CP776
Park Home Insulation
Cheshire East Council

Technical Evaluation Report

Paul Rogers and Michael Hamer
October 2018

Background

About National Energy Action

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

About the Technical Innovation Fund

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

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

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

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

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

Technical monitoring and evaluation

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

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

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

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

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

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

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

Acknowledgements

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Executive summary

Project overview

The issue of fuel poverty among residents of park homes has long been recognised. Cheshire East Council was keen to address this issue locally by delivering a project installing external wall insulation (EWI) on park homes in the district. The project had the following aims:

- Insulate 11 park homes on 2 sites in Cheshire East district.
- Assess changes in resident comfort following installation of the EWI through questionnaires and use of temperature and humidity loggers.
- Assess any reduction in energy consumption using meter readings
- Determine household satisfaction with the installations
- Identify other potential benefits of EWI installation to park homes that could be considered in cost benefit analysis for any future park home insulation projects.

Context

Park homes are prefabricated buildings which are occupied as permanent residences and are located with others on a site. They are also known as mobile homes and frequently resemble bungalows. The 2011 census showed there to be almost 160,000 people living in about 84,000 mobile homes across 2,000 sites in the UK. A study in 2002 noted that 68% of residents were elderly. In Cheshire East there are over 500 park homes across 19 rural sites.

Park homes frequently have poorly insulated walls, roofs and floors. They are often located at sites which are off the gas grid. In those locations, residents generally rely on more expensive oil, LPG or electric heating. The poor insulation means in winter, households suffer from cold room temperatures, have high heating bills, with costs even higher when off the gas grid.

Energy efficiency schemes like the Energy Company Obligation (ECO) have failed to adequately address this issue. During the period of ECO1 and ECO2 between January 2013 and 31 March 2017, there were 212 park homes which received funding for EWI. The NEA Technical Innovation Fund (TIF) has focused on trials of energy saving technologies not normally covered in mandated fuel poverty and energy efficiency schemes. Several other projects within TIF installed EWI on park homes, insulating 113 park homes elsewhere in England.

The technology

InstaClad External Wall Insulation (EWI)

External wall insulation improves the heat retention and energy efficiency of homes by putting an insulating jacket around the property. This should improve the thermal performance of the building fabric, ensuring a warmer living space in winter months and potentially a cooler living space in the summer months. Other benefits of the technology include improved sound-proofing and an attractive new appearance to the property.

The InstaClad park home EWI system uses panels of 40mm grey expanded polystyrene (EPS) insulation bonded to 9mm calcium silicate boards. It is a lightweight EWI system, putting less strain on the park home structure and can be fitted in all weathers, with faster installation times than some other systems. The system has a 25-year warranty and is BBA certified. InstaGroup claim that insulation could lead to mains gas savings of £326, with £184 coming from insulating the walls, £78 for insulating the floor and £64 from insulating the loft of an 86m^2 park home built between 1983 and 1995.

During installation, external fixings such as downpipes are removed, and windows and doors are protected. Steel supporting rails are fitted to the external walls and in areas surrounding windows and doors. The InstaClad insulation panels are cut to size. They are then slotted into a starter rail that is fitted around the base of the wall and the panels are screwed onto the supporting rails. A 1.5mm coat of render is applied by trowel for the outer layer.

Where properties had limited roof insulation, a loft top up was provided to 270mm where this was possible, in addition to the EWI.

The project

Insulation was installed on 11 privately owned park homes at 2 sites in Cheshire East district:

- Astbury Marsh Caravan Park in Congleton, which is owned by the council
- Lindow Court Park, Mobberley, which is privately owned.

While the park homes at Astbury Marsh had mains gas connections, those at Lindow Court Park were off the gas grid and households mostly relied on LPG for heating.

As well as fitting InstaClad EWI, loft insulation was topped up to 270mm for the properties. Among the 4 households that were insulated at Astbury Marsh, 3 also received new boilers from another funding stream and 1 of these also had underfloor insulation.

There were 7 households at Lindow Court Park which had EWI funded by the project. Residents at a further 5 park homes at the site later privately funded EWI on their properties with a top-up grant from the Council.

A total of 11 park homes with InstaClad EWI and 4 control properties took part in an evaluation of the park home insulation between May 2016 when the first park homes were insulated and March 2018. The monitored properties comprised of:

- 4 insulated park homes at Astbury Marsh
- 6 park homes at Lindow Court Park where the insulation was funded by the project
- 1 park home at Lindow Court Park where the insulation was privately funded
- 4 park homes at Lindow Court Park which did not receive EWI and acted as controls

The following methods were used to determine the benefits of the insulation:

- Household interviews to assess behaviours and household satisfaction
- Measurement and analysis of temperature and humidity in the park home
- Assessment of consumption of mains gas and LPG heating fuels

Historic gas meter readings for 3 of the 4 properties at Astbury Marsh were used to calculate gas consumption prior to insulation while regular meter readings by Cheshire East Council provided post-insulation gas consumption data.

The properties at Lindow Court Park were mainly heated using boilers fuelled by 47kg LPG gas bottles. In order to accurately assess the LPG consumption of these properties, meters were fitted in December 2016 to monitor heating fuel consumption at 5 of the insulated park homes and 3 of the control properties.

Summary of findings

Resident satisfaction

- Following the installations, all the households at Astbury Marsh and Lindow Court Park were very satisfied with how well their home kept in the heat. Prior to this, all but 1 was either very dissatisfied or dissatisfied.
- After having the InstaClad EWI, all households thought:
    - Their home was warmer and more comfortable
    - Their house kept in the heat better
    - There was an improvement to the quality of their home
- Other benefits noted by some households included:
    - A reduction in energy bills
    - Improved sound proofing
    - Improved appearance
    - The home was stronger and more stable

Energy costs

To effectively demonstrate the impact of the insulation measures on the households in terms of energy requirements and energy expenditure, it is necessary to collect energy usage data for a period before the measures were fitted, and a similar period after the measures were fitted. To make best use of the data, and statistically "correct" for differences in outdoor temperatures, regular readings are required for winter months during both periods. The following key points were discovered:

- Comparable energy cost data was only available for one of the sites, Astbury Marsh, where the properties were connected to the gas network. For the properties occupying the Lindow Court Park site, it was not possible to gather consumption data pre-installation, as the occupants were dependent on LPG heating and there were no metering facilities in-situ. Social evaluation and complementary data sets have been used in this study to demonstrate likely impact on costs.
- A property which received EWI and a loft insulation top-up at Astbury Marsh saw a 21% reduction in gas consumption following the installation. The associated cost saving was £195.
- The largest park home in the study with the highest gas consumption received a new boiler as well as EWI and a top-up to the loft insulation. Here the reduction in gas consumption was 27.8% and the saving was £353.
- A household at Astbury Marsh which had low consumption and was under-heated received a new boiler and insulation for the walls and loft. There was an increase in gas consumption of 21%, with the gas cost rising by £49
- The other monitored insulated properties were at Lindow Court Park and used higher cost bottled LPG for heating. Costs after the EWI was installed ranged from £433 for a park home with floor area of 27m^2 to £1,511 for a larger park home with an area of 77m^2.

Thermal comfort

Thermal comfort levels were obtained from both automated thermal dataloggers and through household feedback through semi structured questionnaires.

- Between 1 Oct 2017 and 15 Mar 2018, 2 households at Astbury Marsh maintained their living rooms at 16°C or above with averages of 21.35 and 22.1°C respectively.
- Another property at Astbury Marsh was under-heated, with an average living room temperature of 16.21°C, but a minimum temperature as low as 4.5°C
- At Lindow Court Park, 3 households had an average living room temperature between 22 and 23°C, while the others were in the range 19.45°C to 20.41°C. The minimum living room temperatures for all these properties ranged from 14.5°C to 19°C.
- The average temperatures of the bedrooms for the insulated properties at Lindow Court Park ranged from 17.14°C to 22.49°C, with the bedrooms between 0.29 and 2.31°C cooler than the living rooms.
- For the single property with a monitoring period before and after the installation, the average living room temperature increased from 18.76 to 19.98°C and the average bedroom temperature increased from 17.67 to 18.87°C.

Damp and humidity

To avoid negative consequences such as mould, or increased risk of bacteria, humidity within a home should be maintained within an optimum range of 40 to 60%. This is further explained in section 3.5. As part of the monitoring, data was recorded on humidity levels at regular intervals through the evaluation period.

- The average living room relative humidity was in the normal range of 40 to 60% for all the properties in the study during the period 1 Oct 2017 to 15 Mar 2018.
- Values ranged from an average relative humidity of 58.3% for a property which was under-heated to 41.34% for an overheated property.
- The average bedroom relative humidity of 3 of the households at Lindow Court Park exceeded 60%. These properties all had average bedroom temperatures of less than 19°C. The highest average relative humidity of 69.18% was for a household where the average bedroom temperature was 17.12°C. The fluctuation in humidity is likely explained by the temperatures within the bedroom i.e. if a bedroom was under or overheated. As temperature falls, the relative humidity rises.
- Where it was possible to monitor a property before and after it was insulated, there was negligible change in the average living room relative humidity which increased from 59.63% to 59.95%.
- There was a greater change in the average bedroom relative humidity which increased from 64.51% to 66.15% after insulation. The maximum relative humidity was 82.5% for both periods. The average bedroom temperature of less than 19°C and household behaviour are likely to explain these higher values.

Conclusions and recommendations

- Installation of InstaClad external wall insulation (EWI) and loft insulation proved overwhelmingly popular with residents, with high levels of satisfaction.
- Residents felt that after the insulation their homes kept in the heat better.
- The savings and fuel consumption measured for the insulated park homes were comparable to those from another NEA park home insulation projects.
- Overall average living room temperatures were maintained at an acceptable level; however, 2 properties were noticeably under-heated.
- EWI is particularly beneficial for park homes without access to mains gas as this will have greater impact on reducing heating costs and improving thermal comfort.
- Older park homes benefit more from EWI as these had a poorer level of insulation at the time of manufacture.
- Remedial work may be necessary to the structure of an older park home to ensure it is strong enough for insulating panels to be fitted, however the retrofit can extend the life of the property and the installation includes a 25-year guarantee.
- It was difficult to persuade private owners of park home sites to allow promotion of the scheme offering free EWI to households. New engagement techniques, incentives or regulations may be necessary to encourage private site owners to allow residents to access such schemes.
- There has been limited uptake of EWI for park homes in mandated fuel poverty schemes like ECO. Greater support is necessary for such installations, with a particular focus on homes that are off the gas grid.
- The payback time determined in this study for EWI for a property on the gas grid was about 40 years although there are other benefits in addition to fuel savings. For a property that is off the gas grid with space heating fuelled by bottled LPG, the payback time is about half that period.

1. Project overview

1.1 Introduction

The issue of fuel poverty among residents of park homes has long been recognised. Cheshire East Council was keen to address this problem with a project installing external wall insulation (EWI) on park homes. Insulation was installed on 11 park homes at 2 sites in the district: Astbury Marsh site in Congleton, which is owned by the council and Lindow Court Park, Mobberley, which is privately owned. The residents at a further 5 park homes at Lindow Court Park later privately funded EWI on their properties with a top-up grant from the Council. While the park homes at Astbury Marsh had mains gas connections, those at Lindow Court Park were off the gas grid and households mostly relied on LPG for heating.

The InstaClad EWI system is a light weight design for park homes which overcomes the problems of adding excess weight to a flimsy structure. The insulation is BBA approved and carries a 25-year insurance backed guarantee. The InstaClad panels consist of a calcium silicate board (9mm thickness) bonded to graphite-enhanced (also known as grey) EPS insulation boards which are 40mm thick. The external surface was finished with a 1.5mm render layer. Where properties had limited roof insulation, a top up was provided to 270mm. The installer for the properties at Astbury Marsh was Heatex Quality Insulation Ltd of Stoke-on-Trent. Broad Oak Properties Ltd of Stoke on Trent was used for the properties at Lindow Court Park.

A total of 11 park homes with measures were monitored as part of the study. These included 10 funded by the project and 1 which was privately funded. A further 4 households which had not been insulated acted as controls properties for the study.

1.2 Aims

The project had the following aims:

- Insulate 11 park homes on 2 sites in Cheshire East district.
- Assess changes in resident comfort following installation of the EWI through questionnaires and use of temperature and humidity loggers.
- Assess any reduction in energy consumption using meter readings
- Determine household satisfaction with the installations
- Identify other potential benefits of EWI installation to park homes that could be considered in cost benefit analysis for any future park home insulation projects.

1.3 Context

Park homes are prefabricated buildings which are occupied as permanent residences and are located with others on a site. They are also known as mobile homes and frequently resemble bungalows. The 2011 census showed there to be almost 160,000 people living in about 84,000 mobile homes across 2,000 sites in the UK[1]. A study in 2002 noted that 68% of residents were

[1] Call for Evidence on Energy Issues Affecting Park Homes. Department of Energy and Climate Change, (2014), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/332939/call_for_evidence_on_energy_issues_affecting_park_homes.pdf (Accessed 8 June 2018)

elderly[2]. In Cheshire East there are over 500 park homes across 19 rural sites.

Park homes often have poorly insulated walls, roofs and floors. They are frequently located at sites which are off the gas grid. In those locations, residents are reliant on more expensive oil, LPG or electric heating. The poor insulation means in winter, households suffer from cold room temperatures, have high heating bills, with costs even higher when off the gas grid. On hot summer days, the poor insulation and lack of thermal mass means that room temperatures can be too high for residents. Residents with health conditions and the elderly are particularly vulnerable to living in cold[3] or overheated homes[4].

Fuel poverty statistics do not record the rates among park home residents. A survey by Age UK among 211 park home owners in 2015 found that 58% of respondents had problems keeping warm in their home over the winter. Also 53% of the respondents had a household member with a health condition made worse by the cold[5]. Age UK also wrote a report highlighting the issue of elderly residents living in cold and hard to heat park homes and the need for energy efficiency schemes to address the problem.[6] At the time of the Coalition Government, the Department of Energy and Climate Change (DECC) had a call for evidence on energy issues affecting park homes in 2014[7], but little progress has been made to address the issue of fuel poverty in park homes since the election in 2015.

Park homes do not typically come under building regulations. Instead, factors like the level of thermal insulation at manufacture are determined by British Standard 3632. The specification has required greater levels of insulation as new revisions have been produced, with the latest in 2015[8].

Although new park homes perform better, there are many older properties with poor insulation. Energy efficiency schemes like the Energy Company Obligation (ECO) have failed to adequately address this issue. During the period of ECO1 and ECO2 between January 2013 and 31 March 2017, there were 212 park homes which received funding for external wall insulation[9]. Ofgem however noted that only 11 Park Home external wall insulation measures had been approved under ECO2 from April 2015 to the end of August 2017[10].

[2] Economics of the Park Homes Industry, Office of the Deputy Prime Minister (2002), http://www.housingcare.org/downloads/kbase/2024.pdf (Accessed 8 June 2018)

[3] The Health Impacts of Cold Homes and Fuel Poverty, Marmot Review Team (2011), http://www.instituteofhealthequity.org/resources-reports/the-health-impacts-of-cold-homes-and-fuel-poverty (Accessed 8 June 2018)

[4] Impacts of overheating in homes, Zero Carbon Hub http://www.zerocarbonhub.org/sites/default/files/resources/reports/ZCH-OverheatingLeaflet-1-Impacts-S.pdf (Accessed 8 June 2018)

[5] Older people in park homes struggle to keep warm https://www.ageuk.org.uk/latest-press/archive/older-people-in-park-homes-struggle-to-keep-warm/ (Accessed 8 June 2018)

[6] Don't leave park homes out in the cold, Age UK (2015), https://www.ageuk.org.uk/Documents/EN-GB/Campaigns/winter%20health/4982%20Age%20UK%20ID202741%20Park%20Homes%20Campaign%20Report.pdf?dtrk=true (Accessed 8 June 2018)

[7] Call for Evidence on Energy Issues Affecting Park Homes, (DECC, 2014), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/332939/call_for_evidence_on_energy_issues_affecting_park_homes.pdf (Accessed 8 June 2018)

[8] Standard for residential park homes is revised (BSI, 2016) https://www.bsigroup.com/en-GB/about-bsi/media-centre/press-releases/2016/january/Standard-for-residential-park-homes-is-revised-/ (Accessed 8 June 2018)

[9] Household Energy Efficiency National Statistics, headline release May 2018 (BEIS) https://www.gov.uk/government/statistics/household-energy-efficiency-national-statistics-headline-release-may-2018 (Accessed 8 June 2018)

[10] Energy Company Obligation Monthly Update, October 2017 (Ofgem) https://www.ofgem.gov.uk/system/files/docs/2017/11/eco_newsletter-issue_28.pdf (Accessed 8 June 2018)

Some of the reasons why it has proved difficult for park home residents to benefit from EWI under the ECO scheme were discussed at the time of the DECC call for evidence in 2014[11]. These included the inability to lodge Energy Performance Certificates (EPCs) for Park Homes until 2014,[12] the requirement for British Board of Agreement (BBA) approval and suitable guarantees for the EWI in order to secure the ECO funding. Other issues that were likely to have affected the low uptake were the high upfront cost and low payback period for the installation as well as a lack of experienced installers for wall, floor and roof insulation on Park Homes.

The NEA Technical Innovation Fund (TIF) focused on trials of energy saving technologies that were not normally covered in mandated fuel poverty and energy efficiency schemes. Several projects within the TIF programme installed insulation on Park Homes. In Scunthorpe, EWI was fitted on 61 Park Homes at 3 sites in projects with YES Energy Solutions and North Lincolnshire Council[13]. Insulation was also installed on 52 Park Homes in Elton in projects with Cheshire West and Chester Council[14]. There was a marked improvement in resident's comfort levels and energy expenditure, following the installation of these measures through these park home projects. Among the Park Home residents interviewed in Scunthorpe, most were dissatisfied with how well their home kept in the heat before the EWI was fitted and all were very satisfied afterwards. Gas consumption reduced on average between 17 and 27%.

