Centre for Sustainable Energy

Evaluation of solid-wall insulation in fuel poor households in the private sector

Interim report to eaga Charitable Trust

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We are a national charity that shares our knowledge and experience to help people change the way they think and act on energy.

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1 Executive Summary

Whilst the technical challenges of solid wall insulation (SWI) are widely acknowledged, there has been little exploration to date of the human barriers to uptake. These are likely to be substantial, given the disruption involved and the impact of measures on building appearance. To help address this knowledge gap, CSE, with funding from eaga Charitable Trust, has undertaken a thorough evaluation of a solid wall insulation scheme (Freedom From Fuel Poverty (FFFP)) delivered in the Bath and North East Somerset area.

The study comprises a qualitative evaluation of the experience of eleven households receiving the SWI measure. The evaluation was scheduled to run for at least one full heating season however due to delays in measures being installed through the scheme, work was not completed on some houses until early 2011. Consequently the study has been extended to run until spring 2012, with a full and final report to be completed in June 2012.

This interim report presents the headline findings to date with recommendations for practitioners, policy makers and others interested in the uptake of solid wall insulation systems. Our findings and associated recommendations are of three general types:

- Comfort and coping strategies amongst low income households living in homes with very poor fabric standards
- The impact on comfort and lifestyle from installation of SWI
- Householder experience of the installation process itself

Key findings are presented in boxed format in the body of the text so that they are contextualised. Recommendations are presented and discussed in the final part of the report. Both key findings and recommendations are summarised below.

1.1 Comfort and coping

Our study found a rich variety of behaviours, habits and practises as householders struggled to maintain comfort in homes that all had poor insulation standards, were usually leaky and sometimes had very poor heating systems as well. Comfort seeking strategies often involved heating the body rather than the space. In extreme cases these strategies severely compromised lifestyle, restricting activity within the home. In one instance even heating the body using sleeping bags was insufficient in keeping sufficiently warm so that the household was forced to leave the home altogether to spend parts of the day in warmer spaces. We also found that some strategies involving adjustments to heating controls or remedial efforts to prevent draughts sabotaged the design intent of the building, for example by blocking ventilation points or using thermostats as on-off switches. Although the logic of these practises was entirely understandable in the context of a home with a very poor fabric, prone to drafts, cold spots and sudden fluctuations in temperature it was evident that these practises potentially resulted in further energy wastage or other undesirable and unintended consequences such as increased condensation and damp.

Recommendation 1. Householders develop integrated clusters of habits, behaviours and beliefs in their efforts to maintain comfort. In homes with very poor fabric and control systems some of these may be actively wasteful of energy. These modes of practise are supported by wider normative beliefs around what is expected, modern, desirable etc. Consequently, policy makers should anticipate that SWI, an intervention having significant multiple impacts on the home's

thermal performance, will not only make households warmer - it will have potentially transformative effects on many aspects of lifestyle and even the beliefs underpinning certain lifestyle and energy consuming habits. This is likely to be particularly evident in households adopting extreme comfort seeking behaviours as a result of living in underheated homes.

1.2 Impacts of SWI

All households noticed changes to their comfort, lifestyle and even health as a result of the measure. Households often described their homes "warming up more quickly" whilst heat was considered to be dispersed more "evenly" throughout the home and the property thought to "hold the heat" for longer.

Although all noticed improvements to their comfort, in some instances the transformation was "massive" whilst in others effects were more subtle. In particular, in cases where the household deliberately underheated the home because of fuel cost concerns, we found that most or all savings from SWI were likely to be taken in improved comfort. Other households heated their home to desired comfort levels prior to the measure and therefore experienced the additional service provided by the SWI in more complex ways. In some instances there was even a sense that the home had become uncomfortably warm following SWI and therefore a downward adjustment of temperature settings had been required. In all instances where households heated their home to comfortable levels prior to the measure, our study found behavioural responses to SWI which should deliver energy savings.

Recommendation 2. Unlike some energy efficiency and micro-generation measures, impacts of SWI on "liveability" and comfort in the home are noticed by householders and can be profound, especially where homes are underheated prior to the measure. Scheme designers and policy makers should maximise awareness of these multiple benefits as part of social marketing strategies supporting mass rollout of SWI systems.

The study highlights that comfort taking from energy efficiency interventions is a continuum: even in fuel poor households all potential savings from the measure will be taken as comfort in only a minority of cases. The majority will fall somewhere between the two extremes of 100% comfort taking and 100% bill savings. As such, the actual impact of SWI at any one property is very difficult to predict. Wide disparity in comfort taking amongst fuel poor groups could result in situations whereby otherwise identical households are differently eligible for green deal finance even with ECO subsidy.

Recommendation 3: In formulating Green Deal policy these findings highlight the importance of considering what constitutes a "saving" against the counterfactual case i.e. a situation where the household is either comfortable or is underheated prior to the SWI measure. Given dramatically different rates of comfort taking amongst fuel poor groups the finding presents a case for deeming SWI savings and setting eco subsidy rates accordingly - rather than attempting to account for differences in personal norms and preferences and consequent comfort taking rates when deciding green deal eligibility.

The study found that the SWI systems markedly reduced the sense of draughtiness. This is, of course, a positive outcome. However, because of very poor fabric standards in some properties, we found a number of undesirable practices had developed to counteract drafts, specifically taping up

or blocking off controlled ventilation points. In all likelihood these practises will continue post SWI installation out of habit or lack of awareness that the remedial measure is no longer appropriate.

It is known that SWI will increase the moisture content of the air as it will tend to be warmer as a result of the measure therefore it is particularly important in this instance that controlled ventilation points are allowed to operate as intended in order to avoid a marked increase in condensation problems on cold bridges.

Recommendation 4: Because of a) unanticipated potential effects of SWI such as increased likelihood of condensation formation and b) various maintenance aspects which differ from conventional external wall treatments e.g. painting and susceptibility to damage from point loads we feel that SWI systems should come with a user guide, "living with your new insulation" and/or a requirement to give verbal advice to the householder once the system is installed. This should mitigate potential issues and allow householders to get the best from the systems.

By making the home more comfortable, warmer and liveable a range of impacts on health, social dimensions and lifestyles of the households were found. Several respondents reported improvements to their general wellbeing as a result of the measure with fewer coughs, colds and flu events. Households were also more disposed to spend time at home and to bring others to their home.

The SWI also had a number of unanticipated benefits such as making the home quieter and having a noticeable impact on occupants' sense of comfort in summer months: homes were thought to be cooler and more comfortable. This may reduce or eliminate the need for supplementary cooling using fans and other devices and therefore modest energy savings may result. A final major benefit that had not always been anticipated was in the marked improvement in appearance of the property (both on the outside with EWI and inside with IWI) and the reduced maintenance requirement. This particular aspect was heavily praised by scheme participants.

Recommendation 5: Because of its impact on the appearance of a property, solid wall insulation lends itself to marketing as a 'home improvement' measure to a much greater extent than other energy efficiency measures which may be invisible. Branding it this way should enhance its appeal to householders and better portray the nature and cost of work involved which can be extensive compared to other insulation measures.

1.3 The installation process itself

One of the key challenges of the scheme was in identifying and reaching the target audience (i.e. the fuel poor). Even once identified and targeted with the offer the take up of measures was very slow. This was linked to the unusually high grants being offered – the 'too good to be true' notion – and the low income status of the target audience meant they were particularly risk averse. Having council endorsement of the scheme was important here, particularly in reassuring the older customers on the scheme.

Recommendation 6: Amongst low income and consequently risk-averse groups some sort of official endorsement of the scheme, for instance by a local authority should be in place as this could be critical to uptake.

Several different approaches were used in marketing the scheme including advertising in local papers and taking referrals through the EST advice centre. The most successful marketing technique,

however, proved to be a doorstep flyer drop by a B&NES Council Officer in an area where solid wall insulation was being installed in some social housing. The directness of this approach, combined with the 'first hand' experience of householders in seeing the work carried out on neighbouring properties appeared fundamental to uptake of the grant offer in this area.

Recommendation 7: Our findings suggest that an area-based approach to future solid wall insulation could be effective. The high visibility of SWI could be exploited as a motivating and reassuring factor in promoting uptake (see recommendation 5). This could be maximised by the use of information boards/leaflets at sites where work is in progress.

The FFFP scheme specifically set out to test the effectiveness of solid wall insulation and solar installations in helping hard-to-treat households in fuel poverty. However, it was fully acknowledged by scheme managers that these did not always represent the most cost effective energy efficiency measures.

Recommendation 8: Future schemes should be designed such that the most cost effective measures are applied in sequence, and the householder is lifted out of fuel poverty at minimum cost. However, the order of measures would also need to make sense from a practical point of view– i.e. windows at the same time as external wall insulation, radiators at the same time as internal wall insulation, etc. This would require multiple trades on site as well as significant project management of the works on a house by house basis.

In particular the FFFP scheme highlighted that there may be numerous unforeseen additional costs to SWI (structural or survey related). When considered in addition to known high costs of the SWI measure itself (and the relatively small financial savings) then SWI status as a "next most cost effective measure[1]" unlikely to meet Green Deal Golden Rule requirements is clear.

Recommendation 9: Green deal providers should consider the value of installing packages of measures in combination, to deliver additional savings/revenue (i.e. from FIT and RHI) to subsidise the costs of most expensive measures that won't deliver the Golden Rule on their own.

An issue raised by several customers in this evaluation related to on-site and overall scheme management. SWI necessitates a number of different trades being on-site to complete different elements of the work. On-site management is a key factor in ensuring each element is delivered in a timely and orderly manner, and the finish is to both the customer and contractors satisfaction. This is particularity relevant with solid wall insulation which, much like cavity wall insulation in its early days, seems to create an uncertainty with customers who feel that the potential risks do not outweigh the benefit.

Recommendation 10: Ensuring contractors have formal process for onsite project management with a single point of contact for the SWI recipient will make a significant difference to the customer journey in many cases. While smaller companies might argue this sort of structure can be restrictive, being contractually bound to a process should help all the necessary project requirements be fulfilled.

[1] Extra help where it is needed: A new Energy Company Obligation. DECC 2011. http://www.decc.gov.uk/assets/decc/what%20we%20do/supporting%20consumers/green_deal/1732-extra-help-where-it-is-needed-a-new-energy-compan.pdf

1.4 ..and the final result

In the main this qualitative study has found uniformly positive attitudes to both the experience of installation of SWI and its subsequent impacts on comfort and lifestyle. The only exceptions to this general sense occurred when a period of extreme cold weather extended the work in some instances for much longer than originally anticipated. All respondents stated that they would recommend the measure (both EWI and IWI) to others, whilst expounding clear and tangible benefits to comfort, financial savings, health and even the appearance of the home. These findings must be seen in context of a sample which was offered the measure for free. Nonetheless, it seems clear that SWI offers multiple benefits and that the disruption entailed by the installation process itself need not, if carefully managed, be an undue restraint on mass SWI rollout. The study has identified a number of ways in which the unique characteristics of SWI may be harnessed to this effect.

"We're just feeling a lot more comfortable in here and it was just a bit depressing before..now at least you know when you do put your heating on its making a difference and the children haven't been so ill." (C24)

Warmer…

"I'm just very, very happy. It's beyond what I thought it was going to be. I thought, Well it might be just a little bit warmer, but it's completely different" (C.32)

Health benefits…

…And Cooler

"Until it was done, you don't realise how cold it was and how warm it was. That's the thing, because when we had that hot weather, I said to my husband, [who used to really suffer from the heat] 'it's not so hot in here anymore', and he said, 'no, it's lovely'". (C.34)

Potential bill savings…

"I've not had to have the heating on for two weeks now. So even when it has felt cold I haven't put the heating on at all which has been brilliant so hopefully I'm going to save an absolute packet on my heating bills." (C53)

Looks nicer...

…A facelift for the exterior

…and a lick of paint for the interior

"We thought that maybe it would make the rooms look a lot smaller but it doesn't…we haven't noticed the loss of space at all. In a way it, kind of makes them look a bit bigger. I don't know whether it's because they're painted white or whether the windows look deeper set, so it just make the room look a bit bigger." (C.24

Quieter…

"I'll tell you something else; it's not so noisy either. We can't hear the things outside so much. It's insulated the walls so we don't hear so much traffic." (C. 34)

2 Introduction

2.1 Background

The UK faces a major challenge over the next decade in tackling fuel poverty. Schemes to reduce fuel poverty and carbon emissions have typically been focused on cavity wall insulation as their main technical solution but, of the 24.5 million homes in the UK, almost nine million (36%) have no cavities. Whilst solid wall insulation work has been undertaken in the social housing sector, there has been very little experience of promoting, funding or managing schemes for private housing, let alone evaluating their impact. The Community Energy Saving Programme (CESP) and Pay as You Save (PAYS) pilots for whole house refurbishment provide more experience of the costs and technological solutions required to tackle private solid-walled housing. However, neither programme has a specific focus on tackling fuel poverty – indeed the loans provided through the PAYS pilots are likely to be largely targeted at able to pay groups – and there has been no detailed evaluation.

The delivery and financing of energy efficiency, sustainable energy and fuel poverty objectives in the UK's housing stock is undergoing a significant change. The Energy Bill[2], introduced into the House of Lords in December 2010, sets out the Government's broad plans for this new policy framework under the banner of the Green Deal, which aims to:

"create a new financing framework to enable the provision of fixed improvements to the energy efficiency of households and non-domestic properties, funded by a charge on energy bills that avoids the need for consumers to pay upfront costs." (Energy Bill 2011 Brief[3])

The basis for this no upfront cost is driven by the 'Golden Rule' – that is "the *expected* financial savings must be equal to or greater than the costs attached to the energy bill". The extent to which these savings will (a) be calculated and (b) be realised in practice is fundamental to the success of the programme.

Acknowledging that there will be limited scope for some households to save on their energy bills – particularly low income and vulnerable households (who are likely to be under heating) and hard-to-treat properties that require the more expensive, less cost-effective measures - the Government plans to incorporate into the Green Deal a new obligation on energy suppliers – the Energy Company Obligation (ECO) - that will succeed existing policies in delivering carbon emissions reductions and fuel poverty targets (i.e. CERT and CESP, which cease at the end of 2012). With the demise of Warm Front from 2013, the ECO will therefore be the primary mechanism for addressing fuel poverty and delivering energy efficiency measures to low income and vulnerable households. Within this, there is a key aim of stimulating the market for solid wall insulation:

"[The ECO] will focus particularly on those householders (e.g. the poorest and most vulnerable) and those types of property (e.g. the hard to treat) which cannot achieve financial savings without an additional or different measure of support." (Energy Bill 2011 Brief: Energy Company Obligation[3])

[2] http://services.parliament.uk/bills/2010-11/energyhl.html
[3] Department for Energy and Climate Change (2011) Energy Bill Documents. Available at: http://www.decc.gov.uk/en/content/cms/legislation/energy_bill/energy_bill.aspx

2.2 'Freedom from Fuel Poverty'

In 2009 Bath and North East Somerset Council (B&NES) launched a new, pilot grant scheme - *Freedom from Fuel Poverty* (FFFP) - aimed at providing free solid wall insulation, solar hot water or solar photovoltaic systems to people living in fuel poverty. The scheme, managed by the Centre for Sustainable Energy (CSE), initially aimed to fully fund solid wall insulation measures in 14 eligible homes in the area. Due to higher than expected installation costs, this had to be reduced to eleven households. Although modest in scale, the scheme was particularly innovative in aiming to install external and internal solid wall insulation systems into privately owned homes of varying construction types.

Whilst the technical challenges of solid wall insulation are widely acknowledged, there has been little exploration to date of the human barriers to uptake. These are likely to be substantial, given the disruption involved and the impact of measures on building appearance (external insulation) and room size (internal insulation). If the householder experience of solid wall insulation retrofit is not properly understood, there is a risk that national solid wall insulation schemes will be undermined, especially if a lack of sensitivity to householder needs translates into growing resistance to such schemes. This is particularly pertinent given the direction UK Government energy efficiency policy is moving, as discussed above.

To help address this knowledge gap, CSE, with funding from eaga Charitable Trust, undertook a detailed and thorough evaluation of the FFFP scheme. To ensure sufficient time to experience any impacts of the insulation, on both thermal comfort within the home and on household energy bills, the evaluation was scheduled to run for at least one full heating season. Due to delays in measures being installed through the scheme, work was not completed on some houses until early 2011. As such, the study has been extended to run until Spring 2012, with a full and final report to be completed in June. This interim report presents the headline findings to date.

2.3 Aims

The main aims of the evaluation are to:

- Describe the impact that solid wall insulation can have on fuel poverty, home energy use and carbon reduction;
- Describe the experience of solid wall insulation schemes from the householder's perspective, identifying the issues and obstacles that will affect wider roll-out;
- Encourage other insulation scheme providers to use and learn lessons from this scheme.

2.4 Objectives

The main objectives are to:

- Assess the impact of the measures on participating households' interior temperatures, fuel costs and carbon emissions;
- Describe the impact of the measures on householders' behaviour including effects on the use of heating systems and room occupancy, and indirect effects such as changes in daily routines, social life, spending patterns and the strategies employed to cope on a low income;

- Assess the impact of the measures on the relative cost of fuel within household budgets (and therefore on fuel poverty status), taking account of any changes in coping strategies and other household needs;
- Describe the impact of the measures on householders' comfort, health and quality of life;
- Describe householders' experience of, and attitudes to the measures, before, during and after installation and their assessments of the costs and benefits of the scheme;
- Identify issues that may enable or inhibit wider delivery of solid wall insulation schemes;
- Collate, publicise and disseminate findings, promoting best practice in delivering grant schemes for solid wall insulation in private sector homes.

