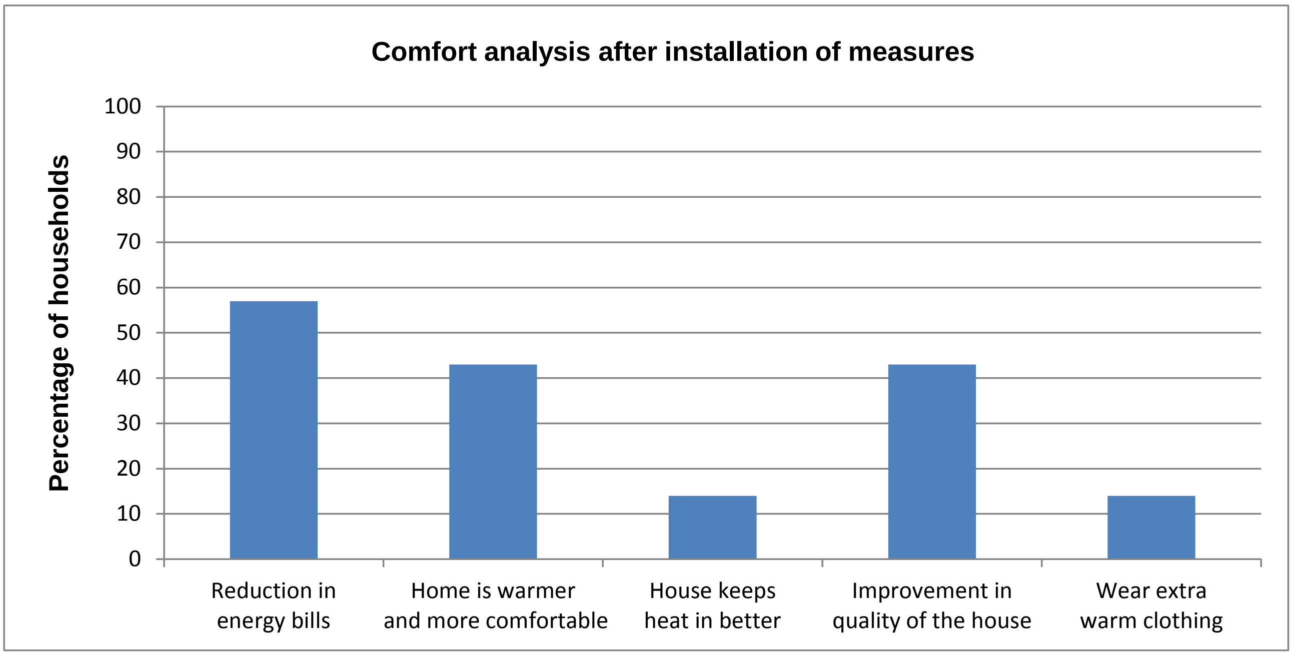

Figure 3.10 Benefits experienced by householders after installation of Oxypod and Ventive S

It is found, with the exception of a single marker, householders experienced an improvement of between 5 and 10% in indices of financial security as measured at the beginning and end of the monitored period.

At the beginning of the monitored period, 56% of households indicated they worried about money a lot of the time. At the end of the monitored period it was found this had decreased to 24% of households. However this improvement could be a consequence of behavioural change a change in circumstances, or a combination of factors not necessarily just due to the installed measures. Prior to measures being installed a majority of householders disagreed with the statement 'I often worry about paying the bills on time'. After measures had been installed a greater number of householders strongly disagreed with this statement, suggesting a slight improvement in perceptions of meeting energy costs and more generally affordability of energy.

Overall householder responses suggest a slight improvement in financial security after installation of measures in comparison with the period before.

3.7 Householder feedback: Comfort and benefits

Figure 3.10 shows householder responses regarding perceived comfort after installation of Oxypod and Ventive S to their homes. EWI had been fitted the year prior to the beginning of the monitored period, and this may have impacted *perceived* measures of human comfort despite it not being relevant to this study.

Just under 60% of households noticed a reduction in energy bills which does suggest a positive benefit from the installed measures. Over 40% of residents considered their house to be warmer and more comfortable, **however** again this perception may have been influenced by the installation of EWI and measures relevant to this report not wholly responsible.

Just over 10% of householders felt their homes kept heat in better. This may indicate residents had already adjusted to their EWI, hence the modest increase expressed in this study. Just over 40% of residents considered Oxypod and Ventive S had caused an improvement in the quality of the house. 14% of residents stated they used to wear extra warm clothing to keep warm, this compared to 57% of residents prior to installation of Oxypod and Ventive S.