1.4 Project timeline

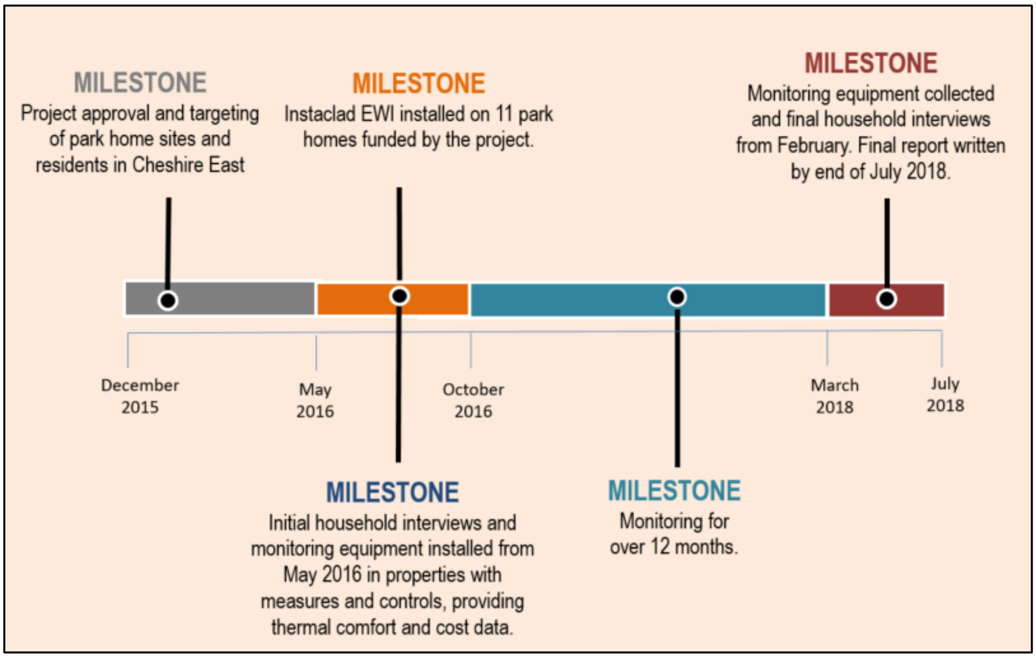


Figure 1.1 Project timeline

[11] Park Homes: will we ever insulate them? Colin Anderson (2014) https://energyprofessional.wordpress.com/2014/10/02/park-homes-will-we-ever-insulate-them/ (Accessed 8 June 2018)

[12] BRE Energy Assessors Technical Update, Issue 029, February 2014 http://www.bre.co.uk/accreditation/newsletters/EPBDTechupdate/2014_02/FEB_2014.htm (Accessed 8 June 2018)

[13] External wall insulation on park homes in North Lincolnshire, Elizabeth Lamming, Jamie Barnes, Paul Rogers and Michael Hamer (NEA, 2017), http://www.nea.org.uk/wp-content/uploads/2018/06/CP783-4-TIF-Report-FINAL-04062018-v5.pdf (Accessed 11 June 2018)

[14] Park home heat recovery ventilation and energy improvement pilot, Kathy New, Paul Cartwright, Hayley Grocock, Marvin Beckett and Michael Hamer, (NEA, 2017) http://www.nea.org.uk/wp-content/uploads/2018/04/CP777-789-TIF-Report-FOR-PUBLICATION-08092017.pdf (Accessed 11 June 2018)

The grant for the project was approved in December 2015 and in the following months Cheshire East Council promoted the project and found park homes to be insulated. The 4 EWI installations at Astbury Park were fitted by Heatex Quality Insulation Ltd between May and July 2016. The 7 installations at Lindow Court Park which were funded by the project took place between August and October 2016 and installed by Broad Oak Properties Ltd, with the 5 privately funded installations completed by February 2017.

1.5 Attracting beneficiaries and establishing a monitored group

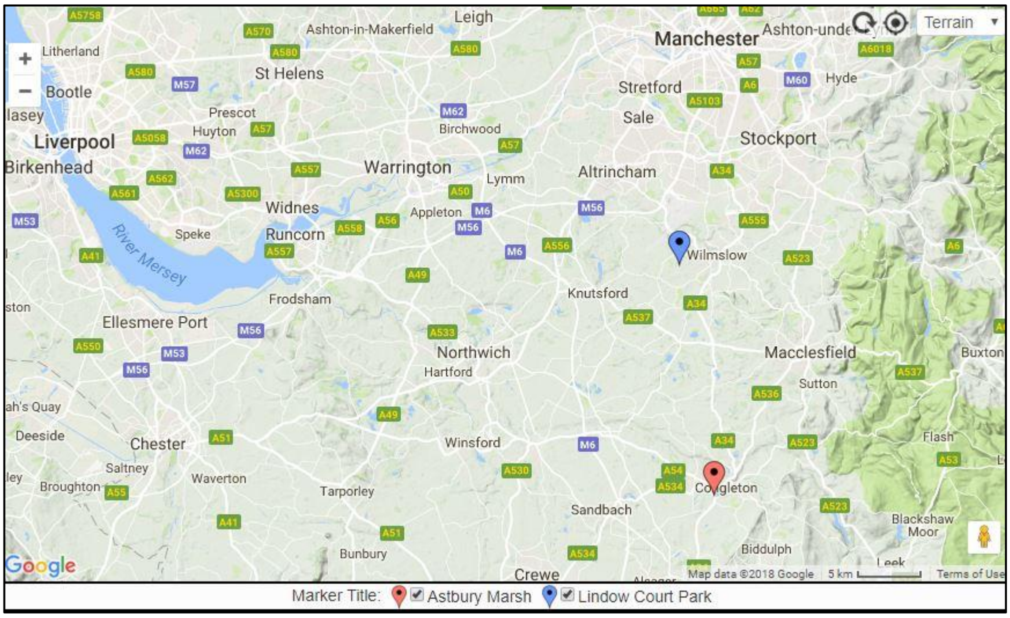


Figure 1.2 Location of park homes sites where installations took place

Figure 1.3a Astbury Marsh caravan site

Figure 1.3b Lindow Court Park site

Cheshire East Council initially identified 39 potential park home sites and prioritised their engagement activities with 10 sites. Out of these, there were 2 sites where the landowners were willing to allow EWI refurbishment of the park homes on the site.

* Astbury Marsh in Congleton is a Council-owned permanent Gypsy site, with 18 homes occupied and settled by Gypsies who have occupied the site since the 1960s. There are a mixture of working families and retired households living in the park homes, but some with caravans. The homes are all privately-owned and residents pay ground rent to the Council. The site is on the gas network.
* Lindow Court Park in Mobberly is a privately-owned site of 54 park homes in a rural off-gas grid area. Until recently, only residents over 55 were allowed to live at Lindow Court, but this was recently reduced to those over 45. The homes are privately owned, with a mixture of park homes and caravans, up to 50 years old. All residents use LPG (Calor gas) to heat their homes.

Engagement was easiest at Astbury Marsh as the Council was the site owner and no permission was required to approach the park home owners. Things were less straightforward for the privately-owned park home sites. Here many of the landowners were unwilling to allow EWI refurbishment of park homes on the site for various reasons. After agreement was obtained from the site owner to engage residents, letters were sent out to eligible residents on the site, offering free EWI installations.

* 4 households were recruited for installations at Astbury Marsh and each of these became part of the monitored group. Insulation of the properties was carried out between May and July 2016 and temperature and humidity loggers were fitted in July 2016.
* There were 7 households at Lindow Court Park which received EWI installations and 6 of these were recruited to be part of the monitored group for the evaluation. Here the logging equipment was fitted between July and September 2016 and the installations were completed between August and October 2016. A household who privately funded the EWI installation also joined the monitored group. Here the temperature loggers were initially set up in August 2016 and the installation took place in February 2017.
* 4 households at Lindow Park Court were recruited to be control properties for the study for comparison with the monitored group which received insulation measures.

Out of the park homes assessed for installations by Cheshire East Council, there were 3 properties at the sites which were rejected due to their age and condition.

* Astbury Marsh – a traditional holiday style caravan of metal construction, built in about 1980 and occupied by an elderly couple in fuel poverty. The flexibility of the structure prevented EWI insulation panels being installed. However, the Council were able to use alternate funding to carry out underfloor insulation and install a replacement water heater.
* Lindow Court Park – a property constructed in the 1960s with a fragile timber structure. The roof had been replaced with concrete tiles which caused the roof to spread and the walls to bow under the weight. The homeowner, who was in fuel poverty and receiving treatment for cancer, employed a friend to carry out remedial work to the structure. There was no heating in the property and the Council secured grants for a complete central heating system. It was necessary to use radiators fixed to the floor due to the fragility of the building.
* Lindow Court Park – a timber building constructed in the 1970s and occupied by an elderly resident in poor health. The flimsy timber structure and extent of rot prevented InstaClad panels from being installed. The Council was able to secure alternate funding which along with a contribution from the resident allowed the replacement of 3 walls of the property and fitting of insulation.

Tables 1.4 and 1.5 provide details of the 4 park homes at Astbury Marsh Caravan Site and 7 park homes at Lindow Court Park which were insulated and took part in monitoring for the evaluation. Each property was assigned a technical reference number to ensure anonymity for the residents. Data was derived from Energy Performance Certificates (EPCs), surveys and questionnaires completed by the households.

At Astbury Marsh Caravan Site, new boilers were also fitted in properties T-01, T-13 and T-17 at the same time as the insulation. The EPCs before and after the installation indicated the loft insulation had increased from 100mm to 250mm in each case. Underfloor insulation was also installed at property T-01. Savings for these properties resulted from a combination of the EWI, improved loft insulation, underfloor insulation and replacement gas boilers. Property T-05 only had EWI installed.

The EPCs for the properties at Lindow Court Park after the measures were fitted reflected there was no loft insulation. However, these installations included a top up of mineral fiber loft insulation, often from 50mm to 270mm as well as fitting InstaClad EWI, so whilst we would expect the SAP ratings to be low (partly due to using LPG as a heating fuel), the values shown are lower than they should be due to not taking into account the installation of loft insulation. This means the space and water heating demand from the EPC is unrealistically high and these values are excluded from table 1.5.

Technical Reference Number	Estimated date of manufacture	Floor area (m^2)	Heating system	Approximate boiler age	SAP rating after insulation	EPC Space and water heating demand (kWh)
T-01	1997	81	Mains gas boiler with radiators, programmer, thermostat and TRVs	2016	72	10,138
T-05		82	Mains gas boiler with radiators, programmer, thermostat and TRVs		73	9760
T-13	1990	112	Mains gas boiler with radiators, programmer and room thermostat	2016	74	12703
T-17	1998	82	Mains gas boiler with radiators, programmer, thermostat and TRVs	2016	67	10,308

Table 1.4 Details of park homes receiving measures and monitored at Astbury Marsh Caravan Site

Technical Reference Number	Estimated date of manufacture	Floor area (m^2)	Heating system	Approximate Boiler age	SAP rating after insulation
T-03	1996	27	Boiler, radiators, bottled LPG, programmer, RT, TRVs	2013	40
T-04	1980	-	Gas-combi, radiators, LPG, RT	1980	
T-07	1975	50	Boiler, radiators, LPG, programmer, RT, TRVs	2016	33
T-09	1994	77	Boiler, radiators, LPG, programmer, RT, TRVs	2012	25
T-75	1968	65	Boiler, radiators, bottled LPG, programmer, RT, TRVs	2010	
T-79	1981	44	Boiler, radiators, bottled LPG, programmer, RT, TRVs		17
T-80	1996	73	Boiler, radiators, LPG, programmer, RT, TRVs	1996	31

Table 1.5 Details of park homes receiving measures and monitored at Lindow Court Park

In addition to the 11 properties in the evaluation that received measures, there were also 4 properties at Lindow Court Park which took part in the study and acted as controls. Details of these are shown in table 1.6 with information derived from interviews with the residents.

The standards for manufacture of a park home are subject to BS 3632 Residential Park Homes[15]. The level of insulation required at manufacture has increased over the years, with BS3632 introduced in 1970 and revised in 1981/1989, 1995, 2005 and the latest version in 2015 (see Appendix 2). As a result, the estimated date of manufacture of the park homes in tables 1.4 to 1.6 can provide an indication of the level of insulation prior to installation of the EWI.

Technical Reference Number	Estimated date of manufacture	Heating system	Approximate boiler age
C-11	1996	LPG combi-boiler, room thermostat	2010
C-77	ca 1990	LPG gas boiler with tank, programmer	1998
C-99	2002	LPG combi-boiler, room thermostat	2002
C-101	ca 1980	Oil combi-boiler, programmer and RT	2013

Table 1.6 Details of control properties at Lindow Court Park

[15] BS 3632:2015 Residential park homes specification, BSI, https://shop.bsigroup.com/ProductDetail/?pid=000000000030253830 (accessed 6 July 2018)

1.6 Factors affecting the planned evaluation methodology

Issue	Description and mitigation
Recruitment of households	It was easier to recruit households at the council owned park homes site. It was much harder at privately owned sites as permission was required from the site owner to approach the residents with the offer of free insulation. Out of all of the identified privately-owned park home sites approached, only Lindow Court Park gave permission to approach the residents.
Monitoring using temperature and humidity loggers	Thermal loggers were intended to record a period of pre-installation thermal data, but due to delays in recruitment of participants, logger installation was delayed and were only installed at sites in Astbury Marsh at the time of the initial interviews in June and July 2016. This was shortly after the properties were insulated. At Lindow Court Park the properties that were insulated had thermal loggers fitted between July and September 2016. Most of the installations took place between 20 Sept 16 and 1 Nov 16. Household T-75, which was privately funded, was insulated in early February 2017. Only very limited pre-installation data was therefore available. The battery life for the loggers was about a year so an interim visit was schedule to replace loggers July 2017. Loggers were finally collected during the final visit in March 2018.
Monitoring of gas consumption	The properties at Astbury Marsh were on the gas grid. Meter readings were collected by Cheshire East Council staff on a regular basis. Lindow Court Park was off the gas grid and most residents used 47kg LPG gas bottles. Gas meters were fitted in late December 2016 at 5 properties which received insulation and 3 control properties. Event loggers were fitted on these meters, but 3 of these failed for unknown reasons and recorded no data. Despite this, readings were also regularly recorded manually from these meters by Cheshire East Council staff which enabled an accurate record of the consumption of LPG to be made.
Changes to the monitored group	A resident at Astbury Marsh passed away at the end of 2017 and therefore we only have only analysed information from the initial questionnaire and monitoring on this property concluded early. The overall project was extended to include a second winter, however the resident at household T-79 was not willing to continue to take part in the project for the extra period and withdrew. This meant that further data and a final questionnaire was not available for this household.

2. Social evaluation and impacts

2.1 Qualitative feedback from initial questionnaire

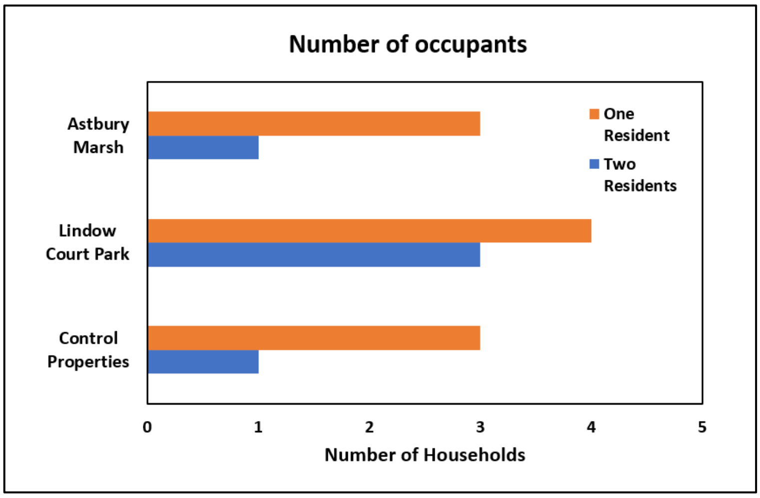


Figure 2.1 Number of occupants of the monitored park homes

The park homes monitored in the project all had either 1 or 2 residents. At both Astbury Marsh and the control properties at Lindow Court Park, 3 of the 4 households had a single resident. For the properties at Lindow Court Park which received insulation, there were 4 households with a single resident and 3 which had 2 residents.

All the residents of the control properies were aged over 70 years. The households which received insulation at Astbury Marsh and Lindow Court Park each had a single resident aged between 30 and 59 and also over 85 years. They also had 2 residents between 60 and 69 years. At Astbury Marsh there was a single resident in the age bracket 70 to 84 years. At Lindow Court Park there were 4 residents in this age bracket where the household received insulation and 3 where the household was a control property. Figure 2.2 provides a breakdown of the age profile of residents across the 3 groups.

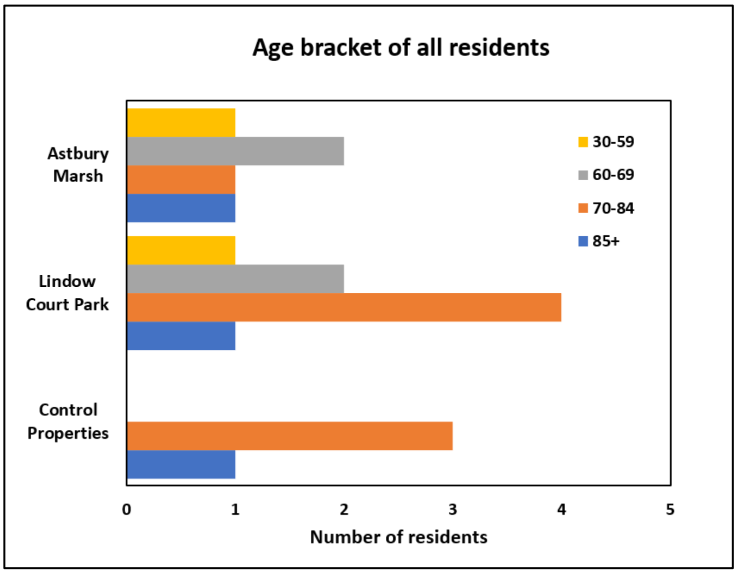


Figure 2.2 Age bracket of the residents of the monitored park homes

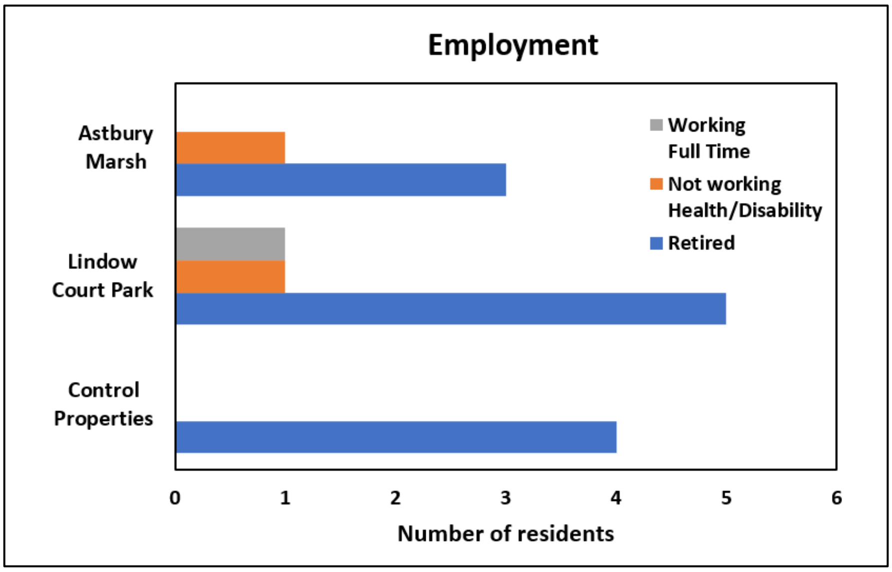


Figure 2.3 Employment status of residents in the study

Figure 2.3 shows that only 1 resident at Lindow Court Park was working full time. At both Astbury Marsh and Lindow Court Park there was a single resident interviewed who was not working due to a health condition or disability. The other residents interviewed were all retired. This is not surprising as all but 2 of the residents interviewed in the study were over 60 years old.

