What Works ...

... in encouraging the take up of low carbon products and services in households?

Dr Samantha Organ, The University of the West of England
Nicholas Schoon, Bioregional
Dr Graham Squires, The University of Birmingham
Dr Matthew Wood, Bioregional

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Dr Samantha Organ, The University of the West of England
Nicholas Schoon, Bioregional
Dr Graham Squires, The University of Birmingham
Dr Matthew Wood, Bioregional

Acknowledgments

In preparing this report we interviewed four UK-based experts:

Interviewee 1: **Dr Tina Fawcett**
Senior Researcher, Environmental Change Institute, Oxford University.

Interviewee 2: **Dr Aaron Gillich**
Research Fellow, Centre for Efficient and Renewable Energy in Buildings,
London South Bank University.

Interviewee 3: **Dr Andrew Reeves**
Visiting Research Fellow, Institute of Energy and Sustainable Development, De Montfort University.

Interviewee 4: **Dr Jan Rosenow**
Principal Consultant Ricardo-AEA Group, Visiting Research Associate at Environmental Change Institute, Oxford University.

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The conclusions are our own, as are any errors.

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Bioregional
BedZED Centre
24 Helios Road
Wallington, London
SM6 7BZ
United Kingdom
+ 44 (0)20 804 4880
info@bioregional.com @bioregional @oneplanetliving

www.bioregional.com

Contents

Government can encourage take-up of low-carbon products and services in UK homes by appealing to different motivations, tailoring interventions to the needs of different kinds of household, and targeting people in periods of transition.

Heat and electricity used in homes amounts to more than a quarter of the UK's carbon dioxide emissions. There has been real progress in improving the energy efficiency of UK homes over the past decade with the total energy consumed by households over the past decade falling along with their carbon emissions. But the rate of progress has slowed in recent years when it needs to be maintained or accelerated if the UK's carbon reduction budgets are to be met.

Home energy saving upgrades can also lower bills, tackle fuel poverty and increase energy security. It is clear the market alone will not achieve this.

The barriers to uptake

The upfront cost of buying low-carbon products and services is a major barrier for most people. Householders typically lack the capital to install major low-carbon measures. Where they do, they are more likely to want to spend their hard-earned cash on other things. For those who are aware of the potential savings they could make on their fuel bills if they installed low-carbon measures, those savings are considered insufficient to justify the expenditure – particularly on larger measures. People also apply discount rates to low-carbon measures, which can deter uptake- they see money in the future (from savings) being worth less than money today (paid out on energy saving measures).

Another major barrier to uptake is lack of knowledge. Most people are unfamiliar with major low carbon-retrofits, which are relatively new and little understood. Although the media is becoming more familiar with the concept of 'ecohomes', which has raised some awareness, there is limited information on what steps are entailed in creating such homes. Not only that, knowledge of and skills for 'eco refurbishments' are limited within industry and lack of trust in 'eco products' is a major issue.

The need for segmentation

Driving greater uptake will require targeting different population segments in order to appeal to a range of values and motivations. For example, householders' receptiveness to adopting low-carbon measures is likely to rise when they are in a period of transition. These periods include moving into a new home, where the householder has a young or growing family, or where time spent at home increases. Information can therefore be framed to target those in periods of transition, which can reduce inconvenience and disruption.

Those undertaking home improvements are also a key segment. Measures that enhance character or aesthetics are likely to be as attractive as those that help reduce fuel bills, particularly when they are installed alongside other improvement works. Solid wall insulation can be problematic here. It is perceived as costly, inconvenient and disruptive; in some cases potentially detracting from the character of the property. Yet increasing the uptake of solid wall insulation is crucial given its potential to achieve substantial carbon reductions.

It is also important to tackle the private rented sector, which is the most energy inefficient and includes a higher proportion of solid-walled properties.

The need for incentives

To date, those in lower income groups have been more likely to have higher levels of low-carbon measures installed. This can be attributed to previous initiatives directed at this population segment, as well as the importance of affordable warmth for this group. But it is these very groups at greater risk of fuel poverty that are most likely to be unable to fund improvement works without help.

Financial incentives are key to addressing both cost and trust issues, and experience shows that they can be successful. The most successful incentive to date appears to be the Carbon Emissions Reduction Target, which saw a significant increase in the installation of loft and cavity wall insulation from 2008 to 2012. Its successor, the Energy Company Obligation, has not achieved the same level of uptake, whilst the unsuccessful Green Deal energy saving loan scheme was abandoned in 2015. Schemes similar to the Green Deal in France and Germany emphasise the need for loans to be low or zero interest rates for greater uptake.

Yet incentives will only be effective if people get the information they need, tailored to their personal motivations, and delivered at the right time through the right means.

Policy implications

A combination of policy tools is likely to be most effective, using information, regulation and economic incentives. It is critical that policy is well designed from the outset to ensure mixed messages are avoided. This can result in inertia amongst householders who are typically risk averse and will favour the status quo.

Sudden changes to policy will only deter the adoption of low carbon measures. Householders favour measures with low upfront costs which will result in increased efficiency and reduced energy bills. They also favour convenience and limited disruption, and reliable contractors.

Policy will be needed for all income levels and for all socio-demographic groups to best encourage uptake across the housing stock. However, it will need to skilfully target the most cost-effective measures in relation to overall energy and carbon savings, those households at risk of fuel poverty, and the most energy inefficient homes. This will have positive implications for health and wellbeing, and therefore on potential costs to the NHS.

There is limited information on future overheating resulting from a changing climate and the health implications; household energy efficiency policy will have to consider this issue.

What works - the ten key points

1 Increase the number of home energy-saving upgrades.

The most important policy objective for reducing the energy consumption of UK housing, and its carbon emissions, is to increase the number and depth of home energy saving upgrades. This is likely to deliver greater and more sustained savings than policy focussed on changing people's shorter term energy behaviours.

2 Tap the market for wider home renovations.

Policy should focus on harnessing energy efficiency upgrades to the large and sustained market in wider home renovations.

3 Think local.

The local/community level is very important for increasing the number of upgrades, with community energy groups and local authorities having a leading role to play in facilitating and encouraging these. But they are not a panacea, and they can only be effective against a background of national policy which promotes upgrades and provides them with the resources required.

4 Face-to-face contact is important.

Households which are interested in, or might be interesting in, having an energy saving upgrade could often benefit from face to face contact with a facilitator who understands energy saving upgrades in general and the households' own circumstances. Such sustained contact, taking the household from an energy audit/assessment through to commissioning an upgrade, can make it more likely that they will in the end opt for an upgrade.

5 Incentives work.

This has been seen with measures like the boiler scrappage scheme and the Feed-in Tariffs. They are essential for driving up the number of upgrades - information, campaigns, advice and exhortation will not suffice.

6 Learn and share lessons from the Green Deal's failure.

The Government needs to understand why it did not meet expectations and has not had a significant positive impact on either the supply or the demand sides of home energy upgrades.

7 Supply and demand must work together.

Policy has to be integrated so that supply and demand grow alongside each other in a sustained way, with competent and qualified local contractors able to meet local requirements for upgrades. Polices that work at the local/community level can contribute to that in local upgrade markets.

8 Understand the motivations of those able to pay.

Policy should aim to evoke the maximum response from the able-to-pay market with the minimum of incentive/subsidy. To succeed in this, it will have to be based on a good understanding of the factors motivating people to have home energy upgrades, including trigger points, and the barriers that stand in their way. Segmentation studies can help with this, targeting different incentives, messages and information at different audiences.

9 Continue to target reductions in fuel poverty,

but recognise that this may not deliver large reductions in energy demand.

10 Integrate policies.

Successful policies are likely to involve several approaches such as financial incentives, improved information and advice and regulations which help to drive up the number of upgrades. They need to be carefully integrated.

This report reviews what works best in encouraging UK households to make their homes more energy efficient and to reduce their carbon dioxide emissions from domestic heating and electricity consumption. It is based on an extensive literature review and on interviews with four experts carried out in 2015.

The context for this review is that there has been real progress in improving the energy efficiency of UK homes over the past decade. But this needs to be maintained or accelerate in order to meet carbon targets, tackle fuel poverty, deliver energy security and contain household energy bills. In fact there has been a deceleration in the past two years (Committee on Climate Change, 2015).

Heat and electricity used in UK homes are responsible for more than a quarter of the UK's carbon dioxide emissions (DECC, 2016a). New homes are considerably more energy efficient than the existing stock and their carbon emissions are correspondingly lower. But they are replacing today's homes very slowly and it is estimated that between 70 and 90% of these will still be standing in 2050 (Dowson et al., 2012; Wright, 2008; Boardman, 2007; Lowe, 2007). Sustained action is needed in relation to this existing stock if UK carbon targets are to be met, opportunities for cost effective carbon abatement taken and fuel poverty tackled. Earlier technical models have shown an 'all measures' refurbishment approach will be required (Natarajan and Levermore, 2007; Peacock et al., 2007; Johnston et al., 2005), and successive analyses by the Committee on Climate Change have supported this (Committee on Climate Change, 2014 and 2015).

People can change their behaviour and habits to save energy at home and they can choose to buy more efficient electrical appliances. In general, however, the main potential for large and sustained reductions in energy consumption within the home comes from making homes better insulated and more draught proof, installing more efficient heating and hot water systems and making use of zero or low carbon energy generation systems – in short, giving them energy saving upgrades. In this report, we focus primarily on what policies might work in delivering this kind of change to UK homes.

To date, UK government initiatives have primarily focused on encouraging lower cost, 'cost effective' energy efficiency measures (e.g. loft insulation, cavity wall insulation) through grants, subsidies and obligations placed on energy suppliers, mainly directed at lower income households and neighbourhoods. However, the current rate of uptake coupled with the level of carbon savings made by these measures implies that housing will not make its expected contribution to meeting UK carbon reduction budgets and targets (Committee on Climate Change 2015; Davies and Osmani, 2011). Many millions of homes remain with low levels of energy efficiency, while many others with middling levels of efficiency require improving. Most are occupied by households with the resources to finance some level of upgrade, at least for small to medium improvements (e.g. new boiler, better insulation). The challenge is to develop a mix of policies which will trigger energy saving upgrades carried out by this 'able to pay' majority which are large enough in number and scope, while delivering upgrades for the minority who cannot afford them.

We begin by examining the main domestic energy saving trends over the past 10 and 20 years, in order to consider what has been working to date.