3 Methodological approach

This is a wholly qualitative study. Its aim is not to seek statistically robust evidence through large sample sizes but to gain a richly detailed understanding of the experience of a small number of households having solid wall insulation installed. Our approach is described below. This covers the process of household recruitment, household eligibility assessment, installation and final evaluation. The first two of these were administered by the scheme managers, but all findings have been made available for inclusion in this evaluation[4].

1. Recruitment of households

Households were recruited to the scheme via referrals and local advertising in Bath and North East Somerset. Full participation in the evaluation study was a condition of recruitment. The incentives for households were considerable as the entire package of measures was provided at no cost. All households referred to the scheme underwent an initial telephone survey to establish eligibility. Eligible households then had a full site survey, upon which recommendations for measures were based.

2. Household energy surveys and SAP assessments

Each participating household was subject to detailed surveys of the energy performance and fabric condition of the home to give a SAP rating before and after the installation of the measures. Recommendations for measures were made based on the site survey and a quote for works drawn up for approval by B&NES. Once approved, any necessary planning applications were submitted for the works, and, once consented, the contracted installer agreed a start date with the client.

3. Analysis of household fuel consumption and bills

CSE has collected data on actual (based on household utility bills and on-site meter reads) and theoretical (SAP-based) household energy consumption and related costs before and after the installation of measures. This, combined with data on household income, was used to assess changes in fuel poverty status and carbon emissions resulting from the scheme. In addition, internal temperature loggers were installed in all households once measures were in place.

4. Qualitative investigation of behaviour, attitudes, experience

Three sets of face-to-face interviews have been conducted with all householders participating in the insulation scheme[5]. Interviews were conducted in the customers' home, and all were audio recorded and transcribed.

Pre-installation interview

The first interview was carried out once a start date for work had been agreed, but prior to the installation of any measures. This initial interview takes a broad view of householders' lives, describing their strategies for keeping warm in winter, the trade-offs they make between heating and other living costs, the effects of cold interiors on their well-being, their attitudes to energy-saving and their expectations of the changes that the measures will bring. Householders were also asked to complete a short questionnaire (Annex I) in order to gain an indicative measure of pre-

[4] A full report on the delivery of the scheme is available at:
http://www.cse.org.uk/downloads/file/freedom_from_fuel_povert_final_report.pdf

[5] Only properties that had insulation work carried out were included. Two of these also had photovoltaic panels fitted. Seven properties receiving only PV or solar hot water were not included in this evaluation.

installation knowledge, attitudes and behaviour. Each interview lasted approximately 30 to 60 minutes.

Post-installation interview

The second round of interviews, conducted after the installation of measures, explored the householders' experience of the installation process and any specific problems encountered. Interviews were conducted within one month of the certificate of completion of works being received by CSE.

Final impact evaluation interview

The final round of interviews to explore the impact of the measures on all aspects of householders' lives, including changes to behaviour, health, well-being and household finances over the winter period, was initially scheduled to take place in Spring 2011, to allow customers to experience a full heating season with the insulation. However, due to delays in the installation process (largely weather-related), some households did not have the work completed until early 2011, thus would have had only a limited time to experience any impact on thermal comfort and energy bills. As such, the final round of interviews will now be conducted in Spring 2012. However, recognising the policy relevance of this study, an "intermediate" final interview was conducted with all households in June 2011 to feed-in to this interim report. This interview focused on exploring any changes in how householders heat their home, their level of comfort and any other impacts of the insulation work. The questionnaire conducted in the first interview was also repeated and data from the internal temperature loggers downloaded for analysis (devices were then reset and left with the customer for retrieval at the final interview in 2012).

Analysis and results

As noted above, a full report on the Freedom from Fuel Poverty scheme has been produced by the scheme managers[6]. Whilst we do not wish to duplicate in the presentation of material, some of the findings from their report are presented here, to provide a complete overview of all measured impacts of the scheme.

Whilst some figures are presented in this report, it is important to bear in mind the nature of this pilot scheme and evaluation, in terms of both scale (n=11) and target audience (fuel poor households). However, whilst findings are based on only a small and specific sample, and as such not considered generalisable to the population as a whole, we do not feel this detracts from the importance of lessons learned and the recommendations that stem from each customer's experience: the methodology employed has generated a wealth of data (summarised below) about each household participating in the scheme and all elements have been drawn upon as far as possible in writing this interim evaluation report.

To provide context to the discussion that follows, a description of all the participating households and a timeline of events is shown below. For anonymity all customer names have been omitted. Customer reference numbers used in this report have been retained from the FFFP scheme manager's report[6] to enable direct comparability between the two.

[6] Freedom from Fuel Poverty Final Report. December 2010.
http://www.cse.org.uk/downloads/file/freedom_from_fuel_povert_final_report.pdf

Table 1. Summary of data collected

Data	Description
Householder socio-demographics	Including age, income, number of occupants, collected in the initial telephone survey and provided by the scheme managers
Pre- and post-SAP ratings	Providing an overview of the physical characterises of all properties before and after measures
Pre- and post- fuel poverty status	Based on income and SAP assessments
Costs of measures installed	Provided by the scheme managers
2x Householder questionnaires	Assessing perceived level of comfort, burden of bills etc before and after measures
3x Householder interviews	Covering heating regimes, thermal comfort within the home, managing energy bills, expectations and experience of the measures
Internal temperature data	Showing hourly internal temperature profile (post-installation only)
Fuel bills	A complete review of householders energy bills over the last couple of years and most recently available
Meter readings	Derived from fuel bills and taken by the interviewer at each visit to the house
Photographs	Of the property before, after and in some instances during the installation of measures

4 The scheme and the households

To provide context to the discussion that follows, a brief description of the Freedom from Fuel Poverty Scheme and participating households is provided here. Annex II provides an overview of the complete process in the Freedom from Fuel Poverty Scheme, from customer application to the installation and sign-off of measures. Table 2 summarises household types and a timeline of events at each property. For anonymity all customer names have been omitted. Customer reference numbers used in this report have been retained from the FFFP scheme manager's report[6] to enable direct comparability between the two.

4.1 Scheme criteria

The FFFP scheme was initially targeted at customers suffering from 'severe fuel poverty[7]'. The aim was to lift households out of fuel poverty by fully funding innovative thermal efficiency improvements and renewable energy measures over and above the standard measures available through the existing programme ('Warm Streets'). The focus was therefore primarily on solid wall insulation and/or solar thermal installation.

However, the scheme struggled with very low take up for a number of months, which was apportioned mainly to the 'severe fuel poverty' criteria. As result, this was relaxed and scheme eligibility was extended to, firstly, those simply in fuel poverty (10%+ of their full income spent on heating) and latterly to 'vulnerable' occupants of solid wall dwellings, mobile homes and other hard to treat homes with a low energy efficiency rating (for full details of the scheme criteria please refer to the scheme managers report)[8].

Given the change in scheme criteria, not all homes were in fuel poverty (based on the SAP survey). Customers 1, 2, 10, 11, 20 and 53 were fuel poor according to the official definition. Customers 24 and 34 were not based on theoretical spend on fuel, but were according to their actual spend. Customer 24 has oil central heating, the cost of which is often underestimated in SAP based assessments of costs. Customer 34 appeared to be heating their home to their desired needs (above 21^{o}C at times) and had reasonable income levels to cover this.

4.2 The households

As previously noted, only households receiving wall insulation were included in this evaluation (some households had solar PV or solar thermal only). As table 2 shows, two of the properties in the scheme were Park Homes, four were 'non-traditional' build (three steel-framed and one 'Cornish') and the remaining five 'normal' solid wall properties, though no Victorian as might be expected. This represents some particularly unique and hard-to-treat building types, which is important in considering the results presented here, particularly on costs of work involved and timescales for installation.

[7] A household is defined as being in 'severe fuel poverty' if required to spend more than 20% of their total income on all household fuel use, in order to maintain a satisfactory heating regime and cover other normal heating costs.
[8] http://www.cse.org.uk/downloads/file/freedom_from_fuel_povert_final_report.pdf

Table 2. Description of participating households and timeline of events

Customer ID	Occupancy	Property type	Main heating fuel	Insulation	applied to scheme	initial survey	measures approved	work started	work complete	N months app. to finish	N months start to finish
C1	Single, female, retired	Park Home	Electric	External	Oct-09	Oct-09	Jan-10	Apr-10	Jul-10	9	3
C2	Single, male, retired	Park Home	Oil	External	Oct-09	Oct-09	Jan-10	Apr-10	Jun-10	8	2
C10	Single, male, retired	1950's Semi	Mains gas	Sempatap	Dec-09	Jan-10	Apr-10	May-10	May-10	5	0
C11	Single, female, retired	Mendip stone, mid-terrace	Mains gas	External, back only	Dec-09	Jan-10	Jun-10	Jul-10	Nov-10	11	4
C20	Single, female, retired	1930's Semi	Calor gas	External	Dec-09	Jan-10	Sep-10	Oct-10	Feb-11	14	4
C22	Couple, retired	1930's, Detached bungalow	Mains gas	External & PV	Jan-10	Feb-10	Jun-10	Sep-10	Dec-10	11	3
C24	Young family	Mendip stone, end-terrace	Oil	Mainly internal & PV	Jan-10	Feb-10	May-10	Jul-10	Aug-10	7	1
C32	Single, male, not working	1940's steel frame, Semi	Mains gas	External	Feb-10	Mar-10	Jul-10	Nov-10	Feb-11	12	3
C34	Couple, retired	1940's steel frame, Semi	Mains gas	External	Feb-10	Feb-10	Aug-10	Nov-10	Dec-10	10	1
C36	Single, female, retired	1940's steel frame, Semi	Mains gas	External	Feb-10	Mar-10	Aug-10	Nov-10	Dec-10	10	1
C53	Single-mum, young family	'Cornish house', Semi	Mains gas	External	Apr-10	May-10	Nov-10	Jan-11	Jul-11	15	6

Some other key characteristics to note about individual participating households include:

Customer 10, who is elderly and partially sighted, was on a fixed tariff for his gas and electricity. As such, costs were less of a consideration and constraint for him. Having said that, this customer was still careful with his heating use and concerned about what might happen to his tariff in the future if he were to use his heating to excess.

Customer 24 had only moved into their home the previous September (2009). Therefore whilst they had experienced a full winter season in the property, which was an incredible struggle in terms of energy bills and comfort, prior to measures being installed, there is a lack of complete 'before' data on fuel consumption.

Similarly, **customer 53** only moved into her property in the April (2010), applied to the scheme almost immediately and work commenced the following February. Thus, again, the customer had experienced most of a heating season before measures were installed, but there is lack of data on consumption.

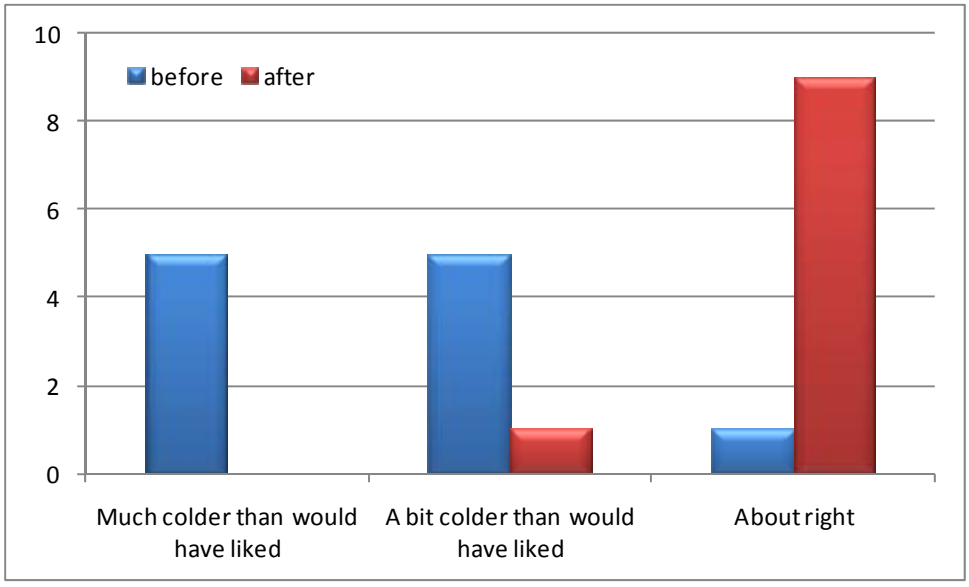
5 Comfort in the home

A state of thermal comfort results when householders are able to control their internal environment and their personal situation to their satisfaction. Behaviours and habits such as thermostat settings, choice of clothing or seating position will arise and be maintained to meet the need for thermal comfort. But, as this study and an extensive literature have shown, the sensation of comfort is complexly determined. It is a function of physical characteristics of the internal environment; the physical characteristics of the individual themselves; and a range of psychological and social factors, such as beliefs about what is a "normal" or healthy temperature for a living room.

Maintenance of comfort within the home must also be understood in the context of its cost. Where the cost of maintaining a preferred level of warmth is considered excessive the household may: be forced to compromise comfort (i.e. be cold); adopt coping strategies which maintain comfort but may compromise other aspects of lifestyle (such as going to bed early); or adopt an unsustainable approach in the reallocation of financial resources to pay for fuel (i.e. at the detriment to other budgetary demands or getting into debt). In practice households, particularly those on a low income and living in poorly insulated properties, adopt a combination of these behaviours to meet their needs for thermal comfort as best they can.

The majority of households participating in this study described the overall level of warmth in their home as colder than they would have liked in the previous winter prior to insulation, but on the whole 'about right' post-installation of measures (Figure 1).

Figure 1. Householders' perception of internal temperature, before and after measures



But what does "about right" mean in practice? How is this state maintained and how is it differentiated from conditions before the SWI systems were installed? In order to understand the multiple impacts of the solid wall insulation (SWI) intervention, the study firstly explored householder behaviours and control strategies for maintaining comfort in the home and underlying beliefs guiding them prior to the measure being implemented. Our findings are described below.

5.1 Control of heating systems

In seven of the eleven cases, central heating systems were controlled by a room thermostat linked to a timeclock. Some used this control system to heat their home to the desired temperature, for the desired periods, whilst others "*would have liked the home warmer*" (C11), but, because of cost constraints, restricted their heating. Indeed, limiting the use of heating systems because of concerns about the cost was evident in the majority of participating households (Table 3). In addition to turning the heating down, many would employ a combination of restricting heating spatially (i.e. heating only certain rooms) and temporally:

"We didn't always put the bedroom ones on [radiators], the back ones. I mean mid-day we'd put this one [gas fire] on and sort of put the radiators on later really…No way could you set it to come on in the morning and keep it on all day." (C20 single, female, retired)

Table 3. Actions to limit use of heating because of concerns about the cost

	N
Turned heating off, though preferred to have it on	2
Turned the heating down, though preferred it to be warmer	5
Turned the heating down or off in some rooms but not others	5
Only heated and used one room for periods of the day	3
Used less hot water than would have preferred	3

In households without thermostatic and timeclock control particular behaviours had arisen suited to the idiosyncrasies of the individual heating system and the circumstances of the householder. For example, one customer (C10) had no room thermostat and consequently regulated internal temperature by manually adjusting the flow temperature from his boiler:

"I adjust it frequently. I have no room thermostat as such but I can adjust the boiler and so I adjust the temperature to suit myself by controlling the boiler temperature. Of course having been an engineer in the past I'm quite happy to do that sort of thing." (C10 single, male, retired)

In contrast, another (C22) had no timer but did have a thermostat resulting in a similarly "manual" approach to temperature regulation. In this instance, the heating was allowed to run 24/7 but the thermostat was used as an on/off switch – turned up when heating was required and turned down when no heating was needed.

Several other households described how they used the thermostat as an on/off switch, rather than setting it to a comfortable level and allowing it to remain at that setting. Whilst this practise may result from a misunderstanding of the operation of thermostats, it is quite possible that the poor building fabric standards and constrained income of households in the study are also influential.

As discussed, comfort in the home is influenced by a complex mix of factors in addition to internal air temperature. A poorly insulated space with a leaky fabric will be prone to fluctuations in the radiant temperature of the walls, air movement caused by convection currents and to draughts. All will impact on sense of comfort, which could prompt thermostat adjusting behaviour. For example, although the internal air temperature may feel acceptable, a draught or a localised cold area of wall may create a sensation of chill or cold. As a result the occupant may feel that the thermostat should be adjusted upwards.

At times of more extreme cold a variety of additional strategies were employed. Some would turn up the thermostat: *"But if it's really cold then obviously I crank it up a bit more. But I don't want it on a higher setting and to then forget about it, so I put it on 16 and if I feel warm enough that's it and if not I put it up to 18. A couple of times I have had it up to 20 when we had that really bad cold. It was really cold then." (C32 single, male, not working)*

Although turning up the thermostat when the weather is colder than normal seems to make intuitive sense, in fact it is evidently a waste of fuel if one feels comfortable at lower temperatures. Again it is possible that the very low thermal performance standards found in homes in the study resulted in this practice. Customers noted the rapid loss of heat from their properties. Therefore, unless the heating period was extended, higher internal temperatures resulting from a raised thermostat setting in periods of exceptional cold would result in a home that felt warmer for a longer period: more heat energy driven into a space over a given period will take longer to dissipate through the (poorly insulated) fabric.