Most households in the study had members with a health condition, disability or limiting long term illness. In figure 2.4, all of the households at Astbury Marsh and who were within the control group had a member with a health condition. Among the households at Lindow Court Park which received insulation, 5 of the 7 had members with a health condition. Among the illnesses reported were: arthritis, cancer, chest infections, COPD, depression, diabetes, heart disease, mobility issues and pneumonia. Among those who reported having household member with a health condition, all but 1 felt the condition was made worse by cold living conditions.

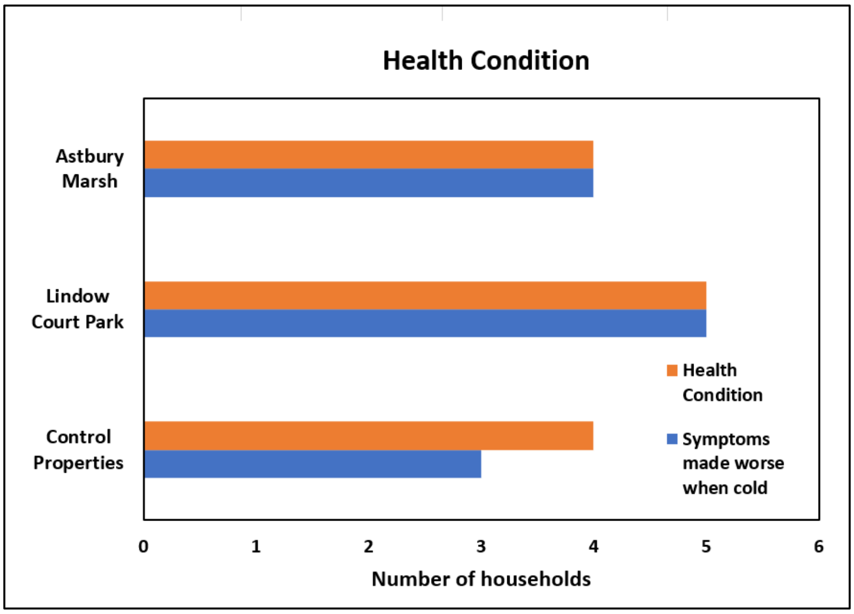


Figure 2.4 Households with a health condition, disability or limiting long term illness

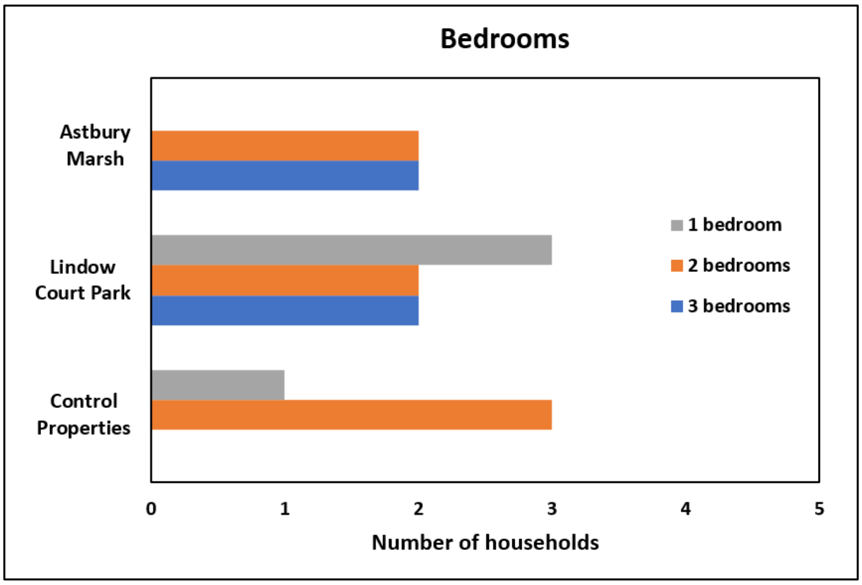


Figure 2.5 Number of bedrooms in the monitored properties in the study

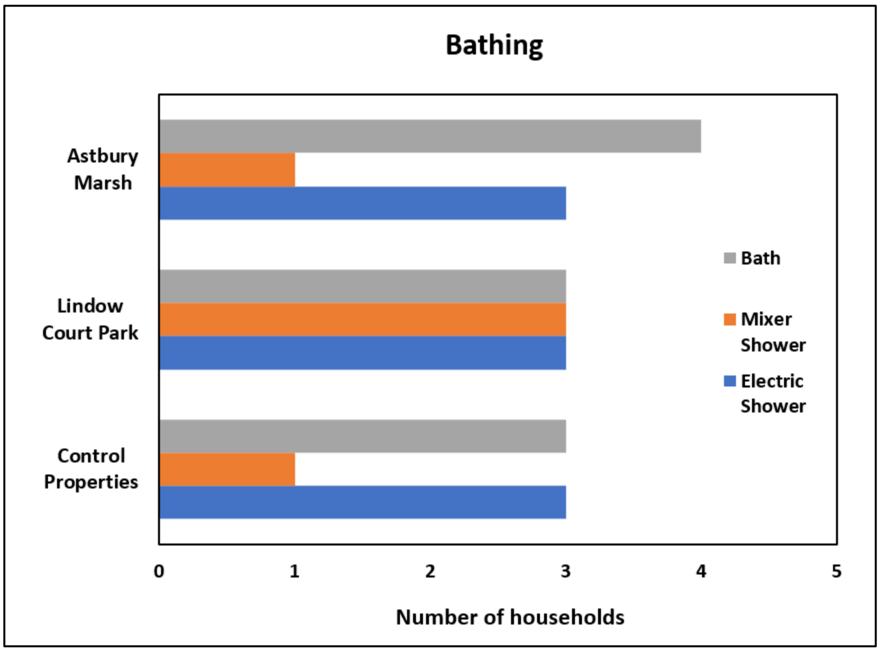


Figure 2.6 Number of baths and showers in the monitored properties in the study

None of the properties that were monitored at Astbury Marsh had a single bedroom. Half had 2 bedrooms and half 3 bedrooms. Among the properties which received insulation at Lindow Court Park, 3 had a single bedroom and there were 2 which had 2 bedrooms and 3 bedrooms.

While all the households at Astbury Marsh had baths, 3 of the 4 had electric showers despite being on the gas grid. At Lindow Court Park, only 3 of the 7 households which received insulation had baths. The other 4 households only had a shower with 3 of these electric. There were 2 households at Lindow Court Park with both a bath and mixer shower. Among the control properties, there were 3 households with a bath and electric shower and 1 which only had a mixer shower.

2.2 Affordability of energy bills

During the initial and final interviews, householders were asked how much they agreed with a series of statements about the affordability of their energy bills. The responses were either ‘strongly disagree’, ‘disagree’, ‘agree’ or ‘strongly agree’. Each of the responses was assigned a score where ‘strongly disagree’ scored 0 and ‘strongly agree’ scored 100. An average (mean) score between 0 and 100 was calculated for the periods before and after the installations.

Figures 2.7a and 2.7b show the scores calculated for each question based on responses from households who completed both the initial and final interviews. Although there was some decrease in the concern over affordability of energy bills among the residents at Lindow Court Park, the decrease was significant among the residents at Astbury Marsh Caravan Site.

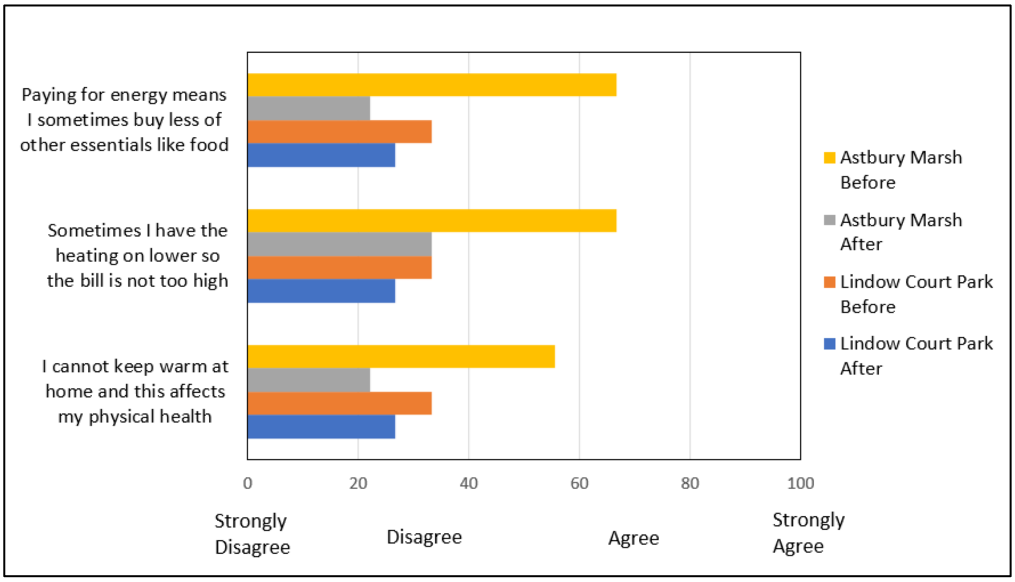


Figure 2.7a Affordability of energy bills before and after installations

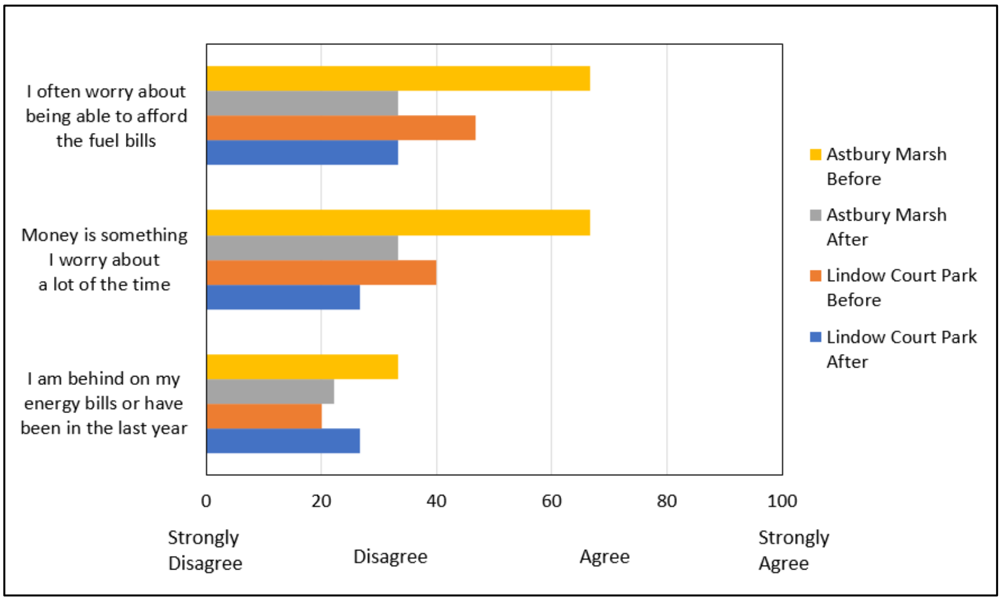


Figure 2.7b Affordability of energy bills before and after installations

The greater improvement at Astbury Marsh was likely to be due to several factors. At Astbury Marsh, new gas boilers were installed at the same time as the insulation with funding from another source, which complicated analysis of the impact of the insulation measures. Advice was provided to residents at Astbury Marsh and this led to a significant improvement in the finances for 1 of these households (see case study in Appendix 3).

The householder feedback at Lindow Court Park suggested that the occupants may have been generally better able to afford their energy bills before the start of the project compared to the respondents from Astbury Marsh. 100% of households from the Lindow Court Park monitored group disagreed with the statements in figure 2.7a during the initial interview. However, there were two households at Lindow Court Park who agreed that they often worried about being able to afford their fuel bills at the start of the project. In the final questionnaires, one of these households changed their response from agree to strongly disagree on this question. None of the residents at Astbury Marsh or Lindow Court Park agreed that they had been behind on their energy bills in the last year.

2.3 Resident acceptance and satisfaction

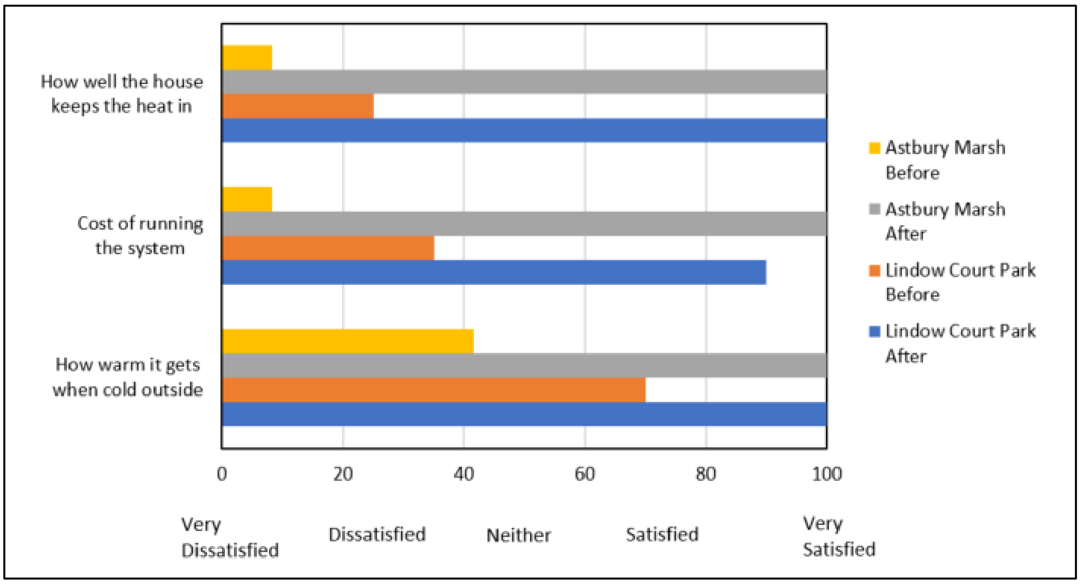


Figure 2.8a Resident satisfaction with their insulation and heating system

Residents were also asked a series of questions during the initial and final interviews about how well their home kept in the heat and the effectiveness of their heating system. For each question the response was either ‘very dissatisfied’, ‘dissatisfied’, ‘neither’, ‘satisfied’ or ‘very satisfied’. Each of these responses was assigned a score where ‘very dissatisfied’ scored 0 and ‘very satisfied’ scored 100. An average (mean) score of between 0 and 100 was calculated for each park home site for the period before and after the installations.

Following the installations, all the residents at Astbury Marsh and Lindow Court Park were very satisfied with how well their home kept in the heat. This was a dramatic improvement over the response before the installation, particularly for the households at Astbury Marsh. Here 2 households were very dissatisfied and the other was dissatisfied. At Lindow Court Park before the installations, 3 of the households were dissatisfied and 1 each were ‘neither’ and ‘very dissatisfied’.

On the question of the cost of running the heating system, there was again a substantial improvement in the satisfaction for the residents at Astbury Marsh (figure 2.8a). Again, all the residents were ‘very satisfied’ after the installation with 100% responding that they were ‘very dissatisfied’ or ‘dissatisfied’ before. The improvement was not so substantial at Lindow Court Park site, although 100% respondents were satisfied or very satisfied (40% and 60% respectively) with the cost post installation, their satisfaction pre-installation varied from satisfied to very dissatisfied rather than entirely dissatisfied as in the Astbury Marsh group.

All the residents interviewed at both sites were ‘very satisfied’ with how warm their home got when it was cold outside after the installations. Before the installations, the residents at Astbury Marsh were either ‘satisfied’ or ‘dissatisfied’, while the responses at Lindow Court Park were either ‘satisfied’ or ‘neither satisfied or dissatisfied’.

A further two questions were asked relating to the heating system of the property (figure 2.8b). Again, there was an improvement in the satisfaction ratings after the installations. The improvement was greater for the properties at Astbury Marsh, and this is likely explained by the installation of new gas boilers at the time the insulation was installed.

Before the installation, the responses from residents at Astbury Marsh were either ‘satisfied’ or ‘neither satisfied or dissatisfied’ on how easy their heating system was to use. All recorded an improvement in their satisfaction over the ease of use of their heating system. At Lindow Court Park before the installations, all the households apart from 1 were ‘satisfied’ with the ease of use of their heating system. The remaining household was ‘very satisfied’. After the installations, all but 1 household were ‘very satisfied’, with the other ‘satisfied’.

When asked about the amount of control over their heating system, all the residents at Astbury Marsh were ‘very satisfied’ after the installations. Beforehand, 2 were ‘satisfied’ and the other ‘dissatisfied’. At Lindow Court Park, all of the households apart from 1 were ‘satisfied’ with the amount of control prior to installation. The other household was ‘dissatisfied’. At the time of the final interview, there was 1 household ‘satisfied’ with the amount of control of the heating while the rest were all ‘very satisfied’. Although the heating systems at Lindow Court Park were not replaced, the improvement in satisfaction with the level of control of the heating system might be due to the home heating faster due to the improved insulation.

Residents were asked to rate their feelings about the installation process on a scale of between 1 and 5, where 1 is negative and 5 is positive. The average rating for the households at Astbury Marsh was 4.33 and at Lindow Court Park it was 4.2.

