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Article

External Wall Insulation (EWI): Engaging Social Tenants in Energy Efficiency Retrofitting in the North East of England †

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Abstract: The question of how best to tackle the problem of energy inefficient older housing in the UK is considerable, and is further complicated by the question of tenure. Social landlords are working to update and improve their properties, which make up around 15% of the total UK housing stock (4 million properties). The success of such efficiency improvements depends in part on the cooperation of tenants, and their ability and willingness to engage with the process of change. This paper describes the experiences of eleven social housing tenant households whose properties were fitted with External Wall Insulation (EWI), based on pre- and post-installation interviews and data collection. It includes discussion of tenants' knowledge, attitudes, and expectations prior to and following installation; household thermal comfort and energy spending before installation; tenant experiences of having EWI installed; tenant perceptions regarding the effects of EWI on thermal comfort, energy spending, and housing attractiveness; impacts of EWI on internal temperatures and heat loss (measured via thermal imaging); energy bill comparisons. Households experienced an average saving of 33% on energy bills following EWI installation, and the majority of tenants reported benefits including improved thermal comfort and related positive impacts on health and wellbeing. The paper concludes by highlighting potential learning points for engaging tenants in the process of enhancing energy efficiency in UK social rented housing.

Keywords: sustainability; buildings; refurbishment; energy usage; external retrofit; social housing; behaviour change

1. Introduction

Reducing energy use and improving efficiency in the nation's housing stock is one of a number of measures that are necessary to help the UK to work towards its ambitious CO_2 reduction targets [1]. Such efforts are complicated by the existing poor energy efficiency of an ageing housing stock, much of which is likely to remain in use over the long term [2]. A range of measures may be taken to improve energy efficiency and reduce domestic energy demand, and there is a need for robust evidence identifying how effective such measures are, and how their effectiveness may be influenced by variables such as housing types, tenure, and the attributes of occupiers.

This paper describes a study which evaluated the performance of External Wall Insulation (EWI) on a small number of older residential properties offered for social rent in north east England.

It aimed to measure the effectiveness of EWI in improving energy efficiency across several different house types, all of which had been identified as being hard to heat. It also explored developments in occupants' attitudes, knowledge, and behaviours relating to climate change and energy use through the process of EWI installation, in order to identify the additional benefits that EWI may provide to social housing tenants. This was achieved through in-depth interviews with tenants both before and after EWI installation, and technical monitoring of properties undergoing EWI installation. Previous research into EWI has focused on its optimal technical specifications, energy saving performance, and cost-effectiveness, and this study's findings support this body of knowledge while providing an additional perspective on the tenant experience, pre- and post-EWI.

2. Literature Review

2.1. Carbon Reduction in the Housing Sector

The UK government is currently working to meet stringent CO_2 reduction targets, with an 80% reduction on 1990 levels required by 2050 [1]. Domestic energy use amounts to a significant proportion of energy consumption [3]: it has been estimated as accounting for over 40% of the UK's overall energy use, and is responsible for 25% of the country's CO_2 emissions [4]. This makes the housing sector an obvious focus for efforts to improve energy efficiency. Reducing domestic energy use, and therefore emissions, is a key part of the UK carbon reduction strategy.

A significant proportion of the UK's housing stock consists of older properties, with over 35% predating 1945. Much of this older housing is likely to remain in use for the foreseeable future, and may well be still standing in 2050, contributing substantially to high energy consumption and inefficiency in the housing sector [2]. While UK strategies to tackle domestic energy emissions have so far been largely directed towards new build properties, there is also a clear need to address energy inefficient older housing.

2.2. Energy Use in Existing Housing Stock

The average UK monthly household fuel bill in 2014 was £112 [5], although there may be significant variation in domestic energy use according to the size of the property, its level of insulation (which may be a result of building materials, housing design, additional insulation, glazing, or a combination of some or all of these), and the habits of its tenants. Banfill and Peacock [6] found a big difference in energy bills between identical homes, which suggests that the actions and behaviours of the occupiers are crucial in determining the amount of energy used.

