ERDF Social Housing Energy Management Project: Pre-Works Report

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1 Executive Summary

This is the Pre-Works report for the Social Housing Energy Management project, as funded by the European Regional Development Fund (ERDF). This project is based around insulating hard to treat prefabricated homes which are used for social housing, and monitoring in depth before and after to understand the levels of improvements created. The project also supports Small to Medium Enterprises (SMEs) in the North East of England, although this Pre-Works report focuses on the energy efficiency measures.

North East England has the second highest levels of fuel poverty in England [1]. As a result, the National Renewable Energy Centre (Narec) formed a project consortium with South Tyneside Homes and Homes for Northumberland to undertake thermal energy efficiency improvements in almost 400 socially rented hard-to-treat (off-gas or non-traditional construction) properties. The consortium has received £1.9m investment from the European Regional Development Fund (ERDF).

The detailed analysis of pre and post work data of buildings will, allow the fuel poverty and financial improvements for residents to be quantified. This Pre-Works report details the work carried out in assessing, testing and monitoring the buildings prior to any improvement being carried out. As the building work is completed, further monitoring and analysis will take place resulting in the post-works report due in summer 2013.

The measures carried out, and buildings used are shown in Table 1:

Partner	Properties	Technologies
South Tyneside Homes	132 dwellings in total in 3 high-rise blocks of flats in Jarrow, Tyne & Wear	• Solid wall insulation • Replacement glazing • Lighting • Replacement central boiler • Connection of Elson Tanks to district heating system • TRVs in flats
South Tyneside Homes	136 Tarran Newland Houses in Marsden, South Shields	• Photovoltaics • Replacement glazing • Solid wall insulation • Lighting • High efficiency boilers
Homes for Northumberland	53 houses in Blyth, Northumberland	• Solid wall insulation • Lighting • Secondary heat exchange • Voltage optimisers

Table 1: Summary of works

All residents were given a questionnaire about their use of heating and comfort levels. 10% of the properties were monitored using temperature data loggers, and the residents of these properties filled in more detailed questionnaires on their energy usage.

Thermal imaging of the properties was carried out in December 2011 to see where heat was escaping from the homes. Air pressure tests were done to see how leaky the houses were during summer 2011.

Results from these tests and tenant questionnaires showed various issues with the buildings:

- Gaps around windows measuring several millimetres
- Incredibly high air change rates making some buildings impossible to heat with the present heating systems
- Thermal bridging
- Thermal loss from perpetually open vents on high rise flats

Thermal modelling of the buildings was carried out using Integrated Environmental Solutions <Virtual Environment>.

The test data and models are provided in chapters 14 and 15 of this full report.

The major findings of the project to date are:

- Fuel poverty is a major problem amongst the residents of homes in South Tyneside Homes and Homes for Northumberland
- The air change rates are up to 19.26 $m^3(h\ m^2)$ @50pa, which is twice that allowed under the 2010 Part L building regulations, and ~7 times that allowed for new build social housing in the UK under the Code for Sustainable Homes
- Approximately half of residents are dissatisfied with the heating systems in their homes
- According to the questionnaires, ~70% of residents turn off their heating systems to save money
- The worst case of fuel poverty in this project showed properties where residents (if they heated their home adequately) would spend 25% of their income on energy bills.
- One fifth of the Tarren Newlands residents, if they heated their homes adequately, would spend over one fifth of their income on energy bills.
- Some residents have heating bills per year of £2,500 – suggesting approximately 90MWh of heat, six times the amount that should be required for their property type.

In the post-works report, these findings will be compared with data taken after the building work has been completed to understand the improvements in thermal performance.

2 Introduction

North East England has the second highest levels of fuel poverty in England [1]. As a result, the UK's National Renewable Energy Centre (Narec) has formed a project consortium with South Tyneside Homes and Homes for Northumberland to undertake thermal energy efficiency improvements in almost 400 socially rented properties.

The Social Housing Energy Management Project, funded by the European Regional Development Agency (ERDF), is a collaborative project to improve and analyse post war prefabricated social housing through a range of measures, whilst also assisting Small to Medium Enterprises (SMEs). This document concentrates on the fuel poverty alleviation parts of the project. The properties included in the project are Tarran Newlands, Wimpey No-Fines high rise blocks, and Wimpey No-Fines houses.

This document is the Pre-Works report. It will cover the state of fuel poverty in the UK and the current trends, before covering the detailed work carried out in assessing, testing and monitoring the buildings prior to any improvements being carried out.

The European Regional Development Fund exists to reduce economic disparities within and between member states by supporting economic regeneration and safeguarding jobs. Since 2000, England alone has benefited from more than €5bn of funding, with a further €3.2 billion being invested between 2007 and 2013 in local projects around the country [2].

3 The Current State of Fuel Poverty

According to the Warm Homes and Energy Conservation Act 2000, fuel poverty is defined as:

"a person is to be regarded as living "in fuel poverty" if he is a member of a household living on a lower income in a home which cannot be kept warm at reasonable cost." [3]

Clearly, to statistically measure this across the UK is a complex task, and an analytical definition needs to be created. The original statistical definition used for Fuel Poverty in the UK was when 10% or more of a household's income would need to be spent to raise the temperature of a dwelling to a comfortable and safe level. It is important to note it is not based on the actual energy used by a resident to heat their dwelling, as clearly those in poverty will not heat their home as much as is necessary, simply because it is too expensive. With the publication of the Hills Report into fuel poverty in 2012, a new definition is now being used. This defines fuel poverty as when a household's **required** fuel costs are above the median level; and if they were to spend what is required, then the household would be left with a residual income below the official poverty line. Additionally, a Fuel Poverty Indicator has been created, which shows how far into fuel poverty households are, not simply if they are in poverty or not. Finally, the Hills Report recommends that the number of individuals, not just households, in fuel poverty should be considered.

No statistical method can be considered totally accurate; they are purely models to understand reality. Where possible this report will consider using the Hills definition of fuel poverty, but as most historical data uses the 10% definition, we will also use the original. It is important to remember these are simply two different ways of looking at the same problem.

Using the two different methodologies gives quite different views. Using the original definition, it looks that fuel poverty has dramatically increased from 2004 to 2009. Alternatively, using the Hills methodology, it shows that the numbers of dwellings in fuel poverty is roughly constant, but those households already in fuel poverty are sinking further into fuel poverty. To put it simply, it shows that the poor are getting poorer [4].

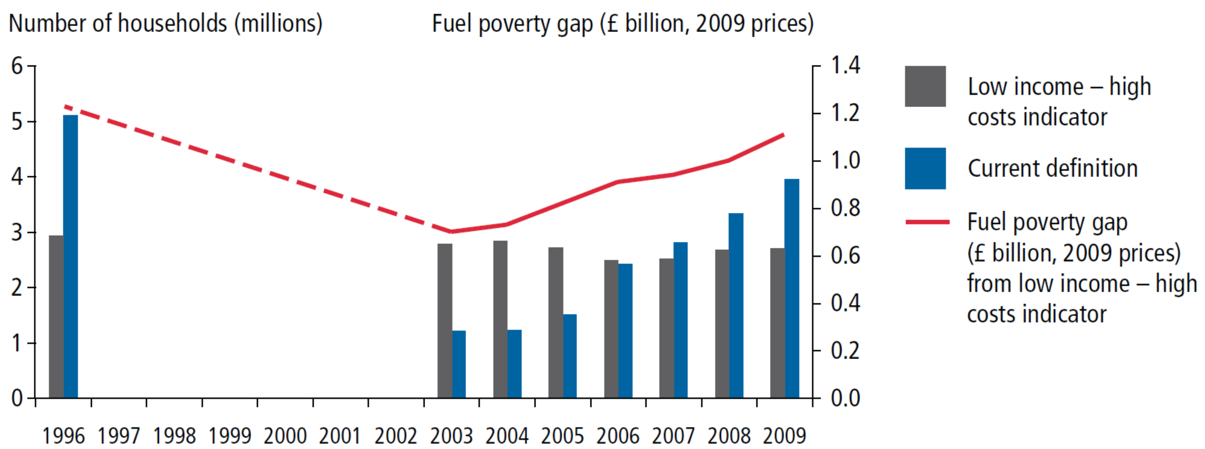

Figure 1: historic fuel poverty in the UK [4]

An important way to measure the impacts of fuel poverty is to consider excess winter deaths. In common with other countries, more people die in England and Wales in the winter than in the summer. These are referred to as Excess Winter Deaths (EWD). The standard method to calculate this is to compare the number of deaths in a winter period (defined as December to March) and compare this with the average number of deaths occurring in the preceding August to November and the following April to July [5].

There were 25,400 excess winter deaths in England and Wales in 2009/2010 and 2,760 excess winter deaths in Scotland in 2009/2010. An important question to ask from these statistics are is how many of these are related to fuel poverty. Additionally, there is evidence fuel poverty can negatively impact on residents mental health, and clearly result in a poor quality of life [6].

Within the private rental housing stock, half of the housing stock provided by private landlords doesn't meet official building regulation standards. Tenants find it difficult to complain about their conditions because their landlords can easily evict them [6]. Social housing from Housing Associations suffers a range of problems. One major issue is the level of substandard housing inherited by housing associations from local authorities, such as the thousands of post war prefabs. Often, the higher quality housing has been bought up through the right-to-buy scheme and has not been replaced, leaving a smaller number of suitable housing properties for those most in need [7].

These issues, compounded by rising fuel costs, unemployment, welfare reform and the increasing cost of living leaves households in a position where they can no longer afford to warm their homes to an adequate level.

It is very important to stress that some families who are living in poverty are not necessarily living in fuel poverty. This could be, for example, a situation where people are living in highly efficient social housing so have very low fuel bills. Therefore it is important to understand that although fuel poverty is related to poverty, it is not the same thing.

3.1 Fuel Bills in the UK

One major factor in fuel poverty is clearly the size of fuel bills. These are currently increasing for several reasons, primarily due to the cost of wholesale gas. A detailed breakdown of cost increases is given in the report "Household energy bills – impacts of meeting carbon budgets" by the UK Government's committee on Climate Change, the bill increases were split up as follows from 2004 to 2010 [8].

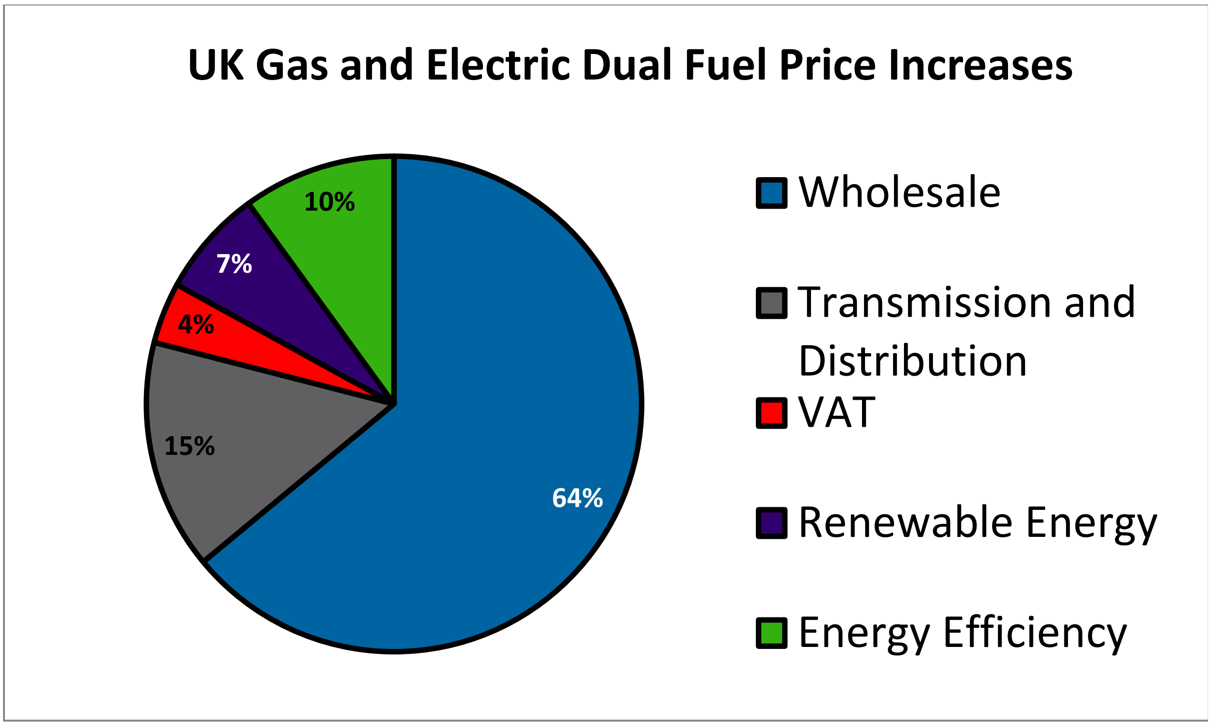

Figure 2: UK dual fuel price increases 2004-2010 [8]

Current bills are set out as follows:

	Electricity	Gas
Wholesale	59%	65%
Transmission, distribution and metering	22%	26%
Renewables/low carbon	14%	4%
VAT	5%	5%

Table 2: Fuel cost makeup in the UK [8]

It is important to stress that money funding low carbon measures, such as Carbon Emissions Reduction Target (CERT), is being used to insulate homes, and thus though the low carbon measures have slightly increased bills, this money is being used to lift the most vulnerable out of fuel poverty.

It seems likely that fuel bills will continue to increase with the wholesale price of fossil fuels, which are showing a general long term increasing trend. This is a major concern for fossil fuel users, and although greater dependence on renewable energy will protect the UK somewhat from these increases, the UK only expects to have 30% of electricity from renewables by 2020 [9] . The gas grid will be mainly natural gas, unless there is a considerable increase in the production of gas through methods such as anaerobic digestion. Currently this is limited to a few brewery waste and sewage schemes, so there is considerable growth potential.

3.2 Tariff Problems

Those most at risk of fuel poverty tend to pay more for their electricity and gas due to the large amount of pre-payment meters. This is the most expensive way to buy electricity and gas in the UK compared to the option of using direct debit. For example, an annual dual fuel bill for a customer with average consumption would be £1,176 per year for electricity and gas via direct debit, compared against a customer with a pre-payment meter who would pay £1,255. This means an average customer with pre-payment meters pays around £80 extra for their electricity and gas every year [10].

The use of pre-payment meters is increasing. In 2004 a large proportion of pre-payment meter installations were on a voluntary basis but over time there has been a significant increase in the proportion installed to collect debts. In the second quarter of 2011 around 53,000 electricity pre-payment meters and around 52,000 gas pre-payment meters were installed. Of these, around 90% of electricity and 87% of gas pre-payment meters were installed to collect debt. This contrasts with 2004 where only 44% of electricity and 50% of gas pre-payment meters were installed to collect debt [10].

3.3 Physical Health and Fatalities

Ultimately, whatever methods are used to count those in fuel poverty, the simple and somewhat brutal way to measure the effects are to look at excess winter deaths. This, clearly, is fraught with issues. It is hard to understand if people have died because of fuel poverty, or other issues associated with the cold weather. The Hills report suggests that 10% of excess winter deaths are due to fuel poverty [11], which against current research seems a perfectly reasonable assumption, though this is one issue which does need to be looked into in more detail.

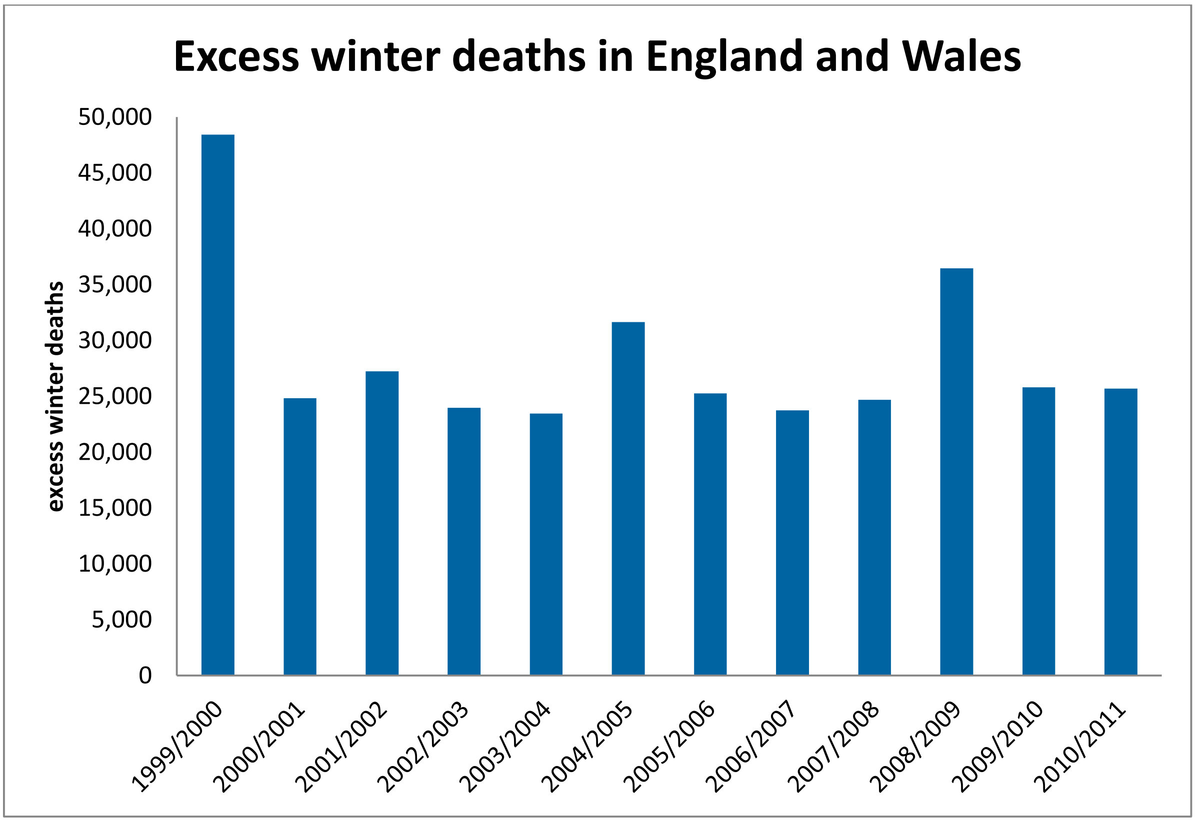

Figure 3: Excess winter deaths in England and Wales, graph created using data from [12]

Of the medical issues that cold temperatures can either cause or exacerbate, the most serious conditions are cardiovascular and respiratory illnesses. The temperature ranges for these issues are

[13]:

- *16°C – respiratory problems*
- *12°C – circulatory problems*
- *5-6°C – risk of hyperthermia*

According to Macmillan Cancer support, 85% of health professionals who took part in a survey believe that feeling cold can affect a patient's recovery. The same survey showed that 77% of professionals have seen evidence of patients suffering from pain, for example neuropathic pain, triggered or worsened by feeling cold [14].

Additionally, lower temperatures will lead to a loss of dexterity from cold induced muscle seizures, leading to more accidents such as trips and falls. Cold indoor temperatures also increase pain for those suffering from arthritis [15].

The interaction of low temperatures and high humidity can lead to the growth of mould and dust mites, which can lead to or exacerbate respiratory illnesses such as asthma [16]. Mould growth, in poorly warmed homes, can be a major problem for children. Figure 4 shows respiratory illness does have an increased prevalence amongst the fuel poor [17] [18].