F1⇨ A poorly insulated and leaky fabric will necessitate a variety of control strategies in the struggle to maintain comfort. Some of these may inadvertently sabotage the design intent of the home, for example, blocking ventilation points or using thermostats as on-off switches. This may result in energy wastage or undesirable and unintended consequences such as increased condensation.

One customer (C32) had a further strategy for exceptionally cold weather. He would turn radiators in non-essential spaces off or down rather than up. In a thermostatically controlled environment this is a logical response to an overriding concern to save money on fuel as in periods of colder weather the boiler will be working even harder to maintain a thermostatic set point.

In very cold weather other householders would simply extend the operating period, often through use of the system override:

"It's on a timer, and I try to cut down [the times] when it was on. You can try and override it or whatever, you know if you want it hotter but I try not to do that because of the cost". (C11 Single, female, retired)

The practise of restricting heating to certain spaces for certain periods was often conducted in conjunction with use of supplementary heating systems, commonly oil filled radiators, fan heaters and, where installed, the radiant gas fire in the lounge. The supplementary heating was often used to provide a "boost", for example to a bedroom, shortly before going to bed. This was considered a cheaper practice than heating the space using the central heating system. Where heating system control is poor this may indeed be the case.

Supplementary heating was usually used during exceptionally cold periods, but in some cases, the practise had become habitual. In one instance a particular area of a bedroom was heated with supplementary heating in order to tackle a problem with damp.

5.2 Coping strategies in a cold home

As noted above, most participants in this study were, to at least some extent, limiting their use of heating systems because of concerns about the cost. Furthermore, all properties were (by nature of the scheme) poorly insulated. The study found a rich variety of non-heating system control-related behaviours employed by householders' to maintain thermal comfort in the absence of heating and/or an inherently cold home. Many of these involved heating the body rather than the space.

For example a number of householders reported wrapping up in blankets in the evenings to create an "instant heat" (C1, single, female, retired; C10, single, male, retired). In one extreme instance the householder used sleeping bags to stay warm in the living room (C24, young family). Others went to bed somewhat earlier than they would have liked (C1, single, female, retired; C24, young family; C53, single parent). One householder reported moving around the home through the day to track the radiant heat from sunlight:

"If the sun wasn't out you would notice it [the cold], but it will gradually go around and often in the afternoons I'll go in that room to, say, knit or read when the sun was there and you'd come back in here [the lounge] and you'd think, "ooh" such a marked difference when the suns gone round." (C20 Single, female, retired)

Three households reported the importance of the flame effect on an electric radiant fire and the visual aspect of a gas radiant fire in creating a sense of comfort: *"Well there again although I do try not to put it [the gas fire] on all the time in the evening, if I'm a bit low I do because it lights up you know." (C11, single, female, retired)*

This aspect of comfort i.e. the sense of cosiness created by the visual appearance of flame, is unlikely to be impacted by the effects of the solid wall insulation system.

The findings from the depth interviews provide significant insight into the strategies adopted by low income households living in poorly insulated properties to maintaining comfort within the home. Whilst all were living on a constrained income, the extent to which they limited their use of heating in line with their budgetary constraints varied. Thus some were maintaining a level of warmth satisfactory to their needs, but paying the price with unsustainably high fuel bills. Others were heating to their financial capacity which generally meant not being as warm and comfortable as they would like. In the most extreme case, the household was heating to almost beyond their means (borrowing money from family to pay for fuel; sacrificing spending in other areas) yet were still "freezing".

F2⇨ Where use of control systems to create comfort is either ineffective or proscribed because of concerns over the cost of heating, householders will adopt a range of comfort seeking strategies usually involving heating the body rather than the space. In extreme cases this can compromise lifestyle and restrict activity within the home.

5.3 The effect of a poorly insulated home

5.3.1 Fuel poverty status

As noted in section 3, as part of the FFFP scheme eligibility assessment procedure all households were subject to detailed surveys of the energy performance and fabric condition of the home to give a SAP ('Standard Assessment Procedure') rating. The SAP rating gives a ***modelled*** value for household energy bills and carbon emissions, both before and after the installation of measures. This is based on an assumed need for heat and power in the home (i.e. for space and water heating, cooking, lighting and appliances) and is used to assess fuel poverty status (Figure 2). The definition of fuel poverty is based on a theoretical requirement for a household to spend more than 10% of its income on all fuel to heat the home to an adequate standard of warmth. This is generally defined as

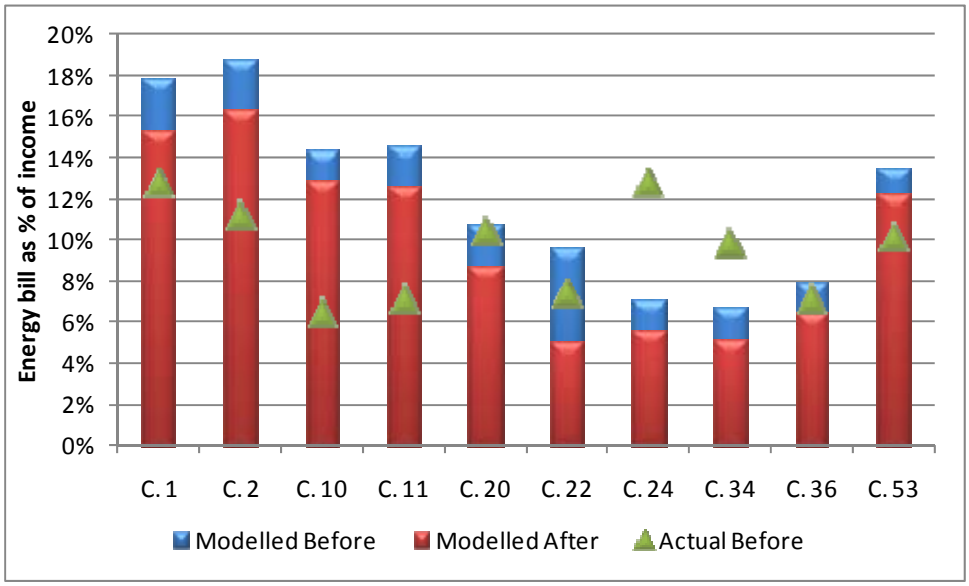
21°C in the living room and 18°C in other occupied rooms. Hence, fuel poverty status shown below is based on the modelled household energy bill derived from the SAP assessment.

Customer 32 is omitted from this graph as their circumstances were quite unique: having only recently been made redundant and with no regular source of income at the time of application to the scheme, modelled (and indeed actual) household energy bills represented more than 100% of household income. For the majority of households however, modelled energy bills represented between 7 and 19% of household income before measures. Overall, seven of the eleven properties in the scheme were fuel poor according the official definition. It is interesting to note that even after the application of measures, six remain fuel poor by definition. This suggests therefore that for these households, the installation of solid wall insulation alone is not sufficient and supplementary measures and/or raised income will be needed to lift these households fully out of fuel poverty.

F3.⇨ One measure alone may not be sufficient to lift the most severe cases out of fuel poverty. For these households a package of measures and/or raising household income will be required.

Figure 2 also shows actual household fuel bills (based on an assessment of past energy bills and direct debit payments) as a proportion of household income. For all but two households, bills are lower than the modelled required spend on fuel, suggesting these households may be under-heating and going cold. This may be due to a combination of factors, including the poor thermal efficiency of the property; household budget constraints; ineffective use of heating systems; and personal preferences and norms.

Figure 2. Fuel poverty status: before and after measures



5.3.2 Interior temperatures

Whilst high spending on fuel (relative to income) despite efforts to the contrary was consistent amongst scheme participants, householders' experience of internal temperatures was very different: some maintained a level of warmth just about satisfactory to their needs, whilst others suffered cold homes. This is based on customer's own perception of level of warmth. However, data from the internal temperature data loggers provides some interesting context to these perceptions.

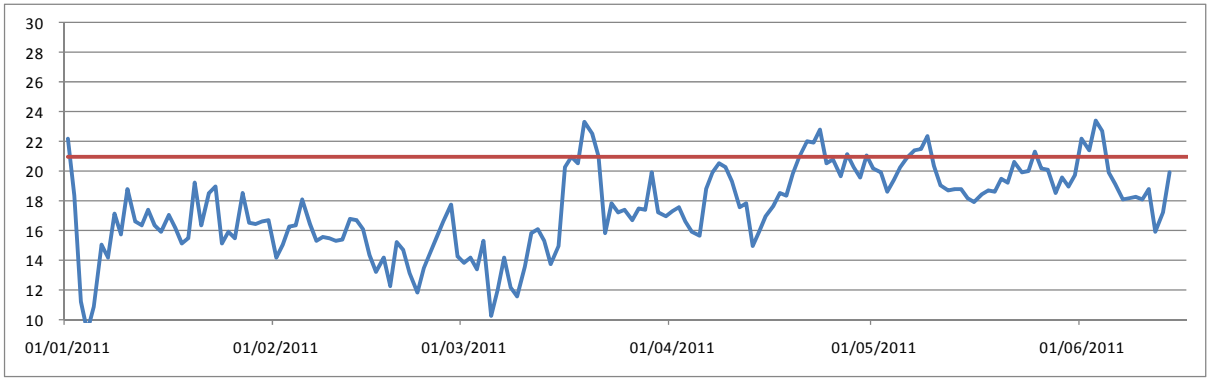
Due to scheme and project timescales, it was unfortunately not possible to obtain detailed 'before' data on the internal temperature of the homes. However, temperature data loggers were installed in all households post-installation and will remain in place until the final evaluation (c.May 2012), giving a complete annual profile.

The full spread of data obtained so far from these devices has been analysed to produce a daily average (between the hours of 8am to 10pm) temperature profile in customers' homes from the beginning of January to mid-June 2011 (Annex III – Daily average internal temperature). This is shown relative to the standard target 21^{o}C in living areas.

The graphs show very clear differences in the interior temperature of households in the study, which corresponds with customer's own perception of the level of warmth. Whilst some maintain a heating profile in line with the recommended standard, others appear to be heating to temperatures well short of this, and some exceed it (quite surprising given the income status of households in the study). The depth interviews with householders suggest these differences are as a much a reflection of the different physical household characteristics (structure, size, heating systems etc) as they are of occupancy characteristics (budgetary constraints, heating practices and personal preferences).

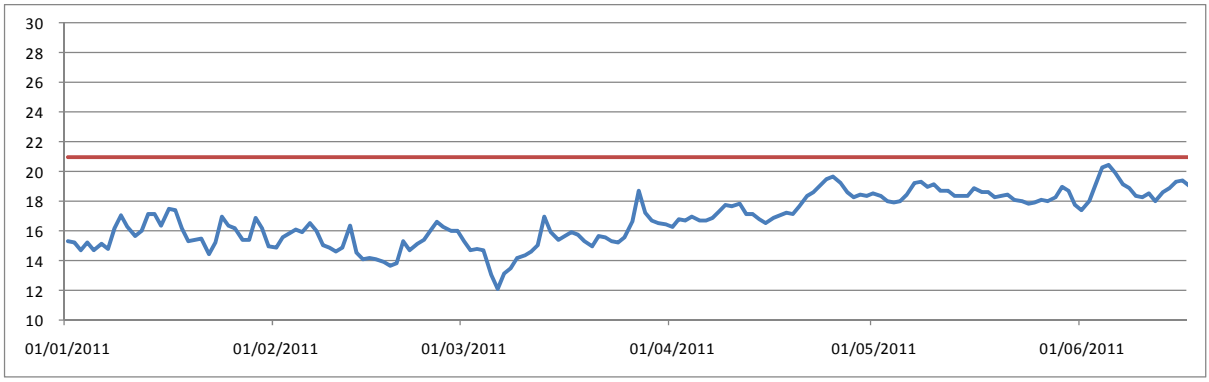
For example, customer 32's heating profile corresponds with his stated preference for a cooler internal temperature – describing in the interviews how he does not tend to feel the cold –and lifestyle which requires him to go away at short notice, thus he prefers to control the heating manually, leaving it off completely when he is out/away.

Figure 3: C32 average lounge temperature



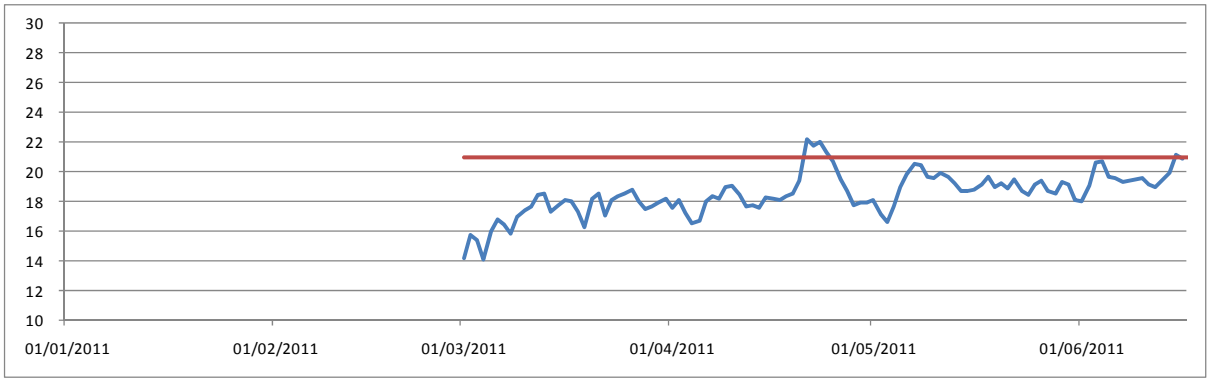
Customer 24 also shows a low internal temperature. This household described their home as "freezing" during the previous winter. Whilst they also note considerable improvements post-installation (discussed later), the temperature profile suggests comfort may still be compromised due to budget constraints: they heat their home to their financial capacity, but, even with the property fully insulated, this is not sufficient to achieve the standard level of warmth.

Figure 4: C24 average lounge temperature.



Similarly, customer 53 described a very frugal approach to using the heating, partly due to cost concerns but also a perception that it is 'unhealthy' to heat the home too much, which is evident in the internal temperature profile of her home.

Figure 5: C53 average lounge temperature



Thus whilst all homes participating in the scheme were 'hard-to-treat' and all occupants relatively low income and fuel poor, the way they heat their home and their experience of internal temperature is very different. As such, their experience of the insulation work is also likely to be very different: some may notice a marked difference in internal temperature (i.e. take the benefits as comfort); whilst others may find they can reduce their use of heating systems and experience lower fuel bills as a result.

F4.⇨ The diversity of practices adopted by householders in heating their home and their experience of internal temperature is likely to translate into a diverse range of responses to, and impact of, the insulation.

6 Customers' experience of the measures

This section describes customers' complete experience of having solid wall insulation installed, including: their understanding, motivations and expectations of the measures (before installation); their experience of the actual installation process; and how they feel about the work once complete.

6.1 Motivations and expectations

Householders' motivations to take up the insulation offer were on the whole centred on achieving lower energy bills and a more comfortable living environment. However, the emphasis placed on each factor depended on individual circumstances. The scheme 'fuel poverty' criteria meant that all participants had high energy bills relative to income, of which they were fully aware (Figure 6). Furthermore, and as discussed in section 5.1, customers' energy bills remained a significant financial burden despite their consistent efforts to limit fuel consumption: seven out of the eleven participants had made some attempt to limit their use of heating in the previous winter because of concerns about the cost (Table 3, page 20). This was often in parallel with attempts to reduce expenditure in other areas and/or seek additional sources of income (Table 4).

Figure 6. Householders' perceived financial burden of energy bills

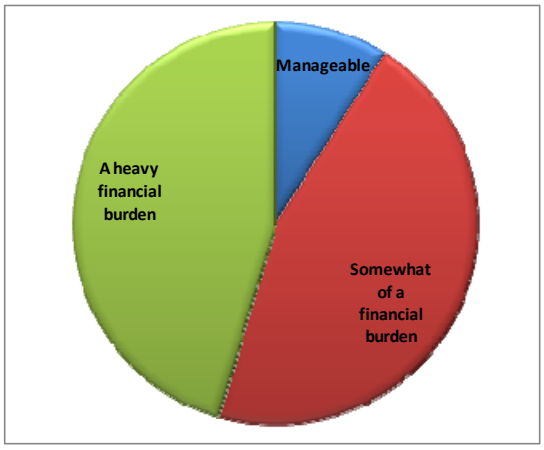


Table 4. Measures taken to help make ends meet in the last 12 months

	N
Cut back on spending on heating	6
Cut back on spending on non-essentials	4
Cut back on spending on other essentials	3
Used savings put aside for other things	3
Sold things I/we owned to raise extra cash	2
Borrowed from friends, family, or other individuals	2
Cut back on spending on food	1
Earned extra income by taking on more work or hours	1

Householders' motivations for insulating their property appear both reactive – i.e. they were responding to their immediate circumstances (a cold home/unmanageable energy bills) – and more considered, being driven by a longer-term perspective. With respect to the latter, the majority of

participants acknowledged the increasing cost of energy. Thus to these households, insulating their home provided some level of (anticipated) protection against future price rises.

