NEA Action for Warm Homes TECHNICAL INNOVATION FUND

External wall insulation on park homes in North Lincolnshire
YES Energy Solutions

Technical Evaluation Report

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September 2017

CP783/4
External wall insulation in park homes in North Lincolnshire
YES Energy Solutions

Number of Households Assisted	61
Number of Households Monitored	28

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 EAS in Scotland, 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 or 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:

YES Energy Solutions – lead partner
North Lincolnshire Council – other partner
Kelvick Ltd – installer

NEA team:

Elizabeth Lamming – Project Development Coordinator, NEA
Jamie Barnes – Consultant (Technical), NEA
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Legal limitations and disclaimer

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Executive Summary

Project overview

This project was delivered by YES Energy Solutions in collaboration with North Lincolnshire Council. It had the following aims;

- To establish benefits of external wall insulation (EWI) to households living in park homes.
- To identify other potential benefits of EWI installation to park homes, that could be considered in future cost benefit analysis prior to proposed park home treatment.
- To determine household satisfaction with the installation process.
- To contribute towards a growing evidence base for retrofitting of park homes to enhance energy efficiency and also longevity and aesthetic appearance of older models.

Context

There are an estimated 85,000 households living throughout the year in park homes on 2000 sites in England. A disproportionately high number of households are elderly or have a health condition. Park homes, particularly older examples, have poor levels of energy efficiency[1]. They are frequently not connected to mains gas[2] which means households are often reliant upon expensive heating fuels such as liquefied petroleum gas (LPG), fuel oil or electricity to heat their home. Additionally they are not subject to building controls and whilst they are seen as an affordable housing option the running costs can be significantly higher than residents expect and can afford, as insulation standards are less rigorous and enforced than in a traditionally built property.

This combination leads to high costs for households who are often vulnerable, on low incomes, and struggle to pay their fuel bills. By cutting back on their heating, the households risk low room temperatures which impact on health and well-being. They are usually unable to afford wall insulation and access to funding under the Energy Company Obligation (ECO) has often proved difficult.

External wall insulation

External wall insulation (EWI) is an established technology that improves heat retention and energy efficiency. In essence, EWI provides an external jacket to a park home that significantly enhances thermal efficiency. This should improve performance of existing building fabric, ensuring a warmer living space in winter months, and cooler living space in the summer months. A further stated benefit of EWI is improved sound proofing, which can further enhance the living experience of householders.

EWI has generally been installed in ‘hard to treat’ households, in particular system built social housing and older solid wall properties. Installation to park homes is an application for EWI systems that is increasingly being explored. It has the potential to significantly enhance both human comfort and the aesthetic appearance of park homes, whilst also extending the lifespan of the property.

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[1] Cert demonstration action insulation improvements to residential park homes scheme Ref: SSEN09132, Alba Building Sciences Ltd, June 2011 https://www.ofgem.gov.uk/sites/default/files/docs/2012/05/park-homes-alba-report---cert-demonstration-action_0.pdf (Accessed 14 July 2017)
[2] Scoping ECO for Park Homes, NEA, March 2014 http://www.nea.org.uk/wp-content/uploads/2014/03/Scoping-Eco-for-Park-Homes.pdf

Four EWI systems were used on this project; SPS Envirowall; JUB Jubizol Premium System; Alumasc Swisslab and ParexTherm acrylic render system. Each used grey expanded polystyrene insulation (EPS). After the insulation was mechanically fixed to the exterior wall, a rendered coating was applied, which incorporated a reinforcing mesh. The upper layer was a weather proof render with decorative finish. The partners wanted to consider the relative merits and costs of each system, both in terms of cost and resident benefit. On some properties 50mm of Kingspan Thermafloor underfloor insulation was fitted where required and where the underfloor areas were accessible and suitable to receive this measure.

The project

This project installed EWI to 61 park homes at three sites in Scunthorpe. Ashfield Park and Charnwood Park were both privately owned, while Manifold Road was owned by North Lincolnshire Council. Charnwood Park and Manifold Road were both off the gas grid and residents relied on more expensive LPG (bottled gas) to fuel their heating systems – with either LPG gas tanks or purchasing bottled gas.

A total of 17 SPS Envirowall installations took place at Ashfield Park, with 11 of these park homes also having under floor insulation. There were also 21 JUB Jubizol Premium installations at Ashfield. The remaining installations at Charnwood Park consisted of 13 ParexTherm systems and 5 Alumasc Swisslab systems. There were also 5 Alumasc Swisslab installations at Manifold Road.

Among the installations at Ashfield Park and Charnwood Park, a total of 28 were monitored. These were 10 SPS Envirowall (including 7 with under floor insulation), 11 with JUB Jubizol Premium, 6 with ParexTherm acrylic render and one with Alumasc Swisslab. The monitoring included:

- Household interviews to assess behaviours and household satisfaction
- Measurement and analysis of temperature and humidity in the park home
- Assessment of energy consumption before and after installation of the EWI

The average SAP rating pre-installation was 40.95 and this increased to 50.44 after the EWI was fitted. Energy Performance Certificate band E is SAP 39-54 therefore the park homes went from the bottom to near the top of band E. This meets the government's first fuel poverty milestone for 2020.

Summary of findings and insights

An improvement in overall satisfaction and comfort

- Following the installation of the external wall insulation, there was significant improvement in the satisfaction of householders over how well their park homes kept in the heat.
- At least 90% of households with each EWI technology thought their home kept in the heat better and the house became warmer faster.
- Other benefits noted by households included an improved appearance to the park home, better sound-proofing and reduced condensation.

Lower gas consumption following external wall insulation

- There was an average reduction in gas consumption of 16.8% for households with SPS Envirowall and under floor insulation.
- Households with SPS Envirowall EWI on its own saw average savings of 26.2%, but this better performance was likely to be due to the nature of those households and the pre-install standard of their properties.
- Households which received wall insulation using JUB Jubizol Premium made average savings of 18.8%, while for the Parextherm acrylic render system the savings were 17.7%.
- A single monitored household that received Alumasc Swisslab saw an increase in consumption of 5.2% which is accounted for by greater occupancy post installation and improved thermal comfort taking.
- Across these installations, the change in gas consumption ranged from a reduction of 39% to an increase in consumption of 11%.
- Where EWI was combined with other measures such as a new boiler or windows, households achieved savings between 28% and 41%.

Households benefited from reduced gas consumption and/or improved thermal comfort

- Park homes which were previously over heated were more likely to make larger savings in gas consumption, particularly where there was a reduction in room temperature.
- Where properties were previously under heated, households were more likely to take at least some of the benefit from the external wall insulation in improved thermal comfort (leading to lower savings or an increase in gas consumption).
- Older park homes had poorer levels of insulation and these households tended to see greater savings after installation of the EWI.

Park homes lost their heat more slowly after installation of external wall insulation

- The decrease in room temperature overnight was studied before and after installation of external wall insulation.
- After properties were insulated the temperature decreased at a slower rate and heating systems could be switched on later in the morning.

Energy Bill savings

- Other factors over the course of the study impacted the energy prices paid by the residents. A number of them changed their supplier or tariff and had new boilers installed. These were in some instances as a result of the energy advice they received and the assistance to manage household energy and bills

Conclusions and recommendations

Overall the project enabled many households to successfully reduce their heating costs and keep their homes warmer. The study helped to confirm that future installations would be particularly beneficial for:

- **Park homes which are off the gas grid and reliant on more expensive heating fuels**
- **Older park homes which had poorer levels of insulation at manufacture than more modern units**

It is important to determine early on that the properties will meet minimum spacing requirements after insulation is fitted. Older park homes might need additional refurbishment prior to installation of the EWI. The report demonstrates sufficient evidence that EWI provides many benefits to households living in park homes and so access to grants to fund installations should be made easier to these residents.

Potential impact on fuel poverty

This report shows that following installation of external wall insulation households reduced their gas consumption by up to 39%, with average savings between 17% and 19%. Households making lower savings benefited from warmer homes and increased comfort.
Insulation of park homes can therefore save heating costs, improve thermal comfort and health for households.
The average SAP rating increase was 10 which on average increased from 40-50 SAP and towards the top of EPC band E (the Government's milestone for fuel poor households in England by 2020).

1. Project overview

1.1 Introduction

This project was delivered by YES Energy Solutions, in collaboration with North Lincolnshire Council. It involved installing external wall insulation (EWI) on park homes at three sites in Scunthorpe.

Ashfield Park and Charnwood Park were both privately owned, while Manifold Road was owned by North Lincolnshire Council. Charnwood Park and Manifold Road were both off the gas grid. YES Energy Solutions were originally contracted to carry out 57 EWI installations, but the final total achieved with the funding was 61 EWI installations. As part of the project, 11 of these also had under floor insulation installed, where it was required, and where access to the underside of the property was safe and accessible.

There were 4 different EWI technologies installed by Kelvick Ltd which used grey expanded polystyrene (EPS) insulation. These technologies were: SPS Envirowall, JUB Jubizol Premium, ParexTherm acrylic render system and Alumasc Swisslab. The floor insulation installed was the Kingspan Thermafloor 50mm insulation.

1.2 Aims

- To establish benefits of EWI to households living in park homes.
- To identify other potential benefits of EWI installation to park homes, that could be considered in future cost benefit analysis prior to proposed park home treatment
- To determine householder satisfaction with the installation process
- To contribute towards a growing evidence base for retrofitting of park homes to enhance energy efficiency, and improve longevity and aesthetic appearance of older models

1.3 Context

There are an estimated 85,000 households living throughout the year in park homes on 2000 sites in England. A disproportionately high number of households are elderly or have a health condition. Park homes, particularly older properties, have poor levels of energy efficiency[3]. They are frequently not connected to mains gas[4] which means households are often reliant upon expensive heating fuels such as liquefied petroleum gas (LPG), fuel oil or electricity to heat their home.

This combination leads to high costs for households who are often vulnerable, on low incomes, and struggle to pay their fuel bills. By cutting back on their heating, the households risk low room temperatures which impact on health and well-being. They are usually unable to afford wall insulation, and accessing funding for the work under the Energy Company Obligation (ECO) has often proved difficult.

NEA was keen to further understand the benefits of park home insulation. It was anticipated that the project would offer a blueprint for future schemes and highlight some of the impacts, processes

[3] Cert demonstration action insulation improvements to residential park homes scheme Ref: SSEN09132, Alba Building Sciences Ltd, June 2011 https://www.ofgem.gov.uk/sites/default/files/docs/2012/05/park-homes-alba-report---cert-demonstration-action_0.pdf (Accessed 14 July 2017)
[4] Scoping ECO for Park Homes, NEA, March 2014 http://www.nea.org.uk/wp-content/uploads/2014/03/Scoping-Eco-for-Park-Homes.pdf

and potential pitfalls of park home insulation.

1.4 Project timeline

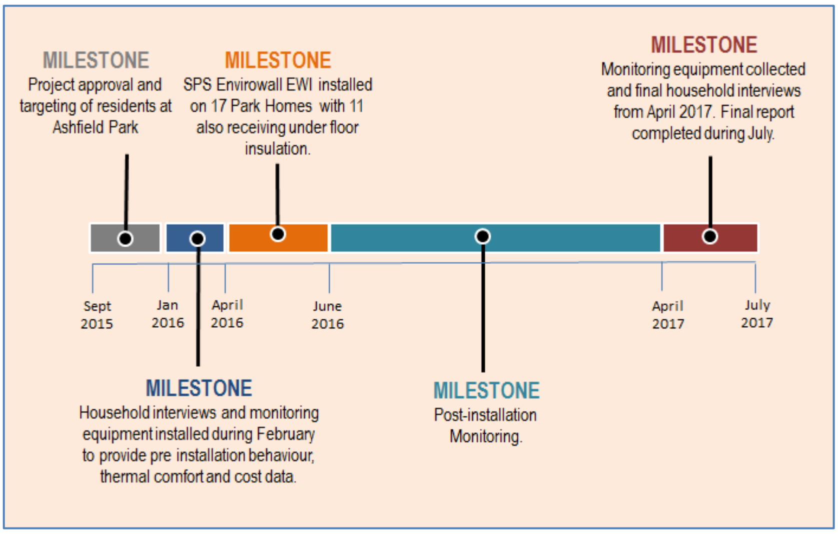

Figure 1.1a Project timeline, SPS Envirowall at Ashfield Park

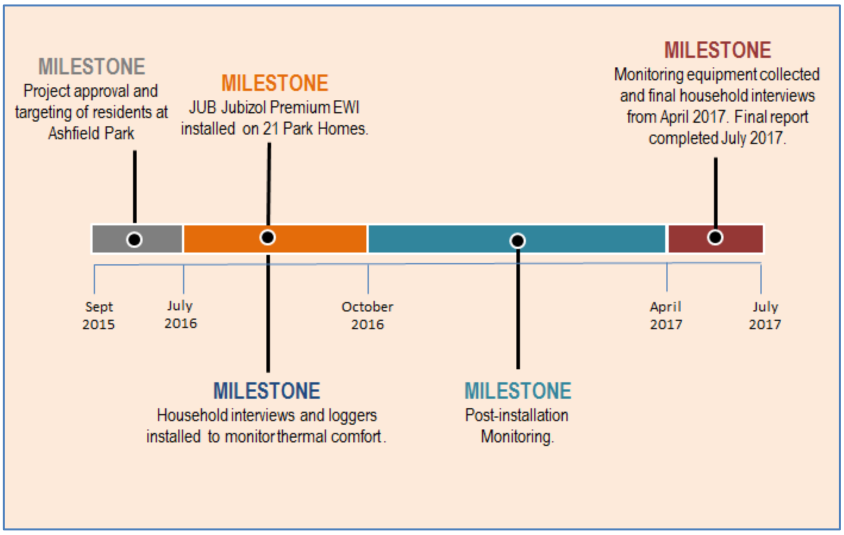

Figure 1.1b Project timeline, JUB Jubizol Premium at Ashfield Park

The project was approved in September 2015, and the main community engagement event recruiting households for installations at Ashfield Park took place in December 2015. Figure 1.1a shows the timeline for the SPS Envirowall installations. The initial interviews with the households that agreed to take part in the monitoring and evaluation process were carried out in February 2016. Thermal and humidity loggers were also placed at the time of the initial interviews. The 17 installations of SPS Envirowall (including 11 with under floor insulation) took place between April and June 2016.

There were 21 installations of JUB Jubizol Premium at Ashfield Park between July and October 2016 (Figure 1.1b). The thermal and humidity loggers were set up and initial household interviews carried out in August 2016.

At Charnwood Park, there were a total of 18 installations between September and November 2016- 13 ParexTherm and 5 Alumasc Swisslab installations. Initial interviews were carried out during April 2016 and thermal and humidity loggers were also set up at the same time.

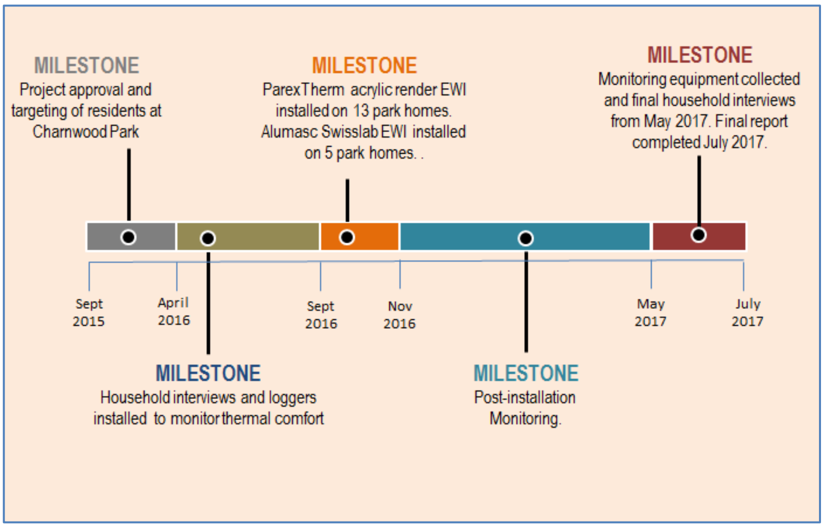

Figure 1.1c Project timeline, EWI Installations, Charnwood Park

A further 5 Alumasc Swisslab installations were carried out at Manifold Road during November 2016, but none of these households were monitored.

The final interviews with the households which had been monitored were carried out during April and May 2017. The temperature and humidity loggers were collected at this time.

1.5 Attracting beneficiaries and establishing the monitored group

YES Energy Solutions identified potential beneficiaries with support from the North Lincolnshire Council Affordable Warmth Officer who was able to provide details of the residents who had approached the council for help with fuel bills, or energy saving advice:

- Letters were sent to households who were potentially eligible which explained the park home insulation scheme and eligibility criteria, as well as monitoring requirements. These were presented as a pre-requisite to joining the scheme. After initial expressions of interest were received, householders were invited to a presentation where the scheme could be explained in detail.
- Households were then visited by a domestic energy assessor from YES Energy Solutions to undertake an initial EPC assessment and feasibility study. A chartered surveyor was engaged to ensure that following installation of EWI the space between park homes would meet fire safety requirements, along with other suitability tests defined in the installation instructions for the insulation system being deployed. Following surveys, householders who wished to proceed officially signed up to the scheme.
- Between February and August 2016, NEA staff placed temperature and humidity loggers in the homes of the monitored group. Initial interviews were completed at this time and historical meter readings and energy bills were also collected.
- One property where insulation measures were not being fitted was used to compare the impact and the resident agreed to have monitoring equipment installed.

Location of project and details of households

The monitored households in the study were located at either Ashfield Park or Charnwood Park in Scunthorpe, North Lincolnshire (Figures 1.2 to 1.4). There were 21 monitored households (which received EWI) at Ashfield Park, and 7 at Charnwood Park. 1 household where no insulation was being fitted agreed to act as a 'control' to compare the impact of the measures. NEA had originally requested 6 control properties, but it was not possible to obtain consent from the wider population on the sites. The monitored households were each allocated a reference number to ensure their anonymity. These technical reference numbers will be used throughout this report when referring to individual households.

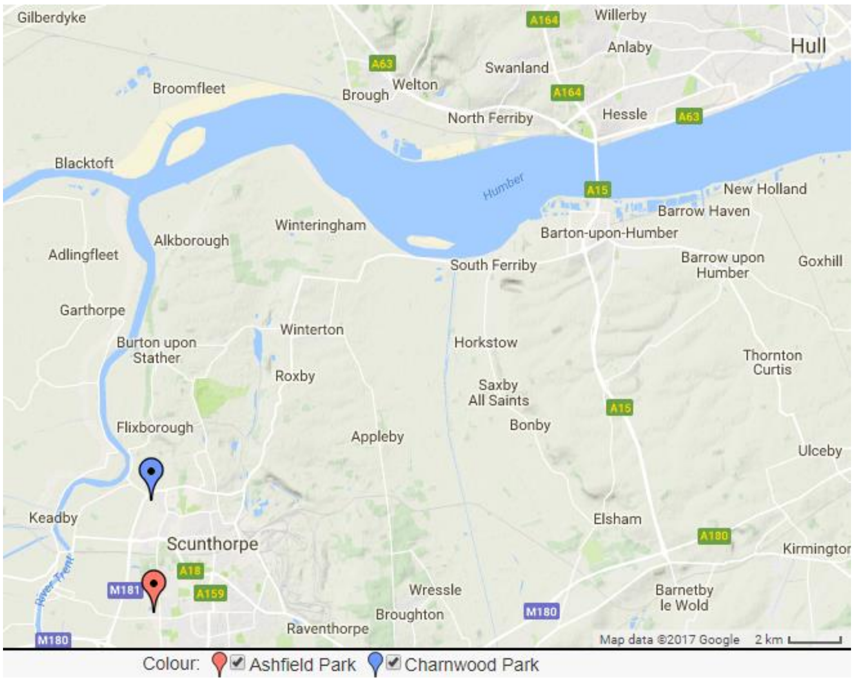

Figure 1.2 Location of park homes sites at Ashfield and Charnwood in Scunthorpe

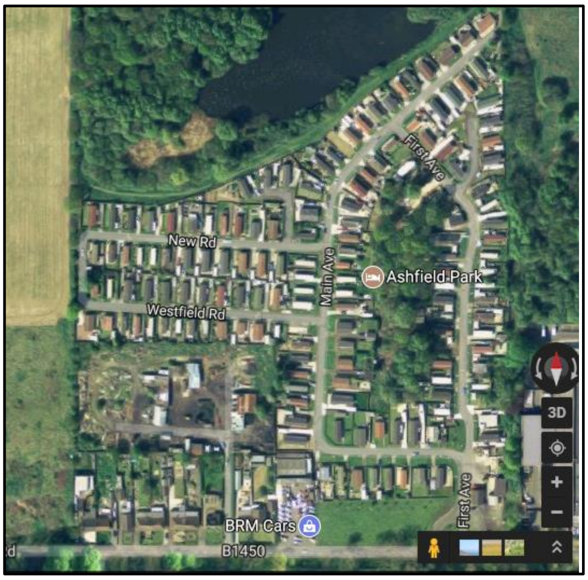

Figure 1.3 Ashfield Park, Scunthorpe

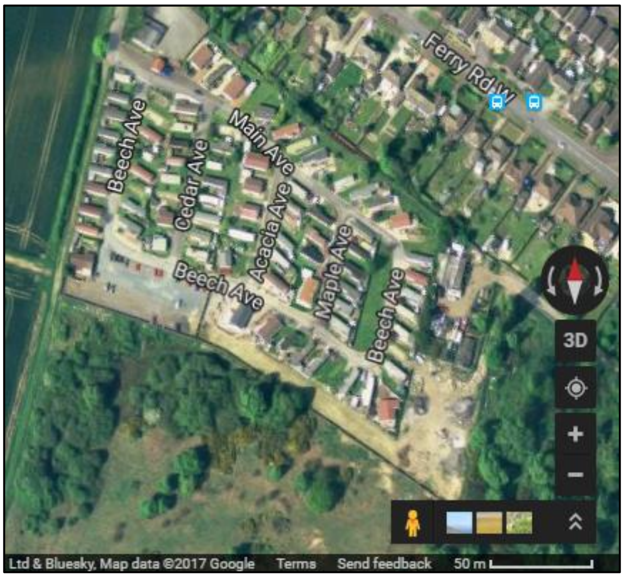

Figure 1.4 Charnwood Park Scunthorpe

Figure 1.5 Example of a park home prior to installation of EWI

1.6 External wall insulation technologies

Overview of EWI installations

EWI is an established technology that improves heat retention in a property, thereby improving its energy efficiency. This should improve the performance of the building fabric, ensuring a warmer living space in winter months, and cooler living space in the summer months. A further stated benefit of EWI installation is improved sound proofing.

EWI has generally been installed in ‘hard to treat’ properties, in particular system built social housing and older solid wall properties. Installation to park homes is an application for EWI systems that is increasingly being explored. It has the potential to significantly enhance the comfort of the residents and the aesthetic appearance of park homes, whilst also extending the lifespan of the properties.

4 EWI systems were monitored in this study: SPS Envirowall, JUB Jubizol Premium System, Alumasc Swisslab and ParexTherm. Each is made up of grey expanded polystyrene insulation (EPS). All measures satisfied the relevant standards including suitability for installation in a park home setting, and that of fire resistance.

The nature of park home substrates (building structure) necessitated extensive pull testing and evaluation to ensure fixing of EWI to park homes could be conducted using established mechanical EWI fixing techniques without risk of present or future damage to substrate or structural elements of the homes. Following pull testing, measures were developed to enhance substrates where necessary. In most instances manufacturers specified fixing techniques were adequate and were used. The exception was ParexTherm, typically an adhesive fixed system, where due to complications with the substrate it was necessary to also use a mechanical fixing technique.

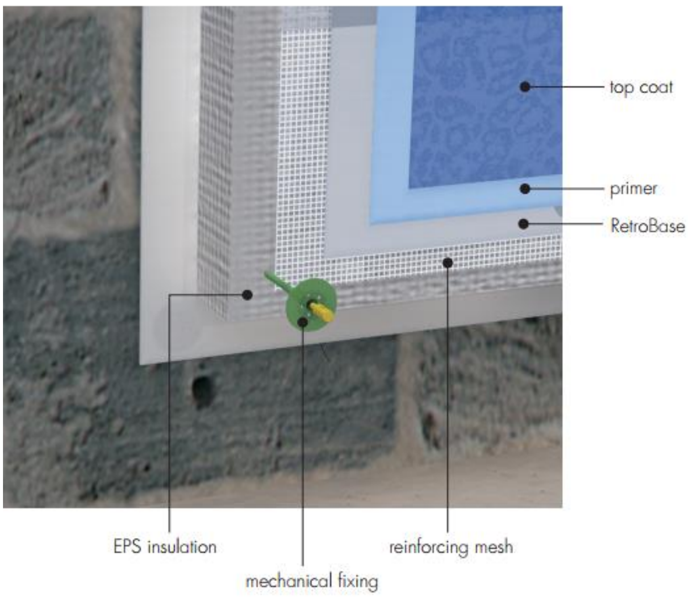

Figure 1.6 SPS Envirowall

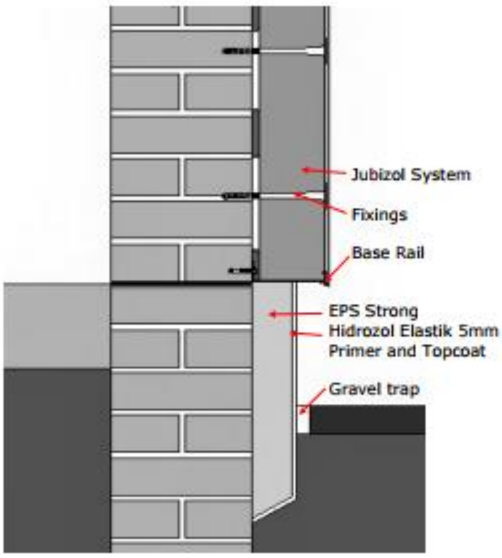

Figure 1.7 JUB Jubizol Premium System

Figure 1.8 Alumasc Swisslab

Figure 1.9 ParexTherm

Figure 1.6: SPS Envirowall (installed to 10 monitored households)

Mechanically fixed BBA (British Board of Agrément)approved system, 100mm thick. Acrylic render finish available in a variety of palettes. Subject to installation by an approved contractor, the system comes with 25 year SWIGA (Solid Wall Insulation Guarantee Agency) and 25 year manufacturer's guarantees. The system has been tested to achieve a U-value of 0.3 W/m^2K.

Figure 1.7: JUB Jubizol Premium (installed to 11 monitored households)

Mechanically fixed ETA approved system, 90mm thick. Finished with silicone render which the manufacturer claims is self-cleaning, and mould and algae resistant. Subject to installation by an approved contractor, the system comes with 25 year SWIGA and a 25 year manufacturer's guarantee.

Figure 1.8: Alumasc Swisslab (installed to 1 monitored household)

A BBA approved mechanically fixed system with textured rendered finish. The manufacturer claims the finish is mould resistant and vapour permeable subject to installation by an approved contractor. Alumasc EWI systems are available with a range of warranties, subject to expected design life of a specific system installed.

Figure 1.9: ParexTherm Acrylic Render system (installed to 6 monitored households)

This is a standard EWI system that when installed in typical circumstances use an adhesive bond to substrate. It was found when installing to park home substrates it was also necessary to use a mechanical fixing to augment the adhesive. The system is BBA approved and carries a manufacturer's warranty.

Kingspan Thermafloor 50mm floor insulation (installed to 7 monitored households)

Thermafloor is an established floor insulation system. For park homes, it is installed using the same method as applied to joist and board floors in traditional buildings. Installation to monitored households was carried out by YES Energy Solutions using a qualified installer. It was found that installation was not possible at all of the park homes due to health and safety concerns, and difficulties with access to under floor areas of park homes.

Stage 1

Stage 2

Stage 3

Stage 4

Figure 1.10 Installing EWI on park homes

Installation of EWI on park homes

Prior to each installation, a survey was completed to ascertain the impact on the spacing between the park homes and ensure it met relevant fire regulations. Also a pull test was conducted on subject park home substrates to determine ability to support the additional mass of EWI. Pull tests are conducted by specialists using precise protocols to determine the energy required to pull out a fixing. Where pull tests failed, additional measures were identified to strengthen and enhance the structure prior to installing the EWI. The work was conducted by a single experienced contractor, Kelvick Ltd, and the length of time taken for installations was dependent upon the complexity of the job and weather conditions.

Installations typically involved first attaching marine plywood to the outside of the park home to provide strengthening and a suitable surface for the insulation board to be attached (Figure 1.10a). A breathable membrane layer was fitted (Figure 1.10b) before the grey EPS insulation. The insulation board was cut to shape with a saw and was secured with fixing anchors (Figure 1.10c). Adhesive mortar was applied onto the insulation board and a sheet of reinforcing mesh was embedded into the mortal. A base coat was applied to the cured reinforcement coat and the final decorative render was subsequently applied by trowel. Figure 1.10d shows the appearance of one of the park homes after completion of the EWI installation.

2 Social impact evaluation

2.1 Householder demographics and heating behaviour (initial questionnaire)

The age brackets for the monitored householders in the study are shown in Figures 2.1. At Ashfield Park the largest proportion of households interviewed were within the 60-69 age range, but there were only 4% more in that category than households in the 70-84 and 30-59 age brackets.

At Charnwood Park the largest proportion of households interviewed were in the 70-84 age bracket, with 33% of households falling within the 30-59 age range. This indicates that, although generally a majority of householders living in park homes fall within an older demographic, in fact the park home sites monitored in this study were more diverse, with a significant proportion of households of working age.