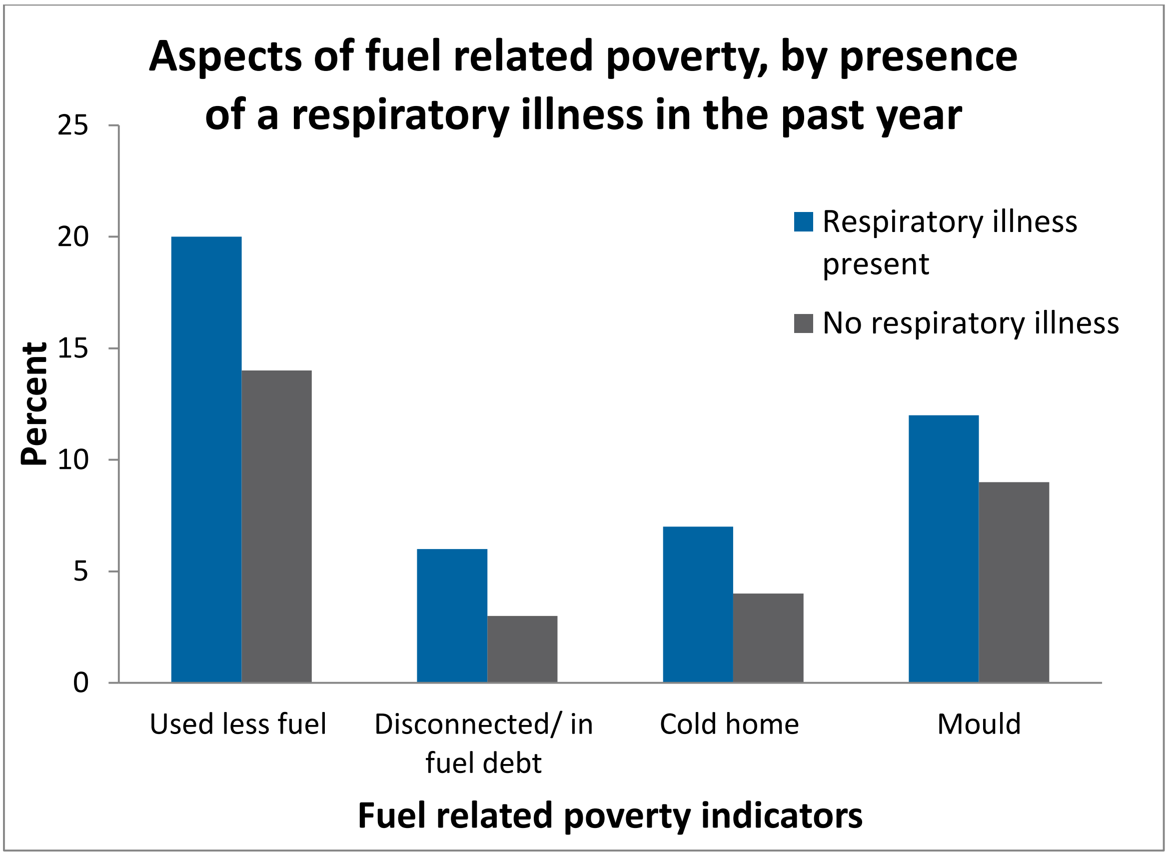

Figure 4: Fuel poverty and respiratory illness [17]

According to the British Medical Association, the following applied to Excess Winter Deaths (EWD): [19]:

- Countries which have more energy efficient housing have lower EWDs.
- There is a relationship between EWDs and low SAP rating/low indoor temperature.
- EWDs are almost three times higher in the coldest quarter of housing than in the warmest.
- 21.5% of all EWDs are attributable to the coldest quarter of housing, because of it being colder than other housing.
- Around 40% of EWDs are attributable to cardio-vascular diseases.
- Around 33% of EWDs are attributable to respiratory diseases.

There is a clear relation between the age of buildings, and the levels of fuel poverty deaths. This is suggestive of a bias being created through fuel poverty, as the best insulated homes have the lowest excess winter deaths. This has been shown for example by Wilkinson and associates, who analysed 80,331 deaths from cardiovascular disease in England between 1986 and 1996. The results are given in Table 3 [20].

Property age	Excess winter deaths compared with total annual deaths
Pre1850	28.0%
1850–99	25.6%
1900–18	24.1%
1919–44	26.0%
1945–64	23.9%
1965–80	17.1%
Post1980	15.0%

Table 3: Excess winter deaths per building type in England and Wales [20]

3.4 Psychological Issues

In addition to the physical illnesses caused by fuel poverty there are also psychological effects. Issues which have been shown to have a high prevalence amongst the fuel poor include:

- Depression
- Bipolar
- Anxiety

Various studies have been conducted which have found positive mental health impacts as the result of fuel poverty alleviation measures. A study using GHQ12 scores showed that those with anxiety or depression reduced from 300 per 1000 to 150 per 1000. This is a significant impact. [21] According to work by Macmillan Cancer Support, 92% of social care professionals believe there is a link between feeling cold and mental wellbeing [14].

3.5 Costs to the NHS

All of the above leads to a major cost on the National Health Service (NHS). Overall, according to the Chief Medical Officer, illnesses caused by cold homes cost the NHS more than £850 million a year [22].

3.6 Effects on Children

Fuel poverty can have major effects on children. A good introductory text on this is "The Impact of Fuel Poverty on Children" policy briefing written by Professor Christine Liddell [23]. This looked into peer reviewed research globally on the effects of fuel poverty on children.

For example, a study in the US compared two groups of low income children in five different cities. Group 1 lived in families which were receiving a winter fuel subsidy, and group 2 were not. It was found that infants in homes without subsidy were 40% more likely to be admitted to hospital or primary care clinics in their first three years. They were also more likely to be underweight. The reasons for this would be that as with any human being, infants stay warm by burning calories. Thus when they are cold they have fewer calories available for other bodily functions such as growing or building a healthy immune system. Additionally, the paediatricians involved in the US study speculated that there are risks to children's cognitive development from years of being underweight.

3.7 Disabled

The increase in fuel poverty amongst the disabled has been somewhat dramatic as of late, in 2003, 2.7% of households containing a disabled person were in fuel poverty, by 2010 that had increased to 6% [24]. Additionally, living costs for disabled and ill people is higher than the UK average, according to the Joseph Rowntree Foundation report "Disabled people's costs of living: More than you would think" there are higher costs in food, clothing, household maintenance, fuel and power, household goods and services, transport, communications, recreation/culture, education, health, personal care, insurance and special occasions [25]. This puts disabled people at risk of fuel poverty.

As specified in section 3.3, low temperatures can have major health impacts, which the disabled are more vulnerable to due to reduced activity.

3.8 Elderly

In 2010, according to Department of Energy and Climate Change figures, 38% of households where the youngest member was over 60 were in fuel poverty, looking at households where the youngest member is over 75, then in 2010, 53% of households were in fuel poverty [24]. Clearly this group are prone to various health complications, which fuel poverty can aggravate.

3.9 Single Parents

According to figures from the Department of Energy and Climate Change, in 2010 22% of single parents were in fuel poverty [24]. Research carried out by YouGov on behalf of the organisation uSwitch shows that in 2011 39% of single parents are in fuel poverty. This jump is blamed primarily on the increases in fuel prices [26].

These issues can be very detrimental for the development of children, and on the mental health of the parents as they struggle to deal with their financial situation.

4 Future Trends for Fuel Poverty in the UK

4.1 Costs of fuel

According to data from the Office of National Statistics (ONS), from 1990 to 2011 fuel prices have increased by 93% (electricity) and 163% (gas). The historic costs are plotted in Figure 5 using ONS data [27] [28]. Figure 7 shows fuel prices have dramatically risen since 2005 and that those on pre-payment meters consistently pay more.

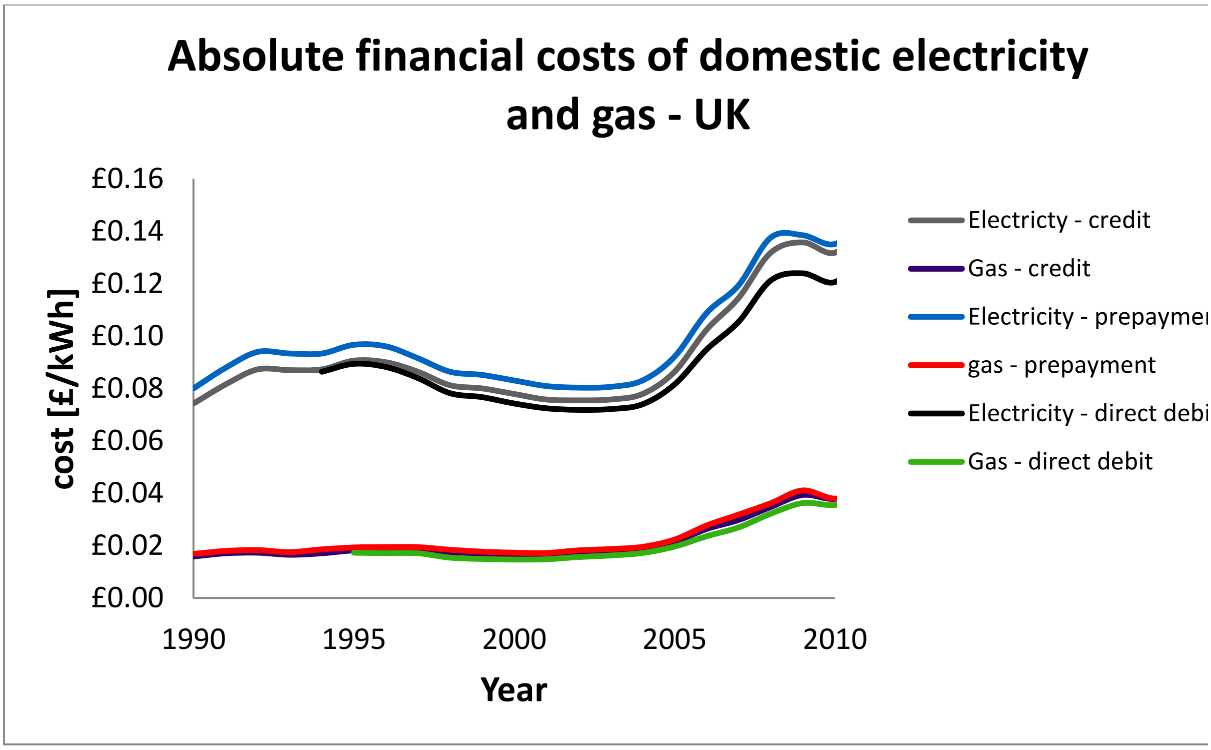

Figure 5: fuel costs in the UK for electricity and gas

Figure 8 shows the average extra annual spend to achieve an adequate level of warmth in relation to income banding. It is clear those of lowest income spend the greatest extra keeping adequate levels of warmth

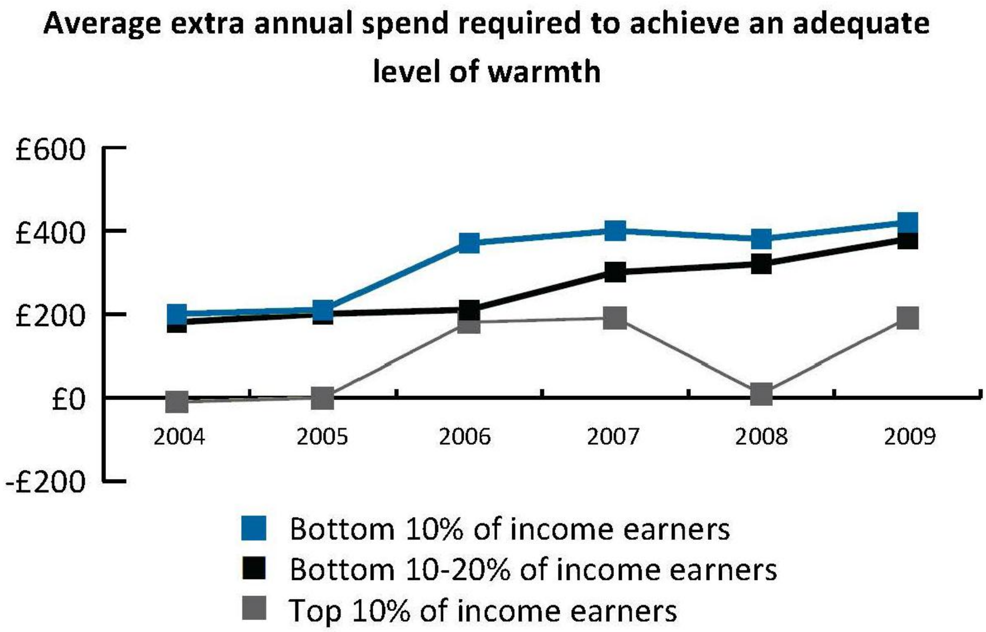

Figure 6: Cost of heating a home compared against poverty level [10]

4.2 Economic factors

Current unemployment in the UK is at 2.485 million, which equates to 8% of the working population [29]. Therefore, more people may find themselves in fuel poverty.

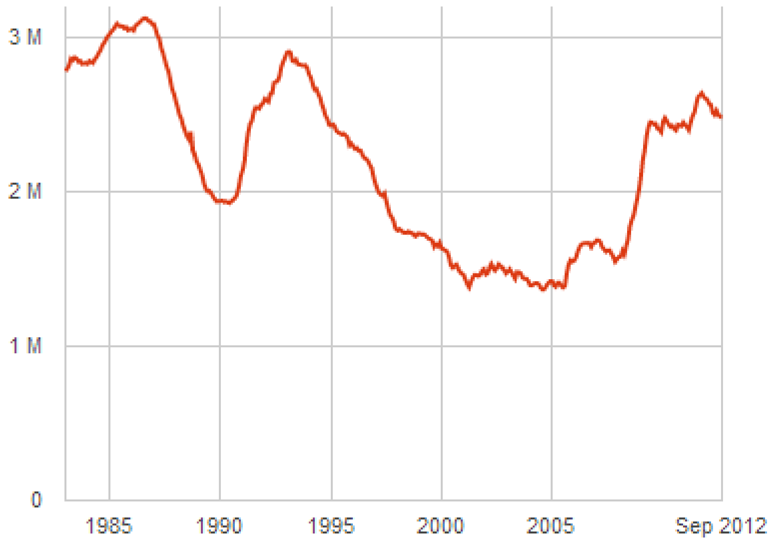

Figure 7: historic seasonally adjusted unemployment in the UK - data from Eurostat, visualised with Google Public Data

4.3 Winter Fuel Payment

The winter fuel payment was introduced to help pensioners pay their winter fuel bills, and in winter 2010/2011 was worth £250 for the over 60s and £400 for the over 80s. However, in 2011 this was reduced by the government to £200 and £300 for the two age groups in the winter of 2011-12 [30].

4.4 Climate and Extreme Weather Conditions

The Earth's climate is changing, and this will lead to major regional variations and an increased prevalence of extreme weather conditions, such as sudden cold snaps during winter [31]. These would presumably increase the levels of fuel poverty, and most probably the excess winter death rate. In a longer term, although not probable in the next hundred years, the Thermohaline current (known colloquially as the Gulf Stream) may slow or change direction, resulting in a change in the UK's climate to one resembling that of Canada. This is a strange but not impossible result of anthropogenically enhanced global warming [32].

5 Energy Hierarchy

When producing an energy strategy for any building, the energy hierarchy provides the most practical and cost effective methodology to achieve a low carbon development. This is a five stage process as detailed below:

Energy Reduction

Reduce the amount of energy used. In the simplest form this means turning off equipment which is not needed. Looking at intelligent lighting systems, timing the heating system for optimum operation, ensuring air conditioning does not turn on at the same time as heating.

↓

Energy Efficiency

Using energy efficient systems, such as A+++ rated electrical appliances and insulating the building as much as possible. Additionally, it means looking at passive design elements such as south facing windows and overhangs to capture solar energy efficiently.

↓

Renewable Energy

Having reduced the energy demand of a building as much as possible, the remainder of power must be generated. This phase involves generating heat and electricity from renewable generators. This includes photovoltaic panels and wind turbines for electricity, solar thermal for water heating.

↓

Low Carbon Energy

For the energy which cannot be generated through renewables, low carbon technologies can be used. These include ground/air/water source heat pumps.

↓

Conventional Energy

With no other options left, the final part of a building's energy demand will be generated through using conventional polluting options. In an optimum development this final phase will not be reached.

The measures designed within the ERDF Social Housing Energy Management Project have followed this hierarchy.

6 History of Buildings

The buildings within this project are all post war prefabricated buildings. These were built to replace the high levels of dwellings destroyed or damaged during the Second World War. The legal outline for the build of these was outlined in the Temporary Accommodation Act 1944. The plan from Winston Churchill was to build 500,000 prefabricated dwellings, with a planned life of up to 10 years. The buildings were to be all built within five years of the end of World War II. The final plan legally drawn up by the Labour government was reduced to 300,000 dwellings. The government set aside a budget of £150m for this construction. The idea was to use wartime production facilities and experience to roll out the construction of these homes quickly and effectively [33].

By the end of the program in 1951, a total of 156,623 prefabricated dwellings had been constructed. These were in addition to other social housing construction projects of non-prefabricated buildings which had led to over one million homes being built [34].

66 years on from the beginning of the project, there are many prefabricated buildings left over which are still surviving and still in use as social housing. As would be expected, 56 years after they were intended to have been replaced, dramatic improvements are needed to ensure these properties are suitable housing for residents to have a good quality of life.

The prefabricated building project was coordinated by the Ministry of Works, who used the wartime manufacturing and organisation structure to roll out the building project in a military style. They opened a competition for designs of prefabricated buildings from commercial companies, and received 1,400 entries. After review of the proposals, and testing and construction of the most promising, the following designs were put into production by the post war government; Portal, Airey, Arcon, AIROH, BISF, Cornish Unit, Hawksley, Howard, Laing Easi-Form, Mowlem, Orlit, Phoenix, Reema, Swedish, Tarran, Uni-Seco, Unity structures, Wimpey No-Fines.

The types of prefabricated buildings in this project are Taran Newlands, Wimpey No-Fines High Rise and Wimpey No-Fines houses.

6.1 Tarran Newlands

Figure 8Figure 8. The Tarran Newlands in the ERDF Social Housing Energy Management project are owned by South Tyneside homes, and are on Lincoln Road and Marsden Road. The buildings on Lincoln Road and Marsden Lane have received various improvements throughout their lifetime.

6.2 Wimpey No-Fines

This design was created by the George Wimpey Company. “No-Fines” refers to the type of concrete used, which is concrete with no fine aggregates.

The buildings in Northumberland, specifically Blyth, are all Wimpey No-Fines. Unlike the Tarran Newlands there are multiple designs of the Wimpey No-Fines, although all following the same basic construction.

6.3 Jarrow Flats

There are three block of flats in Jarrow which are involved in this project. These are Monastery Court, Wilkinson Court and Ellen Court. All three are Wimpey No-Fines construction.

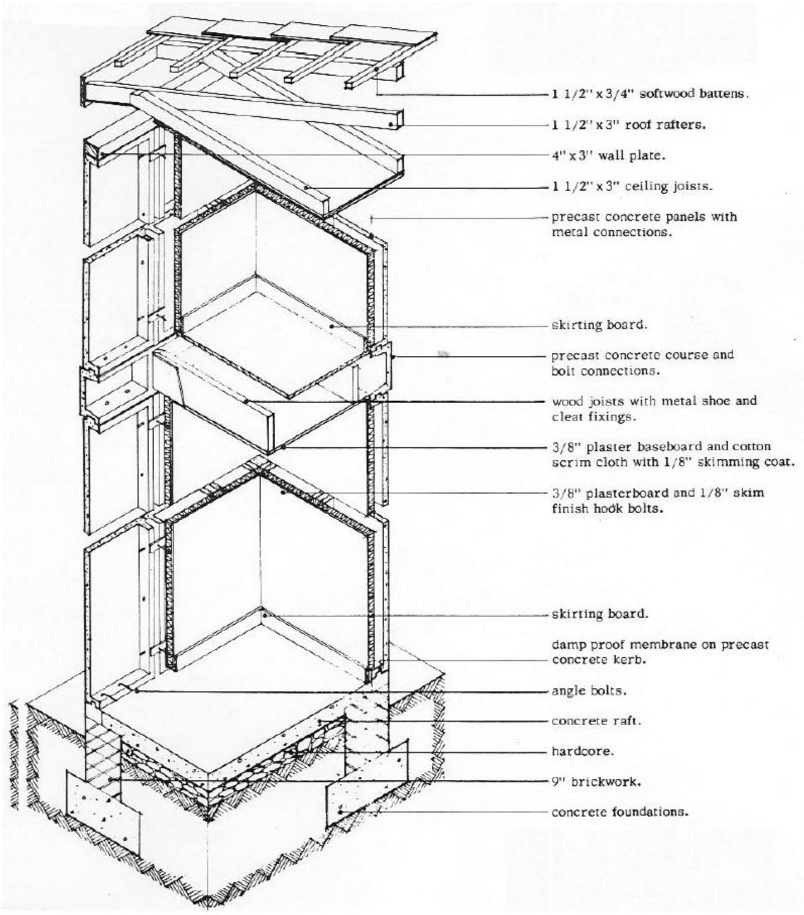

Figure 8: Tarran Newland cross section

Of these buildings, the following numbers are being improved within the ERDF Social Housing Energy Management Project.

- High Rise
    - Monastery Court – 44 dwellings
    - Wilkinson Court – 44 dwellings
    - Ellen Court – 44 dwellings
- Tarran Newlands
    - Lincoln Road – 95 dwellings
    - Marsden Lane – 47 dwellings
- Wimpey No-Fines
    - Brookside Avenue – 23 dwellings
    - Brierley Road – 9 dwellings
    - Hartleigh Place – 5 dwellings
    - Tynedale Drive – 12 dwellings
    - Malton Close – 6 dwellings

Total properties: **328**

Figure 9: Tarran Newland – South Tyneside

Figure 10: Wimpey No Fine – Blyth

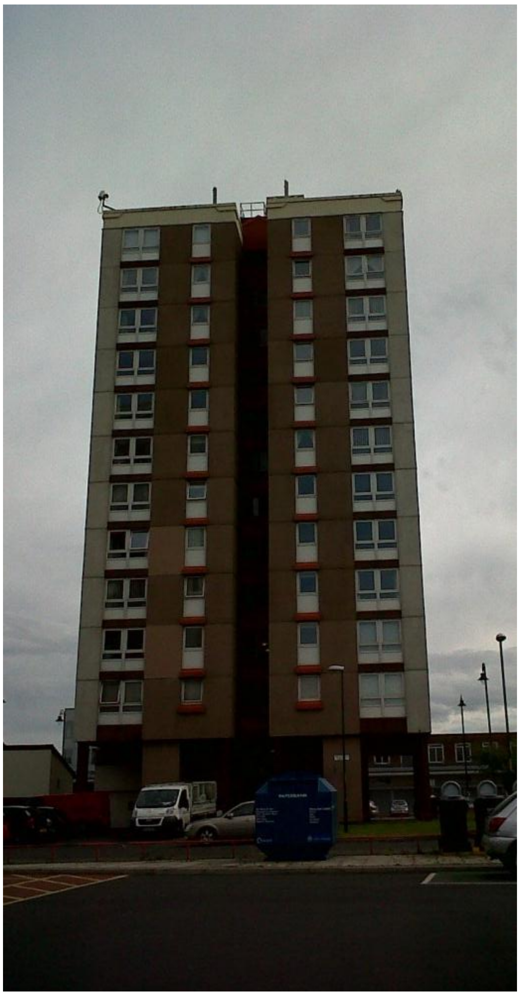

Figure 11: Wimpey No-Fines flats - Jarrow

6.4 State of the Properties

6.4.1 Tarran Newlands

The Tarran Newlands buildings on Lincoln Road and Marsden Lane were all built between 1935 and 1949. They are all two storey semi-detached properties. The properties all have been retrofitted with double glazed uPVC. The walls have had no added insulation since construction, and the walls are merely 20mm of concrete panelling, with an air gap and then 25mm of fibre glass insulation, finished with a thin layer of fibreboard. This compares with a typical new build from this decade, which would have two layers of bricks 102.5mm thick surrounding a 75mm cavity which is relatively easy to fill using blown fibre, a common ECO/CERT measure. Almost all have a standard boiler (except for 2 with condensing boilers), these are fuelled by natural gas, and also fuel the domestic hot water systems. The air change rates, as measured in section 12 on page 31 are considerable.

