energy technologies institute

HOUSING RETROFITS – A NEW START

An insights report from the Energy Technologies Institute

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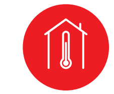
Housing retrofits are expensive and should be targeted appropriately

Improving the delivery of retrofits will require significant investment in the supply chain



HOUSING RETROFITS A NEW START

Comfort and security are bigger drivers for consumers than efficiency

only a third are motivated to spend effort and money on saving energy

Current major opportunity to improve housing efficiency at modest carbon prices lies in tackling the

c4million

hard to treat cavity walls across the UK

Retrofitting programmes should work in partnership with the development of local area energy plans and advanced home heating controls

Targeted retrofitting activity can help the most vulnerable who live in the lowest quality housing – but comes with an economic risk

KEY HEADLINES

Heating the 28 million homes in the UK accounts for 17% of energy-related CO_2 emissions. This is dominated by space heating, with contributions from hot water and cooking. When indirect emissions from electric heating are included, 20% of UK emissions come from domestic heat.

- Improving the thermal efficiency of significant parts of the existing UK housing stock over the next thirty years is an important part of a cost-effective UK decarbonisation strategy but cannot substitute for decarbonising the supply of energy to buildings.
- Uptake could be increased by making efficiency improvements an integral part of improving the amenity and value of the dwellings, rather than a series of independent measures.
- A focus on the interests of the owners and occupiers of the dwellings and the performance of the supply chain in delivering retrofit to them is critical to progress.
- Efficiency measures can provide cost-effective carbon savings and improve people's comfort and living experience considerably. Although cost savings are rarely enough to justify the work at current energy prices, there is nevertheless a strong case for improving the quality of the UK housing stock, with energy being one element in this.
- There are significant opportunities to improve the performance of a traditional business-as-usual approach to housing retrofits. The culture, structure and practices of large parts of the supply chain will need non-trivial changes and investment to deliver this.
- A coherent long-term strategy that recognises the underlying economics will enable more entrepreneurial businesses to invest in the changes required to deliver more cost-effective, high performing retrofits. This will enable progress towards energy, poverty, health and housing goals.

Progress with retrofits will depend on recognising that efficiency savings are a very weak driver and that some combination of improved comfort and amenity, improved supply-chain performance and mechanisms that mandate or reward carbon savings will be required, both in the social and able-to-pay sectors. Targeting an appropriate mix of measures on the most promising combinations of housing and occupants is more likely to be a successful "sell" than a blanket approach.

Although very deep retrofits are technically feasible, their cost could potentially be similar to the cost of rebuilding the entire UK housing stock (in excess of £2tn). A coherent whole systems approach to meeting UK climate change targets suggests that a more measured expenditure of £10bn of private and public funds over the next ten years would provide a platform that would enable investment of roughly £100bn out to 2050. Developing the platform would ensure that this money would be well spent as part of an overall housing and energy strategy.

CONTEXT

The Energy Technologies Institute (ETI) has undertaken considerable analysis on potential pathways to future affordable, secure and sustainable UK energy systems. The fourth leg of UK energy strategy is about fuel poverty and, in the context of both housing and transport, equity is an important consideration.

There is widespread agreement that the majority of housing in use in 2050 has already been built and that the extent of new build will depend on some combination of housing policy and population growth. How to decarbonise and improve the overall quality of this existing housing stock is therefore an important question. It is however finely balanced. Depending on assumptions about the whole energy system, the cost of supplying low carbon energy and the cost and performance of fabric retrofits, our assessment of the economic optimum level of retrofits varies from very modest to a significant national investment. Decarbonising energy supply is always a higher strategic priority.

Within the overall energy transition, efficiency plays an important role. In the short term, using fossil fuel more efficiently reduces costs and greenhouse gas emissions and makes a modest contribution to security and equity. In the longer term, end-use efficiency reduces the upstream investment required in low carbon energy supplies. It makes sense to set very high efficiency standards for new cars, ships, planes, buildings etc. The marginal added cost of making new assets more efficient is outweighed by the total economic and social benefits over their useful lives.

Replacing existing assets (or major components such as windows or whole heating systems) before they need it is rarely effective in cost or carbon terms. Even significant efficiency gains cannot offset the embedded energy, cost and carbon of a new asset. The exception is boilers, which have very high energy use intensities per kg of material in the boiler. It is important to ensure that assets and components which are being replaced for other reasons are also highly efficient. This is particularly true for items such as lighting, televisions, IT etc. where there is a trend of more and bigger.

ETI has undertaken projects across the whole energy system, informed by and feeding back into our whole system analysis. Publication of this report is prompted by completion of our second project in housing retrofits. The first project identified significant potential to reduce wasted time and materials, reduce costs and improve quality through industrialising the planning and execution of housing retrofits.[1] This was set against the current baseline of bespoke, craft-led individual interventions on a single dwelling basis. Although projects which have renovated large numbers of similar dwellings in a single location have demonstrated efficiencies of scale, this approach is only relevant to a small part of the housing stock.

1 Optimising Thermal Efficiency of Existing Housing: Summary Report, Energy Zone Consortium, September 2012. Available at: http://www.eti.co.uk/library/thermal-efficiency-housing

The second project set out to simulate this more industrialised approach on five typical dwellings, to learn where the pinch points are in reality and identify what might be deliverable in practice. The project team then analysed what capability building would be required to deliver it consistently. We set out to test two packages of defined measures – RetroFix and RetroPlus.

When fully implemented within an experienced supply chain, our targets for RetroFix were £12,000 for a typical semi, with a 25% improvement in thermal performance; for RetroPlus the targets were £19,000 with a 50% improvement. Keeping on-site work down to ten days of disruption for the occupants was a challenging but critical target. Costs, savings and suitability will vary between individual buildings, so these figures are broad brush generalisations.

Over the period from 2030 to 2050 the first project team projected continued improvements in organisation, new materials and methods and the skills and experience of front-line workers. These should deliver ongoing progress with cost and reliability, so that similar efficiency gains could be made at costs for RetroFix and RetroPlus of £7,500 and £13,750 respectively. Although there will be individual examples of retrofits that have already been carried out that beat these cost and performance targets, the aim of industrialisation is to deliver them as the average performance across a large population of average dwellings in real-world (ie less than perfect) circumstances.

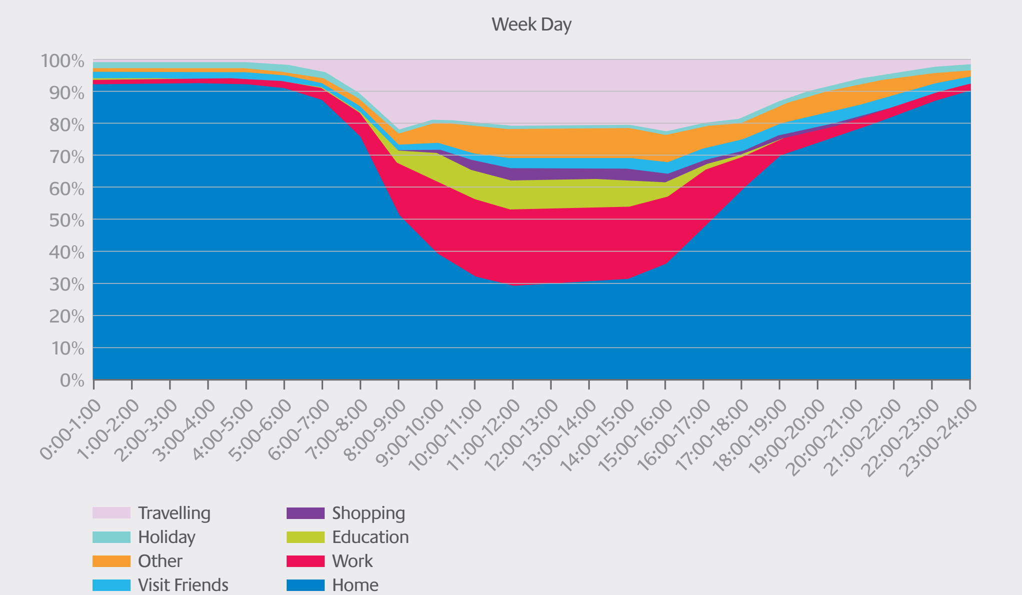
This report sets the learning from the second project in the context of our wider system analysis and also from studying other data and reports, for example from ECO.