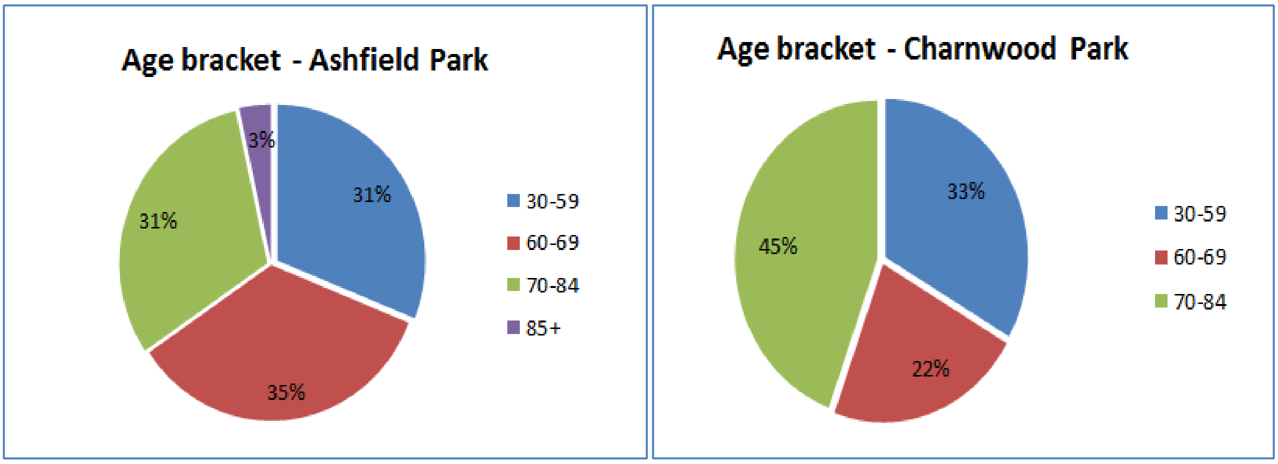

Figure 2.1 Age bracket for householders interviewed at Ashfield Park and Charnwood Park

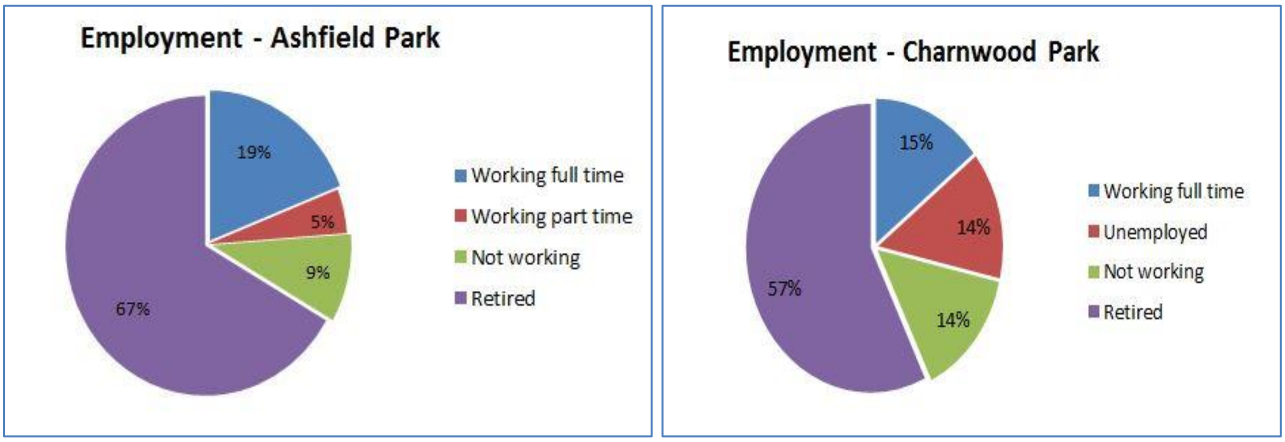

Figure 2.2 Occupation and employment status at Ashfield Park and Charnwood Park

Figure 2.2 shows the occupation and employment status of the main energy bill payers for both Ashfield and Charnwood Parks. At both sites the largest proportion of householders were retired (67% and 57% for Ashfield and Charnwood respectively), with the next largest percentage of householders working full time at both parks. Ashfield Park was restricted to those over 50 years old, but there were no age restrictions at Charnwood Park. A greater proportion of households were unemployed when initial interviews were taken at Charnwood Park than was recorded at Ashfield.

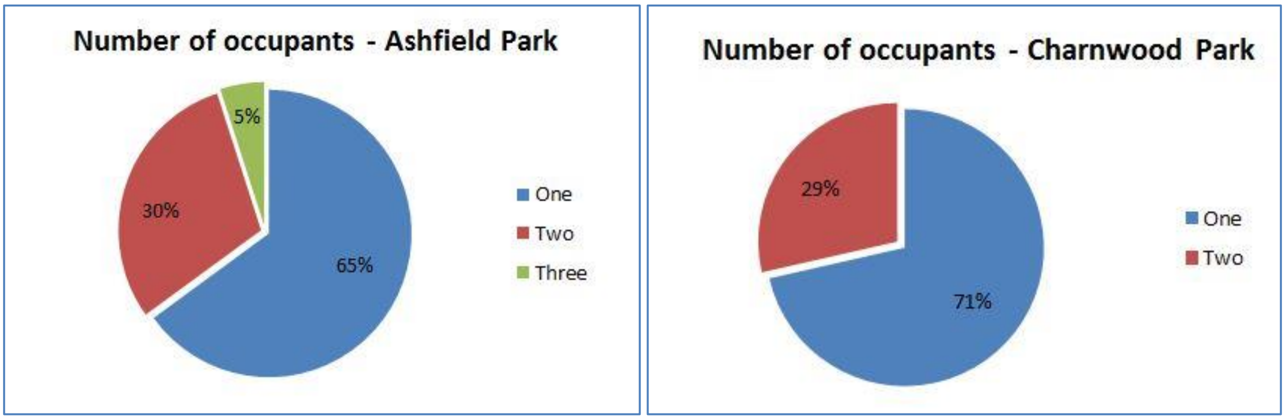

Figure 2.3 Number of occupants, Ashfield Park and Charnwood Park

Figure 2.3 shows the majority of households were single people, with 65% and 71% of households at Ashfield and Charnwood Parks respectively. The next largest group was households with 2 occupants, with 30% at Ashfield and 29% of households at Charnwood. At the time the initial questionnaire was taken, only 5% of households at Ashfield Park had more than 2 occupants, with no households larger than 2 occupants at Charnwood Park.

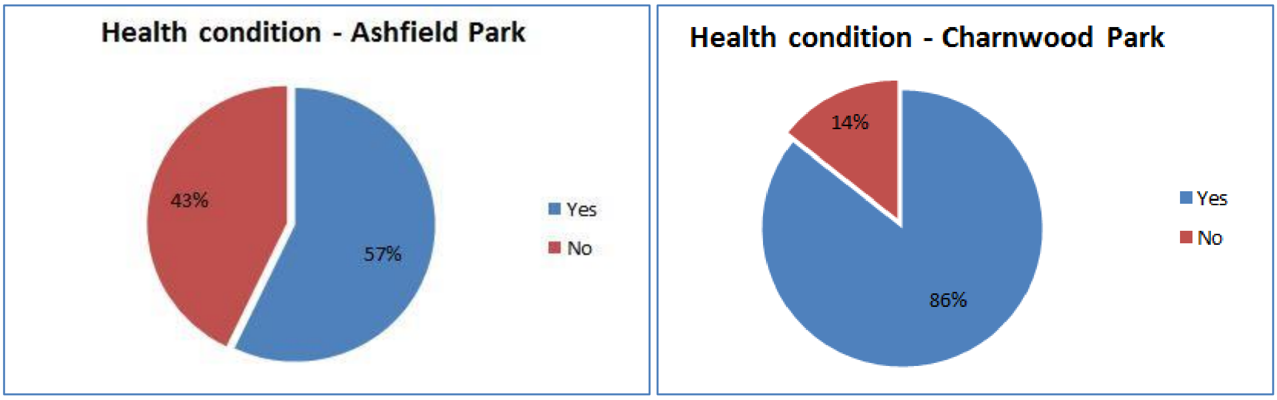

Figure 2.4 Percentage of households with a disability or long term health condition made worse by the cold

Figure 2.4 shows a majority of the occupants had a health condition made worse by the cold at the time of initial survey, at both Ashfield and Charnwood Parks. Stated health conditions included asthma, rheumatism, stroke, depression and cancer. Several householders in all age groups also had limited mobility. This indicates a majority may be more vulnerable due to a health condition or disability in the home made worse by the cold and more at risk if suffering from fuel poverty. Ill health may be exacerbated by the poor thermal performance, particularly of older park homes.

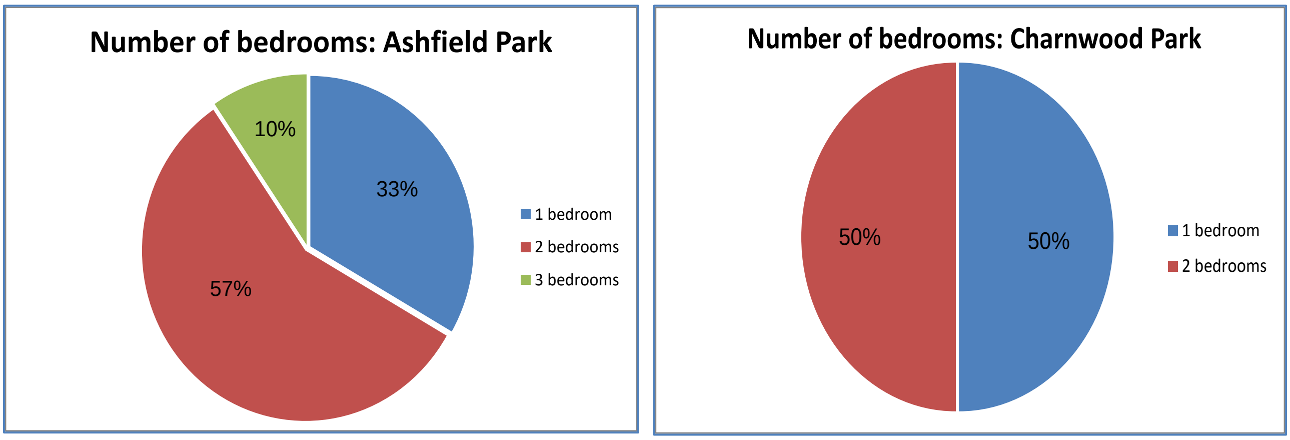

Figure 2.5 Number of bedrooms, Ashfield Park and Charnwood Park

Figure 2.5 shows 57% of households at Ashfield Park lived in 2 bedroom park homes. The next largest proportion had 1 bedroom homes, while only 10% had larger 3 bedroom park homes.

All park homes at Ashfield were connected to mains gas and had gas central heating installed. At Charnwood Park, half the monitored households had 1 bedroom and half had 2. All these monitored households relied on LPG to fuel gas central heating.

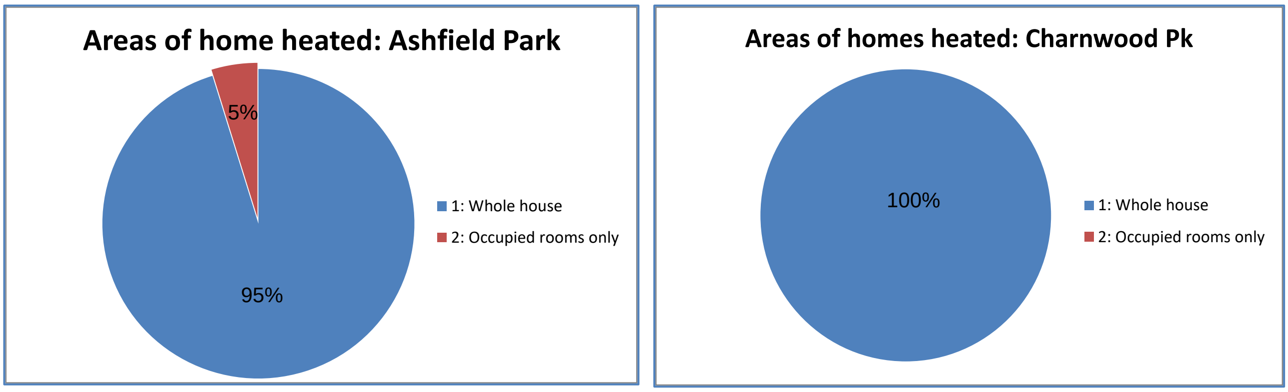

Figure 2.6 Areas of home heated before installation of measures, Ashfield Park and Charnwood Park

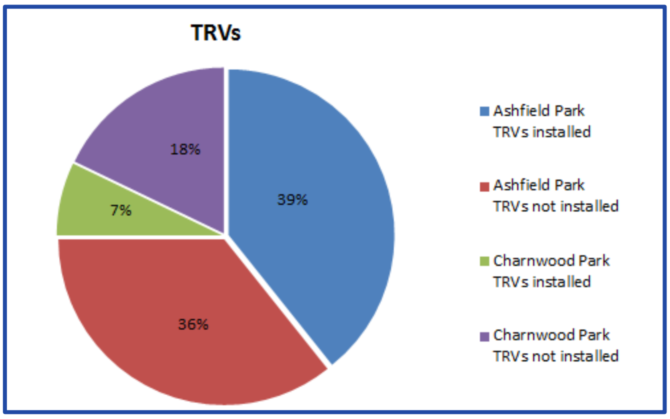

Figure 2.7 TRVs installed/not installed to park homes

Figure 2.6 shows before installation of measures, 95% of households at Ashfield Park and all households at Charnwood Park heated all rooms in their park homes regardless of whether they were occupied or in regular use. This may be a consequence of some park home gas central heating systems reported as not having thermostatic radiator valves (TRVs) installed (Figure 2.7), preventing greater control of the heating system in rooms where heat is not always required.

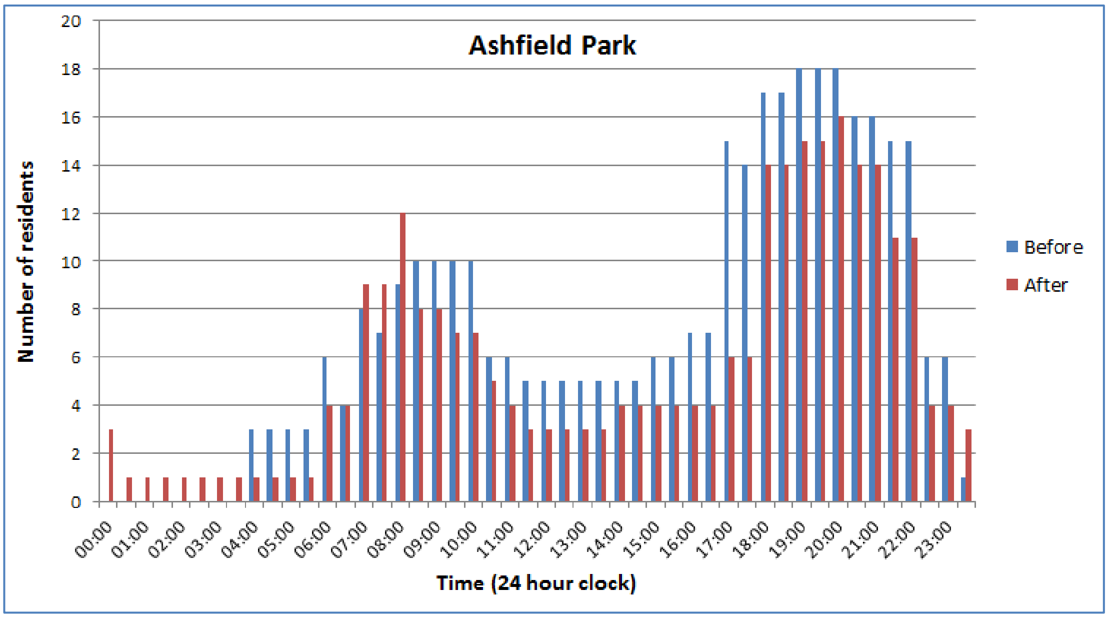

Figure 2.8 Times when it was important for the households to have a warm home (Ashfield Park)

2.2 Qualitative feedback given in questionnaire, before and after periods

Households were asked whether there were specific times of the day they liked to have a warm home. This might be when washing/dressing, first thing in the morning, when they arrive home in the evening, or when they are least active e.g. sitting down watching television in the evening. The preferred heating times observed here, have been used to inform analysis of thermal comfort in this report. For example, in thermal comfort analysis, the period 17.00 to 21.00 was used to measure the 'evening heating period'.

Figure 2.8 shows questionnaire responses from monitored households at Ashfield Park, with a comparison between responses taken before and after installation of measures. It is observed that during the 'before period' a majority of households liked a warm home between the hours of 07.00 and 11.00 in the morning, and 17.00 to 22.00 in the evening. A small group of households also liked to maintain a warm home throughout the daytime, indicating they probably remained within the home most of the time.

Questionnaire responses taken after installation of measures show a majority continue to prefer a warm home between 07.00 and 11.00 in the morning. However, the number with this preference is lower than for the 'before' period. The evening heating period post installation was 18.00 to 22.00. This preference was an hour later than the 'before' period and again this preference was expressed by a smaller number of households. The number of households who maintained a heated home throughout the daytime also reduced, although a single household stated they now required a warm home throughout the night and early hours.

Questionnaire responses from the final interview showed a change in the warmth requirement, compared to the period before the measures were installed. This may indicate installation of EWI caused park homes to retain a more consistent internal temperature, leading households to adhere less to specific heating periods; or the specified heating period doesn't have to be as long in order to allow for a comfortable environment. While changes or deterioration in the health conditions of some households may have influenced changes in the periods they required warmth, no other obvious social or circumstantial reasons were given in the questionnaire that may have influenced data.

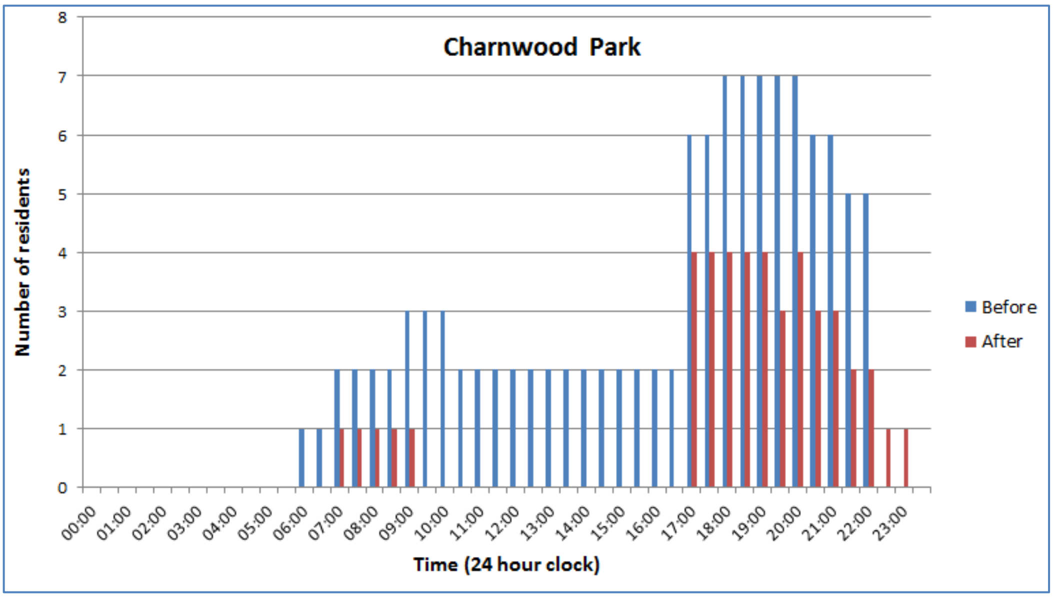

Figure 2.9 Times when it was important for the households to have a warm home (Charnwood Park)

Figure 2.9 reflects monitored households' at Charnwood Park preferred heating times before and after installation of the EWI.

A significant number of households pre-installation said they prefered a warm home between 09.00 and 10.00 in the morning.This may suggest the park homes subject to monitoring had poor thermal efficiency prior to measures being installed, and rapid heat loss following a morning heating period caused households to operate heating throughout the day. During the evening, the highest proportion of households in the 'before'said they preferred a warm home between 18.00 and 20.00, although most wanted an extended period from 17.00-21.00.

Figure 2.10 shows that 1 household at Ashfield Park had a new boiler fitted during the monitored period. This may have led to a reduction in gas consumption due to a more modern and efficient boiler. Prior to installation of EWI, 7 households used supplementary heating in addition to the primary gas central heating system to keep warm and cooling measures in the summer. This figure reduced to 1 household after installation of EWI, illustrating changed householder behaviour and a consequent reduction in energy consumption. At the Ashfield site, 1 household had used a dehumidifier to reduce humidity within their home. They no longer found it necessary to use their dehumidifier post installation of EWI. This also indicates a positive impact on energy use and humidity levels.

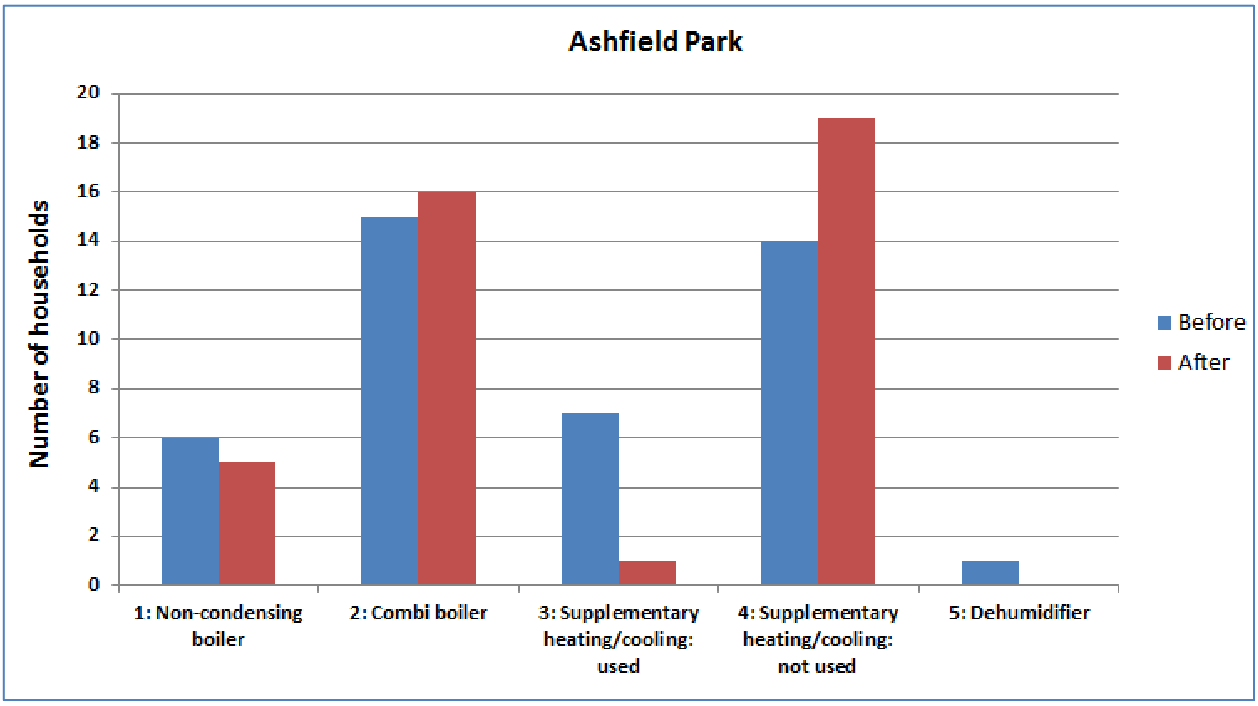

Figure 2.10 Changes in boiler type, useage of supplementary heating/cooling and dehumidifier, before/after

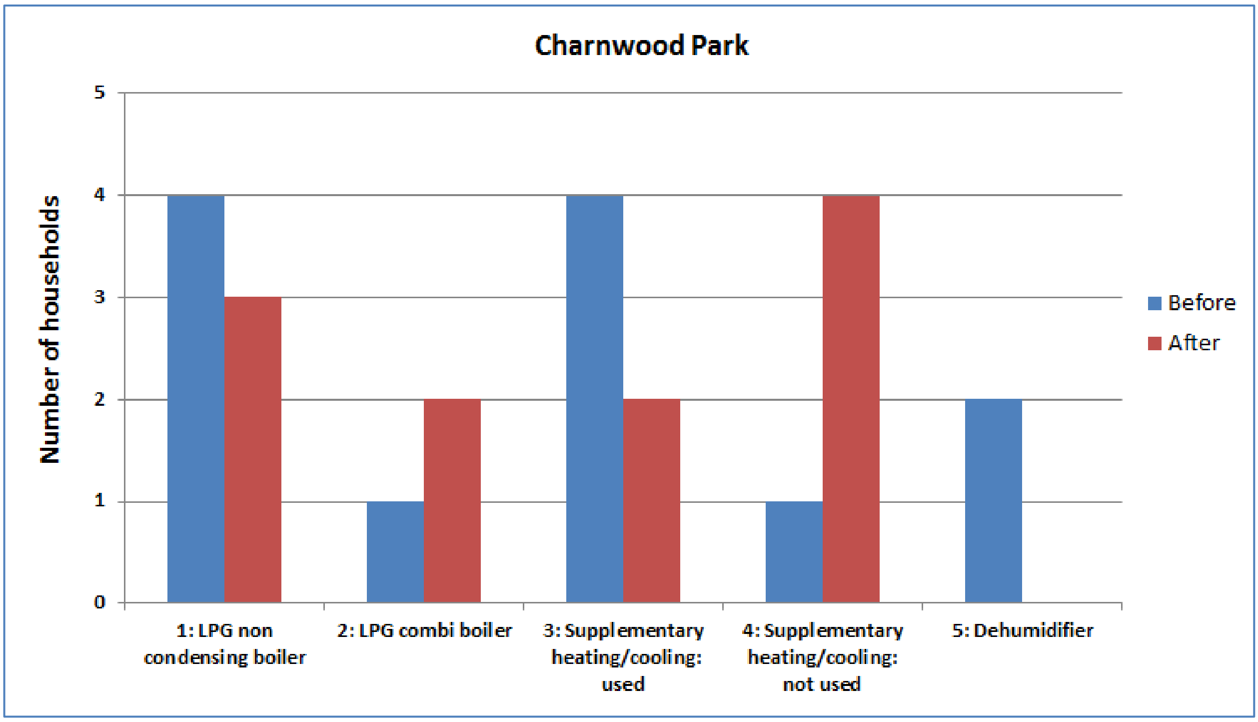

Figure 2.11 Changes in boiler type, useage of supplementary heating/cooling and dehumidifier, before/after

Figure 2.11 displays the same data for households at Charnwood Park. Questionnaire responses indicate 2 households changed their boiler type during the monitored period from older non-condensing LPG boilers, to more efficient LPG condensing combi boilers. This should have had an additional impact on energy consumption beyond that which may be attributable to EWI installation. When households were asked at the start of the monitored period whether they used supplementary heating and cooling in addition to their principal system, 4 households responded they did with 2 saying they did not.

At the end of the monitored period a significant change of behaviour is reflected, with 4 households responding they no longer felt the need to use supplementary heating and cooling, and just 1 household in the monitored group (who received measures) saying they did. A further household did not provide a response to this question. It was also found that 2 households who used dehumidifiers at the start of the monitored period no longer found their use necessary when the final questionnaire was collected. The responses from the Charnwood residents mirror those in the larger and more comprehensive data set of Ashfield. This indicates a degree of consistency that can contribute to the findings of this study.

2.3 Qualitative feedback given post installation of measures

	Tech Ref	Changes/new appliances during monitored period that may impact energy consumption (not including measures subject to monitoring)	Change of energy provider/tariff during monitored period
Ashfield Park	T-01	New gas boiler in January 2016	Changed provider/tariff
	T-02		Changed tariff
	T-03		Changed provider
	T-04		Changed tariff
	T-05	TRVs installed/1 radiator replaced in bedroom during study	Changed tariff
	T-06		
	T-07		Changed provider
	T-08		
	T-09	Double glazing (March 2016), new boiler (January 2017)	
	T-10		
	T-00	New UPVC windows/doors and replacement roof (Summer 2016)	Changed provider
	T-35	New cooker	Changed provider
	T-36	New gas boiler along with dishwasher, fridge freezer and electric plinth heater in new kitchen (December 2016)	
	T-37		Changed tariff
	T-38		Changed tariff/Direct Debit/online billing
	T-39		
	T-40		
	T-41		Changed provider
	T-42		Changed tariff
	T-43		Changed tariff
	T-44	New boiler/radiators/TRVs installed (about December 2015)	
Charnwood Park	T-11		
	T-12		
	T-20	Gas hob and oven replaced by gas hob and electric oven in July 2016	
	T-21	Combi boiler installed April 2017	
	T-24		
	C-15	New boiler in June 2016, but still no thermostat or TRVs	

Table 2.12 Changes during monitored period that may impact energy use or household perception of energy cost

Table 2.12 shows changes that may impact fabric performance or energy consumption of households in the monitored group.

Ashfield Park households are connected to mains gas. Many households changed tariff or provider during the monitored period following advice from NEA staff which led to energy bill savings unrelated to the measures installed.

Charnwood Park households use bottled LPG with no access to more competitively priced supplies. Most purchased 47kg LPG bottles when required from a local retailer and the costs remained the same during the study.

During the final interview, 2 households at Ashfield Park reported new or worsening health conditions that may have led to a greater demand for warmth in the home. A further household had an extra family member move in for 3 months. This may have caused an increase in energy consumption during that period.

A single household of Charnwood Park reported a decline in mobility during the monitored period. This may have caused longer periods of time within the home, and a subsequent increase in heating use and energy consumption.