Whilst the energy used to power domestic appliances, air conditioning, and lighting results in substantial CO_2 emissions [7], space heating accounts for the largest share, at around 60% of energy use in homes [1,8], making it by far the largest component of domestic energy bills. The amount of household energy consumed to heat homes is influenced by the behaviour and characteristics of occupants, as well as the type of heating controls; for instance, homes in which older people live tend to have higher consumption [9].

Keeping properties warm by reducing heat loss is a key way to boost energy efficiency in homes and thus minimise unnecessary energy use or energy waste. Heat can be lost through windows and doors, poor insulation, damp spots, leaking pipes, and decomposing structures. High conductivity and excessive heat loss associated with such hard-to-heat properties can cause or be linked to problems such as high fuel bills, increased carbon emissions, health problems for occupants, damp and mould growth on or in walls.

Saving money is not always the most important goal of energy saving, and residents may also be motivated to save energy by the desire to 'do the right thing', to set a good example to their children, or to have a more comfortable home [10]. Energy has been described as an invisible resource, and research has focused on the value of feedback as a means to positively influence occupier behaviour [11–13]. This feedback may come in a number of different forms, such as energy usage, energy bills, or levels of thermal comfort. There may be variation in how occupiers respond to feedback: for instance, an increase in internal temperatures due to improved energy efficiency may be seen as an opportunity to reduce heating demand, or simply to enjoy the resulting increase in comfort, described as the 'temperature take back factor' [14]. Housing improvements involving measures to improve thermal comfort can have a positive health impact on residents [15]. A recent study from Japan emphasized the importance of wider economic impacts of energy saving measures such as insulation, referred to as 'non-energy benefits'; these include health improvements and associated reductions in medical expenses and sickness leave from work [16]. In addition, studies by Chiu et al. [17], and Gilbertson et al. [18] have provided in-depth analysis of retrofitting on a large scale, and work by Love [19] has demonstrated the interaction between occupants' heating systems and fabrics [19]. This paper gives a snapshot of the effects of EWI in relation to hard-to-heat homes specific to the north of England, and incentives given by the green deal scheme.

2.3. External Wall Insulation (EWI)

Home insulation is one of the most important ways to maintain internal temperatures by preventing heat loss in colder climates, such as that of the UK.

Insulation of buildings has been proven to reduce the energy consumption needed for space heating [20], with the most effective insulation having the potential to save 46% of energy consumption and reduce CO_2 emissions by 41%, thus substantially mitigating the environmental impact of buildings [21]. Various types of insulation exist, including loft, cavity wall, and solid wall insulation; EWI is an example of the latter, where an additional layer of insulating material is added to the external walls of a building.

A number of studies have explored the cost-effectiveness of EWI by measuring the initial cost of installation against subsequent energy savings [22]; its financial and environmental benefits [23,24] have also been considered, as have the effectiveness of different types of materials for EWI [25], and optimal EWI thickness [23], both of which may vary from place to place according to local climate [26]. The Carbon Emissions Reduction Target (CERT) (2008–2012) and Community Energy Saving Programme (CESP) (2009–2012) programmes, which obliged energy suppliers to promote and install energy saving measures in homes across the UK, delivered 60,000 and 75,000 EWI installations during their respective periods of operation [27,28]. Insulation measures made up the majority of interventions in both programmes, with EWI accounting for 85.9% of CESP's insulation activity, and almost half of the total energy savings achieved [28]. A review of the CERT and CESP programmes described solid wall insulation as a growth area and identified the need for further research into its impacts and cost-effectiveness [29].

Home insulation has a convenience advantage for residents in that, once it is fitted, it requires minimum adaptation or maintenance and no behavioural changes in order for residents to experience its benefits. There are also no further costs after the initial, fairly modest outlay. This distinguishes it from more active forms of energy efficiency measure. For instance, microgeneration, such as solar PV panels and wind turbines, and other equipment such as energy efficient boilers are not only expensive to buy and fit, but may have highly specific operating instructions to achieve maximum efficiency. Insulation also carries minimal risk of malfunction or breakdown, and little opportunity for tampering (whether innocent or not).