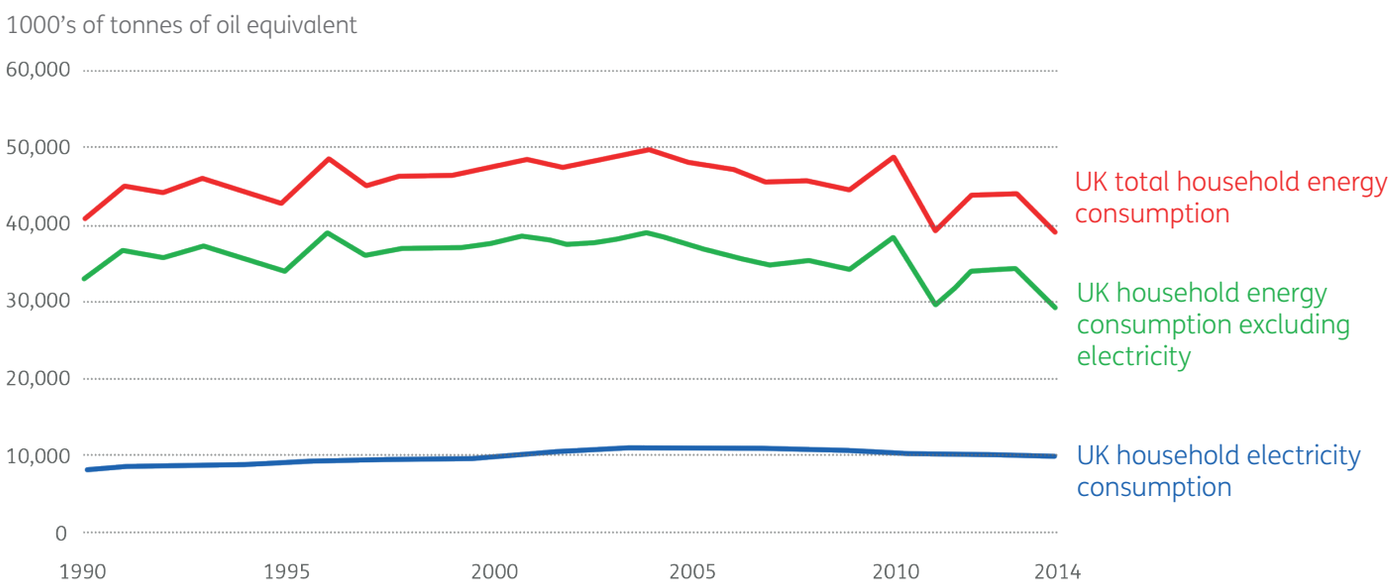
"The current version of our policy is an evolution. They haven't just appeared out of nowhere. They are evolving too slowly and are not sufficiently learning from these programmes"

Interviewee 2

The total energy consumed by households over the past decade has been falling, in large part because the energy efficiency of UK homes has risen.

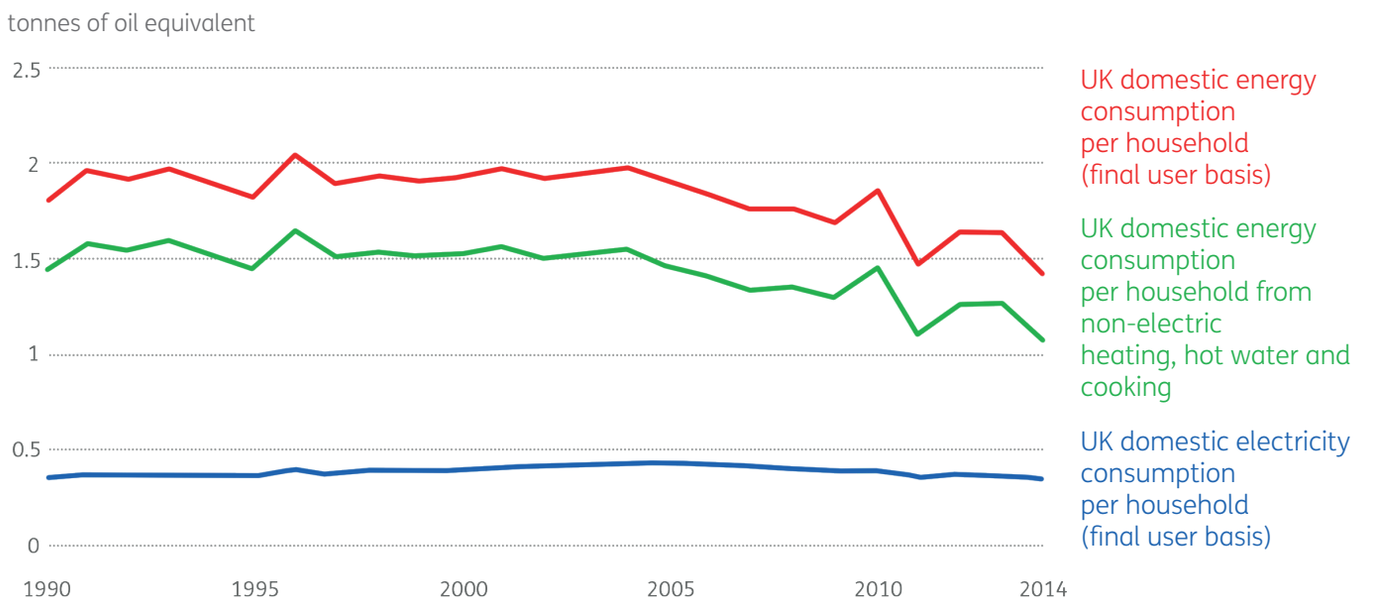
Total energy consumption by UK households (used for heating, hot water, cooking, lighting, electrical appliances and home electronics) has been falling over the past decade (Figure 1).
Total household electricity consumption has been falling very slowly.

Figure 1: Total energy consumption by UK households, final user basis
Source: DECC (2015a)



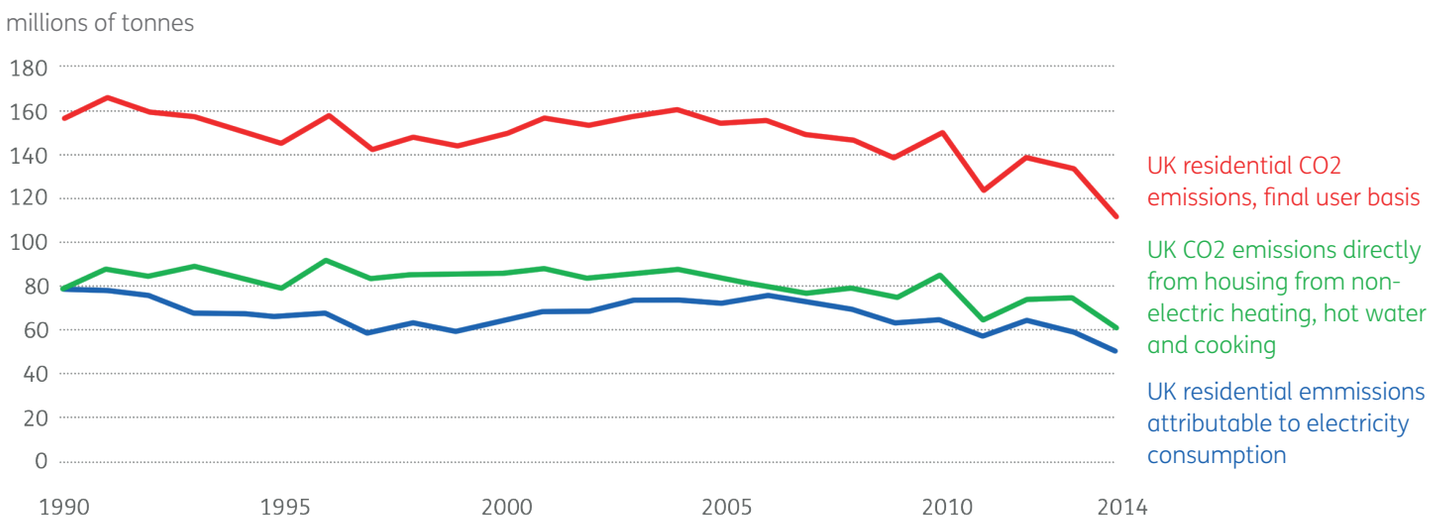
The number of UK households grew by 19% between 1990 and 2015, from 22.7 million to 27.0 million, and by 7% between 2005 and 2015 (ONS, 2016) so energy consumption per household has been falling more rapidly than total energy consumption over the past decade while electricity consumption per household has been falling too (Figure 2).

Figure 2: Average energy consumption per household, final user basis
Source: DECC (2015a) and Office of National Statistics (ONS) (2016a)