2.4 Satisfaction with the installation process

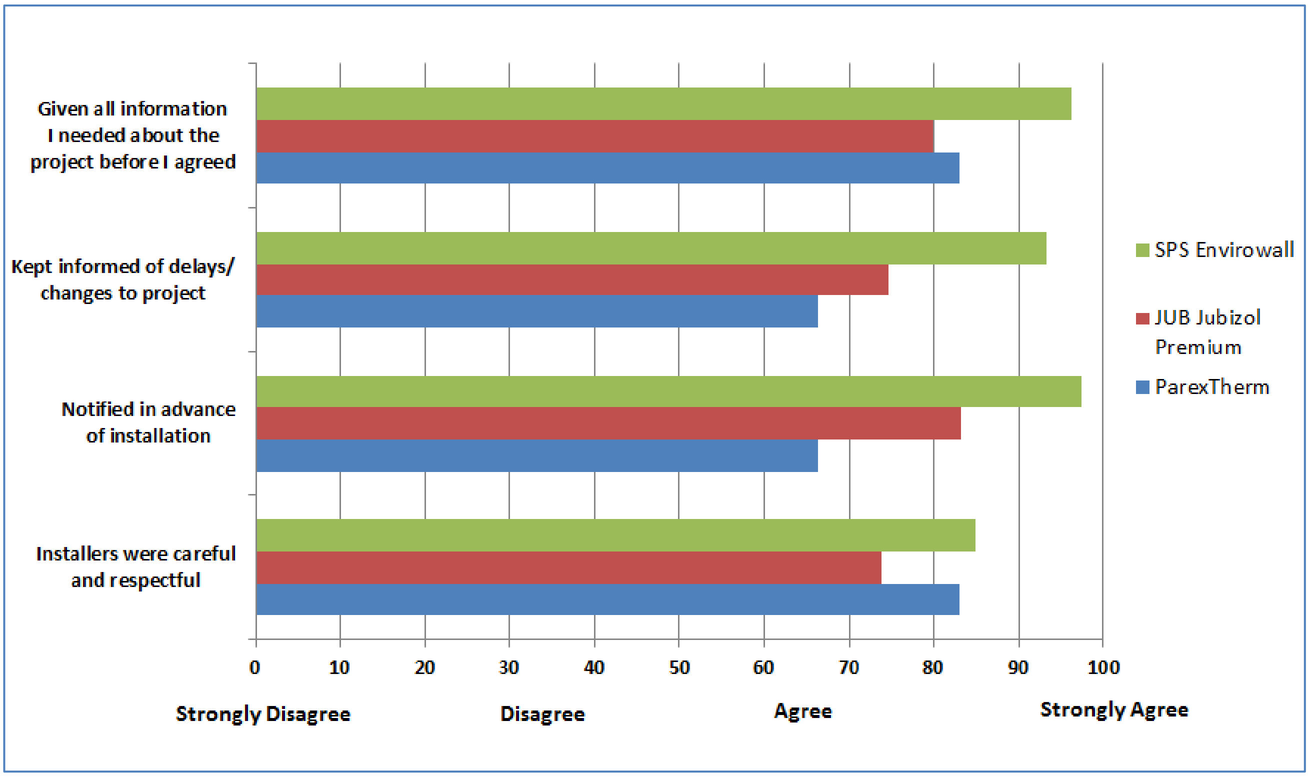

Figure 2.13 Assessment of household satisfaction with the installation process

During the final interview, the residents were asked a series of questions relating to their satisfaction with the organisation and installation of the EWI. Figure 2.13 shows the scores relating to the statements posed and reflect the performance of the contractor during different phases of the project not the performance of the product.

2.5 Perceived comfort and benefits

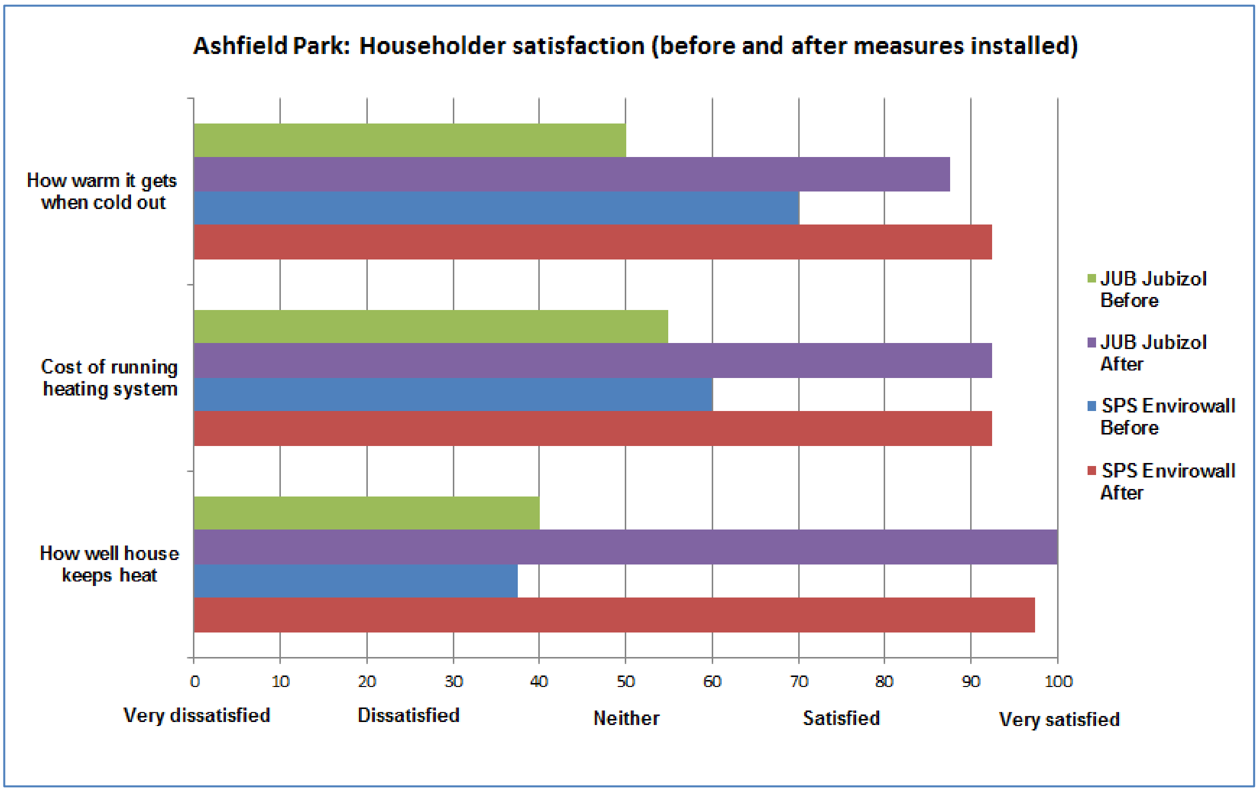

Figure 2.14 Satisfaction of households (Ashfield Park) before and after installation of measures

Residents were asked to rate their satisfaction with their heating system using one of the following responses: ‘very dissatisfied’, ‘dissatisfied’, ‘neither’, ‘satisfied’ or ‘very satisfied’. Each of these responses was assigned a score where ‘very dissatisfied’ scored zero and ‘very satisfied’ scored 100. An average (mean) score of between zero and 100 was calculated for each of the installed measures. Responses from households at Ashfield Park are shown in Figure 2.14.

Before measures were installed, residents of households where the JUB Jubizol Premium EWI system was fitted stated they were neither satisfied nor dissatisfied with how warm their park homes got when it was cold outside. Following installation of EWI, at the end of the monitored period the majority of householders stated they were either satisfied or very satisfied with how warm their homes get when cold outside. This household perception indicates a considerable benefit to human comfort within homes following installation of the JUB Jubizol Premium EWI system.

Households that received the SPS Envirowall EWI system were asked the same question before and after installation of the measure. Before, it was found that a higher number of households were satisfied with how warm their park homes got when cold outside. When asked at the end of the monitored period, responses stated a slightly higher degree of satisfaction than for households in receipt of the JUB Jubizol Premium system. These results may be a consequence of householders perceiving benefits differently rather than a direct comment upon the efficacy of individual EWI systems.

When householders at Ashfield Park were asked about the cost of running their heating system prior to installation of measures, most responded they were neither satisfied nor dissatisfied. Following installation of both JUB Jubizol Premium and SPS Envirowall EWI systems, households in receipt of both systems responded they were mainly very satisfied with impact upon cost of heating households. This suggests householders perceived a positive benefit in this regard from both EWI systems.

When asked how well their park home retained heat before measures were installed, the majority of householders responded they were dissatisfied. This response may be indicative of poor thermal performance of older park homes. Following installation of measures, those households with JUB Jubizol Premium fitted to their park home all responded they were very satisfied with how well their home kept heat in. This is a highly positive response based upon householder perception. For households fitted with SPS Envirowall EWI, the majority responded they were very satisfied with some households satisfied. However, this again is a very positive reflection of EWI and perception of benefits by householders.

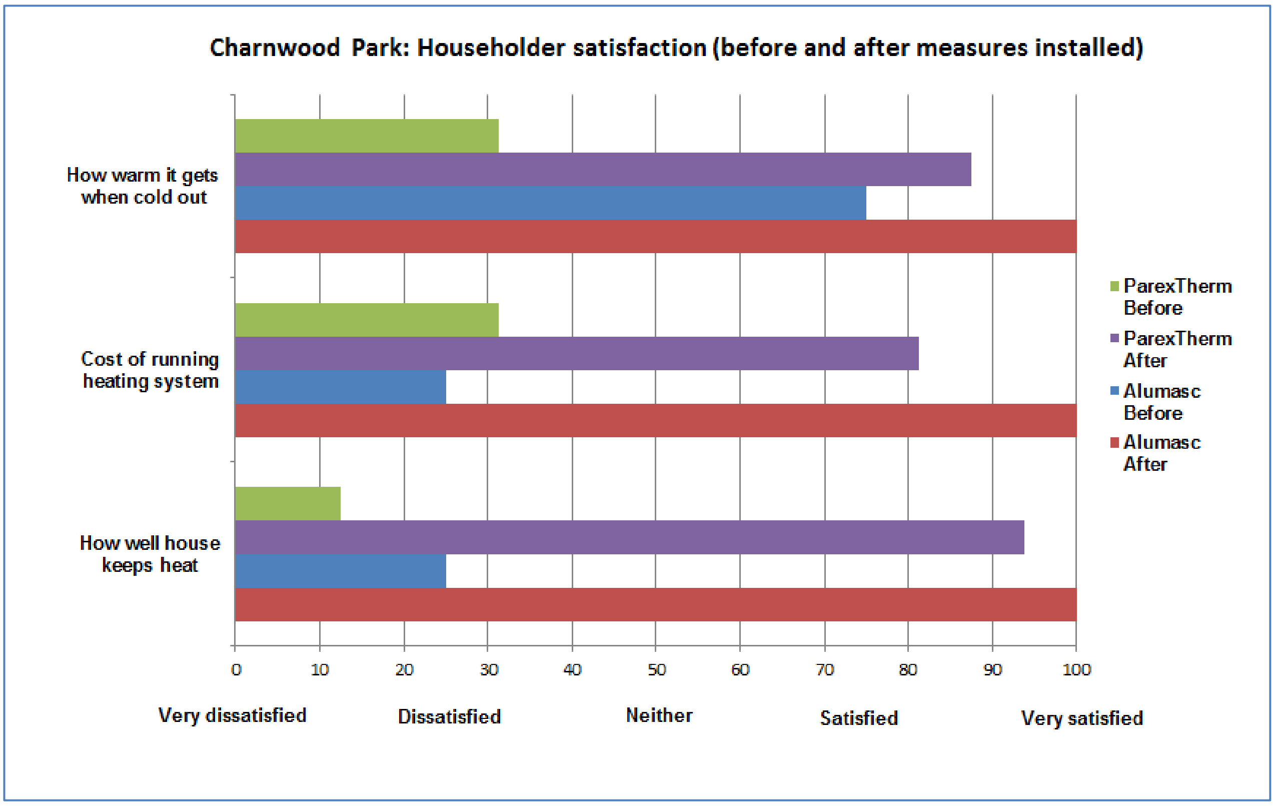

Figure 2.15 Satisfaction of households (Charnwood Park) before and after installation of measures

Satisfaction levels from Charnwood Park shown in Figure 2.15 were based upon a smaller group of households than for SPS Envirowall and JUB Jubizol Premium at Ashfield Park. For Alumasc Swisslab, the householder perception was based on a single household, while for ParexTherm it was based on 4 households who completed both the initial and final questionnaires.

The pattern of responses before and after installation at Charnwood was broadly comparable to that at Ashfield Park, with a significant improvement in satisfaction after installation of the EWI. When asked about how warm their home gets when cold outside, prior to installation of EWI, the household who received Alumasc Swisslab was ‘satisfied’ and after installation they were ‘very satisfied’. The households with the ParexTherm system were mainly ‘dissatisfied’ with how warm their home got before the installation, but either ‘satisfied’ or ‘very satisfied’ afterwards.

Before installation of Alumasc Swisslab, the household was ‘dissatisfied’ with the cost of running their heating and afterwards ‘very satisfied’. Opinions ranged from ‘very dissatisfied’ to ‘satisfied’ over the cost of the heating prior to the ParexTherm installations. However the households were either ‘satisfied’ or ‘very satisfied’ after the ParexTherm was fitted.

The greatest improvement in levels of satisfaction at Charnwood Park was found on the question of how well their house keeps in the heat. This was also seen at Ashfield Park, but the change in satisfaction was less dramatic, probably due to the larger sample size.

The household with Alumasc Swisslab was ‘dissatisfied’ with how well their house kept in the heat before the insulation was fitted, but ‘very satisfied’ afterwards. Before the ParexTherm acrylic render system was fitted, the households were either ‘dissatisfied’ or ‘very dissatisfied’ with how well the house kept in the heat. After the installation, the majority of residents with ParexTherm were ‘very satisfied’ with heat retention in the home.

1 of the households at Charnwood Park with a ParexTherm installation noticed a real difference in how the household retained the heat. They said that previously on cold nights the temperature would drop to 8 to 10°C, but after insulation it only dropped to 12°C. They also said their home was much warmer when they returned home after being out and they were definitely using less gas.

A similar response was given by a householder at Ashfield Park who had a JUB Jubizol Premium installation. They said they “don’t need the heating on so high or as long as previously as the home holds the heat in better. We would recommend anyone to have EWI installed”.

A single household at Charnwood Park who had the ParexTherm acrylic render system said they were: “Absolutely satisfied with the EWI. It was the best thing I’ve had done. I’ve seen a real difference in the comfort of my home. It’s lovely”.

Reduced bills and an improvement to the home were noted by a household with SPS Envirowall at Ashfield Park. They said the installation was: “Well worth having done. My direct debit on my gas has halved and my home looks better too”.

Households were also asked about potential benefits following installation of the EWI. The responses in the form of percentages of the households at both Ashfield Park and Charnwood Park are shown in Figure 2.16. These were based on 10 households with SPS Envirowall, 10 with JUB Jubizol Premium, 4 with ParexTherm and 1 with Alumasc Swisslab. Overall, the responses were very favourable, with 75% or more of households with each EWI technology seeing 7 of the 8 benefits.

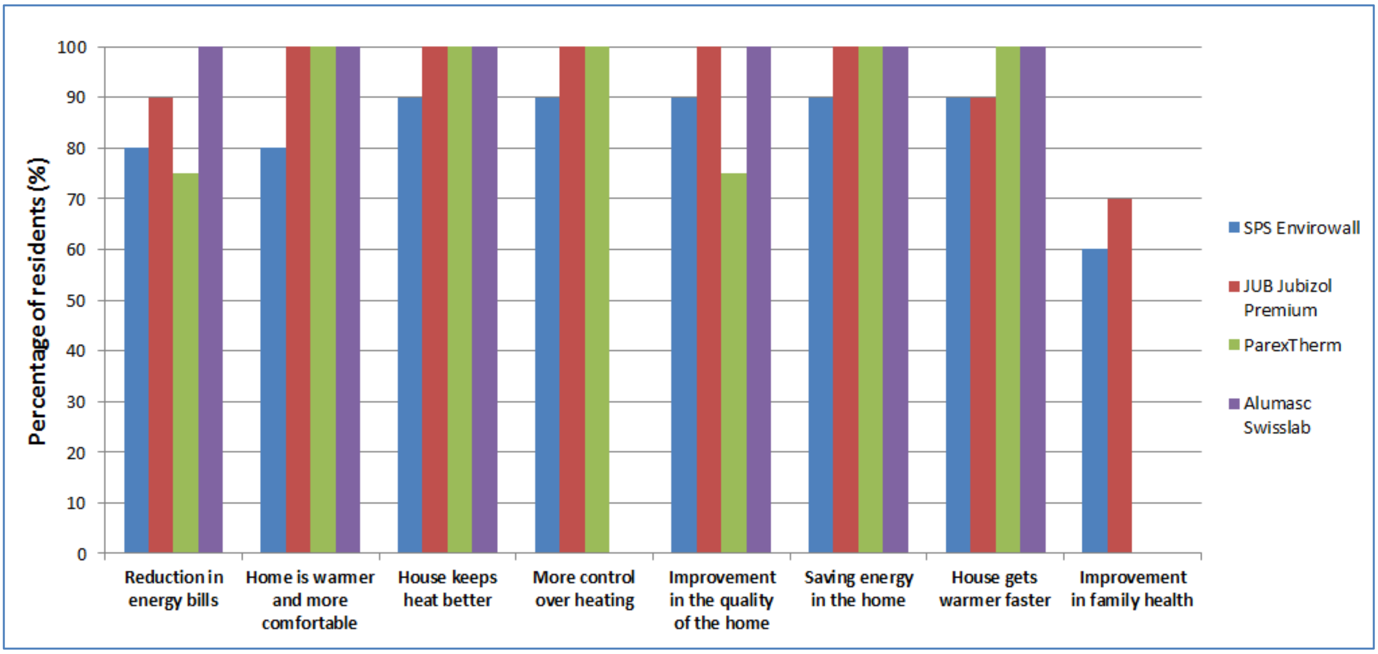

Figure 2.16 Benefits perceived by households after installation of the external wall insulation

For the households with SPS Envirowall, 80% felt they benefited from a reduction in energy bills and their home was warmer and more comfortable. 90% thought their house kept in the heat better, got warmer faster, they were saving energy and there was an improvement to the quality of their home. Following the installation, 60% of the households with SPS Envirowall thought there was an improvement to their family's health.

All the households who had JUB Jubizol Premium EWI thought there was an improvement to the quality of their home, their home was warmer and more comfortable, kept in the heat better and they had more control of their heating. 90% thought their house got warmer faster and they were saving energy in the home and thought they saw a reduction in their energy bills. Among these households, 70% saw an improvement in their family health after the EWI was installed.

The responses from the households with ParexTherm and Alumasc installations were again very favourable. The household with Alumasc noted 6 of the 8 benefits.

All the households with ParexTherm felt their home was warmer and more comfortable, their house kept in the heat better, they were saving energy in the home and the house warmed faster. 75% of the households reported a reduction in their energy bills and thought there was an improvement to the quality of their home.

Additionally 5 households reported that their home was less noisy and 5 also commented on a reduction in condensation.

"Really pleased and glad I had it done. It has increased the value of my home as well as reduced my bills. Really love how it has made my home look too" Household at Charnwood Park

3 Technical evaluation

3.1 Monitored households

Each of the monitored households in the study was allocated a technical reference number to ensure the anonymity of the households. There were a total of 28 households with EWI that were monitored along with 1 control household at Charnwood Park that was unable to have an installation due to spacing issues.

Table 3.1 shows details of the 10 monitored households with SPS Envirowall at Ashfield Park. Out of these, 7 households also had under floor insulation. Manufacture dates were obtained where possible from a badge on the park homes. For the households with SPS Envirowall, the park homes were manufactured between 1962 and 1992.

The level of insulation at manufacture for park homes is specified by the British Standard BS 3632. Table 3.2 shows that the maximum U-value at manufacture has decreased and therefore the thermal performance requirements increased following revisions of BS 3632. Older park homes such as T-06 and T-08 are likely to have been built with lower levels of insulation than newer models such as T-05. The thermal performance of the building fabric is likely to have deteriorated over time, assuming no refurbishments. For more information see Appendix 2. In this project, YES Energy Solutions targeted older park homes with poorer insulation for the retrofits.

Details such as the floor area, SAP rating, and space and water heating demand were obtained from Energy Performance Certificates (EPC) lodged before and after the installation of the EWI. The average SAP rating increased from 50 to 59 after the SPS Envirowall insulation was fitted. Before the installations, the space and water heating demand was in the range 9,929 to 14,030 kWh but this decreased to between 6,907 and 11,170 kWh after insulation.

Tech Ref	EWI Technology	Other improvements	Date of manufacture	Floor Area	Pre-EWI SAP Rating	Pre-EWI Space & Water Heating Demand (kWh)	Post-EWI SAP Rating	Post-EWI Space & Water Heating Demand (kWh)	Heating Fuel
T-01	SPS Envirowall	Underfloor insulation	1982	53	51	14030	62	9622	Mains gas
T-02	SPS Envirowall		1986	36	54	12044	62	8742	Mains gas
T-03	SPS Envirowall	Underfloor insulation	1975	41	54	12847	66	8018	Mains gas
T-04	SPS Envirowall	Underfloor insulation	1982	53	52	13661	63	9231	Mains gas
T-05	SPS Envirowall		1992	36	50	11189	60	7873	Mains gas
T-06	SPS Envirowall	Underfloor insulation	1970	30	34	12897	38	11170	Mains gas
T-07	SPS Envirowall	Underfloor insulation	1980	36	54	9929	63	6907	Mains gas
T-08	SPS Envirowall		1962	46	50	13611	57	10464	Mains gas
T-09	SPS Envirowall	Underfloor insulation	1987	57	57	11009	65	8113	Mains gas
T-10	SPS Envirowall	Underfloor insulation		34	43	11454	56	7802	Mains gas
Maximum			1992	57	57	14030	66	11170	
Minimum			1962	30	34	9929	38	6907	
Average			**1980**	**42**	**50**	**12267**	**59**	**8794**	

Table 3.1 Details of monitored households receiving SPS Envirowall external wall insulation at Ashfield Park

BS Standard	U-value (W/m²K) Wall	Floor	Roof
BS 3632: 1970	1.70	1.70	1.70
BS 3632: 1981 / 1989	1.00	1.00	0.60
BS 3632: 1995	0.60	0.60	0.40
BS 3632: 2005	0.50	0.50	0.35
BS 3632: 2015	0.35	0.35	0.20

Table 3.2 U-values from BS 3632 for householdial park homes[5] [6]

5 Cert demonstration action insulation improvements to residential park homes scheme Ref: SSEN09132, Alba Building Sciences Ltd, June 2011 https://www.ofgem.gov.uk/sites/default/files/docs/2012/05/park-homes-alba-report---cert-demonstration-action_0.pdf (Accessed 14 July 2017)

6 Actis Insulation Solutions http://www.insulation-actis.com/documentations/183pdf3.pdf (Accessed 14 July 2017)

Tech Ref	EWI Technology	Other improvements	Date of manufacture	Floor Area	Pre-EWI SAP Rating	Pre-EWI Space & Water Heating Demand (kWh)	Post-EWI SAP Rating	Post-EWI Space & Water Heating Demand (kWh)	Heating Fuel
T-00	JUB Jubizol	Double glazing & roof	1975	29	52	12029	60	8771	Mains gas
T-35	JUB Jubizol	-	1989	32	63	8174	68	5998	Mains gas
T-36	JUB Jubizol	-	2000	45	59	9855	66	7199	Mains gas
T-37	JUB Jubizol	-	1989	40	51	10127	59	7686	Mains gas
T-38	JUB Jubizol	-	1988	39	64	9385	70	6474	Mains gas
T-39	JUB Jubizol	-	1980	33	63	8250	69	6049	Mains gas
T-40	JUB Jubizol	-		41	63	9385	68	7146	Mains gas
T-41	JUB Jubizol	-	1995	46	65	9865	70	7600	Mains gas
T-42	JUB Jubizol	-	1987	28	44	9085	52	7069	Mains gas
T-43	JUB Jubizol	-	1987	29	43	9610	51	7411	Mains gas
T-44	JUB Jubizol	-		53	63	11414	67	9193	Mains gas
Maximum			2000	53	65	12029	70	9193	
Minimum			1975	28	34	8174	38	5998	
Average			**1988**	**38**	**57**	**9744**	**64**	**7327**	

Table 3.3 Details of monitored households receiving JUB Jubizol Premium external wall insulation at Ashfield Park

Details of the 11 monitored households at Ashfield Park which received JUB Jubizol Premium EWI are shown in Table 3.3. The date of manufacture ranged from 1975 to 2000 and so these were on average newer households than those with SPS Envirowall. The average SAP rating increased from 57 to 64 after the JUB Jubizol EWI was fitted. Prior to installation, the space and water heating demand was between 8,174 and 12,029 kWh. This decreased to between 5,998 and 9,193 kWh following the installations. Household T-00 was an older park home in a poor state of repair and required new windows and doors along with a new roof before the EWI could be fitted.

Table 3.4 shows that at Charnwood Park, 6 ParexTherm acrylic render systems and one Alumasc Swisslab installation were monitored. It was only possible to obtain two manufacture dates for the park homes and these were in the early 1990s. The SAP ratings for these households were low and ranged from 1 to 34 before the installations. Use of LPG as a heating fuel led to lower SAP ratings. For T-11 and T-21 the value was only 1 and this was influenced by the heating being provided by old back boilers fuelled by bottled LPG. The pre-installation space and water heating demand at Charnwood Park was between 9,251 and 16,312 kWh. This fell to between 7,065 and 13,229 kWh after the EWI was installed. The demand was particularly high for household T-22 which had no room thermostat or cylinder thermostat. Households T-11 and T-21 also had hot water cylinders without a thermostat, which led to them having a higher water heating demand. The table also shows a control household, C-15 which was unable to have external wall insulation fitted due to spacing issues with the park homes.

Tech Ref	EWI Technology	Other improvements	Date of manufacture	Floor Area	Pre-EWI SAP Rating	Pre-EWI Space & Water Heating Demand (kWh)	Post-EWI SAP Rating	Post-EWI Space & Water Heating Demand (kWh)	Heating Fuel
T-11	ParexTherm	-		33	1	16312	1	12870	LPG
T-12	ParexTherm	-		33	34	9323	44	7038	LPG
T-19	ParexTherm	-		47	33	9251	45	7065	LPG
T-20	ParexTherm	-		42	20	10461	29	8480	LPG
T-21	ParexTherm	-	1992	47	1	14385	1	11464	LPG
T-22	ParexTherm	-		73	10	16244	18	13229	LPG
Maximum				73	34	16312	45	13229	
Minimum				33	1	9251	1	7038	
Average				**46**	**17**	**12663**	**23**	**10024**	
T-24	Alumasc Swisslab	-	1993	65	26	12539	39	9198	LPG
C-15	Control	-		45	25	11698		-	LPG

Table 3.4 Details of the monitored households at Charnwood Park

3.2 Temperature and humidity in monitored homes

Temperature and humidity was recorded every hour using a Lascar EL-USB-2 temperature and humidity logger (Figure 3.5)[7]. These were placed in the living rooms of 27 of the monitored households and in the bedroom of 1 household (T-11).

Households at Ashfield Park were asked to regularly record their gas meter readings in a log book. Recent and historic gas meter readings were also obtained from energy bills and by contacting the gas supplier (with householder consent). Electricity was supplied through the park home site owner and regular monthly consumption figures were obtained.

At Charnwood Park, most of the households used 47kg bottled LPG as their heating fuel. Gas consumption figures were estimated from the dates of delivery of the bottled gas. 2 of the households had 380 litre gas tanks. Details of the date and quantity of gas delivered were obtained from receipts. Electricity at Charnwood Park was again provided for households by the site owner. Quarterly receipts with meter readings were used to assess the electricity consumption.

Figure 3.5 Lascar EL-USB-2 temperature and humidity logger

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

3.3 Factors affecting the evaluation methodology

Issue	Description and mitigation
Size of the monitored group at Charnwood Park	In order for the EWI installations to go ahead, the spacing between the park homes had to be greater than 5m to pass fire regulations. While this was not a problem at Ashfield Park, a number of the park homes at Charnwood Park were too close together which led to delays in the installations at the site. One household at Charnwood Park withdrew from the monitored group because their home was too close to the next to have an installation. Another householder who was unable to have an installation continued in the monitored group as a 'control'. A third householder at Charnwood Park decided not to go ahead with the installation.
Late installation	Out of the 7 monitored households with installations at Charnwood Park, 4 were carried out in September and three in November 2016. The final interviews took place in May 2017. Most households at Charnwood Park used 47kg bottles of LPG as their heating fuel. The short post installation monitoring period and use of bottled gas for heating made it difficult to assess the post installation gas consumption. It was also a challenge to assess the electricity consumption for secondary heating as most households could only provide one or two electricity receipts after the installation.
Temperature and humidity loggers	Temperature and humidity data was obtained from all the SPS Envirowall installations. Data was more limited for the homes where JUB Jubizol and Parextherm. .
Other measures	During the course of the study some households installed further measures such as a new boiler or double glazing. The evaluation methodology was amended to take account of these changes to avoid the influence of these other measures on the calculation of savings from the EWI.

3.4 Monitoring results

Cost

Analysis using gas meter readings and energy bills – Ashfield Park

Gas meter readings were recorded during the study. Consumption data was also obtained from bills prior to the monitoring period. These meter readings allowed the gas consumption of households to be compared before and after the installation of the external wall insulation.

SPS Envirowall was installed on monitored park homes at Ashfield during May and June 2016. Installations of JUB Jubizol Premium systems at Ashfield Park occurred later, between July and September 2016. Meter readings from the 'before' installation period were in the range August 2014 to August 2016. Those from the 'after' period ranged from shortly after the EWI installation up until May 2017. Table 3.6 shows the gas consumption (in kWh) for the 'before' and 'after' periods and the cost of the gas in £/30 days, using a standard gas price of 5p/kWh.

Table 2.12 shows that some of the properties had other measures such as new boilers installed during or shortly before the monitoring period. It should be noted that the dates of installation of the other measures were based on responses from the households during the final interview.

The date range of the meter readings used for calculating the savings from the EWI in Table 3.6 was reduced where possible with these households to avoid the influence of savings from the other measures. Where the measures were installed at a similar time, or limited meter readings were available, the combined savings are shown in Table 3.7. This table includes 3 households also shown in Table 3.6, but using meter readings over a wider time period which allowed the savings for the combined measures to be calculated.

In order to properly analyse energy use for space heating, account must be taken of the weather. For example, it is poor practice to compare the heating costs for two 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. The heating requirement for a building is proportional to the number of heating degree days (HDD) 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[8]. Good quality temperature data was available from Doncaster Sheffield Airport (EGCN) which is located about 15 miles from Ashfield Park. An average of the number of degree days per year over a 20-year period was only available on a regional basis, which was used to normalise the savings which can be expected in the following analysis. In this case, 2145 degree days, the value for the East Pennines region was used as Ashfield Park and Charnwood Park were located in this area[9].