2.4. Social Housing

According to the 2011 Census, 17% of UK residents (around 10.3 million people) live in social rented properties [30]. Social rented dwellings account for 5 million of the total 28 million strong UK housing stock, with Housing Associations owning around 2.75 million properties [31]. Housing Associations are potentially key contributors to carbon reduction targets, which presents them with significant challenges with regard to the management of their existing stock.

An important issue in retrofitting social housing is the disconnect between the initial investment and the potential savings to be made through enhancing energy efficiency, which is related to the amount of control householders have over the retrofitting process. Owner occupiers may be motivated to spend money on energy efficiency measures for several reasons, including the knowledge that this investment is likely to pay for itself in the long term, saving them money via reduced energy demand and lower bills, and potentially enhancing the value of their property. They may have carried out research before deciding to embark on the process, and are thus likely to be knowledgeable and willing to endure discomfort or difficulties, as well as to make any necessary behavioural changes in order to optimise their savings. The fact that they have actively chosen to commit to the process illustrates their level of engagement.

Tenants, meanwhile, are more passive; they have fewer decision-making powers and lack the autonomy to make such changes to their homes, so they are unlikely to choose energy saving measures. Their landlords make that choice for them, probably informing tenants of any changes that will affect them, but without seeking their approval or permission to carry out works. Tenants may not possess full knowledge and understanding of the process or support the need for it; they may resist it, resent the disruption it causes, merely lack interest, or be unwilling to make changes in order to ensure the retrofit is a success that will benefit them. They are not motivated by the desire for cost-effectiveness or the need to recoup any initial investment. However, it is possible that experiencing the benefits of energy saving passively, without having made a conscious decision to engage with it, may heighten tenants' interest and encourage them to pursue energy saving further. Attitudes towards energy saving retrofitting are likely to be linked to levels of control, engagement, and commitment, which could all be key factors in determining householders' perceptions and experiences, and, ultimately, successful energy saving.

3. Methodology

The research focused on the evaluation of a 2014 property improvement programme by two social housing providers in the north east of England, to jointly provide EWI to over 800 properties. The research aim was to evaluate the effectiveness of EWI in a sample of homes in terms of both tenant experience and property performance. Interviews were carried out with tenants prior to the start of the building works, and around 8–10 months after EWI had been fitted. Interviews covered environmental knowledge, attitudes and beliefs, everyday behaviours regarding energy use, energy consumption, and health and wellbeing, generating quantitative datasets and allowing further qualitative exploration of particular issues. Tenants were also asked to provide regular readings of their electricity and gas meters. An overview of the methodology is provided in Figure 1.

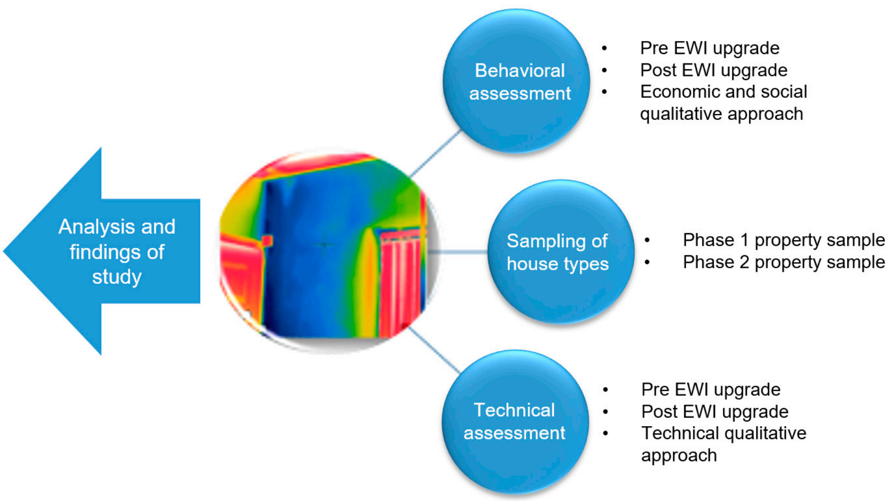

Figure 1. An overview of the methodology.