A common theme amongst households participating in this scheme related in particular to an individual now living alone in what had been the family home. This tended to mean a single adult occupying a fairly large property, with correspondingly high heating costs (i.e. a typical under-occupied, 'fuel poor' household). Despite energy bills being a financial burden and cause for concern, their desire to remain in the family home dominated and was a key motivation for taking up the insulation offer:

"I'm trying to get the house so I don't have to worry too much about it you know, because I really want to stay here, if I can, make it much more affordable" (C.11, retired widow).

In a similar vein, a retired couple talked of concerns for the future, specifically one of them being able to remain in the home and live comfortably and manage the bills on a single pension (should the other pass away). For these households, longer term concerns took precedence over short term comfort gains.

F5.⇨ Insulation's capacity to "future-proof" the home against fuel price rises and/or a reduced income coupled with an understandable desire to remain in the existing home may make an unsustainable existence more sustainable.

6.2 Understanding of the measures

All participants appeared very aware that their property was poorly insulated, and had made some attempt to make their homes warmer in the past, including: upgrading heating systems; insulating lofts, hot water tanks and pipes; fitting draught excluders; installing double-glazed windows and doors; lining curtains; fitting boards on internal walls; and sealing up vents. However, customers' understanding and prior experience of solid wall insulation varied significantly. Some had never heard of a wall insulation system appropriate for their property, whilst others had actively pursued this measure for some time. Of the latter, two had enquired about grant funding in the past (and been refused) and were considering a 'pay-as-you-save' approach (with a low-interest loan) to self-fund the work, despite the repayments representing a "*significant chunk of my income*" (C1). One customer had been trying to get the walls insulated for some nine years and at one time had been fully prepared to self-fund the work (which never came to fruition due to the installer pulling out):

"I would have been prepared to pay £16,000 at that time 'cause my wife was living and working and I was working. We'd have had to get sort of like half of it on a bank loan but I was prepared to do that just to save me money…Nine years of frustration and the coldness, I just had to get it done" (C.32, widower, retired)

Those that were aware of solid wall insulation had all seen other properties in their area have the work done. This firsthand experience appears an important motivating and reassuring factor:

"We had seen some people having their cladding done because the Housing Association had done their houses here on the green and down further. And I said to my husband, 'Well maybe that's the way to go?' So we had started making enquiries about having some cladding done." (C36, single, female, retired).

This is a strong argument for a geographic approach in rolling out solid wall insulation schemes: having an 'exemplar' property, being able to discuss the work with neighbours and experience it firsthand could significantly help in promoting awareness and uptake of the measure.

F6. ⇨ The high visibility of SWI suggests an important role for exemplar properties as a motivating and reassuring factor in promoting uptake of solid wall insulation as part of an area-based approach to targeting and marketing.

6.3 Selling the scheme

Despite varying motivations, levels of understanding and past experience of solid wall insulation, customers consistently expressed very few concerns or reservations about having the work done. On the whole, they felt well-informed about what was involved and were unperturbed by the (expected) level of disruption. This was to some extent linked to both 'desperation' to make their home warmer and/or lower their fuel bills and the fact the scheme was 100% grant funded. It is possible that participants were prepared to put up with a level of disruption that others in less desperate situations and/or having to self-fund the work may be deterred by.

All seemed well aware and incredibly grateful that such extensive and costly measures were being offered for free. However, this also provoked some scepticism and concern around it being 'too good to be true'. This was a key finding noted in the scheme managers' report:

"One of the challenges of the scheme was reaching those people in fuel poverty so that they were aware of what was offered through the scheme. Once these customers were found the next challenge was to convince them that the offer was genuine and that the scheme really was fully funded. Due to the unusually high grants involved this was a significant challenge but was in some way overcome by the fact the scheme was funded and endorsed by the council - this was particularly reassuring to the older customers on the scheme."[9]

F7. ⇨ The "too good to be true" aspect of the scheme highlighted the importance of council endorsement when such extensive and costly measures are being offered for free or at heavily subsidised rates, particularly to vulnerable households.

6.4 Costs of SWI measures

Whilst most were fully reassured by the scheme managers and contented that the offer was genuine, two householders still expressed cost-related reservations about the work. This related to a genuine concern that they would end up bearing the brunt of some unexpected costs. Being on a low income and constrained budget, understandably made householders very risk averse where costs were concerned: *"being retired, small savings, there's no way we can afford to have this done" (C.34, retired couple)*

One case was fairly unique here in that the customer was aware of a damp problem in the house: on the one hand he was really hoping (albeit not overly optimistically) that the insulation would solve, or at least reduce, the problem. On the other hand however, he was very apprehensive that something would go wrong with the work or it would uncover further, more complex problems that

[9] p.100, Freedom from Fuel Poverty Final Report. December 2010.
http://www.cse.org.uk/downloads/file/freedom_from_fuel_povert_final_report.pdf

he would then be burdened with. For this customer, much hinged on the outcome of the insulation work and the whole process was a real source of anxiety:

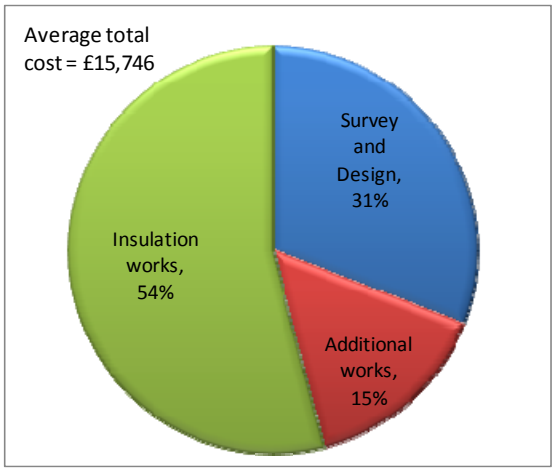
"If I was a wealthy person I wouldn't worry about it because if anything went wrong then I'd have it put right but if something goes wrong that's through no fault of my own, I haven't got the resources to pay for it to be done" (C.22, retired couple).

This customer's concern actually became reality for another householder. The installation works resulted in unforeseen problems with a roof extension. These were significant and required remedial action. There was some uncertainty over whether the problems were the result of the installation or related to previous work on the property. In this case, the contractor addressed the problems, and bore the associated financial implications.

Analysis of the complete cost of installation works at each site (as reported in the scheme manager's report and included in Annex IV of this report) shows the significance of such additional costs that should not be underestimated. The average total cost of the external wall insulation was around £15,750. However, only just over half of this was attributed to actual insulation costs: the site survey and design (including planning and building regulation fees) accounted for some 30% and 'additional works'[10] at the site for around 15%. These additional costs have significant implications for future solid wall insulation schemes, as was highlighted in the scheme manager's report:

"While the high survey costs (31%) can be avoided in part by using an approved system based approach, the costs of the additional works cannot be avoided (15%). For the purpose of this scheme, working with vulnerable people, it was important to cover these costs as additional costs could otherwise discourage a customer from going ahead with the works" (p.22).

Figure 7. Breakdown of costs of external wall insulation



In shaping and designing future solid wall insulation schemes, roles, expectations and the extent of work covered need to be carefully assessed and clearly defined at the outset. In targeting measures at low income households, it is likely that costs of all aspects of work will need to be covered by the scheme to ensure measures reach those who most need them.

[10] Additional works included: extending boiler flues; guttering removed and replaced including down pipes; satellite/BT removed and replaced; structural reinforcement to allow for additional weight of insulation (park homes); extending window sills/surrounds; removed/refitted canopy, burglar alarm, outside lights, outside tap; extended drainage pipes/remove and refit stack; scaffolding.

F8 ⇨ Customer and contractor expectations of the works included in installing solid wall insulation need to be carefully managed and defined.

F9 ⇨ In any scheme targeting low income households, it is likely that the full cost of any works required for the insulation to be installed will need to be covered to ensure uptake.

6.5 Disruption and the customer journey

Customer expectations of disruption during the installation process seemed well-managed. All participants expected and were prepared for some level of disruption and this was of little concern. However, householders' experience of the actual installation process was very diverse. The length of time from application to the scheme to completion of works ranged from as little as five months (customer 10) to fifteen (customer 53). Similarly, actual installation time ranged from less than one month to over six. There were a number of reasons for this, both personal to the customer (two households (C20 and C36) experienced a family bereavement during the application phase and as such temporarily put installation on hold) and related to the installation process itself. There are some important implications and lessons that can be drawn from the latter in the context of considering a wider rollout of a solid wall insulation scheme, as discussed below.

Figure 8. Before, during and after SWI installation at the park home of C1

Before

During

After

6.5.1 Building regulations and planning complexities

Several of the properties in this pilot scheme were within a 'World Heritage City' boundary and/or were of non-traditional construction. This introduced an additional level of complexity, with detailed building surveys required before work could be agreed. For one household in particular, this revealed structural problems inherent in the concrete construction of the property[11] which had to be resolved prior to any insulation works. Such complexities can introduce significant delay and cost to the process. Customer expectations need to be carefully managed in this respect, and in the context of a wider rollout of a solid wall insulation scheme, the cost of surveying and additional work need to be considered, as discussed above.

[11] The building is non-traditional construction known as 'Cornish house', constructed of precast reinforced concrete (PRC) after the war for social housing. The structural survey concluded that if the insulation and cladding system was fixed to the existing concrete panels, there would be significant risk to the structural integrity of the building. The solution was to use auxiliary timber frame supports, with insulation in between and a hybrid cladding over, with an outer board coated with a render to match the Bath stone of existing and proposed properties on the estate.

6.5.2 The weather

Two of the installations (customer 20 and 32) coincided with a particularly severe period of winter weather. The wet render system being applied to these properties requires temperatures above 5^{o}C for at least five consecutive days. This introduced significant delays: work at these two properties could not be completed for some four months (whilst the customer had expected it to be done within about 3 weeks). This meant scaffolding had to remain in place on site, at the inconvenience of both the customer and contractor (the latter of which would also have incurred significant cost implications). This also coincided with the Christmas period when the customers had family visiting. Despite the significant delays and obvious inconvenience, customers were understanding and patient with the process: they recognised that the delays were beyond the builders' control; felt they had been treated considerately; and were satisfied by the overall level of service. But again, such potential interruptions to work need to be considered by both installers/scheme managers and the customer.

6.5.3 Snagging

Whilst the bulk of the insulation work was often completed within a matter of weeks, snagging issues prolonged the period before work could be signed off (to both the customers' and building inspectors' satisfaction). The installation of solid wall insulation requires a number of different artisans to be on site - plasterers, electricians, plumbers, carpenters etc. Several participants reported less than satisfactory finishes in some areas (e.g. poor carpentry, shoddy fittings) which resulted in tradesmen having to be recalled to the site and prolonging the overall installation process. Such issues all add to the cost of the work, as discussed in section 8.

6.5.4 Impacts of disruption

The points above, the latter two in particular, were significant in shaping customers' overall views of the insulation works. Whilst there was a real sense amongst participants of not wanting to complain (mainly because they had a firm grasp of the extent and cost of work they were being offered for free and were very grateful for this), there are some key lessons to be learned from their experience. Householders generally expected some level of disruption and mess – acknowledging this was inevitable with any building work. However, three households had a particularly negative experience with builders not clearing up after themselves satisfactorily, whilst others reported a number of snagging issues which could have been avoided with greater care and attention to detail.

"I knew it was going to be an upheaval, I expected that and that's fine, that didn't bother me. I thought, it's going to be disruptive, I could have put up with, well I did put up with it, but I mean, all these little bits I had to pull them up on, I didn't like that really." (C.11, retired female)

On-site management and communications have a key role to play here. With the range of works required in installing solid wall insulation, ensuring that there is one individual to oversee all processes at the site and to act as a single point of contact is fundamental to the customer journey.

F10 ⇨ These issues highlight the importance of on-site management to oversee all elements of work involved in installing solid wall insulation and the importance of a single point of contact for the customer in the event of any concerns and questions about the installation process.

In summary, most households were very happy with the level of service provided, experienced a level of disruption within their expectations, and satisfaction with the end result outweighed any temporary inconveniences:

"We did know it would be a disruption, but now it's done we're glad we've had it done. Considering we've got small children it wasn't half as bad as it could've been really" (C.24, young family)

Even those who had experienced significant delays and/or unsatisfactory levels of disruption and mess, this did not detract from them recognising the overall benefits of having the work done and would still recommend it to others:

"I'd say, 'Yes, definitely have it done', but be prepared!" (C1, single, female, retired)

6.6 Leveraging opportunities for further efficiency measures

The results from SAP assessments showed that one measure alone – albeit an expensive and extensive one - was not always sufficient to lift the most severe cases out of fuel poverty. For these households a package of measures and/or raising household income will be required[12]. Having gained access to the property, and with customer consent for extensive work to be carried out, there is argument for ensuring all possible measures are installed where practicably possible and energy efficiency advice delivered in tandem – i.e. to 'future-proof' the property.

F11⇨.Future schemes should be designed such that the most cost effective measures are applied in sequence, and the householder is lifted out of fuel poverty at minimum cost. However, the order of measures would also need to make sense from a practical point of view– i.e. windows at the same time as external wall insulation, radiators at the same time as internal wall insulation, etc. This would require multiple trades on site as well as significant project management of the works on a house by house basis.

[12] A key finding in the 'How Much? The cost of alleviating fuel poverty' report: http://www.cse.org.uk/pdf/pub1110.pdf

7 Impacts of measures

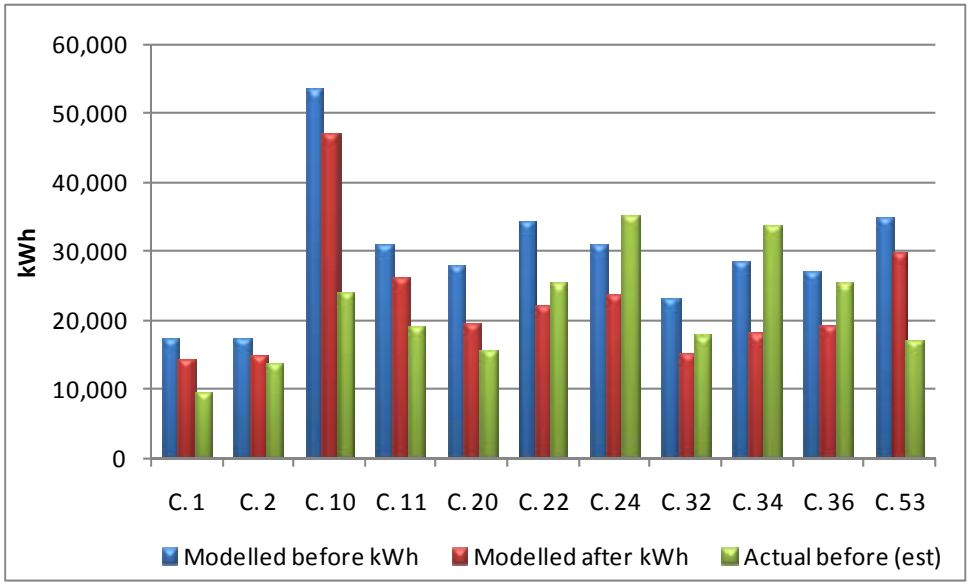
Householders reported a wide variety of impacts, mainly related to thermal comfort, but also on noise levels, damp and condensation issues, health and on the "general atmosphere" of the home. These impacts are explored in more detail below.

7.1 Household energy consumption

Figure 8 below shows modelled (SAP-based) total household energy consumption (in kWh) before- and after-measures, alongside actual consumption before measures. Note the latter is estimated from energy bills and these values should be treated with some caution. This is particularly pertinent in the case of C24 and C53 who had not been in their home for a whole year prior to joining the scheme.

The data suggests that, for most participants, actual energy consumption before measures was much lower than the modelled estimated level of energy consumption needed to adequately heat their home. This is consistent with participants' reported experience of struggling to maintain satisfactory levels of warmth over the winter period. Where households are under-heating, there is increased likelihood that benefits of insulation measures will be taken as comfort. Again, there is evidence of this thus far in the evaluation, albeit early days post-installation for some households. Revisiting the properties next year will provide further scope to assess and quantify any impacts on energy bills and consumption.

Figure 9. Modelled household energy bills before and after measures



7.2 Household energy bills

As discussed above, customers had varying expectations of the impact of the insulation on their energy bills. Due to installation and project timescales, it was generally too early for customers to experience any actual impact on fuel bills as a result of the insulation. However, as part of the scheme manager's evaluation, the impact of measures on modelled bills (based on the SAP survey) was assessed. The modelled savings were also applied to actual energy bills (based on a review of bills and direct debit payments prior to measures being installed). The results, shown below, suggest

customers could expect financial savings of between £160 and £530, based on modelled before and after bills, and £100 and £800 based on modelled savings applied to actual energy bills[13].