[8] https://www.carbontrust.com/resources/guides/energy-efficiency/degree-days/ [Accessed 20/03/2017]
[9] http://www.vesma.com/ [Accessed 05/05/2017]

	"Before" period							"After" period with external wall insulation								
Tech Ref	Period	Days	Total Period (kWh)	Gas[1] £/30 days	Degree days	kWh per Degree Day	Estimated Annual Gas Cost[2]	Period	Days	Total Period (kWh)	Gas[1] £/30 days	Degree days	kWh per Degree Day	Estimated Annual Gas Cost[1]	Cost Saving	% Saving
T-01	17/02/16 - 13/05/16	86	3,535	£61.65	709	4.98	£534.44	25/05/16 - 01/05/17	341	8,909	£39.19	1,804	4.94	£529.53	£4.91	0.9%
T-03	17/02/16 - 18/05/16	91	3,119	£51.42	736	4.24	£454.73	16/06/16 - 12/04/17	300	7,664	£38.32	1,631	4.70	£504.00	-£49.27	-10.8%
T-04	27/05/15 - 17/02/16	266	6,732	£37.96	1,193	5.64	£605.26	26/-5/16 - 12/04/17	321	6,138	£28.68	1,678	3.66	£392.22	£213.04	35.2%
T-06	17/10/15 - 29/05/16	225	8,427	£56.18	1,639	5.14	£551.50	10/06/16 - 23/05/17	347	7,540	£32.59	1,844	4.09	£438.57	£112.94	20.5%
T-07	26/08/14 - 11/05/16	624	10,166	£24.44	3,768	2.70	£289.35	02/06/16 - 03/04/17	305	3,624	£17.82	1,606	2.26	£241.95	£47.39	16.4%
T-09	21/03/16 - 12/05.16	52	1,380	£39.81	367	3.76	£402.93	09/06/16 - 30/12/16	204	2,435	£17.90	788	3.09	£331.48	£71.45	17.7%
T-10	03/02/15 - 04/05/16	456	16,147	£53.11	2,719	5.94	£636.83	25/05/16 - 03/05/17	343	6,699	£29.29	1,813	3.70	£396.32	£240.50	37.8%
Average	SPS Envirowall + under floor insulation					4.63	£496.43						3.78	£404.87	£91.57	16.81%
T-02	01/11/14 - 23/05/16	569	16,584	£43.72	3,643	4.55	£488.13	18/06/16 - 03/05/17	319	5,868	£27.59	1,756	3.34	£358.43	£129.70	26.6%
T-05	06/08/15 - 05/05/16	273	6,867	£37.73	1,755	3.91	£419.57	19/05/16 - 05/05/17	351	6,261	£26.76	1,837	3.41	£365.45	£54.12	12.9%
T-08	06/08/15 - 11/05/16	279	10,895	£58.58	1,773	6.14	£658.93	04/08/16 - 03/05/17	272	6,429	£35.46	1,715	3.75	£402.04	£256.89	39.0%
Average	SPS Envirowall					4.87	£522.21						3.50	£375.31	£146.90	26.2%
T-35	24/10/14 - 03/08/16	648	21,813	£50.49	3,764	5.80	£621.44	23/08/16 - 03/05/17	253	8,348	£49.50	1,701	4.91	£526.26	£95.18	15.3%
T-36	17/10/14 - 17/06/16	548	26,133	£71.53	3,330	7.85	£841.52	23/08/16 - 09/01/17	139	5,072	£54.73	825	6.15	£659.55	£181.98	21.6%
T-37	31/10/14 - 11/05/16	558	17,515	£47.08	3,603	4.86	£521.32	03/08/16 - 04/05/17	274	6,833	£37.41	1,720	3.97	£425.94	£95.38	18.3%
T-38	12/11/14 - 05/08/16	632	19,804	£47.00	3,672	5.39	£578.32	12/09/16 - 05/05/17	235	8,326	£53.14	1,699	4.90	£525.61	£52.71	9.1%
T-39	02/05/15 - 10/05/16	374	10,951	£43.92	1,992	5.50	£589.63	18/08/16 - 03/05/17	258	6,385	£37.12	1,703	3.75	£402.02	£187.61	31.8%
T-40	02/02/15 - 03/08/16	548	6,014	£16.46	2,902	2.07	£222.26	07/09/16 - 04/05/17	239	3,860	£24.23	1,698	2.27	£243.77	-£21.50	-9.7%
T-41	02/05/15 - 10/05/16	374	14,226	£57.06	1,992	7.14	£765.94	03/08/16 - 03/05/17	273	9,050	£49.73	1,715	5.28	£565.91	£200.03	26.1%
T-42	01/05/15 - 10/05/16	375	14,138	£56.55	2,001	7.06	£757.55	03/08/16 - 03/05/17	273	8,629	£47.41	1,715	5.03	£539.56	£217.99	28.8%
T-43	25/11/14 - 25/05/16	547	21,892	£60.03	3,487	6.28	£673.26	12/09/16 - 12/04/17	212	7,035	£49.78	1,560	4.51	£483.64	£189.62	28.2%
Average	Jub Jubizol Premium					5.77	£619.03						4.53	£485.81	£133.22	18.8%

1 - Gas cost = 5p/kWh

2 - Using the 20 year average annual degree-day value for East Pennines = 2145 degree days per year

Table 3.6 Analysis of gas costs before and after installation of EWI at Ashfield Park using bill and meter readings

In Table 3.6, the figure of kWh per degree day was calculated by dividing the gas consumption by the number of degree days for the same period. The estimated annual gas cost for the sites was obtained by multiplying the unit gas cost by the number of kWh per degree day for the household and the twenty year average number of degree days in the East Pennines region.

For the 3 households which had SPS Envirowall insulation without under floor insulation, the estimated annual gas cost before insulation ranged from £420 to £659. After the EWI was installed this reduced to between £358 and £402, with the households with the highest bills making the greatest savings. The savings in gas consumption ranged from 12.9% to 39%, with an average of 26.2%.

The households with under floor insulation along with the SPS Envirowall EWI, had average annual gas bills in the range £289 to £637 before installation. All the households apart from T-03 saw a reduction in their gas bills after the insulation was fitted. The post installation average annual gas bills were between £242 and £530. The average saving was 16.8%, with households T-10 making a saving of 37.8% and T-03 seeing a 10.8% increase in gas consumption. The 3 households with the highest initial bills made the greatest savings.

The results apparently show there was no benefit in having under floor insulation along with the EWI as the households with only SPS Envirowall made greater average savings than those which included floor insulation. The change in energy consumption after the installations ranged from approximately 40% savings to about a 10% increase in consumption. With a small sample of households, atypical performance such as T-03 could distort the average. If that household was omitted, the group with SPS Envirowall and under floor insulation would show an average reduction in gas consumption of 21.4%. Although there was significant variation in performance, the lack of any clear additional savings from the under floor insulation suggests that benefits from this measure may have been fairly limited.

	"Before" period							"After" period with external wall insulation								
Tech Ref	Period	Days	Total Period (kWh)	Gas[1] £/30 days	Degree days	kWh per Degree Day	Estimated Annual Gas Cost[2]	Period	Days	Total Period (kWh)	Gas[1] £/30 days	Degree days	kWh per Degree Day	Estimated Annual Gas Cost[1]	Cost Saving	% Saving
T-01	25/11/14 - 26/05/15	182	10,491	£86.47	1,538	6.82	£731.34	25/05/16 - 01/05/17	341	8,909	£39.19	1,804	4.94	£529.53	£201.81	27.6%
	SPS Envirowall + under floor insulation + new boiler (installed Jan 16)															27.6%
T-09	01/05/15 - 29/02/16	309	6,228	£30.23	1,426	4.37	£468.41	09/06/16 - 30/12/16	204	2,435	£17.90	788	3.09	£331.48	£136.93	29.2%
	SPS Envirowall + under floor insulation + Double Glazing (installed Mar 16)															29.2%
T-00	07/11/15 - 22/08/16	289	8,416	£43.68	1,638	5.14	£550.80	04/10/16 - 12/04/17	190	4,567	£36.05	1,513	3.02	£323.63	£227.17	41.2%
	JUB Jubizol Premium + double glazing and new roof															41.2%
T-36	17/10/14 - 17/06/16	548	26,133	£71.53	3,330	7.85	£841.52	09/01/17 - 05/05/17	116	5,408	£69.93	887	6.10	£654.14	£187.39	22.3%
	JUB Jubizol Premium + new boiler (installed in about Dec 16)															22.3%
T-44	24/11/14 - 26/05/15	183	10,895	£89.30	1,550	7.03	£753.92	03/08/16 - 24/05/17	294	7,877	£40.19	1,795	4.39	£470.63	£283.29	37.6%
	Jub Jubizol Premium + new boiler (installed in about Dec 15)															37.6%

[1] - Gas cost = 5p/kWh

[2] - Using the 20 year average annual degree-day value for East Pennines = 2145 degree days per year

Table 3.7 Analysis of gas costs and savings before and after installation of EWI and other measures at Ashfield Park

Prior to installation of JUB Jubizol Premium, the average household annual gas bills were in the range £222 to £842 with an average gas bill of £619. All the households saw a reduction in gas consumption apart from T-40, which had the lowest initial annual gas bill. The post installation average annual gas bills ranged from £244 to £660, with an average of £486. The average saving was 18.8% with household T-39 showing the greatest saving of 31.8% and household T-40 seeing a 9.7% increase in consumption.

Table 3.7 shows the savings from households which had other measures in addition to the EWI. Household T-00 which had JUB Jubizol Premium installed saw the greatest savings on the project. The annual gas bill decreased from £551 to £324 with savings of 41.2%. This park home was manufactured in 1975 and one of the oldest in the project. It was in a poor state of repair and had replacement windows and doors installed at a similar time to the EWI. The roof was also replaced about a month before. The significant improvement of the building fabric due to the combination of measures led to the high savings.

As well as the JUB Jubizol Premium EWI installed in July 2016, household T-44 also had a replacement gas boiler fitted in December 2015. Over the periods analysed, the annual gas cost for T-44 decreased from £754 to £471 with a 37.6% saving. The pre-installation period was from November 2014 to May 2015 and so the savings after installation included the impact of both the new boiler and the EWI.

Household T-36 also had a new gas boiler which was installed in about December 2016. Table 3.7 used a post installation period of between 9 Jan 17 and 5 May 17, which included the benefits of both the JUB Jubizol EWI and the new boiler. The pre-installation average gas cost was £842 and this decreased to £654 with a saving of 22.3%. The results in Table 3.6 tried to reduce the effect of the new gas boiler by ending the post installation period on 9 Jan 17. With limited influence from the new boiler, the average gas cost after installation was £660, or a saving of 21.6%.

Table 3.7 includes two households with SPS Envirowall and under floor insulation which were shown in Table 3.6, excluding the effect of a further measure. Household T-01 had a new gas boiler in January 2016. The savings from the combination of the wall and floor insulation and the new boiler was 27.6%. The pre-installation meter readings in Table 3.6 were restricted to exclude those before January 2016 and the effect of the new boiler. In this case the savings were only 0.9%, but were based on only 86 days of data. It is likely that the long term savings from the wall and floor insulation were greater than 0.9% and the combined savings for the insulation and boiler at 27.6% are likely to be more accurate. Household T-09 fitted double glazing as well as the floor and wall insulation. The savings from the three measures was 29.2%. The savings for the wall and floor insulation alone was 17.7%, but this analysis used a pre-installation period of 52 days in spring 2016. For comparison, there was a 309 day pre-installation period for T-09 in Table 3.7 which showed the savings after double glazing, wall and floor insulation were fitted.

Analysis using gas meter readings and energy bills – Charnwood Park

	"Before" period							"After" period with external wall insulation								
Tech Ref	Period	Days	Total Period (kWh)	Gas[1] £/30 days	Degree days	kWh per Degree Day	Estimated Annual Gas Cost[2]	Period	Days	Total Period (kWh)	Gas[1] £/30 days	Degree days	kWh per Degree Day	Estimated Annual Gas Cost[1]	Cost Saving	% Saving
T-11	26/07/14 - 26/09/16	793	11,345	£32.19	3,996	2.84	£456.62	11/11/16 - 18/04/17	158	2,669	£38.01	1,325	2.02	£324.18	£132.44	29.0%
T-12	09/06/14 - 11/06/16	733	14,014	£43.02	3,941	3.56	£571.95	29/09/16 - 15/05/17	228	5,339	£52.68	1,719	3.10	£499.45	£72.50	12.7%
T-19	27/06/14 - 11/05/16	684	12,012	£39.51	3,830	3.14	£504.55	22/10/16 - 02/06/17	223	4,004	£40.40	1,647	2.43	£390.98	£113.57	22.5%
T-22	29/10/14 - 05/10/16	707	24,540	£78.10	3,831	6.41	£1,030.30	30/11/16 - 09/02/17	71	4,126	£130.74	691	5.97	£960.21	£70.09	6.8%
Average	**ParexTherm acrylic render system**					3.98	£640.85						3.38	£543.70	£97.15	17.7%
T-24	03/01/15 - 26/10/16	662	16,580	£56.35	3,407	4.87	£782.91	12/12/16 - 18/05/17	157	6,167	£88.38	1,204	5.12	£823.83	-£40.91	-5.2%
Average	**Alumasc Swisslab**					4.87	£782.91						5.12	£823.83	-£40.91	-5.2%
C-15	08/10/14 - 05/05/16	575	16,684	£65.28	3,665	4.55	£732.28	22/06/16 - 15/05/17	266	7,341	£62.09	1,758	4.18	£671.70	£60.58	8.3%
Average	**Control property without EWI**					4.55	£732.28	**Period after new boiler installed, but with no EWI**					4.18	£671.70	£60.58	8.3%

[1] - LPG Gas cost = 7.5p/kWh

[2] - Using the 20 year average annual degree-day value for East Pennines = 2145 degree days per year

Table 3.8 Analysis of gas costs before and after installation of EWI at Charnwood Park using bill and meter readings

Charnwood Park is off the mains gas grid. The majority of households relied on 47kg LPG (propane) bottles to provide gas for their heating systems. It was not possible to fit a meter between the gas bottle and the household to measure consumption. The number of gas bottles ordered during the pre and post-installation period was however determined with the assistance of households and the supplier. This allowed consumption rates to be calculated, but the errors were larger than with gas meter readings. For example there may be inaccuracies in the consumption period as new gas bottles may have been delivered before the previous bottle was finished.

It was assumed that a 47kg gas bottle contained 93.82 litres of gas and that one litre of propane was equivalent to 7.113kWh.[10] A standardised cost of 7.5p/kWh was used for LPG, which was equivalent to a cost of about £50 including VAT at 5% for a 47kg bottle. Households T-20 and T-22 had 380 litre gas tanks on site which received less frequent deliveries. The cost per kWh for larger deliveries was about 6.9p/kWh, but there was also a standing charge. Since most households at the site used 47kg bottles, all cost calculations used a figure of 7.5p/kWh.

It was possible to assess the costs and savings for four of the households with ParexTherm acrylic render systems. Prior to installation, the gas costs ranged from £457 to £1,030, with an average of £641. After the EWI was fitted, the costs were between £324 and £960, with an average of £544. The average saving from ParexTherm was 17.7%. The health of the householder in household T-22 deteriorated during the study. He spent more time at home and most likely required warmer temperatures. As a result, the savings were the lowest out of the ParexTherm installations.

There was just one Alumasc Swisslab household monitored. Here the gas costs increased from £783 to £824 per year, which is an increase of 5.2%. The health of the residents in this household also deteriorated during the study. The increase in consumption is likely again to be due to the

[10] Countrywide Farmers plc, Cylinder FAQs https://www.countrywidelpg.co.uk/lpg-cylinders/cylinder-faqs/ (Accessed 11 July 2017)

resident spending more time at home and requiring warmer temperatures. There was a monitored control household at Charnwood Park which was unable to have EWI fitted. During the study period this household installed a new gas boiler and it was possible to assess the savings which resulted from this. The annual gas cost before the installation was £732 and this decreased to £672 after the new boiler was fitted. The saving was 8.3%, which was lower than the average savings from external wall insulation.

Influence of annual gas consumption and EPC space heating demand on savings

Ashfield Park

The space and water heating demand on an Energy Performance Certificate (EPC) provides an indication of gas consumption requirements to achieve a standardised level of thermal comfort for a household. This calculation uses the RdSAP model which aims to take into account among other things the U-values for walls, windows and the roof along with the efficiency of the heating system. Although more accurate models are available for the energy performance of buildings, a good approximation can be obtained from an EPC produced following a standard domestic energy assessment. The Standard Heating Pattern used by RdSAP assumes 9 hours of heating per day for week days and 16 hours per day for weekends, where the living area is heated to 21°C and other rooms to 18°C[11]

The building fabric heat loss from the walls is given by:

$$Q_w = U_w \times A_w \times \Delta T$$

Where Q_w is the heat loss through the walls, U_w is the U-value for the walls, A_w is the area of the walls and ΔT is the difference between the inside and outside temperature. The total fabric heat loss is given by the sum of the heat losses from all the elements such as the walls, roof, floor, windows etc.[12] Savings following installation of the EWI will be dependent upon changes to the U-value for the wall and the inside temperature.

The annual gas consumption (normalised for temperature) is calculated by multiplying the value of kWh per degree day by the 20 year average number in the region. The ratio of the annual gas consumption to EPC space and water heating demand can give a measure of the thermal comfort of the household and will be denoted as the ‘relative thermal comfort ratio’. This can be calculated during the pre and post installation periods using EPCs with and without the EWI.

If the relative thermal comfort ratio or ratio of the annual gas consumption to the EPC heating demand is greater than 1.0, the households typically had a higher level of thermal comfort or heating demand than predicted by the RdSAP software for the EPC. There is likely to be more potential to make savings for those households where the ratio is greater than 1.0 during the pre-installation period. Likewise if the ratio is significantly less than 1.0, the household is under heated and the household may take any benefits in improved thermal comfort. This may be seen as the ‘relative thermal comfort ratio’ increasing after the EWI was installed.

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[11] RdSAP Manual Methodology, Stroma (2015), https://stromamembers.net/files/rdsap/documents/RdSAP%20Manual.pdf (Accessed 18 Jul 2017)
[12] Calculating the total heat loss of a house, The Open University, http://www.open.edu/openlearn/nature-environment/the-environment/energy-buildings/content-section-2.4.1 (Accessed 17 July 2017)

		'Before' period				'After' period				
Tech Ref	Measure	Pre-install EPC space and water heating demand (kWh)	kWh per Degree Day (Before)	Pre install annual gas consumption (kWh)1	Ratio of annual consumption to EPC heating demand [2] (pre install)	Post-install EPC space and water heating demand (kWh)	kWh per Degree Day (After)	Post install annual gas consumption (kWh)[1]	Ratio of annual consumption to EPC heating demand [2] (post install)	Cost Saving
T-01	SPS Envirowall + UF	14,030	4.98	10,689	0.76	9,622	4.94	10,591	1.10	0.9%
T-03	SPS Envirowall + UF	12,847	4.24	9,095	0.71	8,018	4.70	10,080	1.26	-10.8%
T-04	SPS Envirowall + UF	13,661	5.64	12,106	0.89	9,231	3.66	7,845	0.85	35.2%
T-06	SPS Envirowall + UF	12,897	5.14	11,031	0.86	11,170	4.09	8,772	0.79	20.5%
T-07	SPS Envirowall + UF	9,929	2.70	5,787	0.58	6,907	2.26	4,839	0.70	16.4%
T-09	SPS Envirowall + UF	11,009	3.76	8,059	0.73	8,113	3.09	6,630	0.82	17.7%
T-10	SPS Envirowall + UF	11,454	5.94	12,737	1.11	7,802	3.70	7,927	1.02	37.8%
Average		12,261	4.63	9,929	0.81	8,695	3.78	8,098	0.93	16.8%
T-02	SPS Envirowall	12,044	4.55	9,763	0.81	8,742	3.34	7,169	0.82	26.6%
T-05	SPS Envirowall	11,189	3.91	8,392	0.75	7,873	3.41	7,309	0.93	12.9%
T-08	SPS Envirowall	13,611	6.14	13,179	0.97	10,464	3.75	8,041	0.77	39.0%
Average		12,281	4.87	10,445	0.84	9,026	3.50	7,507	0.84	26.2%
T-35	JUB Jubizol Premium	8,174	5.80	12,429	1.52	5,998	4.91	10526	1.75	15.3%
T-36	JUB Jubizol Premium	9,855	7.85	16,831	1.71	7,199	6.15	13,192	1.83	21.6%
T-37	JUB Jubizol Premium	10,127	4.86	10,427	1.03	7,686	3.97	8,519	1.11	18.3%
T-38	JUB Jubizol Premium	9,385	5.39	11,567	1.23	6,474	4.90	10,513	1.62	9.1%
T-39	JUB Jubizol Premium	8,250	5.50	11,793	1.43	6,049	3.75	8,041	1.33	31.8%
T-40	JUB Jubizol Premium	9,385	2.07	4,445	0.47	7,146	2.27	4,876	0.68	-9.7%
T-41	JUB Jubizol Premium	9,865	7.14	15,320	1.55	7,600	5.28	11,319	1.49	26.1%
T-42	JUB Jubizol Premium	9,085	7.06	15,152	1.67	7,069	5.03	10,792	1.53	28.8%
T-43	JUB Jubizol Premium	9,610	6.28	13,466	1.40	7,411	4.51	9,673	1.31	28.2%
Average		9,263	5.77	11,957	1.34	6,959	4.53	9,717	1.33	19.1%

[1] Annual gas consumption calculated using the 20 year average degree-day value for East Pennines = 2145 degree days per year
[2] 'Relative Thermal Comfort Ratio' = Ratio of annual gas consumption to EPC space and water heating demand

Table 3.9 Influence of space and water heating demand on savings from EWI at Ashfield Park

Table 3.9 shows data from Ashfield Park including the annual gas consumption, EPC space and water heating demand, ‘relative thermal comfort ratio’ and savings following installation of the EWI. Household T-10 showed the greatest savings (37.8%) among those with SPS Envirowall and under floor insulation. Since the pre-installation ‘relative thermal comfort ratio’ was greater than one, it suggests the household had a higher level of thermal comfort than the standard level for RdSAP. Post installation, the combination of an improved U-value and a likely reduction in internal temperature led to the high savings. Responses from the questionnaires showed the householder used a secondary gas fire before the EWI was fitted, but this was not required afterwards.

Households T-04 and T-06 saw reductions in gas consumption of 35.2% and 20.5%. Here the park homes were manufactured in 1982 and 1970 and being older households benefited from a greater improvement in the U-value of the wall after insulation. There was also a reduction in the ‘relative thermal comfort ratio’. A combination of the improved U-value and an acceptable reduction in thermal comfort are likely to have led to the relatively high savings.

The reduction in gas consumption for T-07 and T-09 was 16.4% and 17.7% respectively. The park homes were built in 1980 and 1987. With these households the pre-installation ‘relative thermal comfort ratio’ suggests the households were under heated. Following the installation, there was an increase in the ‘relative thermal comfort ratio’. The savings may be lower than for T-04 and T-06 as a result of increased thermal comfort.

For household T-01 a saving of only 0.9% was measured, although over a longer time period and when combined with the savings from a new gas boiler there was a 27.6% reduction in consumption. There was a significant increase in the ‘relative thermal comfort ratio’ after the installation which may account for the limited reduction in gas consumption. Household T-03 saw an increase in gas consumption of 10.8%. The park home was built in 1975 and so following installation of the EWI, there was likely to be a significant improvement in the U-value of the walls.

However, there was a significant increase in the ‘relative thermal comfort ratio’ after installation. Warmer room temperatures and greater occupancy might account for the increase in gas consumption.

The oldest property in the study was T-08 which was manufactured in 1962 and had SPS Envirowall installed with no under floor insulation. The combination of a significant improvement in the U-value of the walls and a decrease in the ‘relative thermal comfort ratio’ may account for the high savings of 39%. For household T-02 there was a negligible change in ‘relative thermal comfort ratio’ after installation and the savings were 26.6%. With T-05, the ‘relative thermal comfort ratio’ showed a significant increase after the EWI installation, which might account for the lower savings of 12.9%.

The ‘relative thermal comfort ratios’ for all but one of the JUB Jubizol Premium installations were greater than 1.0 both before and after installation of the EWI. This suggests overheating and in some cases significant overheating of the households. It should be noted that a different Domestic Energy Assessor carried out the EPC surveys for the households with JUB Jubizol Premium than was used for those with SPS Envirowall. The average space and water heating demand for the households with SPS Envirowall was about 12,270kWh compared to 9,263kWh for those which received JUB Jubizol Premium at Ashfield Park. Households T-00 and T-44, which had higher values of space and water heating demand, were not included in Table 3.8 as they had more than one measure installed during the study period.

The more recent manufacture of the park homes with JUB Jubizol Premium may have influenced the lower space and water heating demands. However it is also possible that differences in how elements of the park home were recorded during the survey might have affected the space and water heating demand for the JUB Jubizol Premium households compared to the households with SPS Envirowall.

Household T-40 was the only park home with a JUB Jubizol Premium installation which saw an increase in gas consumption after the EWI was fitted. The pre-installation annual gas consumption for T-40 was less than half that of the household with the next lowest consumption in that group. The ‘relative thermal comfort ratio’ was only 0.47, which indicated that the household was significantly under heated. Following installation of the EWI, there was an increase in thermal comfort. This was partly due to improved insulation, but also as a result of the increased gas consumption. During the final interview the household commented on being able to turn up the heating as the home keeps the heat in much better.

All the other households had ‘relative thermal comfort ratios’ greater than 1.0 based on the pre-installation EPC space and water heating demand and the pre-installation annual gas consumption. The 4 households which made the greatest savings: T-39, T-42, T-43 and T-41 with savings between 26.1% and 31.8%, all saw a decrease in the ‘relative thermal comfort ratio’. Households T-38 and T-35, which made lower savings (9.1% and 15.3%), both saw significant increases in the ‘relative thermal comfort ratios’. Households T-36 and T-37, which made savings close to the average, saw slight increases in the ‘relative thermal comfort ratio’.

Charnwood Park

		'Before' period				'After' period				
Tech Ref	Measure	Pre-install EPC space and water heating demand (kWh)	kWh per Degree Day (Before)	Pre install annual gas consumption (kWh)1	Ratio of annual consumption to EPC heating demand [2] (pre install)	Post-install EPC space and water heating demand (kWh)	kWh per Degree Day (After)	Post install annual gas consumption (kWh)[1]	Ratio of annual consumption to EPC heating demand [2] (post install)	Cost Saving
T-11	ParexTherm	16,312	2.84	6,089	0.37	12,870	2.02	4,323	0.34	29.0%
T-12	ParexTherm	9,323	3.56	7,626	0.82	7,038	3.10	6,660	0.95	12.7%
T-19	ParexTherm	9,251	3.14	6,728	0.73	7,065	2.43	5,213	0.74	22.5%
T-22	ParexTherm	16,244	6.41	13,738	0.85	13,229	5.97	12,803	0.97	6.8%
Average		12,783	3.98	8,545	0.69	10,051	3.38	7,250	0.75	17.7%
T-24	Alumasc Swisslab	12,539	4.87	10,439	0.83	9,198	5.12	10985	1.19	-5.2%
C-15	Control	11,698	4.55	9,764	0.83					

[1] Annual gas consumption calculated using the 20 year average degree-day value for East Pennines = 2145 degree days per year

[2] 'Thermal Comfort Ratio' = Ratio of annual gas consumption to EPC space and water heating demand

Table 3.10 Influence of space and water heating demand on savings from EWI at Charnwood Park

Table 3.10 shows the annual gas consumption, EPC space and water heating demand, ‘relative thermal comfort ratio’ (ratio of annual gas consumption to EPC heating demand) and cost savings for households at Charnwood Park. This shows the performance of four of the ParexTherm acrylic render systems and the single monitored Alumasc Swisslab installation. Also included for reference is the control household which was unable to have EWI fitted. Calculations of annual gas consumption and cost savings were less accurate here because these figures typically relied on numbers of gas bottles consumed rather than a gas meter reading.

Based on the EPC, household T-11 had the highest pre-installation space and water heating demand among the households in table 3.9. It also had the lowest pre-installation annual gas consumption. This resulted in a particularly low value of 0.37 for the ‘relative thermal comfort ratio’. This indicated that the household had a significantly lower level of thermal comfort than the Standard Heating Pattern used by RdSAP of 21°C in the living area and 18°C in other parts of the house. The post installation ‘relative thermal comfort ratio’ was lower than before the ParexTherm EWI was fitted. This suggests the household did not increase thermal comfort as gas consumption fell. There was a reduction in gas consumption of 29% following the installation, with all the benefits from the EWI taken as reduced gas consumption.

For household T-19, there was effectively no change in the ‘relative thermal comfort ratio’ after installation of the ParexTherm acrylic render system. All the benefits from the insulation were taken as the 22.5% savings in gas consumption. Household T-22 only saw a 6.8% decrease in gas consumption. The ‘relative thermal comfort ratio’ increased after insulation to nearly one. Part of the benefit of the insulation was taken as improved thermal comfort and part as reduced gas consumption. The health of the household deteriorated during the study, which led to a higher occupancy of the household and a need for warmer temperatures. Household T-12 saw a reduction of 12.7% in their gas consumption. The increase in ‘relative thermal comfort ratio’ indicates that again part of the benefit of the wall insulation was taken as improved thermal comfort and part as reduced gas savings.

Household T-24 saw an increase in gas consumption of 5.2% following installation of Alumasc Swisslab wall insulation. There was an increase in ‘relative thermal comfort ratio’ from 0.83 to 1.19 following installation of the EWI. Again, the health of the householder deteriorated during the study. The benefit from the insulation along with additional heating led to much improved thermal comfort.

Graphs of kWh against number of Degree Days

Where there are sufficient meter readings it is possible to plot a graph of gas consumption against number of degree days. Adding the performance line to the graph using a line of best fit allows a judgement to be made on how well the heating has been controlled in respect to outside temperatures. Data points appearing on the performance line indicate that there has been good control of the heating system which has enabled a consistent temperature to be achieved. Scattered data points indicate less control and more variation in the internal temperature. Data points above the line indicate overheating and below, under heating.