Property performance before and after EWI installation was assessed through temperature logging and thermal imaging using infrared thermography [32]. This allows automatic spot recognition of temperature gradients in walls, pinpointing where heat loss occurs and identifying areas of heat loss such as thermal bridges. Figure 2 illustrates the energy loss before and after EWI.

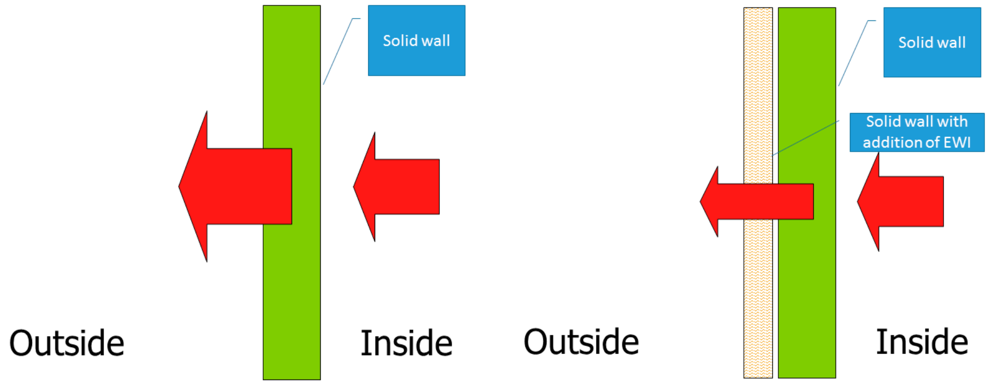

Figure 2. Illustration of heat loss from a building: inside to outside, before and after EWI.

The technology works on the principle that all objects above zero degrees Fahrenheit (about 273 °C) emit infrared radiation that cannot be seen by the human eye. An object coloured in red indicates heat loss or an inefficient building fabric, while a blue object indicates heat is retained. The gradient is the same whether the images are external or internal, although the interpretation is different, with, for instance, blue areas on external images showing effective heat insulation, while blue areas on internal shots indicate heat loss.

Sampling

The sampling process used in the research was dictated by the clients' wish to include illustrative examples of each specific property type that was targeted by the improvement programme, and also by the need to study properties that were at the appropriate development stage when the research began, namely immediately pre-installation. Fifteen properties were initially identified by the housing providers for inclusion in the research. The property types, all post World War II designs, were 2 and 3 bedroom Wimpey No Fines (both mid- and end-terrace and flat roof); Wimpey No Fines maisonette, 1 bedroom Wimpey No Fines bungalow; 3 bedroom Dorran; and 3 bedroom BSIF (British Steel Frame). Ultimately, only 11 properties were included in phase 1, (November 2015–December 2016) and 8 in phase 2 (January 2016–February 2016). This was due to a variety of factors including the timing of the works, changes to the programme of works which meant some properties included at phase 1 did not receive EWI, and difficulties contacting tenants at both phases.

Limited information was recorded about household size and respondents' economic status. In brief, of the 11 households participating at phase 1, six were families of one or two adults living with 1–3 children, three were couples, and two were adults living alone. Four respondents were retired and receiving pensions, one was a full-time carer, one was employed, and the others were economically inactive and in receipt of benefits.

A more detailed account of the methodology, including information about data recording and analyses, can be found in Lilley et al. (2016) [33].