Inevitably when working with a small population of houses, some information needs to be held back to respect the privacy of the occupants. Some photographs and other information that might have been helpful to readers cannot therefore be used in this report.

INTRODUCTION

People spend the majority of their lives within domestic dwellings. Even when we are asleep our dwellings continue to provide a comfortable, secure and serviced environment, with hot water on tap. On average on weekdays people spend more time in a dwelling than at work, at school or travelling and at weekends they are even more likely to be at home or visiting friends. Energy services include comfort, cleanliness, security, entertainment, communications, lighting, cooking, food preservation etc. – all vital to home life.

Figure 1
Where people are: ETI analysis of National Travel Survey



Space and water heating are the largest consumers of energy at home[2], accounting for over 80% of energy use; electronics, computing and appliances are the next largest and growing category; lighting and cooking are usually minor uses, but significant contributors to current peak electricity demand. Three quarters of domestic energy is supplied as fuels, mostly gas, and one quarter as electricity. Space and water heating and cooking at home and in other buildings accounted for 17% of direct UK greenhouse gas emissions in 2014[3]. Statistics on heat vary from year to year, depending on the impact of weather on space heating. Data from different sources can therefore have significant differences.

Given the importance and challenge of decarbonising heat, the ETI established a Smart Systems & Heat programme (SSH). The programme aims to create future-proof and economic local heating solutions for the UK. This is by connecting together the understanding of consumer needs and behaviour with the development and integration of technologies and new business models to deliver enhanced knowledge to facilitate a UK heat transition from 2020. Phase one of the programme, funded by the ETI until 2017, is being delivered by the Energy Systems Catapult (ESC). The Department for Business, Energy and Industrial Strategy and the ESC are working together to establish funding opportunities for a phase two large-scale demonstration of the designs and technologies developed within the programme. The contribution of domestic dwelling fabric thermal retrofits is part of phase one of the SSH programme, within an integrated systems approach to buildings energy supply and use[4].

The market value of the UK housing stock is currently around £4.5tn. Of this very roughly £2.5tn is the rebuilding cost and £2tn the implied value of the land. Buildings dwarf other energy producing and using assets in value, even vehicles. Annual investment in new build, maintenance and refurbishment is around 2% of rebuilding cost (or greater than one third of the NHS budget).

The UK housing stock is very diverse, with different styles of buildings being built with different construction methods and materials over many decades. Subsequent modifications have created an even more diverse stock. Efficiency standards were weak until the late 20th century, so the UK housing stock has relatively poor thermal efficiency compared to many other countries (but no more so than France, for example). There is therefore both an opportunity and a challenge to find cost-effective ways of retrofitting the least efficient parts of the stock.

There is limited robust information about the cost and effectiveness of deep fabric retrofits carried out in the UK. However a reasonable judgement from projects such as Retrofit for the Future[5] is that delivering 80% or more improvement in average fabric efficiency across the existing housing stock would cost slightly more than rebuilding it and it would create large emissions of greenhouse gases to manufacture the materials of construction.

2 DECC. (2015). Energy Consumption in the UK. [online] Gov.UK. Available at: https://www.gov.uk/government/collections/energy-consumption-in-the-uk

3 Committee on Climate Change. (2016). UK emissions by sector. [online] Available at: https://www.theccc.org.uk/charts-data/ukemissions-by-sector/

4 Douglas, J. (2015). Decarbonising heat for UK homes. [online] Available at: http://www.eti.co.uk/insights/heat-insight-decarbonising-heat-for-uk-homes

5 Institute for sustainability. (2012) Retrofit insights: perspectives for an emerging industry. [online] Available at: http://www.instituteforsustainability.co.uk/uploads/File/KeyFindings.pdf

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The alternative strategy of supplying low carbon heating will certainly cost much less than £2.5tn. The question for any particular building in any particular location is the best combination of refurbishment, low carbon heating system and low carbon energy distribution system for that location. This is bound up with wider questions of housing, employment, energy and transport strategy and spatial planning within that area. Within the SSH Programme, ESC staff are working with three local authorities across the UK to develop a process of local area energy planning, integrated into other spatial planning activities.

Historically the emphasis in the UK has been on single measures such as boiler replacements, loft and cavity wall insulation, etc. Combined with higher standards for new build and for major components such as boilers, windows, appliances etc., there has been a significant improvement in the average energy efficiency of UK housing stock. The impact of these policy interventions is something of a success story. However there are therefore fewer easy and cost-effective opportunities remaining.

The typical (median) UK dual fuel energy bill[6] in 2014 was £487 for electricity and £666 for gas – £1,153 in total. Just over one tenth of households were in fuel poverty (Low Income High Costs). The median fuel bill for these was £1,485 compared to £1,266 for the total population.[7] Higher heating bills for the one fifth of households heating with electricity, oil or LPG can be seen by comparing the median bill for dual fuel customers with the median for all households.

Since poorer people are significantly more likely to have electric heating, increasing environmental and social costs on electricity have a disproportionately regressive impact on fuel poverty. Nevertheless over 60% of households in the 2014 English Housing Survey said they had no difficulty meeting their energy bills, more than three times the number who had difficulty.

Set against the hassle, risks and intrusion of refurbishing building fabric, potential savings of £165 off the annual gas bill at our target cost of £12,000 are not immediately attractive.

We are therefore looking to stimulate investments where they can be integrated into wider home improvements and where the consumer benefits are greater than these energy savings alone. Part of this will be targeting buildings where energy saving is likely to be higher and costs lower and part will be improving the cost and performance of the retrofit. Our work has shown that energy savings are a low priority for most consumers in how they choose to spend their limited time and money. Making it more attractive, lower risk and less hassle must be important.

6 www.ovoenergy.com

7 DECC. (2016). Annual fuel poverty statistics report. Gov.UK [online] Available at: https://www.gov.uk/government/collections/fuel-poverty-statistics

Comfort, security, appearance, ease of maintenance and other factors should be an important part of the consumer proposition. For example, the most recent Energy Follow Up Survey[8] discovered that a minority of occupants report being unable to get comfortable in their living rooms in winter, despite the average room temperature being the same as the overall population. Although the published analysis did not investigate this, the characteristics of the houses suggest strongly that this is due to cold radiation from poorly insulated walls and windows, in combination with draughts. Average internal temperatures are an unreliable predictor of comfort.

In consumer study work carried out by the ESC as part of the SSH Programme, 40% of people reported discomfort due to over-heating in winter[9].

Nearly a third of privately rented English dwellings in 2014 were categorised as Non Decent[10], ie that they had some combination of poor repair, outdated facilities, poor insulation and ineffective heating. There are a significant number of Non Decent dwellings for all tenures and income levels. Integrating measures to deliver benefits to individuals in terms of amenity, health and energy savings would also reduce other government expenditures[11] on dealing with the consequences of poorer quality housing.