Figure 10. Modelled household energy bills before and after measures

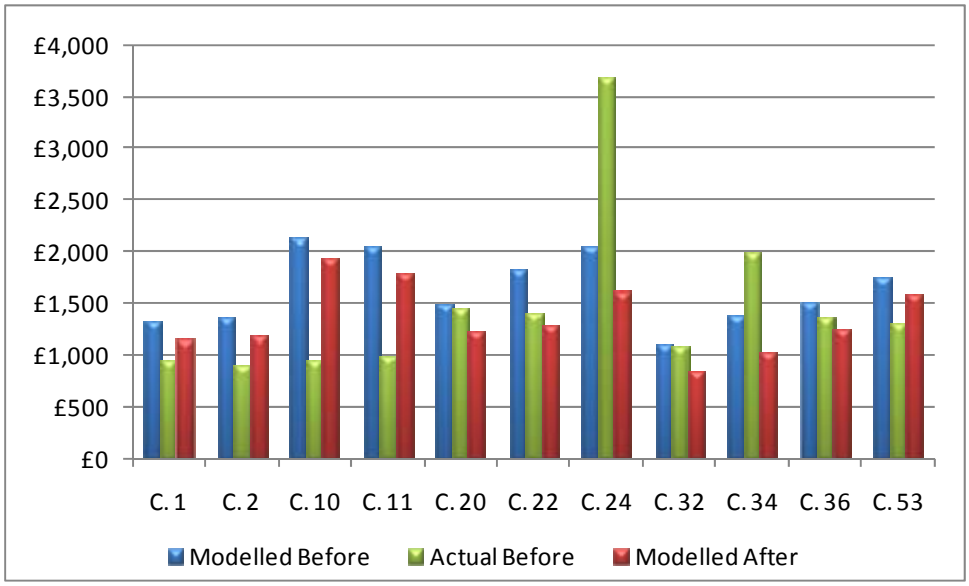
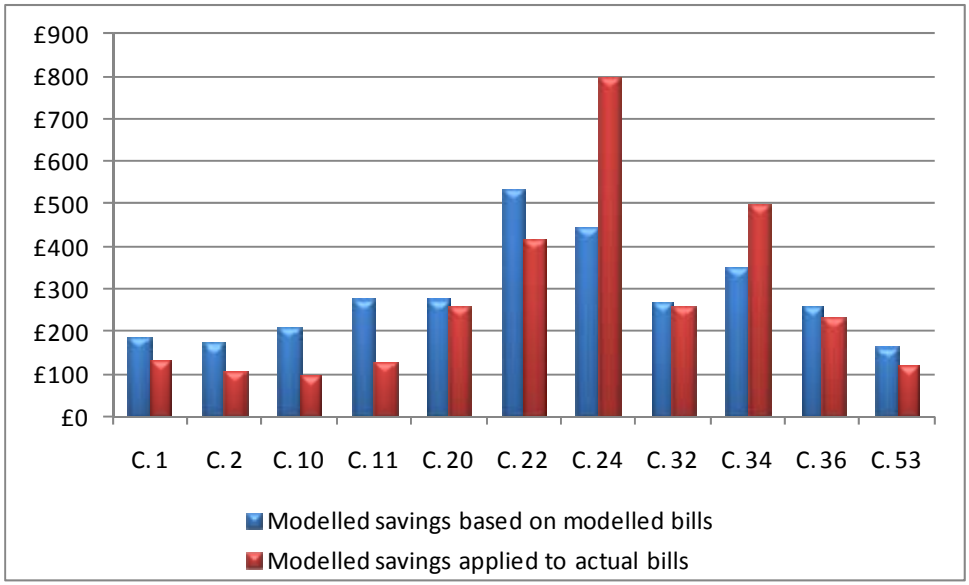


Figure 11. Estimated financial savings following the installation of measures



Whilst it was generally too early for customers to experience any actual impact on fuel bills as a result of the insulation, two householders had prevented their energy supplier from increasing direct debit payments in light of anticipated impact from the insulation work.

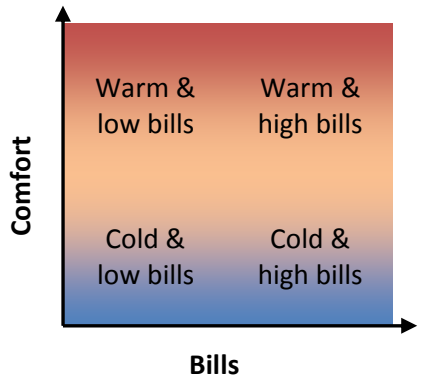
The actual impact on energy bills will depend on both individual customer response and the energy market. On the whole customers in this scheme had high energy bills (relative to income) but were still not as warm as they would have liked – i.e. they sat somewhere to the right and lower half of the bills/comfort spectrum. As a result of insulating their property, these customers may therefore:

[13] Results based on actual energy bills should be treated with some caution. Two of the households – customers 24 and 53 - had been in their property for less than a year before applying to the scheme, hence there is insufficient historical records. In these cases estimations of actual spend are presented but this is unlikely to be an accurate reflection of annual consumption (being based on their experience over winter months only).

1. Maintain their existing heating regime and take all the benefits as comfort (i.e. same fuel expenditure but they're warmer – i.e. shift up the spectrum);
2. Feel able to reduce their heating use whilst maintaining a satisfactory level of comfort as a result of the insulation and see the benefit in lower fuel bills (i.e. shift to the left on the spectrum).

The potential for the latter will, however, also depend on the market: fluctuations in the unit price of energy could swallow up any potential savings from reduced consumption. Thus customers may: take benefits as comfort but still see their bills go up (thus remaining in fuel poverty); or reduce their fuel consumption whilst maintaining satisfactory levels of comfort, but detect no difference in the fuel bills due to price rises.

Figure 12. Bills and comfort spectrum



Although it is still early days in the evaluation in terms of impact on household fuel bills, there is evidence to suggest customers are experiencing the full range of scenarios described above. For example, one customer felt the home was warmer "*straight away*" and as such had *"not had to have the heating on for two weeks now. So even when it has felt cold I haven't put the heating on at all which has been brilliant so hopefully I'm going to save an absolute packet on my heating bills."(C.53).* Thus this customer is experiencing benefits of improved comfort whilst simultaneously putting less energy into the home.

Another customer (who had experienced a full heating season with the insulation installed) was sure he had used less oil, but this had not translated into cost savings due to unit price fluctuations: *"Since I've had this done, yes it's fine because I haven't used as much oil, but although I haven't used it, it's cost as much because the price has gone up." (C.2)*

These trade-offs between fuel bills and thermal comfort are explored further below.

7.3 Thermal comfort

All households reported improvements to their thermal comfort as a result of the insulation, although the extent of impact was more subtle for some than for others. Reported impacts ranged from very little discernable difference in internal heat levels (C10) to "massive" differences (C24). Furthermore, this additional comfort was experienced in a number of ways. For example, customers noted their home warming up more quickly; heat was considered to be dispersed more "evenly" throughout the home; and the property "held the heat" for longer:

"If I'd been out say and it's [the heating] been off practically all day and I come back in and it doesn't strike you like it used to, you think 'oh there's nothing on but it feels really snuggly and warm" (C.20)

The differences in customer response and experience of the impact of the insulation on their thermal comfort can be better understood in the context of customer heating regimes and approaches to controlling internal temperature before the insulation was installed. As discussed in section 5.3 these factors will be highly influential in determining whether householders experience a marked increase in thermal comfort or whether only marginal impacts are detected. The most common possible responses and the distribution of householders exhibiting these responses are summarised in a matrix:

Table 5. Matrix of thermal comfort: customer heating practices and impacts of insulation on comfort

		Post-installation thermal comfort	
		Same	**Improved**
Pre-installation heating practice	**Home under-heated**	No change in comfort. Savings from the measure taken entirely as lower energy input to the home (therefore expect lower bills). ⇨No customers fell into this quadrant	Same heating regime maintained but comfort improved. Energy input to the home similar to prior to insulation measure therefore some or all potential savings taken as comfort. ⇨ *C1, C11, C20, C24*
	Home heated to desired temperature	No or marginal change in comfort. Savings from the measure taken as lower energy input to the home (therefore expect lower bills). ⇨ *C10, C22*	New increased level of service exceeds comfort requirements potentially resulting in discomfort. Controls and settings adjusted accordingly. Savings taken as lower energy input to the home whilst maintaining pre-measure comfort levels. ⇨ *C2, C32, C36*

Benefits taken as improved comfort & lower bills: *C34, C53*

Findings from this study suggests that over half of the households are under-heating – whether this be due to budget constraints, poor thermal fabric, inefficient heating systems, or ineffective use of heating systems (or a combination of these factors). All respondents who felt their home was colder than they would have liked prior to the measure ('home under-heated'), noted a marked improvement post-installation. Interviewee responses suggest these householders are maintaining the same heating regimes (timings and thermostat settings) as prior to the measure, but the property's new thermal characteristics meant that these settings now delivered a more comfortable environment.

This group (C1, C11, C20, C24) effectively take potential financial savings from insulating their homes as comfort. Consequently, energy consumption post-installation is expected to be similar in these homes as pre-measure levels, but their homes will be warmer (for longer). Households falling into this response bracket are unlikely to see much reduction in their bills, as C1 describes in her experience: *"I don't think I've saved anything. I don't think I've saved any money, but I've been, I've been warmer for the money that I've spent." (C1, single, female, retired).*

For some underheated households, the improvements in comfort were such that they had notably less need for supplementary strategies for keeping warm: *"I'm less likely to find other ways of trying to keep warm other than actual heating. Whereas before I might have a couple of fleeces that I would put round and a hot water bottle, two hot water bottles when it was really cold sometimes" (C.1, female, single, retired)*

Whilst others reported changing patterns of supplementary heating usage after the measure: oil filled radiators, fan heaters and gas fires were thought to be used less often in a number of instances. These households could therefore see some reduction in energy bills, albeit fairly minor, even though in their own mind they are using their main heating system to the same extent as prior to installation.

A second "underheated" group (C34, C53), shown in the middle of the matrix, had the sense they had captured both savings and improved comfort. Both customers described experiences of living in a cold home prior to the measure, although their extent of heating was very different: C53 was very frugal in the use of heating systems and hence cold; whilst C34 was fairly liberal in their use of heating but extremely poor thermal efficiency and a draughty property meant they still felt the cold. However, post-installation both customers noted a marked improvement in comfort, to the extent that they felt warmer and were able to reduce their heating use:

Husband: "Actually the temperature, I've cut the boiler down by one notch." Wife: "And I'll get out of bed in the morning when the heating has started and think gosh this is hot in here and I'll turn it off and we don't have it in the morning then." (C34, couple, retired)

"I've not had to have the heating on for two weeks now. So even when it has felt cold [outside] I haven't put the heating on at all which has been brilliant so hopefully I'm going to save an absolute packet on my heating bills."(C53, single parent)

F12.⇨Our findings suggest that comfort taking from energy efficiency interventions is a continuum: all potential savings from the measure will be taken as comfort in only a minority of cases. The majority will fall somewhere between the two extremes of 100% comfort taking and 100% bill savings. As such, the actual impact of SWI at any one property is very difficult to predict.

Householders who were already heating their home to desired levels responded somewhat differently to the improvements in thermal efficiency compared to the under-heating groups. Following the measure, households had lowered thermostat settings, turned off radiators, reduced heating periods or done a combination of these things:

"It's surprising how quickly it warms up in here when the heating comes on now. Whereas before it used to take quite a while, I had to keep the heating on all the time. Whereas now, I turn it down quite often, when it's too hot, definitely." (C2, single, male, retired)

"I don't have the heating on at the times I would have done previously. It's at least 3 or 4 degrees below but the house is much warmer because the heat is staying in and not going out." (C32, single, male, not working)

Households that had reduced thermostat settings - "turning down the heating a notch" - following the measure, had previously heated their homes to desired levels under thermostatic control. It may therefore seem slightly puzzling that the same internal temperature was considered to be uncomfortably hot following the measure. One explanation may lie in the multiple determinants of

a sense of comfort: air movement and radiant heat temperatures as well as air temperature all play a role. Solid wall insulation systems will reduce draughts, create a more even temperature distribution in the house thereby reducing convection currents and will increase the temperature of the inner surface of the wall thereby increasing the radiant heat experienced by the householder. It is likely that the combination of these impacts is sometimes sufficient to cause air temperatures previously experienced as comfortable to become uncomfortably warm. By reducing heating periods and thermostat settings this group is taking efficiency gains as financial savings rather than adding to comfort.

The final group (C10, C22) who also heated their home to the desired level prior to the measure, but experienced little improvement to their comfort post-installation, principally differ from the 'uncomfortably warm' group because of how they control their heating. In both instances heating was not under thermostatic control. C22 used their thermostat as an on-off switch because the system had no timer, whilst C10 had no thermostat at all, controlling room temperature by constantly adjusting the flow temperature of the boiler. Consequently, in both instances, desired comfort was delivered reactively by manual adjustment of settings both before and after the installation of SWI. This will make the impacts of the measure very difficult to detect - particularly in terms of improved comfort. Benefits from the measure are more likely to be taken as financial savings rather than improved comfort.

F13. ⇨ In cases where a household both underheats the home because of cost concerns and inhabits a poor building fabric, most or all savings from SWI will be taken in improved comfort. However some underheated households will capture both savings and comfort improvements. Where homes are already heated to desired comfort levels prior to the measure more complex responses result from SWI. Depending on control strategy (use of thermostats etc), some households may notice only marginal improvements to comfort. Others may even experience discomfort and adjust settings accordingly. In both cases, financial savings should result.

7.4 Summer comfort

A number of respondents felt their homes were difficult to keep comfortably cool in the summer months and resorted to a variety of practises to stay comfortable including using fans (C1, single female, retired), (C10, single male, retired) and sometimes more drastic measures, *"a wet flannel, feet in a bowl in the summer, it was so hot, it was like an oven". (C34, couple, retired)* ". However those experiencing a summer with the SWI system installed reported a noticeably cooler internal temperature. This resulted in a much more comfortable environment, *"my bedroom, at night, because the sun comes round that way at night, it used to be like really hot but I did notice it was so much different and I suppose that is partly because it [the SWI] keeps the heat out as well as holding it in one way or another" (C2, single male, retired*). In some instances the cooler temperatures, removed the need for cooling devices such as fans, *"I did notice that in other years when I've had to get out my free standing fan, I didn't need to get it out at all last year. So I think it does keep it a little bit cooler although I wouldn't say drastically so." (C1, single female, retired).*

F14 ⇨ SWI has a noticeable impact on occupants' sense of comfort in summer months. Homes that are thought to be to be uncomfortably hot are thought to be cooler and more comfortable. This may reduce or eliminate the need for supplementary cooling using fans and other devices. Modest energy savings may result.

7.5 Damp and condensation

Damp and excessive condensation was an important issue for some households in the study. C22, in particular, experienced heavy condensation on the glazing and seemed more concerned about tackling an ongoing damp problem in a bedroom via the measure than with improving comfort. The damp problem required a particular heating regime with radiators left on in the bedroom and occasionally use of supplementary heating. However, as a result of the measure the damp problem appeared to be "cured":

"As my wife says, last year we were actually wiping our hand over the wall behind the bed and it has come away wet…Now that seems to be cured." (C22, couple, retired).

Although the damp problem had improved, the problem with condensation appeared to be "worse than I've ever known it" and was considered by the respondents to be a possible unforeseen outcome of the insulation work, which is possible: the insulation may have the effect of raising the internal air temperature, which would then be capable of holding more moisture, thus condensing in greater quantities on cold bridges such as glazing[14].

F15. ⇨ SWI insulation systems should come with guidance on tackling condensation issues as they are likely to be exacerbated by the warmer internal temperatures and the reduction in uncontrolled ventilation following installation of the measure.

7.6 Draughts

As suggested by the comfort analysis, the measure had a significant and noticeable impact on the draughtiness of the home. Prior to the measure the majority of the respondents reported that their home was draughty and had taken a number of remedial measures to try and cut down drafts often with little success, *"we did everything - all the joints in the wood are taped, and round the skirting board you'd have a draught you know" (C20, single female, retired).* This respondent also reported taping up the ventilation grill in the kitchen each winter. Blocking off ventilation points in a bid to counteract "draughts" was reported by other respondents also. For example, *"In the front room, we've got a vent on the window which I've actually put plastic over it and taped it down because a lot of cold was coming through there" (C53, single female, retired*).

This practise of taping up ventilation points, particularly in areas where the air will be more humid such as kitchens and bathrooms, will inevitably result in greater damp and condensation problems where there are cold bridges. This is clearly not a desirable practise but entirely understandable in the context of a draughty uncomfortable home. It might be expected that a less draughty fabric resulting from a solid wall insulation system would result in less incentive to block off ventilation points where it is actually required. However, it may be difficult to break habitual practises in some cases. This could lead to increased problems with condensation and potentially damp on cold bridges in homes having SWI because of its effects on the thermal properties of the building envelope.

A number of respondents did report noticeable reductions in the draughtiness of the home following the measure. For example, "*I put two doors on the passage outside to cut the draughts down, but*

[14] This issue is well understood as a potential consequence of solid wall insulation and a range of guidance exists to mitigate such impacts, See, for example, English Heritage guidance on the subject: http://www.climatechangeandyourhome.org.uk/live/content_pdfs/779.pdf

we still hung a blanket over the back door, cause that's where most of it was coming from, but that's gone now, we've got rid of that [following the measure]". *(C34, couple, retired)*

F16.⇨ In some poorly insulated properties with leaky fabrics, a number of undesirable practices may have developed to counteract drafts, specifically taping up or blocking off controlled ventilation points. SWI insulation systems will tend to reduce draughtiness and increase the moisture content of the air therefore it is particularly important in this instance that controlled ventilation points are allowed to operate as intended in order to avoid a marked increase in condensation problems on cold bridges.