4. Results

4.1. Knowledge, Attitudes, and Beliefs

Tenants' knowledge, attitudes, and beliefs relating to climate change and energy saving were tested before and after EWI installation. All tenants were aware of climate change, and most were concerned about its long-term effects at both phases, with effects such as extreme weather events being cited, and tenants demonstrating awareness of terms such as pollution, greenhouse gases, and the ozone layer. The majority of respondents exhibited awareness of actions that could be taken to ameliorate the effects of climate change, including reducing energy use, although two individuals said they thought nothing could be done to stop it. This was the same at each phase.

Tenants were asked whether they considered their own environmental impacts; at phase 1, five respondents said they did not think about this, while six said they did. By phase 2, only one said they did not think about their environmental impact. Asked whether they tried to reduce their environmental impact, the majority agreed they tried to do so at both phases, and the most frequently mentioned way they achieved this was by recycling.

4.2. Environmental Behaviours

Tenants were asked whether they performed a range of behaviours associated with energy saving either frequently, occasionally, or never. The majority of respondents reported that they did practise these behaviours either frequently or occasionally at both phases, with some exceptions. Around half said they never kept their thermostat at less than 20 °C or closed the curtains to keep the heat in, and slightly more than half never programmed their central heating or radiator controls to provide heat where and when it was needed. Further exploration revealed that common behaviours included switching the heating on and off as it was needed, setting thermostats high to ensure the heating came on, and using thermostats to control the heating, with tenants exhibiting detailed knowledge as to how their particular heating systems worked and needed to be used to heat their homes satisfactorily. Most tenants used more than one method of heating control simultaneously at both phases.

At phase 2, there was an increase in the proportion of respondents who said they only heated their home when it was occupied, used energy saving lightbulbs, turned off unnecessary lights and appliances, and boiled only the amount of water they needed in the kettle. Conversely, respondents were less likely to put on warm clothing rather than turn the heating up when they were cold at phase 2.

Asked what factors were most important to them when buying large electrical appliances, only two tenants mentioned efficiency at phase 1, with cost being the most common answer, cited by five people. By phase 2, six people considered efficiency to be one of the most important factors.

4.3. Energy Spending and Saving

Tenants were asked if they thought the amount that they spent on their energy bills was low or high. At phase 1, five tenants thought that the amount they were spending on energy was high or very high. At phase 2, just three thought the amount they spent was high, and none thought it was very high, see Table 1.

At phase 1, around half of tenants said they thought they could reduce the amount of energy they used if they had access to more information about this (with some reporting that they already did this by checking the meter and monthly bills, and found it to be successful in minimising energy spending), while the rest thought that they could not use any less, whether this was because they were already using as little as possible, or because they felt they could not do so without compromising their own health and comfort. By phase 2, following EWI installation and the resulting reduction in energy bills, seven out of eight tenants thought that they would not be able to further reduce their energy use.

Tenants' motivations for household energy saving were explored. Saving money was considered to be a slightly more important motivator than saving the environment for tenants at both phases, although the majority of respondents agreed that both reasons were important.

All tenants who provided information reported that their energy bills had fallen since EWI installation, with reductions ranging from 16 to 56%. The mean reduction was around one-third, at just under 33%. Tenants said that they had noticed saving money since EWI installation.

Table 1. Energy spending by household pre- and post-retrofit.

Property	Energy Spending in Phase 1, Pre-Retrofit *	Energy Spending in Phase 2, Post-Retrofit *	% Change
1	£115	£80	−30%
2	£92.50	£41	−56%
3	£60	£45	−25%
4	£153	£84	−45%
5	£120	£100	−16%
6	£117	£92	−21%
7	£80	£50	−37%

Note: * = Combined gas and electric costs per month.

4.4. Thermal Comfort

Tenants were asked if they were satisfied with the level of warmth in their homes. At phase 1, almost half of respondents said that they were, although in some cases this came at the price of high heating use:

"The heating is on constantly though".

"It is comfortable when the heating is on all of the time".