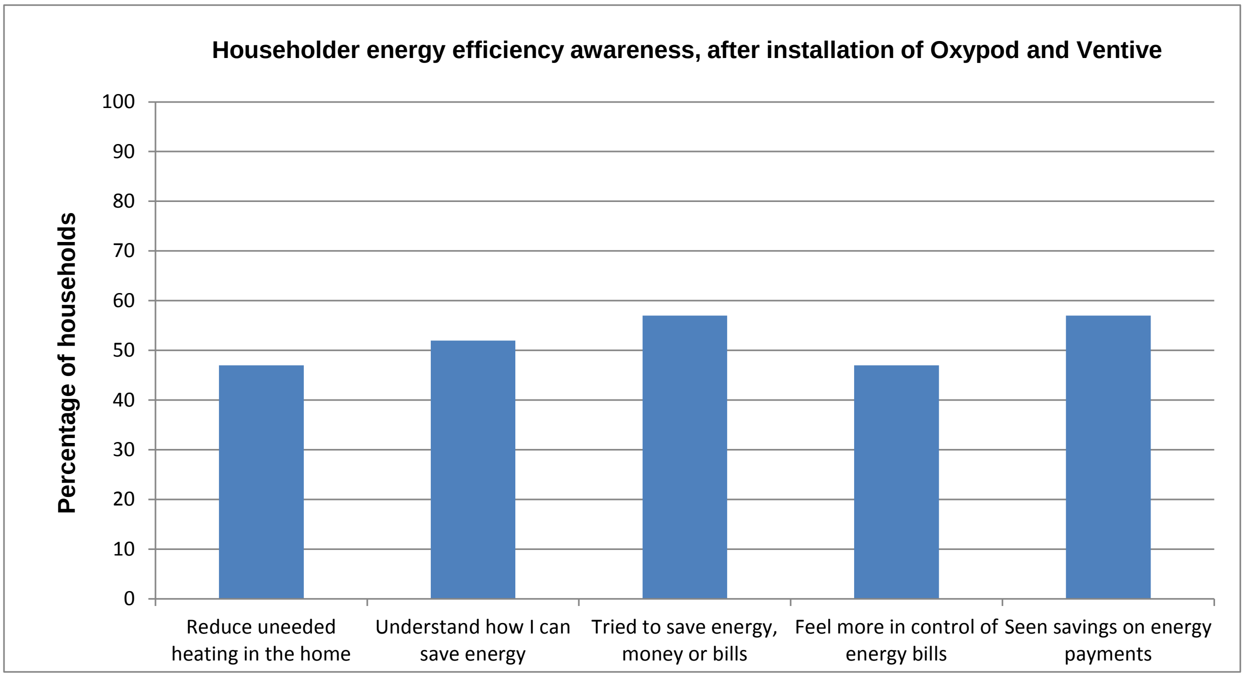

Figure 3.11 Householder responses on questions of energy efficiency awareness

Figure 3.11 shows householders' responses regarding awareness of control of their energy usage to gain maximum benefit from energy efficiency measures installed in their homes. It is seen that 47% of respondents understood the need to reduce instances of unneeded energy in their homes, while 52% understood how they can save energy within the home. 57% had tried to save energy during the monitored period and 47% said they felt more in control of their energy bills. An encouraging 57% suggest they had seen savings on energy payments following installation of Oxypod and Ventive S in their homes.

These responses indicate that, alongside installation of Oxypod and Ventive S, a greater understanding of ways individual householders can interact with their heating systems to save energy enables residents to feel more in control of consumption. This, combined with the installed measures, has led to over half of the households seeing savings on their energy bills. These responses reinforce conclusions reached in previous areas of this report regarding householder interaction with TRVs and wall-mounted thermostats. This indicates alongside installation of tangible measures designed to reduce energy consumption there should also be an effective advice on managing household energy.

4. Technical evaluation: Oxypod and Ventive

4.1 Analysis using electricity meter readings and energy bills

Gas meter reading data was recorded by households during the monitored period with varying degrees of success. Meter reading data had been taken from bills for a period prior to the Oxypod and Ventive S installation, to allow a comparison to be drawn of gas consumption before and after. It is presumed that EWI was fitted during the summer of 2014, however due to the installation company going into receivership, no records were available to assert with certainty installation dates. Therefore, a buffer period has been included to ensure with reasonable confidence, that the meter reading data-set used for this study presented an accurate representation of energy consumption, and fairly reflects performance of Oxypod and Ventive S. The data sets were also adjusted accordingly for two households where new gas meters were fitted during the monitored period.

In all cases the first meter reading post installation was taken approximately 1 month afterwards.. Depending on the installation date, for some households this allowed a late part of winter 2015/16 to be included in the data-set. Other later installations have caused the data set to begin in early spring 2016. A theoretical price for gas of 5 pence per kWh was used to apply a cost to consumption data. This is generally slightly higher than typical, but partly takes into account standing charges. A significant number of households within the monitored group use prepayment meters, and is often a more expensive way of paying for energy compared to standard tariffs. This is also factored into the 5 pence per kWh figure.

In order to properly analyse energy use for space heating, account must be taken of weather conditions. For example, it is poor practice to compare the heating costs for 2 periods without compensating for different outdoor temperatures. An external temperature of 15.5°C is accepted by energy professionals as the outside temperature below which heating will be required, and above which no heating is necessary. Degree days (denoted DD in the table below) are the heating requirement i.e. the number of degrees below 15.5°C that the average temperature is on each day during the period. When the average outside temperature drops to 14.5°C, this is classed as 1 degree-day, for example. Degree days are added together for the required period to give the total number of degree days for the period.

Different periods can then be compared for their energy consumption and the results used to predict energy consumption on a normalised basis taking into account the outside temperature for those different periods[11]. Degree day data was obtained from weather station EGLL, Heathrow Airport. This provided the nearest long-term quality assured data set to monitored properties. 20-year average degree day values are only available on a regional basis, therefore the available data set for Thames Valley was used, into which the Royal Borough of Greenwich falls.

[11] https://www.carbontrust.com/resources/guides/energy-efficiency/degree-days/ [Accessed 20/03/2017]

	"Before" period						
Tech Ref	Period	Days	Total Period (kWh)	Cost per 30 days	Degree days	kWh per Degree Day	Estimated annual cost#
T-03	31/03/2015-17/02/2016	323	12,257.2	£56.92	1,188.20	10.316	£944.92
T-04	14/03/2015-15/02/2016	338	6,575.3	£29.18	1,301.60	5.052	£462.74
T-05	13/03/2015-15/02/2016	327	6,192.1	£28.40	1,199.20	5.164	£472.98
T-09	25/04/2015-15/02/2016	296	11,725.6	£59.42	1,037.60	11.301	£1,035.14
T-16	29/06/2015-15/02/2016	231	6,216.2	£40.37	869.40	7.150	£654.94
T-20	17/09/2015-03/02/2016	145	2,793.9	£28.90	713.60	3.915	£358.64
T-21	29/07/2015-04/02/2016	190	2,535.9	£20.02	760.10	3.336	£305.60
Average						6.605	604.994

Table 4.1a Analysis of gas costs before Oxypod and Ventive S were fitted using bill and meter readings (12 month estimated cost based on 20 year degree day data for Thames Valley region)