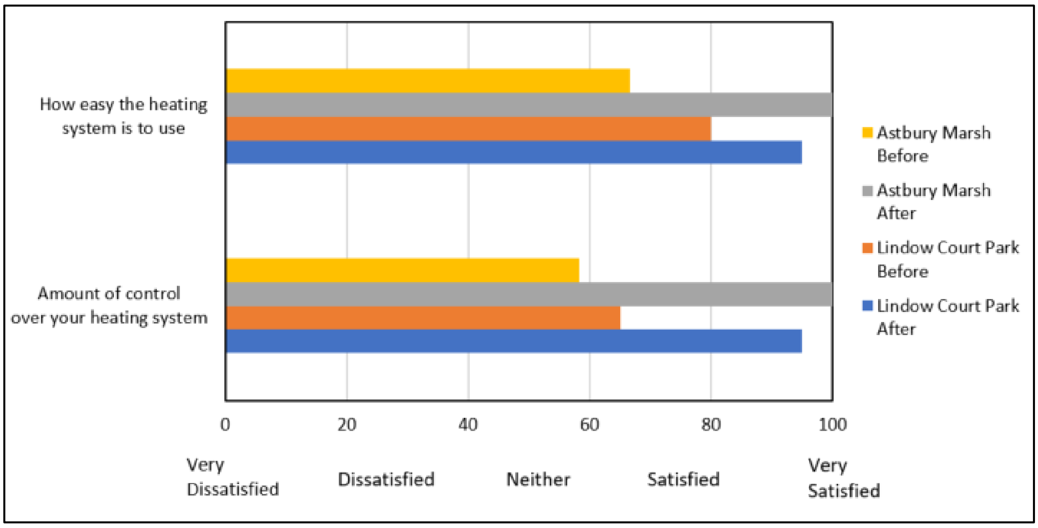


Figure 2.8b Resident satisfaction with their insulation and heating system

2.4 Perceived comfort and benefits

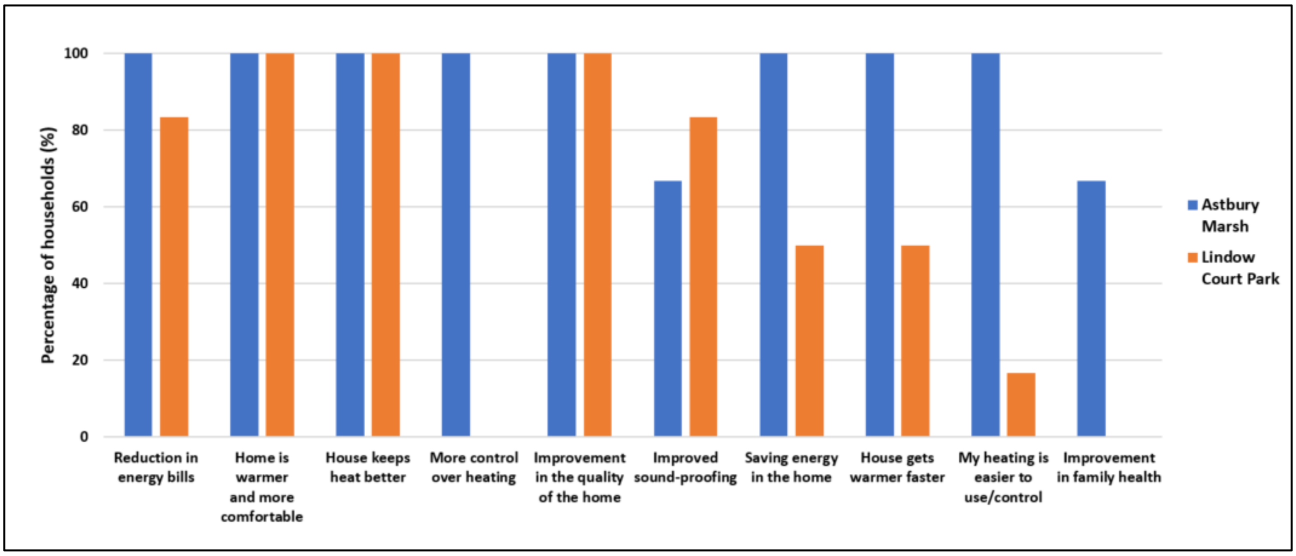


Figure 2.9 Benefits perceived by residents after installation of the insulation

The benefits noted by the households at the time of the final interview are shown in figure 2.9. All the residents at Astbury Marsh and Lindow Court Park who completed the final interview felt that their home was warmer and more comfortable and kept in the heat better. They also all felt there was an improvement to the quality of their home following the refurbishment to the outside of the park home.

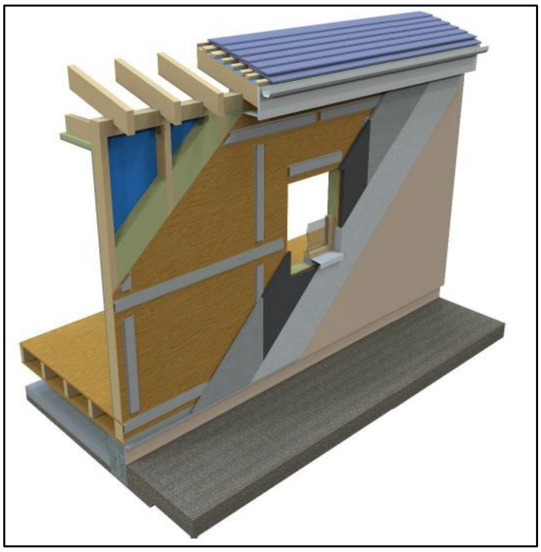
All the households at Astbury Marsh also perceived a reduction in energy bills, they had more control over their heating, they were saving energy in the home, their house got warmer faster and their heating was easier to use or control. In contrast, none of the residents at Lindow Court Park noted they had more control of their heating and only 16.7% felt their heating was easier to use or control however this is probably explained by the difference in the accompanying measures installed – Astbury Marsh residents received a gas boiler at the same time as the EWI whereby no such heating improvement was made at Lindow Court Park.

Two thirds of the households felt there was improved sound-proofing following installation of the EWI. Although two thirds of the residents at Astbury Marsh felt there was an improvement to their health following the installations, none at Lindow Court Park perceived that benefit.

When asked if their energy bills were cheaper, about the same or more expensive, all the households at both sites said they were cheaper. The households were also asked if there was any impact on damp, condensation or mould and whether it was better, about the same, worse or not applicable. All the residents at Astbury Marsh felt the question was not applicable. Among those at Lindow Court Park, 3 households reported that it was better and 2 that the question was not applicable.

3. Technical evaluation and results

3.1 Overview of technology



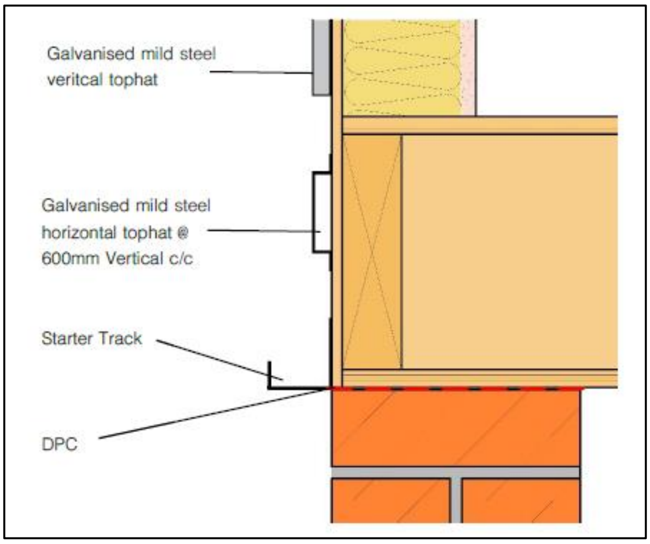


Figure 3.1a Schematic of InstaClad system[19]

Figure 3.1b Cross-section with starter track for insulation board[19]

The InstaClad park home EWI system uses 40mm of grey EPS (expanded polystyrene) insulation. It is lightweight, putting less strain on the park home structure and can be fitted in all weathers, with faster installation times[16]. The system has a 25-year warranty and is BBA certified[17].

In the preparation stage, external fixings such as downpipes are removed, and windows and doors are protected. A metal starter track is attached to the base of the wall, while galvanised mild steel 'tophat' rails are attached along the walls and in areas surrounding windows and doors[18]. The supporting rails fitted on the walls provide additional stability and impact resistance as well as fixing points for the insulation panels.

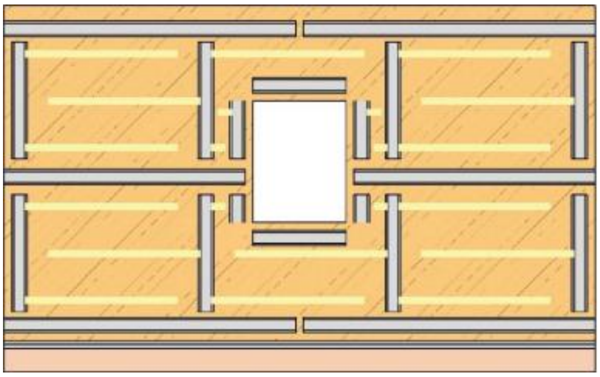


Figure 3.2 Schematic and photograph showing 'tophat' rails fitted on the walls and around the windows of a park home[19]

[16] InstaClad Park Home System – Advanced solid wall insulation for park homes http://www.instagroup.co.uk/media/39744/parkhomes_02_2017.pdf (Accessed 24 July 2018)

[17] BBA Approval Inspection Testing Certification Agrement Certificate 15/5201, External Wall Insulation Systems, InstaClad All Weather External Wall Insulation Composite System (2015), https://www.instagroup.co.uk/media/36091/instaclad_all_weather_bba_cerrificate_no_15_5201_ps1.compressed.pdf (Accessed 24 July 2018)

[18] InstaClad Park Home Installation Guide, version 5 (July, 2016)

The InstaClad panels consist of a calcium silicate board (9mm thickness) bonded to graphite-enhanced (also known as grey) EPS insulation boards which are 40mm thick. Insta SW Expanding Foam is placed horizontally between the rails. The InstaClad panels are cut to size and the edge of the insulated panel is fitted along the starter track at the base of the wall. The InstaClad panels are screwed onto the supporting rails. A thin coat of joint filler is applied where there are joints between panels and scrim tape is bedded in. A 1.5mm coat of render is applied by trowel for the outer layer and this can have a flat trowel or textured finish.

InstaGroup claim that insulating a park home could lead to a £326.40 reduction in the annual gas bill for an 86m^2 park home built between 1983 and 1995 using mains gas for heating and having 100mm of existing loft insulation[19]. The savings from the wall insulation were £183.37, with £77.59 due to floor insulation and £64.44 from loft insulation.

Figure 3.3 InstaClad panel slotting into the starting rail on an EWI installation[20]

Figure 3.4a Tophat rails and Instafoam on park home[20]

Figure 3.4b InstaClad panels fitted on park home[20]

[19] InstaClad Park Home System: Advanced solid wall insulation for park homes (2017) http://www.instagroup.co.uk/media/39744/parkhomes_02_2017.pdf (Accessed 2 August 2018)

[20] InstaClad Park Home Installation Guide, version 5 (July, 2016)

Figure 3.5 Park home retrofit showing joint filler on the InstaClad panels (left) and the final rendered surface (right)

3.2 Technological monitoring

Temperature and humidity levels were recorded every hour in the monitored and control properties using Lascar EL-USB-2 temperature and humidity loggers (Figure 3.6)[21]. These were placed in the living rooms and bedrooms of the properties. Loggers were initially put in place at the time of the initial household interviews and these took place between June and September 2016. The batteries for the loggers last about a year and so the loggers were replaced in July 2017 and interim questionnaires were completed at the same time. The replacement loggers were collected in March 2018 at the time of the final questionnaires.

Figure 3.6 Lascar EL-USB-2 temperature and humidity logger

Astbury Marsh Caravan site was on the gas grid. Recent and historic gas meter readings were obtained from energy bills and Cheshire East Council staff reading the meters on a regular basis.

Lindow Court Park was off the gas grid and most households used 47kg bottled LPG for their heating fuel. Gas meters were fitted to monitor the LPG consumption on 5 of the properties at Lindow Court Park which were insulated. There were also meters fitted for 3 of the control properties. Out of these, 2 used LPG and 1 used oil for heating. These meters were fitted in December 2016 and again, Cheshire East Council staff regularly read the meters manually to ensure accuracy of automatically collected data from loggers. Event loggers were fitted on 5 of the

[21] Lascar EL-USB-2 datasheet https://www.lascarelectronics.com/media/2925/easylog-data-logger_el-usb-2.pdf (Accessed 30 July 2018)

meters, to provide enhanced data by time, however 3 of these loggers failed for unknown reasons – proving the value of the manual readings taken by council staff. Further work would be needed to understand the reasons for the logger failure, but it is possible that the fault lies with the gas meter pulse output itself, as loggers were found to be functioning when returned to the office.

3.3 Cost

An assessment of the cost of heating the park homes was made using gas meter readings. For the households at Astbury Marsh, historic meter readings from energy bills, the gas supplier and a meter reading at the start of the project were used to calculate the pre-installation performance. Gas meters were fitted to the properties heated by LPG at Lindow Court Park. These were fitted in December 2016, after all but 1 of the installations. The remaining household, T-75, had just 1 meter reading over a short time before it was insulated. As a result, it was not possible to assess the savings at Lindow Court Park using pre-installation LPG consumption.

Standard values of 5p/kWh were used for mains gas and 10p/kWh for bottled LPG in the calculations below. In order to properly assess energy use for space heating, account should be taken of the weather and this was carried out using degree days in the analysis (explained below).

It is good practice when comparing the heating costs for two periods, to compensate for differences in outdoor temperatures during the equivalent period[22]. 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[23].

Good quality temperature data was available for Manchester Airport (EGCC) which is located about 3 miles away from Lindow Court Park and about 15 miles from Astbury Marsh. Long term averages of the number of degree days per year are only available on a regional basis. Both Astbury Marsh and Lindow Court Park are in the West Pennines region which has a 20-year average of 2201 degree days per year[24]. This value was used to normalise the savings in the following analysis.

[22] http://www.vesma.com/ddd/ddleaflet.pdf [Accessed 30 August 2018]
[23] https://www.carbontrust.com/resources/guides/energy-efficiency/degree-days/ [Accessed 1 August 2018]
[24] http://www.vesma.com/ [Accessed 1 August 2018]

Before installations							
Tech Ref	Period	Days	Total Period (kWh)	Gas[1] £/30 days	Degree Days	kWh per Degree Day	Estimated Annual Gas Cost[2]
T-05	15 Jul 14 to 23 Jun 16	709	33,595	£71.08	4,242	7.92	£871.44
T-13	16 Jan 15 to 20 May 16	490	37,479	£114.73	3,250.9	11.53	£1,268.55
T-17	11 Jul 14 to 8 Jul 16	724	8,965	£18.57	4,271.1	2.10	£230.96
Average						7.18	£790.32

1 Gas cost used = 5p kWh

2 Using the 20 year average annual degree-day value for West Pennines = 2201 degree days per year

Table 3.7 Analysis of mains gas costs before the park homes at Astbury Marsh were insulated

After installations									
Tech Ref	Period	Days	Total Period (kWh)	Gas[1] £/30 days	Degree Days	kWh per Degree Day	Estimated Annual Gas Cost[2]	Cost Saving	%Saving
T-01	7 Mar 17 to 7 Mar 18	365	12,810	£52.64	2,085.2	6.14	£675.97		
T-05	14 Oct 16 to 13 Oct 17	364	12,451	£51.31	1,993.20	6.25	£687.35	£195.47	21.13%
T-13	7 Mar 17 to 7 Mar 18	365	17,349	£71.30	2,085.2	8.32	£915.48	£353.07	27.83%
T-17	7 Mar 17 to 7 Mar 18	365	5,301	£21.78	2,085.2	2.54	£279.73	-£48.77	-21.12%
Average						5.81	£639.63		9.28%

1 Gas cost used = 5p kWh

2 Using the 20 year average annual degree-day value for West Pennines = 2201 degree days per year

Table 3.8 Analysis of mains gas costs after the park homes at Astbury Marsh were insulated

Tables 3.7 and 3.8 show the gas consumption and estimated annual cost for the park homes at Astbury Marsh before and after insulation. 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 20-year average number of degree days in the West Pennines region.

Household T-05 had a gas consumption of 7.92kWh/degree day before the installation and an estimated annual cost of £871.44. The property had EWI fitted and a top-up of the loft insulation. During the period after the installation, the consumption was 6.25kWh/degree day and the cost decreased to £687.35, providing a saving of 21.1%. The floor area of the property was 82m^2 and the SAP rating increased from 60 to 73 after receiving the insulation.

No pre-installation gas consumption was available for household T-01. As well as having EWI installed, the property received a new gas boiler, a top-up to the loft insulation and under-floor insulation. During the post-installation period, the gas consumption was 6.14kWh/degree day and the annual cost was £675.97. The SAP rating increased from 57 to 72 following the upgrades to the park home which had a floor area of 81m^2.

Among the households where meter readings were available, T-13 had the highest gas consumption. Before the installation of a new boiler, loft insulation top-up and EWI, the gas consumption was 11.53kWh/degree day, with an estimated annual cost of £1,268.55. This decreased to 8.32kWh/degree day and an annual cost of £915.48 after the installation, resulting in savings of 27.83%. The property had the largest floor area (112m^2) among the park homes in the study and the SAP rating increased from 56 to 74 after the installation.

Household T-17 had low gas consumption before the new boiler and EWI was fitted. The consumption was 2.10kWh/degree day and the estimated annual cost was £230.96. Following the installation, the gas consumption increased to 2.54kWh/degree day, with an annual cost of £279.73. The post-installation SAP rating was 67 and so was less energy efficient than the other upgraded properties at Astbury Marsh. It was also comparable in size to T-01 and T-05, with a floor area of 82m^2. The low gas consumption was due to the resident under heating the property. It is likely that the thermal comfort of the property increased compared to the pre-installation period due to a combination of the effect of the energy efficient retrofit and increased use of the gas boiler. The gas consumption at 2.54kWh/degree day was still substantially lower than for households T-01 and T-05 with comparable floor areas and better SAP ratings. Despite the increased gas consumption, temperature logger data showed that this property was still under-heated.

The post-installation LPG consumption for the park homes which received EWI at Lindow Court Park is shown in table 3.9. Here a calorific value of 95MJ/m^3 or 26.39 kWh/m^3 was used for LPG (propane)[25] instead of 11.22 kWh/m^3 for mains gas. The cost for 47kg bottles of LPG used in the calculations was 10p/kWh.

Household T-03 recorded the lowest consumption of all the households in the project. The LPG consumption was only 1.97kWh/degree day and this resulted in an estimated annual cost for the LPG of £433.16. The park home had only 1 bedroom and a floor area of 27m^2, which was less than a third of the size of the park homes at Astbury Marsh. The size of the park home is likely to be a major factor in the low consumption, however thermal data also shows the bedroom was under-heated as well. The SAP rating for the property was 40 and this takes into account the use of LPG for heating. However, the EPC surveys at Lindow Court Park assumed there was no loft insulation in the properties which was not the case. As a result, they were not considered accurate.

The LPG consumption for household T-04 was much higher at 6.13kWh/degree day. The floor area of the property was not available, but it was also a 1-bedroom park home. The estimated annual cost of the LPG was £1,347.93. The resident had the heating on 24 hours a day throughout the year and only turned down the thermostat in the summer.