Two thirds of the properties have 100mm insulation in the roofs, but one third only have 50mm. This is possibly due to the difficulty of placing insulation in the shallow roofs of the Tarran Newlands. The external walls of the properties are made up of 20mm of concrete panelling.

6.4.2 Jarrow Flats

Also built following the war, these are of Wimpey No-Fines construction. All have double glazing with plastic frames, although site visits showed that these were poorly sealed with excessive draughts, as evidenced by the high air change rates. The properties are heated with a communal heating system. Each resident must purchase heating tickets, at a cost of £15.67, each of these supply 200kWh of heating. However, due to the high levels of energy required to heat the homes these do not last long. Additionally, due to the tickets only being purchased from the Town Hall, elderly residents do run out of tickets over the Christmas period whilst the Town Hall is closed, putting their health in danger. The domestic hot water is served by individual Elson tanks in each property.

The properties are constructed on No-Fines concrete blocks, which are approximately 439mm thick (including finishing). The estimated U-Values for the walls is 0.74W/m^{2}K, this is far higher than the individual houses in this project, but still could be improved. The roof includes 200mm of concrete slab and 25mm Cork/PUR insulation. The roofs have a U-Value of approximately 0.34W/^{2}mK, but as a tower block this only affects the top floor flats; a small percentage of the total.

6.4.3 Wimpey No-Fines

There are three types of property in the Wimpey No-Fines, all of the same construction. The only differences are in the positions of doors and windows, and some internal walls. The three types are described in the Appendix.

<table>
<tr><th colspan="60">Type of house</th></tr>
<tr><td colspan="20">Semi</td><td colspan="20">Mid-terrace</td><td colspan="20">End-terrace</td></tr>
<tr><td colspan="20">67%</td><td colspan="20">13%</td><td colspan="20">20%</td></tr>
<tr><th colspan="60">Loft Insulation</th></tr>
<tr><td colspan="12">50mm</td><td colspan="12">75 mm</td><td colspan="12">100mm</td><td colspan="12">150mm</td><td colspan="12">200mm</td></tr>
<tr><td colspan="12">4%</td><td colspan="12">17%</td><td colspan="12">56%</td><td colspan="12">13%</td><td colspan="12">11%</td></tr>
<tr><th colspan="60">Heating system</th></tr>
<tr><td colspan="15">Standard boiler</td><td colspan="15">Condensing boiler</td><td colspan="15">Condensing combi boiler</td><td colspan="15">Room heaters (eg gas or coal fires)</td></tr>
<tr><td colspan="15">6%</td><td colspan="15">69%</td><td colspan="15">24%</td><td colspan="15">2%</td></tr>
</table>

Table 4: Data on Wimpey No-Fines properties

All the properties have double glazing with plastic frames. The solid walls have had no insulation added since their construction. The water systems are connected to the space heating, which are both fuelled by natural gas. Condensing boilers are the most common heating systems.

The properties have concrete profiled tiling on treated timber battens which are in turn on a roofing membrane. The loft insulation, although present, is poor, with the majority only having 100mm of loft insulation, and none having 250mm.

The external wall construction is No-Fines concrete. This is finished internally with 12mm of plaster, and externally with 20mm of render with a thick pebbledash finish. Most of the properties (87%) are either semi-detached or end of terrace, so have a high surface to volume ratio, which means there is a high area for energy loss through external walls.

The ground floor is likely to be 28mm of screed on 100mm of 1:3:6 concrete on a polythene sheet, which in turn is on 100mm of hardcore base.

6.5 Fuel Poverty Levels

Warm Zones, a national fuel poverty alleviation charity, provided the project with fuel poverty data they already had from previous work. This included 15 properties from Marsden Lane/Lincoln Road, 45 flats from the Jarrow High Rise flats, and 36 properties from the Blyth Wimpey No-Fines housing stock. Only properties involved in the project have been included in this analysis.

Location	House Type	Homes in survey	% in fuel poverty	Maximum fuel poverty index
South Shields	Tarran Newlands	15	66%	25%
Jarrow	High Rise	45	9%	13%
Blyth	Wimpey No-Fines	36	19%	15%

Table 5: Summary of Warm Zones data

The most concerning is the Tarran Newlands, where the level of fuel poverty is approximately 4 times that of the national average, with two thirds of dwellings suffering from fuel poverty. Additionally, the fuel poverty index goes up to 25%. This means families are spending a quarter of their income on their energy bills.

6.6 Proposed Works

6.6.1 Tarran Newlands

The solid walls are extremely thin, so cladding is necessary to improve the insulation of the construction. Externally, 40mm of Kooltherm K5 EWB/K15 Rainscreen board is being fitted, with 13mm of Wetherby system render on top. Internally the original 25mm glass fibre quilt (where still present) and vertical timber battens are be removed and replaced with a 45mm Gyproc I stud with a minimum of 25mm Rockwool infill between studs. Finally, 12mm Gyproc foil backed plasterboard has been installed, with tape and plaster skim, and painted with standard white emulsion. This will increase the U-value of the walls from 2.35W/m^{2}K to 0.29W/m^{2}K, this is a substantial improvement. All of the above fits in with NBS specifications.

Although not funded by ERDF, 3.2kW peak photovoltaic systems are to be installed on all south facing roofs possible in the Lincoln Road/Marsden Lane area. It is important to note that residents need to be educated over how to change their energy usage habits to maximise the help the photovoltaic systems give, so running laundry equipment at mid-day for example.

6.6.2 Wimpey No-Fines

The roofs will be improved with top up insulation to bring all properties up to 270mm insulation. Additionally insulation will be installed in the box eaves. The wall constructions are being improved with external insulation. This is made up of WBS 70mm phenolic insulation board, WBS scrim adhesive coat (4-6mm) reinforced with alkali resistant glass fibre reinforcing mesh, WBS scrim adhesive levelling coating (2-3mm) finished smoothly, with a final layer of WBS silicone finish coat (1.5mm).

Voltage Optimisers will also be installed in properties as part of this project. As part of a separate project funded by Homes for Northumberland, some properties have also had photovoltaic systems installed. Other improvements include the installation of a secondary heat exchanger (Gas saver unit) to recycle wasted heat from the central heating boiler flue and low energy light bulbs.

6.6.3 Jarrow Flats

As with the other properties, the Jarrow flats are to be improved with external cladding, which will increase the U-Value to 0.22 W/m^{2}K. The roofs will be use a decotherm system of insulation, which will bring the U value down to 0.18 W/m^{2}K. The windows will be replaced with new double glazing, which should not have as high an air leakage rate as the current windows.

The Elson Tanks used for domestic hot water are to be replaced with a heat exchanger design working directly from the communal heating system

In order to give residents a greater control of heating throughout the flats, thermostatic radiator valves are to be installed on all the radiators.

Finally, the large open ventilation grills on the landings are to be closed to stop excessive energy loss.

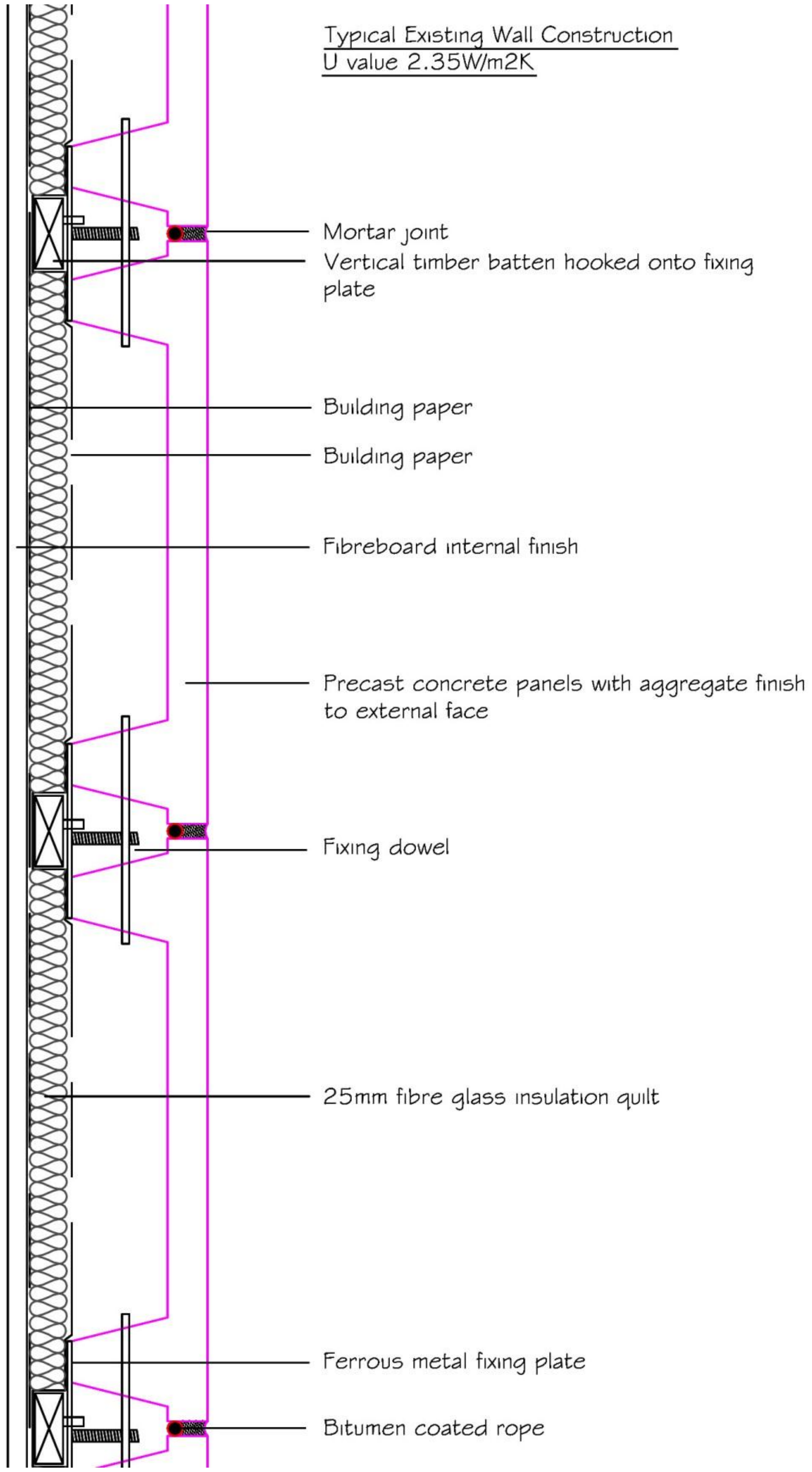

Figure 12: Tarran Newlands before the works

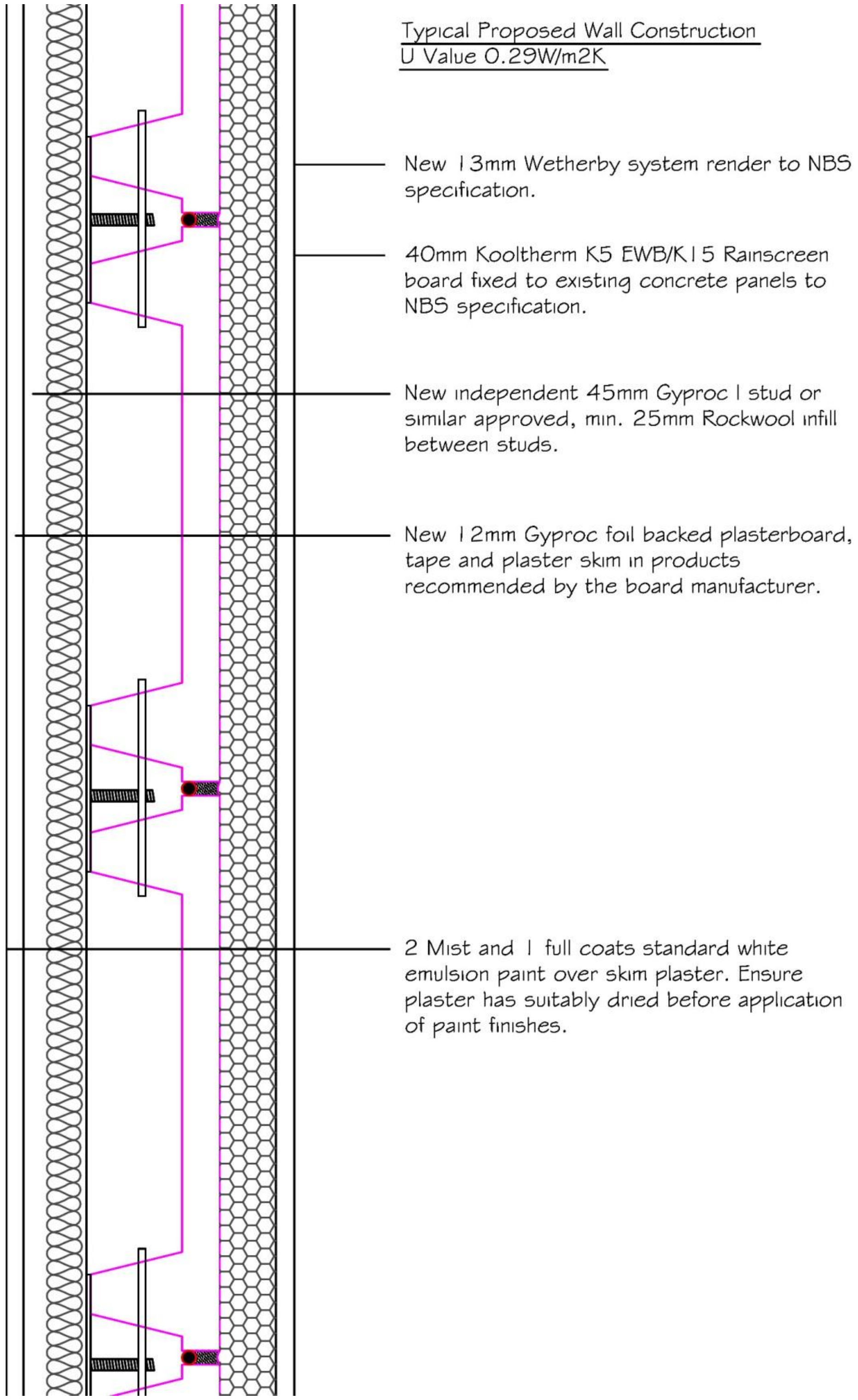

Figure 13: Tarran Newlands proposed works

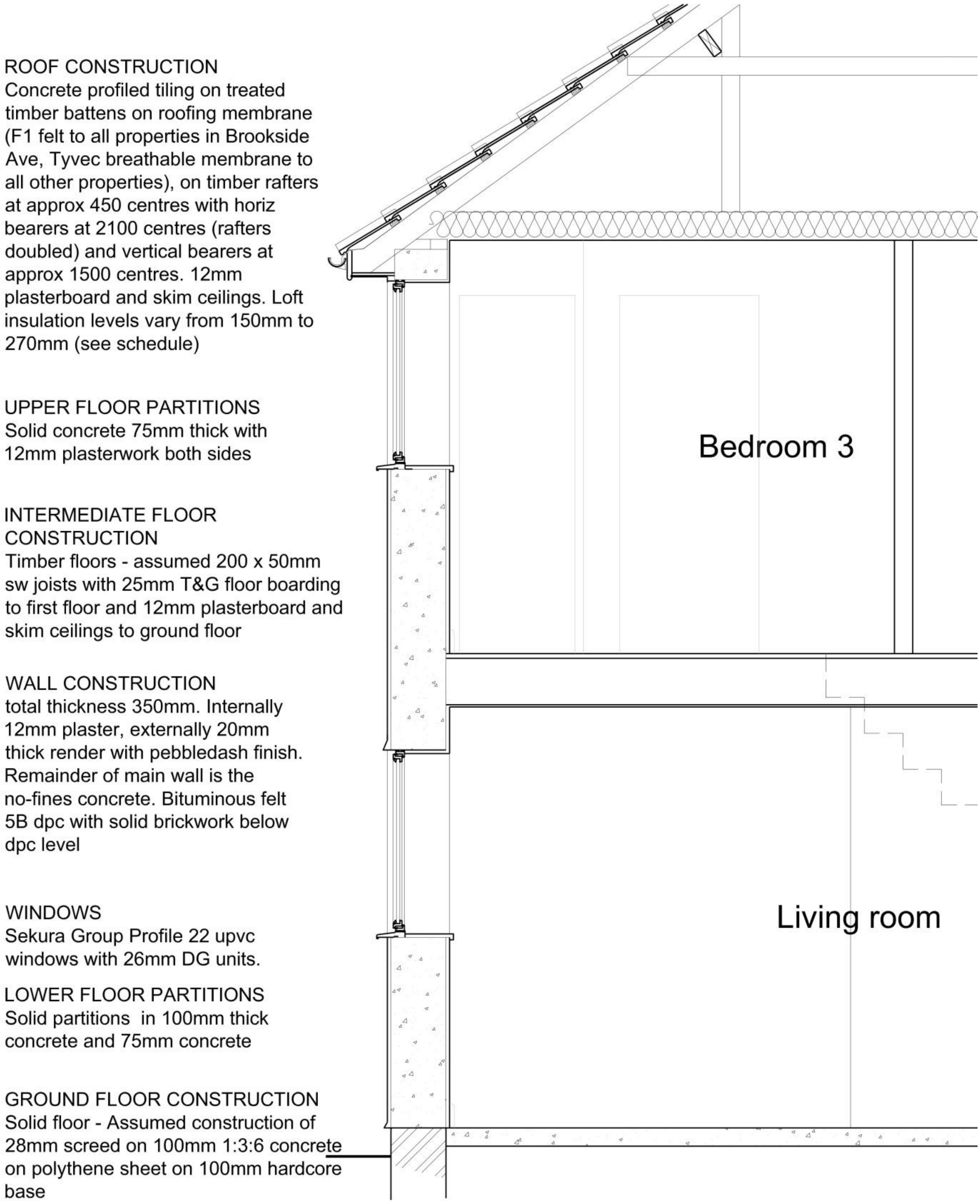

Figure 14: Wimpey No-Fines construction Pre-Works

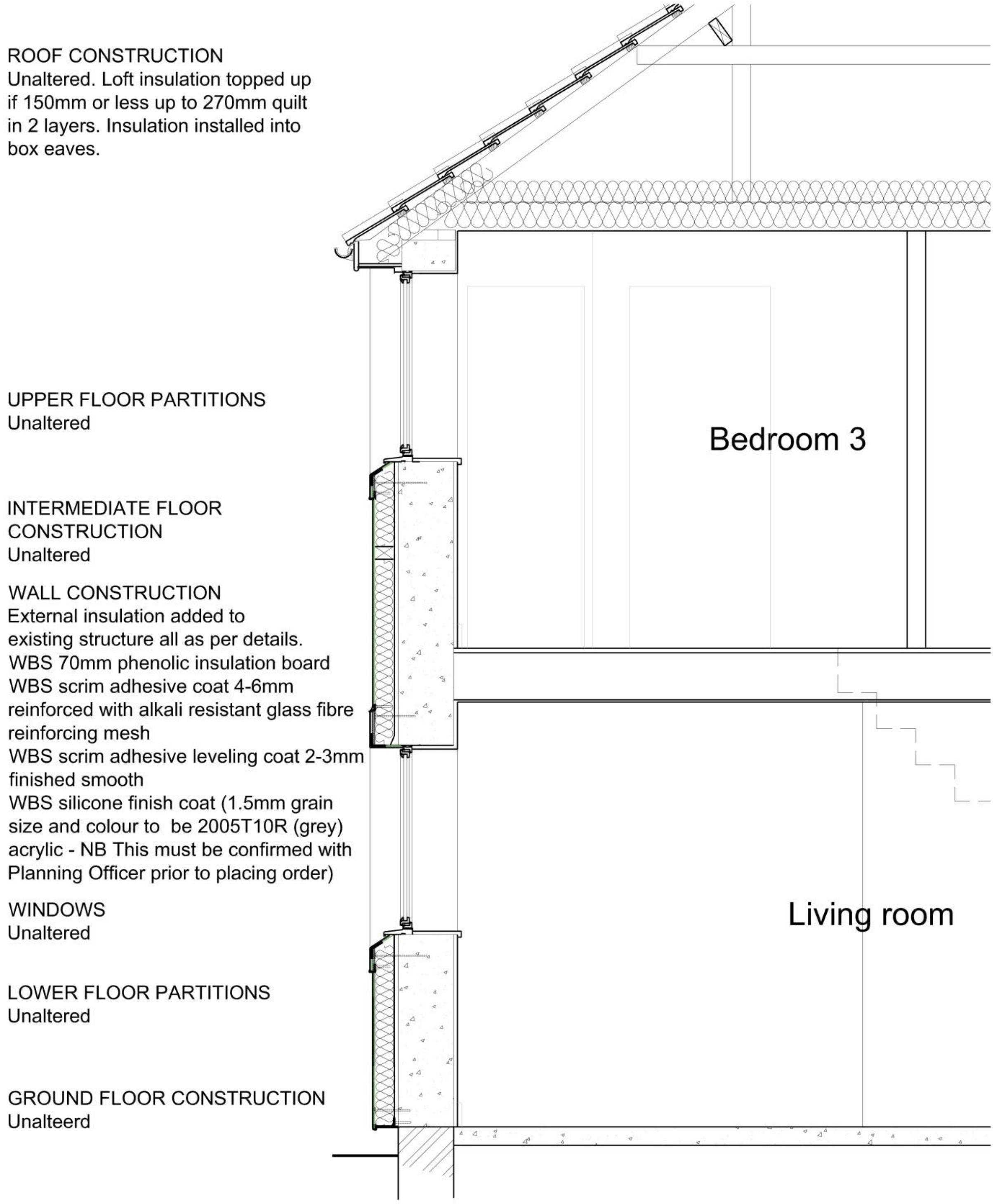

Figure 15: Wimpey No-Fines construction - proposed

7 Photovoltaic Systems

Photovoltaic (PV) systems are being installed on the roofs of the south facing roofs on the Wimpey No-Fines and Tarran Newlands. These are 2.3kW peak systems. It is important to stress that the ERDF project has funded the enabling work for these systems, whilst the actual systems themselves were purchased by the housing associations using their own funds.