The proposition of greater comfort and amenity at the same or reduced cost is likely to be far more compelling than savings on the energy bill. Housing condition should therefore be the primary target and more attention should be paid to comfort measures rather than average internal temperature alone. Most owner occupiers would prioritise other expenditures over energy savings if they are presented as incompatible alternatives in the design of policy support mechanisms.

The body of this report will position domestic energy efficiency and more effective retrofits within the landscape of decarbonisation, local area spatial planning and housing condition and amenity set by the Context and Introduction.

(Within this report, reference is made to the Department of Energy & Climate Change (DECC). From earlier in 2016 its functions are now part of the Department of Business, Energy & Industrial Strategy (BEIS).

8 DECC and BRE. (2013). Energy follow up survey 2011 Report 1: Summary of findings. Gov.UK [online] Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/274769/1_Summary_Report.pdf

9 Lipson, M. (2015). Consumer challenges for low carbon heat. [online] Available at: http://www.eti.co.uk/insights/smart-systems-and-heat-consumer-challenges-for-low-carbon-heat

10 DECC. (2014-2015). English housing survey 2014 to 2015: headline report. Gov.UK. [online] Available at: https://www.gov.uk/government/statistics/english-housing-survey-2014-to-2015-headline-report

11 NEA. (2016). Warm homes campaign, policy briefing. [online] Available at: http://www.nea.org.uk/wp-content/uploads/2015/11/NEA-Policy-Briefing-FEB16.pdf

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What is efficiency?

"Efficiency" is used by people in different ways in different contexts. We define efficiency as providing the same or improved levels of service with lower inputs. For example, a control system that avoids over-heating unoccupied rooms provides an efficiency benefit where the occupant gets what they want with less wasted energy. However, reducing demand through voluntarily turning down the thermostat or in response to high bills does not match this definition.

Insulation, better appliances, more efficient light bulbs etc. are all examples of efficiency. Sometimes the quality of the experience is different. For example, early high efficiency light bulbs took a long time to reach full illumination and produced harsh lighting. The efficiency came with a loss of performance. Insulating walls and windows better and stopping draughts reduces the energy required to maintain the same thermostat set point but it also provides a much more comfortable room at that set point. Changes in performance are usually more important to consumers than efficiency.

The most authoritative recent report[12] on domestic energy efficiency provides a good basic reference for different measures and reasonable cost estimates. Measures estimated to have the potential to save more than 1MTe UK emissions annually are reproduced below.

Measure	Cost £/TeCO_2e saved	UK potential MTeCO_2e/yr
Internal Solid Wall insulation	£79	6.2
Pre 2002 double glazing to latest standard	£777	4.4
External Solid Wall insulation	£361	3.2
Solid floor insulation	£121	3.1
Reduced infiltration (draught proofing)	£16	2.4
Hard to Treat Cavity Wall Insulation	-£30	1.8
Primary TV	-£322	1.5
Easy to Treat Cavity Wall Insulation[13]	-£136	1.4
A++ rated fridge freezer	-£348	1.3
Halogen to LED	-£253	1.2
Single to double glazing	£202	1.2

12 Element Energy and Energy Savings Trust. (2013). Review of potential for carbon savings from residential energy efficiency. [online] Available at: https://www.theccc.org.uk/wp-content/uploads/2013/12/Review-of-potential-for-carbon-savings-from-residential-energy-efficiency-Final-report-A-160114.pdf

13 Research for BEIS suggests that many of these nominally Easy to Treat Cavities are in fact Hard to Treat; ETI shares this assessment of the evidence and therefore the UK potential is less than this report proposed.

Cost per Te saved looks at the excess cost of the measure above that justified by energy cost savings. The negative green figures show savings which pay for themselves through energy savings alone. In the case of electricity, the report assumed that the electricity saved has the same carbon intensity as the current grid average over the life of the measure; the savings may therefore be over-estimated. However, more efficient appliances are attractive through reducing future investment in low carbon supplies.

The attractive figures for appliances come with a caution. They only apply to replacement at or near end of life. The amount of energy and greenhouse gas emissions embedded for example in the manufacture of a TV or a fridge is so great that it would be better to encourage people to keep their existing ones rather than replace them. Carbon budgets should always be done on a lifecycle basis.

The table has examples both of electrical appliance and fabric efficiency. Thermal efficiency is a combination of fabric and heating system efficiency. As well as saving energy, the insulation, glazing and draught proofing are likely to improve comfort. Although changing single to double glazing appears to make no sense from an energy policy perspective, most people have chosen to do it because the benefits of sound proofing, draught reduction and reduced maintenance exceed the costs. A narrow focus on thermostat settings and energy costs misses the majority of the consumer value in retrofits.

There is a risk in focusing on usage of energy as the measure of efficiency. Currently just over one tenth of households are in fuel poverty, with the median fuel poverty gap being £215 per year per household. Encouraging people in or close to fuel poverty to reduce their heating through some combination of raising anxiety and prices would count as an efficiency gain on a usage but not on a service basis. It is important to measure efficiency against service delivery, even though that requires more careful data collection and analysis.

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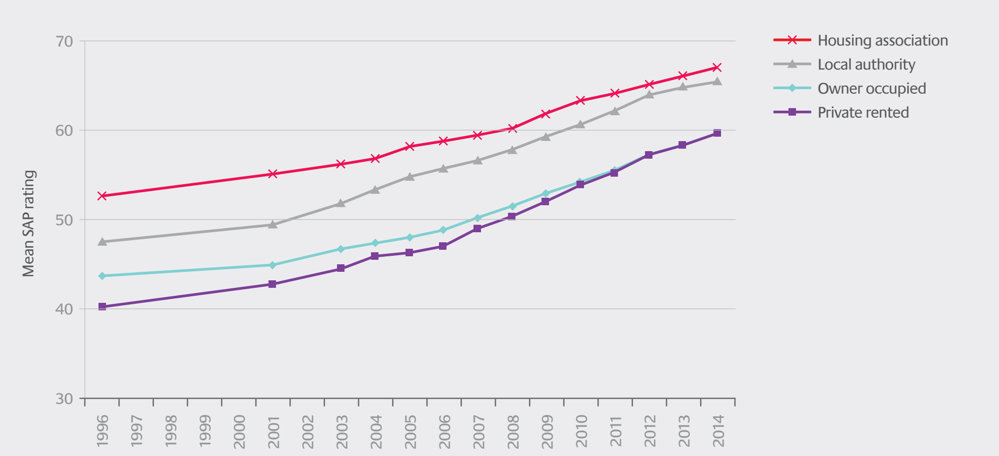
How thermally efficient is the UK housing stock?

The best available general measure of energy efficiency is the Standard Assessment Procedure (SAP) rating; averages for this by housing tenure are shown in Figure 2. This combines thermal efficiency with appliance and lighting efficiency. Micro-generation is counted as negative use and therefore an efficiency measure (on a beyond the meter usage basis).

Figure 2

SAP rating by tenure, English Housing Survey, DCLG



SAP is based on an energy use model – BRE Domestic Energy Model (BREDEM). It is well known that using BREDEM (and therefore SAP) to predict energy use in individual or even quite large groups of dwellings is problematic. Cambridge Architectural Research compared their models of housing stock with DECC meter data and found significant differences on many dimensions[14]. Others have made similar research findings.

These differences are due to a combination of:

- Occupancy factors – when people are in, how they heat rooms, how many baths and showers they have etc.
- Building physics and energy systems descriptions – insufficient data on the characteristics of populations of buildings and the energy using devices in them.
- Model assumptions – even a model as sophisticated as BREDEM has to make simplifying assumptions about buildings and it is difficult to prevent these adding up to consistent deviations at the population level.