[25] Calor Technical Publication – Liquefied Petroleum Gases (LPG) Characteristics and Fire Control https://www.calor.co.uk/media/wysiwyg/PDF/lpg-characteristics-and-fire-control.pdf (Accessed 1 August 2018)

After installations							
Tech Ref	Period	Days	Total Period (kWh)	LPG[1] £/30 days	Degree Days	kWh per Degree Day	Estimated Annual LPG Cost[2]
T-03	8 Feb 17 to 16 Mar 18	401	4,748	£35.52	2,412.2	1.97	£433.16
T-04	8 Feb 17 to 16 Mar 18	401	14,775	£110.54	2,412.2	6.13	£1,347.93
T-07	17 Jan 17 to 16 Mar 18	537	14,161	£79.11	2,643.4	5.36	£1,178.92
T-09	8 Feb 17 to 16 Mar 18	401	16,561	£123.90	2,412.2	6.87	£1,510.87
T-75	8 Feb 17 to 16 Mar 18	401	11,027	£82.50	2,412.2	4.57	£1,006.00
Average						4.98	£1,095.37

1 LPG cost used = 10p kWh for 47kg gas bottles

2 Using the 20 year average annual degree-day value for West Pennines = 2201 degree days per year

Table 3.9 Analysis of LPG costs after the park homes at Lindow Court Park were insulated

The park home where household T-07 lived also had 1 bedroom and the floor area was 50m^2. The LPG consumption was 5.36kWh/degree day and the estimated cost of the LPG heating fuel was £1,178.92. The property had been kept warm due to a family member being unwell.

The LPG consumption for household T-09 was the highest among the insulated properties at Lindow Court Park. The floor area was 77m^2, which was also the highest recorded among the properties at Lindow Court Park, but caution should be exercised when making direct comparisons of energy usage with Astbury Marsh, as property sizes and types differed. The LPG consumption was 6.87kWh/degree day with a cost of £1,510.87 per year, which was the highest in the study due to the cost of LPG being higher than mains gas. Such a high consumption suggests the property may have been overheated. Table 3.17 confirms that the average living room temperature for household T-09 was above 21°C

Household T-75 had a LPG consumption of 4.57kWh/degree day and an estimated annual LPG cost of £1,006. The floor area of the 3-bedroom park home was 65m^2. This suggests the room temperatures were likely to be lower than for T-04, T-07 and T-09, which is confirmed in table 3.17.

Table 3.10 shows the LPG consumption and costs for 2 of the control properties in the study which had gas meters. Household C-77 lived in a 2-bedroom park home. The floor area was not available as none of the control properties had EPCs. The LPG consumption was 5.43kWh/degree day with an annual cost of £1,195.64. Meter readings were used up to 15 January 2018 as consumption dropped in February/March due to problems with the boiler. The park home for household C-99 may have had a lower floor area as it was a 1-bedroom property. The LPG consumption was lower than for all the properties in the study at Lindow Court Park apart from T-03, with a consumption of 3.56kWh/degree day. The annual LPG cost was £783.39. Such a low LPG consumption was likely to result in low room temperatures. Table 3.18 shows that the average living room temperature was 17.5°C between 1 October 2017 and 15 March 2018.

Tech Ref	Period	Days	Total Period (kWh)	LPG[1] £/30 days	Degree Days	kWh per Degree Day	Estimated Annual LPG Cost[2]
C-77	8 Feb 17 to 15 Jan 18	341	9,415	£82.83	1,732.9	5.43	£1,195.64
C-99	7 Mar 17 to 15 Mar 18	373	7,676	£61.74	2,156.3	3.56	£783.39
Average						4.50	£989.51

1 LPG cost used = 10p kWh for 47kg gas bottles

2 Using the 20 year average annual degree-day value for West Pennines = 2201 degree days per year

Table 3.10 Analysis of LPG costs for the control properties at Lindow Court Park

Technology	Fuel	Number of installations	Range of kWh per degree day	Average kWh per degree day	Range of % savings	Average % saving
SPS Envirowall EWI	Gas	3	3.34 to 3.75	3.5	12.9 to 39%	26.2%
SPS Envirowall EWI + underfloor insulation	Gas	7	2.26 to 4.94	3.78	-10.8 to 37.8%	16.8%
SPS Envirowall EWI + underfloor + new boiler	Gas	1	4.94	4.94	27.6%	27.6%
Jub Jubizol Premium EWI	Gas	9	2.27 to 6.15	4.53	-9.7 to 31.8%	18.8%
Jub Jubizol Premium EWI + new boiler	Gas	2	4.39 to 6.10	5.25	22.3 to 37.6%	30.0%
ParexTherm EWI	LPG	4	2.02 to 5.97	3.38	6.8 to 29.0%	17.7%
Alumasc Swisslab EWI	LPG	1	5.12	5.12	-5.2%	-5.2%

Table 3.11 Consumption and savings data for comparison from park home insulation project in North Lincolnshire[26]

It was only possible to obtain pre-installation consumption for 3 of the properties at Astbury Marsh to allow savings to be calculated for the installations. For comparison, table 3.11 shows post installation fuel consumption and savings data from another NEA park home insulation project where 4 EWI technologies were installed that used 90mm of grey EPS insulation[26].

The post installation fuel consumption of park homes on the other project ranged from 2.02 to 6.15 kWh/degree day compared to 1.97 to 8.32kWh/degree day on this project. Savings for household T-05 on this project which had EWI and loft insulation were 21.13%. This compares to savings between -9.7% and 39% for park homes with just EWI and average savings for the different EWI technologies of 17.7 to 26.2%. Household T-13 with a new boiler and EWI made savings of 27.83% compared to average savings of 30% for Jub Jubizol Premium with a new boiler on the other project. The greatest increase in consumption in table 3.11 was 10.8%, but T-17 which had a new boiler and EWI and was under-heated saw an increase in gas consumption of 21.12%.

Overall the technical analysis reflected that in the majority of cases, where pre and post installation data was available, households showed a reduction in energy consumption and cost of energy bills. There was an exception to this in the case of T-17, however this property was underheating prior to installation, and despite an increase in consumption this was associated with an improvement to thermal comfort.

[26] External wall insulation on park homes in North Lincolnshire, Elizabeth Lamming, Jamie Barnes, Paul Rogers and Michael Hamer (NEA, 2017), http://www.nea.org.uk/wp-content/uploads/2018/06/CP783-4-TIF-Report-FINAL-04062018-v5.pdf (Accessed 11 June 2018)

Performance line graphs for gas consumption

Where there are sufficient meter readings it is possible to plot a graph of gas or LPG consumption (kWh) 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.

Figures 3.12a and b show Performance line graphs for household T-05 before and after the installation of the EWI. 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 that the data points are closer to the line of best fit. It can be seen that the data points were close to the line and R^2 was close to 1.0 in both figure 3.12a and b. This indicates that household T-05 maintained consistent temperatures and good control of the heating before and after the EWI was installed. The y-intercept was negative for T-05 prior to installation, which suggests the property had been under-heated, but may have been overheated after being insulated. Unfortunately, data logger information for this property was limited.

Table 3.8 shows that the household T-13 was the highest consumer among the properties where gas consumption was recorded. Data points were close to the Performance line in figure 3.12c, indicating that household T-13 maintained a consistent temperature. The y-intercept for the line of best fit had a high positive value which indicates that the property was overheated or there was a high non-heating electrical consumption.

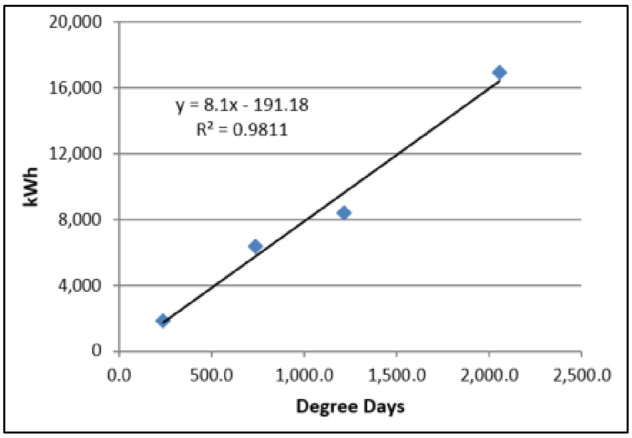


Figure 3.12a   T-05 at Astbury Marsh before EWI installation

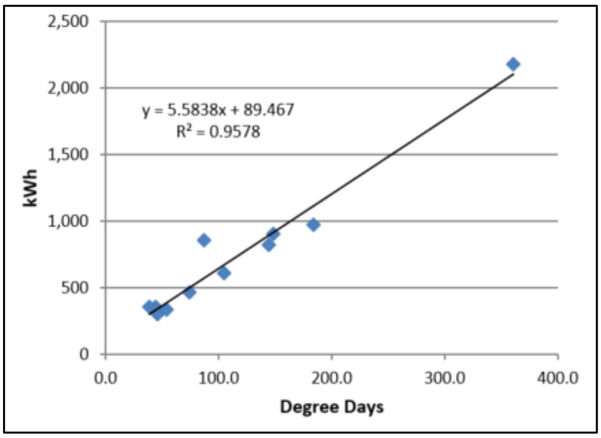


Figure 3.12b T-05 at Astbury Marsh after EWI installation

Household T-17 was the lowest gas consumer among those at Astbury Marsh. The Performance line for T-17 in figure 3.12d shows significant scatter of the data points and a lower value for R^2. This indicates that the heating system was poorly controlled and heating use in the property was not aligned to external temperatures during the analysis period (between March 2017 and March 2018). The y-intercept for the Performance line was negative which also indicates the property was under-heated.

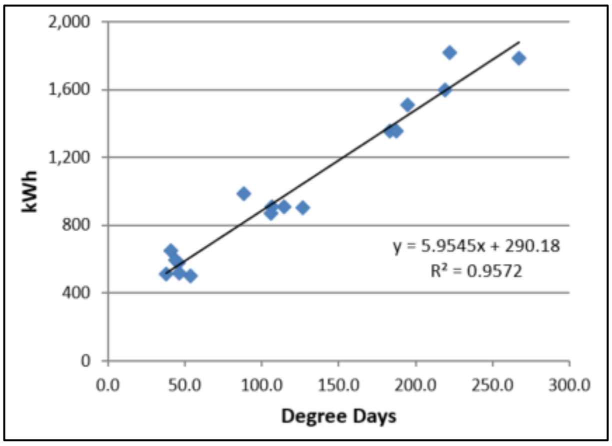


Figure 3.12c T-13 at Astbury Marsh after boiler and EWI

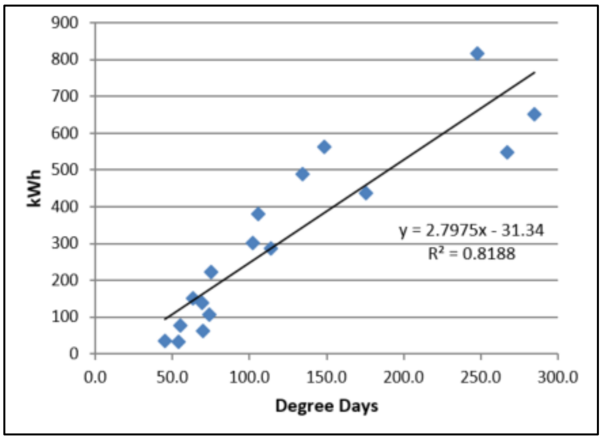


Figure 3.12d T-17 at Astbury Marsh after boiler and EWI

The lowest consumer of LPG in the study was household T-03 at Lindow Court Park. In this case the park home had a floor area of 27m^2 compared to 82m^2 for T-17. The heat consumption per m^2 for T-17 was however significantly lower than for T-03.

The Performance line graph for household T-03 in figure 3.13a shows the data points were close to the Performance line which indicates the property was maintained at a consistent temperature, and the heating system was well controlled. There was however a negative y-intercept for the Performance line, which indicated that this property was also under-heated despite having a floor area one third the size of T-17.

Figure 3.13b shows the graph of LPG consumption against number of degree days for household T-04, another single bedroom park home. In this case the Performance line had a high positive y-intercept, which indicated the property was overheated. This was due to the household having a member with a medical condition and requiring the home to be warm.

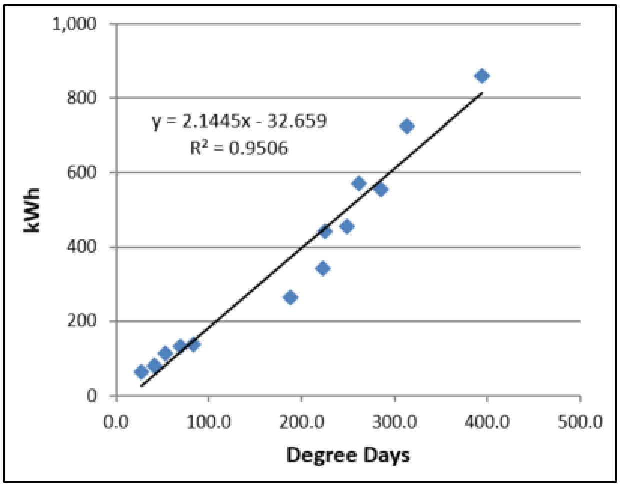


Figure 3.13a T-03 at Lindow Court Park with EWI

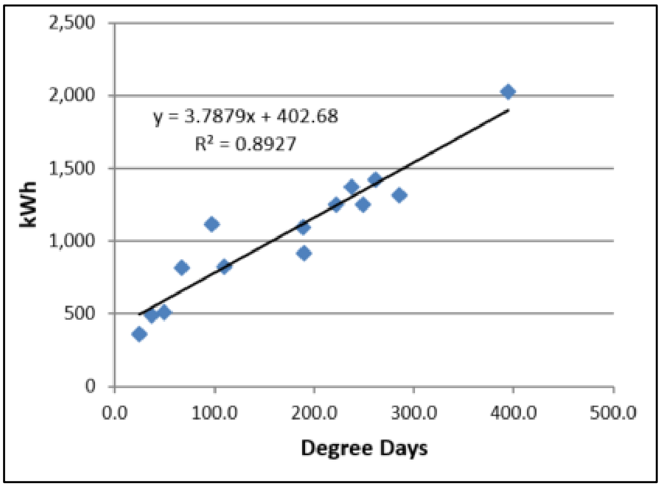
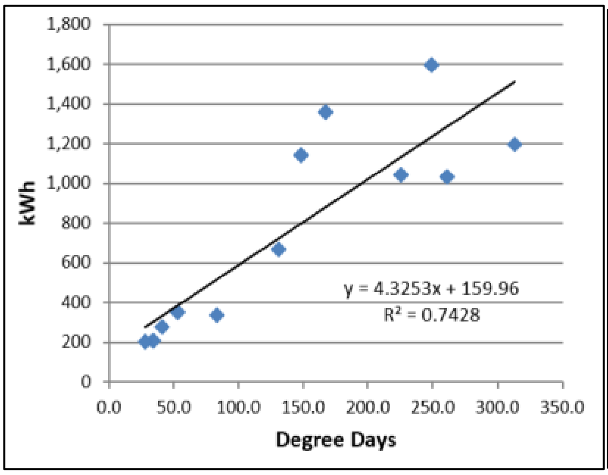


Figure 3.13b T-04 at Lindow Court Park with EWI

The scatter of the data points in the plot for control property C-77 in figure 3.14a was significant. This was particularly noticeable for colder periods with higher numbers of degree days. Data points from February to April 2017 were above the line of best fit and those from November 2017 to

January 2018 were below the line. The consumption dropped further after January 2018 as the boiler broke down. Between 1 Oct 2016 and 31 Mar 2017, the average living room temperature was 18.52°C. This average decreased to 16.01°C between 1 Oct 2017 and 15 Mar 2018.

In contrast to control property C-77, the data points in figure 3.14b for C-99 were close to the Performance line and the value for R^2=0.9697. This suggests there was good control of the heating system and the temperature was more consistent that for C-77. Since the y-intercept for the Performance line has a negative value, it suggests the property was under-heated.



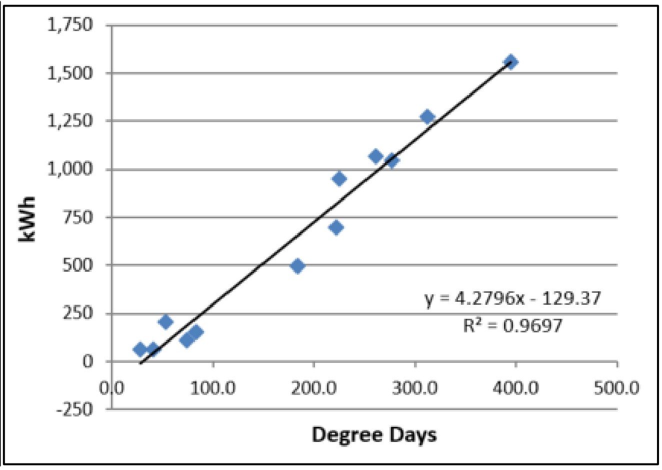
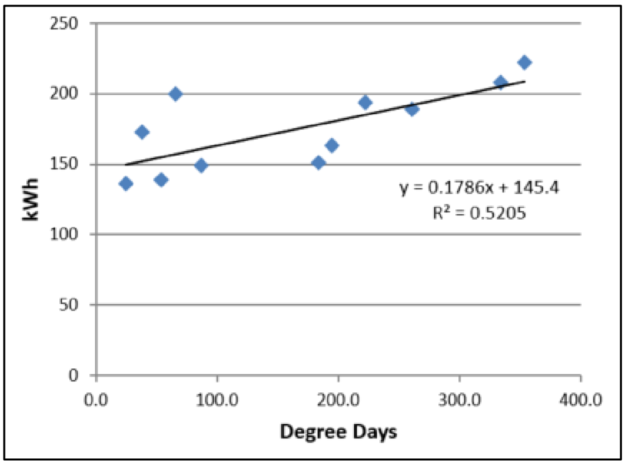


Figure 3.14a Control property C-77 at Lindow Court Park   Figure 3.14b Control property C-99 at Lindow Court Park

Performance line graphs illustrated the temperature control of properties. Households T-03, T-05, T-13 and C-99 maintained consistent temperatures and the heating system was well controlled. Households T-17 and C-77 did not maintain consistent temperatures, with T-17 significantly under heating the property. There was a positive intercept to the y-axis for households T-04 and T-13 indicating over-heating or a high non-heating component.