Calculations of the energy output of the systems were carried out using the Photovoltaic Geographical Information System, which is a European funded system which is part of the SOLAREC action at the JRC Renewable Energies Unit. Calculations were carried out using the PVGIS-CMSAF database, which is based on ground solar data from 1998 to 2006.

This showed for a roof pointing 0 degrees off South, with a pitch of 14 degrees, a 2.3kWp system would have a total yearly output of 2.040MWh.

The monthly outputs are shown in the below table:

Month	Daily Average [kWh]	Monthly total energy [kWh]
Jan	1.75	54.2
Feb	3.12	87.4
Mar	5.60	173
Apr	7.91	237
May	9.75	302
Jun	9.14	274
Jul	8.91	276
Aug	7.52	233
Sep	5.94	178
Oct	3.74	116
Nov	2.11	63.4
Dec	1.39	43.1
Yearly average	**5.59**	**170**
Total for year		**2,040kWh**

Table 6: PVGIS calculations for Tarran Newlands PV systems

To put these figures in perspective, a typical average household in South Tyneside uses 3.262 MWh of electricity a year. Therefore the photovoltaic system such as this could produce 63% of the electricity needs of the property. However, it is important to remember power will be exported in times of excess production, so this will not lower the bills by the full 63%.

8 Data Monitoring

Detailed temperature monitoring was fitted to 10% of the properties in the project. South Tyneside Homes and Homes for Northumberland ensured that there was a wide range of socio-demographics within the work, to make sure this 10% was representative of the whole sample in terms of socioeconomic status, demographics and number of residents per dwelling.

For this 10%, Gemini Tinytag Transit 2 TG4080 dataloggers were fastened to internal walls within the properties to record temperatures before and after. In each property one datalogger was placed in the living room, and one in the main bedroom. These recorded the temperature every 30 minutes, to an accuracy of +/- 0.01°C using an internally mounted 10K NTC Thermistor.

In addition to these dataloggers, three others were placed to measure outside temperatures. These were Gemini Tinytag TGP-4017 loggers, which again were measuring the temperature every 30 minutes. These were placed in the following locations:

- Roof of Ellen Court on the east side of the plant room
- A Fence at the back of a property on Marsden Lane
- The fence of a property on Malton Close in Blyth

9 Fuel Bills

Historical Fuel bills were taken from the properties when the data loggers were installed. At the end of the project these will be collated allowing for a full comparison between before and after the improvement works. Comparisons have been made with the Digest of United Kingdom energy statistics (DUKES), which provides detailed regional and national data of various types of energy usage and production up to 2009.

The bills that were collected showed the following:

In Blyth, the average bill per year was £1,334, ranging from a minimum of £720 to a maximum of £1,908. Taking these figures and assuming standard npower 2012 tariffs (for electricity this was £0.1376 /kWh for the first 728kWh units and £0.1323/kWh for the rest, whereas for gas this was £0.07308/kWh for the first 4572kWh and £0.02388/kWh for the rest) this showed the electricity usage ranged from 3,426kWh to 7,478kWh. Gas ranged from 4,898kWh to 26,973kWh. With regard to the heating, both the minimum and maximum values give cause for concern. The lower figure is not enough to adequately warm the building, so the residents are presumably living in extreme cold over winter. The higher figure is a concern because the average gas consumption in Northumberland is 15,954kWh, meaning these properties are using twice that value. The corresponding data logger information shows the properties are not excessively heated , so this must be the energy necessary to keep the properties at a reasonably comfortable level.

In the Tarran Newlands the total energy bills varied from £528 to £1,664. Taking the same logic as the Blyth bills, this meant that the electricity usage varied from 950kWh per year all the way up to a maximum of 90,285kWh/year. This is extremely concerning, as it compares with the average kWh gas usage in South Tyneside of 15,715kWh. This means the residents are using six times the local average for heating their homes. The data loggers and site visits showed these homes were still cold despite the high levels of energy used by residents for heating. With regard to electricity, the average consumer in South Tyneside used 3,262kWh, which compares to an average in the Tarran Newlands of

4,951kWh/year. This difference could be due to residents using electric heaters as backup for their gas heating systems.

Of all the properties, the High Rise seemed to be in the best condition. Despite the high cost of fuel from the heating ticket scheme, which provides energy at a cost of ~8p/kWh (cheaper than electricity but more expensive than gas) the average energy usage of home was 7,099kWh. This did vary between 2, 250kWh and 14,625kWh. The electricity for the High Rise varies from 2,890kWh to 8,609kWh. These figures, compared with the averages for South Tyneside described above, do seem reasonable. It should be noted that although these properties are far better than the others in this project, there is still fuel poverty and poverty in these homes, but comparatively the high rise flats bills show the residents to be in a better position.

In comparison with national data, the average kWh gas usage in South Tyneside per consumer during 2009 was 15,001kWh, which compares with a north east average of 15,715kWh and an average per consumer in England Scotland and Wales of 15,383kWh. With regard to electricity, the average consumer in South Tyneside used 3,262kWh during 2009, which compared to a North East average of 3,572kWh and an average in England, Scotland and Wales combined of 4,152kWh.

This shows that consumers in South Tyneside on average use less energy than the North East or Great Britain. There are a number of drivers on the energy usage by consumers:

- Number of individuals in a property
- Occupancy profiles
- Health of residents
- Energy required to heat home (due to quality of building and size)
- Financial ability of residents to heat home

This means that figures such as those from DUKES should be treated carefully, as low energy usage could be due to residents in other areas having a well-insulated home, or it could be simply that they cannot afford to put the heating on, and in fact are living in poverty.

10 Questionnaire Information

Two different questionnaires were used, a short version for the majority of properties, and a more detailed version for the 10% of properties which had data loggers installed. A total of 166 questionnaires were returned.

The general findings from the questionnaires included:

- All residents questioned use the heating in all rooms (in the case of the flats in Jarrow, there were no Thermostatic Radiator Valves (TRVs) so the residents had little choice)
- The majority of residents who answered said they turned off their heating to save money. This was divided up as follows
    - 71% of residents in the Wimpey No-Fines houses
    - 66% of residents in the Jarrow High Rise
    - 77% of residents in the Tarran Newlands houses
- In the Wimpey No-Fines, 54% considered the heating of their property inadequate, 18% satisfactory and 29% very satisfactory
- In the Jarrow High Rise, 25% considered the heating of their property inadequate, 36% satisfactory and 39% very satisfactory
- In the Tarran Newlands, 82% considered the heating of their property inadequate, 16% satisfactory and 2% very satisfactory
- Timers were generally not used by residents; instead they would turn on the heating manually when they felt too cold. Thermostats varied between 7 and 30 degrees (suggesting use as a switch) in their settings, with the majority in the region of 18 to 21 degrees.

11 Psychological Investigation

Although not part of the ERDF project, it is worth mentioning that South Tyneside Homes in association with the NHS are carrying out a wellbeing investigation before and after the improvements to the three high rise tower blocks in Jarrow. This will look at a sample of 75% of the 114 flats which are expected to be improved (the remaining flats are owned by private residents). This will include use of the peer reviewed Lodex Wellbeing Tool (a validated measure of health and wellbeing).

The areas that this test will focus on will be:

- Mental health and wellbeing
- Perceived general health
- Smoking status
- Feelings of comfort within the home
- Anxiety around the security of the home

The results of this work will be shared with residents through the ‘Housing Matters’ magazine, which is produced quarterly by South Tyneside Homes and goes to all South Tyneside Homes residents. Additionally the findings will be distributed to peer reviewed conferences and journals. The results in the peer reviewed literature will be used to improve and inform the data and conclusions drawn from the ERDF funded work.

12 Air tightness

Air tightness tests were conducted on five properties in the project. These were in the following locations:

- Lincoln Road, South Shields – Tarran Newland
- Monastery Court, Jarrow – Tower Block
- Ellen Court, Jarrow – Tower Block
- Harleigh Place, Blyth – Wimpey No-Fines
- Brookside Avenue, Blyth – Wimpey No-Fines

These were tested using a de-pressurisation method conducted in accordance with BS EN 13829:2001 Method B – Test of the Building Envelope and the ATTMA Technical Standard Issue 2, This work used a single fan automatic procedure utilising computer control of fan operation and measurement recording. The equipment used in this test was a model 3 Minneapolis Blow Door S/N APNT-06.

These buildings will be tested post works, to show the level of air leakage improvement. The information also informs the dynamic thermal models created using IES<VE>.

Address	Building Type	Air permeability	
		$m^3(h.\ m^2)$ @ 50Pa	Ach @ 50Pa
Lincoln Road, South Shields	Tarran Newlands	19.26	19.33
Monastery Court, Jarrow	Tower Block	3.56	4.72
Ellen Court, Jarrow	Tower Block	5.08	7.22
Harleigh Place, Blyth	Wimpey No-Fines	7.40	8.00
Brookside Avenue, Blyth	Wimpey No-Fines	11.09	11.67

Table 7: Air change rate results

To put this in context, legally under the Code for Sustainable Homes social housing built from 2010 onwards must be built to Code Level 3. This means a maximum air permeability of 3 $m^3(h^{-1}\ m^2)$. Prior to this the maximum air permeability was 10 $m^3(h^{-1}\ m^2)$. Whereas Passivhaus buildings, the incredibly energy efficient domestic house standard used primarily in Germany and Austria require a level of air tightness of 0.6ach @50Pa. Therefore, none of the buildings in this project would be acceptable as new build social housing, and Lincoln Road specifically has major problems. These figures fit in with the conversations with residents, where the Tarran Newlands residents are suffering greatly from the cold, whereas the Tower Block residents have homes which, though cold, do not appear to be dangerously cold.

13 Thermal imaging

Thermal images were taken of a selection of Tarran Newlands homes on Marsden Lane and Lincoln Road, Monastery Court Jarrow and a number of Wimpey No-Fines building in Blyth. This was carried out in December 2011. This was in order to show the areas where there is the most heat loss. This will be compared with the thermal imaging at a later date of the same properties to see how the improvements to the building have improved fabric heat loss and air leakage. Further imaging will be carried out in winter 2012/2013.

All properties showed significant heat loss from windows, with thermal bridging issues increasing this effect. Thermal bridging is the process where poor thermal insulators penetrate a material, offering a path of least resistance for thermal energy. Specifically the Tarran Newlands suffered from high levels of thermal bridging.

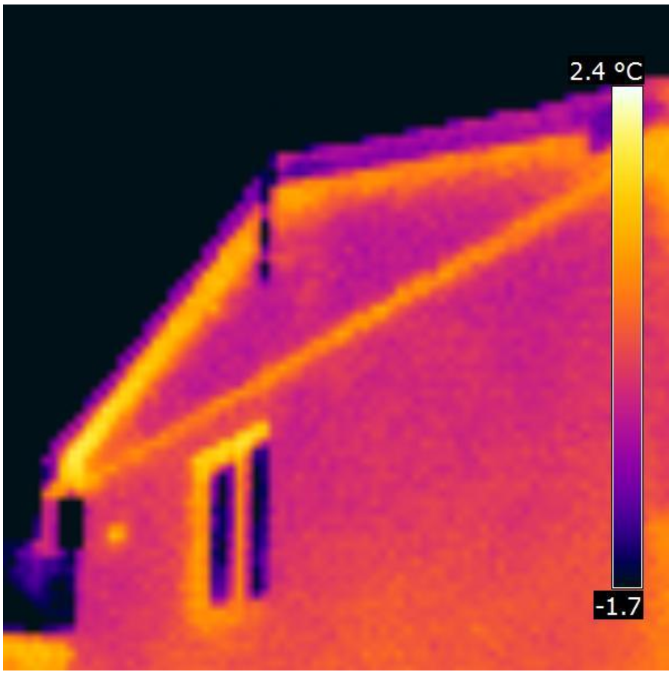

Figure 16: Thermal bridging on the roof of a Tarran Newlands home on Lincoln Road.

With regard to the Wimpey No-Fines buildings in Blyth, it was also found that the walls were leaking more heat that the roofs, as the roofs had already been insulated in other projects.

Figure 17: Image of Wimpey No-Fines in Blyth showing clear differences between energy leaking from roof and walls

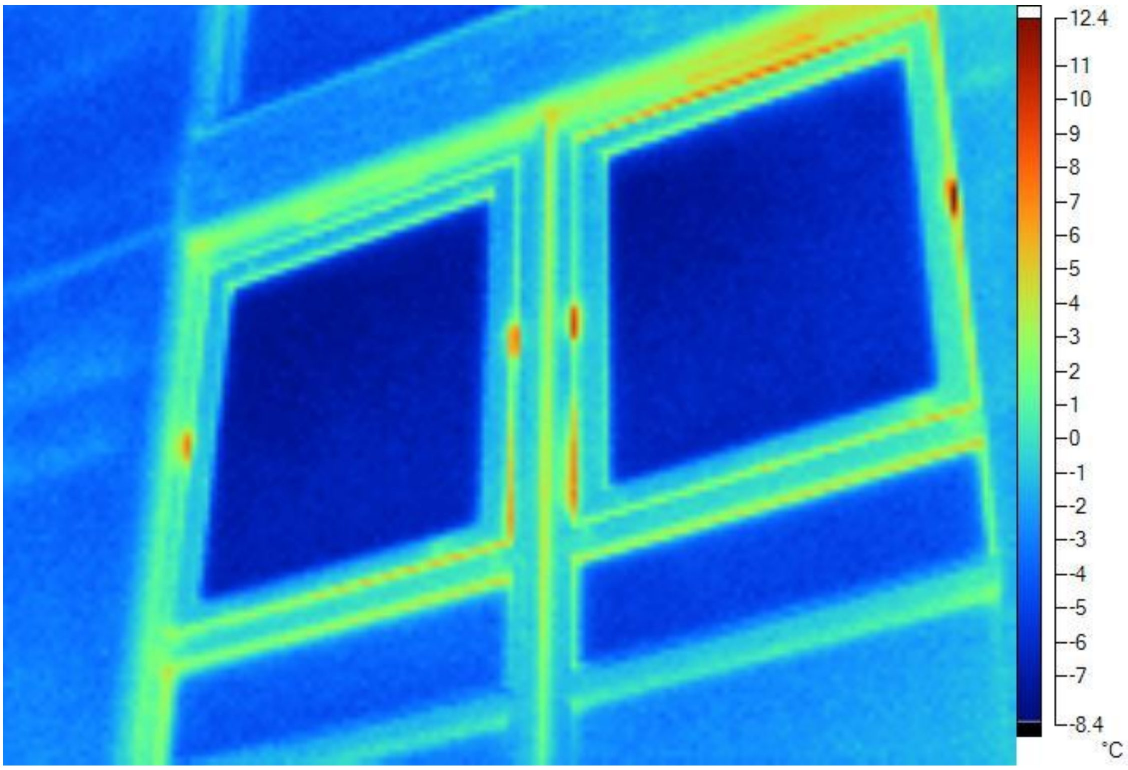

Figure 18: Thermal imaging of tower blocks in Jarrow – note the thermal bridging and air leakage losing high levels of heat, to the window frames are reaching 12.4°C whilst the surrounding area is around -6 degrees

The High Rise blocks in Jarrow suffered major heat loss coming from the permanently open ventilation grills on every landing. This meant heat was leaking from each flat into the landing and then straight out of the building.

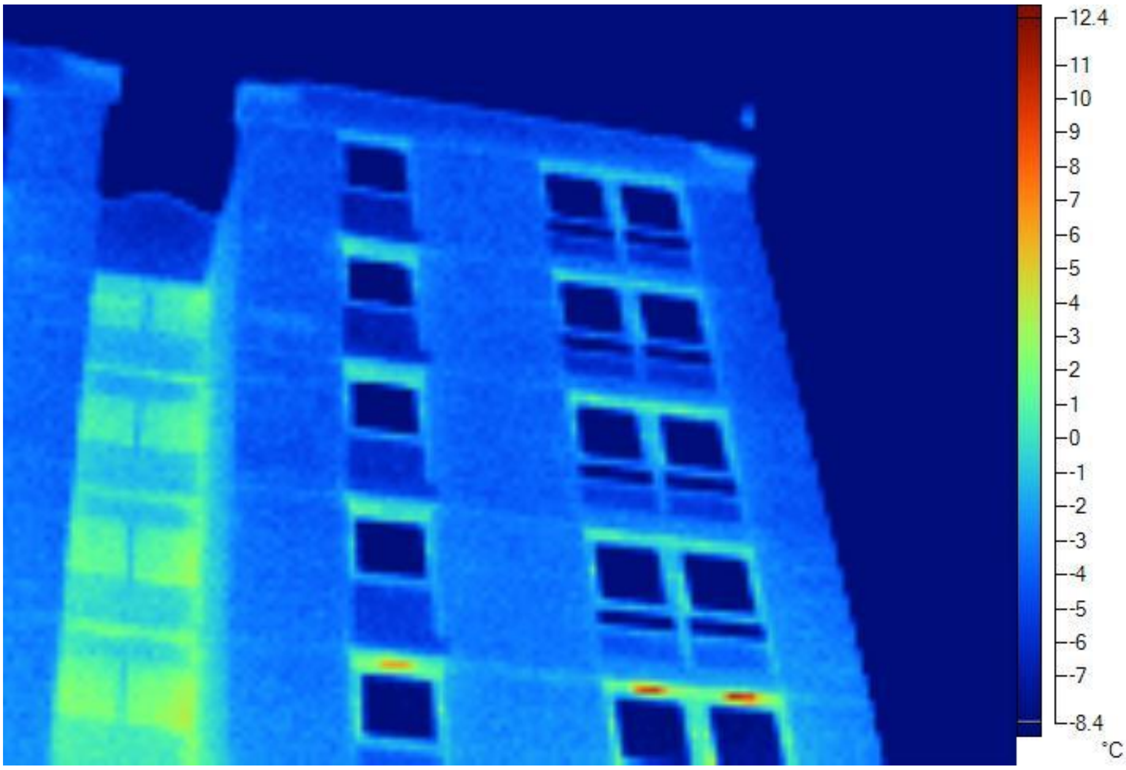

Figure 19: Thermal imaging of tower blocks in Jarrow – note the high levels of thermal leakage from the open window grills on the landings of each floor.

14 Data Logger Results

14.1 Homes for Northumberland

The logger results for Blyth are presented here against the outdoor temperatures.