In the absence of large amounts of fine-grained and statistically robust data on these factors, especially occupancy, the results of using BREDEM on large populations are made to match by adjusting general parameters, such as the typical internal temperatures in dwellings. When these are investigated (for example in EFUS[15]), they are shown to be significantly in error. Although these assumptions can be corrected, this then raises the question as to where the systematic inaccuracies really are in representing the population using BREDEM. It is also the case that energy use in homes is changing quite rapidly, as demonstrated by the trend in SAP ratings and other statistics on appliances, energy usage etc. Keeping the data up to date is a challenge.

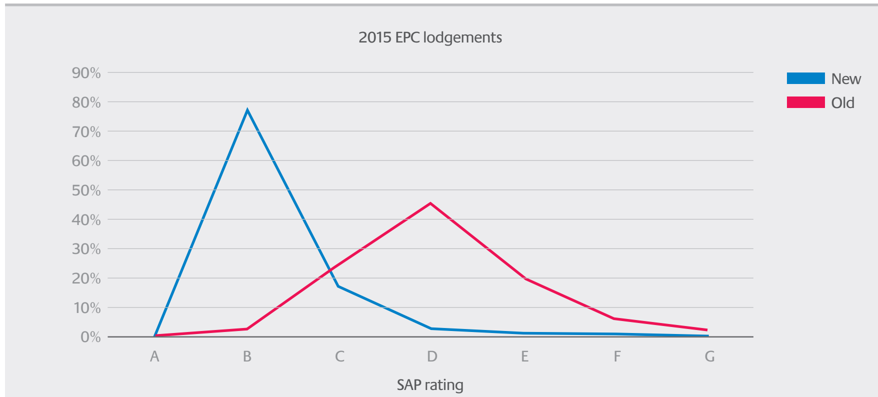
The DECC sponsored NEED[16] and HEED[17] databases have considerable information on buildings energy efficiency but access to them has a number of limitations.

The latest published official data on domestic energy performance is from Energy Performance Certificate (EPC) registrations[18].

Figure 3 shows newly lodged EPC ratings for newly built and also existing housing at the point of sale. Although there is some risk of sample bias, this provides a reasonable view of the England and Wales housing stock. The numbers are consistent with the trend data in Figure 2.

Figure 3

SAP rating from EPC certificates for houses newly built or sold in 2015[18]



14 Armitage, P, Palmer, J, Tilson A. (2013). Comparing the Cambridge housing model against the national energy data-framework and meter readings. Cambridge architectural research. [online] Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/225871/need_chm_mpan_comparisons.pdf

15 BRE. (2013). Energy follow up survey. Gov.UK. [online] Available at: https://www.gov.uk/government/statistics/energy-follow-up-survey-efus-2011

16 DECC. (2016). Summary of analytics using the National energy efficiency data-framework (NEED). Gov.UK. [online] Available at: https://www.gov.uk/government/collections/national-energy-efficiency-data-need-framework

17 Energy Savings Trust. (2016). HEED Online 2: Full technical guide 2.0. [online] Available at: http://www.energysavingtrust.org.uk/sites/default/files/HEED%20Online%202%20Full%20Technical%20Guide%20v2.01.pdf

18 DECC. (2016). Live tables on energy performace of buildings certificates. Gov.UK. [online] Available at: https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates

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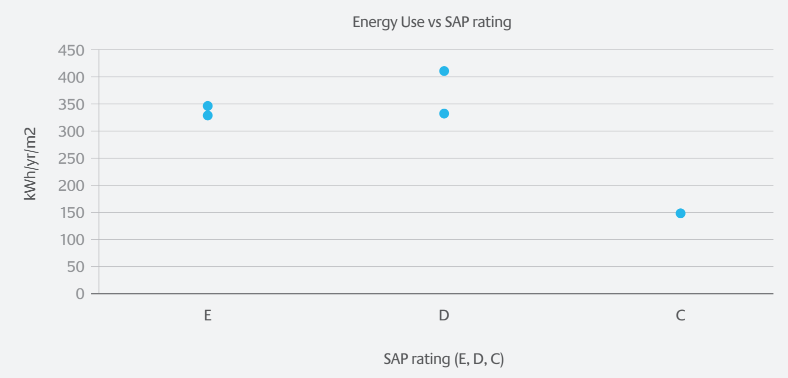
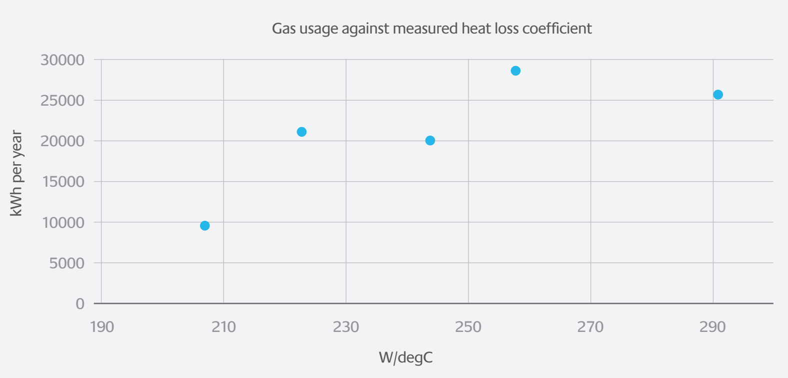
The historic energy use in the five properties retrofitted as part of ETI's second project illustrates the loose connection between SAP rating and energy use.

Figure 4
Historic energy use against SAP band for our 5 properties



If SAP rating was a strong predictor, we would expect a line sloping from the top left to bottom right. Comparing gas usage for each against heat loss rates measured by the project team shows a much better correlation with remaining variations due to measurement errors, occupancy factors and variations in local weather.

Figure 5
Historic gas use against measured fabric efficiency for our 5 properties



This is consistent with SAP rating being only a moderate predictor of thermal efficiency, even for these relatively conventional types of buildings. The project also showed that measurement of fabric performance can be relatively reliably carried out by the type of HEMS[19] prototype that is being developed within the ETI SSH Programme.

Overall we can say that there is a reasonable level of information about the efficiency of the UK housing stock but that there are risks in extrapolating the data too far from its original purpose. More granular data based on measurements, such as those undertaken as part of EFUS, would help to inform more robust models. The quarter of the existing ("Old") housing stock in bands E to G are the natural target for RetroFix and RetroPlus.

One of the issues with targeting older and less efficient properties is the impact of Historic Conservation Area location and local Article 4 Directions on the potential for retrofit. Little is known about housing in Conservation Areas, however attempts have been made to estimate the building population affected[20]. There are about 1 million dwellings in Conservation Areas, nearly half of them in London. Unsurprisingly, older and less efficient properties are more likely to be in such areas. The reference estimates that a quarter of dwellings built pre-1919 are in Conservation Areas. Pre-1919 dwellings represent one fifth of the housing stock and therefore the majority of dwellings in Conservation Areas will be pre-1919.

There are a further 100,000 dwellings in National Parks which are likely to have the usual bi-modal distribution between very expensive and well-maintained buildings and buildings with low thermal efficiencies. As a further complication, people whose homes are in Conservation Areas and National Parks are likely to be disproportionately drawn from upper and lower income bands. The complexity of the interaction between location, building type, building condition, tenure and occupancy argues for broad policy objectives being developed centrally but for a strong local element in detailed design and delivery, including feeding back accurate data.

One of the dwellings in the ETI project was deliberately chosen from a Conservation Area. This enabled the project team to test the planning approval process and additional measures to gain approval.