Performance line graphs for electricity consumption



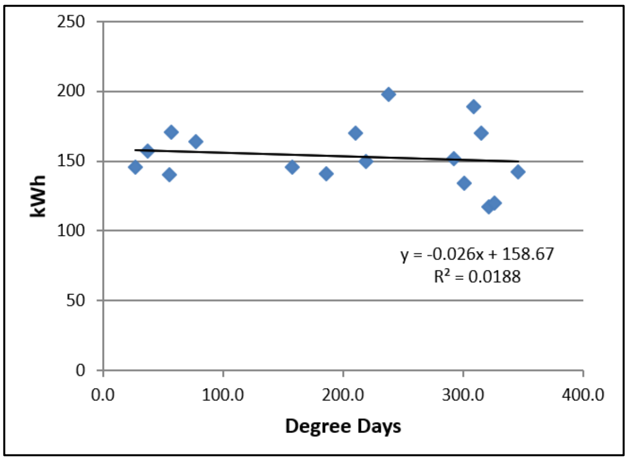


Figure 3.15a T-17 at Astbury Marsh with EWI and a boiler   Figure 3.15b T-07 at Lindow Court Park with EWI

Electricity meter readings were taken at the same time as gas/LPG meter readings. It was therefore possible to see how electricity consumption was affected as the weather became colder by plotting graphs of electricity consumption against number of degree days.

Household T-17 had the lowest gas consumption among the properties at Astbury Marsh. Figure 3.15a shows a plot using approximately monthly electricity meter readings between March 2017 and February 2018. There appears to be a baseload consumption of about 145kWh per month, with the consumption increasing slightly in colder weather possibly due to increased use of supplementary heating or other higher energy consuming appliances in the colder weather. When interviewed the resident did not confirm any use of supplementary heating.

Figure 3.15b shows a plot for household T-07 at Lindow Court Park. Here approximately monthly meter readings between October 2016 and March 2018 were used. There was a baseload consumption of about 150kWh per month, but little or no temperature dependence on the consumption, as seen with park homes in another study.[27]

3.4 Temperature and thermal comfort

Average, maximum and minimum temperatures are shown in table 3.16 for the living room and the main bedroom for 3 of the properties at Astbury Marsh caravan site between 1st October 2017 and 15th March 2018. The average temperature in the living room over that period for T-01 and T-13 was 21.35°C and 22.1°C respectively. The minimum temperatures at 16°C and 19°C were not too low, although there were periods of over-heating as indicated by the maximum temperatures of 27°C and 28°C.

Temperature data was available for household T-05 for the period 1 October 2016 to 31 March 2017, but data was not available for the following year for the full period. Here that average temperature for the period in 2016/17 was 20.4°C

The average temperature for household T-17 was low at 16.21°C and the minimum temperature of 4.5°C is of a level where the cold could have significant health impacts[28]. The minimum temperature during the 5pm to 9pm period was 9.0°C. The room thermostat was set at 16°C at the time of the final interview and the resident noted having the living room temperature normally between 16 and 18°C.

In the bedroom for household T-01, the average temperature recorded was 9.82°C, with a minimum temperature of -1.5°C. The householder explained the lower temperature in the bedroom was caused by a blockage with the single radiator in the bedroom which was not repaired until about March 2018. She did not believe the average temperature was as low as 9.82°C and the minimum temperature reached -1.5°C, but she regularly opened windows even during the winter.

[27] External wall insulation on park homes in North Lincolnshire, (NEA, 2017), http://www.nea.org.uk/wp-content/uploads/2018/06/CP783-4-TIF-Report-FINAL-04062018-v5.pdf (Accessed 11 June 2018)
[28] The Health Impacts of Cold Homes and Fuel Poverty, Marmot Review (2011) https://friendsoftheearth.uk/sites/default/files/downloads/cold_homes_health.pdf (Accessed 30 Jul 2018)

1st October 2017 to 15th March 2018	Living Room							Bedroom						
Tech Ref	Mean Temp 24h	Max Temp 24 h	Min Temp 24 h	SD	Mean Temp 5-9	Max Temp 5-9	Min Temp 5-9	Mean Temp 24h	Max Temp 24 h	Min Temp 24 h	SD	Mean Temp 5-9	Max Temp 5-9	Min Temp 5-9
T-01	21.35	27.0	16.0	2.00	22.4	27.0	18.0	9.82	19.0	-1.5	3.61	10.44	19.0	-0.5
T-13	22.1	28.0	19.0	0.72	22.28	24.0	19.0							
T-17	16.21	23.0	4.5	3.21	17.41	22.5	9.0	17.32	23.0	7.0	3.07	17.39	23.0	9.0
Maximum	22.1	28.0	19.0	3.21	22.4	27.0	19.0	17.32	23.0	7.0	3.61	17.39	23.0	9.0
Minimum	16.21	23.0	4.5	0.72	17.41	22.5	9.0	9.82	19.0	-1.5	3.07	10.44	19.0	-0.5
Average (Mean)	**19.89**	**26.00**	**13.17**	**1.98**	**20.70**	**24.50**	**15.33**	**13.57**	**21.00**	**2.75**	**3.34**	**13.92**	**21.00**	**4.25**

Table 3.16 Living room & bedroom temperatures at Astbury Marsh after insulation of the park homes (Period 1st October 2017 to 15th March 2018; number of degree days over the period = 1523.7

The average temperature for the bedroom of T-17 was 17.32°C and therefore warmer than the living room. The minimum temperature was 7°C which again was less cold than the value for the living room.

Household T-13 had a gas consumption rate of 8.32 kWh/degree day which was the highest among all the insulated properties. The park home had the highest floor area in the study (112m^2) and also had the highest average temperature over the full 24 hours for the properties at Astbury Marsh. The gas consumption rate for T-01 was lower at 6.14 kWh/degree day. This can be explained by the average temperature of the living room over 24 hours being 0.75°C lower than for T-13 and having a lower floor area of 81m^2. Also, the average temperature recorded in the main bedroom was low with the radiator not working. Household T-17 was a particularly low energy user, consuming 2.54kWh of gas per degree day. Here the property was a 2-bedroom park home with a floor area of 82m^2. The average living room temperature of 16.21°C was much lower than the temperatures for T-01 and T-13 of 21.35°C and 22.1°C respectively. This is likely to account for the low gas consumption of household T-17.

Temperature values for the monitored insulated properties at Lindow Court Park are shown in table 3.17. The average living room temperatures were in the range 19.45°C to 22.78°C. All the properties had comparably low minimum temperatures in the range 9.5 to 11.5°C while the maximum temperatures were between 25 and 28°C. The properties were warmer during the 5pm to 9pm period. The minimum temperatures during the early evening were also not as cold as for the full 24-hour, ranging from 14.5°C to a more comfortable 19.5°C.

The average temperatures in the bedrooms were cooler than for the living room for all the monitored insulated properties at Lindow Court Park. The average temperatures ranged from 17.14°C to 22.49°C over the 24-hour period. The temperature difference between the 24-hour averages for the living room and the bedroom ranged from 0.29°C for T-04 to 2.31°C for T-03. Households T-03 and T-75 had the lowest average temperatures for both the living rooms and the bedrooms. The minimum temperatures for the bedrooms were in the range 10.0 to 12.5°C, which is comparable to the values for the living rooms.

1st October 2017 to 15th March 2018				Living Room				Bedroom						
Tech Ref	Mean Temp 24h	Max Temp 24 h	Min Temp 24 h	SD	Mean Temp 5-9	Max Temp 5-9	Min Temp 5-9	Mean Temp 24h	Max Temp 24 h	Min Temp 24 h	SD	Mean Temp 5-9	Max Temp 5-9	Min Temp 5-9
T-03	19.45	25.0	11.0	1.50	20.52	25.0	17.5	17.14	22.0	11.0	1.21	17.67	22.0	15.0
T-04	22.78	29.0	10.0	1.50	23.33	26.5	18.0	22.49	31.5	10.5	1.44	22.91	28.0	18.5
T-07	22.15	26.5	11.0	1.44	22.82	26.5	19.5	21.3	26.5	12.0	1.82	21.22	26.5	16.0
T-09	22.07	29.0	9.5	2.78	22.96	29.0	15.0	19.84	27.0	12.5	2.01	20.7	26.0	15.0
T-75	19.7	25.0	11.5	2.26	21.01	24.0	17.5	17.89	23.0	10.0	2.45	19.07	23.0	12.0
T-80	20.41	26.5	9.5	2.92	22.71	26.0	14.5	18.92	22.5	11.5	1.64	19.48	22.5	13.5
Maximum	22.78	29.0	11.5	2.92	23.33	29.0	19.5	22.49	31.5	12.5	2.45	22.91	28.0	18.5
Minimum	19.45	25.0	9.5	1.44	20.52	24.0	14.5	17.14	22.0	10.0	1.21	17.67	22.0	12.0
Average (Mean)	**21.09**	**26.83**	**10.42**	**2.07**	**22.23**	**26.17**	**17.00**	**19.60**	**25.42**	**11.25**	**1.76**	**20.18**	**24.67**	**15.00**

Table 3.17 Living room & bedroom temperatures at Lindow Court Park after insulation of the park homes (Period 1st October 2017 to 15th March 2018; number of degree days over the period = 1523.7)

Out of the properties at Lindow Court Park where LPG consumption was recorded, the highest value was 6.87kWh/degree day for T-09. This property had the 3rd highest living room and bedroom temperatures in table 3.17. The LPG consumption was high due to the low SAP rating of 25 for the property and it also having the highest floor area of the insulated properties at Lindow Court Park.

Household T-04 had a consumption of 6.13kWh/degree day in a 1-bedroom property. Here the resident left the heating on all the time and just turned it down in summer. This household had the highest average temperatures for the living room and bedroom. The lowest LPG consumption in the study of 1.97kWh/degree day was for household T-03. Here the property had the lowest average temperatures among the insulated properties at Lindow Court Park and the lowest floor area recorded in the study (27m^2).

Tables 3.18 shows the average, maximum and minimum temperatures for the control properties at Lindow Court Park. Among the 4 control properties, C-11 and C-101 could be classed as having warmer living room temperatures. Here the average temperatures over 24 hours were 24.19°C and 20.04°C respectively. The minimum temperatures for the 24-hour period for both properties were 10.5°C. Households C-77 and C-99 had colder living rooms with the average over 24 hours being 16.01°C and 17.51°C. The minimum temperatures were particularly cold at 3.0 and 4.0°C respectively. The average temperatures for the 5pm to 9pm periods for C-77 and C-99 were more comfortable at 19.99°C and 20.92 respectively. For the early evening period, the minimum temperatures were 8.5°C and 15°C.

1st October 2017 to 15th March 2018	Living Room							Bedroom						
Tech Ref	Mean Temp 24h	Max Temp 24 h	Min Temp 24 h	SD	Mean Temp 5-9	Max Temp 5-9	Min Temp 5-9	Mean Temp 24h	Max Temp 24 h	Min Temp 24 h	SD	Mean Temp 5-9	Max Temp 5-9	Min Temp 5-9
C-11	24.19	27.5	10.5	1.65	24.64	27.5	20.0	23.44	26.0	11.5	1.52	23.65	26.0	19.0
C-77	16.01	29.0	4.0	4.84	19.99	29.0	8.5	10.62	19.5	1.5	3.45	10.57	19.5	2.0
C-99	17.51	28.5	3.0	4.11	20.92	26.0	15.0	19.45	35.0	4.0	5.64	24.19	34.0	8.5
C-101	20.04	25.0	10.5	2.57	22.01	25.0	15.0	21.08	26.0	13.5	2.2	22.47	26.0	15.0
Maximum	24.19	29.0	10.5	4.84	24.64	29.0	20.0	23.44	35.0	13.5	5.64	24.19	34.0	19.0
Minimum	16.01	25.0	3.0	1.65	19.99	25.0	8.5	10.62	19.5	1.5	1.52	10.57	19.5	2.0
Average (Mean)	**19.44**	**27.50**	**7.00**	**3.29**	**21.89**	**26.88**	**14.63**	**18.65**	**26.63**	**7.63**	**3.20**	**20.22**	**26.38**	**11.13**

Table 3.18 Living room & bedroom temperatures of control properties at Lindow Court Park
(Period 1st October 2017 to 15th March 2018; number of degree days over the period = 1523.7)

There were also warm bedroom temperatures for households C-11 and C-101. There was limited heating in the bedroom for household C-77, with average temperatures of between 10 and 11°C. In contrast, the average bedroom temperature over 24 hours was nearly 2°C warmer than for the living room for C-99 and the average bedroom temperature between 5pm and 9pm at 24.19°C, was the highest of the 4 control properties.

A summary of all the data for the living room temperatures can be seen in the graph in figure 3.19. Comparing all the properties, it can be seen that households T-01 and T-13 at Astbury Marsh had the narrowest temperature range over the full 24 hours and the temperature did not become too cold. Control properties C-77 and C-99 had the widest temperature range, from under 5°C to nearly 30°C over the full 24-hour period. Household T-17 at Astbury Marsh also dropped under 5°C, but only increased to 23°C. Control properties C-11 and C-101 had temperature ranges and averages comparable to the insulated properties at Lindow Court Park.

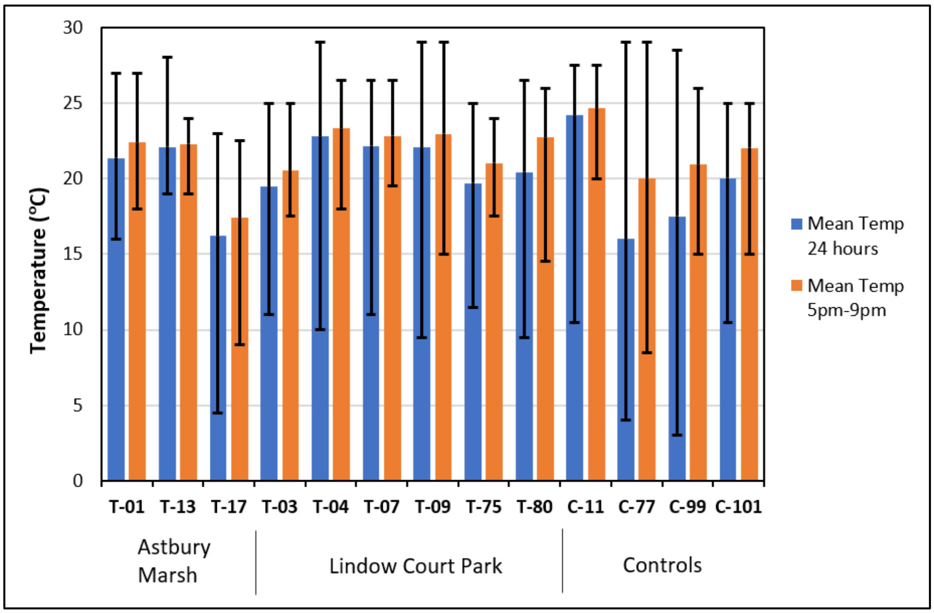


Figure 3.19 Average living room temperatures for monitored park homes in the study
The error bars show the maximum and minimum temperatures
(Period 1st October 2017 to 15th March 2018; number of degree days over the period = 1523.7)

The average bedroom temperatures are shown in figure 3.20 for the properties which had temperature loggers in the bedroom. The values of maximum and minimum temperature are indicated with the error bars on the chart.

Properties T-01 and C-77 both had average bedroom temperatures of about 10°C, with a minimum temperature falling well below 5°C and a maximum temperature of about 19.0°C. The radiator in the bedroom of T-01 had not been working. At the time of the final visit in March 2018, the central heating system for C-77 had been off for 10 days following a leak. This will have affected consumption and temperatures in March 2018.

Again, the average temperatures and temperature ranges for the controls C-11 and C-101 were comparable to the insulated properties at Lindow Court Park. Control property C-11 maintained the narrowest temperature range in the 5pm to 9pm period of between 19 and 26°C. The widest temperature range over the full 24 hours occurred in property C-99 where the temperature was between 4.0°C and 35°C.

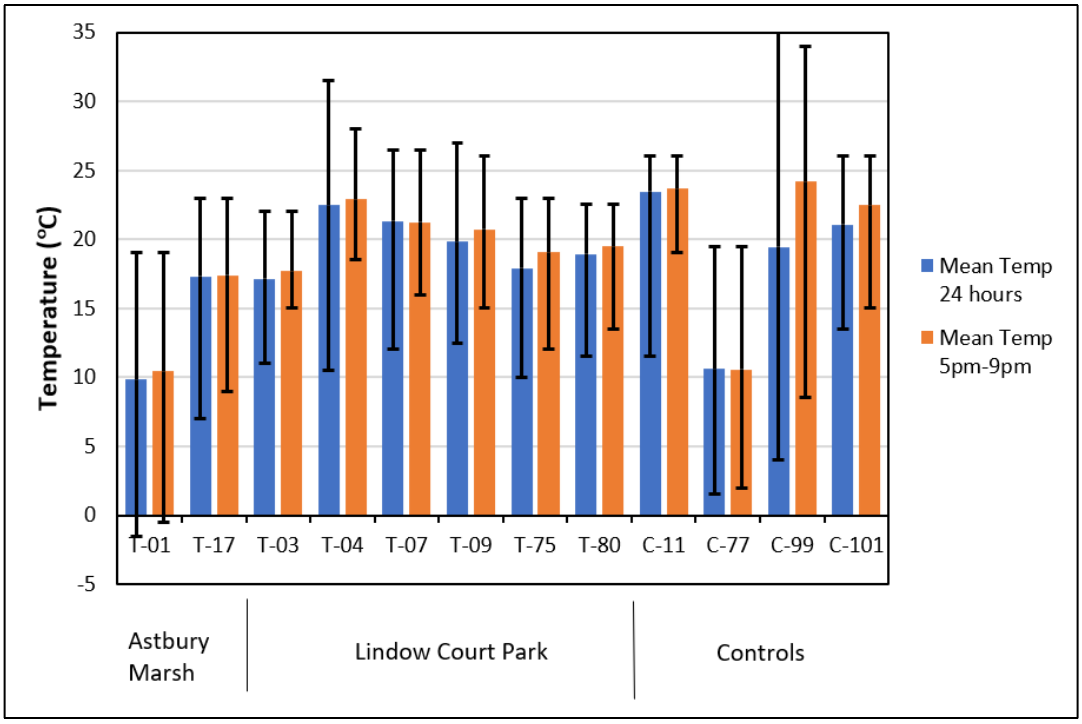


Figure 3.20 Average bedroom temperatures for monitored park homes in the study
The error bars show the maximum and minimum temperatures
(Period 1st October 2017 to 15th March 2018; number of degree days over the period = 1523.7)

Comparing temperature before and after insulation

Temperature loggers were placed in the monitored households in the summer of 2016. All but 1 household had the insulation fitted within a few weeks of the loggers being installed. This meant the loggers did not record a cold period in the park homes before the EWI was fitted.

Household T-75 was originally going to be a control property. However, the residents decided to privately fund an installation after seeing others having it fitted. Although temperature loggers were left at the property on 31 August 2016, the insulation was not installed until the beginning of February 2017.