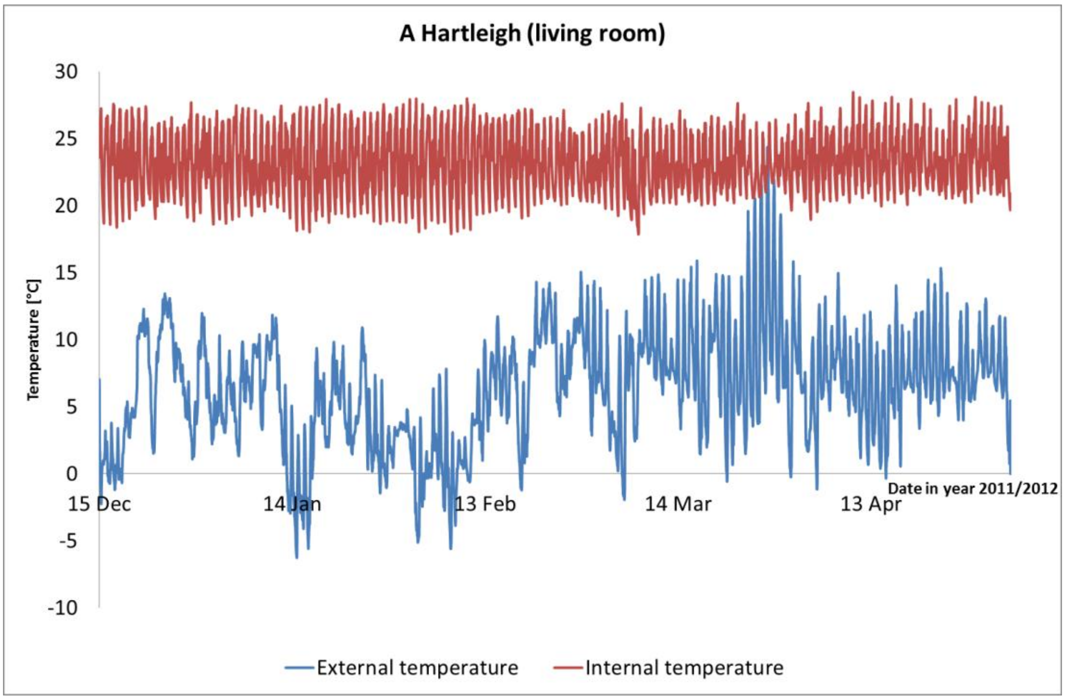

Figure 20: A Hartleigh Place – living room temperature data

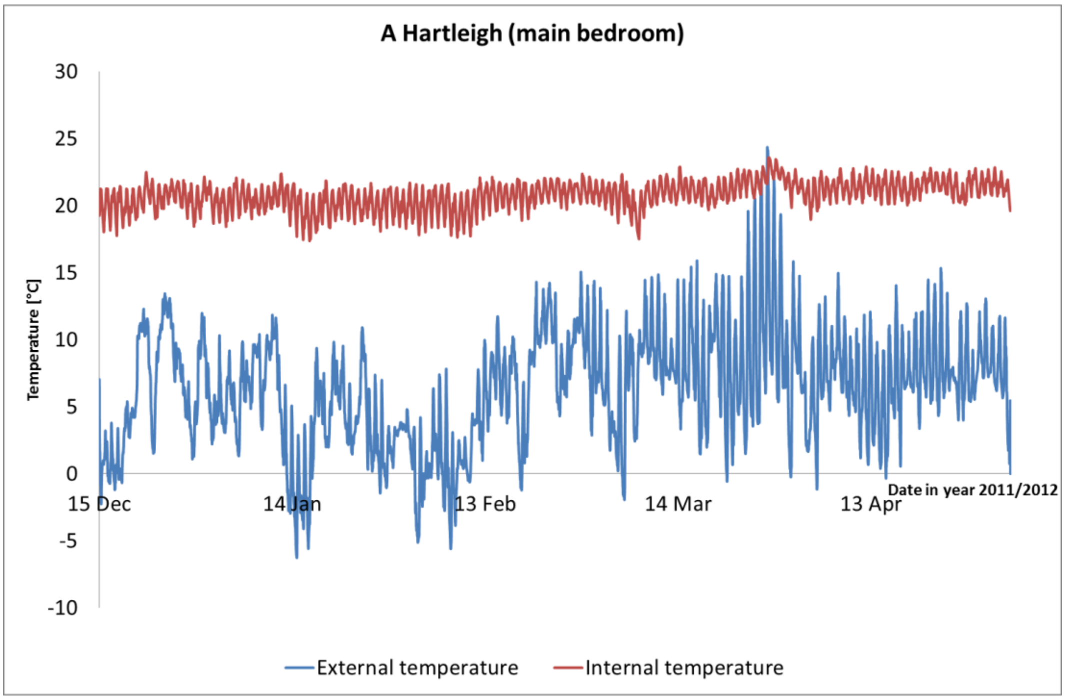

Figure 21: A Hartleigh Place – bedroom temperature data

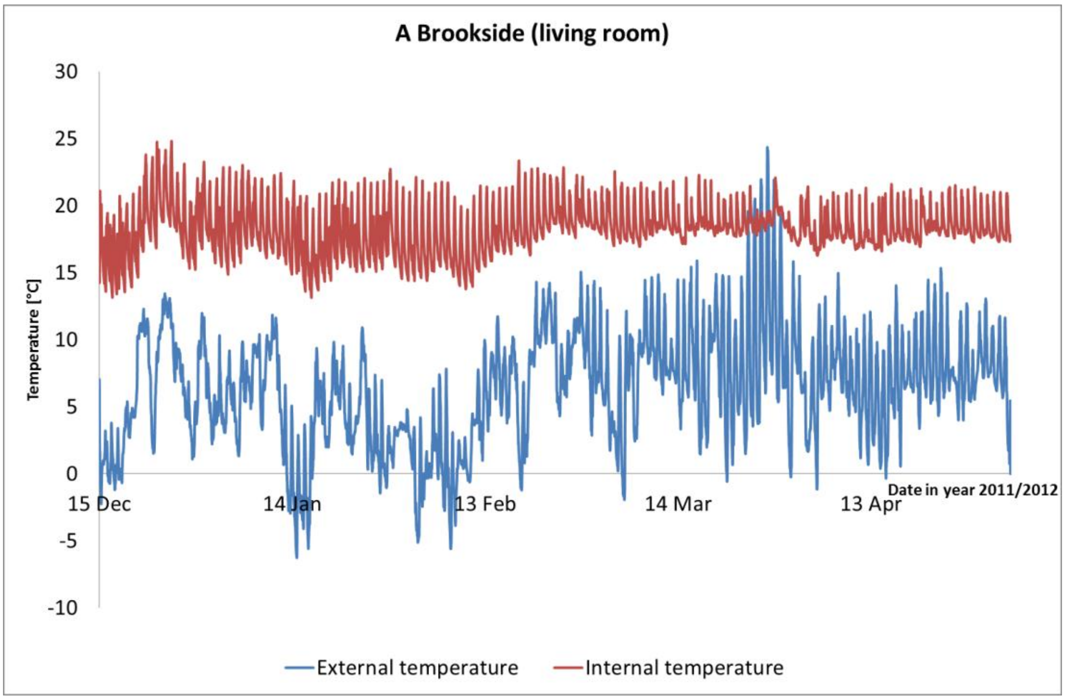

Figure 22: A Brookside – living room temperature data

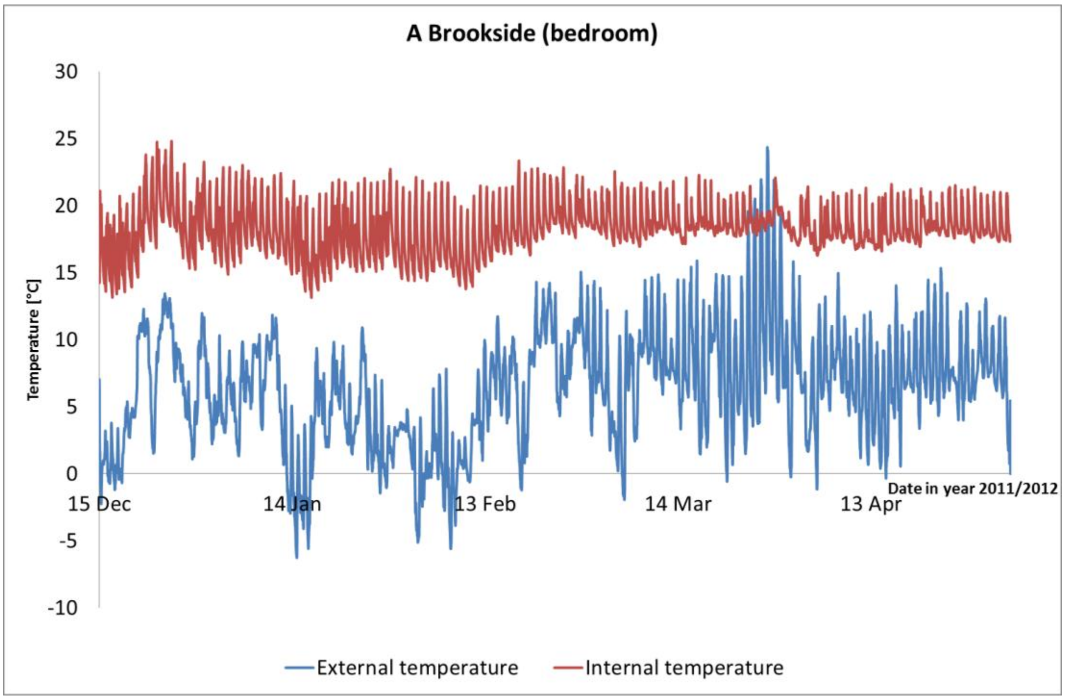

Figure 23: A Brookside –bedroom temperature data

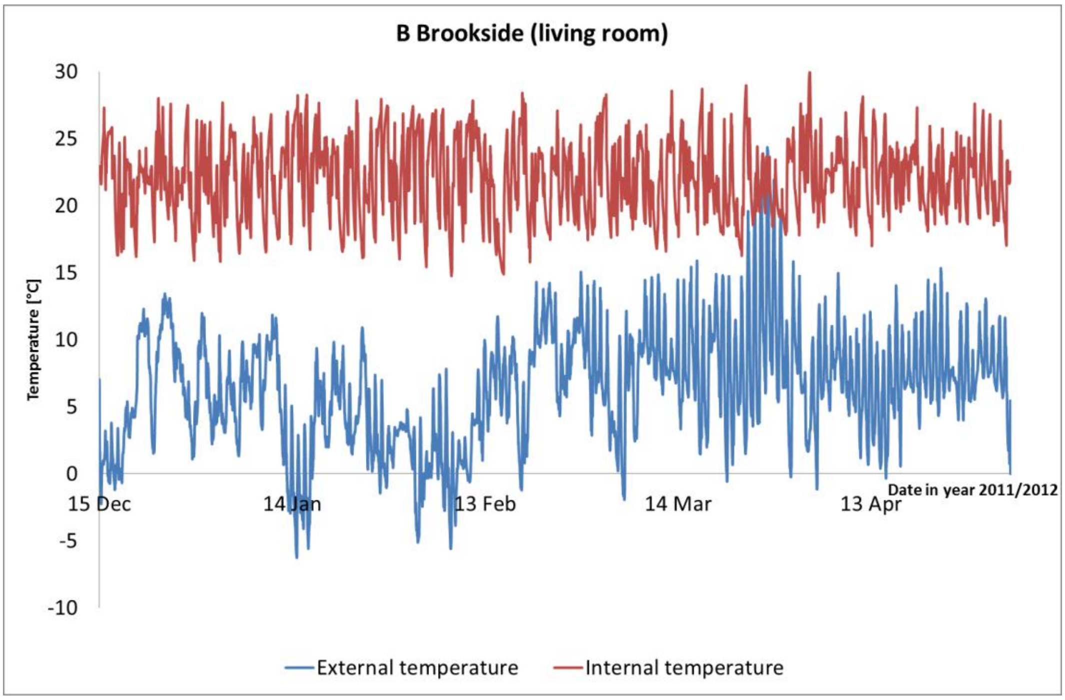

Figure 24: B Brookside – living room temperature data

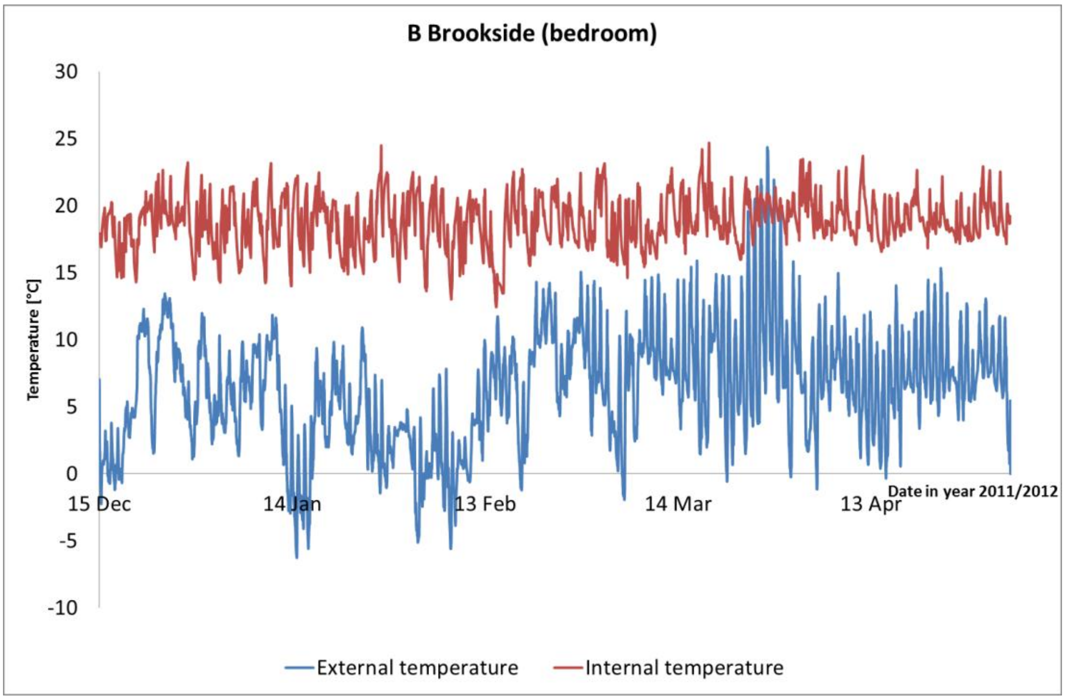

Figure 25: B Brookside – bedroom temperature data

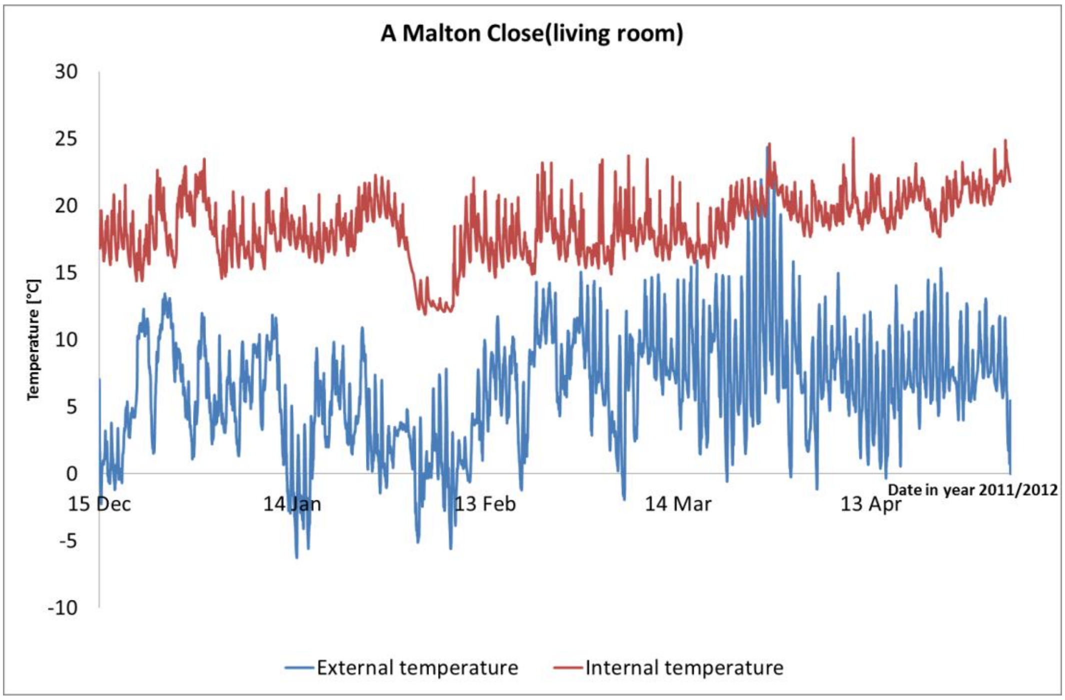

Figure 26: A Malton Close – living room temperature data

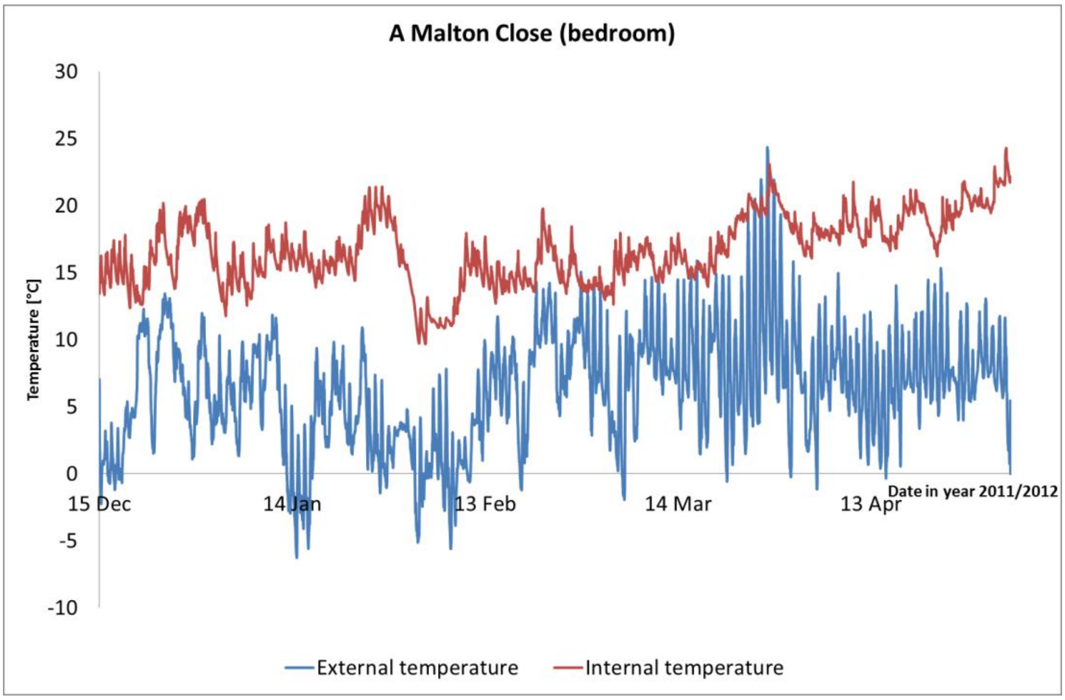

Figure 27: A Malton Close – bedroom temperature data

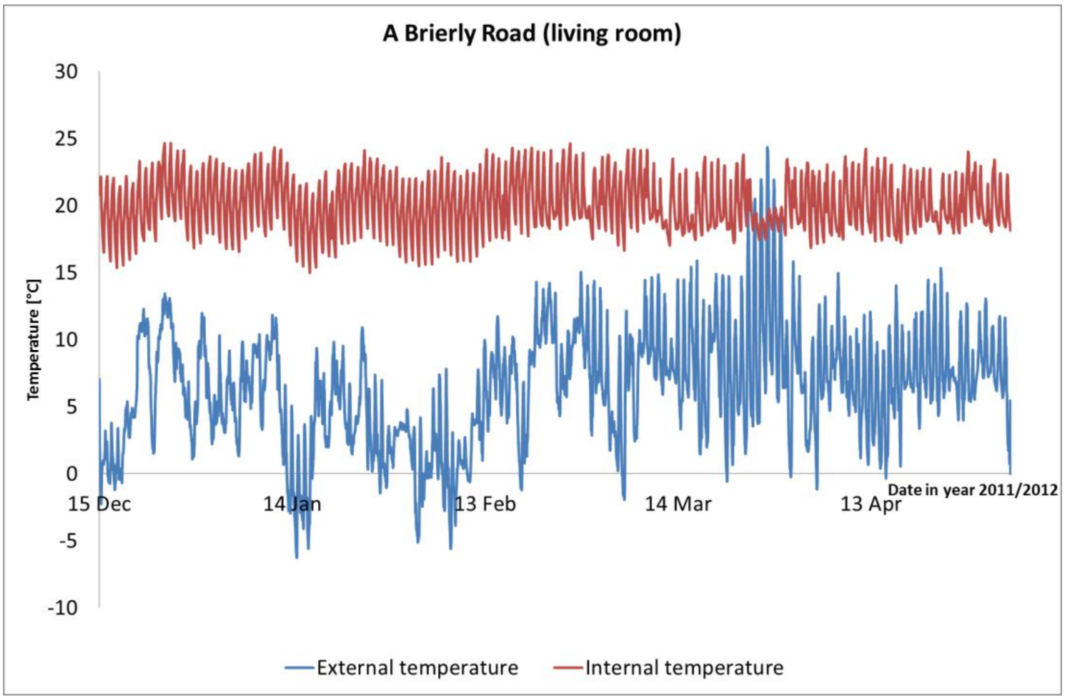

Figure 28: A Brierley Road – living room temperature data

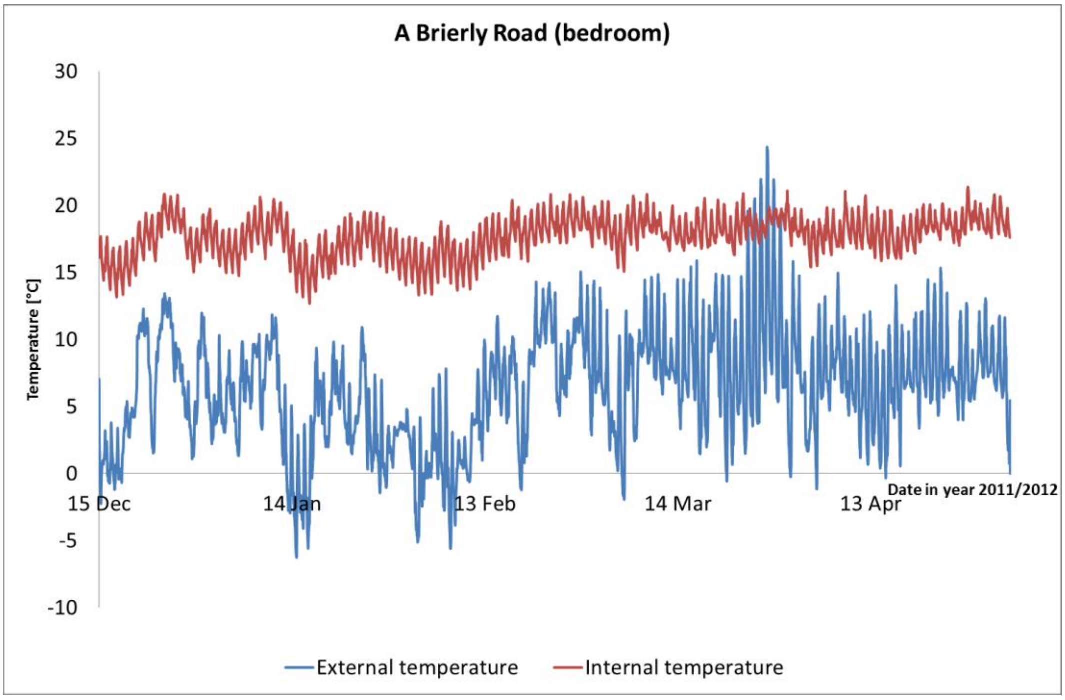

Figure 29: A Brierley Road – bedroom temperature data

Due to the long time periods to install the loggers, as specific appointments had to be made with residents, the data was cut down into purely the times when all the loggers (including the external logger) coincided.