"After" period							Comparison	
Period	Days	Total Period (kWh)	Cost per 30 days	Degree days	kWh per Degree Day	Estimated annual cost#	Cost Saving	Percentage Saving#
28/03/2016-21/03/2017	345	14,321.2	£62.27	1,667.70	8.587	£786.61	£158.32	16.75%
26/04/2016-23/03/2017	331	9,369.2	£42.46	1,554.70	6.026	£552.02	-£89.28	-19.29%
23/02/2016-21/03/2017	391	7,970.4	£30.58	2,035.00	3.917	£358.76	£114.22	24.15%
13/02/2016-21/03/2017	392	17,661.3	£67.58	2,044.90	8.637	£791.13	£244.01	23.57%
29/03/2016-23/03/2017	359	9,380.4	£39.19	1,734.80	5.407	£495.30	£159.64	24.37%
24/02/2016-30/03/2017	381	6,586.5	£25.93	1,990.20	3.309	£303.15	£55.49	15.47%
05/03/2016-23/03/2017	383	6,193.8	£24.26	1,945.30	3.184	£291.65	£13.95	4.56%
					5.581	511.231	£93.76	12.80%

Table 4.1b Analysis of gas costs after Oxypod and Ventive were fitted using bill and meter readings with comparison of monitored households (12 month estimated cost based on 20 year degree day data for Thames Valley region)

Table 4.1a shows annual gas consumption prior to installation of Oxypod and Ventive S varied between 3.3 – 11.3 kWh per degree day with an average consumption of 6.6 kWh per degree day across the monitored group. Table 4.1b shows annual gas consumption after installation of Oxypod and Ventive S ranged between 3.2 – 8.6 kWh per degree day, with an average consumption of 5.6 kWh per degree day across the group.

1 household experienced an increase in gas usage of 19% the reasons for which were not fully explained in the social research. The remainder of households saw a decrease in gas consumption of between 4.6 and 24.4% compared to the period before installation of measures. Across the monitored group, a 12.8% average reduction in gas consumption was observed. This figure compares favourably with the results from another project undertaken with just Oxypod installed, where an average reduction in gas consumption was found to be 7.3%[12]. This indicates Ventive S **may** have a further positive contributory impact upon reduction in gas consumption, despite some issues with incorrect installation and operation.

[12] TIF Project CP770, p. 18….it is important to consider monitored properties of this group may be of a different plan, age, and construction type to those of CP763. Also degree day data will be relevant to the region concerned; all factors that may influence data and findings.

None of the households reported any further works that may have influenced gas consumption findings during this monitoring period.

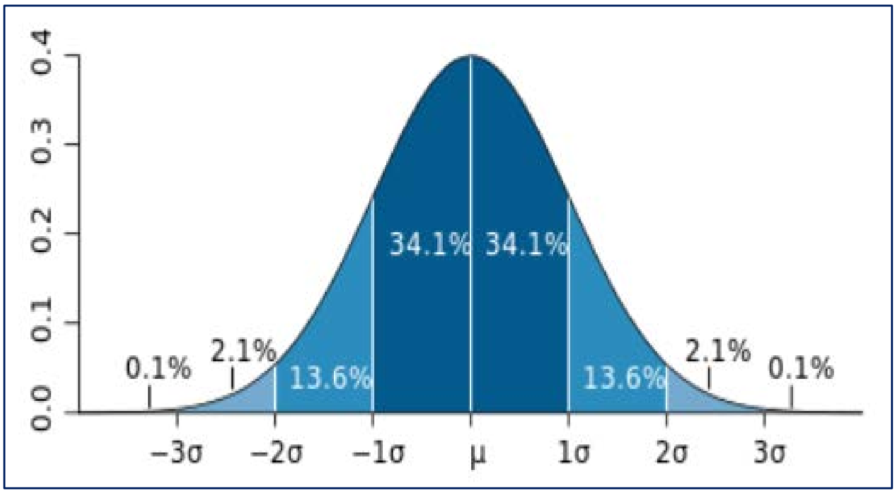

Figure 4.2 Illustration of mean (μ) and standard deviation (σ) in a normal distribution

The average saving was 12.8%; however we see significant variability amongst this small sample. The standard deviation (Figure 4.2) (σ) indicates the sample spread either side of the mean. The σ is 13%, so we can have 68.2% confidence that the mean saving is 12.8% ± 13%, and 95.4% confidence that the mean saving is 12.8% ± 26%. These values mean that savings could be less than zero, as the variability is so wide. Further work – with a larger sample of more similar household types and full recording of usage prior to install - is recommended.

There were, however, a sufficient number of meter readings for all properties to provide a good analysis of usage during the winter heating periods before[13] and after installation of measures. It has been possible to plot graphs of consumption before and after, against the number of degree days.