This meant that it was possible to compare household temperatures in autumn 2016 with autumn 2017 to see the effect insulation had on the temperatures. Whilst some interesting reflections, it is recognised that this is only representative of one sample household and larger sample size would be needed to draw any conclusions. Tables 3.21 and 3.22 show a period before the insulation (1st October 2016 to 31st December 2016 with 730.2 degree days) and a period after the insulation was fitted (1st October 2017 to 31st December 2017 which had 690.4 degree days).

T-75 - Living Room							
Period	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
1 Oct 16 to 31 Dec 16	18.76	24.0	10.5	2.85	20.55	24.0	14.5
1 Oct 17 to 31 Dec 17	19.98	25.0	13.0	2.02	21.09	24.0	18.0

Table 3.21 Living room temperatures for household T-75 before and after insulation of the park home (Period 1st Oct 2016 to 31st Dec 2016, degree days = 730.2 1st Oct 2017 to 31st Dec 2017, degree days=690.4)

T-75 - Bedroom							
Period	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
1 Oct 16 to 31 Dec 16	17.67	22.5	10.5	2.15	19.25	22.5	14.0
1 Oct 17 to 31 Dec 17	18.87	23.0	14.0	1.51	20.14	23.0	17.5

Table 3.22 Bedroom temperatures for household T-75 before and after insulation of the park home (Period 1st Oct 2016 to 31st Dec 2016, degree days = 730.2 1st Oct 2017 to 31st Dec 2017, degree days=690.4)

There was an increase in the living room and bedroom temperatures for household T-75 during the 4th quarter of 2017 (after the property was insulated) compared to the same period in 2016, prior to the EWI being fitted. The minimum temperatures over the full 24-hours was 13.0°C in the living room and 14.0°C in the bedroom in q4 2017 compared to 10.5°C in the living room and bedroom in q4 2016. The average temperature over the full day increased by around 1.2°C for the living room and bedroom. The living room average temperature increased from 18.76 to 19.98°C.

The lower number of degree days in q4 2017 compared to q4 2016 is likely to have had an effect the difference in temperatures in tables 3.24 and 3.25. Likewise, any potential change in occupancy of the park home and settings for the heating system are likely to have had an impact. However, the insulation is also likely to have played a role in the increase in average and minimum room temperatures.

Summary: Overall the monitoring showed that nearly all the households were able to maintain their homes at suitable average temperatures of 19°C or more after being insulated. All the insulated properties at Lindow Court Park had average temperatures between 19.45 and 22.78°C. Despite the improvements, there was still some underheating of properties. Household T-17 at Astbury Marsh was a low gas consumer and had an average living room temperature of 16.2°C. The resident still noted that the home was warmer and kept in the heat better than before. The bedroom temperature of T-01 was also particularly low over the monitoring due to a blocked radiator. The resident later reported that the property typically took about 20 minutes to heat up compared to about an hour prior to the installations. Note that this property had a replacement boiler, underfloor and loft insulation as well as the EWI.

3.5 Humidity

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

Figure 3.23 illustrates the optimum humidity levels as cited by Arundel et al[29]. The study concluded that maintaining relative humidity levels between 40% and 60% would minimise adverse health effects relating to relative humidity. The automated data-loggers recorded 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, 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.

High values are problematic, and can cause damage to building fabric and furnishings, and can cause mould growth and cause health problems associated with this high humidity. From the Building regulations part F[30], 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.

[29] 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]
[30] Available from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/468871/ADF_LOCKED.pdf [Accessed 21/03/2017]

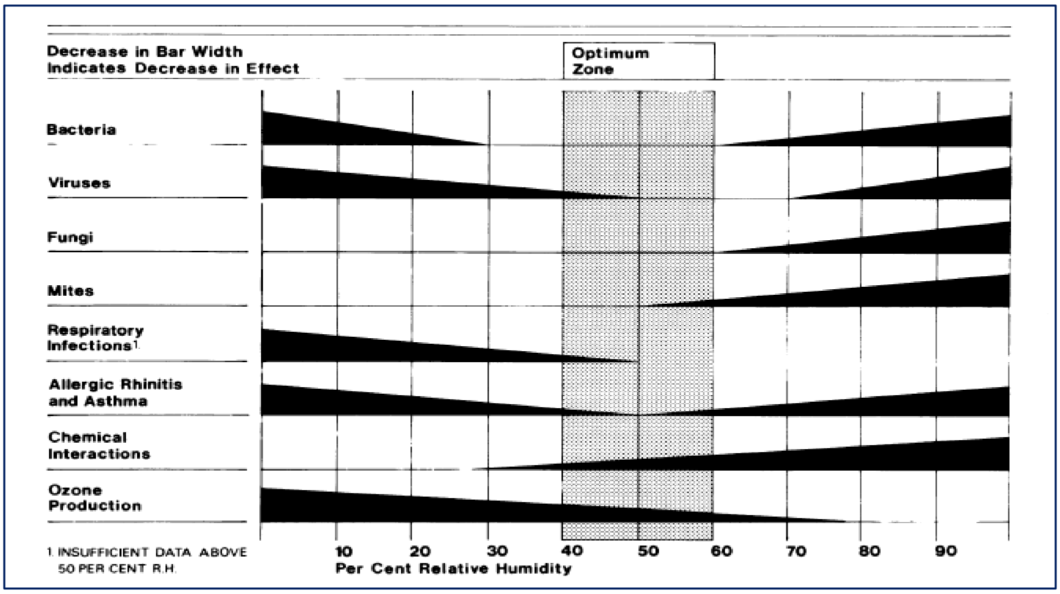


Figure 3.23 Optimum humidity levels to reduce indirect effects from pathogenic organisms or chemicals

1st October 2017 to 15th March 2018				Living Room				Bedroom						
Tech Ref	Mean RH (%) 24h	Max RH (%) 24 h	Min RH (%) 24 h	SD	Mean RH (%) 5-9	Max RH (%) 5-9	Min RH (%) 5-9	Mean RH (%) 24h	Max RH (%) 24 h	Min RH (%) 24 h	SD	Mean RH (%) 5-9	Max RH (%) 5-9	Min RH (%) 5-9
T-01	46.62	71.0	25.5	7.46	46.69	71.0	25.5	68.9	88.0	49.0	6.23	67.88	85.5	49.0
T-13	41.88	56.0	31.5	5.73	41.79	55.5	31.5							
T-17	56.03	79.0	36.5	8.47	55.05	79.0	36.5	50.05	69.5	33.5	8.11	49.71	67.5	34.5
Maximum	56.03	79.0	36.5	8.47	55.05	79.0	36.5	68.9	88.0	49.0	8.11	67.88	85.5	49.0
Minimum	41.88	56.0	25.5	5.73	41.79	55.5	25.5	50.05	69.5	33.5	6.23	49.71	67.5	34.5
Average (Mean)	**48.18**	**68.67**	**31.17**	**7.22**	**47.84**	**68.50**	**31.17**	**59.48**	**78.75**	**41.25**	**7.17**	**58.80**	**76.50**	**41.75**

Table 3.24 Living room & Bedroom relative humidity for households at Astbury Marsh after insulation of the park homes (Period 1st October 2017 to 15th March 2018; number of degree days over the period = 1523.7)

The relative humidity for the living rooms and bedrooms for households in Astbury Marsh is shown in table 3.24. Here it can be seen that the average value for the living rooms over the 24 hour period ranged from 41.88% to 56.03% and this changed little when looking at the 5pm to 9pm period. The highest value of average living room relative humidity was for household T-17 which had the lowest average temperature of 16.21°C. The average values of living room relative humidity were within the optimum range of 40 to 60%, however the value of maximum humidity of 79% for T-17 was high.

The bedroom for household T-01 had an average relative humidity over 24 hours of 68.9%. This was outside the optimum 40 to 60% range. The value of maximum relative humidity of 88% was also very high. This was likely to be due to the average bedroom temperature being only 9.82°C during a period when a radiator was not working. The values of average and maximum humidity in the living room for T-01 might be higher due to a transfer of damp air from the bedroom. The relative humidity in the bedroom for household T-17 may have been lower than for the living room due to the higher average temperature. The average living room temperature for T-17 was 16.21°C compared to 17.32°C in the bedroom.

1st October 2017 to 15th March 2018				Living Room				Bedroom						
Tech Ref	Mean RH (%) 24h	Max RH (%) 24 h	Min RH (%) 24 h	SD	Mean RH (%) 5-9	Max RH (%) 5-9	Min RH (%) 5-9	Mean RH (%) 24h	Max RH (%) 24 h	Min RH (%) 24 h	SD	Mean RH (%) 5-9	Max RH (%) 5-9	Min RH (%) 5-9
T-03	58.27	78.0	37.5	7.45	58.09	74.0	40.5	69.18	85.0	49.5	7.29	68.37	83.5	49.5
T-04	41.34	65.5	24.0	7.33	42.03	64.5	24.0	40.5	68.0	21.5	7.46	38.06	60.0	21.5
T-07	47.2	68.0	29.5	7.84	47.33	68.0	29.5	50	73.0	29.5	8.18	50.01	71.0	33.0
T-09	43.59	73.5	21.0	10.88	43.7	71.0	22.5	50.15	74.5	26.5	9.77	49.67	74.5	28.0
T-75	55.64	73.0	37.5	7.19	56.46	73.0	39.0	63.03	82.5	48.0	7.82	64.05	82.5	48.0
T-80	57.39	76.0	39.5	7.24	56.3	76.0	40.0	61.83	78.5	45.0	7.94	58.38	76.5	45.0
Maximum	58.27	78.0	39.5	10.88	58.09	76.0	40.5	69.18	85.0	49.5	9.77	68.37	83.5	49.5
Minimum	41.34	65.5	21.0	7.19	42.03	64.5	22.5	40.5	68.0	21.5	7.29	38.06	60.0	21.5
Average (Mean)	**50.57**	**72.33**	**31.50**	**7.99**	**50.65**	**71.08**	**32.58**	**55.78**	**76.92**	**36.67**	**8.08**	**54.76**	**74.67**	**37.50**

Table 3.25 Living room relative humidity for households at Lindow Court Park after insulation of the park homes (Period 1st October 2017 to 15th March 2018; number of degree days over the period = 1523.7)

The relative humidity for the monitored insulated park homes at Lindow Court Park is shown in table 3.25. Here the living room averages over the full day ranged from 41.34% to 58.27%, which were in the optimum range. The 24 hour average again differed little from the average for the 5pm to 9pm period. Households T-04, T-07 and T-09 which had average relative humidities of under 50% had average living room temperatures of over 22°C.

For the bedrooms at Lindow Court Park, the average relative humidity over the whole day for the insulated properties ranged from 40.5% to 69.18%. Households T-03, T-75 and T-80 were outside the optimum range of 40 to 60%. For T-03, the average bedroom temperature was 17.14°C and 2.31°C colder than the living room. It is likely that this led to the average relative humidity being 10.91% higher for the bedroom. Likewise the average bedroom temperature for T-75 at 17.89°C was colder than the average temperature of the living room (19.7°C). This is likely to have contributed to the increase in relative humidity from 55.64% in the living room to 63.03% in the bedroom. The maximum humidity rates of 85% and 82.5% for T-03 and T-75 are again high.

1st October 2017 to 15th March 2018				Living Room				Bedroom						
Tech Ref	Mean RH (%) 24h	Max RH (%) 24 h	Min RH (%) 24 h	SD	Mean RH (%) 5-9	Max RH (%) 5-9	Min RH (%) 5-9	Mean RH (%) 24h	Max RH (%) 24 h	Min RH (%) 24 h	SD	Mean RH (%) 5-9	Max RH (%) 5-9	Min RH (%) 5-9
C-11	38.19	67.0	20.5	8.40	38.15	64.0	20.5	39.13	68.5	21.0	8.12	38.49	67.0	21.0
C-77	52.92	73.0	32.0	7.87	49.49	70.5	32.5	76.21	83.0	67.5	1.92	76.08	82.0	68.5
C-99	59.62	83.5	34.5	9.29	57.41	79.0	36.0	54.73	85.5	23.5	13.96	47.29	80.5	26.0
C-101	48.41	66.0	35.0	6.29	47.87	65.0	35.0	49.4	70.0	31.5	7.62	47.26	70.0	31.5
Maximum	59.62	83.5	35.0	9.29	57.41	79.0	36.0	76.21	85.5	67.5	13.96	76.08	82.0	68.5
Minimum	38.19	66.0	20.5	6.29	38.15	64.0	20.5	39.13	68.5	21.0	1.92	38.49	67.0	21.0
Average (Mean)	**49.79**	**72.38**	**30.50**	**7.96**	**48.23**	**69.63**	**31.00**	**54.87**	**76.75**	**35.88**	**7.91**	**52.28**	**74.88**	**36.75**

Table 3.26 Living room & bedroom relative humidity for control properties at Lindow Court Park (Period 1st October 2017 to 15th March 2018; number of degree days over the period = 1523.7)

Tables 3.26 shows the relative humidity in the living room and main bedroom for the control properties for the period between 1st October 2017 and 15th March 2018. Household C-11 had the lowest average living room relative humidity over the whole day for all the monitored households with a value of 38.19%. This was likely to be due to the property having the highest average living room temperature of all the monitored properties at 24.19°C.

The highest average living room relative humidity among the control properties was 59.62% for household C-99. The maximum relative humidity for C-99, at 83.5%, was also the highest in the living room for the controls. Household C-77 had a lower average living room temperature than C-99 with a temperature of 16.01°C compared to 17.51°C, but still had a lower average relative humidity of 52.92%. In this case the household behavour of C-99 may be a significant factor in the high average relative humidity in the living room. This could include poor ventilation after bathing and cooking.

Household C-11 also had the lowest average relative humidity in bedroom with a value of 39.13%. The highest value of average relative humidity among the controls was 76.21% for C-77. This household had a particularly low average bedroom temperature of 10.62°C, which explained the high average for relative humidity. The highest value for maximum relative humidity was 85.5% for household C-99 despite having an average value of 54.73%. This also suggests household behaviour was contributing to the high values for C-99.

Figures 3.27 and 3.28 show plots of the average values for relative humidity for the monitored properties for the period between 1st October 2017 and 15th March 2018. The error bars show the range between values of maximum and minimum relative humidity. It can be seen that there was little difference between the values of average relative humidity over the whole day and over the period 5pm to 9pm. The average values of relative humidity were often higher in the bedroom than in the living room.

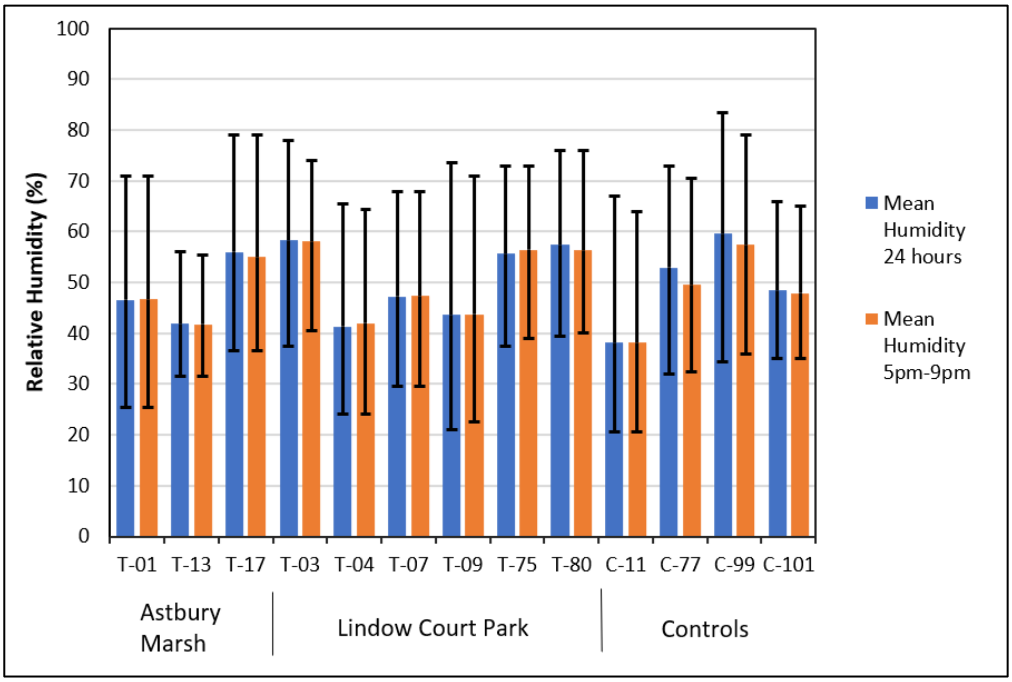


Figure 3.27 Average living room relative humidity for monitored park homes in the study
The error bars show the range between the maximum and minimum values for relative humidity
(Period 1st October 2017 to 15th March 2018; number of degree days over the period = 1523.7)

Among the monitored households it is possible to group those which had a higher value of average living room relative humidity. These were households T-17, T-03, T-75, T-80, C-77 and C-99, which had average temperatures of less than 21°C. Households with a lower relative humidity in the living room were T-01, T-13, T-04, T-07, T-09 and C-11. Here the average living room temperature was above 21°C. There was some variation when looking at the bedroom average relative humidity. In this case, T-01 was also among the households with a high average relative humidity due to the low temperature in the bedroom and C-77 had a much higher average relative humidity for the same reason.

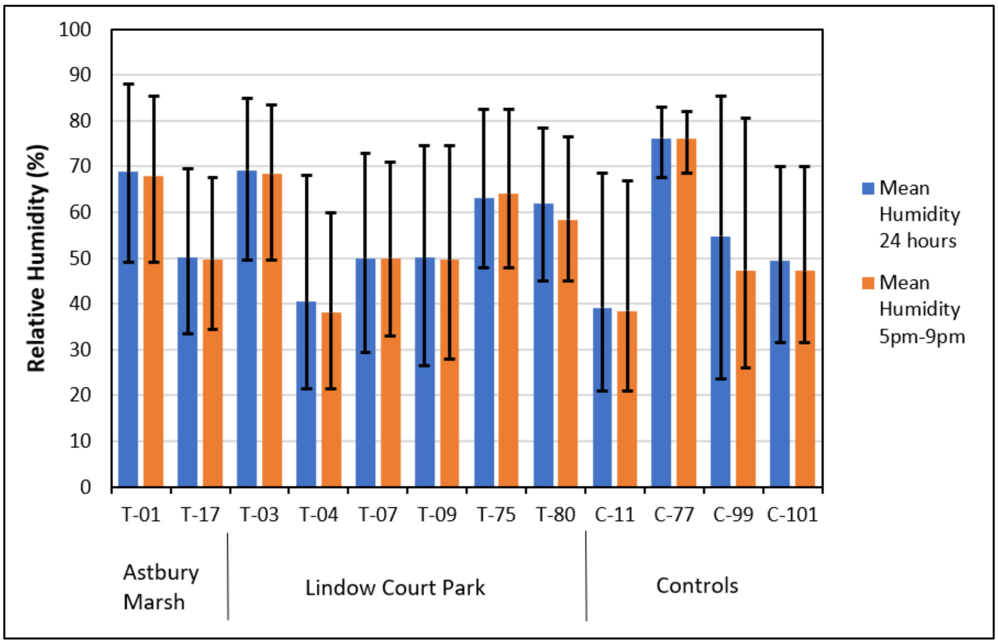


Figure 3.28 Average bedroom relative humidity for monitored park homes in the study
The error bars show the range between the maximum and minimum values for relative humidity
(Period 1st October 2017 to 15th March 2018; number of degree days over the period = 1523.7)

Comparing relative humidity before and after insulation

Household T-75 had the insulation installed in February 2017. Since the temperature loggers were fitted in August 2016, this allowed a comparison of the temperature and relative humidity to be made before and after the insulation was installed. The periods chosen were 1 October 2016 to 31 December 2016 (q4 2016) and 1 October 2017 to 31 December 2017 (q4 2017). The number of degree days for q4 2016 were 730.2 compared to 690.4 in q4 2017. This meant the pre-installation period in 2016 was colder than the post installation period a year later.