19 www.eti.co.uk/project/home-energy-management-system/

20 Bottrill, C. (2005). Homes in historic conservation areas in Great Britain: Calculating the proportion of residential dwellings in conservation areas. [online] Available at: http://www.eci.ox.ac.uk/research/energy/downloads/40house/background_doc_K.pdf

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What kind of interventions are attractive?

In the absence of co-benefits there are a limited number of building fabric efficiency interventions which are attractive on an efficiency only payback basis (at current energy prices). This is due to some combination of poor return on investment, hassle factors and the risks that consumers are expected to bear. In addition, only about one third of the UK population are motivated to spend effort and money on saving energy.

On the other hand, consumers will often consider energy savings as an important co-benefit to other choices that they are making about domestic renovation and amenity improvement. Not only is an unmodernised home with poor fitting and decoration, cold walls and draughts inefficient, it is also uncomfortable.

Two generic strategies would play into this situation:

- Ensure through standards that major components for refurbishment, such as boilers, windows, doors etc. are only available with high real-world efficiency performance.
- Identify opportunities for capital grants at attractive carbon prices and ensure that these can be accessed as part of wider domestic refurbishment plans, not just stand-alone interventions.

Standards for major components have been increased in recent years and attention should now be on enforcement.

A smaller opportunity would arise from situations where developers are making a capital gain from building conversion, sub-division or major refurbishment. Attaching graduated but significant council tax loadings to redeveloped properties that have a post event SAP rating less than 75 would encourage attention on efficiency and comfort as part of the retrofit.

The current major opportunity lies in Hard to Treat Cavity walls (HTTC). The Energy Company Obligation (ECO) campaign from 2013-15 treated around a quarter of a million of these. There are still around 4 million untreated HTTC walls, as well as a few hundred thousand Easy to Treat. HTTC is a broad category of different situations with differences of opinion about both the sub-populations and the costs and risks of treating them. Unfortunately there was no monitoring element to ECO (sampling say 1% of treatments), so we have only anecdotal information from the £150M of customers' funds spent centrally on HTTC treatments.

One could conceive of a programme based on the experience of comfort that focused on draughts, loft insulation and cavity wall treatment; also including the suggestion that consumers might want to think about doors, windows and other replacements at their own expense. Increased physical security might also be a significant co-benefit for some. Government could probably make progress with a percentage capital grant for eligible elements at a carbon price around £50-70/Te.

In parallel, the quality and performance of the supply chain would need to be a focus. The balance should shift, validating pre-certification with sampled post-event monitoring and transparency of consumer feedback.
If government provides a stable market for attractive retrofits together with mechanisms that enable good performers to out-compete poor ones, then the industry will respond.
A particular challenge for government is to ensure that grant funding is mainly spent with high performers without creating a complex and potentially costly administrative burden.

Creating a virtuous circle around this £10bn+ scale potential market opportunity over the next decade would lay foundations for the longer term (2050).

In areas where the most cost-effective longer term solution is district heating, the level of improvement described above may be sufficient. Where heat-pumps are the solution, then higher levels of efficiency are needed. It is also the case that the 7 million dwellings with solid walls will continue to be less comfortable and more expensive to heat. Low carbon energy is relatively cost-effective, provided that strategic mistakes are avoided in technology portfolio selection. In the longer term however we will need to refurbish many solid wall dwellings, as part of switching them to low carbon heat or indeed simply achieving buildings that are comfortable when heated.

In the ECO campaign, around 80 thousand dwellings received solid wall insulation, accounting for 6% of the interventions and 30% of the cost. As no useful technical data was collected, little learning can be shared. A smaller installation programme, as part of a carefully designed and monitored trial, could create the foundations for better policy design and accelerate industry performance. This would be especially true if the main aim of the trial was to deliver and measure comfort improvement rather than focus on energy savings.

In summary the most attractive opportunities are:

1. Monitoring, enforcement and continued improvement of standards for major components.
2. An immediate programme of comfort and amenity improvements, centred around Harder to Treat Cavities (of course including any remaining Easy to Treat Cavities), with some government financial support and attention to the needs and performance of the supply chain.
3. Development and validation of effective comfort measures as a basis for marketing amenity and comfort to consumers, with cost savings positioned as a co-benefit.
4. Trials of major refurbishments of solid wall properties with design and installation data capture and post-event performance monitoring based around comfort.

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A vision of low carbon housing

The ETI Smart Systems & Heat Programme aims to find affordable ways of providing secure low carbon heating to dwellings across the UK. From our work at the whole systems level we recognise that low carbon energy can be relatively affordable, provided that over the next decade key technology options are developed at a sufficient scale to provide investor, customer and public policy confidence.

In any area individual buildings can only connect to the energy supplies that are available: gas, electricity, district heating etc. They can also be supplied with fuels such as LPG, oil, coal and biomass by delivery vehicles. District heating (and cooling) could already be attractive in dense urban areas on a levelised basis, but in the UK suffers from competition with regulated monopolies with publicly underwritten assets.

The transition for any individual dwelling, shop, office etc. therefore depends on the local transition plan for low carbon energy supply. The only potentially feasible long-term options that ETI has identified are decarbonised electricity supply, decarbonised district heating and hydrogen. There may be niche opportunities for biogas and distributing biomass to individual buildings but they are not economically scalable solutions across the UK. Although hydrogen may be an attractive way of repurposing the existing gas distribution system[21], further developments are required before ETI could confidently recommend it as the basis for a local area plan.

In many cost-effective future energy systems, heat-pumps are combined with gas boilers so that relatively short and infrequent needs of high heat output are met by the boiler and the heat-pump provides the typical base space and water heating.

Given some confidence in the timing and availability of low carbon networks and the likely retail cost of the low carbon energy, property owners can consider what investments they want to make in their dwellings, either as owner/occupiers or landlords. This is part of asset lifecycle planning which will depend very much on the circumstances and preferences of each owner. In the absence of this longer term confidence they are likely to focus on immediate benefits and priorities and conserve valuable capital.

In the case of new housing, energy bills should be low enough that the main issue is ensuring that the building can physically accommodate any future change of heating system. Routing of any new pipes, the capacity of the local electricity circuit, availability of a large thermal store and the location and safety factors of the heating "plant room" should all be considered at the design stage.

Ideally any new or refurbished building would have a high function Energy Management System, to gather thermal response, occupancy and performance data, but the market is not as yet providing these.

21 Northern Gas Networks. (2016). The Leeds city gate project report. [online] Available at: http://www.northerngasnetworks.co.uk/wp-content/uploads/2016/07/H21-Report-Interactive-PDF-July-2016.pdf

A NEW START

Continued ›

For the very diverse stock of existing homes, finding a route to a comfortable, affordable and equitable low carbon future is more complex. While there is a temptation to take a "Grand Designs" style of bespoke approach, this is not likely to be affordable, except for a privileged few. The challenge is to create a toolkit of solutions from which an acceptable outcome can be delivered for the vast majority of dwellings. In one sense this industrialised approach is familiar within a building industry that uses standard components and systems but the approach to design and installation of retrofits is not currently systematic, at least not for privately owned buildings.

As well as identifying a thermal efficiency upgrade, the dwelling plan also needs to identify when, where and how the heating system will be replaced and linked in to the planned local networks.

Given the strong latent dissatisfactions that are apparent with the provision of energy services in dwellings and to small business consumers, there is an opportunity for a new kind of service provider (integrator) that aims for a much higher level of service provision, starting with existing energy supplies. The root causes of the dissatisfactions act as a barrier to change – not so much "If it ain't broke don't fix it!", more "Now I've learned to live with it, don't change it!". The majority of consumers would be happy to pay the same or even a little more for better service. As an illustration, concerns over service and the risks of change combine with inertia so that many people don't change suppliers to save the kinds of money that a major retrofit might also save them.