[13] Adjusted to allow for installation of EWI

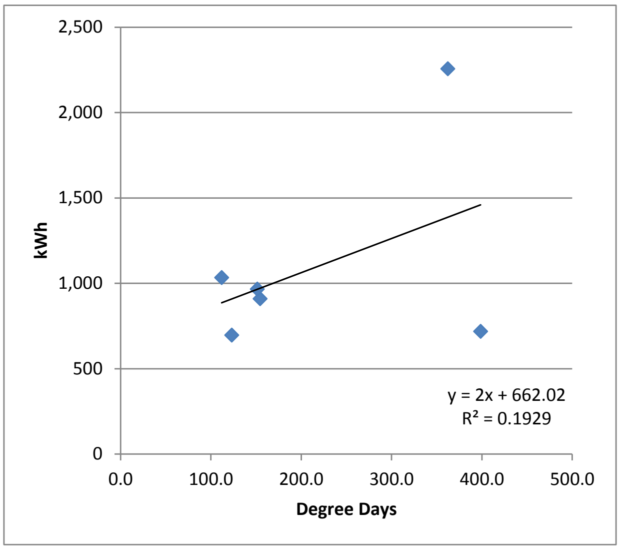

Figure 4.3a Property T-04 before installation

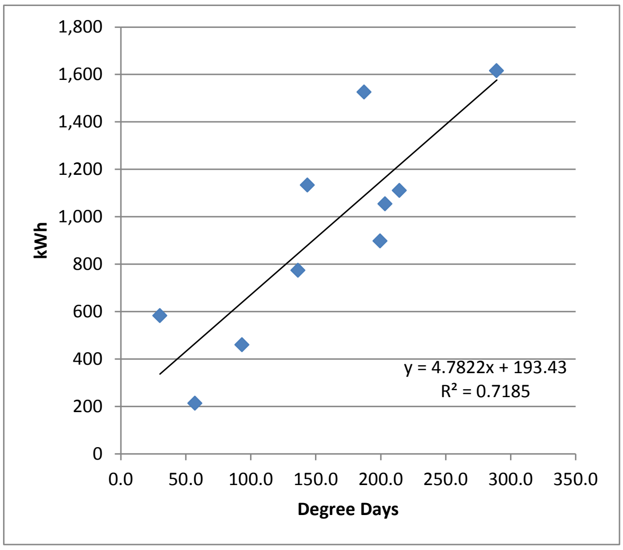

Figure 4.3b Property T-04 after installation

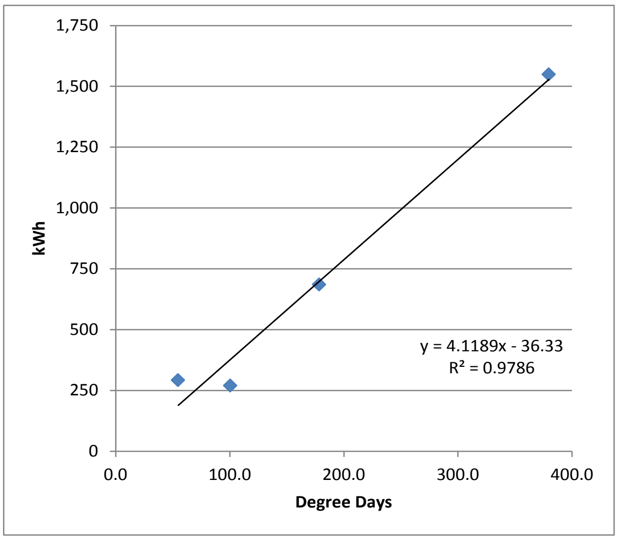

Figure 4.3c Property T-20 before installation

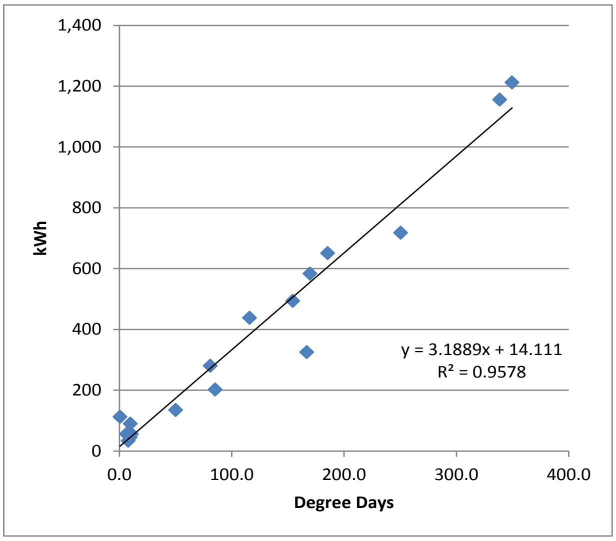

Figure 4.3d Property T-20 after installation

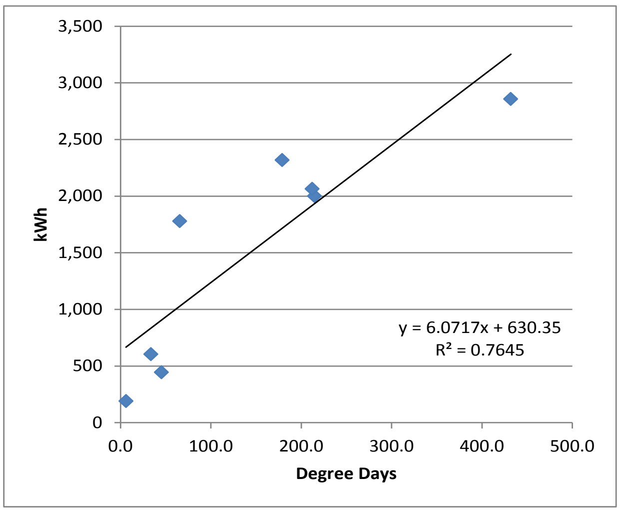

Figure 4.3e Property T-03 before installation

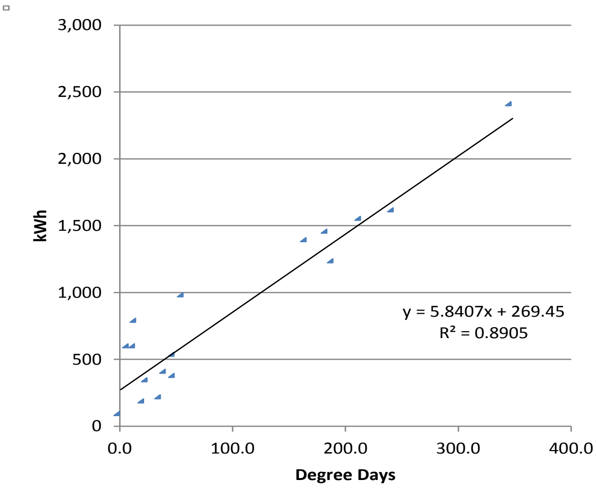

Figure 4.3f Property T-03 after installation

Where there was sufficient meter reading data during the monitored period, it was possible to plot a graph of gas consumption against the number of degree days. The subsequent performance line added to the graph allows a judgment to be made as to how well the heating has been controlled in respect to outside temperatures. Data points appearing on the performance line indicate good control of the heating system whereas scattered data points indicate less control. Data points above the line indicate overheating and below, under-heating. A selection of graphs is presented in Figures 4.3a-f.

Figures 4.3a-b shows gas consumption data for property T-04; this was the only household to demonstrate an increase in gas consumption during the monitored period. It is possible the increase is partly attributable to unreliable data. Figure 4.3a records data for the period prior to installation of Oxypod and Ventive S. Its observed gas consumption is not consistent with number of degree days and control does not reflect outside temperature. Therefore, although not reflected in the householder feedback collected by the study, it is possible the property may have been unoccupied for a period of time relevant to the study and consequently consumption of gas declined during the before-period. Figure 4.3b shows consumption data for the same property after installation, and while some slight discrepancies in data remain apparent, overall consistency and control is notably better. This may provide reasoning for the marked increase in baseload (non-heating related) gas consumption presented by data in Figure 4.3b, and represented by the intersect of the ‘best line of fit’ with the y axis of the graph.