It can be seen in table 3.29 that there was negilible difference in the average living room relative humidity over the whole day between q4 2016 and q4 2017 with values of just under 60%. The minimum relative humidity was the same at 43.5% and there was a small decrease in maximum relative humidity from 74.5% to 73%. During the same periods, the average temperature of the living room increased from 18.76°C in q4 2016 to 19.98°C in q4 2017. The change in average temperature in the living room between the 2 periods was more significant than the change in average relative humidity.

T-75 - Living Room							
Period	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
1 Oct 16 to 31 Dec 16	59.63	74.5	43.5	5.24	59.95	74.5	48.5
1 Oct 17 to 31 Dec 17	59.95	73.0	43.5	6.32	60.75	73.0	46.5

Table 3.29 Living room temperatures for household T-75 before and after insulation of the park home
(Period 1st Oct 2016 to 31st Dec 2016, degree days = 730.2 1st Oct 2017 to 31st Dec 2017, degree days=690.4)

The average relative humidity in the bedroom increased from 64.51% to 66.15% between q4 2016 and q4 2017 (table 3.37). The average bedroom temperature increased from 17.67°C before insulation to 18.87°C after the park home was insulated. It is unusual for the humidity to increase when the temperature increases, which suggests household behaviour contributed to the increase in bedroom relative humidity between q4 2016 and q4 2017.

T-75 - Bedroom							
Period	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
1 Oct 16 to 31 Dec 16	64.51	82.5	50.5	6.00	64.65	82.5	51.5
1 Oct 17 to 31 Dec 17	66.15	82.5	48.5	7.87	66.7	82.5	50.0

Table 3.30 Bedroom temperatures for household T-75 before and after insulation of the park home
(Period 1st Oct 2016 to 31st Dec 2016, degree days = 730.2 1st Oct 2017 to 31st Dec 2017, degree days=690.4)

4. Conclusions and recommendations

4.1 Conclusions

- The project installed external wall insulation (EWI) and loft insulation top-ups for 11 park homes at 2 park home sites in Cheshire East district.
- The EWI technology installed was InstaClad and the insulation panels consisted of 40mm of grey expanded polystyrene bonded to 9mm boards of calcium silicate.
- 4 park homes were insulated at Astbury Marsh Caravan site which was owned by Cheshire East Council and was on the gas grid.
- 3 of the 4 park homes at Astbury Marsh also received gas boilers at the time of the insulation which were financed by another funding stream.
- The second site where 7 park homes were insulated was Lindow Court Park which was privately-owned and residents mainly heated their homes using LPG from 47kg bottles.
- A further 5 park homes at Lindow Court Park privately funded insulation with a top-up grant from Cheshire East Council.
- The monitored group for the evaluation included:
    - 4 households at Astbury Marsh
    - 7 households at Lindow Court Park which had insulation
    - 4 control properties at Lindow Court Park which did not receive insulation.

There was an improvement in resident satisfaction and comfort

- Following the installations, all the residents at Astbury Marsh and Lindow Court Park were very satisfied with how well their home kept in the heat. Prior to this, all households but 1 were either very dissatisfied or dissatisfied.
- All households were also very satisfied after the installation with how warm their home gets when it is cold outside.
- After having the InstaClad EWI, all households thought:
    - Their home was warmer and more comfortable
    - Their house kept in the heat better
    - There was an improvement to the quality of their home

Other benefits noted by some households included:

- A reduction in energy bills
- Improved sound proofing
- Improved appearance
- The home was stronger and more stable

Heating costs and savings were determined for the installations

- Park homes at Astbury Marsh had a pre-installation gas consumption of between 2.1 and 11.53kWh/degree day. This equated to an annual gas cost of between £231 and £1,269 using a standardised gas cost of 5p/kWh.
- Following the installations, the consumption was between 2.54 and 8.32kWh/degree day, with an annual cost of between £280 and £915.

- The savings for household T-05, the only one at Astbury Marsh with just EWI and loft insulation was 21% or £195 per year.
- Household T-13 was the largest park home in the study and had the highest gas consumption. There was a saving of 27.8% after a new gas boiler and insulation was installed. This meant a reduction in the annual gas cost of £353.
- Household T-17 at Astbury Marsh was under heating. After a new gas boiler and insulation were fitted, the gas consumption increased by 21%, resulting in the annual gas cost rising by £49. It is not possible to compare previous temperatures with those recorded during the study as no data is available, but questionnaire responses show a significant improvement in satisfaction across several categories with "how warm it gets when its cold outside" moving from 'dissatisfied' to 'very Satisfied'.
- It was only possible to measure LPG consumption of the insulated properties at Lindow Court Park after the installations. This meant it was not possible to calculate savings resulting from the installations.
- The lowest gas consumption among these properties was 1.97kWh/degree day for household T-03, with the lowest floor area in the study, which was a third the size of T-17. Using a standardised cost of 10p/kWh for LPG, the annual LPG cost was £433.
- The property at Lindow Court Park with the highest consumption was T-09, with a rate of 6.87kWh/degree day. This park home was the largest among those at received insulation site at the site. The annual LPG cost was £1,511 per year.
- In another NEA study where EWI was fitted on park homes, the consumption ranged from 2.02 to 6.15kWh/degree day for homes which were only insulated. Savings ranged from -9.7% to 39%.[31]

Performance line graphs showed properties which were over or under-heated

- Graphs of gas/LPG consumption (kWh) against number of degree days also known as Performance line graphs were plotted for many of the installations. These showed that households T-04, T-09 and T-13 were overheated. Likewise, that households T-03 and T-17 were under-heated, with the room temperature for T-17 not maintained at a consistent level.
- Performance line graphs of electricity consumption against number of degree days showed little or no temperature dependence, suggesting there was little use of electric supplementary heating – confirmed by the questionnaires.

Room temperatures were typically kept warm throughout the winter period

- Between 1 Oct 2017 and 15 Mar 2018, households T-01 and T-13 at Astbury Marsh maintained their living rooms at 16°C or above with averages of 21.35 and 22.1°C respectively.
- The living room for household T-17 was under-heated with an average temperature of 16.21°C, but the minimum temperature was as low as 4.5°C over the full 24 hours and 9°C between 5pm and 9pm.

[31] External wall insulation on park homes in North Lincolnshire, Elizabeth Lamming, Jamie Barnes, Paul Rogers and Michael Hamer (NEA, 2017), http://www.nea.org.uk/wp-content/uploads/2018/06/CP783-4-TIF-Report-FINAL-04062018-v5.pdf (Accessed 11 June 2018)

- At Lindow Court Park, the average living room temperature for households T-04, T-07 and T-09 were between 22 and 23°C. For T-03, T-75 and T-80, they were in the range 19.45°C to 20.41°C. The minimum living room temperatures for the full 24-hour period was between 9.5°C and 11.5°C for all the insulated properties at Lindow Court Park. Over the 5pm to 9pm period, minimum temperatures ranged from 14.5°C to 19°C.
- The average temperatures of the bedrooms for the insulated properties at Lindow Court Park ranged from 17.14°C to 22.49°C. The bedrooms were between 0.29 and 2.31°C cooler than the living rooms.
- At Astbury Marsh, the average bedroom temperature at household T-17 was 1.11°C warmer than the living room at 17.32°C. The bedroom radiator at T-01 was not operating and this led to an average recorded temperature of 9.82°C between 1 Oct 17 and 15 Mar 18.
- Household T-75 at Lindow Court Park had the insulation privately funded at a later date than others in the study. This allowed the temperature before and after the installation to be measured for the 4th quarters of 2016 and 2017. The average living room temperature increased from 18.76 to 19.98°C, while the average bedroom temperature increased from 17.67 to 18.87°C. There was also an increase in the minimum temperatures.

Living room relative humidity was in the normal range after insulation

- The average living room relative humidity was in the normal range of 40 to 60% for all the properties in the study during the period 1 Oct 2017 to 15 Mar 2018.
- The property with the highest average was T-03 at 58.3% which was under-heated, while household T-04 had the lowest average of 41.34% and was overheated.
- The low bedroom temperatures in household T-01 due to the radiator not working led to higher relative humidity. The average bedroom relative humidity was 68.9%, with a maximum relative humidity over the analysis period of 88%.
- The average bedroom relative humidity of 3 of the households at Lindow Court Park exceeded 60%. These properties all had average bedroom temperatures of less than 19°C. The highest average relative humidity of 69.18% was for household T-03 where the average bedroom temperature was 17.12°C.
- There was little change in average living room relative humidity for household T-75 after the park home was insulated. The average relative humidity was 59.63% during the 4th quarter of 2016 and this increased to 59.95% for the 4th quarter of 2017.
- The average bedroom relative humidity for household T-75 was above the optimum range at 64.51% before the park home was insulated and 66.15% after. The maximum relative humidity was 82.5% for both periods. These higher values may be due to a combination of average bedroom temperatures less than 19°C and household behaviour.

4.2 Recommendations for potential future installations

- EWI is particularly beneficial for park homes without access to mains gas as this will have greater impact on reducing heating costs and improving thermal comfort
- Older park homes benefit more from EWI as these had a poorer level of insulation at the time of manufacture. Other remedial work may be necessary to the structure to ensure it is strong enough for insulating panels to be fitted. However, a EWI retrofit can extend the life of a property with the installation having a 25-year guarantee.
- There has been limited uptake of EWI for park homes in mandated fuel poverty schemes such as ECO. Greater support is necessary for installation of EWI for park homes. A particular focus in any new scheme should be on homes that are off the gas grid, which would maximise the savings and reduction in fuel poverty.
- It proved difficult to persuade private owners of park home sites to allow promotion of the scheme offering free EWI to their residents. New engagement techniques, incentives or regulations may be necessary to encourage park home site owners to allow residents to access such schemes.
- To truly verify the impacts of you need an extended monitoring period prior to installation to collect primary data including energy consumption and temperature data. Where homes are off the gas grid and rely on LPG or oil, meters need to be fitted and readings recorded over the winter before the installations take place. Normally projects are based on a tight schedule and installations take place soon after households are identified which makes quantifying the true impacts more challenging.

4.3 Impact on fuel poverty

Fuel poverty statistics are not collected for residents in park homes. However, the 2011 census showed there to be almost 160,000 people living in about 84,000 mobile homes across 2,000 sites in the UK. A high proportion of residents are elderly and have disabilities and so require warm homes. Park homes, particularly older models, have poorly insulated walls, roofs and floors which tends to result in higher consumption requirements to maintain adequate warmth. They are also frequently located at sites which are off the gas grid and so residents rely on more expensive oil, LPG or electricity for heating.

In this study, benefits varied, with one household saving 21.1% on energy costs and another saving 27.8%. Clearly these savings can have a significant impact on fuel poverty status[32] reducing the energy need and therefore expenditure on energy.

32 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/719106/Fuel_Poverty_Statistics_Report_2018.pdf [Accessed 30/08/2018]

4.4 Performance comparison against manufacturer's/manufacturers' claims

InstaClad have noted savings after insulation for a park home with the following characteristics:

- 86m^2 floor area
- Built between 1983 and 1995 and no further modifications
- Supplied by mains gas
- Top up to the 100mm of existing loft insulation

The total annual gas bill saving was £326.40 with £184.37 coming from EWI, £77.59 from floor insulation and £64.44 from loft insulation[33].

Only properties at Astbury Marsh had consumption data available prior to insulation, which allowed a calculation of savings to be made. Out of these, 3 of the 4 also had a new boiler installed at the same time they were insulated which means there is a lack of comparable data to draw conclusions about the impact of InstaClad specifically. Only household T-05 had just InstaClad EWI and loft insulation. The savings measured for T-05 were £195.47, compared to £248.81 in the InstaClad leaflet (using just the savings for EWI and loft insulation).

Household T-05 had a floor area of 82m^2 and the age of the park home was over 50 years. This suggests the property was likely to have been less well insulated prior to the retrofit than the InstaClad example above. Greater savings might therefore have been expected than for the manufacturers claims. Some variation however, may be due to the households having differing occupancy and heating control settings before and after the retrofit. Also, different prices for gas were likely to have been used between the InstaClad and NEA households

Measure	Annual energy cost saving from NEA study	Annual energy cost saving claimed by manufacturer	Differential	Assumptions
InstaClad EWI + loft insulation	£195.47	£248.81	£53.34	• Savings claimed for EWI=£184.37 • Savings claimed for loft insulation = £64.44 • Saving for NEA study come from a single household, T-05

Table 4.1 Comparison of savings in the study with those claimed by the manufacturer

4.5 Economic business case for installation of measures

The cost of loft insulation for household T-05 was £693+VAT while the EWI was £6,937+VAT. Additional costs included £659 for remedial work to the park home prior to the installation and £888+VAT for fitting a handrail for the elderly resident.

Taking just the cost of the insulation and using VAT at 5% for a domestic installation gives a total installation cost of £8,011. The annual saving on the gas following installation was £195. This gives a payback period of 41 years (table 4.2) as a result of the energy savings.

It was not possible to record the preinstallation LPG consumption of properties at Lindow

[33] InstaClad Park Home System – Advanced solid wall insulation for park homes (2017) http://www.instagroup.co.uk/media/39744/parkhomes_02_2017.pdf (Accessed 6 August 2018)

Court Park. Assuming similar values of post installation consumption and percentage savings, the cost savings would be about double the values for households at Astbury Marsh. This would mean a reduction of the payback time to about 20 years due to the higher price of LPG.

It should be noted that there were additional benefits from the installation. These included an attractive new appearance to the home, extending the lifespan of the property, better sound insulation and providing a more solid, robust structure.

Measure	Cost of EWI installation	Cost of loft insulation	Total	Annual energy saving from study	Payback time	Assumptions
InstaClad EWI + loft insulation	£7,283	£728	£8,011	£195	41 yrs	• Private installation with VAT at 5% • Property on mains gas

Table 4.2 Summary of business case for EWI installation with a mains gas heated park home

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*
RT	*Room Thermostat*
SAP	*Standard Assessment Procedure (for assessing home energy efficiency)*
TIF	*Technological 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[34]. Over the years, the standard has been updated and the levels of insulation required have become higher.

BS Standard	U-value (W/m^2K) 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[35 36]

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.

[34] BS 3632:2015 Residential park homes specification, BSI https://shop.bsigroup.com/ProductDetail/?pid=000000000030253830 (Accessed 6 Jul 18)
[35] 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 6 July 2018)
[36] Actis Insulation Solutions http://www.insulation-actis.com/documentations/183pdf3.pdf (Accessed 14 July 2017)

Appendix 3: Case Study

Mr and Mrs H live in a park home and had contacted Cheshire East Council to enquire whether any funding was available to improve their home. This enabled the council to engage with the couple at a very early stage in relation to insulation and repairs available as part of the project. The couple's home has received InstaClad external wall insulation, loft insulation, underfloor insulation, a gas condensing combi boiler and remedial works to the structure to facilitate the insulation installations.

It was apparent during the first visit to the couple's home that they were struggling financially and not receiving the help they were entitled to. They were assisted to apply for a national insurance number for Mrs H as well as council tax support, housing benefit, carers allowance as well as corrections to their pension credit element and attendance allowance. Grants were also accessed which helped to fully replace the existing gas boiler which was deemed to be in a dangerous state of disrepair. The couple was also helped to switch energy providers
.

As a result of the engagement with the couple they are now £11,392 better off annually. This has been achieved through a combination of increased income and reduced outgoings. The greater spending power has resulted in a range of positive outcomes for the couple: ability to keep their home warm at a reasonable cost, reduced stress due to less worrying about being able to afford bills, improved wellbeing and health and better quality of life including interaction with grandchildren and other members of the family. The couple has also been spurred on to continue with further home improvements that they can now afford.

Mrs H can't express her gratitude enough for the opportunities that this insulation has given them as a couple. She regularly says that she feels like she has won the lottery as without the NEA TIF grant it is very unlikely that the Council would have been able to interact with the client to this level. The project has therefore produced another very important, although unintended, outcome – an improved relationship between Cheshire East Council and the residents on the site. It has improved residents' trust of the Council where they can see that they are able to provide help and put residents' interests first.

Appendix 4: Comments from households following installations

Household reference	Comments
T-01	Never seen workers like the installers, they were brilliant. Very respectful and thoughtful – everyone on the site said so. Home feels more solid and stronger – over the moon – first class. Will leave the heating on for the dog in cold weather.
T-03	Keeps thermostat on a minimum of 14°C all the time and up to 16°C during the day. Wasn't happy with installer who urinated in the garden. The insulation is very good and the home definitely warmer.
T-04	Turns the heating down during the summer. The home is quieter after the insulation. It is very good, much warmer and the home keeps the heat better.
T-07	Family member was ill and so heating was on higher. The appearance is better and there has been a reduction in noise.
T-09	The lads who did the installation were smashing. Still a bit of damp in the bedroom after the installation. The house does not rock as much in the wind now. Overall, it's brilliant.
T-13	Installers were fine when you were watching them. Warm – temperature used to be higher, but still felt cold.
T-17	Loads better, warmer. 2 windows need fixing, but am, waiting for better weather.
T-75	Only use heating when it is needed. The damp in the back bedroom has now gone. It all looks good. The porch has damp, but was not insulated, just painted. The installation was all fine.
T-80	The loft and underfloor were insulated in September 2017. Will turn down the heating only when going to bed. The damp has gone from the bedroom. It is less noisy and all looks good, but the finish is still a problem which has not been resolved.

Appendix 5: 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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