Having a plan for the decarbonisation of supply of each dwelling would become a natural business activity for such suppliers, if a market environment can be created over the next 5 years where they start to develop. This is also addressed in the ETI Smart Systems & Heat Programme – the nature of these new businesses and the tools they might need to develop to deliver both high levels of consumer satisfaction and government policy goals such as decarbonisation and fuel poverty alleviation.

A large number of dwellings appear to be at least somewhat uncomfortable, even if the residents can afford to heat them; also ETI's analysis of future energy systems sees retrofits as on a tipping point – in some outcomes a relatively modest number have significant fabric improvements, in others maybe as many as 40%. Therefore we set out to discover what would be involved in reducing the cost and standardising the performance of housing retrofits, concentrating on dwelling types that form a significant part of the overall housing stock.

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Better retrofits

In the first Buildings Retrofit project, ETI funded an external team led by an architect's practice and including experts in energy, building technology and process improvement, as well as a builder and a social landlord; they investigated the opportunity from standardising and reducing wasted time and materials from building retrofits.

Key findings from this project were:

- New approaches could deliver at least a 30% saving over current expected costs.
- Labour effectiveness is the greatest potential improvement with an anticipated 40% improvement achievable across survey and installation with Lean Processes[22].
- A small team that combines the required skills is the basis on which single property, whole house retrofits could be made viable.
- An integrated supply chain with single delivery of all materials, combined with site waste removal, could almost halve material distribution cost.
- Alternative models of supply will remain, but a disruptive franchise-style solution might be one way that learning could be shared and scaled up rapidly while retaining the localism that appeals to customers.

22 For example, see https://www.asme.org/engineering-topics/articles/manufacturing-design/5-lean-principles-every-should-know

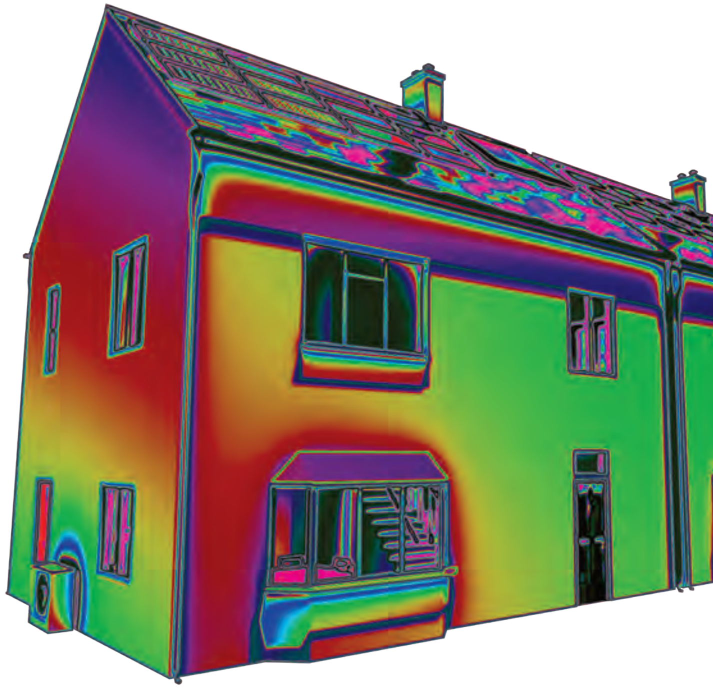
One of the key recommendations was to test these hypotheses through practical field trials. The second project set out to design and install retrofits on one example each of the five top housing archetypes, while simulating as best as possible on a small scale the Lean Process approach proposed by the first project.

The project team had significant overlap with the first project and included the main maintenance contractor for the social landlord and four of their dwellings, as well as a dwelling from a different ETI project and a different and smaller contractor.

One of the dwellings was found to have a pre-existing defect that interacted significantly with the proposed retrofit. Various technical and contractual difficulties prevented agreement on how defect rectification and retrofit could be combined. Although the opportunity to get another data point on installation was lost, the ETI concluded that this was a typical example of pre-existing defects and that the survey and design experience was sufficient learning without finding a replacement dwelling.

Although five dwellings and two contractors is not a statistical sample of UK building refurbishment, ETI has concluded that the project experience provides good insight into the current state of large parts of the industry. No doubt there are small specialist contractors who are developing approaches with similar characteristics to the approach proposed by the first project team but they are isolated examples.

Comments about the difficulties and challenges of implementing the approach are not criticisms of organisations or individuals. They were people doing the best they could, based on their previous experience and trying to adopt a new approach with mixed results.



A NEW START
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The main quantified findings are attached in the Appendix but the headlines from the project are:

- Details of the retrofit designs were too frequently not implementable, despite significant investment in survey and design.
- Perhaps as a result, the tradesmen did not always pay attention to the design information, tending instead to concentrate on making the materials and methods work, based on their experience.
- Introducing new materials and methods into this environment is a high-risk activity. Specifications, methods testing, validation of materials against specifications, ensuring that things that could go wrong are identified and designed out, provision of appropriate and/or specialist tools etc., all seem to be things that are gradually developed through experience rather than systematically developed and tested up front. There were some serious failures.
- Despite attention to communication with the owners and occupiers of the dwellings and their needs, there were still some issues that took time and money to resolve.
- The choice of solutions, especially between external, internal and cavity insulation in different parts of the building involves complex cost, technical, aesthetic, disturbance and performance trade-offs that require significant skill; the expected cost of a retrofit is likely to increase from the initial rough estimate as these trade-offs are made.
- The idea of a small multi-skilled team was alien to the tradesmen involved, who nevertheless tried to make it work with increasing success over a number of buildings but hampered by team changes etc.
- The teams expected to source many of their tools and materials from local builders' merchants through repeated visits; managing delivery against a bill of material was an unfamiliar practice. This can add significant wasted effort on materials procurement and also on site delays.
- Scaffolding and access methods were a significant time, cost and risk area for the project with characteristics similar to other design and install tasks. Design and installation of access by the on-site team appears to be far less problematic than pre-designed access, although the balance between scaffolding and mobile access would need to be determined up front.
- Weather windows are important for external works; while improved technical solutions may improve this somewhat it will always be the case that costs and productivity and both cost and schedule risk will be seasonal.
- One significant pre-existing defect discovered post survey is well within expectations for five house retrofits. The contractual and technical challenges in resolving this were a textbook case. Although it adds significantly to the cost, the contractor pricing in reasonable risks against this would be critical to any property owner with only one or a small number of properties.
- The investment required to develop a more standardised approach to single dwelling retrofits and roll this out across the UK would be considerable but potentially worthwhile compared to the scale of the need. The concept of franchising this (as opposed to large contractors employing most of the staff) was not tested through the project but does appear to be an approach that matches the scale of the investment in capability with the localised nature of much of the supply chain.
- This is unlikely to happen without some combination of confidence in a sustained market and opportunities to develop the practice on low-risk projects, for example with government support. Previous support has tended to be either for point improvements (for example to access) or for retrofits of a level of ambition that will hardly ever be economic. Support for process improvement and standardisation would be a new approach.

Conclusions

The concept of RetroFix (25% improvement for £12,000 for suitable properties) remains valid but it will not become widespread in practice without a different market environment. RetroPlus (50% improvement for £19,000) is perhaps less persuasive, in reality more of a set of bolt-ons to RetroFix in certain circumstances. Although our chosen five properties were not suited to mostly Cavity Wall Insulation installation for their walls, they were not atypical of significant parts of the housing stock. Executing a RetroFix solution where the walls were mostly Cavity Wall Insulation, with some Internal Wall Insulation, should produce RetroFix levels of benefit at a lower cost than the very high costs on our example projects (£32,000-£78,000 achieved).