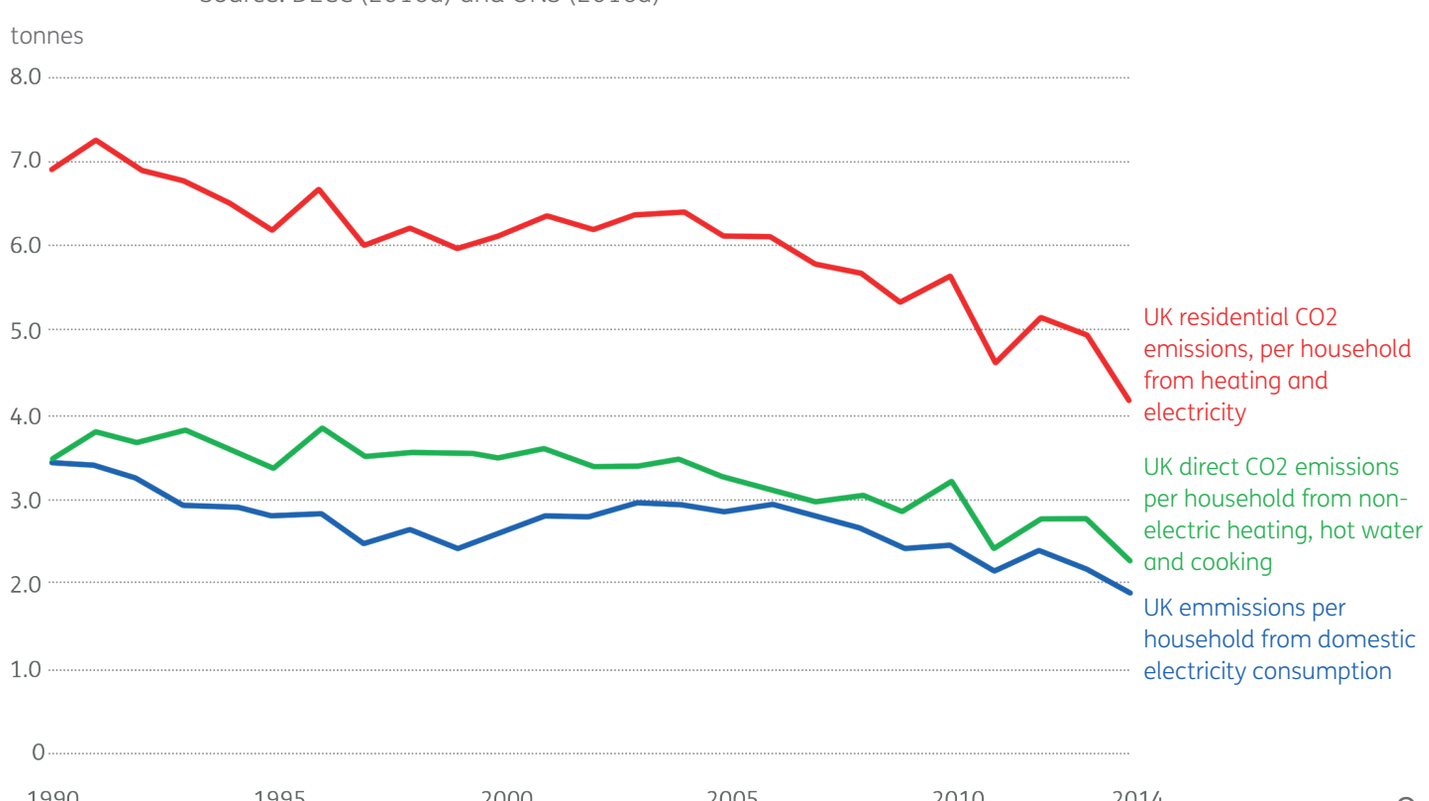
Total CO2 emissions from UK households have also been falling (Figure 3), both from fossil fuels used directly in the home for space heating, hot water and cooking and from electricity consumption. The fall in electricity-related emissions has been driven by decarbonisation of the grid.

Figure 3: Total CO2 emissions attributable to UK households from heating and electricity consumption
Source: DECC (2016a), ONS (2016a



CO2 emissions per household have also been falling more rapidly (Figure 4) than total domestic emissions, due to the rising number of households.

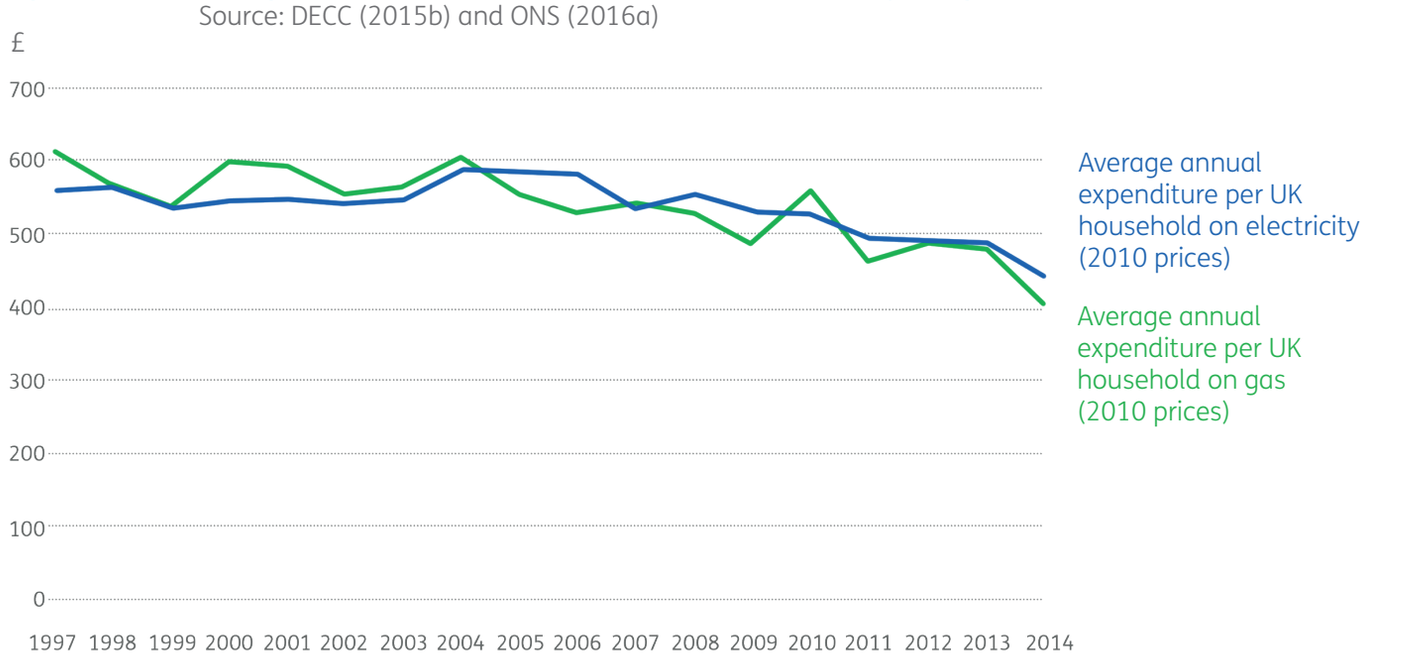
Figure 4: Average CO2 emissions per UK household
Source: DECC (2016a) and ONS (2016a)



The declining trend in household energy consumption appears to have begun around 2001-2003. Before discussing what lies behind it, we examine trends in household spending on energy and the changing energy efficiency levels of the UK housing stock.

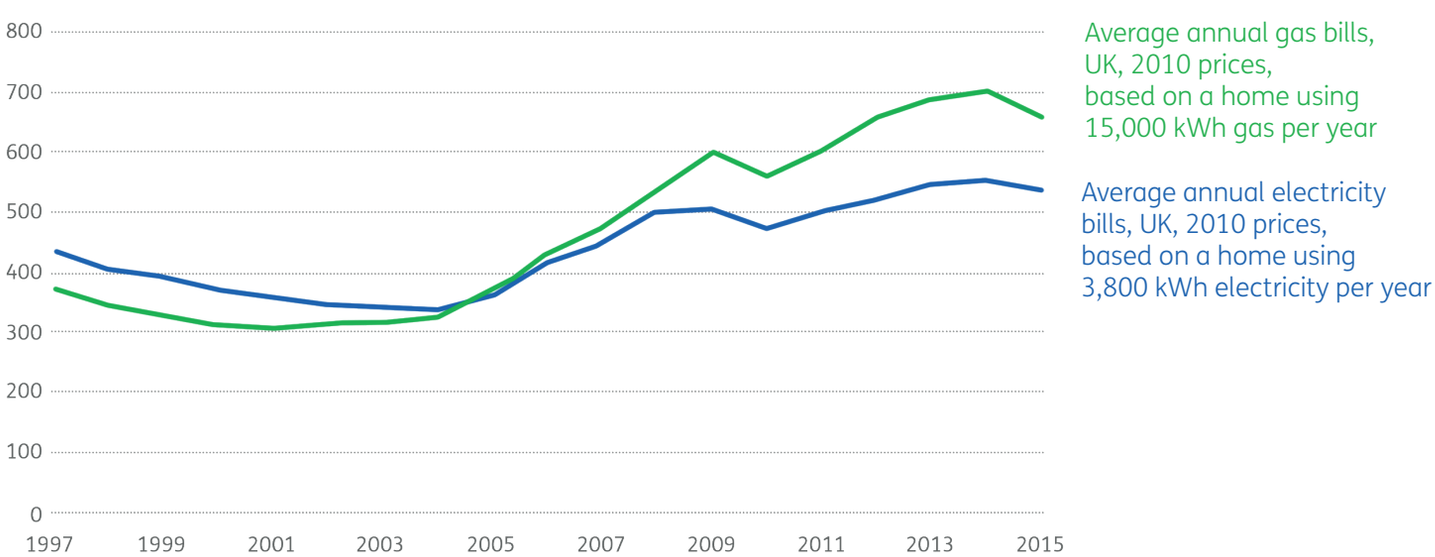
Average spending on domestic energy (mainly natural gas and electricity) per household has fallen slightly over the past decade, once inflation is adjusted for – despite widespread concerns about rising domestic gas and electricity prices (Figure 5).

Figure 5: Average annual expenditure per UK household on electricity and gas, 2010 prices
Source: DECC (2015b) and ONS (2016a)