Figure 3.11 shows Performance Line graphs for household T-08 which had SPS Envirowall EWI and household T-06 which had SPS Envirowall EWI and under floor insulation. The graphs include equations of the line of best fit for the data points as well as the value for R^2. A value of R^2 closer to 1.0 indicates the data points are closer to the line of best fit.

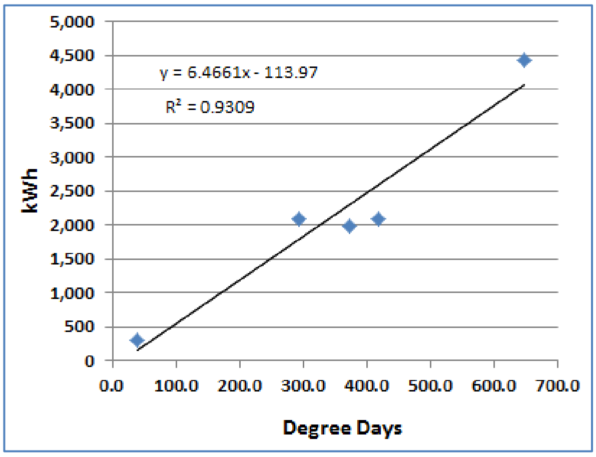

Figure 3.11a T-08 before SPS Envirowall EWI

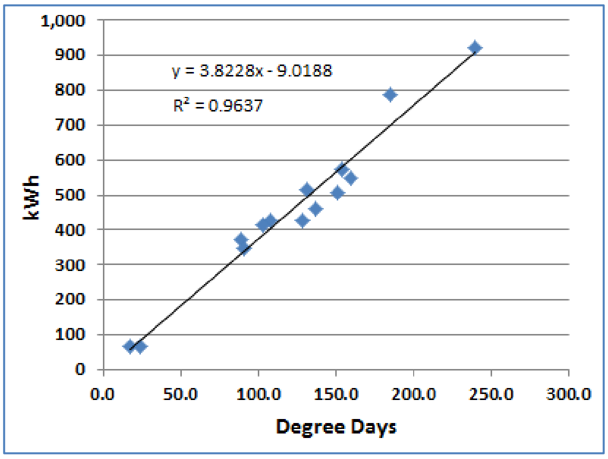

Figure 3.11b T-08 after SPS Envirowall EWI

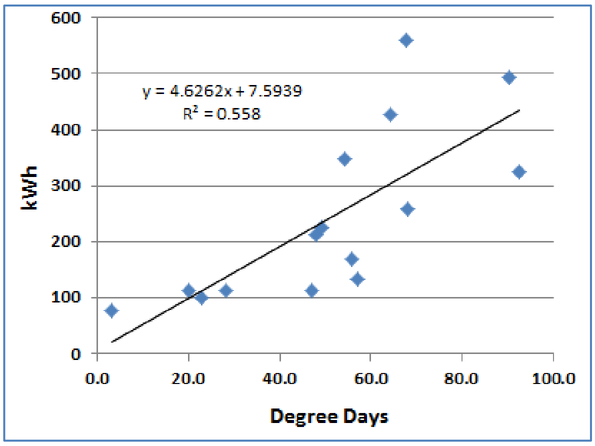

Figure 3.11c T-06 before SPS Envirowall & UF

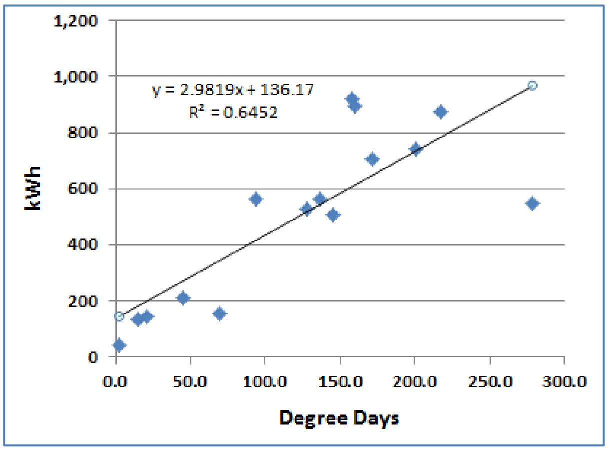

Figure 3.11d T-06 after SPS Envirowall & UF

For household T-08, the data points are close to the performance line and the value of R^2 is close to 1.0. This suggests that the household maintained a consistent temperature both before and after the installation of the EWI. In contrast, with household T-06, there is considerable scatter of the data points and the value of R^2 indicates little correlation with the performance line. This behaviour suggests there was significant variation in temperature in the household. The temperature variation may have reduced following insulation of the walls and floor as the scatter of data points reduced. This household had no room thermostat or cylinder thermostat and this may explain some of the temperature variation.

Performance line graphs are shown in Figure 3.12 for households T-35 and T-40 which had JUB Jubizol Premium EWI installed. There was greater scatter of data points with these performance line graphs than for household T-08, which suggests there was a wider variation of temperature in these households, but not as great as for household T-06 where the scatter was even greater.

The intercept of the performance line with the y-axis or the kWh consumption for zero degree days was negative for household T-40. This suggests that T-40 was under heated and that the increased gas consumption after insulation was due to improved thermal comfort. In contrast the y-axis intercept on the performance line for T-35 was positive suggesting overheating. Table 3.9 shows that the ‘relative thermal comfort ratio’ (ratio of annual gas consumption to EPC space and water heating demand) was 1.52 for T-35 and 0.47 for T-40 and. This supports the suggestion that household T-35 was over heated and T-40 under heated.

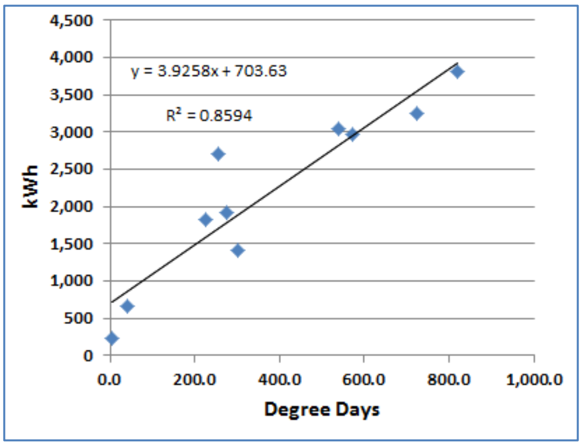

Figure 3.12a T-35 before JUB Jubizol installation

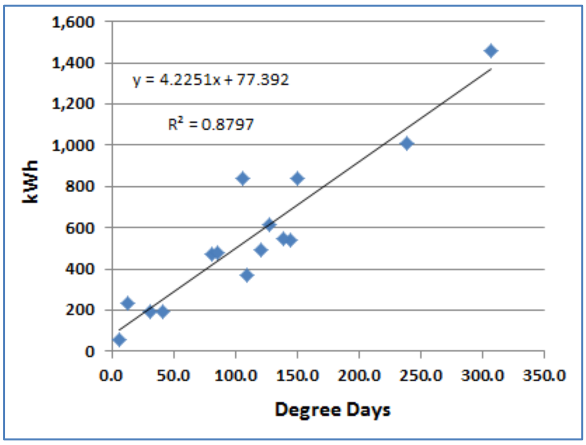

Figure 3.12b T-35 after JUB Jubizol installation

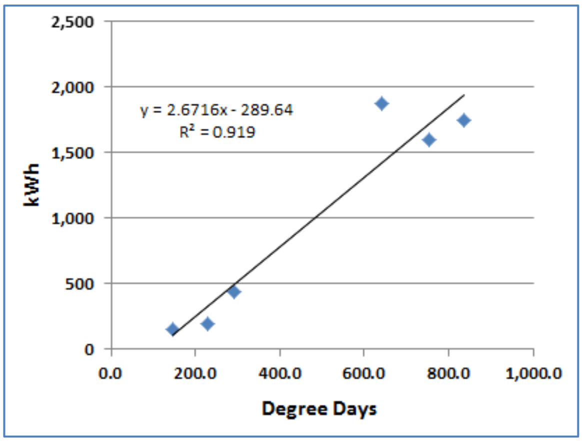

Figure 3.12c T-40 before JUB Jubizol installation

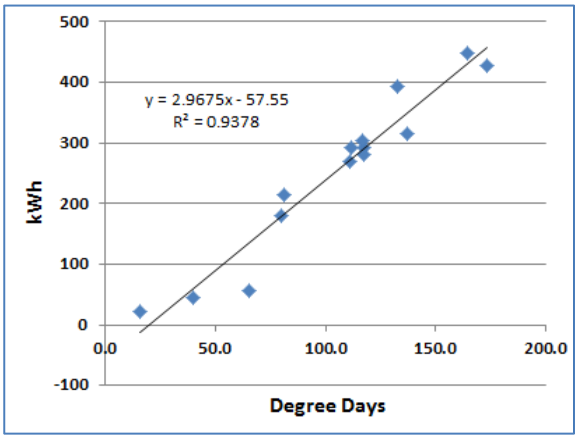

Figure 3.12d T-40 after JUB Jubizol installation

Analysis of electricity consumption at Ashfield Park

After the park homes were insulated, households may have changed their use of secondary electric heating. Monthly electricity consumption figures were therefore obtained for the monitored households at Ashfield Park for the periods before and after the wall insulation. If there was secondary electric heating use, a graph of electricity consumption against degree days would show the electricity consumption increased as the weather became colder. If there was little or no secondary heating, consumption would be largely independent of number of degree days. Other factors would affect the graph such as lighting use which also increases during winter months. However consumption from this would be small compared to secondary electric heating and would most likely be offset by increased consumption in summer from fridges/freezers and fans for cooling.

Table 3.13a and 3.13b show analysis of the monthly electricity consumption for households with SPS Envirowall insulation. The average monthly consumption was calculated using the pre-installation period of January 2015 to December 2015 and post installation period of June 2016 to June 2017.

An estimate of the annual electricity consumption was obtained by multiplying the mean value for these periods by 12 and a unit rate of 16p/kWh. Park home sites cannot charge households more for electricity than they paid for it, including connection charges. At some sites where there is a competitive electricity contract, households may pay less than 16p/kWh[13]. For the analysis of electricity consumption against number of degree days, a longer pre-installation period of October 2014 to March 2016 was used to provide more data points.

Before the installations the average monthly electricity consumption was between 72 and 295kWh with an overall average of 158kWh. After the installation the average monthly consumption ranged from 94kWh to 285kWh with a mean of 158kWh. On average there was no change to the electricity consumption of the park homes following installation of the EWI.

			Before installation					
Tech Ref	Technology	Measure	Average Monthly Consumption (kWh)	Estimated Annual cost [1]	Standard Deviation (kWh)	Performance Line Gradient (kWh/DD)	Performance Line Intercept (kWh)	kWh/DD
T-01	SPS Envirowall	EWI + UF	141.6	£271.84	19.3	0.105	125.6	0.82
T-02	SPS Envirowall	EWI	119.6	£229.60	29.3	0.146	98.0	0.63
T-03	SPS Envirowall	EWI + UF	295.7	£567.68	32.4	0.297	264.6	1.70
T-04	SPS Envirowall	EWI + UF	111.8	£214.72	14.6	0.082	99.7	0.61
T-05	SPS Envirowall	EWI	156.4	£300.32	52.5	0.376	102.3	0.92
T-06	SPS Envirowall	EWI + UF	71.9	£138.00	30.8	0.097	58.8	0.54
T-07	SPS Envirowall	EWI + UF	103.8	£199.20	38.0	0.364	50.3	0.63
T-08	SPS Envirowall	EWI	181.1	£347.68	14.5	0.065	169.9	0.97
T-09	SPS Envirowall	EWI + UF	208.1	£399.52	51.4	0.345	156.2	1.17
T-10	SPS Envirowall	EWI + UF	190.3	£365.44	35.2	0.142	186.9	1.13
	Maximum		295.7	£567.68	52.5	0.376	264.6	1.70
	Minimum		71.9	£138.00	14.5	0.065	50.3	0.54
	Average (Mean)		158.0	£303.40	31.8	0.202	131.2	0.91

[1] Electricity Unit rate = 16p/kWh

Table 3.13a Details of electricity consumption for households prior to insulation with SPS Envirowall insulation

[13] Park (mobile) homes, https://www.gov.uk/park-mobile-homes/charges (Accessed 18 July 2017)

			After installation					
Tech Ref	Technology	Measure	Average Monthly Consumption (kWh)	Estimated Annual cost [1]	Standard Deviation (kWh)	Performance Line Gradient (kWh/DD)	Performance Line Intercept (kWh)	kWh/DD
T-01	SPS Envirowall	EWI + UF	115.3	£221.28	11.3	0.019	112.3	0.74
T-02	SPS Envirowall	EWI	114.4	£219.68	16.1	0.087	100.9	0.74
T-03	SPS Envirowall	EWI + UF	284.9	£547.04	35.9	0.205	253.1	1.84
T-04	SPS Envirowall	EWI + UF	93.5	£179.52	15.2	0.055	84.9	0.60
T-05	SPS Envirowall	EWI	141.5	£271.68	48.3	0.408	78.2	0.91
T-06	SPS Envirowall	EWI + UF	98.9	£189.92	26.4	0.204	67.2	0.64
T-07	SPS Envirowall	EWI + UF	96.3	£184.80	29.2	0.185	67.6	0.62
T-08	SPS Envirowall	EWI	176.4	£338.72	11.5	0.044	169.6	1.14
T-09	SPS Envirowall	EWI + UF	207.9	£399.20	57.3	0.448	138.4	1.34
T-10	SPS Envirowall	EWI + UF	252.9	£485.60	71.3	-0.054	261.3	1.63
	Maximum		284.9	£547.04	71.3	0.448	261.3	1.84
	Minimum		93.5	£179.52	11.3	-0.054	67.2	0.60
	Average (Mean)		158.2	£303.74	32.2	0.160	133.4	1.02

[1] Electricity Unit rate = 16p/kWh

Table 3.13b Details of electricity consumption for households after insulation with SPS Envirowall insulation

The standard deviation indicates the variation of values from the mean consumption. Household T-08 showed little variation in monthly electricity consumption over the pre and post installation period, with values of 14.5 and 11.5kWh respectively. Households with a high standard deviation like T-05 and T-09 showed a significant scatter in meter readings over the year.

Households with a greater gradient for the performance line graph showed a greater increase in electricity consumption as the weather became colder. Those with a larger performance line intercept have a greater monthly 'base' load electricity consumption which is temperature independent. Households T-04 and T-08 had little or no temperature dependence on their electricity consumption.

Household T-03 had the highest 'base' load electricity consumption with a value of 265kWh before the installations and 253kWh afterwards. There was a decrease in the gradient of the performance line from 0.297 to 0.205kWh / degree day. This suggests there may have been a reduction in secondary electric heating at the household after the installation.

Household T-06 had the lowest monthly electricity consumption during the pre-installation period. There was an increase in the gradient of the performance line graph after the insulation was fitted. This may indicate greater use of electric room heating as an alternative to whole house heating with mains gas.

Household T-07 was also a low consumer of electricity, having the lowest base load consumption pre-installation. The gradient of the performance line graph in Figure 3.14a was fairly high, which suggests secondary electric heating was used before the household was insulated. Post-installation, the gradient was lower, which suggests a reduction in secondary electric heating.

Figure 3.15 shows the performance line graphs from T-08 before and after wall insulation with SPS Envirowall. The 'base' load electricity consumption at 170 kWh was quite high and did not change after the household received wall insulation. The performance line was almost horizontal both before and after installation. This indicates there was no use of secondary heating before or after installation.

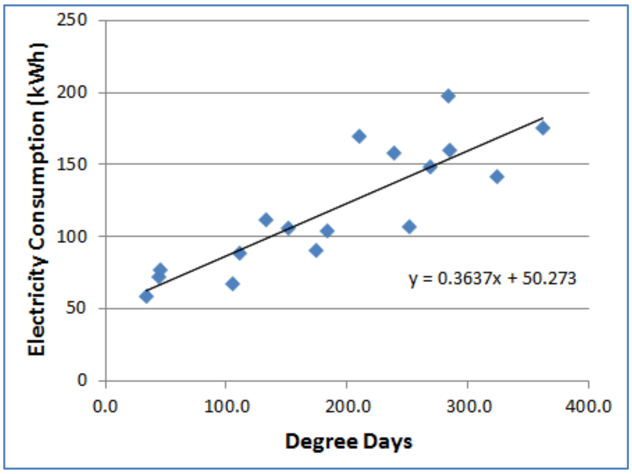

Figure 3.14a T-07 before SPS Envirowall & UF installation

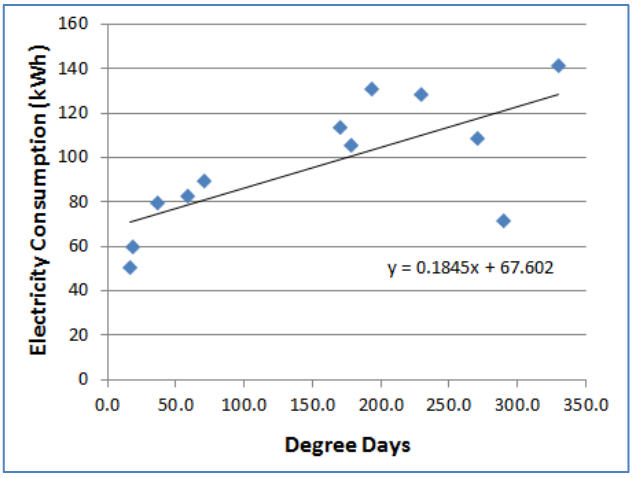

Figure 3.14b T-07 after SPS Envirowall & UF installation

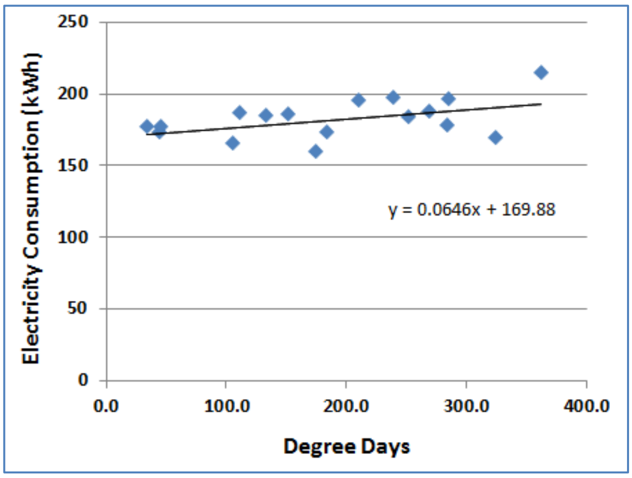

Figure 3.15a T-08 before SPS Envirowall installation

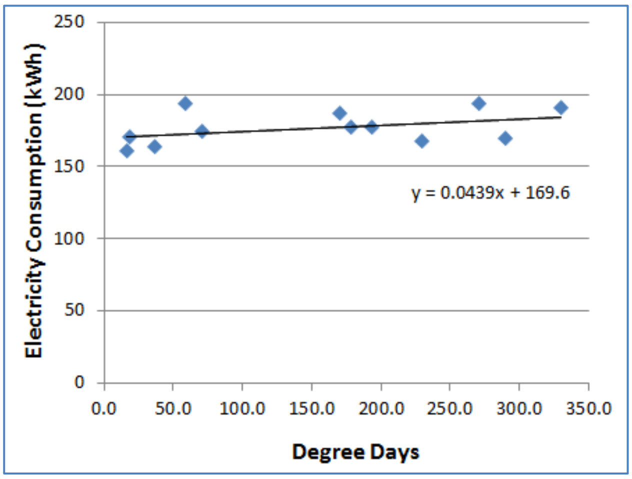

Figure 3.15b T-08 after SPS Envirowall installation

			Before installation					
Tech Ref	Technology	Measure	Average Monthly Consumption (kWh)	Estimated Annual cost [1]	Standard Deviation (kWh)	Performance Line Gradient (kWh/DD)	Performance Line Intercept (kWh)	kWh/DD
T-35	JUB Jubizol Premium	EWI	249.7	£479.36	16.0	-0.058	270.1	1.38
T-36	JUB Jubizol Premium	EWI	262.2	£503.47	48.5	0.316	160.6	1.17
T-37	JUB Jubizol Premium	EWI	114.9	£220.59	18.2	0.077	106.0	0.64
T-38	JUB Jubizol Premium	EWI	202.2	£388.27	14.3	-0.070	201.4	1.00
T-39	JUB Jubizol Premium	EWI	176.0	£337.92	24.8	0.173	144.0	0.94
T-40	JUB Jubizol Premium	EWI	74.1	£142.29	8.1	0.053	62.0	0.38
T-41	JUB Jubizol Premium	EWI	204.6	£392.75	31.0	0.352	144.5	1.12
T-43	JUB Jubizol Premium	EWI	94.9	£182.19	32.9	0.169	62.1	0.50
	Maximum		262.2	£503.47	48.5	0.352	270.1	1.38
	Minimum		74.1	£142.29	8.1	-0.070	62.0	0.38
	Average (Mean)		172.3	£330.85	24.2	0.126	143.8	0.89

[1] Electricity Unit rate = 16p/kWh

Table 3.16a Details of electricity consumption prior to insulation with JUB Jubizol Premium at Ashfield Park

After installation								
Tech Ref	Technology	Measure	Average Monthly Consumption (kWh)	Estimated Annual cost [1]	Standard Deviation (kWh)	Performance Line Gradient (kWh/DD)	Performance Line Intercept (kWh)	kWh/DD
T-35	JUB Jubizol Premium	EWI	241.7	£464.00	20.0	-0.031	247.9	1.22
T-36	JUB Jubizol Premium	EWI	338.8	£650.45	99.7	0.976	144.7	1.70
T-37	JUB Jubizol Premium	EWI	118.0	£226.56	21.3	-0.387	126.0	0.66
T-38	JUB Jubizol Premium	EWI	190.9	£366.51	48.3	-0.005	207.5	0.96
T-39	JUB Jubizol Premium	EWI	174.3	£334.72	15.0	0.027	168.0	0.96
T-40	JUB Jubizol Premium	EWI	83.9	£161.07	8.3	0.037	76.4	0.42
T-41	JUB Jubizol Premium	EWI	207.1	£397.65	29.1	0.216	164.2	1.04
T-43	JUB Jubizol Premium	EWI	58.9	£113.07	10.9	0.030	51.5	0.32
	Maximum		338.8	£650.45	99.7	0.976	247.9	1.70
	Minimum		58.9	£113.07	8.3	-0.387	51.5	0.32
	Average (Mean)		176.7	£339.25	31.6	0.108	148.3	0.91

[1] Electricity Unit rate = 16p/kWh

Table 3.16b Details of electricity consumption after insulation with JUB Jubizol Premium at Ashfield Park

Analysis of the electricity consumption of households which received the JUB Jubizol Premium EWI is shown in Tables 3.16a and 3.16b. The average monthly consumption was calculated using the pre-installation period of September 2015 to June 2016 and post installation period of September 2016 to June 2017. Data was not available for a post installation period of a year. This meant that the average monthly consumption and annual costs are likely to be over-estimated. However it is possible to directly compare the pre and post installation periods.

For the analysis of electricity consumption against degree days, a pre-installation period of October 2014 to March 2016 was used as for SPS Envirowall and the post installation period was September 2015 to June 2016. Here the different date ranges are less critical as account was taken for differences in consumption with temperature.

The average monthly electricity consumption before the properties were insulated was between 74 and 262kWh. The mean electricity consumption of all the households before installation was 172kWh, which was only slightly higher than the pre-installation consumption for the households with SPS Envirowall. After the insulation was fitted, there was little change to the average electricity consumption which increased to 177kWh. Consumption of individual households ranged from 59kWh to 339kWh.

While most households showed a small decrease or increase in electricity consumption following the insulation, T-36 was anomalous, showing a 29% increase in average monthly electricity consumption. Table 3.16a shows there was some temperature dependency in the electricity consumption before the household was insulated and was also considerable scatter in the values of the monthly consumption. The base load consumption for T-36 did not vary significantly before and after the installation as shown by the performance line intercept. There was however a large increase in the gradient of the performance line after the installation.

Table 2.12 showed that a new kitchen was installed in the home of household T-36 in December 2016. The kitchen was also extended into a conservatory. Among the new kitchen appliances was an electric plinth heater which provided heat to the kitchen and conservatory. Consumption data from mid-November 2016 to mid-March 2017 showed an increase in electricity use compared to the same periods in previous years. Use of the electric plinth heater over these winter months is likely to account for this increase in electricity consumption and the gradient on the performance line graph.

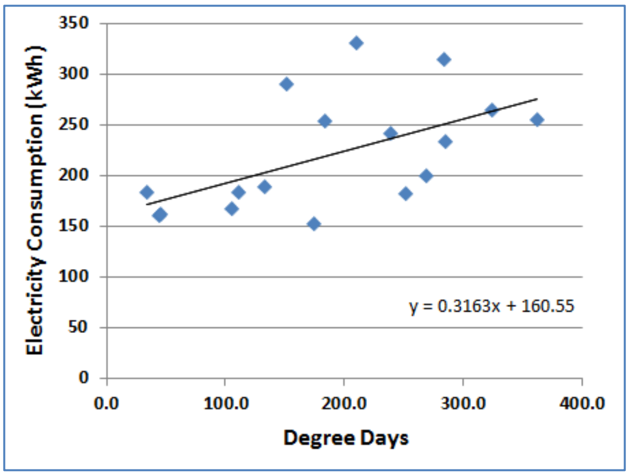

Figure 3.17a T-36 before JUB Jubizol installation

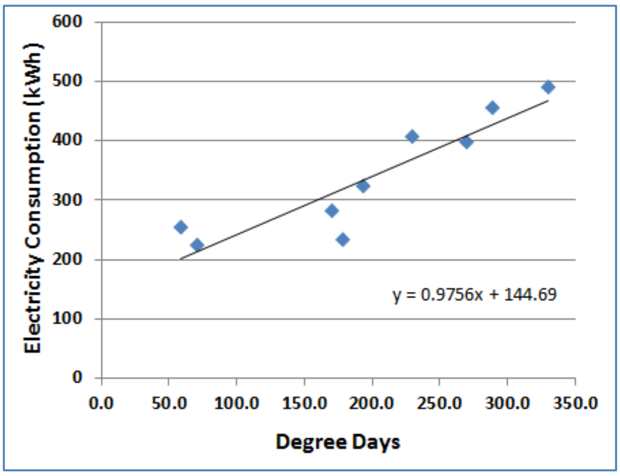

Figure 3.17b T-36 after JUB Jubizol installation

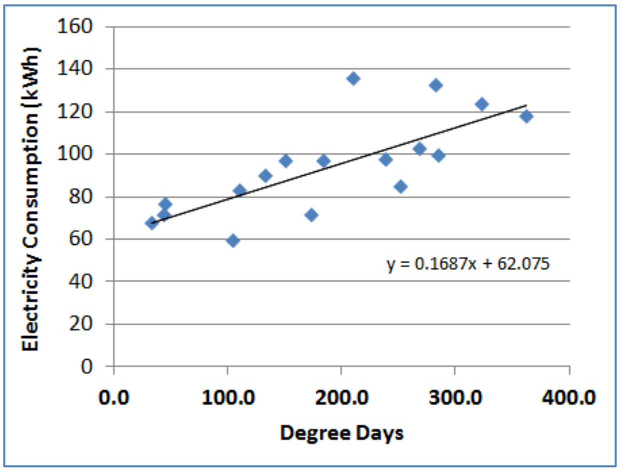

Figure 3.18a T-43 before JUB Jubizol installation

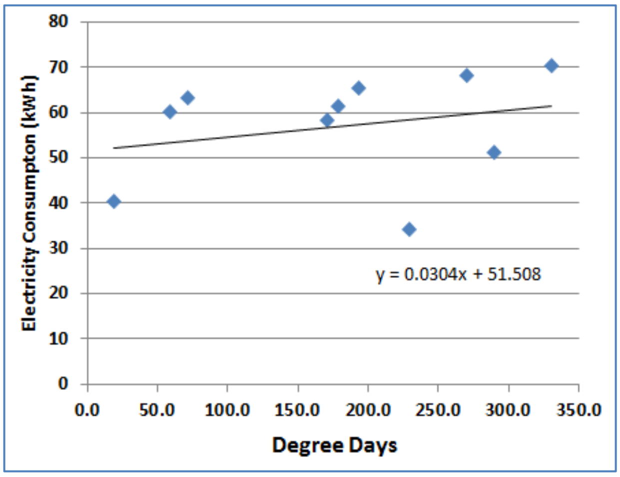

Figure 3.18b T-43 after JUB Jubizol installation

Households T-39 and T-41 showed similar behaviour to T-43, with a decrease in the gradient of the performance line, suggesting there was some reduction in secondary electric heating after the households were insulated.

The performance lines for households T-35, T-37, T-38 and T-40 were similar to T-08 in figures 3.15a and 3.15b This suggest these households made little or no use of secondary electric heating before and after the walls were insulated

3.5 Temperature and thermal comfort

Temperature and humidity loggers were set up in February 2016 in the living rooms of the monitored park homes which received SPS Envirowall installations. The EWI was fitted in these households in May and June 2016. The loggers were collected in April and May 2017.

All but 1 of the monitored households which received JUB Jubizol Premium EWI had temperature and humidity loggers. T-00 which had a replacement roof, doors and windows did not have a logger. Installation of the EWI at the other households took place during July and August 2016 and the loggers were set up in the living rooms of the households during August 2016. Among these loggers, 2 failed and did not record data, while 1 was lost by the household. This reduced the temperature and humidity data available from JUB Jubizol Premium compared to SPS Envirowall. Also there was not a period where the temperature was monitored before the installation. The loggers were again collected during April and May 2017.

At Charnwood Park the temperature and humidity loggers were set up in early April 2016. A logger was also set up in a household which was unable to have wall insulation and this became a control household. Installations of the EWI took place between September 2016 and November 2016 and the loggers were collected in May 2017. Household T-11 with a ParexTherm acrylic render installation had two loggers – 1 in the living room and 1 in the bedroom. The resident in household T-22 moved during April 2017 and so some data collected was from the next occupant. It was not possible to collect the temperature and humidity logger from household T-19.