7.7 Health

A number of households spoke about the relationships between living in a cold home and health impacts. C10, for example (single, male, retired) voiced a concern, *"well certainly the older you get, the more the winter affects you as regards temperature*" and speculated (albeit fairly blithely!) that he may "live even longer" as a result of the measure.

C24 (young family) identified linkages between the "freezing" internal temperatures they had endured prior to the measure and the propensity for illness in the family, including coughs and colds, and even as a cause of her husband's tonsillitis:

"It was too cold. Yeah. Freezing…Yeah we all had bugs as well. We all kept constantly getting bugs, the children and everything." (C24, young family)

Following the measure the customer felt that the warmer environment had resulted in less illness amongst the children:

"We're just feeling a lot more comfortable in here... the children haven't been so ill." (C24, young family).

Several other households speculated that they had suffered fewer colds and flu events since the insulation went in (e.g. C2, male, single, retired; C34, couple, retired).

In addition to improvements to physical health some respondents reported improvements to their wellbeing as a result of the measure. One household reported that concern over unsustainably high heating costs and the coldness of the home had made them feel depressed:

"We were depressed. I mean it's a lovely spot but it was so depressing because you didn't want to come home. We were trying to stay out. "(C24, young family)

Following the measure the household felt much more comfortable:

"Well we're just feeling a lot more comfortable in here. It was a bit depressing before because you think well, we're freezing when we're spending money on heating and nothing's happening but now at least when you do put your heating on you know it's making a difference." (C24, young family).

In summary, whilst acknowledging the limitations of this small qualitative study, these findings do suggest that the measure may have improved the physical health of the occupants. Wellbeing has also been demonstrably improved by the measure.

F17.⇨ It is likely that some SWI recipients will report improvements to their health as a result of the measure

7.8 Lifestyle impacts

The scheme had a number of impacts on the lifestyle and social life of the occupants. By providing a comfortable environment the measure eliminated or reduced the frequency of a whole range of householder behaviours that had arisen in response to the overwhelming need to remain comfortable in a home that was difficult or expensive to heat.

Lifestyle impacts of the measure were principally derived from making the home more "liveable". For example, householders frequently mentioned the need to use less blankets or to wear less clothing indoors:

"N*ow I don't wear another woolly in the winter. I just wear this type of thing in the winter and the summer. I don't have to wear a top woolly now – I don't indoors now anyway, no." (C2, single, male, retired).*

"Before, even when we had the heating on, we needed the blanket as well, because it was still too cold. But now if we have the heating on we're finding it actually got very very warm in here." (C24, young family)

Two households (C1, C53) also mentioned that they would often go to bed earlier than they would have ideally liked to because remaining in the living area was uncomfortable: "*So I find I often think well I'll go to bed about half past nine or something like that and read or watch the television in bed. And rather than stay in the cold in here" (C1, single female, retired).*

Households frequently reported a sense rooms or areas of the house that were especially cold or deliberately unheated to save on fuel bills were more likely to be occupied and used. In one extreme instance, prior to the measure, the home was so cold and uncomfortable, the family had previously spent as little time in it as possible over the previous winter months: *"It was so depressing because you didn't want to come home. We were trying to stay out. Go and stay anywhere like friends houses or taking her to toddlers [groups], 'cause it's warmer in the village hall and that kind of thing. Went out to get in the warm, went to my parents place." (C24, young family).*

Evidently by making the home comfortable, householders in these circumstances will spend more time at home thereby transforming lifestyle from one based around spending time away from home in the winter months to one where activities could take place in the home.

A number of households also remarked that the home seemed cooler during the summer months as a result of the measure. This had also improved the liveability of the space. For one particular household summer overheating in the kitchen area significantly impacted comfort resulting in a number of practises affecting lifestyle, "*he used to sit out there [the kitchen] because he watched telly out there with a flannel on his head", "a wet flannel, feet in a bowl in the summer, it was so hot, it was like an oven". (C34, couple, retired).* Following the installation the temperature of the kitchen was noticeably cooler in the summer months and consequently this practise was no longer thought necessary.

F18.⇨ In all instances SWI was found to improve the "liveability" of the home, removing the need for comfort seeking practises which impacted lifestyle and in opening up areas of the home for use and enjoyment.

The measure will also indirectly impact lifestyle by creating financial savings which may be spent on activities that would otherwise not take place. This indirect impact on lifestyle will be explored in greater detail in our final report.

7.9 Social impacts

Several householders' received comments from visitors, neighbours, and in some cases passers-by, about the insulation work, both whilst work was in progress and on the end result. This included general (wholly positive) comments about the appearance of the property post-installation and enquiries as to the nature of the works. The level of interest generated by these few (and geographically spread) installations implicates the importance of an 'exemplar' property in promoting uptake, as discussed in section 6.2.

External solid wall insulation is by nature highly visible, but less well understood as a home improvement measure. For one customer, the level of interest and enquiries from neighbours became a source of embarrassment. This was mainly because the work was being done for free and he felt uncomfortable having to explain to others how and why this was:

"You know, we've had people stop me and say I hear you're having a lot of work done, that's going to cost you a bit…I would turn around and say it's not going to cost me anything…It's a bit embarrassing because we don't like discussing our finances outside." (C.22, retired couple).

Such situations could be alleviated, and indeed the highly visible nature of external solid wall insulation be exploited, by having some form of information board or leaflet at a site where work is in progress. This could be a useful mechanism to help combat some of the misconceptions/key concerns surrounding solid wall insulation and promote awareness of any local schemes. In areas where there are a high number of similar properties that could benefit from the measure, this could be a particularly effective and low-cost approach to encouraging uptake.

F19.⇨ The highly visible nature of external solid wall insulation could be exploited as a marketing mechanism, through the use of information boards/leaflets at sites where work is in progress.

Scheme participants noted comments (again all positive) from visitors about the impact on internal temperature. The effect here could be two-fold. Firstly any visitors experiencing the impact for themselves may be encouraged to pursue the measure in their own home. This is most relevant in the case of neighbours who live in similar properties:

"A friend of mine that sometimes pops in from up the road, she's got a house like this and she said one day, 'Oh, have you still got your heating on?' And I said, 'No.' And she said, 'It's really warm in here'. And I said, 'Yeah.' And it was about, it might have been lunchtime, just after lunch, when she came and like I say, it [the heating] goes off, at nine or half past." (C.36)

A further potential effect linked to visitors' perceptions of the internal temperature of participants' homes relates to householders tendency for 'thermal hosting' – that is, turning the heating up for the benefit of visitors when they would otherwise have made do without. Several households participating in this scheme noted this behaviour. With the insulation in place and the home maintaining a more comfortable temperature, householders may feel less inclined to do this, thus reducing their consumption.

Before: *"Well I suppose if you've got somebody coming you've got to crank up the heat so they don't come into a fridge. That's about it really but it's costing you money at the end of the day and it's money going out, as I say, because it's not, there's no insulation there… but when my mother comes to stay, I've got no choice [about putting the heating on]"*

After: *"Well everybody's happier when they come in the house now, especially me mother. 'Cause the heating's got to go up to about 16 when she comes and I have to go and get me shorts on and me T-shirt. [Laughter] But I'm much happier now. Much happier. No more earache from me mother and me daughter when she comes in saying, 'Oh, it's cold in here'. It's always been a very, very cold house, because to heat the house you've got to heat the walls first and that's where you're losing all your money. Obviously I'm going to be better off money wise 'cause it's not going to cost me as much." (C32, single, male, retired)*

F20.⇨ In some instances SWI may have quite dramatic impacts on occupant lifestyle and social life. By providing a comfortable environment occupants are more disposed to spend time at home and to bring others to their home.

7.10 Appearance and maintenance

Two key factors emerged as unanticipated benefits of having solid wall insulation, namely: the impact on the appearance and maintenance requirements of the property; and the impact on noise.

Scheme participants were able to have some input into the finish on their property following the installation of measures. In most cases preferences could be satisfied, although at two properties there had to be some compromise due to cost. All participants were wholly satisfied once work was complete, although for some this did follow (some significant) snagging issues which first had to be rectified.

The fact that works were being fully funded was again a key factor here: customers were, in some cases, reluctant to complain, being so appreciative that the work was being done for free. However, this could not detract from the fact it was their home and the appearance and level of finish was important to them. Whether paying for the measures themselves or not, if work is not completed to the customer's satisfaction, this needs to be rectified. As discussed in section 6.5, schemes involving such extensive measures could benefit from an on-site project manager to oversee all aspects of the work.

Having said that, in the majority of cases, the finished product met with, if not exceeded, customer expectations. In particular, an 'added bonus' for many, which had not been anticipated, was the reduced maintenance requirements:

"The thing I like most about it is the fact obviously, it's going to be that much warmer and hopefully, my bills will be down. But also, there's no maintenance for me, I mean, everything's cladded…the contrast with the white, it really does look nice…So yeah, I'm really pleased with it. So many people have stopped and said, 'Oh, I see you've had work done. What's it like, how's it been and it looks really nice.'" (C.36)

"The finish on it, it's guaranteed for so long, I forget, it'll see my lifetime, 25 years I think it was. There's no upkeep, now it's there, it's there. I haven't got to bother with it at all. Whereas previously, the place had to be done over every so many years with stone cement stuff…Thank goodness I don't have to put up with that anymore." (C2, single, male, retired)

Figure 13: SWI improves the appearance of the home as demonstrated by C20's completed installation in comparison with the other half of the semi-detached dwelling.

The one household that had full internal wall insulation offered similarly positive feedback:

"We thought that maybe it would make the rooms look a lot smaller but it doesn't actually make them look any smaller…we haven't noticed the loss of space at all. In a way it, in a strange way, it kind of makes them look a bit bigger. I don't know whether it's because they're painted white or whether the windows look deeper set, so it just make the room look a bit bigger." (C24, young family)

Customer responses to the impact of the insulation on the appearance and maintenance requirements of the property emphasise the applicability of marketing solid wall insulation as a home improvement measure. These 'added benefits' appeared on a par with the improvements in thermal efficiency and/or reduced fuel bills to some customers in this study. Furthermore, expectations for level of disruption may be better aligned with the concept of 'home improvements' than 'insulation'.

F21.⇨ Marketing of solid wall insulation should capture the full range of benefits beyond improved thermal efficiency. Marketing the measure as a 'home improvement' may be more appealing to the customer and more appropriate to the nature of work involved than focusing on the insulation angle per se.

7.11 Noise

Six out of the eleven participating households noted the "sound proofing effect" of the insulation. For those who live on a fairly busy road this was a particularly welcomed (but unexpected) benefit:

"I'll tell you something else; it's not so noisy either. We can't hear the things outside so much. It's insulated the - we don't hear so much traffic. And we get the buses down here." (C.34)

Even for those who did not live in a particularly noisy area, this was still considered an additional benefit and could therefore be framed as such in the marketing of future solid wall insulation schemes.

F22.⇨ The sound proofing effect of solid wall insulation could be included as an additional potential benefit in future marketing of schemes.

8 Key findings and recommendations

This evaluation and the scheme manager's report have produced a number of key findings related to (1) managing comfort and (2) impacts of the measure (3) the process of installing solid wall insulation in hard-to-treat homes. These are summarised below.

8.1 Managing comfort in hard-to-treat homes

Where use of heating system controls to create comfort is either ineffective or proscribed because of concerns over the cost of heating, householders will adopt a range of comfort seeking strategies usually involving heating the body rather than the space. Whilst for some this was a standard practice to which they had become accustomed – i.e. they were habitually conservative with their heating – whilst for others this represented a real compromise of lifestyle and activity within the home, and could be a real source of misery[15]. For example, in one extreme instance the household was forced to leave the home altogether to spend parts of the day in warmer spaces.

Recommendation 1. Householders develop integrated clusters of habits, behaviours and beliefs in their efforts to maintain comfort. In homes with very poor fabric and control systems some of these may be actively wasteful of energy. These modes of practise are supported by wider normative beliefs around what is expected, modern, desirable etc. Consequently, policy makers should anticipate that SWI, an intervention having significant multiple impacts on the home's thermal performance, will not only make households warmer - it will have potentially transformative effects on many aspects of lifestyle and even the beliefs underpinning certain lifestyle and energy consuming habits. This is likely to be particularly evident in households adopting extreme comfort seeking behaviours as a result of living in underheated homes.

A poorly insulated and leaky fabric will engender a variety of control strategies in the struggle to maintain comfort. In terms of the impact of solid wall insulation, some of these practices may sabotage the design intent of the home, for example, blocking ventilation points or using thermostats as on-off switches. This may result in energy wastage or undesirable and unintended consequences of insulating the home, such as increased condensation. There is therefore an important educational element to the installation of complex measures to ensure the full potential benefits are realised (discussed further below).

8.2 Impacts of Solid Wall Insulation

8.2.1 Impacts on Comfort

All households noticed changes to their comfort, lifestyle and even health as a result of the measure. Households often described their homes "warming up more quickly" whilst heat was considered to be dispersed more "evenly" throughout the home and the property thought to "hold the heat" for longer.

The diversity of practices adopted by householders in this study in heating their home is likely to translate into a diverse range of responses to installation of the insulation. We are already seeing some evidence of this, with some householders continuing to heat their homes exactly as before but

[15] This was a key finding as reported in the study: "'You just have to get by' Coping with low incomes and cold homes." http://www.cse.org.uk/downloads/file/you_just_have_to_get_by.pdf

now feeling the benefit of warmth, whilst others are adjusting their heating practices and anticipate this to translate into reduced consumption and bills.

In cases where a household both under-heats the home because of cost concerns and inhabits a poor building fabric, most or all savings from SWI will be taken in improved comfort. However some under-heated households will capture both savings and comfort improvements.

Where homes were heated to desired comfort levels prior to the measure responses to the SWI were found to be dependent on the household's control strategy – principally their use of thermostats. Those households who did not keep their home under thermostatic control, for example by regulating internal temperature through constant adjustment of the boiler flow temperature, seemed to notice only marginal improvements to comfort. In contrast, those who kept their home under thermostatic control, reported that the increased level of service resulting from SWI often made them "too warm" and accordingly adjusted settings downwards.

One explanation for this may lie in the multiple determinants of a sense of comfort: air movement and radiant heat temperatures as well as air temperature all play a role. Solid wall insulation systems will reduce draughts, create a more even temperature distribution in the house thereby reducing convection currents and will increase the temperature of the inner surface of the wall thereby increasing the radiant heat experienced by the householder. It is likely that the combination of these impacts is sometimes sufficient to cause air temperatures previously experienced as comfortable to become uncomfortably warm. For this reason, we believe some households heating their homes to comfortable levels under thermostatic control prior to SWI subsequently experienced internal temperatures as too warm.

This finding indicates that with or without thermostatic control, where homes have been heated to comfortable levels prior to the measure we should expect financial savings should result from the SWI installation thereby directly addressing fuel poverty.

Recommendation 2. Unlike some efficiency and micro-generation measures, impacts of SWI on "liveability" and comfort on the home are noticed and can be profound, especially where homes are underheated prior to the measure. Scheme designers and policy makers should maximise awareness of these benefits as part of social marketing strategies supporting mass rollout of SWI systems.

Differences in household response to the measure are fundamental in the context of the Green Deal and the formulation of the ECO. Consider two identical homes, one underheated because of the occupants' concern about fuel bills, the other heated to desired temperatures, but with an unsustainable impact on household finances. Each has the SWI measure installed. The underheated home takes the savings as comfort and sees no change in their bill, the home that was heated to desired levels takes the efficiency improvements as financial savings.

Under current thinking around the "Golden Rule" the pre-measure comfortable home will potentially qualify for a loan for the measure through the Green Deal whereas the underheated will not. It would be manifestly unfair to only allow the pre-measure "comfortable" household to access Green Deal finance. It would also be unfair to award the pre-measure underheated household a larger eco subsidy than the comfortable household. However, it is also essential that pre-measure underheated householders are actually able to repay any loan made to them under the Green Deal

through making real savings on their bills – and therefore that Green Deal providers show a duty of care in who they offer Green Deal finance to.

This situation suggests that energy savings and comfort taking rates from particular measures in fuel poor groups should be deemed**.** The alternative, an attempt to account for different comfort taking rates driven by different priorities and preferences would seem to open the possibility of unequal access to GD finance and to be extremely onerous administratively.

As this study has indicated, most households will fall somewhere between 100% £ savings and 100% comfort taking – i.e. for the majority of fuel poor households there should be some, perhaps very small, financial savings from the SWI measure. As such the eco subsidy for SWI should be set high enough that the majority of fuel poor households, making some savings from the SWI even if very small, can access the Green Deal loan by meeting the golden rule. For the minority, with chronically underheated homes and taking all savings as comfort, additional arrangements will have to be made.

Recommendation 3: In formulating Green Deal policy these findings highlight the importance of considering what constitutes a "saving" against the counterfactual case i.e. a situation where the household is either comfortable or is underheated prior to the SWI measure. Given dramatically different rates of comfort taking amongst fuel poor groups the finding presents a case for deeming SWI savings and setting eco subsidy rates accordingly - rather than attempting to account for differences in personal norms and preferences and consequent comfort taking rates when deciding Green Deal eligibility.