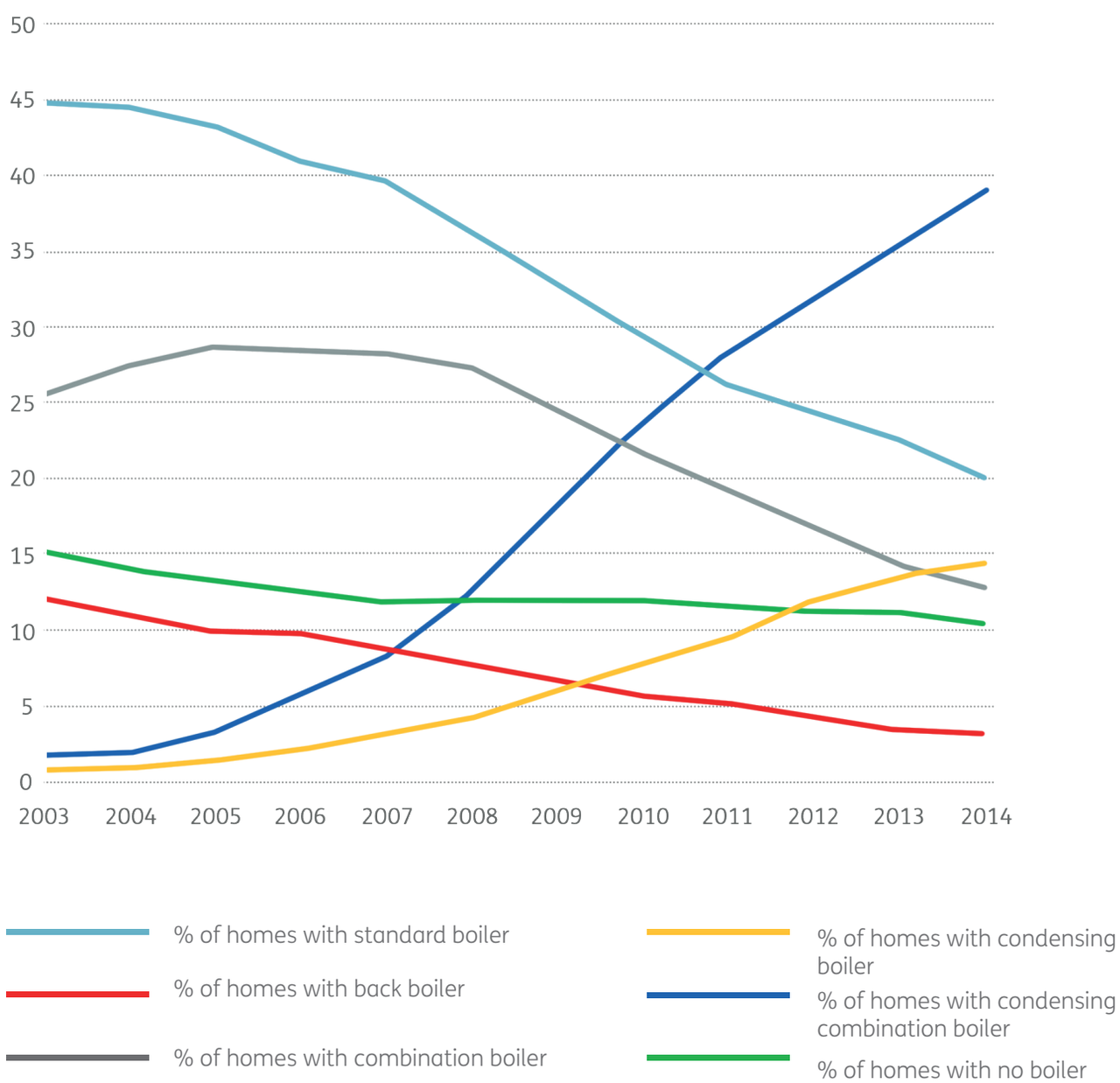
But if the average household had held its energy consumption constant, its energy spending would have risen significantly faster than inflation over the 20104-2014 period. Figure 6 shows how average energy bills (in 2010 prices) would have changed for a household with fixed gas and electricity consumption.

Figure 6: Average annual household energy bills for a home with fixed gas and electricity consumption, 2010 prices
Source: DECC (2015d) and DECC (2015d)



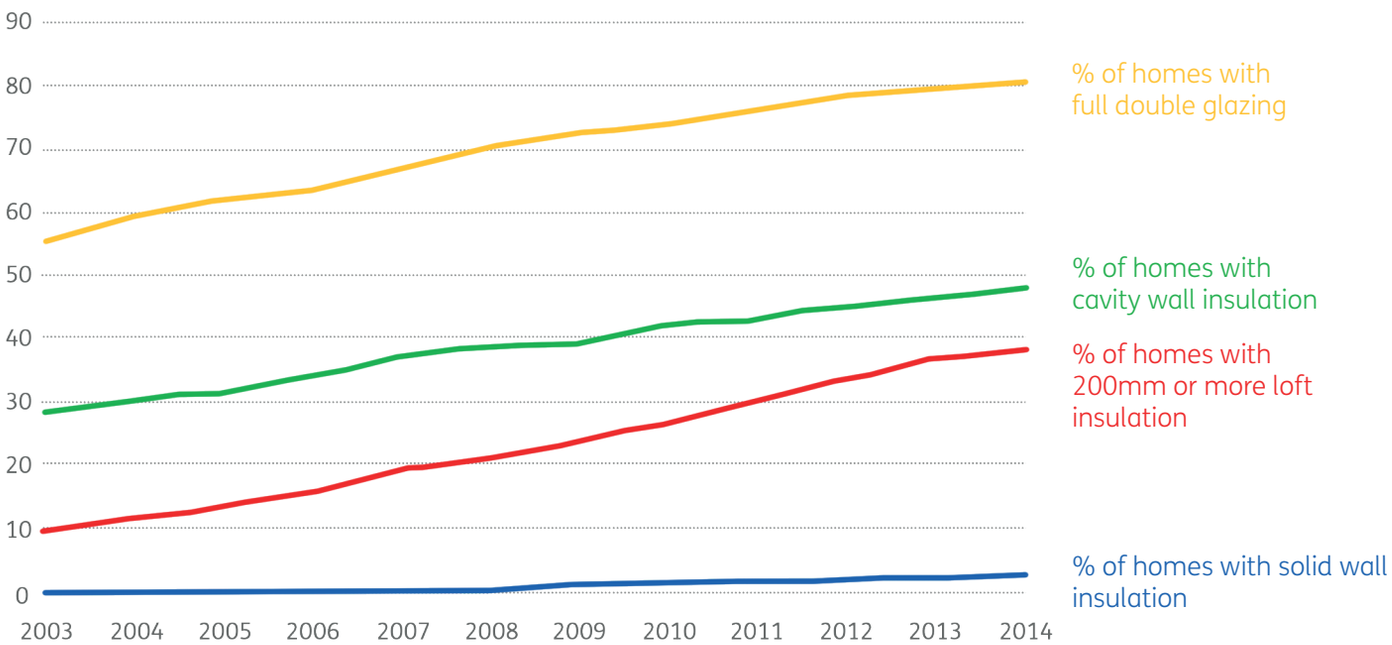
The bulk of the reduction in household energy consumption can be attributed to improvements in the energy efficiency of the UK housing stock. More efficient home heating and higher levels of insulation are the key technologies. Domestic central heating boilers have become more energy efficient as older models have been replaced; new homes built; and central heating systems have been installed in the dwindling minority of existing homes lacking central heating. By 2014 more than half of boilers (53% in England) were condensing or condensing-combination boilers (Figure 7).

Figure 7: Boiler types in UK homes
Source: DCLG (2016)



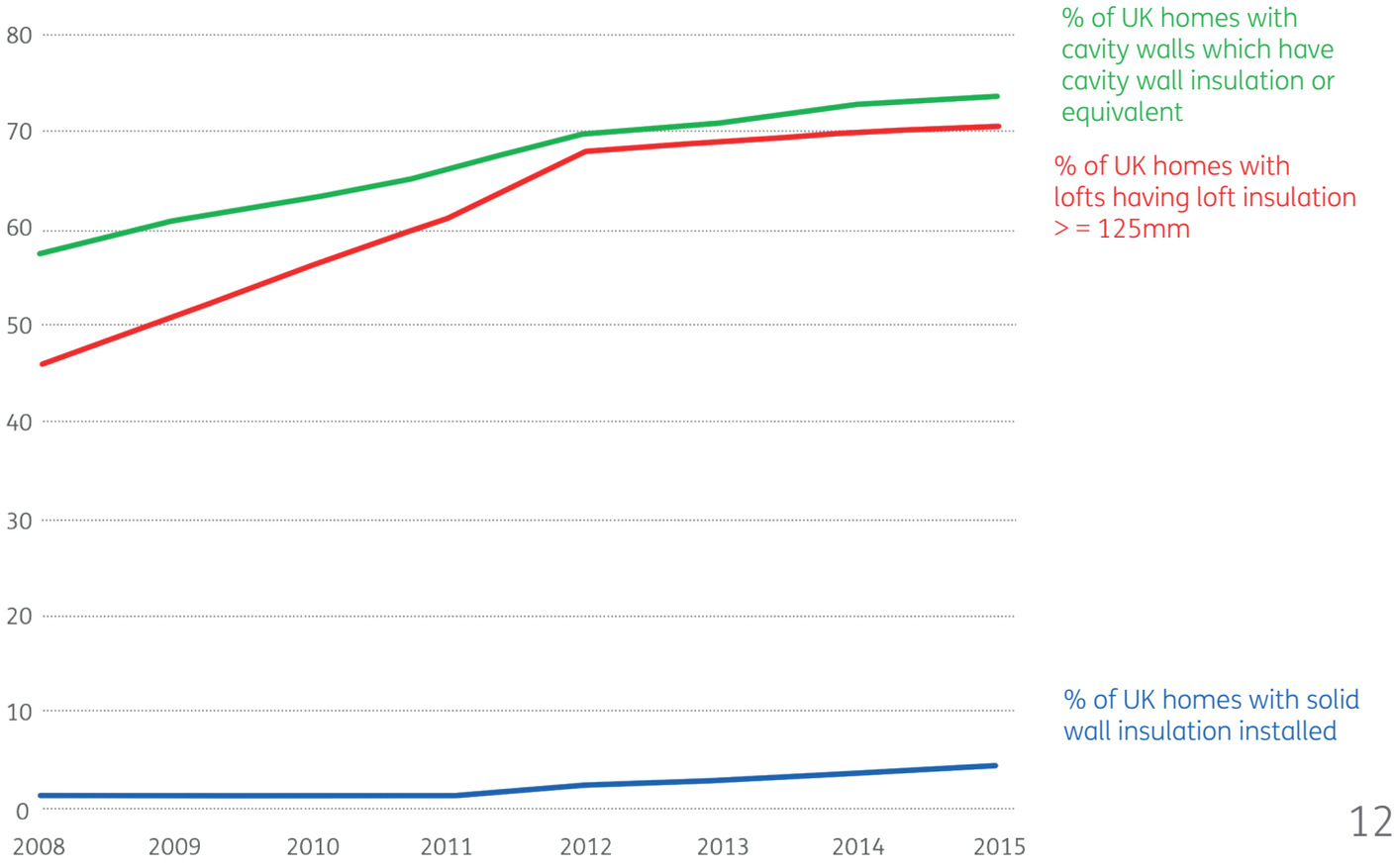
Insulation levels in UK homes have also greatly improved, as shown in Figure 8.

Figure 8: Cavity wall insulation, >= 200mm loft insulation and double glazing in English homes
Source: DCLG (2016). N.B. This is England-only data, but UK changes are similar.



However, there is considerable remaining potential to improve loft insulation, insulate cavity walls and, especially, to insulate solid walls (Figure 9).

Figure 9: Percentages of solid wall insulation, >=125mm loft insulation and solid wall insulation in GB homes compared to full potential
Source: DECC (2016b)



Loft insulation:

one of the most cost effective, low cost and easy-to-install insulation measures, is now found in almost all homes with lofts which can be insulated. Its depth has gradually increased as earlier installations are replaced or 'topped-up'. However, as of December 2015 there are estimated to be just over 7 million lofts in homes in Great Britain with less than 125mm of insulation which could benefit from extra insulation (the recommended depth is 250mm). That potential represents 29% of all GB homes with lofts, although a quarter of this remainder is estimated to be difficult to treat (DECC, 2016b).