The external data logger recorded a very large peak around March 2012. This seemed to increase temperatures above the internal temperatures of the buildings being monitored. It is not clear why this happened, but it appeared to last several days. This began on the 25th of March 2012 and ended on the 30th of March 2012. The highest temperatures recorded during this time were at 2pm on the 28th March 2012 with a temperature at 24.2°C. The reasons for this are not clear, the data logger is in a shaded position and the anomaly went on for four days. There appears to be no spike in the internal temperatures of the buildings. This will require further investigation, possibly comparing with the data from the anemometry hub used on the Narec Offshore Demonstrator Site just a few miles from the coast of Blyth – although the offshore temperatures will be different, they may show if there was a spike in temperatures.

All the properties show a variation over a 24 hour period, showing that heating systems are turned off at night even in winter.

The property temperatures went from a minimum of 6.86°C to 28.44°C. The average temperatures for properties varied dramatically between properties.

It is possible to keep the Wimpey No-Fines at a reasonable temperature, as demonstrated by 2 Hartleigh – however, it is not known what the energy cost of this is. Future work will involve a full study of the changes in energy bills.

Most properties show a close relationship between outside and internal temperature, there were high levels of variation on an hourly basis, suggesting properties do not hold heat

In order to better understand the control of temperatures within the properties, the internal and external temperatures for each property (living room and bedroom) are plotted. This shows how the temperatures internally vary the most in winter. This will be of particular interest to compare with in the post works report to understand if the temperatures control may improve.