8.2.2 Draughtiness

The study found that the SWI systems markedly reduced the sense of draughtiness. This of course a positive outcome however because of very poor fabric standards in some properties, we found a number of undesirable practices had developed to counteract drafts, specifically taping up or blocking off controlled ventilation points. In all likelihood these practises will continue post SWI installation. It is known that SWI will increase the moisture content of the air as it will tend to be warmer as a result of the measure therefore it is particularly important in this instance that controlled ventilation points are allowed to operate as intended in order to avoid a marked increase in condensation problems on cold bridges.

Recommendation 4: Because of unanticipated potential effects of SWI and various maintenance aspects which differ from conventional external wall treatments e.g. painting and susceptibility to damage from point loads we feel that SWI systems should come with a user guide, "living with your new insulation" and/or a requirement to give verbal advice to the householder once the system is installed. This should mitigate potential issues and allow householders to get the best from the systems

8.2.3 Further benefits

This evaluation, albeit small in scale, has revealed a number of 'additional' benefits of solid wall insulation that householders had not been expecting, but which added much to their overall perception and level of satisfaction with the work. In particular the impact of SWI on the appearance of the property (both on the outside with EWI and inside with IWI) and the reduced maintenance requirements were heavily praised by scheme participants.

Recommendation 5: Because of its impact on the appearance of a property, solid wall insulation lends itself to marketing as a 'home improvement' measure to a much greater extent than other energy efficiency measures. Branding it as such may also enhance its appeal to householders and better portray the nature and cost of work involved which can be extensive compared to other insulation measures.

Customers also noted improvements in comfort in the summer months with the insulation providing a cooling effect. This may reduce or eliminate the need for supplementary cooling using fans and other devices, resulting in additional, albeit modest, energy savings.

Customers also noted health, lifestyle and social benefits, including removing the need for comfort seeking practises which impacted lifestyle and opening up areas of the home for use and enjoyment, the importance of which should not be underestimated.

8.3 Installing Solid Wall Insulation in hard-to-treat homes

8.3.1 Targeting and promoting uptake of measures

One of the key challenges of the scheme was in identifying and reaching the target audience (i.e. the fuel poor) and even then take up of measures was very slow. This was linked to the unusually high grants being offered – the 'too good to be true' notion – and the low income status of the target audience meant they were particularly risk averse. Having council endorsement of the scheme was important here, particularly in reassuring to the older customers on the scheme.

Recommendation 6: Amongst low income and consequently risk-averse groups some sort of official endorsement of the scheme, for instance by a local authority should be in place as this could be critical to uptake

Several different approaches were used in marketing the scheme including advertising in local papers and taking referrals through the EST advice centre. The most successful marketing technique, however, proved to be a doorstep flyer drop (by a B&NES Council Officer) in an area where solid wall insulation was being installed in some social housing. The directness of this approach, combined with the 'first hand' experience of householders in seeing the work carried out on neighbouring properties appeared fundamental to uptake of the grant offer in this area.

Recommendation 7: Our findings suggest that an area-based approach to future solid wall insulation could be effective. The high visibility of SWI could be exploited as a motivating and reassuring factor in promoting uptake (see recommendation above). This could be maximised by the use of information boards/leaflets at sites where work is in progress.

8.3.2 Maximising opportunities for additional energy efficiency improvements

The FFFP scheme specifically set out to test the effectiveness of solid wall insulation and solar installations in helping hard-to-treat households in fuel poverty. However, it was fully acknowledged by scheme managers that these did not always represent the most cost effective energy efficiency measures.

Recommendation 8: Future schemes should be designed such that the most cost effective measures are applied in sequence, and the householder is lifted out of fuel poverty at minimum cost. However, the order of measures would also need to make sense from a practical point of

view– i.e. windows at the same time as external wall insulation, radiators at the same time as internal wall insulation, etc. This would require multiple trades on site as well as significant project management of the works on a house by house basis.

8.3.3 Costs of measures

The (high) total costs of installation in this scheme may be somewhat unique given the property types involved (i.e. four out of the eleven being non-traditional). However, all sites entailed some level of costs additional to the actual insulation element. In a scheme such as this, targeted at low income, vulnerable households, it was important that the full cost of measures was covered. However, this is something that needs to be considered in future schemes, particularly in the context of the Green Deal and Golden Rule, which is based on the premise that the insulation will deliver financial savings on energy bills sufficient to cover loan repayments (in theory). This is particularly important for low income households who may not be able to afford the loan repayments if the savings aren't realised. How the cost of additional works (structural or survey related) will play out here is unclear.

Recommendation 9: Green deal providers should consider the value of installing packages of measures in combination, to deliver additional savings/revenue (i.e. from FIT and RHI) to subsidise the costs of most expensive measures that won't deliver the Golden Rule on their own.

8.3.4 The customer journey

An issue raised by several customers in this evaluation related to on-site and overall scheme management. SWI necessitates a number of different trades being on-site to complete different elements of the work. On-site management is a key factor in ensuring each element is delivered in a timely and orderly manner, and the finish is to both the customer and contractor's satisfaction.

Recommendation 10: Ensuring contractors have formal process for onsite project management with a single point of contact for the SWI recipient will make a significant difference to the customer journey in many cases. While smaller companies might argue this sort of structure can be restrictive, being contractually bound to a process should help all the necessary project requirements be fulfilled.

This is particularity relevant with solid wall insulation which, much like cavity wall insulation in its early days, seems to create an uncertainty with customers who feel that the potential risks do not outweigh the benefit. Where the element of customer choice is restricted by having an appointed contractor then there is a responsibility on the scheme to ensure the customer journey is as smooth as possible.

Annex I – Householder questionnaire

Face-to-face survey conducted at beginning and end of project – i.e. in first and third interviews.

1. How would you describe the overall level of warmth in your home last winter? Was it…

1. Much colder than you would have liked
2. A bit colder than you would have liked
3. About right
4. A bit warmer than you would have liked
5. A lot warmer than you would have liked
6. Both too warm and too cold

2. And still thinking about last winter, what kind of heating system/s did you have in your home?

1. Gas central heating
2. Oil central heating
3. Night storage heaters
4. Fixed room fires or heaters
5. Open fires or stoves (solid fuel)
6. Portable heaters: Electric
7. Portable heaters: Bottled gas/paraffin
8. Portable heaters: Oil-filled
9. Other

3. And did you use all of these systems last winter, at any time? If no – Which did you not use?

4. Thinking about any time of day or night, did you (and your partner) cut back on fuel use at home in any of these ways last winter, because you were concerned about the costs?

1. Turned heating off, even though I would have preferred to have it on
2. Turned the heating down, even though I would have preferred it to be warmer
3. Turned the heating down or off in some rooms but not others, even though I would have preferred not to
4. Only heated and used one room in my house for periods of the day
5. Used less hot water than I would have preferred
6. Turned out lights in my home, even though I would have preferred to have them on
7. Had fewer hot meals or hot drinks that I would have liked
8. None of these

5. In the last 12 months, have [*you / you or your partner]* done any of the following things in order to make ends meet?

1. Cut back on spending on food
2. Cut back on spending on heating
3. Cut back on spending on other essentials
4. Cut back on spending on non-essentials

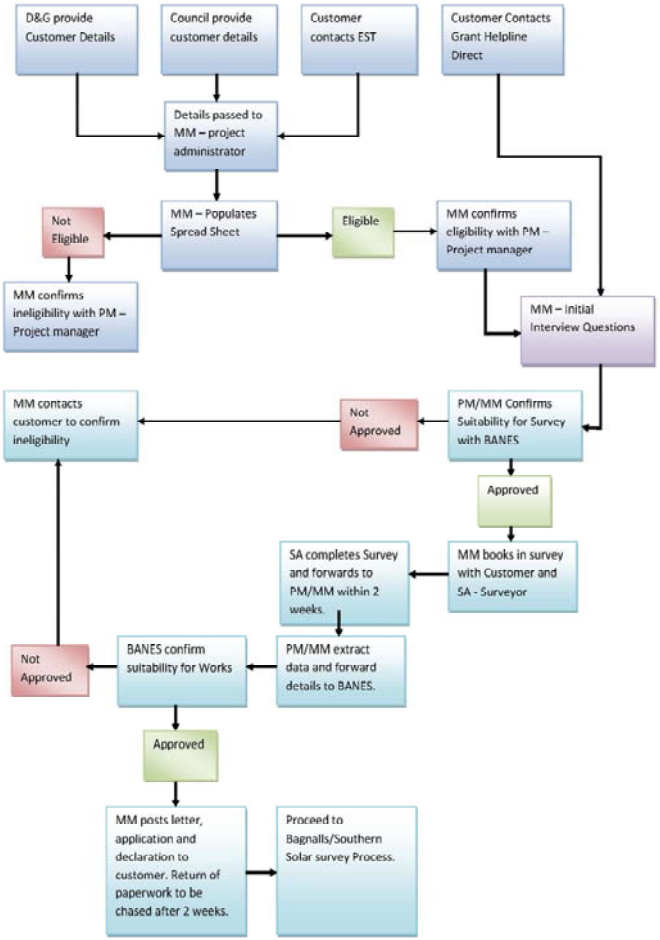
5. Used savings put aside for other things
6. Earned extra income by taking on more work or hours
7. Sold things I/we owned to raise extra cash
8. Borrowed from friends, family, or other individuals
9. Taken out new loans from commercial lenders
10. Increased the amount owed on a credit card or overdraft
11. Delayed making payments on money owed
12. None of these

6. Still thinking back to last winter, would you say your fuel bills were…

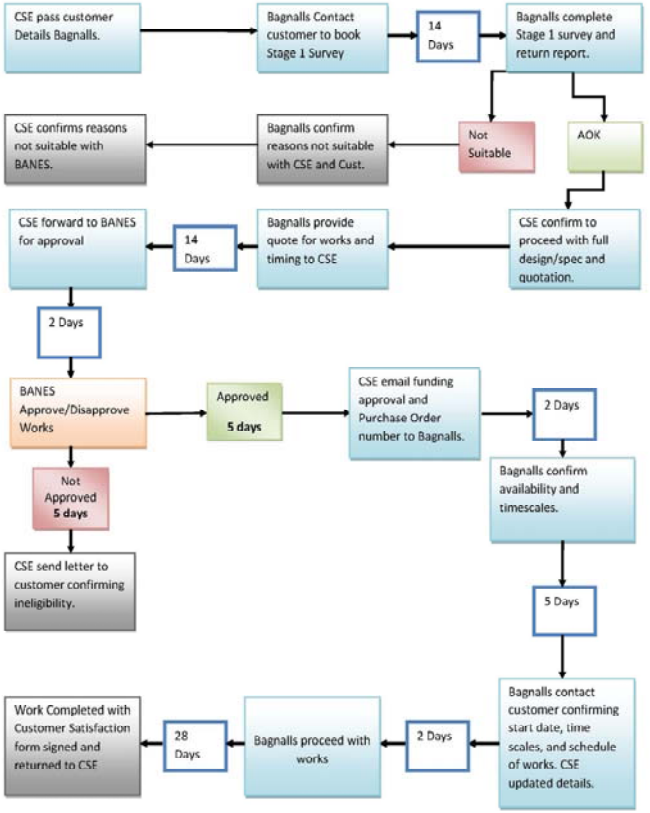
1. A heavy financial burden
2. Somewhat of a financial burden
3. Or not a problem at all?

Annex II – Scheme Process

The application process



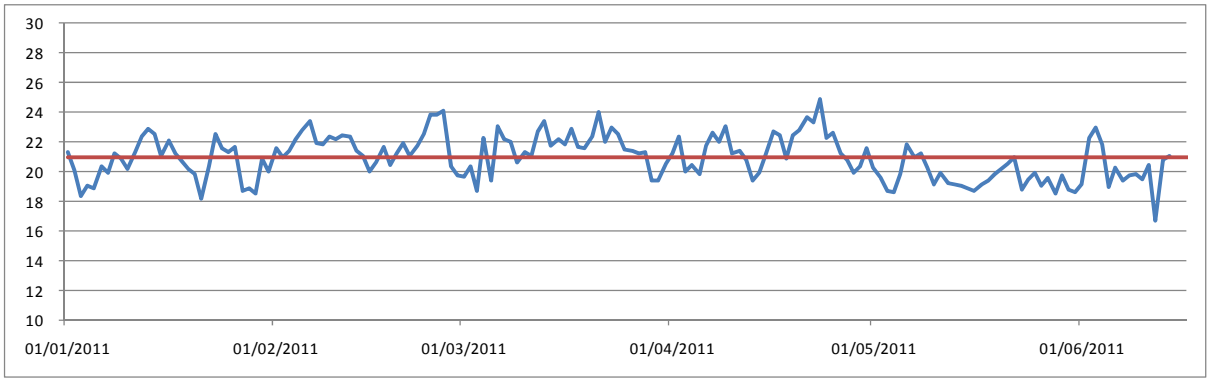
The installation process



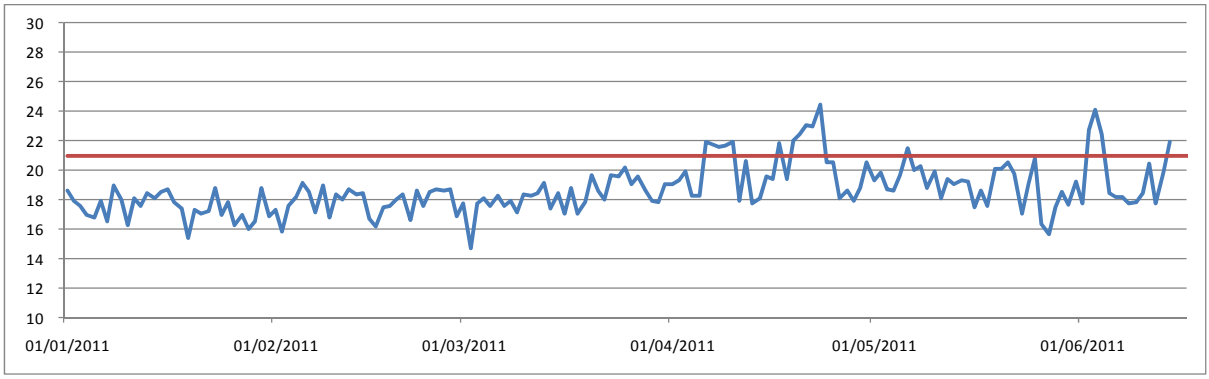
Annex III – Daily average internal temperature

The graphs below show the daily average (8am to 10pm) temperature in customers' homes from the beginning of January to mid-June 2011. All axis are to the same scale for ease of comparison (10°C to 30°C for the y-axis). The standard 21°C in living areas is marked on all graphs by the solid red line.