Cavity wall insulation:

another cost-effective energy-saving measure, which had been installed in 74% of GB homes with cavities by December 2015. The remaining potential consists of 4.7 million homes, but most of these are either judged 'hard-to-treat' or of limited potential in terms of cost-effectiveness. About 500,000 homes with unfilled cavity walls are judged to be suitable for cost-effective insulation while there is uncertainty about 500,000 homes (DECC, 2016b).

Solid wall insulation:

suitable for the large minority of older homes with only poorly insulating solid masonry walls, this is a significantly more expensive and less cost-effective measure. Installing this insulation, either on the inside or outside of the exterior walls, could deliver substantial reductions in CO2 emissions while cutting household energy bills and addressing fuel poverty. There are estimated to be just under eight million such homes in England, Wales and Scotland, mainly built before 1919. As of December 2015 only 4.5% of these had been insulated, with uncertainty about the status of a further 1.6% (DECC, 2016b).

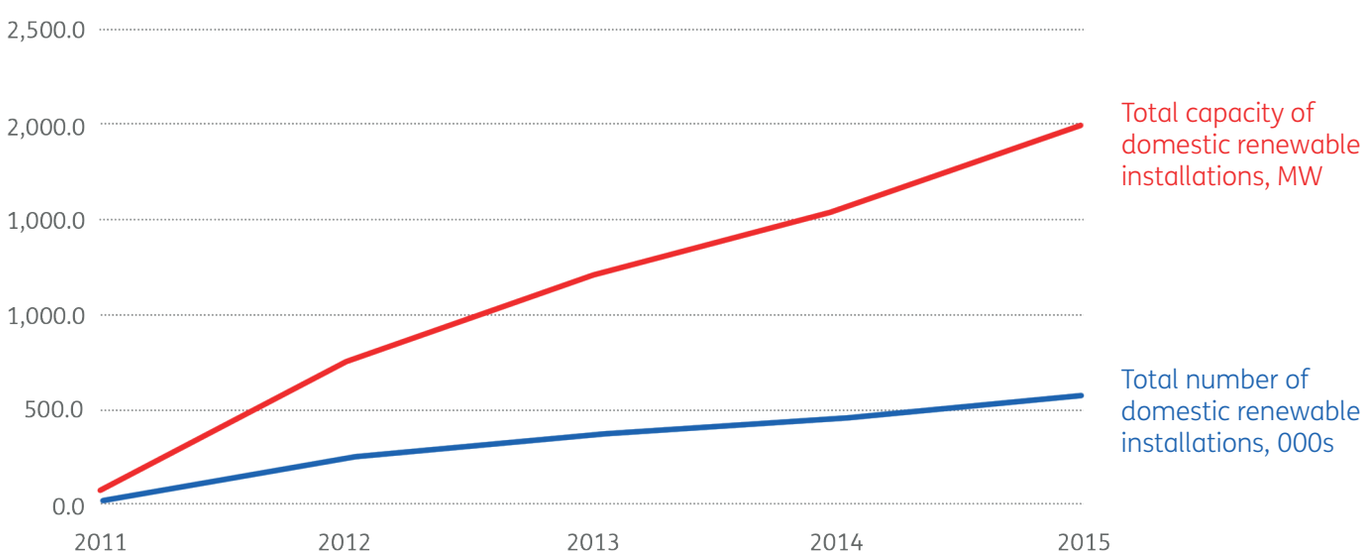
Overall impact:

this progress in improving boiler efficiency and in installing insulation has lifted the energy efficiency of UK housing, as measured by mean Standard Assessment Procedure (SAP) ratings of homes and by the growth in the proportion of the housing stock in higher energy efficiency rating bands. In 2004 only 4.1% of English homes had an Energy Performance Certificate rating of Band A, B or C; by 2014 this had risen to 26.2% (DCLG 2016). The mean SAP rating of housing in England rose from 48.7 points to 60.9 points and over the same period.

Domestic renewable energy sources:

There has also been a rapid increase in the amount of zero-carbon electricity being generated by households (Figure 10), driven by the introduction of the Feed-in tariff. The great bulk of this renewably-generated domestic power (much of it exported to the grid) comes from rooftop photovoltaic panels (DECC, 2015e). Some 2% of UK homes now have their own renewable electricity installation. Fewer UK homes are heated by renewable or low carbon heat sources such as biomass boilers, solar thermal panels and heat pumps, although the Renewable Heat Incentive aims to lift this. Penetration of domestic renewable energy sources is too low to have contributed significantly to the decline in household energy consumption and CO2 emissions observed to date, but is expected to do so in future (CCC, 2014).

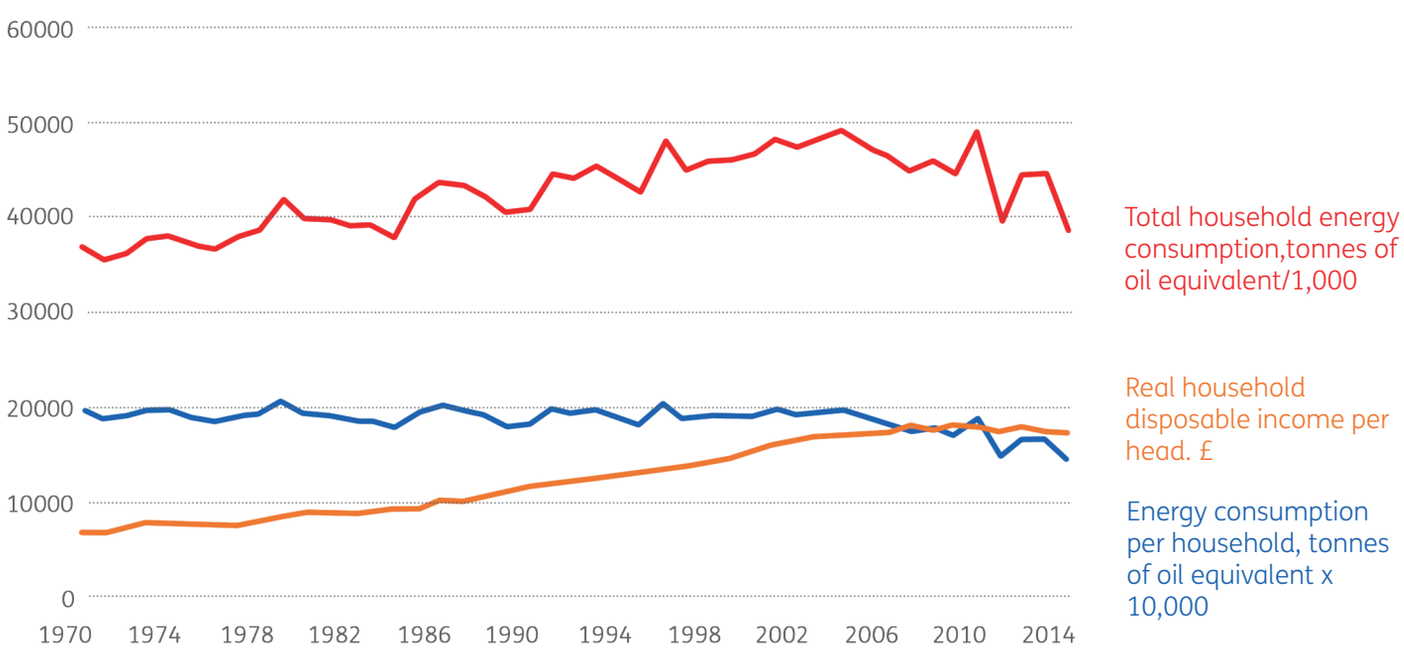
Figure 10: Number and capacity of domestic renewable energy installations in Great Britain
Source: DECC (2015e). Cumulative totals are for end of March each year



Over most of the past half century, total household energy consumption for electricity and heating has been rising (Figure 11). The number of UK households also rose steadily over this period, and average energy consumption per household was fairly stable between 1970 and the first few years of the new century. Over the same period, inflation-adjusted, disposable household incomes also increased fairly steadily. (Figure 11).

However, it appears that a decline in household energy consumption began around 2004 and has persisted since then. This was several years before the onset of the global financial crisis and recession in 2007, which interrupted the trend in rising household incomes and has led to a period of income stagnation (Figure 11).

Figure 11: Household disposable income and energy consumption per household
Source: DECC (2015a), ONS (2016a), ONS (2016b)



Between 2004 and 2014, average energy consumption per household fell by 28% (DECC 2015a and ONS 2016a). Over this period inflation-adjusted disposable household incomes per head rose slightly, by 2%. (ONS, 2016b). This decline in household energy consumption has been driven by:

1. Households responding to increasing domestic energy prices which began around 2002 (Figure 6), or the perception of increasing energy prices, by changing their behaviour to reduce household energy consumption;

2. New homes with higher levels of energy efficiency mandated by the Building Regulations gradually being added to the stock;

3. Improving levels of energy efficiency in the existing housing stock.

Given this substantial fall in UK domestic energy consumption it would be worth investigating the different weights of these three drivers, but we have found no attempts in the literature to estimate their relative weights. There is a substantial overlap between drivers 1) and 3) because households' decisions to improve insulation and heating systems are a complex behavioural response to increasing energy prices and to other factors. We would also expect there to be some quicker acting behavioural responses such as switching unwanted lights off and adjusting thermostats.

It seems likely that the main reason for the decline in household energy consumption has been improvements in the underlying energy efficiency of the existing housing stock. We base this on the evidence that the more immediate behavioural reductions in energy consumption in response to rising energy prices and to better information about energy consumption (such as smart meters) are relatively small and may not be sustained (AECOM, 2011).

These improvements in home energy efficiency can be seen as having three components:

- Several generations of government schemes which oblige energy companies to deliver improvements in domestic energy efficiency, with much of the effort directed to helping fuel-poor and vulnerable households. While much of these have been funded by a levy on energy consumers, some programmes have been taxpayer-funded.

- Successive tightening of the Building Regulations mandating higher levels of insulation and improved heating systems when houses undergo extensive renovation and extension.

- Households, mostly owner occupiers, choosing to fund their own improvements in energy efficiency without any financial incentive or regulatory requirement.

Here, too, we have found no attempts in the literature to investigate the relative weights of these three components.