Just over half of respondents said that their homes were too cold. Tenants were asked to rate their homes according to the level of warmth on a scale of 1–10, with 1 being the coldest and 10 being the warmest. During phase 1, tenants' average warmth rating was 5.1, with several respondents stating that at least some part of their homes felt uncomfortably cold.

Following EWI installation, all but one of the respondents said that they were happy with the level of warmth in their homes. Tenants' average rating of the warmth of their homes had risen from 5.1 to 7.

Only one tenant said they did not find their home warmer as a result of EWI installation. This was in a household where the heating was used very minimally at both phases in order to keep energy costs down. Asked at phase 2 if they thought EWI had influenced the level of warmth of their home, the respondent replied, "*No, it hasn't had any effect, can't feel a difference*". This indicates that while EWI may be effective at retaining heat generated in the home by conventional means, it does not in itself create warmth. This idea is further supported by other tenants' comments at phase 2 that their homes stayed warmer for longer once heated: "*(the house) holds heat longer after the heating is off, we don't have the heating on as often*".

4.5. Other Problems Relating to Cold Homes

Tenants were asked to indicate what, if anything, they felt needed to be done to make their home a better place to live. At phase 1, the main response types concerned addressing cold, damp and draughts, and the need for better insulation. Each of these was mentioned by at least three householders. At phase 2, none of the tenants referred to problems relating to cold, damp or the need for insulation. Draughts were mentioned by several respondents but this was in reference to windows and doors only.

4.6. Other Outcomes

At phase 1, only four respondents said they were happy with the appearance of their homes; by phase 2, all tenants said that they were happy with their home's appearance. Asked if the EWI had any effect on the appearance of their and other homes in the area, all tenants responded positively to this question, with typical comments stating that the houses looked "*much better*", "*nicer*" and "*clean and tidy*".

At phase 2, seven out of eight tenants said that they thought the EWI installation had a positive effect on their health and wellbeing. This was strongly related to the increase in warmth, which made people feel happier and more comfortable, and reduced the impact of arthritis for two tenants.

One individual described feeling less anxious because of spending less on heating their home: *"It does ease the thought of paying a lot and I am not frightened of putting the heating on"*.

Another respondent said they felt better because of the change in the appearance of the local area: *"It is more cheerful looking at the houses, in the summer it shines"*.

4.7. Evaluating the EWI Experience

Respondents were asked what they felt was the best and worst thing about having EWI installed. The main positive outcome for tenants was having a warmer home. Rooms or areas of their homes that were previously hard to heat were no longer as cold, and their homes retained heat for longer, which meant that they needed to use the heating less often. In addition, three people referred to the improved appearance of their home, and one cited the insulating effect against noise which meant their home was quieter than before. No one explicitly mentioned savings on energy bills.

Only two tenants identified any negative aspects of EWI, and this took the form of concerns about a potential problem, rather than an actual one. Their concerns were that the newly finished EWI might start to look dirty as time passed, and that it may be easily damaged through every day wear and tear. Both tenants discussed potential solutions, but also said they were not sure how best to care for the walls or whether there were any steps they could take to ensure their appearance remained attractive.

5. Discussion

The findings indicate clear benefits for occupants of homes with EWI, with tenants reporting that their energy bills had reduced by an average of one-third following EWI installation. This fits with previous findings on EWI [22–24]. The difference in the amount of energy savings made by different households is of interest. While one household's bills were reduced by more than half following EWI installation, another reported a saving of just 16%. While all energy savings are of benefit and therefore worth pursuing, it may be instructive to investigate differences in savings more fully, to find out what factors are influencing energy use in different households. For instance, factors such as house type, household size, and 'temperature take back' [14] may play a role. In addition, further research focusing on changes in the ways heating controls are managed by householders before and after EWI installation, and how this impacts on internal temperatures, may provide some answers.