The household consumption data reflected in Figures 4.3c-f is more typical of overall baseload gas consumption across the group. Property T-20 is an example where points and trend-line are generally quite consistent suggesting the householder has good control over consumption, and the heating system is reactive to outside temperature increase and decrease, indicating minimal unnecessary use of heating. This data suggests the householder was already quite disciplined with regards to energy consumption prior to the monitored period. At the beginning of the monitored period the householder was unemployed. For the period after installation, the householder had entered part-time work. This change of circumstances does not appear to impact the data.

Property T-03 appears to show enhanced control of the heating system during the monitored period. Figure 4.3e suggests the property goes through phases of under and overheating during the period before installation of measures. Figure 4.3f shows, during latter phases of the monitored period, points and trend-line merge, indicating property heating is more consistent with outside temperature fluctuations and degree days. This trend may reflect an impact of energy efficiency instruction provided to the householder by the NEA assessor during home visits. However, it may also reflect a more consistently warm house as a consequence of installed measures. This data could reflect householder feedback as expressed in Figure 3.8 of this report.

4.2 Temperature and thermal comfort

Temperature and humidity loggers were placed in each of the monitored homes during the study period. 1 was located in the main living room, with a second placed in the main bedroom. Loggers were placed in properties approximately 1 month prior to installation of Oxypod and Ventive S. Temperature and humidity data obtained from the installed loggers was analysed for 1 winter heating period, between 1st October 2016 and 1st March 2017, post installation of the measures. The data was averaged to provide an overall view of winter temperature performance.

	Living Room				Bedroom			
Property	24hr average	Maximum	Minimum	SD	24hr average	Maximum	Minimum	SD
T-03	22.1	23	21.5	1.06	20.8	23.5	17	1.17
T-04	21.3	21.3	19	1.43	*No Data*			
T-05	21.5	24	15	1.43	21.4	23.5	15	1.27
T-09	*No Data*				21.3	25	14.5	1.43
T-16	20	23.5	14.5	1.43	20.1	23.5	15	1.41
T-20	18.6	21	15.5	0.83	19.4	22.5	15	1.47
T-21	19.2	22.5	19.5	0.97	19.7	23.5	14.5	1.47

Table 4.4 Temperatures in the monitored properties between 1 Oct 2016 and 1 March 2017 (after Oxypod and Ventive S)

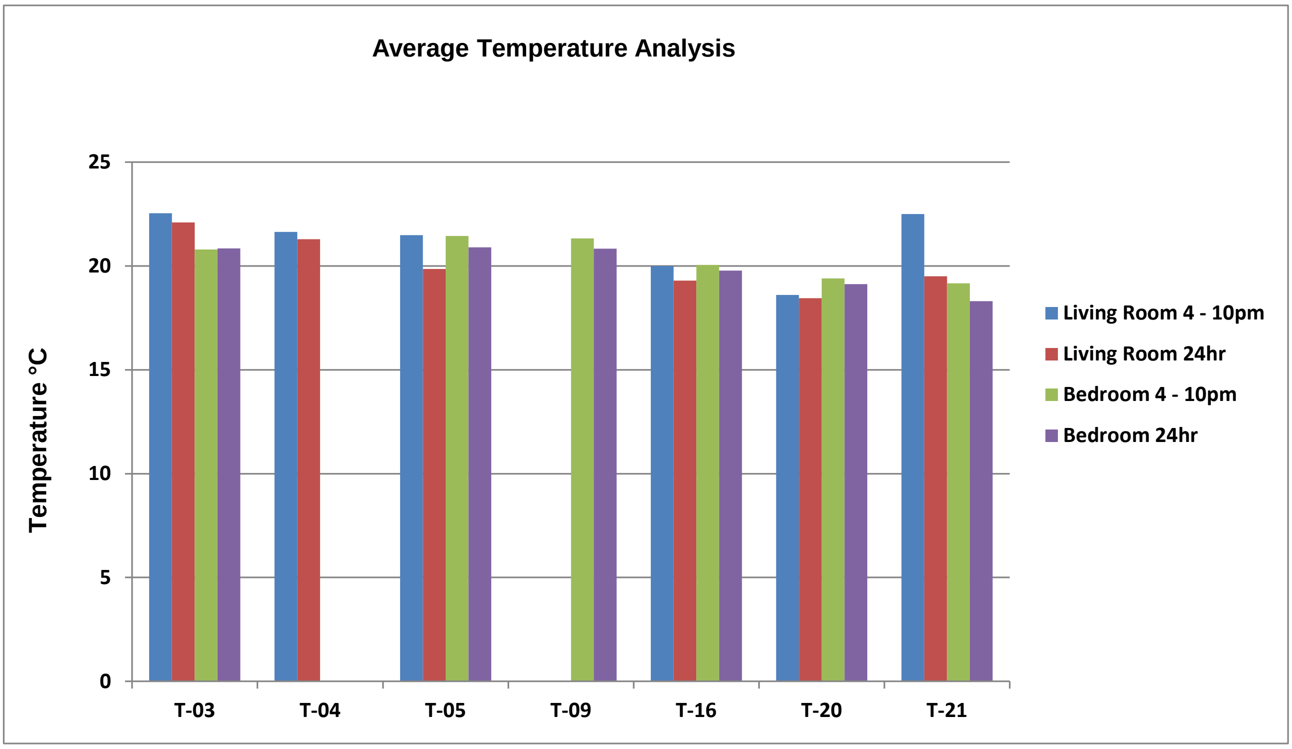

Figure 4.5 Average temperature analysis. Monitored properties evening heating period compared with 24hrs (after Oxypod and Ventive S)

Table 4.4 and Figure 4.5 illustrate the results of the temperature data we obtained from the loggers, for the year following installation of measures. It was stated by T-04 that the bedrooms were not heated through preference. Some householders also stated they prefer a cooler bedroom.