Over the past two decades UK governments have developed a complex and changing array of policies aimed at encouraging households to adopt low carbon services, set out in documents such as their Energy Efficiency Strategy - 2013 Update (DECC, 2013). The evidence shows that these are working, but exactly how they are working and the balance between them is difficult to determine. Rising domestic energy prices have been a factor. While energy policies have added to energy prices, the overall aim of policy is not to drive prices up further to evoke a greater energy saving response. Government has come under sustained pressure to slow or halt the increase in energy prices.

Broadly speaking, policy to date has succeeded in plucking much of the low-hanging fruit – those homes for which it has been relatively cost effective to deliver some level of energy-efficiency improvement through lower-cost measures such as loft and cavity wall insulation and low energy light bulbs. For example, only 0.5 million cavity walled homes of the remaining 4.8 million uninsulated cavity walls are designated as 'easy-to-treat' (DECC, 2015g). Today, the great majority of the UK's housing stock (in Energy Performance Certificate bands C or lower) falls into two categories:

- A large residue of energy-inefficient homes, many of them which are relatively difficult and expensive to insulate, owned by private-sector landlords or owner-occupiers lacking the resources and/or the motivation to improve matters.

- Homes which have middling levels of energy efficiency that could be significantly raised, but at significant cost and with some degree of disruption for householders.

Higher cost, more disruptive measures such as solid wall insulation have generally had a much slower uptake rate. Yet double glazing, a relatively high-cost measure, with a long payback period (estimated at 98 years where replacing single glazing with low-e double glazing for a typical three-bedroom semi-detached house) has been extensively adopted and is expected to reach saturation point over the coming decade (Dowson et al., 2012). This has been attributed to the requirements of the Building Regulations and the introduction of FENSA (Hamilton et al., 2014) but also because double glazing makes an obvious difference to the exterior of a home; it is now strongly associated with property modernisation and reducing noise as well as saving energy (Utley and Shorrock, 2008). This product has also been strongly promoted and advertised by suppliers for more than two decades and has become a 'normal' home improvement.

The challenge now is to develop a range of policies which work for both of these categories of homes. Policies which gain the maximum private sector investment in improved energy efficiency (including owner occupiers) in return for the minimum subsidy from the state (or all energy consumers), while at the same time reducing the number of households in fuel poverty.

"A lot of the evidence from the past, which might be about CFLs or efficient fridges or condensing boilers, might not be applicable to future choices because the choices are different now. Most cavity walls are filled, most lofts have been insulated... People are having to do much more difficult things, like invest in solid wall insulation. The evidence base from the past might not match the decisions people will have to take currently"

Interviewee 1

Households might be expected to adopt energy saving measures which are likely to save them money in the long term, but most fail to do so. Why is this?

The low uptake of some measures has been described as an 'apparent disconnect' (Christie et al., 2011) and as an 'energy-efficiency gap' (Rosenow et al., 2014). This occurs where householders recognise the benefits of energy-efficient technology and want the technology but are still not motivated to adopt it. It has been noted that individuals apply higher discount rates to energy-efficiency decisions than other purchase decisions, and after almost four decades the debate as to whether this gap actually exists or households are, in effect, applying very high discount rates remains unresolved (Rosenow, et al, 2014; Thompson, 1997). Such high discount rates have been attributed to the higher level of investment required for such measures, the irreversibility of the investment (Alberini et al., 2013) and to the fact that the benefits of action accrue over a long period of time while the costs are 'upfront' (Bruderer Enzler et al., 2014). The concept of loss aversion has also been used to explain them, in which individuals favour the status quo (Christie et al., 2011), overestimating potential losses and underestimating potential gains. It has been suggested that households with higher income levels use smaller discount rates and will have a higher investment level than those with lower incomes (Tovar, 2012). Alternative explanations for the energy-efficiency gap include market failure, market barriers, and behavioural failures (Rosenow, et al., 2014).

Most people do not or cannot carefully weigh up the financial costs and benefits of energy-saving measures. It is now widely accepted that humans rarely act as rational economic actors in their day-to-day lives, and that domestic energy efficiency policy has to take account of human behaviour in all of its richness and complexity. There are widely different but overlapping theoretical approaches to this, some based on individualist models of behaviour (economic and psychological theories) and some on socially-oriented models (sociological and educational theories) (Chatterton, 2011) There is a need to consider awareness and understanding of the issues involved, trust, commitment, moral obligation, cultural norms, routine practices, habits, social networks, and fashion – all of which influence behaviour affecting energy consumption (Oikonomou et al., 2009).

Households may be hesitant in acting to upgrade their homes' energy efficiency if energy companies are tasked with deploying these measures, based on a legacy of mis-selling and distrust of energy suppliers (Diaz-Rainey and Ashton, 2008). There is evidence of overall suspicion and distrust among some householders regarding the now abandoned Green Deal energy upgrade loan scheme launched in 2013 (DECC, 2014a), and of private sector organisations generally (Christie et al., 2011; DECC, 2011; Martinsson et al., 2011).

"There is a fairly long history of people studying the issue of barriers and the policy responses to those"

Interviewee 2

"The idea of cost as a barrier is a complicated one. Money is only a problem if you don't have it"

Interviewee 2

There is an extensive literature exploring the adoption of low carbon products and technologies amongst householders. This highlights the complexity of the subject as well as numerous barriers to adoption, particularly the upfront costs of installing energy saving measures, the disruption involved, a lack of trust that the claimed savings and other benefits will be delivered, a lack of awareness and knowledge about such measures and concerns about the difficulty of obtaining the necessary knowledge.

Cost is considered to be a significant barrier to household uptake of low carbon measures (Hamilton et al., 2014; Gillingham and Palmer, 2014; Rosenow et al., 2013; Dowson et al., 2012; Watts et al., 2011; Whitmarsh et al., 2011; Energy Saving Trust, 2011; Gyberg and Palm, 2009; Meijer et al., 2009; Tietenberg, 2009), both in the owner-occupied and rental sectors. Households may lack the savings required to fund an energy-saving upgrade, may be unable to borrow the funds required or prefer to spend their savings (or use their loans) for other things.

Including an energy saving upgrade as part of a wider home renovation project requires 'noticeable effort' relating to both resources and information (Oikonomou et al, 2009). The householder may not be motivated to make the necessary effort, consuming more energy as a result. Barriers are recognised by existing research as being context-based (Stern, 2011), and are outlined in Table 1. Financial aspects are only a part of a wider range of barriers. Other barriers such as a lack of exemplar projects are already being addressed on a smaller scale though events such as Green Open Doors and the Super Home network across the UK. Others such as the landlord-tenant challenge (see page 32) were to have been addressed through the Green Deal coupled with requirements for mandatory levels of energy-efficiency in private sector homes for rent. Previously, some policies such as the Landlord's Energy Saving Allowance have been targeted at the private rental sector (Leicester and Stoye, 2013) to encourage greater uptake of energy efficiency measures.

Table 1: Barriers to uptake of low carbon products and services

Sources: Hamilton et al., 2014; Judson et al., 2014; Chryssochoidis and Wilson, 2013; Dowson et al., 2012; Watts et al., 2011; Whitmarsh et al., 2011; Energy Saving Trust, 2011; Gyberg and Palm, 2009; Meijer et al., 2009; Tietenberg, 2009; Wilson and Dowlatabadi, 2007

Resources	Information	Other
Upfront cost	Lack of information	Social (including internal barriers such as attitude, locus of control, self efficacy, beliefs)
Limited availability of capital	Lack of knowledge and awareness	Loss aversion
Resource constraints (time, capital)	Lack of trust, and perception of institutions	Motivation
Investment alternatives and price volatility (including irreversibility of investment)	Too few best practice exemplars	Inconvenience
Inappropriate products available	Lack of experience	
Other priorities	Lack of feedback	
'Perverse incentives'/ 'landlord-tenant split incentive'		

"Behavioural science research and practical application confirm that simply providing information and financing is insufficient to incentivize widespread energy improvements."

Fuller, et al. (2010), p.5

There are barriers to households installing energy saving measures, but research has identified motivations which can make people want to improve the energy efficiency of their homes. These include saving money, avoiding waste, making a home more warm and comfortable, concern about wider environmental issues such as climate change and complying with regulations such as the Building Regulations (Raw and Varnham, 2010).

Policies can act to enhance these motivations or provide additional incentives in order to overcome the barriers. Some of the most successful pilots to encourage greater take up of low carbon products and services amongst householders are recognised as resulting from a well-designed and appropriate incentive accompanied by sufficient and well-prepared information, targeted marketing, ensuring a good customer experience, and well-trained suppliers. Policy should seek to incorporate these aspects alongside technical, practical, and social considerations. It also needs to be targeted, recognising the major difference in circumstances and resources between households. In this chapter we look at how incentives, provision of information and regulation can help to overcome the barriers.

"If you look back over time there were always some people who would install energy efficiency measures even without policy support. Back in the early 1990s there were about 50,000 – 100,000 cavity walls being insulated but there wasn't really any subsidy provided. So their primary motivation was to save fuel and be more comfortable. And those people would have probably continued to make some improvements. Where we are now, it's much more driven by incentives and subsidies because that's the way the market has evolved...

The Green Deal Home Improvement Fund is interesting in that demand was very much outstripping the supply of incentives and people found it attractive"

Interviewee 4

An overall lesson from research and policy experience is that neither exhortations to cut energy waste, save money and help the environment, nor general advice and information is likely to result in a large uplift in energy saving home upgrades. Some kind of incentive is needed, such as a free or subsidised energy upgrade.

In the UK free upgrades of varying scales – mainly involving new boilers, loft and cavity wall insulation – have been at the heart of successive government schemes placing an obligation on energy companies to increase domestic energy efficiency (Hamilton et al., 2014). These have covered millions of homes and are estimated to have accumulated large carbon and energy savings, It is relatively easy to persuade households to take up such free measures, although a significant minority resist mainly because of distrust and concerns about disruption.

Financial incentives can also be used to trigger investment in upgrades that are financed mainly by households themselves. This kind of incentive is becoming increasingly important, given the high costs of delivering significant energy saving upgrades to the bulk of UK homes, and the difficulties of funding this from public finances or levies on all energy consumers.

UK experience suggests that such incentives can be successful as has been seen with the Boiler Scrappage Scheme, the Feed-In Tariff and the two incentive schemes linked to the Green Deal, the Cashback and the Home Improvement Grant. In 2011 a report from the Cabinet Office Behavioural Insights Team on Behaviour Change and Energy Use (Cabinet Office, 2011) announced a trial offering households a month's council tax 'holiday' or Home Retail Group vouchers to encourage people to take up cavity wall and loft insulation; however, the findings have not been reported or made available.