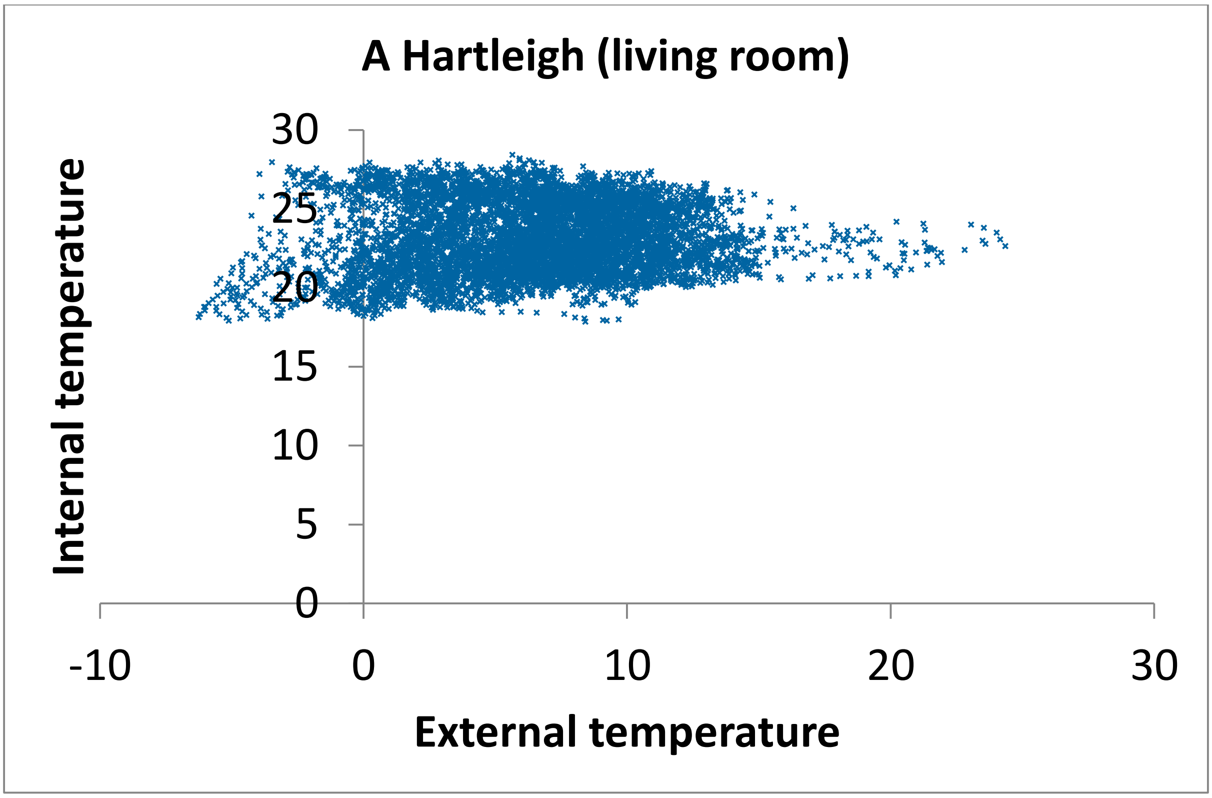

Figure 30: A Hartleigh Place – living room temperature data

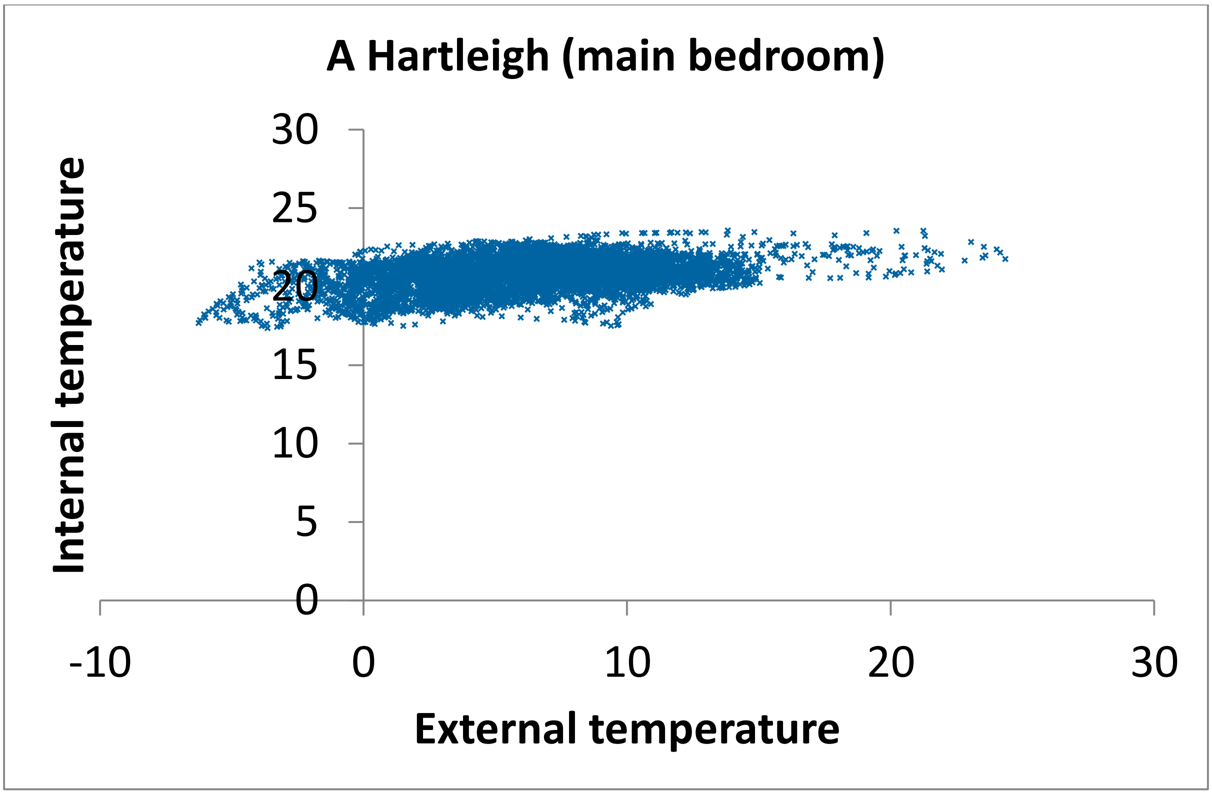

Figure 31: A Hartleigh Place – bedroom temperature data

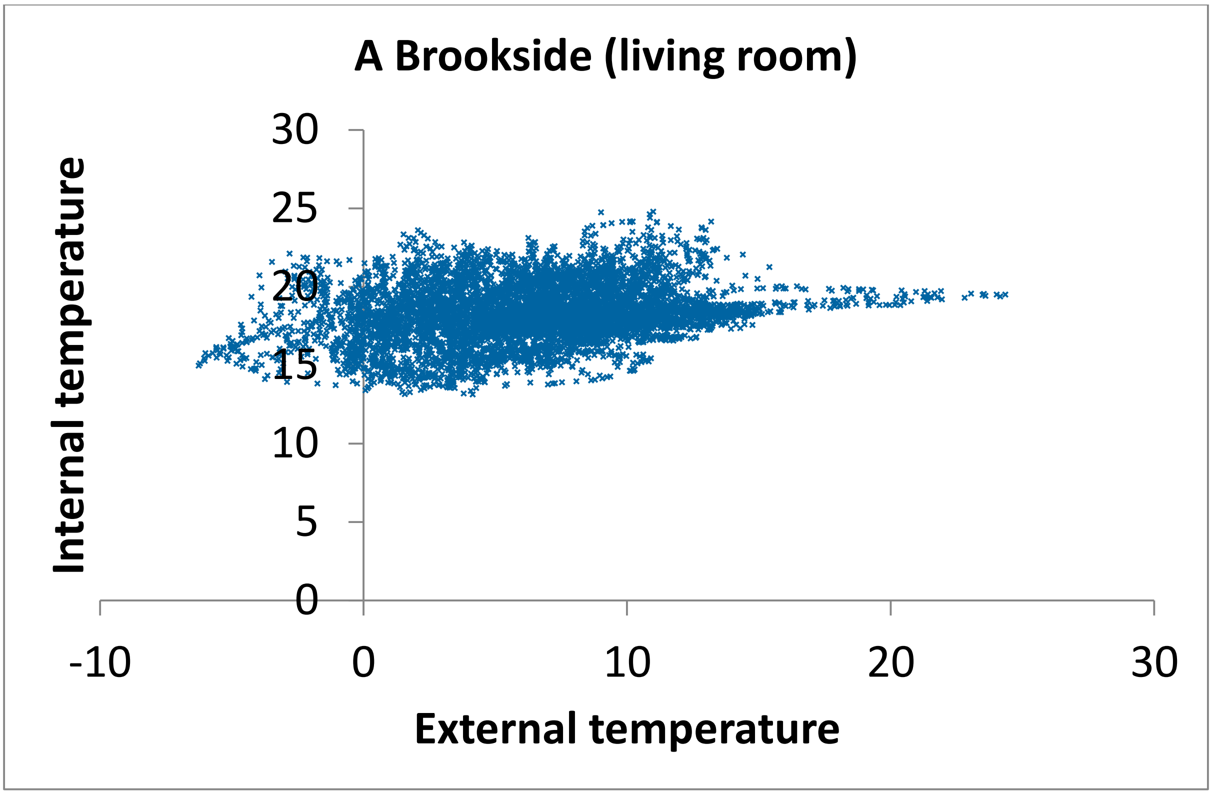

Figure 32: A Brookside – living room temperature data

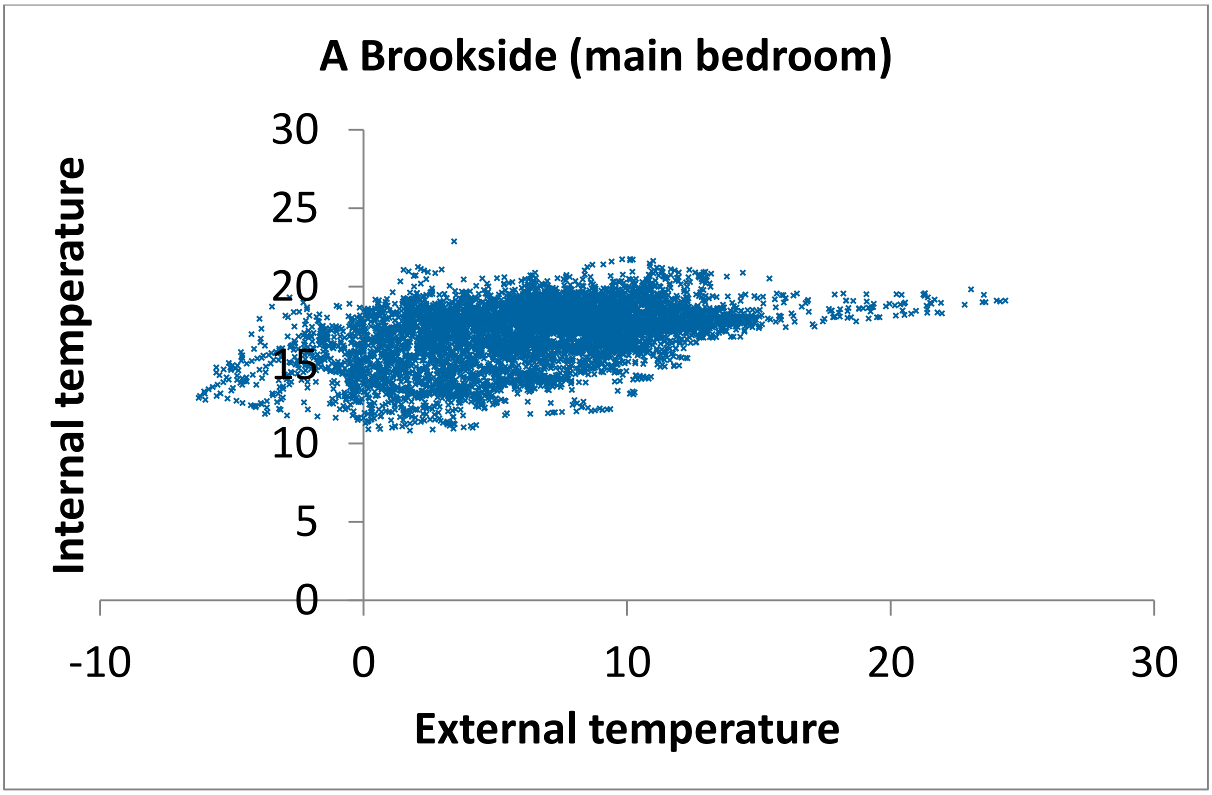

Figure 33: A Brookside – bedroom temperature data

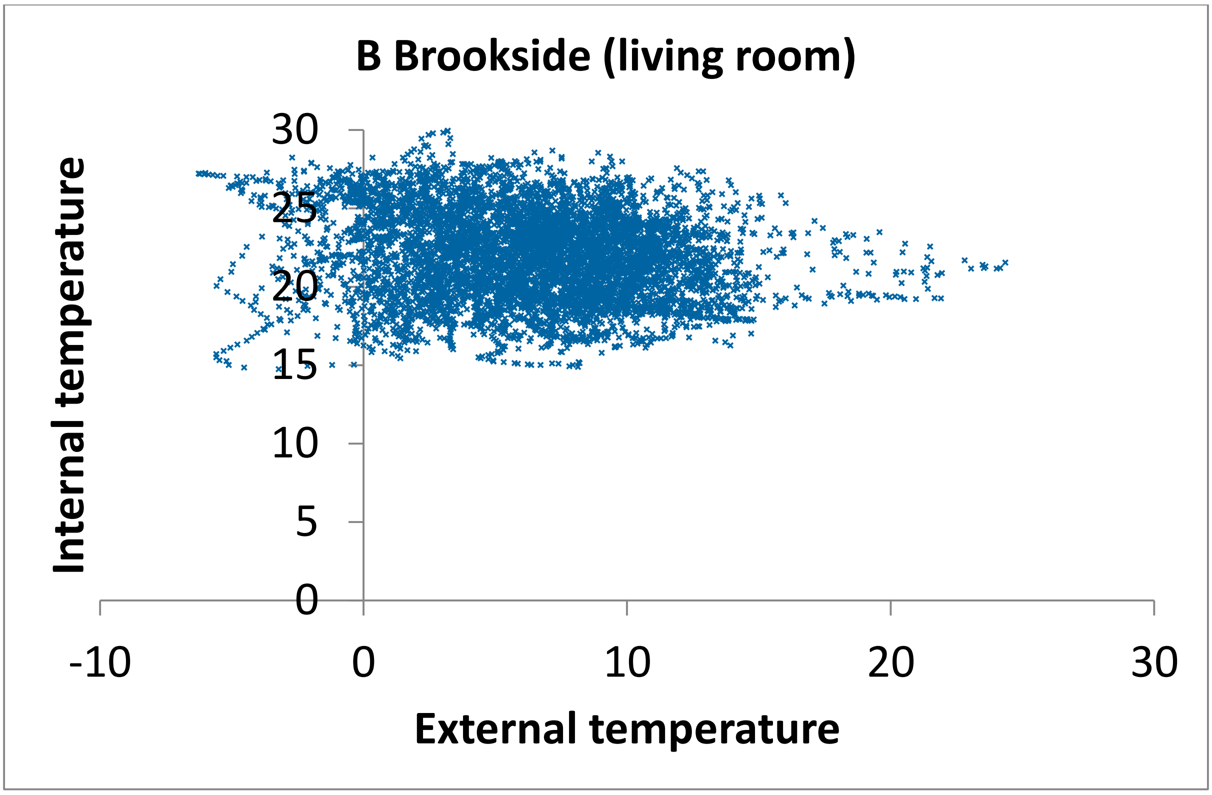

Figure 34: B Brookside – living room temperature data

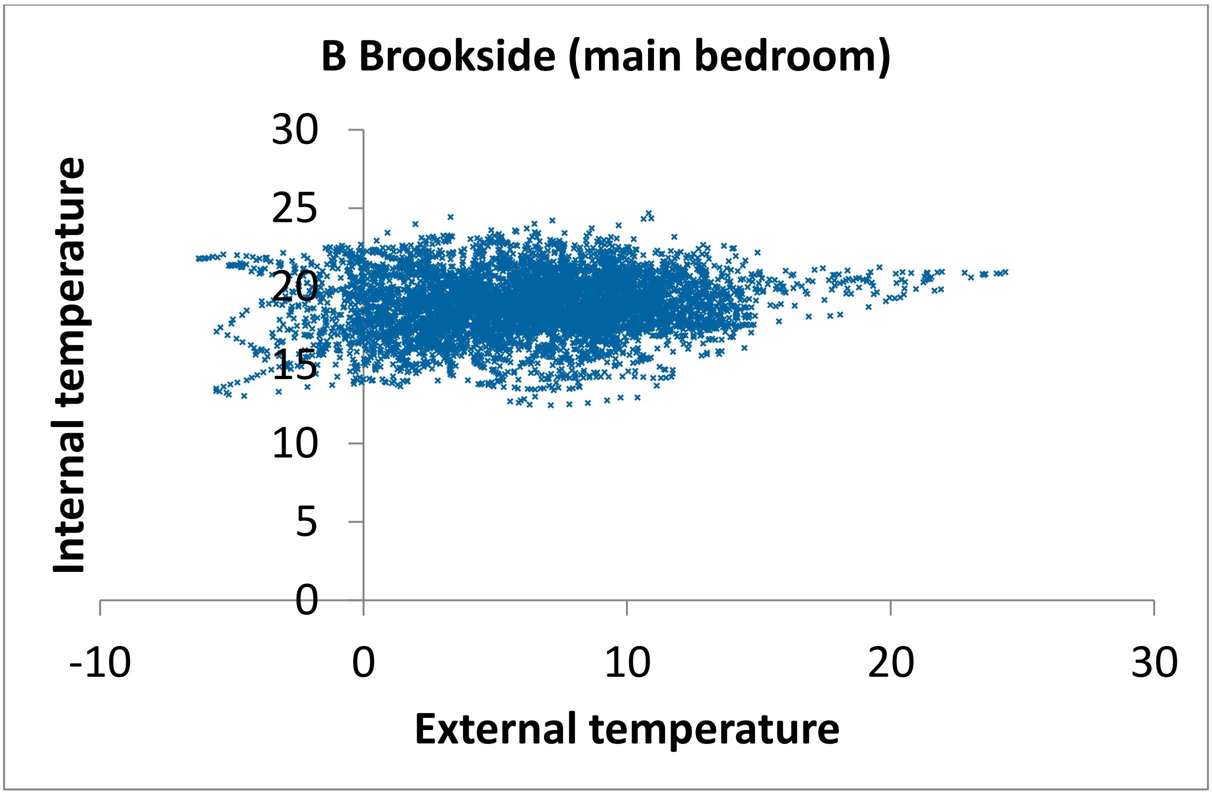

Figure 35: B Brookside – bedroom temperature data

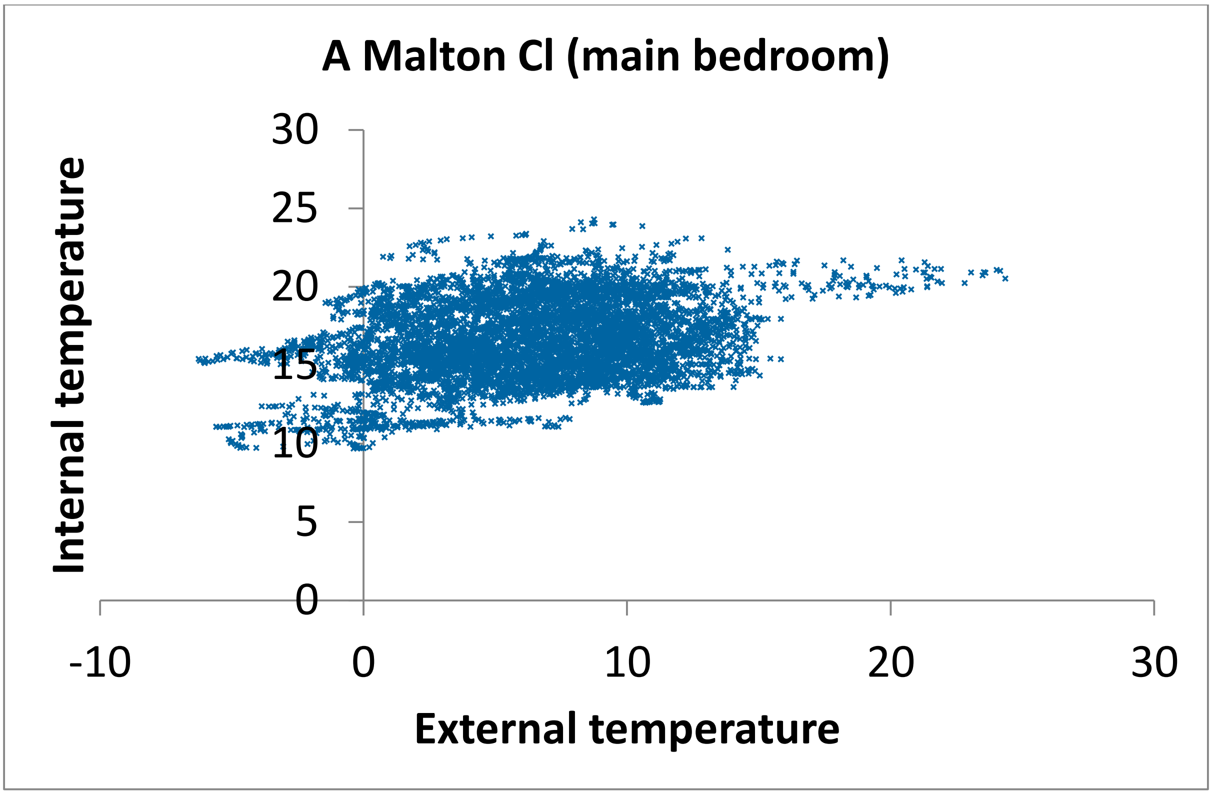

Figure 36: A Malton Close –bedroom temperature data

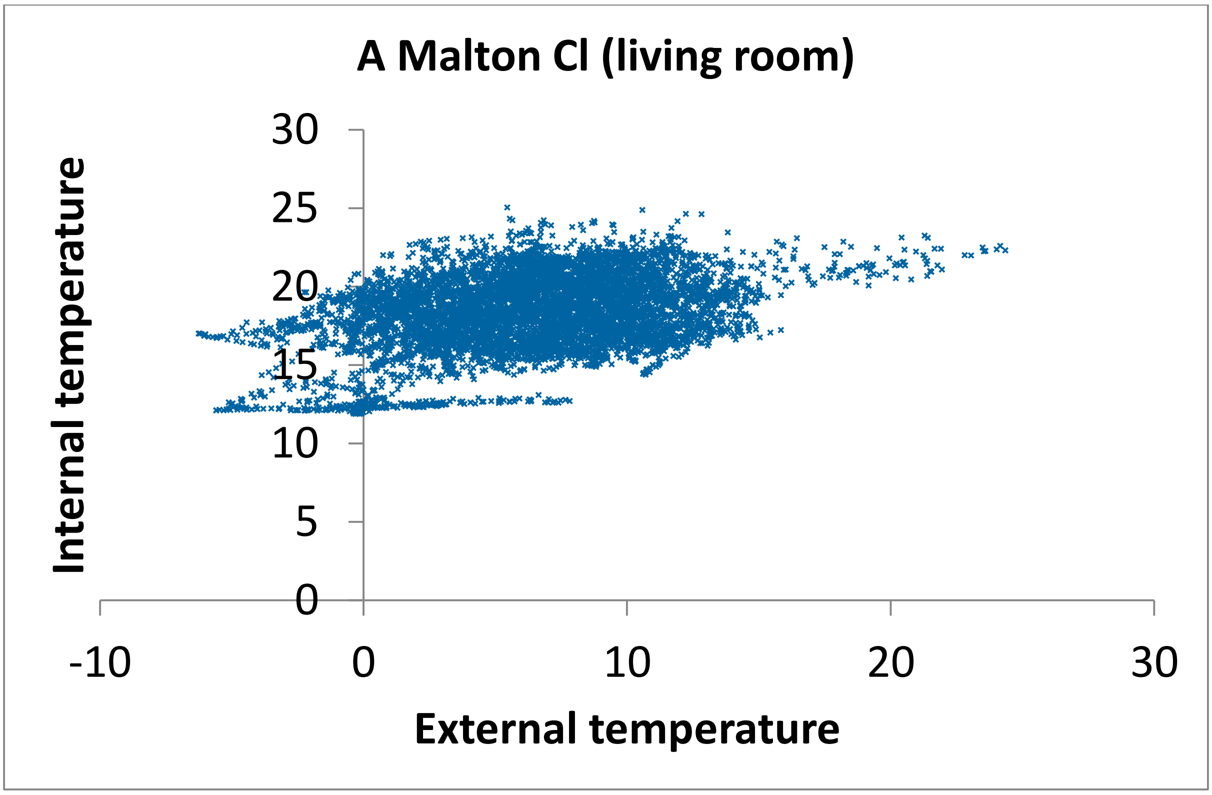

Figure 37: A Malton Close – living room temperature data

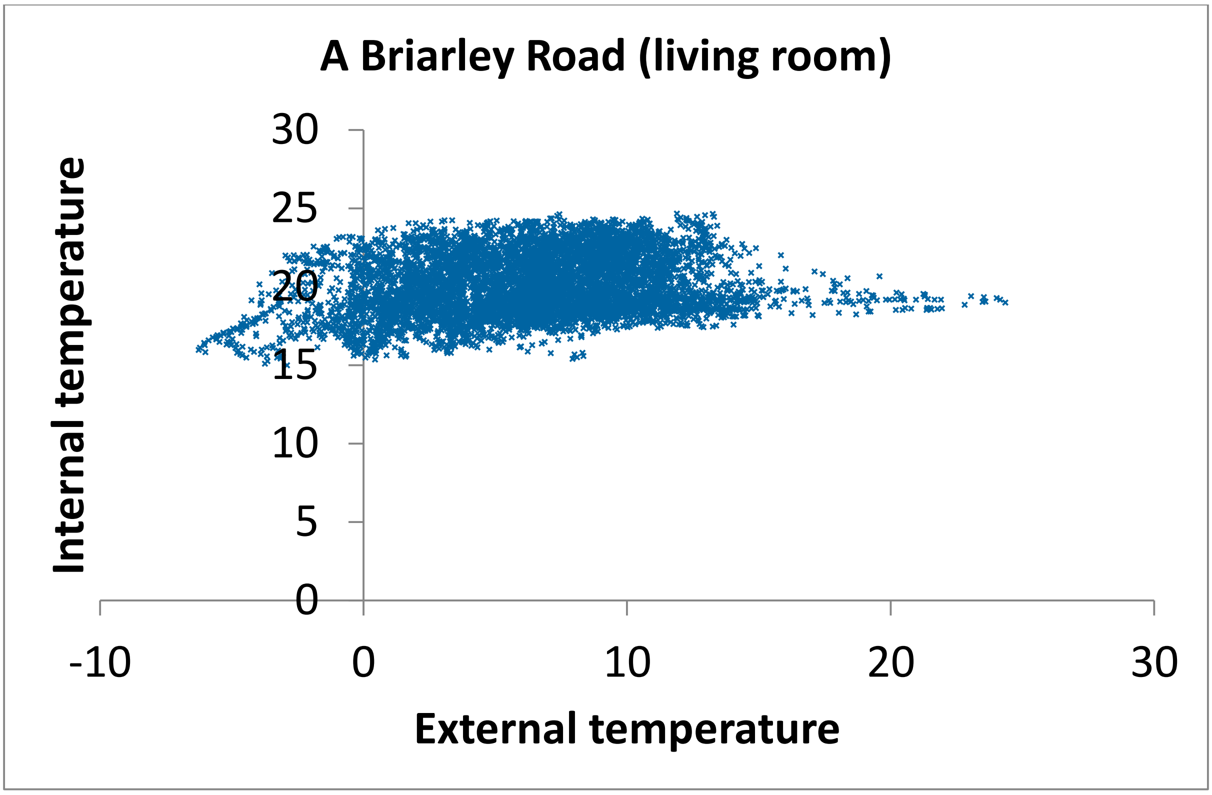

Figure 38: A Brierley Road – living room temperature data

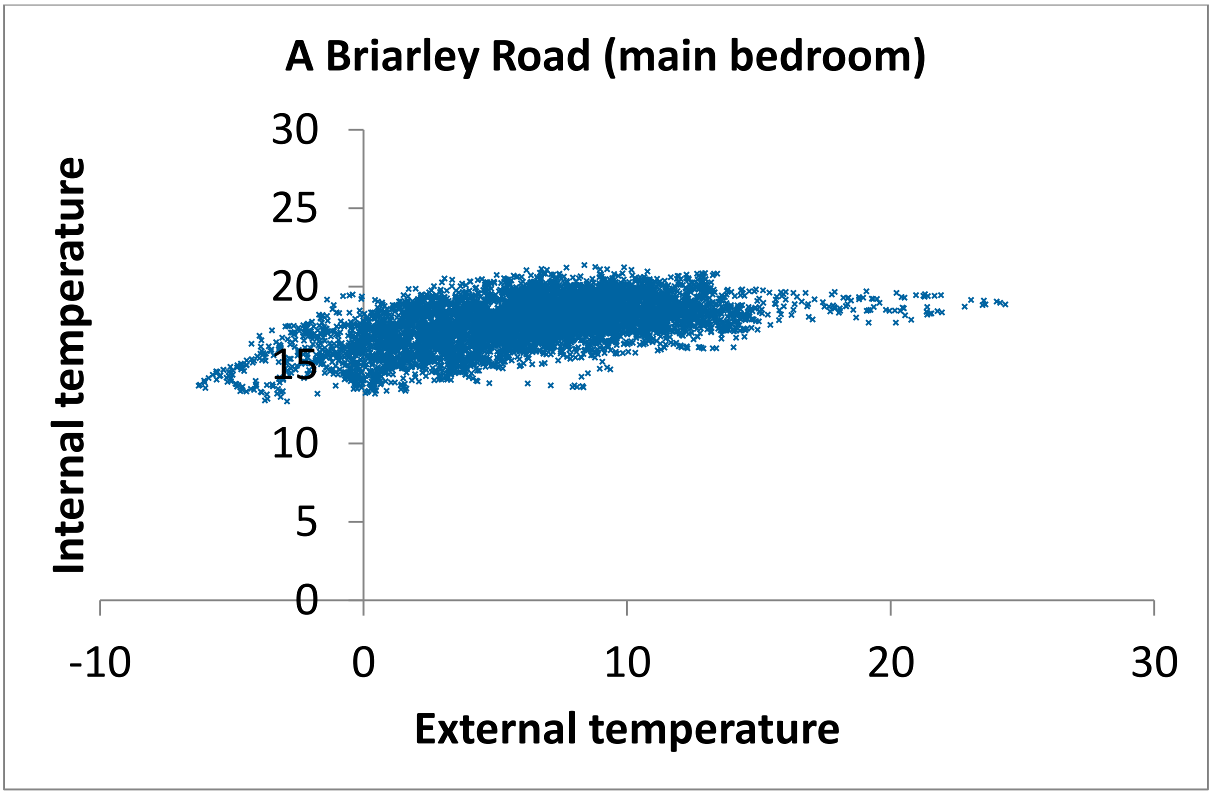

Figure 39: A Brierley Road – bedroom temperature data

14.2 South Tyneside Homes

South Tyneside did suffer from issues of loss of both internal and external loggers during the works. For future similar work we recommend that GPS systems are used on the loggers to reduce the loss rate. However, as with the Blyth data these all show similar issues of high variation in temperature, which suggests a low ability to control the heating of the properties. Internal temperatures ranged from 10 to 25°C, showing some residents will have been living in temperatures which could be considered unsafe. The High Rise loggers did show dramatic spikes for A Monastary Court, which showed the logger reaching a temperature of 40 degrees. As with the Tarran Newlands, some properties were cool, with one averaging at 15 degrees throughout winter.

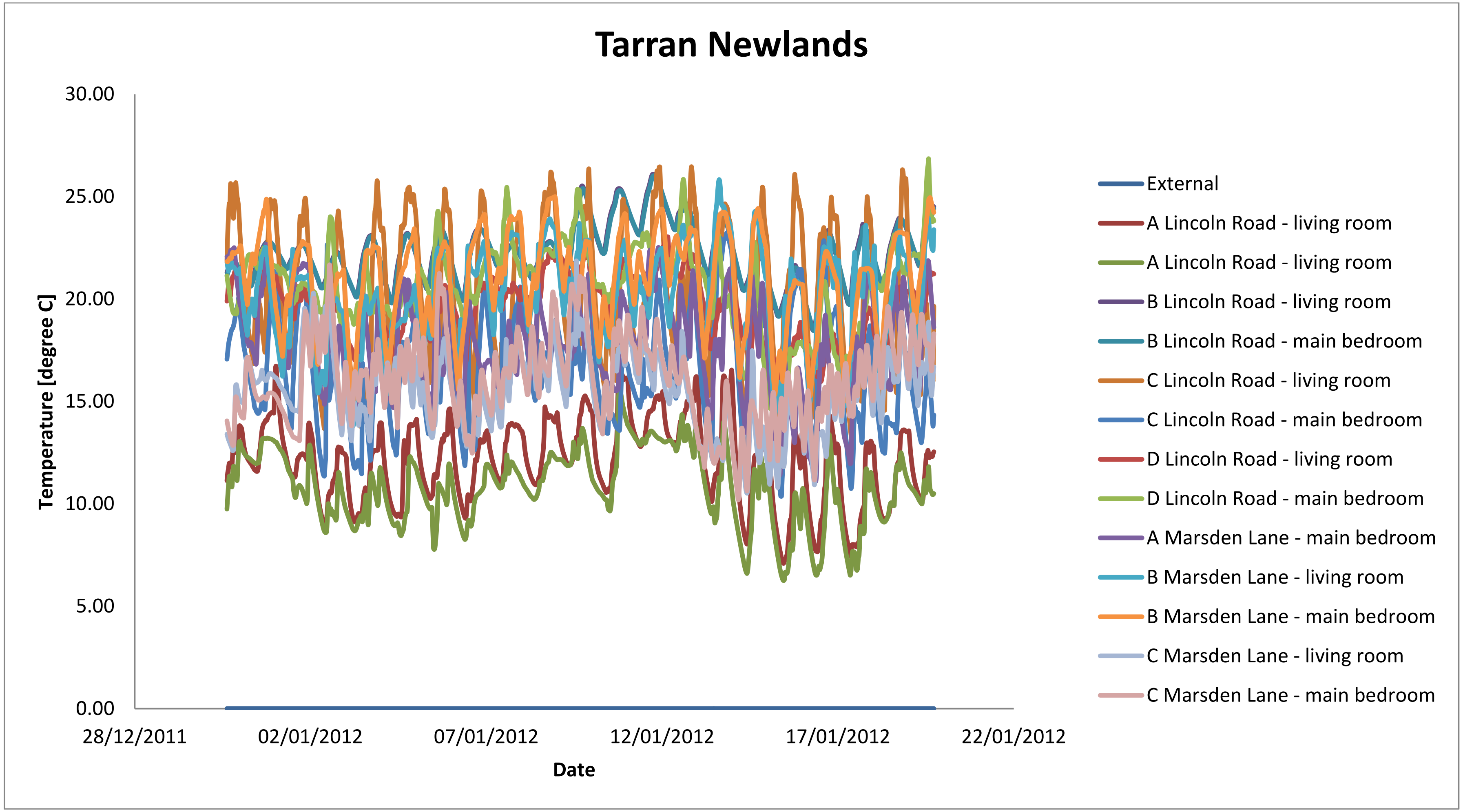

Figure 40: Tarran Newlands temperature data - anonymised

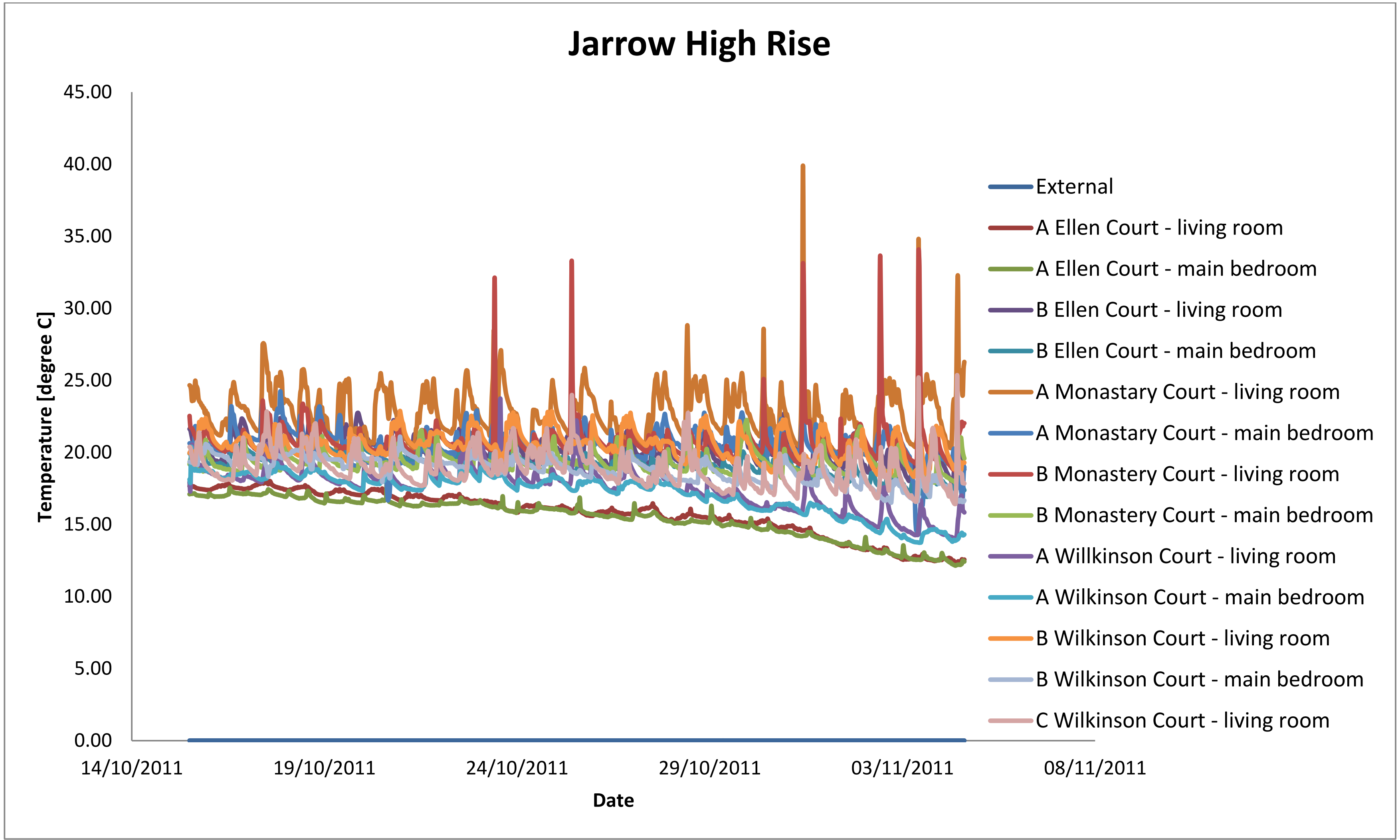

Figure 41: Jarrow High Rise temperature data - anonymised

15 Thermal models

Narec constructed thermal models of the three types of building to be worked on in this project. This was to find what the energy usage would be if they were heated to a reasonable level. It must be recognised that residents in these properties are not heating their dwellings to an acceptable and safe level due to a lack of finances. The models were built for before and after, to estimate what the energy demand of a well heated dwelling would be after the works. This was then compared with the actual present energy usage, to see if residents would be able to afford to heat their home to a safe level after the works.