Table 4.4 shows average temperatures for a single winter heating period, for the living room temperatures vary between 22.1°C and 19.2°C for different periods of the day (evenings from 4-10 pm and 24 hour average). Average temperatures of bedrooms vary between 21.4°C and 19.4°C. The recommended range for comfort and good health is 18 - 21°C. None of the monitored properties have an average temperature that falls below the healthy range, although T-20 is only marginally above. Several households record minimum temperatures that fall below the healthy range in both living rooms and bedrooms. Over the average 24 hour period this is attributable to night-time and daytime periods when heating is not required. As all monitored properties had EWI installed when data was collected, it is expected that residual heat would be effectively retained within properties.

Table 4.4 shows a detailed breakdown of data. It can be observed that all households experience a decrease in temperature outside the evening heating period. This is to be expected, however temperatures are maintained at a reasonably constant level when homes were not being heated. This may be a consequence of Oxypod and Ventive S, or EWI - or a combination of all 3.

Property T-20 reported a faulty living room thermostat (possibly referring to TRV). This may provide an explanation as to why the living room in that property was kept cooler than the bedroom. This problem may also have impact on the efficiency and effectiveness of Oxypod. Households T-05 and T-21 both have members with health conditions that may require a warmer home; this is reflected to a greater extent in consistency of data for T-05 than T-21, although for the latter it can be seen that the living room was maintained at 23°C during the evening heating period.

In data not shown in the graphs, households T-09 and T-16 recorded temperatures below 0.5°C in the bedroom during the winter heating period. This reading is also reflected in living room data collected from T-16. In both cases data for 2 days before shows a gradual decline in temperature. This may suggests both households were unoccupied for a short period, and consequently temperatures recorded outside the healthy range are not significant, however had the householders been present this could have led to serious health implications.

4.3 Humidity

Water vapour, usually measured as relative humidity (RH) or the percentage of water vapour held by the air compared to the saturation level, is not usually considered to be an indoor contaminant or a cause of health problems. In fact some level of humidity is necessary for comfort. On the other hand, the relative humidity of indoor environments (over the range of normal indoor temperatures of 19 to 27°C), has both direct and indirect effects on health and comfort. The direct effects are the result of the effect of relative humidity on physiological processes, whereas the indirect effects result from the impact of humidity on pathogenic organisms or chemicals.

Figure 4.6 below illustrates the optimum humidity levels as cited by Arundel et al[14]. The study concludes that maintaining relative humidity levels between 40% and 60% would minimise adverse health effects relating to relative humidity.

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

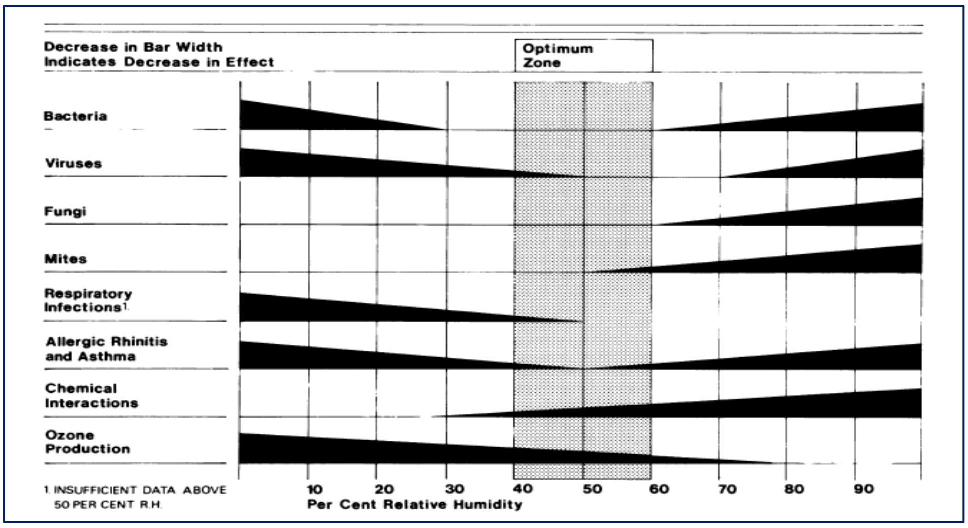


Figure 4.6 Optimum humidity levels to reduce indirect effects from pathogenic organisms or chemicals

The automated data-loggers record both temperature and RH at regular intervals across the study properties. RH is a ratio (expressed as a percentage) of the amount of moisture present in the air at each logging point, relative to the amount that would be present if the air were saturated. Since the latter amount is dependent on temperature, RH is a function of both moisture content and temperature. RH is derived from the associated temperature and dew point for the indicated sample. The higher the value of RH, the more water vapour is contained in the air. High values are problematic, and can cause damage to building fabric and furnishings, and can cause mould growth and the health problems associated with this high humidity. From the building regulations part F[15]; the suggested average monthly maximum humidity levels for domestic dwellings during the heating season is 65%.

	Living Room				Bedroom			
Property	24hr average	Maximum	Minimum	SD	24hr average	Maximum	Minimum	SD
T-03	46.32	55	43	8.48	48.41	56	47	6.34
T-04	57.3	61	54	4.94	*No Data*			
T-05	49.59	54.5	47	5.31	51.74	59	47	8.53
T-09	*No Data*				46.89	55	44	7.84
T-16	56.13	61	54	4.92	65.5	69.5	63	4.61
T-20	54.58	59	50	6.32	53.45	60.5	50.5	6.01
T-21	53.51	57.5	49	6.01	57.93	60.5	56.5	2.82

Table 4.7 Average humidity in the monitored properties with readings taken between 1 Oct 16 - 1 March 17