Table 3.19a and Figure 3.20a show living room temperatures temperatures in March 2016 prior to installation of SPS Envirowall. A post installation period in March 2017 is shown in Table 3.19b and 3.20b. It should be noted that the error bars on the graphs represent the range between the maximum and minimum temperatures recorded during the analysis periods.

The number of degree days in March 2016 was 277.3 and so the period was colder than March 2017 with 197.2 degree days. The heating demand in March 2016 would therefore be higher and with insufficient heating, there may have been lower temperatures.

Tables 3.19a and 3.19b show that the average living room temperature throughout the day in March 2016 ranged from 16.10°C to 22.57°C. In March 2017 the 24 hour average temperatures were between 19.08°C and 23.14°C. Minimum temperatures in March 2016 were between 5.5°C and 21.5°C compared to between 12.5°C and 21°C in March 2017. This indicated that overall there was an improvement in the average household temperature and the minimum temperature after installation of the EWI.

For household T-01, the average of temperature over 24 hours increased from 18.89°C in March 2016 to 20.43°C in March 2017. A significant improvement in thermal comfort explains the negligble savings in gas consumption following installation of the SPS Envirowall.

Household T-02 also saw an increase in average temperature as well as in improvement in the minimum temperature. The minimum temperature between 5pm and 9pm was 10°C in March 2016, but this increased to 17.5°C in March 2017.

		1st March to 31st March 2016						
Tech Ref	Measure	Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Standard Deviation 24 hours	Average Temp (°C) 5pm-9pm	Maximum Temp (°C) 5pm-9pm	Minimum Temp (°C) 5pm-9pm
T-01	SPS Envirowall + UF	18.89	27.0	15.0	2.18	20.13	25.5	18.0
T-02	SPS Envirowall	18.53	28.0	9.0	4.77	20.62	26.5	10.0
T-03	SPS Envirowall + UF	21.11	26.5	13.0	2.55	23.13	25.5	20.0
T-04	SPS Envirowall + UF	19.68	28.5	13.5	3.24	21.87	26.0	19.0
T-05	SPS Envirowall	20.41	27.0	15.0	2.39	21.75	26.5	15.5
T-06	SPS Envirowall + UF	18.15	26.0	9.0	3.50	22.72	26.0	18.0
T-07	SPS Envirowall + UF	16.10	24.5	5.5	4.22	19.47	23.5	11.0
T-08	SPS Envirowall	22.57	25.0	21.5	0.52	22.70	24.5	22.0
T-09	SPS Envirowall + UF	18.53	25.0	7.5	3.95	21.24	25.0	11.0
T-10	SPS Envirowall + UF	22.33	29.5	12.5	3.25	23.05	28.0	17.5
	Maximum	22.57	29.5	21.5	4.77	23.13	28.0	22.0
	Minimum	16.10	24.5	5.5	0.52	19.47	23.5	10.0
	Average (Mean)	19.63	26.7	12.15	3.06	21.67	25.7	16.2

Table 3.19a Living room temperatures for households at Ashfield Park prior to installation of SPS Envirowall (Period 1st March 2016 to 31st March 2016; number of degree days over period = 277.3)

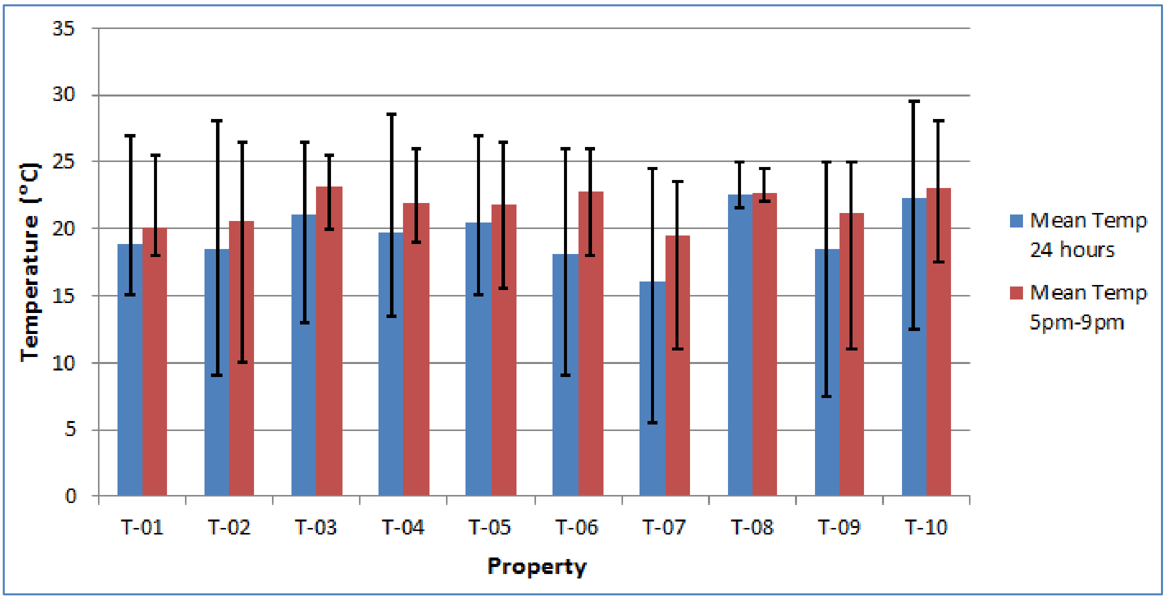

Figure 3.20a Mean living room temp for households at Ashfield Park prior to SPS Envirowall installations (1st Mar 16 to 31st Mar 16)
The errors bars show the range of the maximum and minimum temperatures during the analysis period

		1st March to 31st March 2017						
Tech Ref	Measure	Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Standard Deviation 24 hours	Average Temp (°C) 5pm-9pm	Maximum Temp (°C) 5pm-9pm	Minimum Temp (°C) 5pm-9pm
T-01	SPS Envirowall + UF	20.43	28.0	15.0	2.32	22.01	27.0	19.5
T-02	SPS Envirowall	19.95	27.0	12.5	3.08	22.09	27.0	17.5
T-03	SPS Envirowall + UF	21.43	25.5	13.0	1.84	22.71	25.0	20.0
T-04	SPS Envirowall + UF	20.55	28.0	15.0	2.76	22.57	26.5	20.0
T-05	SPS Envirowall	20.45	27.0	15.0	2.43	21.45	26.5	17.0
T-06	SPS Envirowall + UF	19.08	26.0	14.0	2.67	21.02	26.0	14.5
T-07	SPS Envirowall + UF	20.07	27.0	13.5	2.80	22.31	27.0	17.0
T-08	SPS Envirowall	22.12	24.5	21.0	0.53	22.27	24.5	21.0
T-09	SPS Envirowall + UF	19.17	26.0	13.5	2.83	20.80	26.0	15.0
T-10	SPS Envirowall + UF	23.14	30.5	16.5	2.33	23.36	28.0	19.5
	Maximum	23.14	30.5	21.0	3.08	23.36	28.0	21.0
	Minimum	19.08	24.5	12.5	0.53	20.8	24.5	14.5
	Average (Mean)	20.64	26.95	14.9	2.36	22.06	26.35	18.1

Table 3.19b Living room temperatures for households at Ashfield Park following installation SPS Envirowall (Period 1st March 2017 to 31st March 2017; number of degree days over period = 197.20)

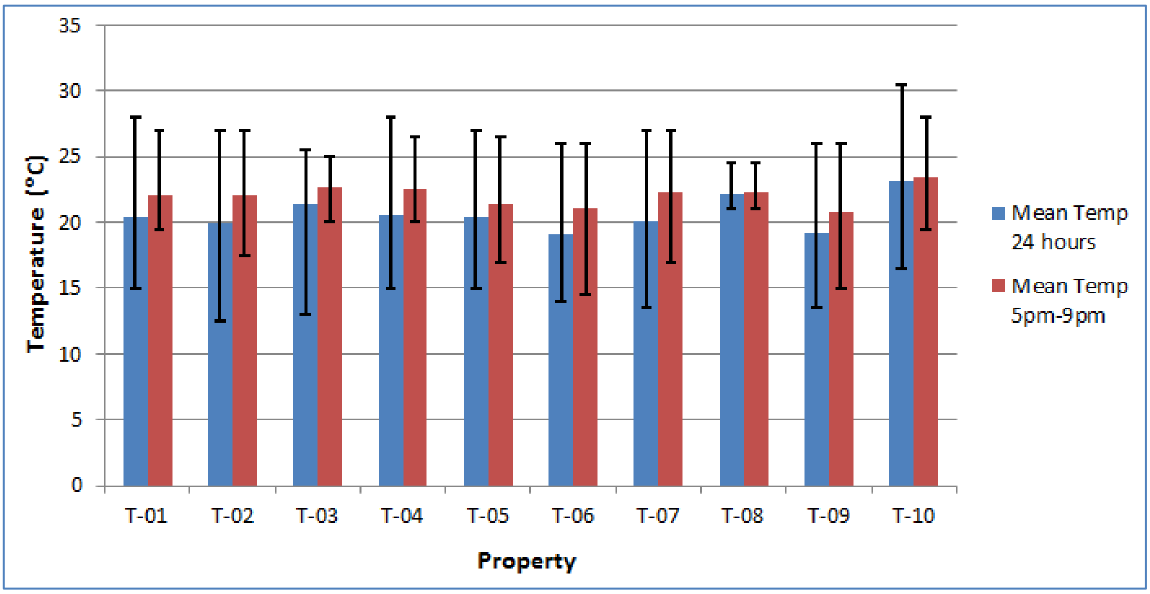

Figure 3.20b Mean living room temp for households at Ashfield Park after SPS Envirowall installations (1st Mar 17 to 31st Mar 17)
The errors bars show the range of the maximum and minimum temperatures during the period

In March 2016, the average living room temperature for T-03 was 21.11°C and this increased to 21.43°C in March 2017. This was the only household with SPS Envirowall EWI which saw an increase in consumption. The pre-installation 'relative thermal comfort ratio' or ratio of annual gas consumption to EPC space and water heating demand was 0.71. This suggested the household was underheating, however the temperatures measured in March 2016 suggest this was not the case. It is possible that the property was less well heated at other times during the pre-installation period.

The average temperature increased between March 2016 and March 2017 for household T-04 but there was little change in the value for T-05. The average temperature for household T-07 in March 2016 was only 16.1°C. Table 3.9 showed that 'relative thermal comfort ratio' was the lowest for all the households receiving SPS Envirowall and indicating it was the most under heated. The average temperature increased to 20.07°C in March 2017. The minimum temperature also increased from 5.5°C to 13.5°C. Household T-07 reduced their gas consumption by 16.4%. This was towards the lower end of the range of savings and could be explained by the improved thermal comfort.

Household T-08 saw a small decrease in the average temperature between March 2016 and March 2017. This household was notable for having a very narrow range between the maximum and minimum temperature. This was seen in Tables 3.19a and 3.19b. The household kept the thermostat set to 21°C. The boiler heating was used 24 hours a day and cut out when it exceeded 21°C.

This household had the highest pre-installation gas consumption and made the greatest savings (39%) after the SPS Envirowall was installed. It was also the oldest park home known to be part of the study, having been manufactured in 1962. Older park homes had poorer insulation and so there would have been a greater improvement in the U-value as a result. The high pre-installation gas consumption was influenced by the poor U-value and the temperature difference between the inside and outside of the park home. The temperature difference was more consistently high for T-08 because the temperature did not drop below 21.5°C in March 2016 & and 21°C in March 2017. The decrease in average temperature, the significant improvement in U-value and the consistently high temperature difference can explain the high savings in gas consumption for T-08.

Household T-09 saw an increase in average temperature from 18.53°C to 19.17°C between March 2016 and the following year.The 'relative thermal comfort ratio' was 0.73 before the installation which suggested in was under heated.

The average temperature for T-10 in March 2016 was 22.33°C, although the temperature ranged from 12.5°C to 29.5°C. In this case the pre-installation 'relative thermal comfort ratio' was 1.11, indicating that the thermal comfort level was greater than the Standard Heating Pattern used by RdSAP. During March 2017, the average living room temperature was 23.14°C, indicating an increase during these analysis periods. This temperature is above the temperatures recommended by health professionals and energy modelling methodology[14], however, the resident reported better heat retention (Dissatisfied to Very satisfied with heat retention), and no need to wear warm clothes to keep warm. No health conditions were reported, and the resident stated that full use was made of the programmer and thermostat.

Household T-10 had the second highest pre-installation gas consumption and showed the second highest savings (37.8%) after the insulation was fitted. While there was an improvement in thermal comfort between March 2016 and March 2017, there may not have been an overall improvement across the whole pre and post installation periods. With high temperatures in household T-10, the greater difference between the outside and inside temperatures resulted in higher gas consumption. As a result, the savings were larger following insulation.

Table 3.21 and Figure 3.22 show temperatures measured in park homes with SPS Envirowall during a post installation analysis period between 1st October 2016 and 31st March 2017. While the data had similarities to the shorter analysis period during March 2017 (table 3.19b), some differences were noted with the longer period. There was a higher average temperature over the full day for households T-02, T-03, T-05 and T-09 during the October to March analysis period. The

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[14] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/639120/Fuel_Poverty_Methodology_Handbook.pdf

minimum living room temperature was lower during this period for T-04, T-05, T-06, T-07 and T-09. This was more noticable for the latter three households.

For household T-06, the heating was typically turned off in the late evening and the temperature fell until the heating was turned on again after lunch. On some days the temperature fell to 9.5°C, but a more typical minimum temperature was 12°C. During the colder weather in January and February there was a morning heating period as well. The households were away for a few days in December and with no heating the room temperature fell to 4.5°C, the lowest temperature recorded during the October 2016 to March 2017 analysis period.

The living room temperature in T-07 was often about 22 to 23°C mid evening, when the heating was turned off. The temperature typically fell until about 9 to 10am the next morning. The minimum temperature was sometimes as low as 11°C. During an extended period in December, the living room temperature remained in the range 9.5°C to 15°C. This all led to a lower average temperature, a low minimum temperature and the standard deviation of the temperature (an indication of the range of temperatures from the average) being the highest of all the households with SPS Envirowall.

A minimum temperature of 8.5°C was recorded for household T-09 in November. Typically the temperature fell overnight from about 24°C to between 13 and 15°C at about 9am the next morning.

1st October 2016 to 31st March 2017								
Tech Ref	Measure	Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Standard Deviation 24 hours	Average Temp (°C) 5pm-9pm	Maximum Temp (°C) 5pm-9pm	Minimum Temp (°C) 5pm-9pm
T-01	SPS Envirowall + UF	19.95	28.0	15.0	1.82	21.00	27.0	16.5
T-02	SPS Envirowall	20.24	27.0	12.5	3.15	22.71	27.0	17.5
T-03	SPS Envirowall + UF	22.29	26.5	13.0	1.73	23.40	26.5	20.0
T-04	SPS Envirowall + UF	20.33	28.0	14.5	2.48	22.24	27.5	17.5
T-05	SPS Envirowall	20.52	28.5	11.5	2.50	22.04	28.5	15.5
T-06	SPS Envirowall + UF	18.33	27.0	4.5	3.88	21.10	27.0	5.5
T-07	SPS Envirowall + UF	18.08	27.5	9.5	3.96	20.13	27.5	9.5
T-08	SPS Envirowall	21.69	24.5	18.5	0.45	21.84	24.5	21.0
T-09	SPS Envirowall + UF	19.97	26.0	8.5	3.06	22.40	26.0	11.0
T-10	SPS Envirowall + UF	22.69	30.5	15.0	2.39	23.41	28.0	17.5
	Maximum	22.69	30.5	18.5	3.96	23.41	28.5	21.0
	Minimum	18.08	24.5	4.5	0.45	20.13	24.5	5.5
	Average (Mean)	20.41	27.35	12.25	2.54	22.03	26.95	15.15

Table 3.21 Living room temperatures for households at Ashfield Park following installation SPS Envirowall (Period 1st October 2016 to 31st March 2017; number of degree days over period = 1470.50)

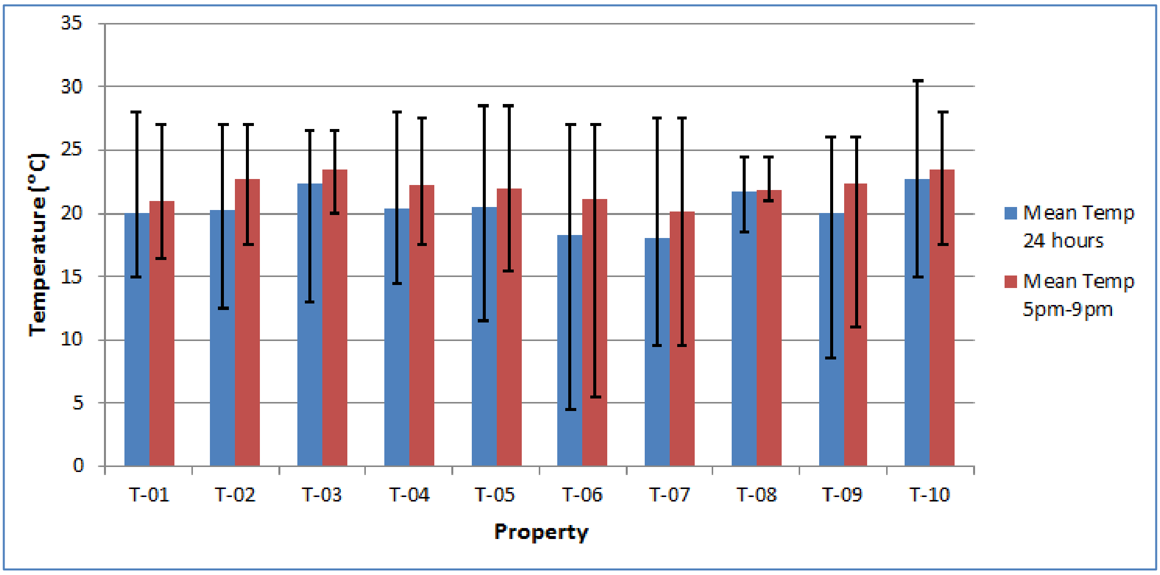

Figure 3.22 Mean living room temp for households at Ashfield Park after SPS Envirowall installations (1st Oct 16 to 31st Mar 17)
The errors bars show the range of the maximum and minimum temperatures during the period

1st October 2016 to 31st March 2017									
Tech Ref	EWI Technology	Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Standard Deviation 24 hours	Average Temp (°C) 5pm-9pm	Maximum Temp (°C) 5pm-9pm	Minimum Temp (°C) 5pm-9pm
T-35	JUB Jubizol Premium	21.77	28.5	16.5	1.33	22.47	28.5	19.0
T-36	JUB Jubizol Premium	20.56	28.0	11.5	1.92	21.12	28.0	14.5
T-38	JUB Jubizol Premium	21.86	26.5	17.5	1.75	23.11	26.0	20.0
T-39	JUB Jubizol Premium	19.89	29.0	16.0	2.32	21.58	29.0	17.0
T-40	JUB Jubizol Premium	16.76	26.5	12.5	2.47	19.13	26.0	14.0
T-41	JUB Jubizol Premium	22.79	28.5	12.5	3.37	25.28	28.5	22.5
T-44	JUB Jubizol Premium	20.21	27.5	11.5	2.58	22.26	27.5	13.5
	Maximum	22.79	29.0	17.5	3.37	25.28	29.0	22.5
	Minimum	16.76	26.5	11.5	1.33	19.13	26.0	13.5
	Average (Mean)	20.55	27.79	14.00	2.25	22.14	27.64	17.21

Table 3.23 Living room temperatures for households at Ashfield Park following installation JUB Jubizol Premium (Period 1st October 2016 to 31st March 2017; number of degree days over period = 1470.50)

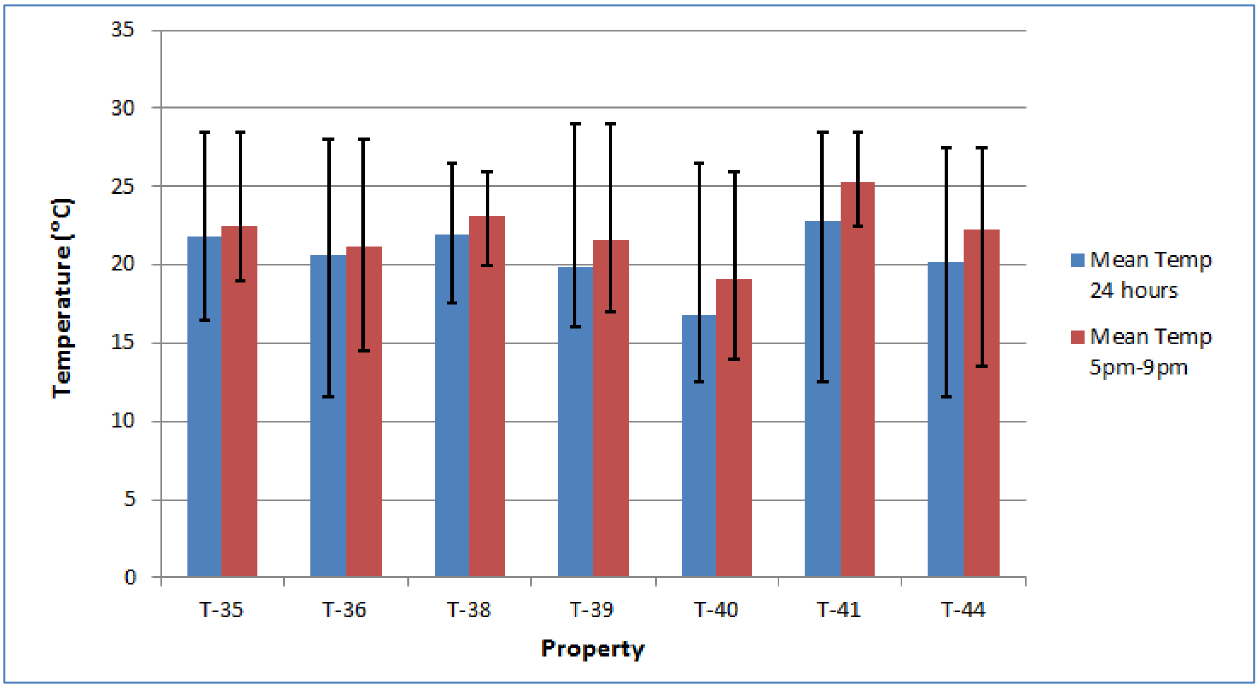

Figure 3.24 Mean living room temp for households at Ashfield Park after JUB Jubizol installations (1st Oct 16 to 31st Mar 17)
The errors bars show the range of the maximum and minimum temperatures during the period

Living room temperatures are shown in Table 3.23 and Figure 3.24 for households at Ashfield Park which received JUB Jubizol Premium EWI installations. This was for an analysis period between 1st October 2016 and 31st March 2017. The average living room temperature over the whole day was 20.55°C compared to 20.41°C for the SPS Envirowall installations.

The average living room temperature for household T-40 was 16.76°C. This was the lowest average temperature for the households which received JUB Jubizol and T-40 was the most under heated in this group. However, during the 5pm to 9pm period, the average was a more acceptable 19.13°C. The resident reported no health conditions, and did not worry about everyday finances.

While the minimum temperature fell below 10°C for three of the households which received SPS Envirowall, none of the households with JUB Jubizol had room temperatures that low. The minimum temperatures for this group was between 11.5°C and 17.5°C. The average minimum temperature for the households with SPS Envirowall was 12.25°C compared to 14.0°C for JUB Jubizol Premium.

Households like T-38 and T-41 were over heating. The average temperatures over the whole day were 21.86°C and 22.79°C respectively. However, when just considering the period 5pm to 9pm, the averages were even warmer at 23.11°C and 25.28°C. Maximum temperatures for the households with JUB Jubizol Premium ranged from 26 to 29°C. The two residents did not state they were excessivly warm in their home, and both residents did not worry about money. Both stated they controlled their heating by programmer and thermostat, and understood how to use them.

The temperature loggers at Charnwood Park were installed early enough to allow a pre-installation period to be analysed. However this was a short period in April rather than during a colder winter month. The pre-installation analysis period chosen was from 10th April 2016 to 30th April 2016 which corresponded to 169.2 degree days in that area. For comparison a post-installation period of

10th April 2017 to 30th April 2017 was used. For this period the number of degree days was 126.8. The weather was therefore colder in the pre-installation analysis period and there was a higher heating demand. It is possible this may have led to colder room temperatures than in the post installation period.

Table 3.25a and Figure 3.26a show the temperatures recorded during the pre-installation period in April 2016 for five of the households with ParexTherm insulation, one with Alumasc Swisslab and the control household. Household T-11 had a temperature and humidity logger in both the living room and the bedroom. Temperatures from the post-installation analysis period in April 2017 are shown in Table 3.25b and Figure 3.26b.

For the pre and post installation periods, the average temperature over the whole day of the control household was 19.09°C and 18.49°C respectively. The minimum temperature in the analysis period in April 2016 was 8.0°C compared to 8.5°C in the analysis period in April 2017. As the temperatures were not significantly different, it is reasonable to also compare pre and post installation temperatures of the households with EWI.

The average living room temperature for the ParexTherm installations in April 2016 was 17.87°C and this increased to 19.26°C for the analysis period in April 2017. The minimum temperatures ranged from 4.5°C to 12.5°C in April 2016, compared to 10.5 to 16.5°C in April 2017. The warmer weather during the analysis period in April 2017 may partly account for the improved minimum temperatures.

Table 3.10 showed that the 'relative thermal comfort ratio' (ratio of annual gas consumption to EPC space and water heating demand) for household T-11 was the lowest in this study. The temperatures shown in table 3.25a support the hypothesis that T-11 was the most under heated household in the study. For T-11 in April 2016, the average temperature over the whole day in the living room was 17.61°C, however in the bedroom it was only 13.26°C. Between 10th April and 30th April 2017, the average living room temperature was 17.22°C for T-11, but the average bedroom temperature had risen to 19.05°C.

		10th April 2016 to 30th April 2016						
Tech Ref	EWI Technology	Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Standard Deviation 24 hours	Average Temp (°C) 5pm-9pm	Maximum Temp (°C) 5pm-9pm	Minimum Temp (°C) 5pm-9pm
T-11-B	ParexTherm	13.26	22.5	4.5	3.74	15.22	22.0	9.5
T-11-L	ParexTherm	17.61	25.0	9.5	2.42	18.58	25.0	13.5
T-12	ParexTherm	19.45	26.5	9.0	4.50	23.20	26.0	19.5
T-20	ParexTherm	21.08	27.5	12.5	3.45	22.46	26.5	15.5
T-21	ParexTherm	17.51	26.0	9.0	3.85	21.55	26.0	17.5
T-22	ParexTherm	18.30	24.0	9.0	3.23	20.18	24.0	12.0
	Maximum	21.08	27.5	12.5	4.50	23.2	26.5	19.5
	Minimum	13.26	22.5	4.5	2.42	15.2	22.0	9.5
	Average (Mean)	17.87	25.25	8.92	3.53	20.20	24.92	14.58
T-24	Alumasc Swisslab	17.28	24.0	11.0	3.50	19.0	23.5	11.5
C-15	Control	19.09	27.5	8.0	4.09	21.3	27.5	16.5

Table 3.25a Room temperatures for Park Homes at Charnwood Park before installation of external wall insulation (Analysis period from 10th April 2016 to 30th April 2016; number of degree days over period = 169.20))

Tech Ref	EWI Technology	10th April 2017 to 30th April 2017 Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Standard Deviation 24 hours	Average Temp (°C) 5pm-9pm	Maximum Temp (°C) 5pm-9pm	Minimum Temp (°C) 5pm-9pm
T-11-B	ParexTherm	19.05	26.5	13.0	2.06	19.10	24.0	15.5
T-11-L	ParexTherm	17.22	24.0	10.5	2.92	18.73	23.5	14.0
T-12	ParexTherm	20.01	25.5	12.0	3.35	22.74	25.5	20.0
T-20	ParexTherm	21.46	26.5	16.0	2.01	22.14	26.0	18.0
T-21	ParexTherm	19.68	23.0	16.5	1.75	20.94	23.0	18.0
T-22	ParexTherm	18.13	29.0	13.0	3.32	20.04	27.0	14.5
	Maximum	21.46	29.0	16.5	3.35	22.74	27.0	20.0
	Minimum	17.22	23.0	10.5	1.75	18.73	23.0	14.0
	Average (Mean)	19.26	25.75	13.50	2.57	20.62	24.83	16.67
T-24	Alumasc Swisslab	20.78	26.0	14.5	2.59	22.76	25.0	19.5
C-15	Control	18.49	27.0	8.5	3.65	21.44	27.0	17.5

Table 3.25b Room temperatures for Park Homes at Charnwood Park after installation of external wall insulation (Analysis period from 10th April 2017 to 30th April 2017; number of degree days over period = 126.80)

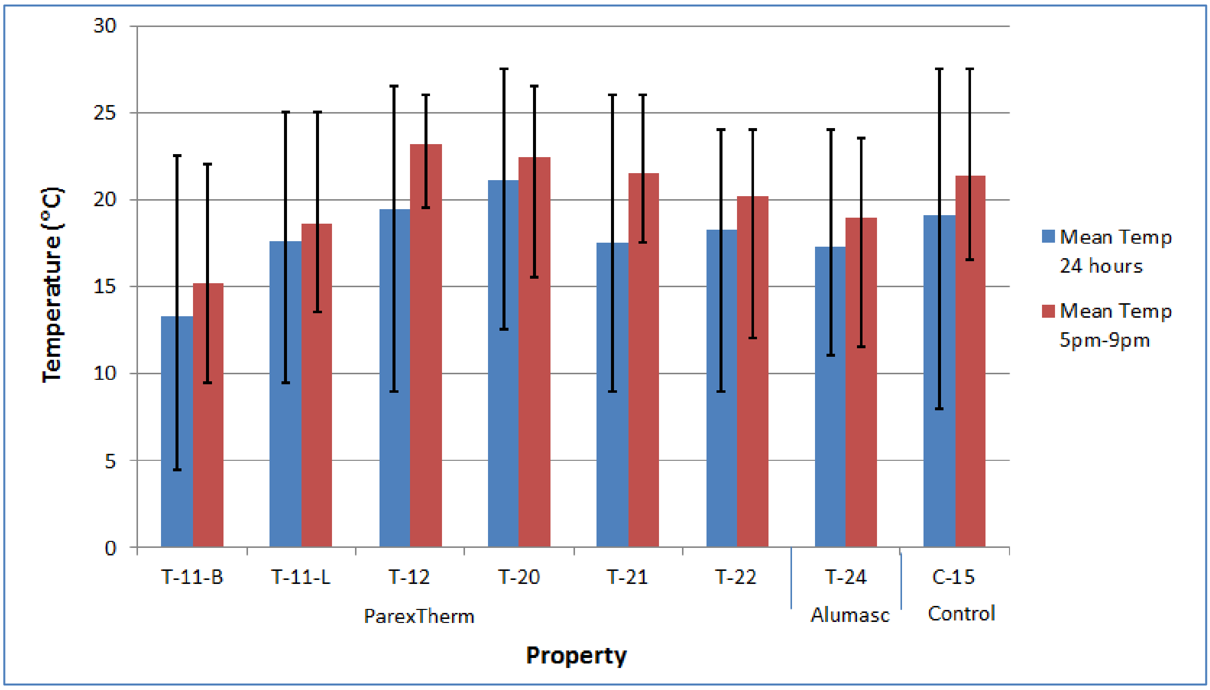

Figure 3.26a Mean living room temp for households at Charnwood Park prior to EWI installations (10th Apr 16 to 30th Apr 16)
The errors bars show the range of the maximum and minimum temperatures during the period

Household T-21 saw an increase in average temperature from 17.51 to 19.68°C following the installation of the ParexTherm EWI. There was also an improvement in the minimum temperature which rose from 9°C to 16.5°C.