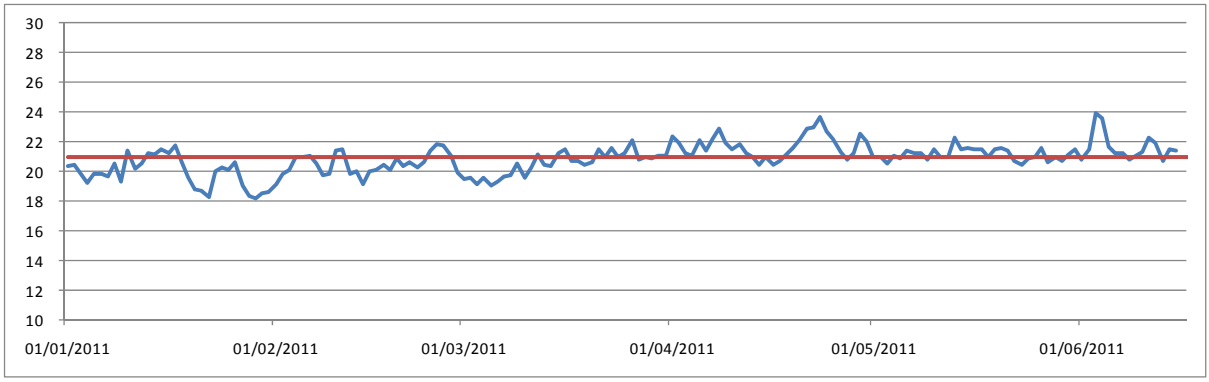
Customer 1



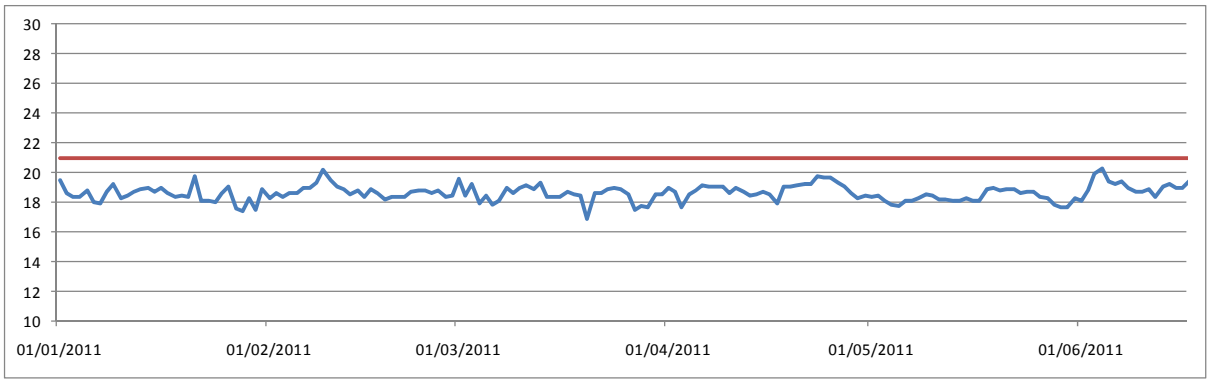
Customer 2



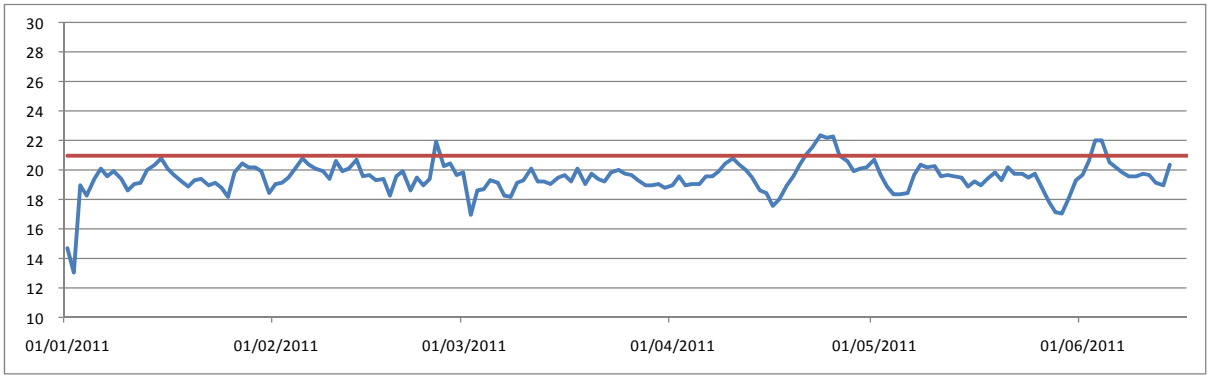
Customer 10



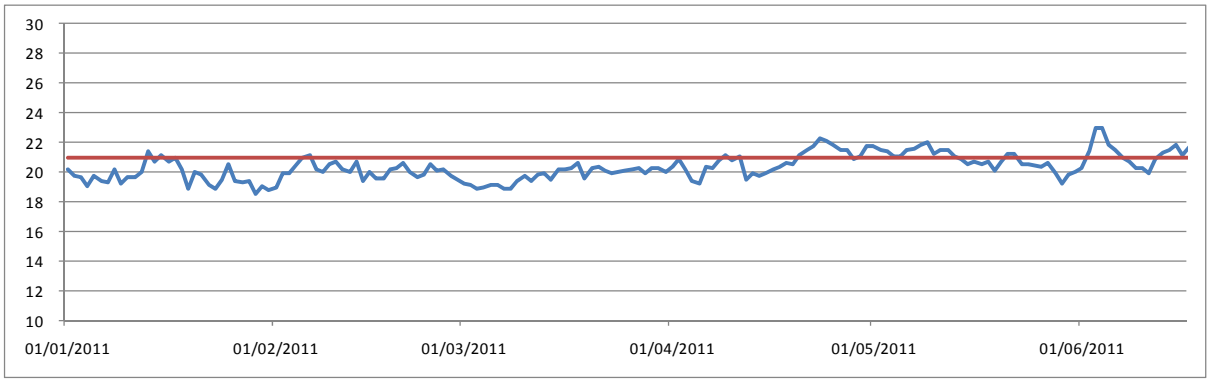
Customer 11



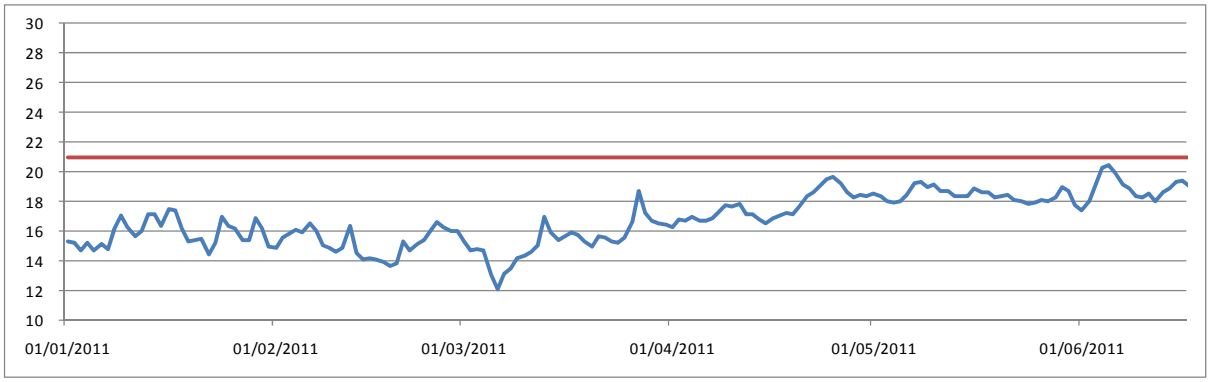
Customer 20



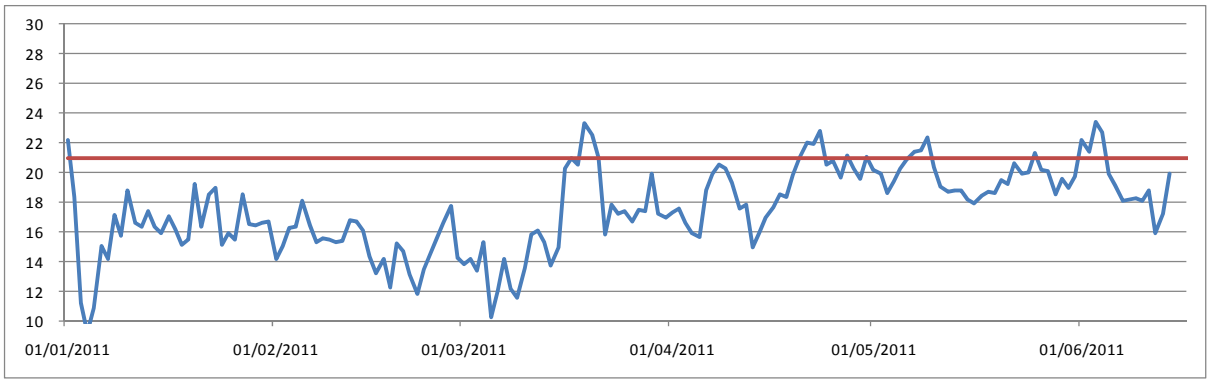
Customer 22



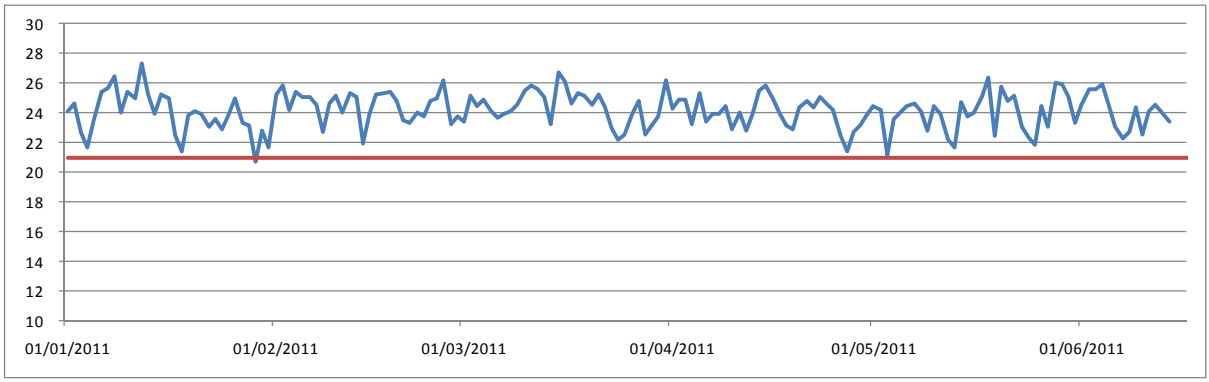
Customer 24



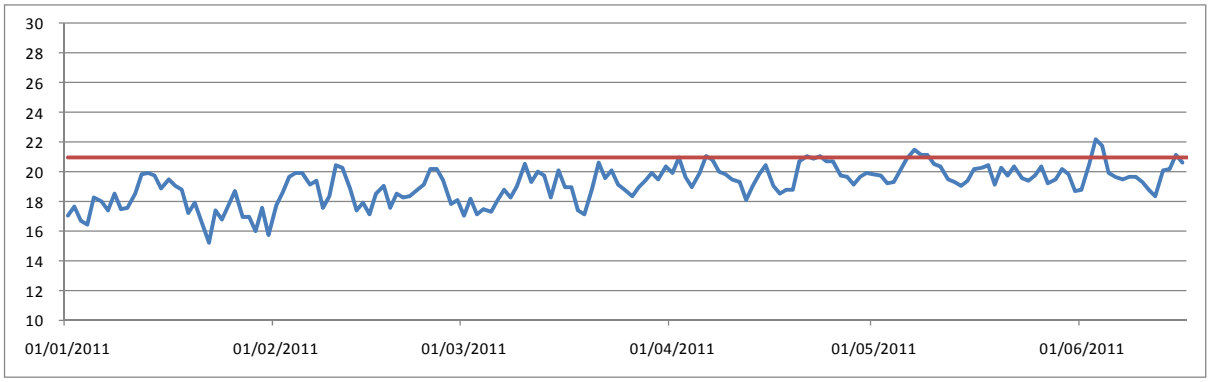
Customer 32



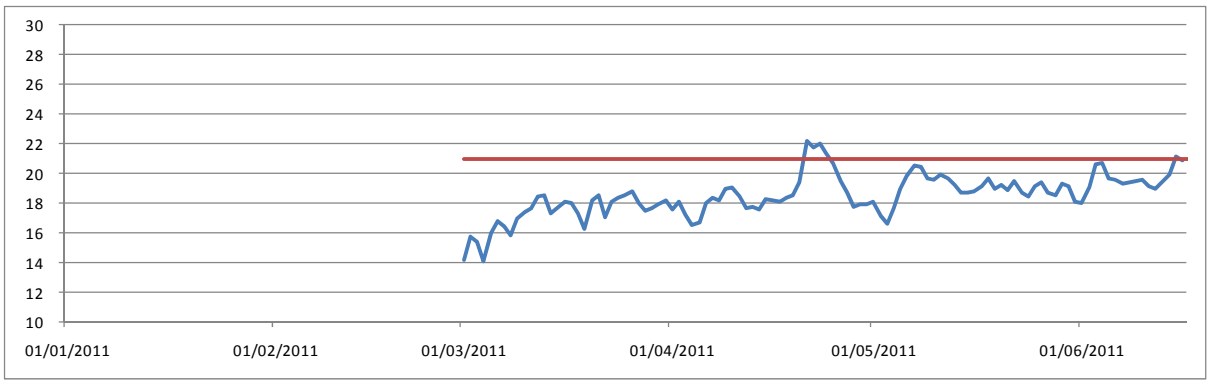
Customer 34



Customer 36



Customer 53



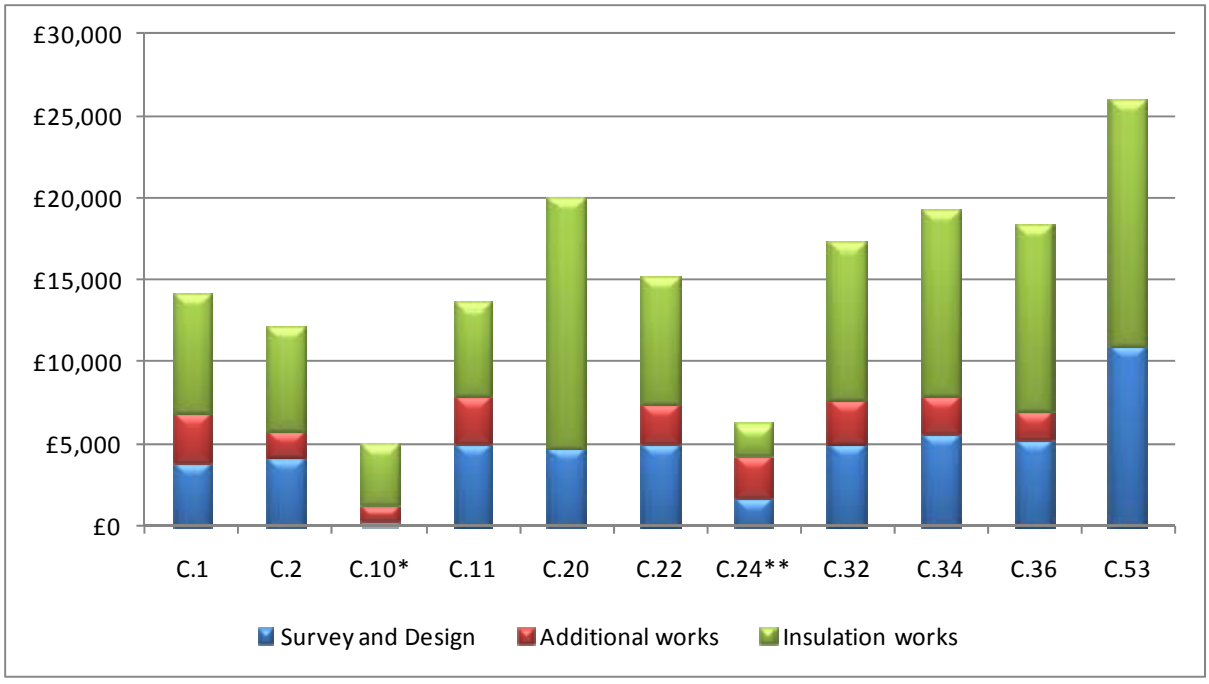
Annex IV – Costs of measures

The scheme manager's final report on the Freedom from Fuel Poverty Scheme includes a detailed breakdown and discussion of the costs of the all measures and associated works. These are summarised below, where:

- Survey and Design costs include planning and building regulation fees
- Insulation works costs include site supervision by structural engineer.

Note the full breakdown of costs for Customer 20 and 53 were not available at the time of reporting, hence the insulation works costs shown include all on-site work.

Annex Figure 1. Breakdown of costs of insulation works



* Sempatap; ** Mainly internal insulation, with small area of external.

Annex Table 1. Average cost of External solid wall insulation

	Average cost	% of Total
Survey and design	£4,862	31%
Additional works	£2,384	15%
Insulation works	£8,501	54%
Total cost	£15,746	100%

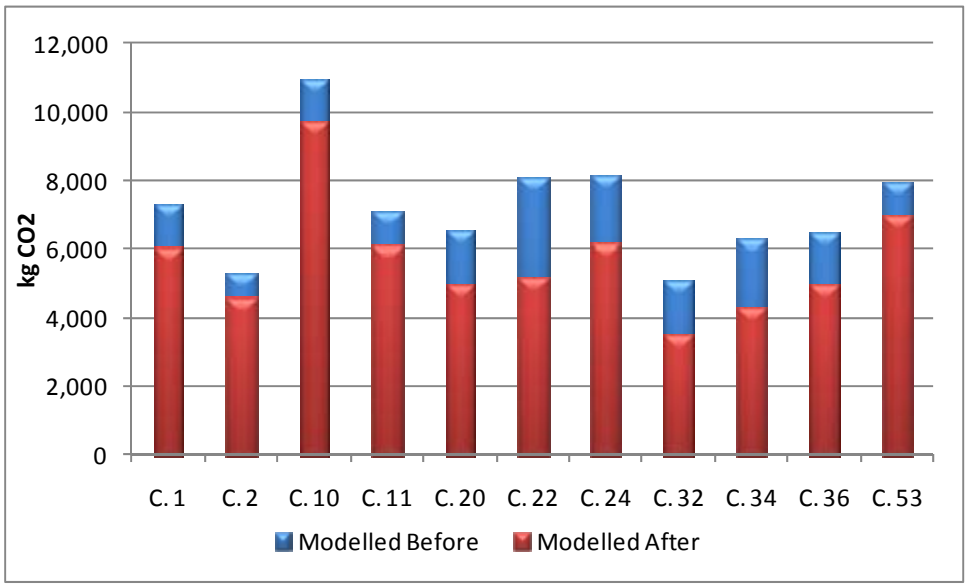
(Costs shown exclude: internal insulation at C.10 and C.24; and C.20 and C.53 where full breakdown not available).

Annex V – Impact on carbon emissions

This evaluation has sought to assess the impact of measures in both the theoretical (SAP-based) and real world scenario. The latter is based on a review of historic bills, direct debit payments and meter readings. In all but two cases[16] sufficient data has been collated to estimate actual household fuel spend, consumption and carbon emissions (by applying carbon emissions factors to consumption values) prior to the installation of measures. However, due to the delays in the installation of measures, at the time of writing there is insufficient data to assess the actual impact of measures. This will be assessed and results presented in the final project evaluation report in June 2012. The results presented here therefore focus on modelled impacts based on the SAP survey data.

Annex Figure 2 shows the modelled annual carbon emissions before and after the installation of measures for each household (note for customer 22 and 24 this includes a saving in electricity consumption from PV generation, but excludes any additional revenue from FITs). Projected savings represent a reduction of between 11 and 36%.

Annex Figure 2. Modelled household CO_2 emissions before and after the installation of measures



[16] Two of the households – customers 24 and 53 - had been in their property for less than a year before applying to the scheme, hence there is insufficient historical records. In these cases estimations of actual spend and consumption are presented but should be treated with caution.