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

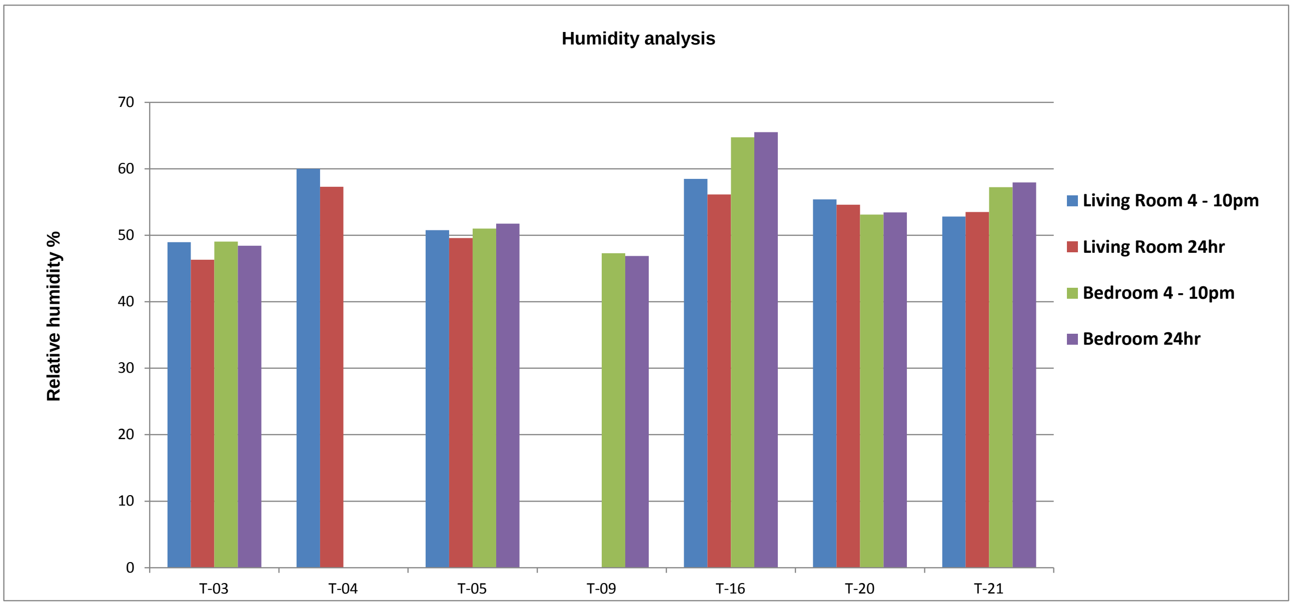


Figure 4.8 Average humidity analysis. Evening heating period compared with 24hr average (after installation of Oxypod and Ventive S)

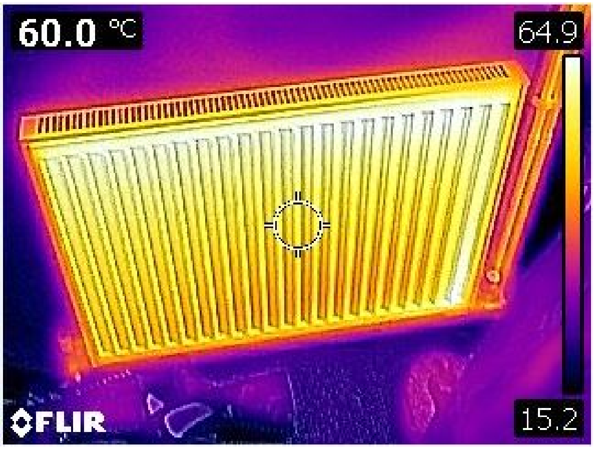
As shown in section 4.2 data is not available for the living room of property T-09 and bedroom of property T-04.

Figure 4.8 shows, with an exception of property T-16, all monitored properties are within the healthy range in terms of humidity within buildings. Consistency between evening heating periods and 24-hour monitoring is reasonable, with little fluctuation observed. This indicates regardless of whether a home is warmer or cooler, humidity remains fairly consistently within the healthy range, and the building is performing well. Within this group, there is no evidence in the data to suggest whether Ventive S has enhanced property performace or not. The effective retention of heat by EWI is a positive factor in reducing high humidity levels in homes but a building's performance with regards to internal humidity levels can be influenced by householder behaviour, for example, opening windows regularly may reduce relative humidity, showering with a bathroom door open may cause data to reflect a slight increase in RH.

Property T-16 provides an interesting case study. Data illustrated in Figure 4.8 shows a clear spike in relative humidity over a 24-hour period. It is shown in Figure 4.5 that no abnormalities were observed in heating behaviour. The face to face interview and completed questionnaire with the resident at that property revealed that a defective Ventive system had been replaced during December 2016 (the original system was installed 14th March 2016). This suggests Ventive S was not operational in this property for approximately half of the measured winter heating period. While this is by no means definitive evidence that a properly functioning Ventive S has a positive impact on levels of humidity, it does show a correlation between data and householder feedback.

4.4 Thermal Imaging

Thermal imaging of radiators in monitored households was collected before and after installation of Oxypod to ascertain whether Oxypod helped to eliminate cold spots, usually caused by trapped air in radiators. (Fewer cold spots suggest the device is removing trapped air from a central heating system, and consequently improving efficiency of radiators and the gas boiler. *However, extremely bright colours within images may be reflection, therefore appropriate caution should be applied in assessing the images*.)



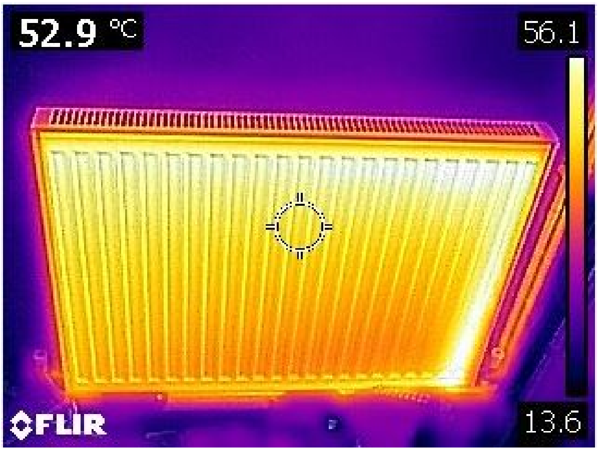
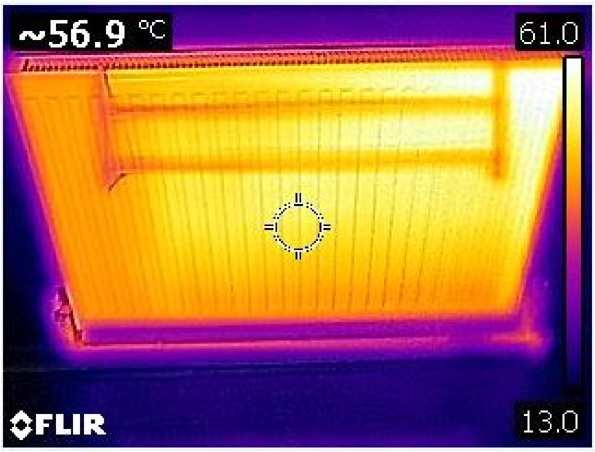