Most respondents reported that their homes felt warmer with EWI and did not lose heat as quickly as before. Most also reported improvements to their health and wellbeing, which was linked to increased warmth in their homes. Again, this reinforces previous findings on positive health effects arising from energy saving measures [15,16]. In homes that were previously considered hard to heat and where some occupants reported that they felt they were never warm enough, tenants considered this improvement in thermal comfort to be more significant than money saving; improvement in thermal comfort was in fact identified as the best thing about EWI, indicating that concerns about quality of life and day-to-day comfort can take precedence over financial savings, even for low-income households. This underlines previous findings that incentives to save energy may not necessarily be financial [10], which may be a learning point with regard to promoting domestic adoption of energy efficiency measures. Although the respondents were not asked to provide any information about their household income, information provided about economic status suggests that none of them were wealthy enough for money saving to be unimportant to them.

Some attitudinal and behaviour changes consistent with heightened environmental awareness and the desire to improve energy efficiency were observed at phase 2. Caution must be exercised because of the small sample size and reliance on self-report, but these findings suggest that tenants were more mindful of energy use following EWI installation, and that their levels of control, engagement, and commitment towards energy saving had increased. This is tempered by the finding that most tenants felt they would be unable to reduce their energy spending any further by phase 2. One behaviour that became less prevalent at phase 2 was putting on warmer clothing instead of turning the heating up when cold; this may be explained by the fact that the homes were now warmer and tenants were less likely to feel cold.

EWI requires little in the way of active behavioural adjustments on the part of householders once it has been fitted (i.e., it is not a technology that requires new controls or training by the user). As well as reducing heat loss and therefore enabling energy saving, it can also lead to additional benefits such as improved property appearance and enhanced soundproofing. These factors may make it particularly well suited to retrofitting social housing, as it brings a range of benefits and does not require extensive 'buy-in' in the form of strongly pro-environmental attitudes and willingness to adapt behaviours among housing occupants, unlike other measures such as renewable technologies. Its relative simplicity means it is less likely to require education or training for users, to break down, or to fail to achieve optimal performance. However, the findings indicate that there may be some value in providing basic information about how to care for EWI to maintain its appearance.

This intervention does not deal with issues of heat loss or the need for effective heating controls, which requires further investigation. This is in line with work by Shipworth et al. [34] that suggests that households with central heating system controls do not have lower demand temperatures or durations compared to households that do not use controls.

The findings suggest that tenants' level of engagement with energy saving may have been heightened over the course of the study. Tenants experiencing the benefits of EWI may be encouraged to adopt other energy saving behaviours. Having EWI fitted to their homes provides householders with simple evidence that actions taken around the home can lead to positive benefits and enhanced quality of life. Even if residents previously had low levels of environmental knowledge and awareness, experiencing tangible and desirable outcomes such as a warmer home and smaller bills may lead them to seek out further energy efficiency actions and measures.

Research Limitations

This was a small-scale, short-term study that studied the effects of EWI on a small number of households. Future similar research incorporating more households and a wider range of property types, over a longer time period, could usefully add to the knowledge base.

Reliance on self-reported data, obtained through interviews with tenants, is potentially problematic when attempting to track behavioural changes; people may not always behave as they say they do. Similarly, individual perceptions of factors such as temperature may be inaccurate. Previous research has revealed a potential disconnect between heating control settings and actual internal temperatures [34], suggesting that more accurate data would have arisen from monitoring internal temperatures in each property before and after retrofitting. A research design similar to the one used to evaluate the effects of the UK Warm Front scheme to improve energy efficiency in homes, which used both residents' self-reported thermal comfort and twice-daily indoor temperature monitoring, may have been preferable [35].

Seasonal differences in temperature and the resulting variation in heating requirements may have influenced the findings. To satisfy the clients' needs, the study took less than a year to complete and did not fully incorporate the coldest time of year. The weather was unusually mild during the study period, which may have influenced tenants' heating demand and levels of thermal comfort (see Figure 3).

Although the reduction in energy bills of 33% following the fitting of EWI indicates a significant benefit for tenants, recent bills at phase 1 would have covered the colder winter months, while at phase 2, the recent summer months may have reduced heating requirements.