Household energy improvement loan and grant in Germany

Germany has extensive experience of such financial incentive schemes. Since 1996 the German development bank KfW has delivered loan and grant programmes which have improved the energy efficiency and reduced the CO2 emissions of millions of existing homes.

These grants and low interest rate loans, the latter covering up to 100% of project costs, support the energy-saving element of major housing refurbishments. The subsidies vary according to the level of energy saving ambition with the most support available for renovations which achieve the highest standard – 55% of the heating energy requirement of a new build home (on a square metre basis).

There is a cap on the proportion of refurbishment costs that can be subsidised and on the amount of subsidy; for the highest level 'KfW 55' project these were set at 17.5% and €13,125 respectively in 2011 (Schröder et al., 2011). The KfW provided retrofit grants for more than 600,000 homes in 2010 (Neuhoff et al, 2012).

The literature recognises that the KfW programmes have succeeded in creating or supporting large numbers of jobs, saving energy, reducing CO2 emissions and delivering a net public benefit, (Schröder et al., 2011; Neuhoff et al, 2012).

This success has depended on these programmes being well integrated with regulations covering household energy efficiency and renewable energy technologies accompanied by public information and energy saving advice provided to building owners from qualified experts (Schroder et al, 2011).

In France a zero interest 'eco loan' is offered covering improvements to the thermal fabric and low carbon technologies for space heating and hot water (Killip et al., 2014), with a repayment period of ten years (see page 35). This has been used as a 'foot in the door' where customers can be encouraged by contractor firms to adopt additional low-carbon measures once the customer initially requests home improvement works (Killip, 2014).

Government-backed financial incentives are considered to be a key driver for reductions in CO2 emissions from homes (Rosenow et al, 2014; Dowson et al., 2012). Criticisms of this type of policy approach have primarily concerned the exclusion of the role of people's values, which may be important in determining whether they take action to cut their energy use (Whitmarsh, 2009; Aune, 2007; Linden et al., 2006). Research has shown that costs of energy efficiency subsidies are partially or wholly offset by increased revenues and savings in areas such as employment and healthcare costs, but the extent depends on the financing mechanism type and the amount of subsidy provided (Rosenow, et al., 2014, p.616). Although effective in encouraging uptake of measures, subsidies can lead to 'free ridership' (Gosche and Vance, 2009) which occurs when individuals take the subsidy who would have refurbished their homes regardless of whether it had been offered (Rosenow and Galvin, 2013). However, researchers find it unlikely that expensive and less cost-effective measures such as solid wall insulation will be widely adopted without subsidies.

Incentives such as the Feed-in Tariff and the Renewable Heat Incentive reward households which finance their own low or zero-carbon energy installations with a guaranteed and subsidised income stream for their generation (Cherrington et al., 2013; Muhammad-Sukki et al., 2013). The FiT has proved highly successful in attracting investment into domestic renewable energy, despite successive reductions in the tariff. But this kind of incentive excludes access to owner-occupiers unable to raise the finance required and those in rental accommodation.

Further, the provision of a subsidy to address the barrier of upfront cost is recognised as being unable to address other important barriers to uptake of low carbon measures and technology (Rosenow and Eyre, 2013). Individuals do not optimise investment decisions based solely on price signals (Mallaburn and Eyre, 2014). Instead, how people respond to financial incentives is influenced by their context, including their social context, and by experience (Mallaburn and Eyre, 2014). Individuals are not economically rational, and therefore to be successful, a policy focus which reduces or removes the cost barrier must also be designed to incorporate context.

To encourage adoption of measures amongst householders, rather than using a 'sales' approach, a 'friendly, knowledgeable' individual holding conversations with householders about what they dislike about their home (e.g. draughty, expensive to run) and advising on improvements based on these conversations have been shown to have some positive effect in the United States federally financed Better Buildings Program, where the local authority can identify how best to use funding in their jurisdiction (AG interview; Research into Action, 2012).

Lessons from the Green Deal

The Green Deal loan scheme launched in 2013 sought to overcome the upfront cost barrier by making loan finance more readily available (particularly to lower and middle income households), turning repayments into a charge on electricity bills attached to the property. It also sought to overcome barriers concerned with information and trust about contractors and the likely level of savings achieved. (Fawcett, 2014). Although a great deal of policy effort and resources went into making the Green Deal possible, including enacting the necessary legislation, initial take up was disappointingly low, leading to a substantial reduction in installations of measures such as cavity wall insulation (Simpson et al., 2015) (Committee on Climate Change, 2015) which had previously been offered to households free or with generous subsidies. In July 2015 the Government announced it was ending the Green Deal, citing "low take-up and concerns about industry standards" (DECC, 2016c).

In April 2016 the National Audit Office published a report which was highly critical of the Green Deal's value for money, both for taxpayers and the wider UK economy (NAO, 2016)

It is important for Government to learn from this experience and understand why the Green Deal has not fulfilled its potential. The incentives that were offered alongside it (the Green Deal Cashback and the Green Deal Home Improvement Grant) were taken up and helped householders with energy-saving upgrades, although many of those have not used Green Deal finance. This supports the case for upfront financial incentives.

The relatively high interest rates for Green Deal finance appeared to be generally unattractive to householders (Mallaburn and Eyre, 2014). This is one of the principal criticisms of the Green Deal, with many households recognising they could access finance with equivalent or lower interest rates from mortgages and other sources (Rosenow and Eyre, 2012). Furthermore, the way the Green Deal's 'Golden Rule' operated (it ensured repayments did not exceed estimated energy bill savings) meant that the scheme could not finance the entirety of typical home upgrades, leaving householders applying for Green Deal finance having to meet much of the upfront costs of an upgrade (Schoon, 2013)

As originally conceived, the Green Deal would have had a regulatory underpinning. 'Consequential improvements' measures in revised Building Regulations obligating householders to upgrade the energy efficiency of their homes when commissioning major renovations and extensions. Green Deal finance was seen as offering them support in meeting this obligation but in the event the 'consequential improvements' proposal was abandoned.

Incentives will only be effective if households can obtain the information they need to move through a decision-making process which ends in them opting for an energy-saving upgrade (Wilson et al., 2013). This information will take a wide variety of forms, from a general awareness about the benefits an upgrade could bring them through to more detailed information specific to that household and its circumstances. That information needs to be appropriately framed, taking account of people's different motivations for an upgrade. Information providers need to understand that households value and depend on the services energy helps to provide such as warmth and comfort, cooked food, clean laundry, home entertainment; many, however, have little day-to-day understanding of how much energy they use, what equipment uses it most, and how that use connects to the bills they pay. Providing information that shows how the upfront costs of an upgrade will eventually be paid off through energy bill savings is unlikely, on its own, to persuade many households to adopt low-carbon technology (Christie et al., 2011; Aune, 2007; Munro and Leather, 1999).

To be most effective, information must be tailored to target audiences (Simpson et al., 2015; Gilligan et al., 2010; Aune, 2007; Henryson et al., 2000), be vivid, from a trusted source (Gilligan, 2010), correct, complete and easily accessible (Gilligan, 2010; Henryson et al., 2000). It should be available at salient, appropriate times (Cabinet Office Behavioural Insights Team, 2011). For householders including tenants, information which is simple and clearly shows its relevance to the individual is typically most effective (Mallaburn and Eyre, 2014). Energy performance certificates and smart meters are thought to be one way of reducing the information barrier (Dowson et al., 2012) and increasing awareness about energy consumption and interest in energy- efficiency measures.

An energy performance certificate (EPC) is provided when a home goes on sale or for rent, and was also part of a Green Deal assessment. It gives an energy performance rating for the property and sets out a range of energy-saving improvements with estimates of their impact on energy bills. However, one investigation found that 45% of homebuyers were not planning on adopting any measures as a result of the EPC while some had undertaken improvement works regardless of the EPC (Watts et al., 2011). EPC ratings form the basis of mandatory improvements in energy efficiency levels for private rental housing from 2018 (DECC, 2015h). Penalties can be imposed where an EPC is not provided at the time of sale or rent of a home (DECC, 2015h), but enforcement appears to be weak. There is preliminary evidence of a link between high levels of energy efficiency and higher house prices (Fuerst et al., 2013). Policy should aim to ensure that EPCs do provide householders with information they can understand and find useful in considering upgrades, and to increase householders' awareness of them.

"There are a lot of good reasons for targeting the private rented sector – it's the least efficient tenancy and they're probably the least powerful political group"

Interviewee 5

Regulation

Regulation has been effective in encouraging take up of some energy efficiency measures. An example of this is condensing boilers, which became a legal requirement in 2005 (Mallaburn and Eyre, 2014), unless inappropriate for the property. Although not part of national policy, 'consequential improvements' have been effectively applied by Uttlesford District Council in Essex for improving the overall energy efficiency of the local housing stock within its area (Simpson et al., 2015). Consequential improvements regulations require householders to install low carbon measures as specified by qualified professionals based on a survey when undertaking qualifying improvement works to their home, such as a home extension. An alternative approach, adopted in Denmark, is to mandate that the recommendations outlined in a property's energy label, such as the EPC, must be installed at the point of any major refurbishment (CAG Consultants, 2010). Similarly, in Berkeley, California minimum energy efficiency standards are required in all existing private housing with improvements triggered by the sale or transfer of a property, or a major refurbishment (CAG Consultants, 2010). Limits are set on the amount of money the property owner is required to invest in the prescribed measures (CAG Consultants, 2010).

A combined approach

There is a consensus that effective policy cannot rely only on information provision and financial incentives to drive changes through householders' rational choices (interviews with AG, AR, JR). Although there is evidence indicating that people prioritise economic factors in energy efficiency decisions (Nair et al., 2010; Bichard and Kazmierczak, 2009), research has shown that even in the presence of incentives, uptake of low-carbon technology can remain low (Christie et al., 2011). It is likely, therefore, that a combination of measures will be more effective (Gilligan et al., 2010; Bichard and Kazmierczak, 2009). In the literature and the research interviews, it is argued that government should build flexibility and adaptability into its support for energy-saving upgrades, so that it can learn from what works best (Tovar, 2012; AG Interview).

Policy for increasing energy-saving home upgrades needs to recognise the wider context of home renovations and the social norms which surround what people do with their homes.

Two important strands for domestic energy efficiency policy emerge from the research literature and are covered by the two appendices to this report.