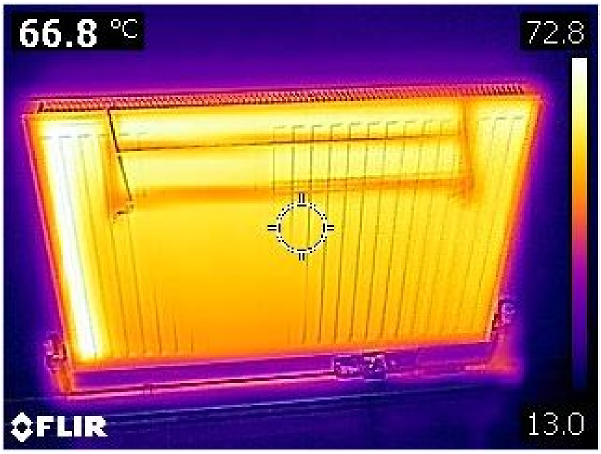
Fig 4.9a: T-05 hallway before Oxypod

Fig 4.9b: T-05 hallway after Oxypod

Fig 4.9c: T-20 hallway before Oxypod

Fig 4.9d: T-20 hallway after Oxypod





Most relevant to this report is not the radiator temperature, but whether there was a more equal distribution of heat across the radiator. If more equal after Oxpod installation, this would suggest the measure achieved the anticipated impact upon the heating system. Generally speaking, the brighter a colour within an image, the greater the temperature measured.

Figures 4.9 a-d show thermal images taken before and after installation of Oxypod. A superficial interpretation of images suggests there may be a marginal improvement in heat distribution across the hallway radiator surface in properties T-05 and T-20.

5. Conclusions and recommendations

5.1 Conclusions

The original aims of the project were;

- To establish whether households experience a reduction in heating costs as a consequence of installed systems.
- To establish whether Oxypod enables a more efficient gas central heating system.
- To establish whether the Ventive system reduces relative humidity (RH) and improves human comfort within dwellings.
- To establish whether Ventive S reduces obvious signs of excess moisture within buildings, such as organic growth or failure of internal decoration due to damp.
- To examine ease of installation, ease of use and resident satisfaction for installed systems.
- To contribute towards a body of evidence that will enable landlords and householders to assess contribution of installed systems to energy efficiency and suitability of systems in older, hard-to-treat housing stock where residents experience fuel poverty.

Savings and performance

- Heating costs (corrected for differences in the before install and after install weather conditions) varied between a saving of £13.95 and £244, one household saw an increase in heating costs of £89. The average saving amounted to £89.
- Across the monitored group, a 12.8% average reduction in gas consumption was observed. This figure compares favourably with a project undertaken with just Oxypod installed into monitored properties, where an average reduction in gas consumption was found to be 7.3%. This indicates Ventive S may have a further positive contributory impact upon reduction in gas consumption within the monitored group, despite some issues with incorrect installation and operation.
- All but 1 household did experience a reduction in gas consumption during the monitored period and there was some evidence to suggest that property may have been under occupied prior to the installation.
- In terms of householder perception of cost, 57% suggest they have noticed a reduction in energy payments after installation of measures.

Humidity

- Data that measures householder perception of installed measures indicates some residents did notice a reduction in obvious indicators of excess humidity.
- Humidity data is inconclusive with regards to efficacy of Ventive S in improving levels of humidity in properties. A single household presents interesting data that may indicate overall benefit of Ventive S, in terms of humidity control and reduction, is substantive. Further evidence must be collected through other trials to provide more robust evidence as this study does not provide conclusive evidence.

Ease of installation, use and resident satisfaction

- There is some, although limited, evidence to suggest heating controllability and performance improved following installation of measures. This is observed in data that

shows internal temperatures became more closely correlated with degree days.
- Householder satisfaction was mixed. Responses regarding the operation of systems are generally neutral (as might be expected with these ‘fit and forget’ systems). Some quite negative feedback was expressed regarding installation issues and the identification and rectification of faulty systems.
- A majority of householders felt their homes did feel warmer after installation of measures.

5.2 Recommendations for potential future installations

- A more realistic time frame for installations and consistent use of experienced contractors familiar with Ventive S would reduce instances of incorrect installation and negative householder feedback.
- For both measures, a longer before and after period of data collection and a larger sample size and stable occupancy levels would enable a more effective technical evaluation. For Ventive S in particular, it may be useful to collect damp meter readings (before and after) from building fabric. This may provide data on building performance and contribution made to internal humidity levels by construction materials and building type.
- Installations should be accompanied by an effective regime of householder instruction. This could include energy saving advice and correct use of existing heating controls and appliances to help them save money.

5.3 Impact on fuel poverty

Ventive S and Oxypod were fitted to older, solid wall ‘hard-to-treat’ properties that had been subject to previous measures designed to improve their energy efficiency and reduce fuel poverty (e.g. EWI and TRVs). It is notable however, that a majority of properties do not appear to have proven, easy to install and cost effective measures such as loft insulation. Therefore, efficacy of installed measures at reducing fuel poverty may be compromised by a missing link in the insulation of internal living spaces. The data available from this study does enable a view to be reached, that Oxypod and Ventive S installed in tandem may contribute to considerable reductions in energy consumption and thereby a reduction in fuel poverty. Further research into the application of these products is recommended to provide greater evidence to substantiate this.

Appendix 1: Glossary of Terms

DD	Degree Days
EPC	Energy Performance Certificate
EWI	External Wall Insulation
HIP	Health and innovation Programme
NEA	National Energy Action – the National Fuel Poverty Charity
PVHR	Passive Ventilation and Heat Recovery
RH	Relative Humidity
SAP	Standard Assessment Procedure (for assessing home energy efficiency)
TIF	Technological Innovation Fund
TRV	Thermostatic Radiator Valve

Appendix 2: Health and Innovation Programme 2015 – 2017

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

The programme comprised 3 funds

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

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

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

What it involved

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

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

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

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

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