These kinds of relatively significant retrofits will have an important role to play with less efficient houses that need modernising, where the total costs of the modernisation are realistic compared to the final property value, the improvement in comfort and amenity and the reduction in energy usage.

How many houses will be economically retrofitted to the extent of >£5,000 purely on fabric efficiency alone will depend very much on the reality of comfort improvements (as opposed to efficiency savings) and how expensive low carbon energy supplies turn out to be, given progress in implementing low carbon energy sources and local distribution networks.

The detailed project reports[23, 24] have analyses of the activities undertaken in the project and recommendations for other organisations on implementation and improvement, based on this experience. From this rich material and interactions with the project team, we have distilled the headlines in the previous section. We will be publishing these reports, once they are finalised, so that people can draw their own conclusions from the original material.

Reading these reports and considering the costs and issues involved in delivery gives a clear indication of the barriers to be overcome before RetroFix will be attractive to a significant number of individual property owners.

23 Key Performance Results of the ETI Approach Demonstrations, PRP and Peabody

24 Conclusions and Opportunities for the ETI Approach, PRP and Peabody

Next Steps

Top Four Opportunities

A number of opportunities were highlighted in the previous section:

1. Monitoring, enforcement and continued improvement of standards for major components.
2. An immediate programme of comfort and amenity improvements, centred around Harder to Treat Cavities (of course including any remaining Easy to Treat Cavities), with some government financial support and attention to the needs and performance of the supply chain.
3. Development and validation of effective comfort measures as a basis for marketing amenity and comfort to consumers, with cost savings positioned as a co-benefit.
4. Trials of major refurbishments of solid wall properties with design and installation data capture and post-event performance monitoring based around comfort.

Without greater clarity on the role that retrofits should play in housing, health and energy policy and the level of funding and policy effort available to deliver them, it is difficult to be clear on the best approach.

An incremental approach, driven mainly by health and housing policy, combined with some modest investments in the four opportunities would recognise that housing retrofits are challenging, expensive and not necessarily strategic to decarbonisation. This would retain the option to accelerate later both from a firmer foundation and also with a clearer view on what retrofits need to deliver.

This would also enable continued work to use these opportunities and other existing policy actions to create better data and experience with the issues.

An alternative approach would be to confirm that retrofits are one important element in energy strategy and to resource them accordingly. There is no single policy or simple set of steps that can deliver an acceleration of retrofits that are cost-effective. When the Bonfield Review report is published there will be an opportunity to respond by signalling the intent to create a new market environment.

The risk of adding to housing costs is highlighted by the recent Living Home Standard[25] 43% of UK homes do not meet this standard. Affordability is the most common reason, at 27% of homes. A retrofit policy that aims for acceleration must recognise that energy savings do not justify more than a very small number of retrofits and that the market structure needs to do three things:

- Create confidence in the minds of building owners and occupiers and their supply chain.
- Recognise the "missing money" by monetising health benefits, improved consumer amenity and carbon savings; health benefits and carbon savings need some combination of mandation and public funding.
- Involve local government closely in the planning and implementation while ensuring that data and learning is pooled rather than fragmented. This also presents the opportunity to integrate planning, health, social welfare and energy more effectively at a local level.

Which of the two approaches is more appropriate is a political choice. In the more incremental approach it will be hard to sustain momentum as the easier opportunities are progressively taken. In the more aggressive approach other areas will slow due to the diversion of resources. In the case of hard choices, the ETI would prioritise resources to other areas of the energy transition.
Our priorities are:

- Carbon Capture & Storage (CCS).
- Increased production and use of sustainably produced UK biomass.
- Efficiency standards for new and replacement assets, especially vehicles, buildings and building components.
- Offshore Wind.
- New nuclear.
- The role of gases (natural gas, hydrogen etc) in future systems.

25 British Gas, Ipsos MORI, Shelter. (2016) Living Home Standard. [online] Available at: http://www.shelter.org.uk/__data/assets/pdf_file/0011/1287848/living_home_standard_full_report.pdf

Appendix

Basic data

All of the dwellings were three bedroom with one bathroom, occupied by families with varied characteristics. Two were without cavities and two had cavity insulation but thermal imaging showed gaps and/or poor performance; one cavity was filled with rubble. All of the properties had gas central heating and E also had partial electric underfloor heating.

The five dwellings represent a large proportion of the UK housing stock in terms of style, floor area, number of bedrooms etc. They have a slightly higher level of occupation than the norm, but not excessively so. Their gas consumption before retrofit was noticeably higher than average household energy consumption, apart from dwelling C. The high electricity consumption of E will be partly due to the electric underfloor heating but there were also other activities in the dwelling that may have been high electricity consumers. Gas consumption in E (as shown in Figure 5), does not seem to have been reduced by any use of electric heating.

House	A	B	C	D	E
Type	Pre 1919 mid terrace	Pre 1919 detached	1945-1964 semi	1919-1944 semi	1980s semi
Wall Type	Solid brick	Solid brick	Partially filled cavity	Rubble filled cavity	Partially filled cavity
Approximate floor area m^2	100	80	83	70	79
Envelope area/floor area	3.05	2.85	2.90	2.90	2.05
SAP band	E	E	C	D	D
Electricity kWh/year[26]	4,300	2,200	2,600	3,400	11,400
Gas kWh/year[27]	28,500	25,500	9,500	20,000	21,000
Standardised energy use kWh/year/m^2	328	346	146	334	410
Aesthetics	Heritage fabric details	Conservation Area	Brick	Rendered	Brick
Access	Rear access only through dwelling; no space at front; parking restricted	One side wall abuts pavement; small roads with potential delivery issues	Narrow street; caravan parked to block access and storage area; access to rear down the side	No significant issues	Good access to front but rear access likely to require bridge or lifting solution
Windows	Double glazed	Single glazed	Double glazed	Double glazed	Double glazed
Doors	Double glazed apart from fanlight	Wood, single glazed	Wood, single glazed	Front door and porch are single glazed	Double glazed
Boiler	Combi condensing	Combi	Boiler with HW cylinder	Boiler with HW cylinder	Boiler with HW cylinder, plus electric underfloor in kitchen
Heating controls	Timer only	Timer, thermostat, TRVs	Timer, thermostat, TRVs	Timer, thermostat, TRVs	Timer, thermostats, TRVs (downstairs)

26 DECC use 3,800 kWh/year as their standard electricity consumption

27 DECC use 15,000 kWh/year as their standard gas consumption

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Retrofit data

None of the homes were suitable for additional cavity wall insulation, for a variety of reasons. The two old brick properties without cavities would be counted within the over 7M solid wall properties in the UK; two properties would be counted as having CWI, despite its poor performance; the final property would be counted as Hard to Treat.