There was a small decrease in the average living room temperature for household T-22, which fell from 18.30°C to 18.13°C. However the maximum temperature rose from 24°C to 29°C in April 2017. This might account for the lower reduction in gas consumption with this household, or the need for more accurate control over the heating. The resident stated tht the heating was controlled only from the programmer (no mention of thermostat or TRVs).

The average living room temperature for household T-24 with Alumasc Swisslab EWI increased from 17.28°C during the analysis period in April 2016 to 20.78°C in April 2017. Also the minimum temperature increased from 11°C to 14.5°C. During the study period, the health of the householder deteriorated and improved thermal comfort was required as a result. The temperatures measured provide evidence of this and can explain the increase in gas consumption experienced by this household after installation of the EWI.

Temperatures for households at Charnwood Park were also analysed over the period between 1st October 2016 to 31st March 2017 for comparison with the households with SPS Envirowall and JUB Jubizol Premium. Due to the EWI being installed on some households at Charnwood in November, only households T-11, T-12 and T-20 along with the control, C-15 could be analysed in this way.

Table 3.27 and Figure 3.28 show temperature data for households at Charnwood Park for the analysis period between 1st October 2016 and 31st March 2017. The average temperatures in the bedroom and living room for household T-11 were 15.11°C and 14.74°C respectively. However, the temperatures frequently fell below 10°C during that period and the minimum temperatures in those rooms were 3.5°C and 1°C. Such low temperatures are a concern and have health impacts[15].

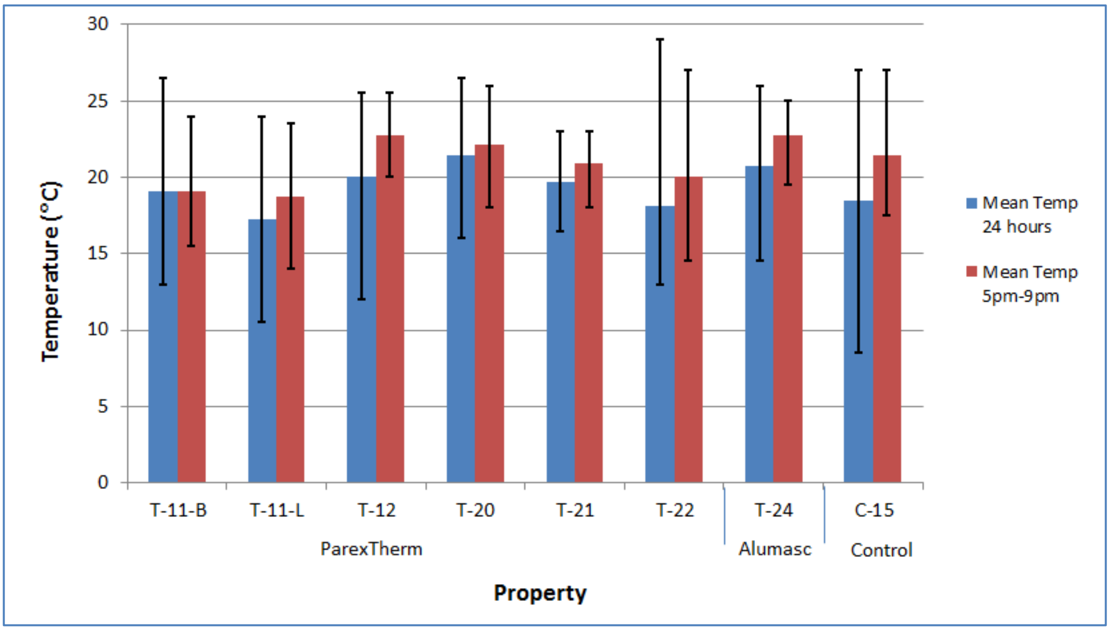

Figure 3.26b Mean living room temp for households at Charnwood Park after EWI installations (10th Apr 17 to 30th Apr 17)
The errors bars show the range of the maximum and minimum temperatures during the period

		1st October 2016 to 31st March 2017						
Tech Ref	EWI Technology	Average Temp (°C) 24 hours	Maximum Temp (°C) 24 hours	Minimum Temp (°C) 24 hours	Standard Deviation 24 hours	Average Temp (°C) 5pm-9pm	Maximum Temp (°C) 5pm-9pm	Minimum Temp (°C) 5pm-9pm
T-11-B	ParexTherm	15.11	27.0	3.5	3.96	14.91	23.0	5.0
T-11-L	ParexTherm	14.74	24.5	1.0	3.93	15.43	23.0	3.5
T-12	ParexTherm	18.84	26.5	8.0	3.7	22.15	26.5	17.5
T-20	ParexTherm	20.73	28.5	7.5	2.77	20.68	28.5	10.5
	Maximum	20.73	28.5	8.0	3.96	22.15	28.5	17.5
	Minimum	14.74	24.5	1.0	2.77	14.91	23.0	3.5
	Average (Mean)	17.36	26.63	5.00	3.59	18.29	25.25	9.13
C-15	Control	16.58	26.0	5.5	3.57	18.35	26.0	8.5

Table 3.27 Room temperatures for ParexTherm at Charnwood Park after installation of EWI (Analysis period from 1st October 2016 to 31st March 2017)

[15] The Health Impacts of Cold Homes and Fuel Poverty, Marmot Review (2011)
https://www.foe.co.uk/sites/default/files/downloads/cold_homes_health.pdf (Accessed 25 Jul 2017)

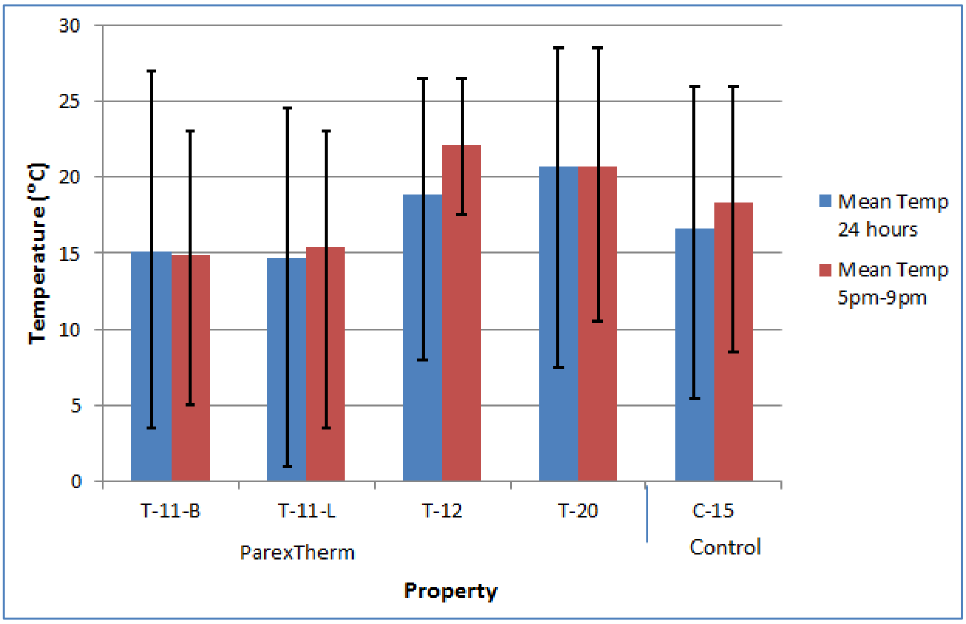

Figure 3.28 Mean living room temp for households with ParexTherm EWI and a control household (1st Oct 16 to 31st Mar 17)
The errors bars show the range of the maximum and minimum temperatures during the period

During interviews the householder stated that the cost of LPG meant he couldn't afford to keep warm. On the initial questionnaire he also noted the bedroom was not heated in winter as it was a large room that was hard to heat. Temperatures in the bedroom increased however after the EWI was installed. The savings in gas consumption at this household was 29%. Had the cost of the LPG been less of a concern for the household, more of the benefit from the EWI could have been taken in improved thermal comfort.

The average temperature for household T-12 was 18.84°C across the day, but during the evening heating period between 5pm to 9pm it was 22.15°C. A comfortable temperature was maintained in the evening with a minimum temperature of 17.5°C. After the heating system was turned off in the evening, the living room temperature decreased overnight from about 22°C to below 10°C on the coldest nights of the year. On 27th January 2017 the living room temperature had fallen to 8°C at 8am. On the 26th and 27th January the number of degree days was 15.5 and 14.7 respectively.

For household T-20 the average temperature across the whole day was 20.73°C, little different from the value of 20.68°C for the 5pm to 9pm period. The minimum temperature was 7.5°C, but this occurred when the householder was away for a period in December 2016. When occupied, the temperature fell to a minimum of 12.5°C overnight on the coldest nights. Normally the morning temperature was not this cold as the householder kept the heating on until 1am or later.

With the control household C-15, although the average temperature during the early evening was 18.35°C, throughout the day it was rather low at 16.58°C. The only household in this study with a lower average temperature over 24 hours during the October 2016 to March 2017 analysis period was T-11. The living room temperature for C-15 regularly fell below 10°C overnight and on two occasions fell to 5.5°C.

Graphs showing the decrease in temperature overnight

Figures 3.29 (a-c) show the decrease in living room temperature overnight for households which received SPS Envirowall, ParexTherm, Alumasc Swisslab EWI and the control household. Data is shown before and after the EWI was fitted on days with similar temperatures which allowed a direct comparison.

For households T-02 and T-06, which received SPS Envirowall, the pre-installation period was 13th -14th March 2016. Here the number of degree days was 10.3 and 9.4. The post installation dates chosen were 1st – 2nd March 2017 which again had 10.3 and 9.4 degree days.

Temperature and humidity loggers were set up in the park homes at Charnwood Park in early April. The pre-installation period chosen for ParexTherm and Alumasc Swisslab was 29th-30th April 2016. Here the number of degree days was 10.3 and 8.7 respectively. This provided the closest comparison available to the post installation period of 1st-2nd March 2017. It should be noted the lower number of degree days on 30th April may have led to a smaller decrease in temperature during the pre-installation period for ParexTherm, Alumasc Swisslab and the control.

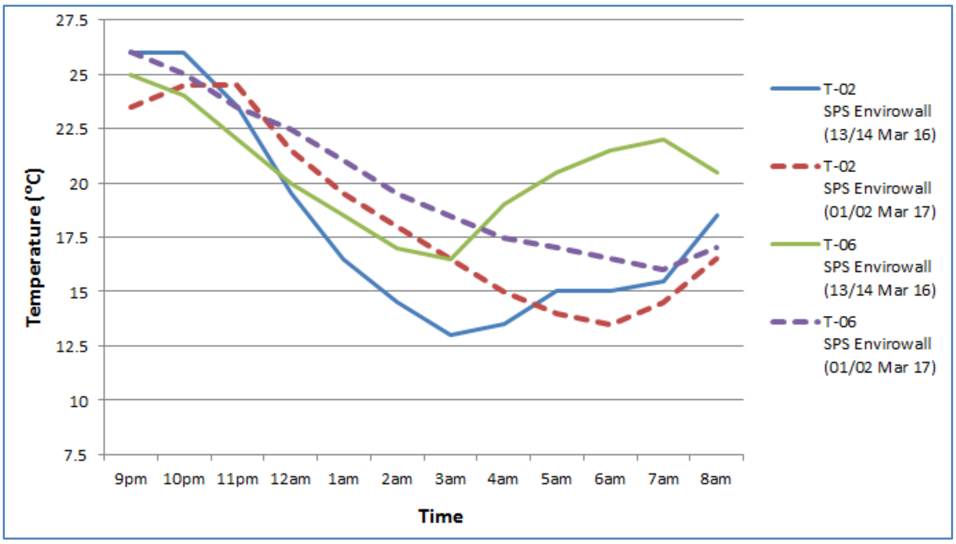

Figure 3.29a
Decrease in temperature overnight before and after insulation of EWI for households T-02 and T-06 with SPS Envirowall
Pre-installation period 13/14 March 2016 and post installation period 01/02 March 2017.
For both the pre and post installation analysis periods, the number of degree days was 10.3 and 9.4

During the pre-installation period, Figure 3.29a shows that the living room temperature for household T-02 was 26°C at 10pm. This fell to 13°C by 3am and the heating was turned on before 4am to start warming the room again. After SPS Envirowall was installed, the temperature fell much less rapidly. On 1st March 2017, the living room temperature was 24.5°C at 11pm, but it had only fallen to 13.5°C by 6am when the heating came on.

For household T-06 with SPS Envirowall and under floor insulation, on 13th March 2016 prior to installation, the living room temperature was 25°C at 9pm. The temperature fell steadily to 16.5°C at 3am. The heating system switched on before 4am to warm the room again. During the post installation period, the living room temperature was initially 26°C at 9pm, but this decreased to 16°C at 7am. For both T-02 and T-06, the heating system was able to switch on later in the morning after the EWI was fitted.

Figure 3.29b shows the difference in temperature decrease before and after installation of ParexTherm at Charnwood Park. It should be noted that the pre-installation analysis period was milder than the period chosen post installation. For household T-12, the temperature at 9pm on 29th April 2016 was 21.5°C. This decreased to 10°C at 5am the next morning around the time that the heating system switched on. The initial temperature at 9pm during the post installation analysis period on 1st March 2017 was 23°C. This fell to 12°C at 8am and the heating switched on by 9am. Although the initial temperature at 9pm was lower during the pre-installation period, the temperature also fell more rapidly. As a result, the main heating system switched on between two and three hours earlier in the pre-installation analysis period.

The living room temperature for household T-22 was 19°C and 19.5°C respectively at midnight on the pre-installation and post installation analysis periods. The temperature fell slightly more rapidly during the pre-installation period (despite milder temperatures) reaching 13.5°C at 5am when the heating system switched on. During the post installation analysis period, the temperature fell to 14°C at 6am around the time when the boiler turned on.

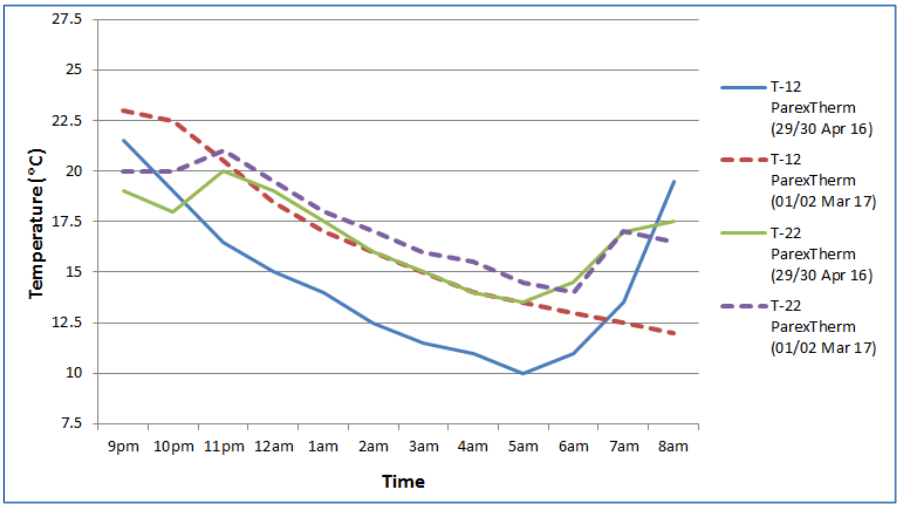

Figure 3.29b
Decrease in temperature overnight before and after insulation of EWI for households T-12 and T-22 with ParexTherm
Pre-installation period 29th April 2016 (10.3 degree days) and 30th April 2016 (8.7 degree days)
Post-installation period 1st March 2017 (10.3 degree days) and 2nd March 2017 (9.4 degree days)

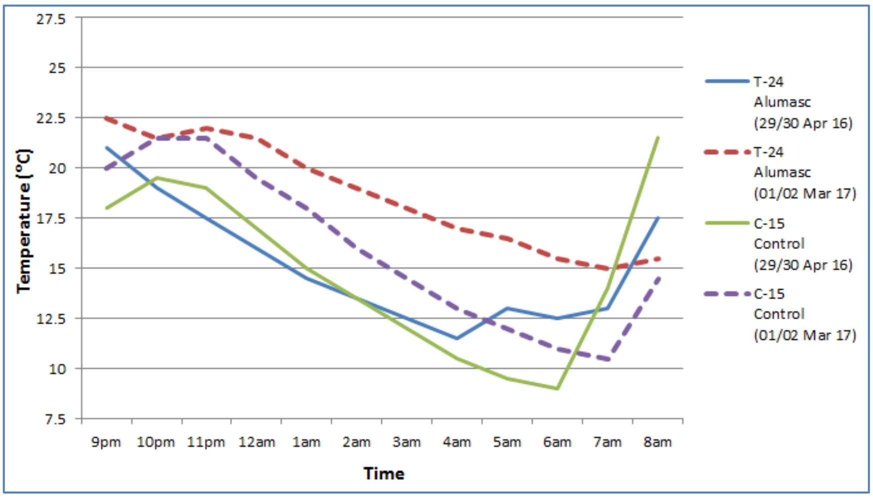

Figure 3.29c
Decrease in temperature overnight for T-24 with Alumasc Swisslab EWI and C-15 the control household
Pre-installation period 29th April 2016 (10.3 degree days) and 30th April 2016 (8.7 degree days)
Post-installation period 1st March 2017 (10.3 degree days) and 2nd March 2017 (9.4 degree days)

Figure 3.29c shows the decrease in temperature overnight for the control household C-15 and T-24 which had Alumasc Swisslab EWI installed. The temperature curves for the control household C-15 during the analysis periods in April 2016 and March 2017 has similarities. The gradient of the curve between midnight and 6am was comparable for the two analysis periods, indicating a similar level of insulation. The curve in 2017 was however displaced to higher temperatures with a peak of 21.5°C at 10pm compared to 19°C in 2016. This meant that the temperature in April 2016 dropped below 10°C at about 4.30am and it was necessary for the heating to switch on at 6am. For the analysis period in 2017, it was possible for the boiler to start later in the morning as the living room temperature was higher at the end of the previous evening.

The initial temperature was also higher for household T-24 during the analysis period after the Alumasc Swisslab was installed. In April 2016 it was 21°C at 9pm compared to 22.5°C in March 2017. The temperature decrease was less rapid after the Alumasc Swisslab was installed as a result of the improved insulation. During the pre-installation analysis period, the temperature fell to 11.5°C at 4am compared to 15°C at 7am for the post installation analysis period.

3.6 Humidity

Water vapour, usually measured as relative humidity 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 3.30 below illustrates the optimum humidity levels as cited by Arundel et al[16]. The study concludes that maintaining relative humidity levels between 40% and 60% would minimise adverse health effects relating to relative humidity.

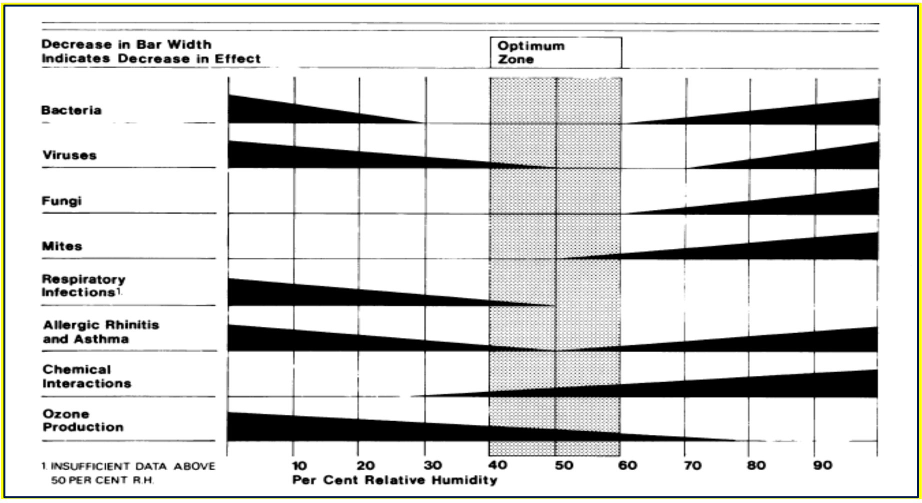

Figure 3.30 Optimum humidity levels to reduce indirect effects from pathogenic organisms or chemicals

[16] 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]

The automated data-loggers record both temperature and relative humidity (RH) at regular intervals across the study households. RH is a ratio (expressed as a percentage) of the amount of moisture present in the air at each logging point, relative to the amount that would be present if the air were saturated. Since the latter amount is dependent on temperature, relative humidity is a function of both moisture content and temperature. Relative Humidity is derived from the associated Temperature and Dew Point for the indicated sample. The higher the value of RH, the more water vapour is contained in the air. High values are problematic, and can cause damage to building fabric and furnishings, and can cause mould growth and the health problems associated with this high humidity. From the Building regulations part F[17]; the suggested average monthly maximum humidity levels for domestic dwellings during the heating season is 65%. The humidity level in the household depends on factors such as household behaviour and room temperature. Levels can be increased by drying clothes inside or from lack of ventilation following showers or cooking.[18]

Table 3.31 and Figure 3.32 show humidity levels for the households with SPS Envirowall for the post installation analysis period between 1st October 2016 and 31st March 2017. The error bars in Figure 3.32 show the range of relative humidity between the maximum and minimum values for the analysis period.

The average relative humidity level across the whole day ranged from 43.95% for T-03 to 58.25% for T-05. The two households with the highest average temperatures (T-03 and T-10) had the lowest average humidity, while the two households with the lowest average temperatures (T-06 and T-07) had the highest average humidity. These average values were all within the optimum range of 40 to 60%.

Values for the maximum and minimum humidity were outside this range. The maximum humidity value for household T-05 at 80% was the highest among the group. The minimum temperature recorded of 11.5°C for that household was not as low as for T-06, T-07 or T-09. The high maximum value is likely to have been most strongly influenced by household behaviour.

Household T-06 had the lowest minimum temperature among the households with SPS Envirowall. This occurred in December 2016 when the household was away. This meant there was no moisture produced from bathing or cooking. The temperature fell to 4.5°C at a time when the relative humidity was 62.5%. The peak in relative humidity occurred at 5pm on a day in mid-November. The relative humidity hit 75.5% when the temperature was 17.5°C.

Household T-08 had the narrowest temperature range of all the households between October 2016 and March 2017. This was not the case for the relative humidity. The maximum value for the humidity at 72.5% was also quite high given that the minimum temperature for this period was 18.5°C. This high value was likely to have been the result of household behaviour.

Anecdotally the householder at T-01 noted there was less condensation in the back bedroom after the EWI was installed. Household T-03 no longer needed to use a dehumidifier in the bedroom wardrobe. The householder at T-05 said there was no longer damp in the spare bedroom while household T-09 no longer needed to use a dehumidifier.

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

[18] Dealing with Damp and Condensation, NEA, http://www.nea.org.uk/wp-content/uploads/2015/07/Resource-Dealing-with-damp-and-condensation-lo-res.pdf (Accessed 22 May 17)

Tech Ref	Measure	Average Humidity (%) 24 hours	Maximum Humidity (%) 24 hours	Minimum Humidity (%) 24 hours	Standard Deviation 24 hours	Average Humidity (%) 5pm-9pm	Maximum Humidity (%) 5pm-9pm	Minimum Humidity (%) 5pm-9pm
		1st October 2016 to 31st March 2017						
T-01	SPS Envirowall + UF	49.04	68.0	35.5	5.49	48.67	64.5	36.0
T-02	SPS Envirowall	48.05	70.0	33.5	6.10	47.29	67.0	33.5
T-03	SPS Envirowall + UF	43.95	66.5	26.0	5.42	43.40	60.5	27.5
T-04	SPS Envirowall + UF	50.60	68.0	26.0	5.53	50.61	66.0	29.5
T-05	SPS Envirowall	51.79	80.0	34.0	6.06	51.49	71.0	38.0
T-06	SPS Envirowall + UF	58.25	75.5	33.0	6.25	55.50	75.5	34.0
T-07	SPS Envirowall + UF	56.51	76.0	34.0	5.42	55.28	76.0	34.5
T-08	SPS Envirowall	54.37	72.5	44.0	5.43	54.97	72.5	44.0
T-09	SPS Envirowall + UF	51.72	65.0	38.5	4.21	50.93	65.0	39.5
T-10	SPS Envirowall + UF	46.82	63.5	24.0	5.95	46.11	60.0	24.0
	Maximum	58.25	80.0	44.0	6.25	55.5	76.0	44.0
	Minimum	43.95	63.5	24.0	4.21	43.40	60.0	24.0
	Average (Mean)	51.11	70.5	32.85	5.59	50.43	67.8	34.05

Table 3.31 Living room relative humidity for households at Ashfield Park following installation SPS Envirowall (Period 1st October 2016 to 31st March 2017; number of degree days over period = 1470.50)

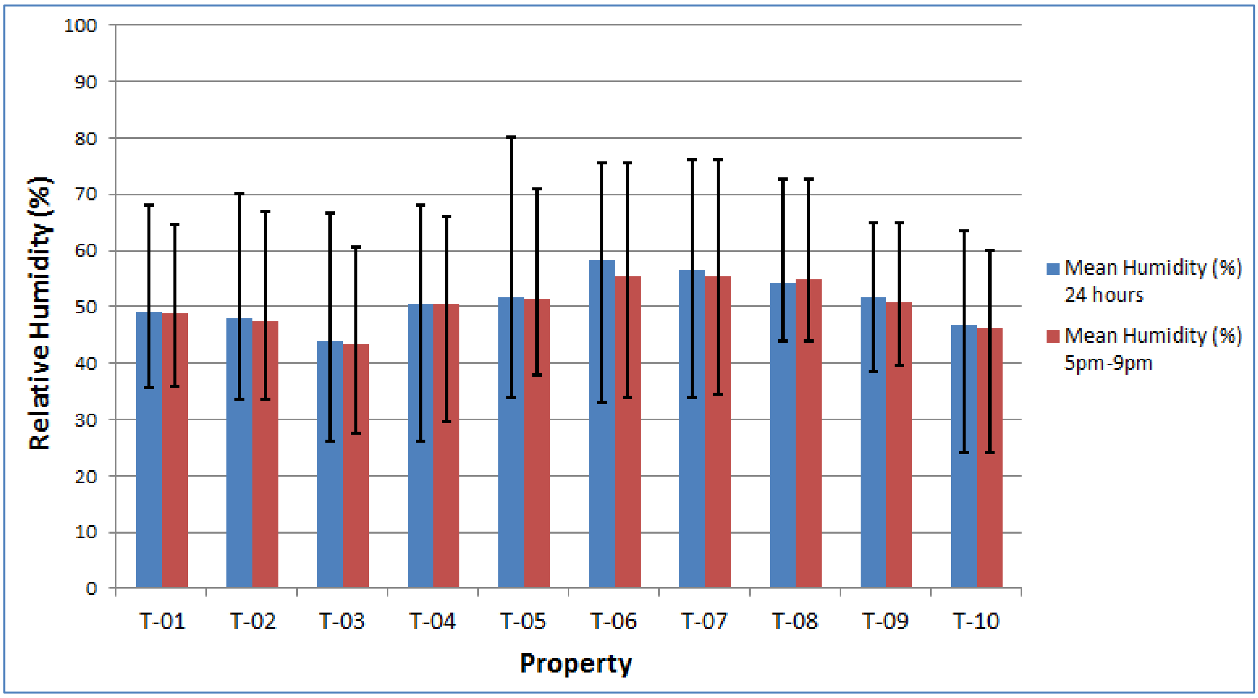

Figure 3.32 Living room relative humidity for households at Ashfield Park following installation SPS Envirowall (Period 1st October 2016 to 31st March 2017; number of degree days over period = 1470.50)

The relative humidity levels for households with JUB Jubizol Premium over the analysis period between 1st October 2016 and 31st March 2017 are shown in Table 3.33 and Figure 3.34. The average humidity for these households was between 39.5% and 54.7%, which was slightly lower than for SPS Envirowall. The range between the maximum and minimum humidity (size of the error bars in Figure 3.34) was typically higher than for the households with SPS Envirowall.