These results will be compared with the actual data logger data from before and after, to find the accuracy of the models. This is important for understanding how thermal modelling can be used to design measures for prefabricated social housing.

IES<VE> is a software package produced by Integrated Environmental Solutions. Using this a CAD model can be built of a dwelling, including the heating system, and using local weather data from the ASHRAE database the energy demands over a typical year can be calculated down to a resolution of 6 minute intervals for a whole year. This includes effects from solar gain, fabric loss/gain and air infiltration. Weather details included are air temperature, cloud levels, precipitation and levels of solar irradiance.

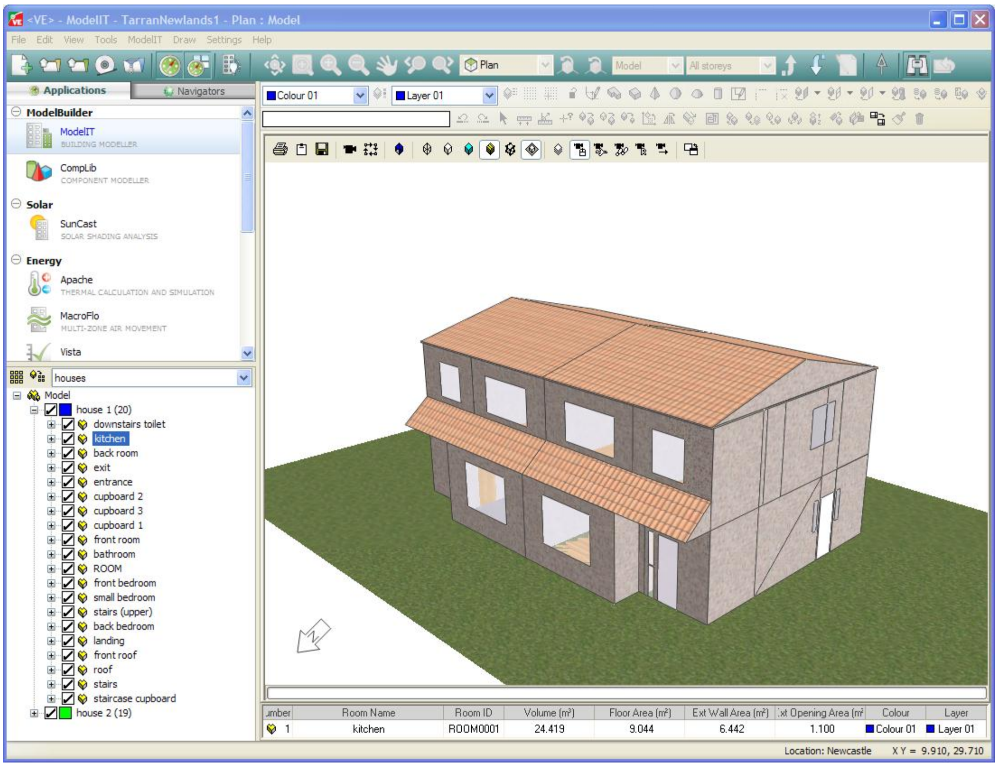

Figure 42: IES<VE> model

15.1 Wimpey No-Fines

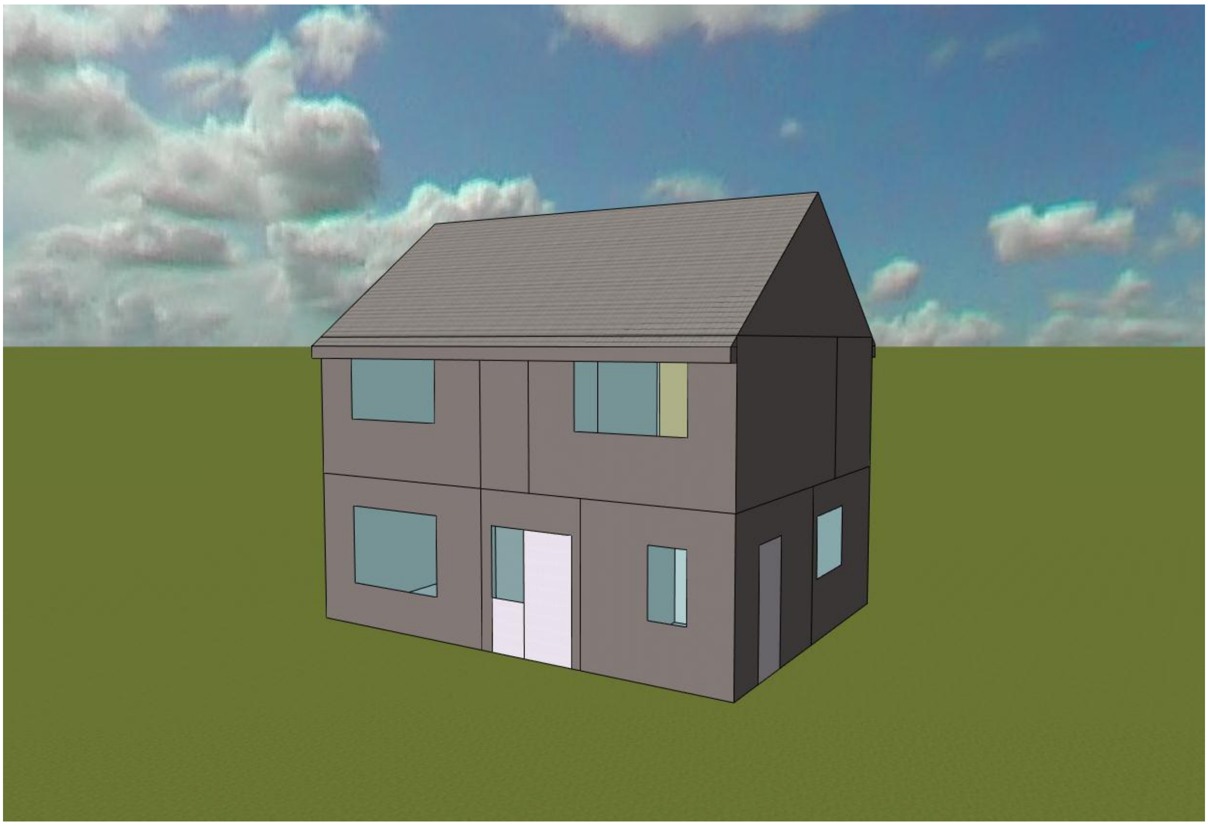

Figure 43: IES<VE> Thermal model of Wimpey No-Fines type A building in Blyth

There are three marginally different types of Wimpey No-Fine building which Homes for Northumberland introduced into this project. Of the three slightly different types of buildings, house type A was modelled. This is a semi-detached or end terraced building. An additional dummy building was modelled next to it to give the levels of insulations and cross flow between buildings that would exist in reality.

U-values were created using the different building constructions on IES<VE> which were most similar to that which the Wimpey No-Fines have. The loft was taken to have 100mm of loft insulation, which would be topped up to 270mm. 70mm of phenolic insulation board was placed on the outside of all walls. No other changes were made. Air change rates in these buildings are not expected to change, as the same windows and doors will be there. The roof and solid wall insulation may have an effect, and this will be quantified with the post works air tightness testing.

Item	W/m²K
External walls (before)	1.940
External walls (after)	0.441
Roofs (before)	0.358
Roof (after)	0.142
Internal walls	2.671
Internal ceiling	2.283
Ground floor	2.082
Doors	2.194
Windows	1.977

The living room was heated to 21°C whilst the kitchen, three bedrooms, bathroom and toilet were all heated to 18°C. All other areas of the property were left with no heating. The building was set at an angle of 40° east of South. This is the same as the angle on Brierley Road. Using the data from the air tightness testing, an air infiltration of 9.838 ach @ 50pa was used, which equates to 0.49175 ach at standard atmospheric pressure. The model included a 25kW condensing gas boiler
The models showed there was a substantial difference in the energy usage in the before and after states.

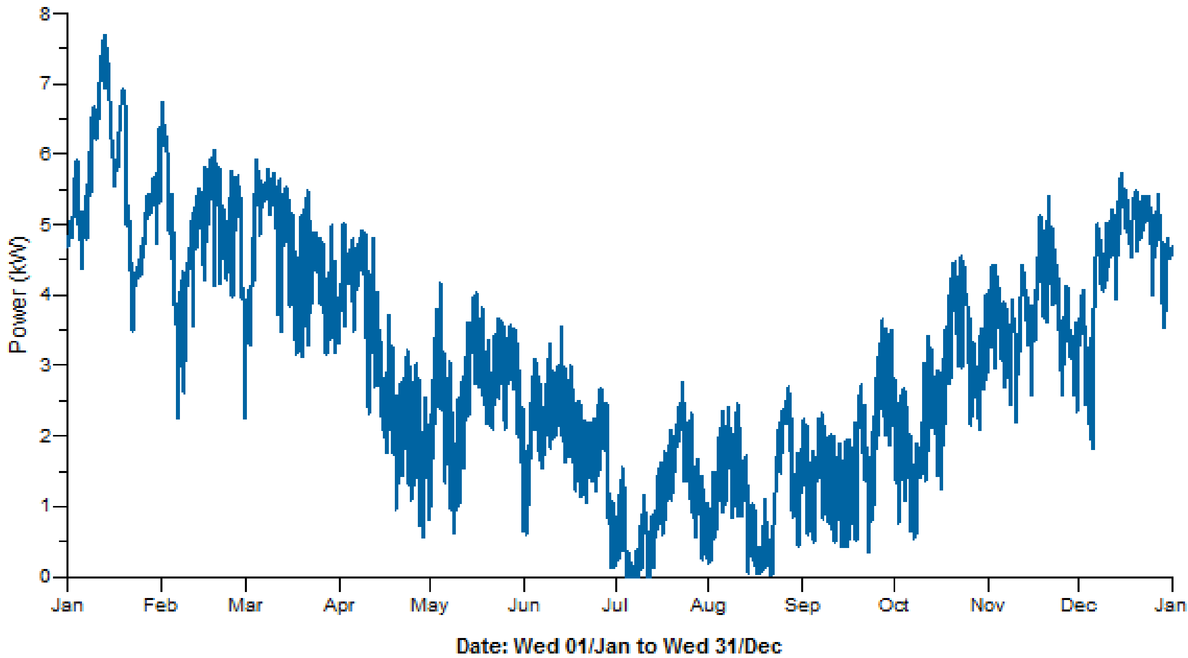

Figure 44: Wimpey No-Fines modelled space heating energy demand over one year - before improvements

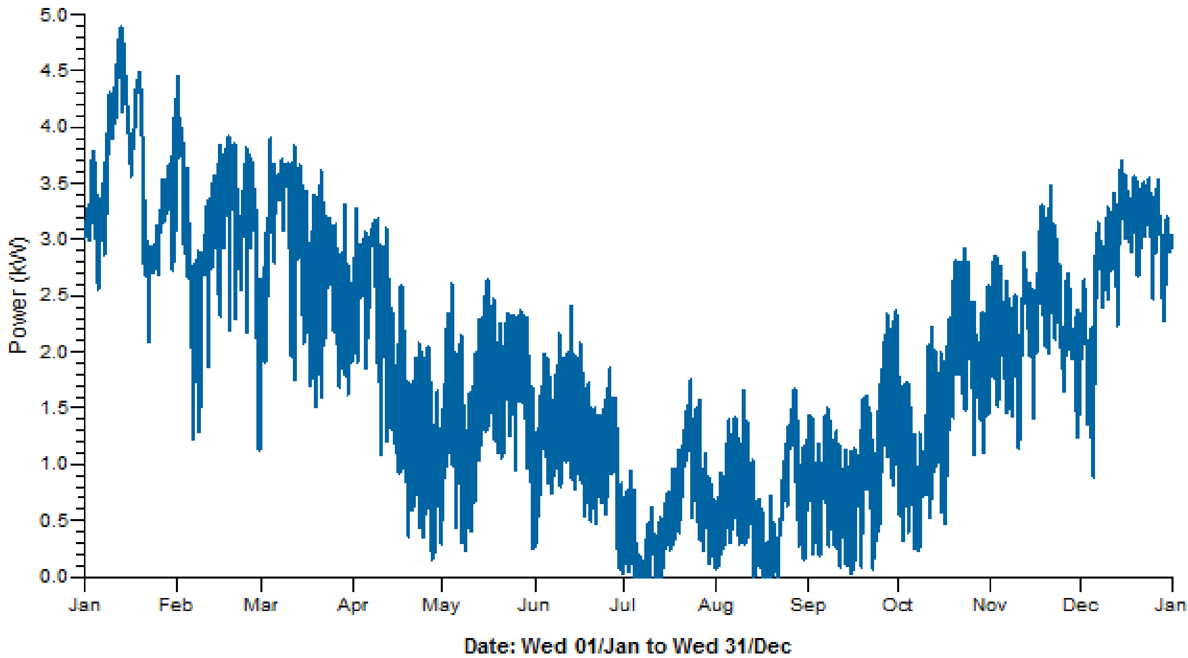

Figure 45: Wimpey No-Fines modelled space heating energy demand over one year after improvements

Before the insulation measures, the building had an energy requirement of 27.5597MWh/year. With the insulation measures this changes to 17.0022 MWh/year. Through simple insulation this had given an improvement of 62% in the energy performance of the building. The before figures compare well with the actual energy bill information from the Wimpey No-Fines residents.

15.2 Tarran Newlands

Figure 46: IES<VE> Thermal model of Tarran Newlands building in South Shields

Tarran Newlands were the buildings which, on site surveys, appeared to be the coldest. The buildings on Lincoln Road and Marsden Lane were near identical, with slight changes around the connecting doors between the living room and kitchens. As the buildings are all semi detached, a full semi detached unit of two buildings has been modelled.

As with the previous model, U-values were created using the different building constructions on IES<VE> which were most similar to that which the Tarran Newlands had. The loft was taken to have 100mm of loft insulation, which would be topped up to 270mm. 70mm of phenolic insulation board was placed on the outside of all walls. No other changes were made. Air change rates in these buildings are not expected to change, as the same windows and doors will be there. The roof and solid wall insulation may have an effect, and this will be quantified with the post works air tightness testing.

Item	W/m²K
External walls (before)	2.186
External walls (after)	0.287
Roofs (before)	1.595
Roof (after)	0.140
Internal walls	1.594
Internal ceiling	1.259
Ground floor	0.706
Doors	2.194
Windows (before)	1.977
Windows (after)	1.400

Table 8: U-values used in model

The living room was heated to 21°C whilst the kitchen, three bedrooms, bathroom and toilet were all heated to 18°C. All other areas of the property were left with no heating.

As the air tightness testing showed such a high rate, three models have been made for the Tarran Newlands, an initial model of before the works where the air change rate was 19.26m($h^{-1}m^{-2}$) @ 50pa, one where the air tightness has been improved up to the level of part L 2010, and a third model which includes the air tightness improvements and the fabric improvements to the buildings.

Scenario	Modelled yearly energy demand [kWh]	Approximate yearly bill (based on npower 2012 standard tariffs)
Current state of building	27,849	£981
Same building but with improved air tightness	22,053	£824
Full works	7,027	£417

Table 9: Tarran Newlands modelling results

These results correlate with the bill data, which showed the average bills in the Tarren Newlands to be £972 for gas. This suggests that residents will see a possible 75% reduction in bills from the building improvements.

15.3 High Rise

Figure 47: IES<VE> Thermal model of Wilkinson Court in Jarrow

Of all the buildings surveys, the flats in Jarrow appeared to be in the best condition. Those residents in the north facing flats commented how they were actually very warm. Generally residents in the south facing flats complained they were too cold. With this model, one floor of flats was studied, containing two small flats and two large flats. A dummy floor above and below was placed into the model, to ensure the flats under study acted thermally as they would in the full block of flats.

U-values were modelled using the known information of the constructions. As before, this meant the U-values were slightly different to those quoted, but within 10%.

Item	W/m²K
External walls (before)	0.375
External walls (after)	0.234
Internal walls	1.186
Internal ceiling	1.929
Doors	2.194
Windows (before)	1.977
Windows (after)	1.600

Table 10: U-values used in thermal model

The living room was heated to 21°C whilst the kitchen, three bedrooms, bathroom and toilet were all heated to 18°C. All other areas of the property were left with no heating.

Scenario	Modelled yearly energy demand [kWh]
Small flat before works	2,245
Small flat after works	1,484
Large flat before works	3,632
Large flat after works	2,662

Table 11: Jarrow High Rise modelled yearly space heating energy demands

These figures do seem quite low compared with the bill data. Reasons for this could be that the air change rates on flats are much higher in some of the flats, or that the model did not accurately take account of the high wind chill factor on the blocks of flats. However, the modelling does suggest a 51% reduction in space heating energy demand from the small flats and a 36% reduction from the larger flats.

15.4 Issues with models

A minor issue to note is that due to the way the IES<VE> models were set up, the addition of external insulation led to the models having a lower internal volume. With less internal volume to heat then the model energy demands would have been artificially lowered.

The weather profile used in this project is from the ASHRAE database profile for Newcastle. This will differ from the actual data as recorded by the external weather loggers, because not every year is identical.

16 Other Projects

There are other similar projects looking at hard to treat buildings. Narec will use information from these to inform the ERDF Social Housing Project, and also to disseminate the results of this work.

16.1 Energy Innovation for Deprived Communities

This programme is being delivered by a partnership of organisations throughout Yorkshire and the Humber. A total fund of £14.9m has been made available, of which £7m is being part-financed through the European Regional Development Fund (ERDF) as part of Europe´s support for the region´s economic development through the Yorkshire and Humber ERDF Programme.

The project will deliver a range of energy efficiency and renewable energy projects within at least 10 of the most disadvantaged communities across the Yorkshire and the Humber, creating 114 new jobs and safeguarding a further 87.

Areas involved are:

- Golcar (Kirklees)
- Chickenley (Kirklees)
- Eightlands, Dewsbury (Kirklees)
- Athersley (Barnsley)
- Wheatley (2 areas of Wheatley) (Doncaster)
- Lower Wortley (Leeds)
- Frodingham (North Lincs)
- East Marsh & Guildford (North East Lincs)

16.2 E2ReBuild

This project is funded through the European Multi-National Framework 7 Program. The vision of E2ReBuild is to transform the retrofitting construction sector from the current craft and resource based construction towards an innovative, high-tech, energy-efficient industrialised sector. In this project, new retrofit solutions in planning, design, technology, construction, operation and use of buildings are implemented, researched and evaluated. Solutions are demonstrated in 7 projects in Finland, Sweden, the Netherlands, France, Germany and the UK.

17 Next Steps

The next steps in this project are:

- Completion of improvements to all homes in the project
- Repeating the thermal imaging
- Repeating the infiltration testing
- Comparing the data loggers from post work to pre work
- Comparing fuel bills
- Understanding the changes in fuel poverty between the beginning of the project and the end of it, and the reasons behind this

These results will be in the post works report, to be published in September 2013

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19 Appendix A

Questionnaire for South Tyneside Homes 10%

Thermal Modelling Residents Questionnaire
Address:

1) What times are your heating set to come on and off?

	weekday	weekend
on		
off		
on		
off		
on		
off		
on		
off		

2) What temperature is your thermostat set to?

3) Are there any noticeable faults with your heating system?

4) What was last year's full gas bill?

£

5) What was last year's electricity bill?

£

6) Which rooms do you have the heating system turned on in?
(ie, radiators turned on etc)

7) Do you use any additional backup heating?
(for example an electric fire as well as central heating)

8) Have any changes been made to either the building or the heating system in the past year?

9) What is your annual household income?

£

10) How content are you with the warmth of your home?

Very content
Satisfactory
Inadequate

11) Do you ever turn off your heating to save money?

Yes
No

12) When is your property occupied?

Week days?
Weekends?
Evenings?

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