House	A	B (works not carried out)	C	D	E
Type	Pre 1919 mid terrace	Pre 1919 detached	1945-1964 semi	1919-1944 semi	1980s semi
Model	RetroFix	RetroPlus	RetroFix	RetroFix	RetroPlus
Walls	IWI to main building (heritage and technical features) and EWI to rear wing	IWI throughout	EWI to all facades	EWI to all facades	EWI to all facades (with brick slips); small amounts of CWI and IWI
Roof	Top up loft; insulate hatches; soffit over door	Top up loft; insulate hatches; insulate sloping ceilings	Top up loft; insulate hatches;	Top up loft; insulate hatches; insulate sloping ceilings; insulate bay window roof	Top up loft; insulate hatches; seal and insulate loft over office
Floor	Insulate floor over cellar; insulate below DPC to rear	Insulate below DPC	Insulate below DPC	Insulate below DPC	Insulate below DPC; insulate and seal suspended floors
Doors/Windows	Draught stripping	Secondary glazing	Draught stripping	Draught stripping	Replace with triple glazing
Airtightness before works / target $m^3/m^2.h$	13.3/7	10.3/5	11/7	8.5/7	31/5
Airtightness	Seal around windows and doors; seal and ventilate chimneys; seal below suspended floors	Seal perimeters; draught stripping; seal skirting and penetrations; seal and ventilate chimneys	Seal perimeters; draught stripping; seal skirting and penetrations; block wall vents	Seal perimeters; draught stripping; seal skirting and penetrations; block wall vents	Seal perimeters; draught stripping; seal skirting and penetrations; seal and ventilate chimney; block up and insulate garage door opening

House	A	B (works not carried out)	C	D	E
Ventilation	Mechanical with heat recovery in kitchen and bathroom	Background ventilation with heat recovery in kitchen and bathroom	Mechanical with heat recovery in kitchen and bathroom	Replace existing fans in kitchen and bathroom to add heat recovery	Mechanical with heat recovery in kitchen and bathroom
Airtightness after works / target $m^3/m^2.h$	9.5/7	NA	5.9/7	6.7/7	12.0/5
HTC before works W/degC	258	291	207	244	223
HTC after works W/degC	193	NA	115	168	172
Reduction in HTC	25%	NA	45%	30%	23%
Reduction in gas consumption[28]	30%	NA	50%	35%	40%

Despite some evidence of increased internal temperatures and increased occupancy, significant reductions in gas consumption were measured, consistent with the measured reductions in HTC. Although the changes in HTC appear to under-estimate the improvements, the methods are not that accurate; it is encouraging that the HTC improvement measurement appears conservative.

28 On a matched heating requirement basis, but uncorrected for take back and occupancy changes

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Costs

There is an extensive analysis of the achieved costs and cost drivers in the first project report. This also projects how these costs might be improved. The second report analyses the issues that were observed during the project and how the supply chain might be developed in future to deliver quality outcomes at the future costs projected in the first report.

House	A	B (works not carried out)	C	D	E
Type	Pre 1919 mid terrace	Pre 1919 detached	1945-1964 semi	1919-1944 semi	1980s semi
Model	RetroFix	RetroPlus	RetroFix	RetroFix	RetroPlus
Ingoing notional target from first project £k	11.4	28.3	12.3	13.5	28.6
Project team initial estimate of typical BAU costs £k	16.8	28.0	17.5	18.2	29.7
Main contractor estimate based on outline scope £k	27.6	NA	29.7	27.8	57.7
Out-turn £k	42.9	NA	77.5	32.5	50.0
Outgoing notional target when supply chain developed £k	18.3	NA	18.7	16.9	31.0

The variability and uncertainty of the cost estimates is noteworthy, given the expertise of the members of the project team.

- The drastic cost over-runs on dwelling C were mainly due to the collapse of the cavity during the process of EWI fixing.
- The main contractor over-estimated the costs that would be incurred by the secondary contractor on dwelling E.
- Part of the reason that work on dwelling B did not proceed was inability to agree how the pre-existing defect would be addressed and who would carry the significant cost. The defect was not identified by the project team but by the ESC "owner's engineer". Proceeding with the retrofit without addressing the defect would have prejudiced the integrity of the building.

The out-turn has been used to recalibrate the estimated future achievable RetroFix and RetroPlus costs for these specific properties.

House	A		C		D		E	
Model	RetroFix		RetroFix		RetroFix		RetroPlus	
£	Out-turn	Achievable	Out-turn	Achievable	Out-turn	Achievable	Out-turn	Achievable
Additional works	4,527	–	4,537	–	1,667	–	5,000	–
Disputed	13,717	–	29,151	–	9,713	–	–	–
Condition Contingency	4,744	3,750	25,109	1,875	1,728	1,875	1,800	1,083
Ohds & Profit	3,241	2,625	3,174	2,625	3,214	2,625	4,125	2,625
Prelims	4,200	2,722	4,200	3,013	4,200	2,781	9,500	6,321
Materials	4,205	1,983	3,124	3,925	3,243	2,382	17,155	11,945
Labour	8,273	7,253	8,237	7,253	8,688	7,253	12,450	9,066
Total	42,907	18,333	77,532	18,691	32,453	16,917	50,030	31,041

Additional works were value-add items (for example building new wardrobes, replacing electrical sockets, clearing rubbish from garden area) that were not central to the retrofit but where the building owner agreed to pay for them, on the basis that the team was already on site. It seems inevitable that such works will occur on any project. This highlights the fact that major works are always part of a wider picture for the owners and occupants about building condition and amenity. While a narrow technical view might exclude these costs, they are part of the overall "project cost" from the perspective of the project funder.

Disputed costs were shared on a negotiated basis 50:50 between the building contractors and the overall project costs funded by ETI. This highlights the risks and challenges faced by building owners in terms of placing and letting retrofit contracts when the number of buildings is too small to justify appointing an architect or building engineer to manage the commercial and technical risks. Disputed items included rework of works below quality, items with no apparent justification and apparently inflated costs, along with other areas of dispute. Unsurprisingly the disputed costs were highest on C, where the wall collapsed inwards on EWI installation.

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Condition costs are driven by activities not fully identified in the initial survey and design. In the case of C, these might have been avoided almost entirely had the right tools and work methods been used. They could certainly have been limited to £5,000. For future retrofits these should be thought of as some kind of insurance payment by the customer that covers items not identified by the contractor in advance. The excess costs are therefore averaged over a large number of projects. There are obvious commercial and business model issues attached to this high-level concept, which are discussed in more detail in the project reports.

Overheads & Profit are required by the contractor and the reports discuss the operational and commercial basis for the future estimates.

Prelims includes items such as survey, design, scaffolding, welfare van etc. that are discussed in more detail in the reports.

Materials are all materials, components and consumables supplied for the work. Reducing waste and market development are the key levers to achieve future reductions. There is an obvious tension between aesthetics and cost. For example the brick slips used on D added very considerably to the EWI cost, compared to render. Also, the balance between cost of materials and cost of installation labour is important to overall cost.

Labour unit costs, productivity, quality, team working and supervision are discussed extensively in the reports. Weather risk is a significant driver of both cost and cost uncertainty with wet application EWI systems.

Observations

It is clear that the future cost targets for RetroFix for properties requiring EWI are around £18,000 and of RetroPlus well over £20,000. Aesthetics, and in particular brick slips, can drive these costs higher still. The actual costs on any individual single dwelling retrofit can be widely variable and the project customer is exposed to significant technical and commercial management challenges; these translate into high levels of cost, performance and disruption risk.

Achieved ECO costs for EWI projects were on average around £9,000. The additional costs in RetroFix represent all the other interventions required to improve fabric thermal performance by 25-45%. The technical targets are achievable through a whole house approach; it is the cost, risk and hassle that presents a barrier to significant thermal performance improvement.

On this basis the obvious first target should be harder to treat cavity wall retrofits, where all of these issues are more manageable. HTTC are significantly harder than standard cavities, especially on a whole house basis (ie RetroFix) but not nearly as challenging as EWI/IWI.

FURTHER READING

Decarbonising heat for UK homes
www.eti.co.uk/insights/heat-insight-decarbonising-heat-for-uk-homes

Consumer challenges for low carbon heat
www.eti.co.uk/insights/smart-systems-and-heat-consumer-challenges-for-low-carbon-heat

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