Tech Ref	EWI Technology	Average Humidity (%) 24 hours	Maximum Humidity (%) 24 hours	Minimum Humidity (%) 24 hours	Standard Deviation 24 hours	Average Humidity (%) 5pm-9pm	Maximum Humidity (%) 5pm-9pm	Minimum Humidity (%) 5pm-9pm
		1st October 2016 to 31st March 2017						
T-35	JUB Jubizol Premium	53.44	82.0	24.0	6.74	52.99	82.0	24.0
T-36	JUB Jubizol Premium	49.57	77.5	29.5	6.53	49.28	73.5	29.5
T-38	JUB Jubizol Premium	39.48	60.0	21.5	5.56	38.41	55.5	21.5
T-39	JUB Jubizol Premium	54.09	73.0	35.0	6.36	52.41	66.5	35.0
T-40	JUB Jubizol Premium	54.70	74.5	34.5	5.37	52.69	70.0	34.5
T-41	JUB Jubizol Premium	43.94	73.5	26.0	5.07	42.58	59.0	26.0
T-44	JUB Jubizol Premium	52.64	81.0	25.0	5.88	51.09	81.0	28.5
	Maximum	54.70	82.0	35.0	6.74	52.99	82.0	35.0
	Minimum	39.48	60.0	21.5	5.07	38.41	55.5	21.5
	Average (Mean)	49.69	74.50	27.93	5.93	48.49	69.64	28.43

Table 3.33 Living relative room humidity for households at Ashfield Park following installation JUB Jubizol Premium (Period 1st October 2016 to 31st March 2017; number of degree days over period = 1470.50)

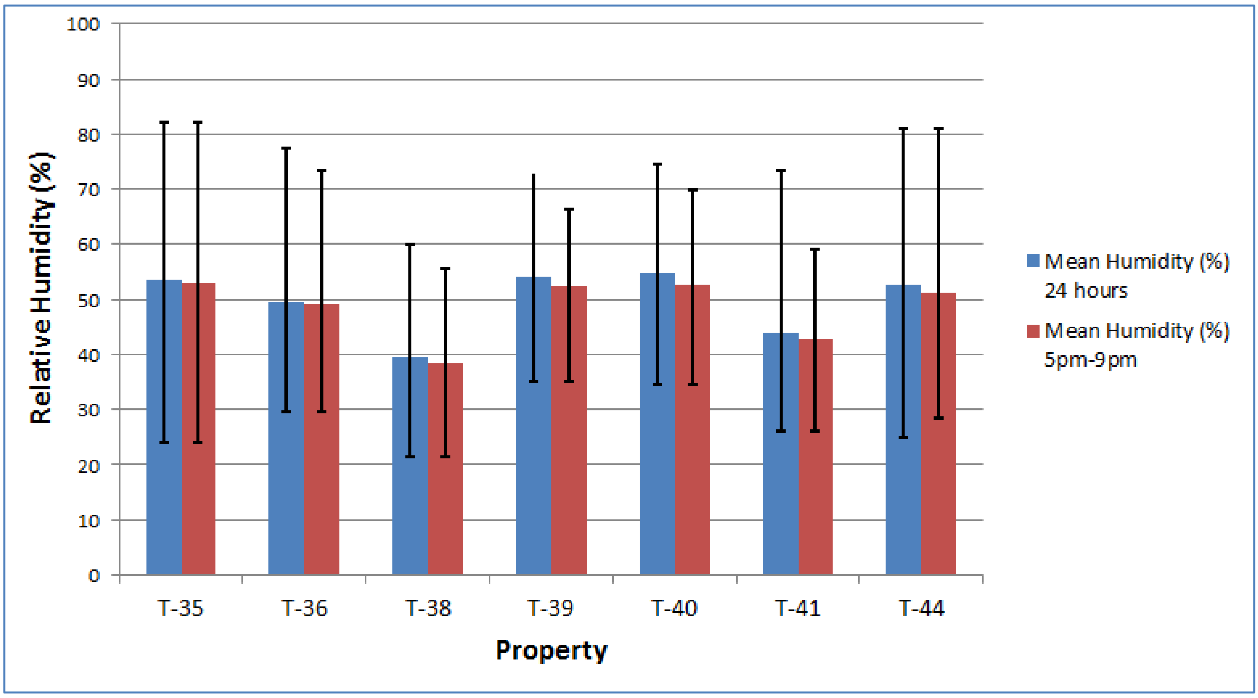

Figure 3.34 Living room relative humidity for households at Ashfield Park following installation JUB Jubizol Premium (Period 1st October 2016 to 31st March 2017; number of degree days over period = 1470.50)

For most of the analysis period, the relative humidity for household T-35 was in the optimum range of 40 to 60%. However this household had the highest maximum humidity among those which received JUB Jubizol Premium EWI. There were sharp changes in relative humidity which were likely to be the result of household behaviour. One example occurred in mid November when the relative humidity increased from 50.5% to 81.5% over the course of an hour. This was the maximum value of relative humidity recorded over the analysis period. At the time, the room temperature was 22°C. The lowest temperature over the analysis period for T-35 was 16.5°C. This occurred on 30th November at 10am after the heating system was turned off overnight. At that time the relative humidity was 51.5%.

Very low relative humidity values were also recorded in the living room for household T-35, with the lowest value measured at the end of March 2017. The room had been overheated for a period of several hours. At 2pm, the temperature was 25.5°C and the relative humidity was 43%. Over the afternoon, the temperature increased to 26°C and by 5pm, the humidity had fallen to 24%.

Table 3.35 and Figure 3.36 show the relative humidity levels recorded for households from Charnwood Park over the analysis period between 1st October 2016 and 31st March 2017. Household T-11 with a ParexTherm acrylic render system had one temperature and humidity logger in the bedroom (B) and another in the living room (L). The other 2 households with ParexTherm EWI and the control household without EWI only had a logger in the living room.

The average humidity for the ParexTherm installations at Charnwood Park ranged from 53.2% to 61.0%, while the value for the control household C-15 was 62.9%. Although there was a small sample of households with ParexTherm installations, it was evident that the average humidity for these was higher than those for the park homes with SPS Envirowall and JUB Jubizol Premium at Ashfield Park.

		1st October 2016 to 31st March 2017						
Tech Ref	EWI Technology	Average Humidity (%) 24 hours	Maximum Humidity (%) 24 hours	Minimum Humdity (%) 24 hours	Standard Deviation 24 hours	Average Humidity (%) 5pm-9pm	Maximum Humidity (%) 5pm-9pm	Minimum Humidity (%) 5pm-9pm
T-11-B	ParexTherm	61.03	77.0	43.5	6.35	61.15	75.0	45.5
T-11-L	ParexTherm	61.02	80.0	38.5	8.27	61.42	80.0	41.0
T-12	ParexTherm	58.80	72.5	45.0	4.97	56.15	67.5	47.0
T-20	ParexTherm	53.21	69.5	38.0	4.86	54.19	68.5	41.5
	Maximum	61.03	80.0	45.0	8.27	61.42	80.0	47.0
	Minimum	53.21	69.5	38.0	4.86	54.19	67.5	41.0
	Average (Mean)	58.52	74.75	41.25	6.11	58.23	72.75	43.75
C-15	Control	62.9	78.5	46.0	4.87	61.7	77.0	46.0

Table 3.35 Relative humidity for ParexTherm at Charnwood Park after installation of EWI along with a control household (Analysis period from 1st October 2016 to 31st March 2017)

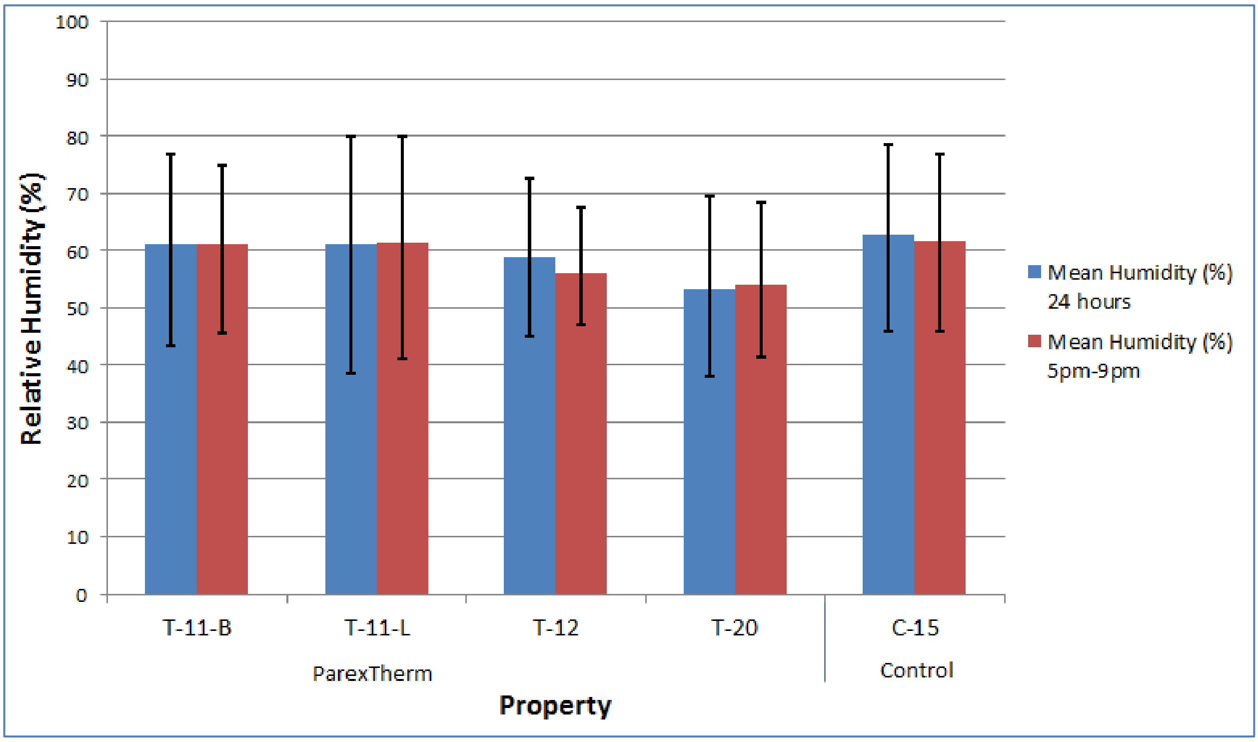

Figure 3.36 Relative humidity for ParexTherm at Charnwood Park after installation of EWI along with a control household (Analysis period from 1st October 2016 to 31st March 2017)

Household T-11 had the highest value of maximum humidity, which at 80% was comparable to T-35 and T-44 with JUB Jubizol Premium. While the values of minimum humidity ranged from 21.5% to 35% for the households with JUB Jubizol Premium, for those with ParexTherm the values were between 38% and 45%.

The highest recorded reading of relative humidity occurred in the living room of household T-11 in mid-November 2016. This was an early evening peak of 80% when the temperature was 18°C. It may have been the result household behaviour such as cooking and washing up.

The minimum value of relative humidity in the living room of T-11 occurred in mid-January 2017. At 10am the humidity was 38.5% and the temperature was 21°C. The temperature had been in the range 19.5 to 22.5°C from 9pm the night before and the humidity had fallen from 51% at 1am.

The minimum temperature in the living room was recorded on 27th January 2017, one of the coldest days in the analysis period. The temperature fell from 6°C at 8pm the night before down to 1°C at 9am on 27th January. At that time the relative humidity in the room was 65.5%. Temperature data from the bedroom of T-11 suggested that the household had retreated into that room during the particularly cold weather. Here the temperature was 13°C at 9am and the relative humidity was 55.5%.

For the control household C-15, the maximum value of relative humidity was recorded at the beginning of November 2016. Values were above 70% after 2am and reached 78.5% at 8am when the temperature was 10°C. The lowest value of relative humidity that was recorded during the analysis period occurred on 13th January 2017. At 9pm, the humidity fell to 46% when the temperature was at 20.5°C. The lowest temperature recorded in the living room of C-15 was on the morning of 30th November 2016. The weather was particularly cold on 29th/30th November with 15.4 and 12.4 degree days respectively. The temperature fell from 17.5°C at 11pm the previous night to 5.5°C at 7am when the relative humidity was 67%.

4. Conclusions and recommendations

4.1 Conclusions

The original aims of the project were;

- To establish benefits of EWI to households living in park homes.
- To identify other potential benefits of EWI installation to park homes, that could be considered in future cost benefit analysis prior to proposed park home treatment.
- To determine householder satisfaction with the installation process.
- To contribute towards a growing evidence base for retrofitting of park homes to enhance energy efficiency, and also improve longevity and aesthetic appearance of older models.

External wall insulation was installed on 61 park homes at three sites in Scunthorpe using four different technologies: SPS Envirowall, JUB Jubizol Premium, ParexTherm acrylic render system and Alumasc Swisslab. Underfloor insulation in the form of Kingspan Thermafloor 50mm was fitted where required and access was available. There was an in-depth study of 28 of these households involving technical monitoring and assessment, interviews and advice on energy tariff switching.

There was an improvement in overall customer satisfaction and comfort

- There was a significant improvement in the satisfaction of households about how well their park homes retained heat.
- At least 90% of households with each external wall insulation technology thought their home retained heat better and the house became warmer faster, while at least 75% felt there was an improvement to the quality of their home.
- Other benefits noted by households included improved sound-proofing and reduced condensation.
- The average SAP rating increase was 10 which on average increased from 40-50 SAP and towards the top of EPC band E (the Government's milestone for fuel poor households in England by 2020). The following impacts were seen on SAP scores across the technologies
  - The average SAP rating increased from 50 to 59 after the SPS Envirowall insulation was fitted
  - The average SAP rating increased from 57 to 64 after the JUB Jubizol EWI was fitted
  - The average SAP rating increased from 17 to 23 after the ParexTherm acrylic render systems were fitted.
  - The average SAP rating increased from 26 to 39 after the Alumasc Swisslab system was fitted.

Please note SAP ratings are heavily influenced by other factors such as fuel used for heating, property size and orientation. As such, these SAP ratings should <u>not be used</u> to solely assess the performance of the products installed.

There was a reduction in household gas consumption and cost

Gas meter readings before and after the installation were used to make a temperature corrected assessment of the annual gas consumption and the associated change in gas costs using a standardized unit rate of 5p/kWh. Seven households were monitored where SPS Envirowall EWI and under floor insulation had been installed.

- The pre-installation gas cost for these households ranged from £289 to £637 per year and after the insulation was fitted it was between £242 and £530, representing an average saving of 16.8%.
- 3 monitored households had only SPS Envirowall fitted and before installation the annual gas cost was between £420 and £659, falling to between £358 and £402 after installation.
- Although savings of 26.2% were achieved with SPS Envirowall, the better performance of the households without under floor insulation was likely to be due to the small sample size and the wide range of savings between households.
- 9 households which received JUB Jubizol Premium EWI were compared and before installation the annual gas costs were between £222 and £842.
- After the JUB Jubizol Premium was fitted the annual gas costs were in the range £244 to £660 with an average saving of 18.8%.

The other external wall insulation technologies, ParexTherm and Alumasc Swisslab were installed at sites off the gas grid; here a standardised cost of 7.5p/kWh was used for LPG.

- LPG gas consumption was assessed for four households which received ParexTherm and the pre-installation costs were between £456 and £1030.
- Post installation, the LPG costs for the households with ParexTherm were in the range £324 to £960 and the average saving was 17.7%.
- 1 household was monitored which received Alumasc Swisslab EWI and the annual LPG gas cost increased from £783 to £824, with a 5.2% increase in consumption.

There was a balance between reduced gas consumption and improved thermal comfort

- Households which were previously under heated compared to the EPC space and water heating demand were more likely to see an increase in thermal comfort and this could result in lower savings or an increase in gas consumption.
- Households where the park home was previously over heated were more likely to make larger savings in gas consumption, particularly if there was a reduction in temperature.
- Older park homes with poorer levels of insulation at manufacture were likely to see greater reductions in gas consumption or improvements in thermal comfort.
- Further savings could have been achieved with better control of the temperatures and further thought needs to be given on how to help residents change heating patterns after installation of insulation to avoid excessive warming and cut gas bills even further.

Installation of external wall insulation had limited effect on the electricity consumption of households with mains gas

The electricity consumption was analysed over the period of one year spanning both before and after installation of SPS Envirowall using a standardized unit rate of 16p/kWh.

- Prior to installation, household electricity costs ranged from £138 to £568 while afterwards the costs were between £180 and £547 with an average of £304.
- For a number of these households, the electricity consumption did not increase as the weather became colder, indicating that they did not use secondary electric heating.
- For some households where there was greater electricity consumption in colder weather, this reduced after the EWI was fitted, indicating a reduction in secondary electric heating.

Properties lost their heat at a slower rate overnight following installation of the EWI
The temperature decrease in the park homes was studied overnight before and after installation of the EWI on days with comparable outside temperatures

- After the properties were insulated, the temperature decreased at a slower rate overnight and households were able to turn on their heating system later in the morning.

Overall the project enabled many households to successfully lower their heating costs and improve their thermal comfort. Comments ranged from "I am absolutely satisfied with the EWI. It is the best thing I've had done. I've seen a real difference in the comfort of my home" to "It has increased the value of my home as well as reduced my bills. Really love how it has made my home look".

4.2 Recommendations for potential future installations

- EWI is particularly beneficial for park homes without access to mains gas as this will have a greater impact on reducing heating costs and improving thermal comfort.
- When installing EWI in park homes off the gas grid, it might be worth considering installation of an air source heat pump at the same time to lower heating costs [See NEA project CP753 where air-to-air heat pumps were fitted on park homes].
- When identifying suitable park homes for EWI, it is important to check the spacing between households early on to ensure that minimum spacing requirements are maintained after addition of the insulation to the property.
- Older park homes benefit more from EWI as these had poorer level of insulation at the time of manufacture - it should be possible to determine the date of manufacture of the park home from a label on the property.
- Older park homes may be in poor condition and it might be necessary to consider replacing other measures such as windows, doors or the roof before the EWI can be fitted.
- It is important to have a supportive park home site owner for the process to run smoothly.

- Installers should plan to complete insulation within a few days as extended installations risk the good will of households as does not clearing up properly at the end of the job.

- EWI has been shown to provide many benefits to households living in park homes and accessing grants to fund installations should be made easier.

- Heating controls should be fitted including TRVs and timers to help residents manage temperature in the homes.

4.3 Impact on fuel poverty

Park homes often have poor levels of insulation and frequently are off the gas grid. This leads to high heating costs and potentially poor levels of thermal comfort. Residents are also more likely to be vulnerable, being on average older and more likely to have a health condition.

Some of the older park homes had very low SAP levels and these are difficult to increase without EWI. On average the SAP levels increased by 7 points and the properties came within the EPC band D.

The temperature corrected savings calculated in this project showed households reduced their gas consumption by up to 39%. The typical savings were between 17 and 19%. Households making lower savings saw an improvement in thermal comfort but many could have made greater savings through better control of temperature. When EWI was combined with another measure like a new boiler or double glazing, savings on this project were between 28% and 41%.

It should be noted that as part of the engagement with households in this project, they were provided with energy tariff switching advice and assisted in accessing the Warm Home Discount rebate of £140 a year. This meant that some households saw a reduction of 50% on their gas bills.

Households with more expensive heating fuels like LPG are liable to limit the time they use their heating. For un-insulated park homes, this means the room temperature is liable to frequently fall below 10°C overnight in winter. There are physiological impacts on the body from living in a home which is too cold, particularly for the elderly and those with pre-existing health conditions. Insulation of park homes can therefore save heating costs, improve thermal comfort and health of the residents.

4.4 Economic business case for installation of measures

External wall insulation of park homes can provide a range of benefits including reduced energy bills, improved thermal comfort, sound-proofing and providing a fresh new refurbished exterior. However it is beneficial to consider the economic benefit resulting from reduced bills alone.

For this analysis a cost of £6,600 has been used for the installation of the EWI and was based on average costs on the current project for multiple installations. The average annual saving for the households was £110. This includes all households apart from those which also had new windows or boilers installed in their property during the analysis period. It also assumes a standardised cost of 5p/kWh for mains gas and 7.5p/kWh for LPG. The maximum saving was achieved by household T-08 where the gas bill fell by £257 (£385 if it had been LPG).

Based on the average saving, Table 4.1 shows that the payback time was 60 years. When using the maximum saving the payback time decreased to 25.7 years.

Measure	Capital cost and installation	Energy saving from the study	Indicative payback time (years)	Assumptions
External wall insulation	£6,600	£110	60	Average saving across properties in the study (excluding those with new glazing and boilers)
External wall insulation	£6,600	£257	25.7	Maximum saving among the properties in the study (excluding this with new glazing and boilers)

Table 4.1 Indicative payback times based on savings from this study

Appendix 1: Glossary of terms

BBA	British Board of Agrément
DD	Degree Days
ECO	Energy Company Obligation
EPC	Energy Performance Certificate
EPS	Expanded Polystyrene
EWI	External Wall Insulation
HIP	Health and Innovation Programme
LPG	Liquefied Petroleum Gas
NEA	National Energy Action – the National Fuel Poverty Charity
RdSAP	Reduced Data Standard Assessment Procedure
RH	Relative Humidity
SAP	Standard Assessment Procedure (for assessing home energy efficiency)
SWIGA	Solid Wall Insulation Guarantee Agency
TIF	Technical Innovation Fund
TRV	Thermostatic Radiator Valve

Appendix 2: British Standard BS 3632 – specification for residential park homes

BS 3632 provides a manufacturing specification for park homes to ensure they are safe and fit for purpose. It provides a minimum specification for factors such as thermal insulation, ventilation, room size and stability[19]. Over the years, the standard has been updated and the levels of insulation required have become higher.

	U-value (W/m^2K)		
BS Standard	Wall	Floor	Roof
BS 3632: 1970	1.7	1.7	1.7
BS 3632: 1981 / 1989	1	1	0.6
BS 3632: 1995	0.6	0.6	0.4
BS 3632: 2005	0.5	0.5	0.35
BS 3632: 2015	0.35	0.35	0.2

Table 5.1 U-values from BS 3632 for householdial park homes[20] [21]

A park home built in 1975 for example would have followed BS 3632: 1970 and had a U-value of 1.7 W/m^2K at the time of manufacture. However over time, the U-value is likely to have risen from the original values as the components age.

[19] BS 3632:2015 Residential park homes specification, BSI https://shop.bsigroup.com/ProductDetail/?pid=000000000030253830 (Accessed 14 Jul 17)
[20] Cert demonstration action insulation improvements to residential park homes scheme Ref: SSEN09132, Alba Building Sciences Ltd, June 2011 https://www.ofgem.gov.uk/sites/default/files/docs/2012/05/park-homes-alba-report---cert-demonstration-action_0.pdf (Accessed 14 July 2017)
[21] Actis Insulation Solutions http://www.insulation-actis.com/documentations/183pdf3.pdf (Accessed 14 July 2017)

Appendix 3: Case study 1 – JUB Jubizol Premium

Figure 5.2 Park Home prior to installation of external wall insulation

Miss P is 45 years old and lives alone in a park home and feels that without the help of the TIF project she would have had to move home last autumn as the increasingly cold home was affecting her health very badly.

Miss P was initially told that her unit could not be insulated due to the age and deteriorating condition of her home which would have required considerable work carried out before external wall insulation could be installed. Miss P therefore started looking for flats as an alternative form of living even though she feared this would have a negative impact on her personal life as she was living amongst friends she had known for 20 years. She states that she would have been heartbroken having to leave the site and would also have been separated from her little dog who might not have been allowed to move into a flat with her.

Miss P’s mobility was deteriorating rapidly due to her suffering from rheumatoid arthritis and fibromyalgia. Before the improvements she was facing losing her home, her job, her friends and even her dog that meant everything to her. However, at that point funding was secured through the TIF project working in partnership with YES Energy Solutions and North Lincolnshire Council which meant that the preparatory work could be completed in order to enable the external wall insulation to be installed.

Before the improvements Miss P had her heating on full all the time in winter but following the installation this is no longer needed. The heating is now used on a lower setting and for considerably less time than previously. Miss P is looking forward to seeing the savings on heating costs as a result of her reduction in consumption. On top of these savings Miss P has also been assisted to switch provider and tariff resulting in additional savings of £29 per month.

Miss P is no longer facing losing her home and that has improved her mental health. She knows that she can stay in her home for the long term and says that she loves the area, the nature around her and her friends on the park home site. She said: “This is better than a lottery win to me; it is the best year of my life, thank you”.

Appendix 4: Case study 2

Mr and Mrs L are in their 50s and live in a park home. Thanks to YES Energy Solutions they received exterior wall insulation and were given energy advice. Mr L said: “The exterior wall insulation has made a huge difference in both summer and winter. Our home has been much warmer and more comfortable during the winter months. During the summer our home has also been more comfortable as it has been cooler and we haven’t had to use fans. This has saved money in both summer and winter. In the winter we saved a considerable amount on our gas bill as it took considerably less gas to heat our home to a much more comfortable standard. In the summer we have saved on electricity as we have not used fans to cool our home. Added to this the sound insulation is fantastic which also adds to the comfort of our home.”

Appendix 5: Comments from households following installations

Household reference	Comments
T-01	The back bedroom used to have quite bad condensation but now it's gone. After taking advice from the NEA advisor I changed to a cheaper provider and tariff.
T-02	At the same time last year at the end of the winter period I was in debt with my gas bill by £116. With no increase in my direct debit this is now reduced to £58.15 debit this year since the exterior wall insulation was installed. The NEA advisor assisted me in obtaining a cheaper gas tariff on both of her visits and the £140 warm home discount. I think it's excellent.
T-03	Our home is vastly improved we don't have to use the dehumidifier in the bedroom wardrobe since the installation of the exterior wall and under floor insulation. The NEA advisor showed me how to get a cheaper tariff last year which lowered my direct debit. It's lowered again this year by another £5 month. My home is much quieter, everything's better. It looks better, bills are cheaper and it's warmer. It's brilliant.
T-04	Even family visitors comment on how much warmer my home is since the exterior wall insulation was installed. As well as getting warmer faster the exterior wall insulation has cut down the noise too. The NEA advisor assisted me in finding a cheaper tariff saving £16 per month. I would do it all again.
T-05	We went to the meeting in the Mallard pub held by YES Energy Solutions after first receiving a letter of invitation. It was really good to see the demonstration. This helped me decide straight away to have the exterior wall insulation installed. We used to get damp in the spare bedroom but this has gone. After taking advice from the NEA advisor we had TRV's installed to better regulate the heating. We changed provider to get a cheaper tariff which halved our gas monthly direct debit. Well worth having done, my gas direct debit has halved. I'm really pleased I had it done, my home looks better too.
T-06	As well as being warmer my home is a lot quieter. The exterior wall and under-floor insulation are very good. The NEA Advisor also helped me change supplier saving another £168 year on bills as well as helping me get the £140 Warm Home Discount. Chuffed and pleased with all of it.
T-07	Everything has been fantastic, really pleased I took part
T-08	My home is a lot warmer and much more comfortable
T-09	We no longer have to use our dehumidifier which is saving us money on electricity. Highly satisfied, the exterior wall and under floor insulation has made a real difference and we are very happy with it.
T-11	I'm glad I took part, it's a lot warmer
T-12	Have noticed a real difference in how my home holds the heat.

	Previously on cold nights temp would drop to 8 to10°C, now only drops to 12°C. It is much warmer when we return to home after being out. We are definitely using less gas.
T-21	Absolutely satisfied with the EWI. Best thing I've had done. Seen a real difference in the comfort of my home. It's lovely. Since having the EWI I can have the heating on for longer.
T-24	Home gets warmer faster and retains heat longer. Very noticeable at night and early morning. Not wearing extra clothes in winter. Noticed a real difference in comfort. Made a big difference to amount of condensation collected in dehumidifier.
T-35	As well as the exterior wall insulation the NEA advisor showed me how to change provider for a cheaper tariff. I saved £150 on my tariff last year and another £32 this year. With the guidance from the NEA advisor I also changed my billing from 'payment on demand' to fixed monthly direct debit which saved me money. It's been good and very helpful to me, glad I took part.
T-36	I am very well satisfied with the product (exterior wall insulation). With the guidance of the NEA advisor I also changed my gas tariff saving £104 on my annual gas bill.
T-37	My home is much improved and I would advise anyone to have EWI installed. I don't need my heating on so high or as long as before the EWI was installed, as my home hold in the heat better. The NEA advisor also assisted me to change to a cheaper tariff saving more on my gas bill.
T-38	My gas bills are 50% less than before the exterior wall insulation, I am chuffed with it. The NEA advisor has shown me how to find a cheaper tariff for my gas bill. I used to pay as the bill came in and had never changed provider or tariff. With the help of the NEA advisor I now have an online account paying by fixed monthly direct debit on a really cheap tariff which is really good and I hope it continues.
T-40	In the past I had the heating on through the night (in the winter months), since the EWI was installed I do not need the heating on at all through the night. The thermostat is still set to 15 degrees but does not come on. I have also been able to turn up the heating as my home keeps the heat in so much better. I think it's very good, damned good thing!
T-41	We're really glad we took part; it's been well worth it.
T-42	I think it's great. I think there should be more projects like this. My home is much warmer and it is easier to control the heating.
T-44	The exterior wall insulation is absolutely brilliant my energy usage has halved this year and I haven't had as many colds. My home is quieter, even the hot water is quicker. It's very good, absolutely brilliant.

Appendix 6: Warm Home Discount (WHD) – added value

All 28 householders taking part in the monitored group were encouraged to apply for Warm Home Discount over the two winters that NEA was in contact with them. This resulted in the majority of the monitored group on both sites receiving a rebate for £140 WHD December/January 2015 and 2016.

In December 2016 the NEA Project Development Co-ordinator held a workshop on both park home sites to enable residents not in the monitored group or in receipt of measures to take advantage of energy advice and apply for a WHD.

A total of 23 householders were seen at the two half day workshops with 21 of these households receiving the £140 rebate.

In June/July 2017 all the householders (estimated total 51 households) who had received the WHD for 2016/17 were invited to apply for free white goods through Charis Grants[22]. All households were eligible for a new washing machine, fridge and freezer if their existing appliance was not an A** rated appliance or they did not have these appliances.

One householder contacted us to tell us she had received a new A** rated Hotpoint washing machine. This appliance was installed and the householder's old appliance removed free of charge.

A second householder has told us they received an A** rated Hotpoint washing machine, fridge and freezer, all installed and old appliances removed free of charge.

Both residents are thrilled with their appliances and noted that if they had not been made aware of WHD, they would not have been eligible to receive these free appliances. Both residents also commented on the efficiency rating of the appliances, particularly the washing machine, noting the impact this would have on their electricity bills, and also mentioned that the 8kg capacity would mean fewer loads were necessary, thus making another saving.

[22] http://www.charisgrants.com/ [Accessed 30/08/2017]

Appendix 7: 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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