Thermal imaging is limited as a data-gathering tool, as it only identifies spots within the building envelope which are more susceptible to heat loss. It gives an instant reading which can be used for further investigation of issues relating to heat loss, but it tells little about, for instance, changes in heat loss over time. Infrared thermography linked with internal monitoring devices would be a more comprehensive data collection strategy for gathering data over a longer time period.

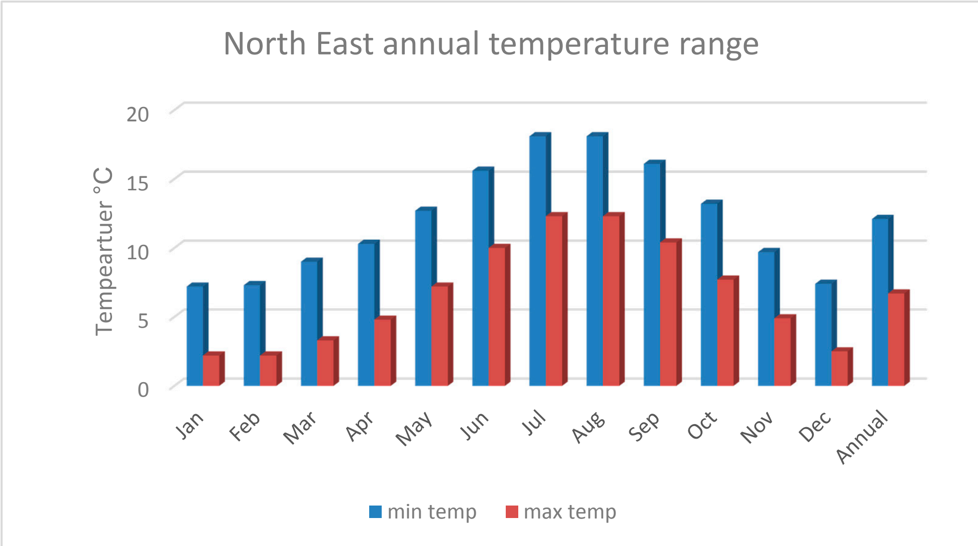

Figure 3. North east England temperatures (2014) and average temperature for Gateshead (2000–2012), data from [36,37].

6. Conclusions

This study tested a small number of property types both before and after External Wall Insulation (EWI) was fitted. The results indicate clear benefits for the occupants, with tenants reporting that their energy bills were reduced by an average of one-third (a range of 16–56%) following EWI installation. All but one reported that their homes felt warmer and did not lose heat as quickly as before, and the same number reported improvements in their health and wellbeing as a result. Other positive outcomes reported by tenants included improved external appearance of their homes and reductions in external noise. No negative outcomes were reported although concern was expressed that the appearance of EWI may deteriorate over time. Potential limitations were identified relating to the small sample size of the current study, the need to monitor the properties over a longer time period to amass a larger body of evidence, and the use of more comprehensive data-gathering strategies.

The findings have potential implications regarding EWI's suitability as an energy saving measure, notably as a relatively passive form of retrofitting which does not require extensive occupier buy-in or behaviour change in order to reap the benefits. This may make it particularly appropriate for use in social housing, where tenants' specific status means they are likely to have low levels of ownership of the retrofit process, and may consequently lack engagement or interest in maximising energy efficiency. This is supported by several studies on pro-environmental attitude or lack of it, such as the theory of planned behavior described by Huebner et al. [38]. With regard to promoting the uptake of energy saving measures, it may be significant that improvements in quality of life and comfort were considered more important than money saving, even for low-income households. Finally, some of the findings suggested that improvements such as EWI may lead to increased interest in adopting energy saving measures on the householder's part.

Further research is recommended in order to find out if the results are replicable on a larger scale and to explore causal relationships regarding the differences in energy savings between different house types and households.

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Conflicts of Interest: The authors declare no conflict of interest.

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