- The potential for community groups and local authorities to play an important role.
- Energy efficiency improvements to a home will often be part of a wider home renovation, and this presents a range of challenges and opportunities.

Much of the research into both of these strands recognises that people can be influenced by what their friends, relatives and neighbours do and say, and what they think is happening in the community around them.

Policy also needs to recognise the complexity of the decision-making process for energy-saving upgrades. How people make decisions on what to install is likely to vary between low-cost and high-cost measures, with the decision-making process becoming more complex and extended for higher-cost measures including major home refurbishment. For higher-cost measures, considerations will usually go well beyond the length of the payback period. Given that past experience has been dominated by policies to encourage uptake of low-cost (or free) measures, this may be of limited use in devising policies to encourage uptake of more expensive measures. Policy needs to recognise this multi-dimensional, multi-factorial decision-making process and avoid oversimplification.

"We must not oversimplify how people make these choices, because if we oversimplify then we will design policy instruments wrongly because we will only think about one aspect of their choice, i.e. if we make it a bit cheaper they 'll do it"

Interviewee 1

Social processes are considered crucial for the sustained adoption of pro-environmental behaviour (Cabinet Office Behavioural Insights Team, 2011). Using social norms and social networks can be an effective method of encouraging people to change the way they do things, thereby saving energy (Cabinet Office Behavioural Insights Team, 2011). In relation to the sustained use of low-carbon products, where the measure is visible from the exterior of the home (as is the case for, say, photovoltaic panels), social norms are arguably more likely to have an influence. Measures such as insulation are not usually visible to visitors and neighbours and therefore the take up of this form of measure is arguably less likely to be affected by social norms. This visibility may have implications for image and self-expression. Research has shown that where householders perceive their home as a means of self-expression or to portray an ideal social image, they are more likely to consider renovating their home (Wilson et al., 2013).

Social norms have been shown to have an impact on encouraging pro-environmental behaviour such as curbside recycling (Barr, 2003), energy-saving behaviour (Martinsson et al., 2011), and the adoption of low carbon technology (Christie et al., 2011). Importantly, social norms also contribute to householders' perception of risk, regret avoidance and loss aversion (Christie et al., 2011) – all important in encouraging the uptake and sustained use of low carbon products and services. However, it has been argued that actions must be readily visible for social norms to have an impact, and householders must be aware of the pressure to conform (Bichard and Kazmierczak, 2009; Barr, 2003).

"In that whole market evolution process you've got the build-up of social norms of behaviour, and [the adoption of low carbon measures] becomes not a weird thing to do, but 'you'd be crazy not to'"

Interviewee 3

"Avoid micro-managing... It's about calibrating solutions to local barriers"

Interviewee 2

A more holistic approach to retrofit has been adopted by a number of emerging local and regional programmes, particularly through community refurbishment schemes, targeting specific properties and undertaking upgrades (Karvonen, 2013). The Kirklees Warm Zone project is an example of how low carbon measures can be installed at a mass scale. The local authority offered 'free to all' cavity wall and loft insulation, insulating 51,000 homes (Butterworth et al., 2011), but there were also some incentives aimed at triggering investment in new heating systems and renewables by households. The benefits of this approach included improved health and reduced cost to the NHS, increased employment, a reduction in fuel poverty in the area and increased house price values (Butterworth et al., 2011). Funding for such intensive and localised schemes could be provided to other local authorities through obligations placed on energy companies (e.g. through ECO); ideally every property in the area covered is surveyed and has appropriate measures installed (Butterworth et al., 2011).

The Kirklees Warm Zone project

The Kirklees Warm Zone was a three-year Local Authority programme (2007 – 2010) based in the metropolitan borough of Kirklees, West Yorkshire. Of 176,000 households in the area, 51,000 households had a collective 64,000 measures installed (Long et al., 2014). In 2009 the project was awarded the Ashden Award for the Best Local Authority Sustainable Energy Scheme in the UK and was the largest local authority insulation scheme in the UK. Improvements in the energy performance of the housing stock was not the scheme's only aim; others included tackling fuel poverty, reducing district-wide carbon emissions, improving the uptake rate of state benefits amongst residents, and creating jobs.
A number of measures were offered to households in Kirklees. These included:

- Free cavity wall insulation and loft insulation
- Free low-energy lightbulbs
- Free heating system improvements for eligible residents (i.e. those in fuel poverty, those in receipt of benefits, those residing in hard-to-treat homes) subject to scheme funding.
- Competitive prices for replacement boilers and central heating
- Interest-free loans for renewable technologies for those customers considered 'able to pay'.

Funding for the scheme was provided through supplier obligations, the council's own investment, the Government's Warm Front scheme, and an energy infrastructure company (Long et al., 2014). On completion in 2010, the project had spent £24 million.
A 'free insulation for all' approach was taken regardless of tenure and income. The purpose of this was to ensure greatest levels of uptake and to reduce administrative overheads.
One challenge that emerged was a lack of trust amongst residents. This was addressed through a marketing programme which included branding, a key message ('free for all') and involved local media. The marketing was based on segmenting household into three types – early adopters; those persuaded by word of mouth; and 'last chance' adopters. Those who had been reluctant initially were returned to at the end of the project.
Those who participated in the programme said they did so because the main measures were free (98% of 505 respondents). Environmental considerations have also been identified as a factor (82% of respondents) (Long et al., 2014).
Benefits of the project have included, job creation, savings to the National Health Service and an average SAP increase of 5.6 points per property. The net benefits have been estimated at £248.9 million (Butterworth et al., 2011).

Community-led initiatives have recently received much attention in the literature (Berry et al., 2014; Burchell et al., 2014; Gupta et al., 2014; Heiskanen et al., 2010; Darby, 2006). Such approaches potentially stimulate and sustain action on energy using collaboration, shared knowledge and social norms to enable action, but often lack resources such as people, time and finance (Berry et al., 2014). Additionally, although community-led activities can foster motivation and encourage adoption of low-carbon measures, barriers such as capital costs and lack of skills still exist which can inhibit adoption (Berry et al., 2014). Community-led schemes can also address the issue of mistrust, something identified in the literature as an issue relating particularly to institutions and organisations (Williams et al., 2013; Oikonomou et al., 2009), by using existing social networks in which trust already exists (Berry et al., 2014).

Locally-based initiatives may offer other advantages. It may be easier for them to build the necessary 'critical mass' of interested households and trained, capable contractors at a local market level. Households covered by a locally-based upgrade scheme may be able to achieve economies of scale by grouping to purchase upgrades for properties which are of the same type and/or in the same neighbourhood. Finally, researchers have suggested that householders considering an energy-saving upgrade strongly prefer to receive face-to-face, personalised advice throughout the process, from expressing an initial interest through having a home energy assessment to the point where they make a decision to go ahead (Research into Action, 2012; Wilson, 2013). Locally-based initiatives may be well placed to provide this kind of service.

Community approaches are being adopted in several UK cities. However, to date these have been a relatively unexplored approach in government policy beyond various community-based initiatives (Karvonen, 2013) (e.g. Refit West, CALEBRE, Kirklees Warm Zone, Plymouth Energy Community). DECC's 2010 Low Carbon Communities Challenge funded six community-based carbon-cutting initiatives focussed largely on energy-saving upgrades for households. This has been investigated and evaluated in depth by the EVALOC research project (Evaluating the impacts, effectiveness and successes of low-carbon communities on localised energy behaviours) and the findings support a strong role for local communities and local authorities (Gupta et al, 2015). The Green Deal Communities programme took a community approach to retrofit but the effectiveness of this has not been reported on. A community approach which uses and links with local community groups and engages the local authority could be effective in reaching households and neighbourhoods where barriers to uptake are higher. To date, however, the difference in the uptake rates between a community-led approach and 'sales pitch', generalised marketing/campaigning approach has been little explored.

Research has recognised that energy efficiency improvements are – or could be - part of wider home renovations, but saving energy and cutting fuel bills is rarely the main or a leading motive for a home renovation. Much of the research sees projects such as new kitchens, bathrooms, extensions and re-roofing as a major opportunity for energy upgrades.

The market for home renovations is very large and sustained and at any one time a large proportion of owner occupiers are contemplating a home renovation project (Wilson et al, 2013; Killip et al, 2014). There are many existing suppliers, mostly small, locally-based businesses, and well-established ways of financing home improvements through personal savings and borrowings. Home renovations are already routinely delivering large quantities of unsubsidised energy efficiency improvements to homes, such as more efficient boilers, double glazing and insulation. Householders accept significant inconvenience and disruption in order to have a home renovation, so the disruption barrier for energy upgrades can be lowered.

However, an alternative view emerging from the research is that full energy-saving upgrades can be so disruptive and expensive (Oikonomou et al., 2009) that there may be a case for more gradual and piecemeal improvements extended over many years, possibly integrated with home maintenance works (Fawcett and Killip, 2014; Energy Saving Trust, 2011). If low-carbon measures and technology are not installed at the time of a major home renovation project, the likelihood of installing larger, disruptive, or more expensive measures outside this period is reduced. People improving their homes are likely to install low carbon measures which appeal to their internal values and beliefs (Tan, 2008; Barr, 2003), as well as basing their decisions on the available incentives, their lifestyles and the type of home they own. When they are undecided about the desired form or use of space (e.g. loft space), unaware of low-carbon products applicable to their home improvement project, or when they have already completed improvement works, they are unlikely to take action. Further, if the proposed measures result in a reduction in valuable space, householders will be disinclined to adopt them (Scarpa and Willis, 2010). Research has shown that, although householders may value measures such as low-carbon technologies, this value is outweighed by the high capital cost of such measures (Scarpa and Willis, 2010). Consequently, higher-cost measures require substantially higher subsidies than previously offered, or the costs of such measures need to fall significantly (Scarpa and Willis, 2010).

Savings on energy bills have been highlighted as only one part of why householders adopt low- carbon measures in the home (Wilson et al., 2013). Householders have been shown to favour lower upfront costs, more reliable contractors, less disruption, and less inconvenience (Wilson et al., 2013). Research has also outlined reasons householders are more likely or less likely to select a measure (Table 2).

Table 2: Reasons for selecting low carbon measures – likely versus less likely.

Source: Williams et al. (2013)

Reasons that increase the likelihood of a measure being selected	Reasons that decrease the likelihood of a measure being selected
Inexpensive	Too expensive (initial cost)
Convenient to install	Involves major building works
Aesthetically pleasing	Detracts from aesthetics/aesthetically displeasing
Desirable lifestyle effects including comfort and reduced noise	Risk of damage to the physical property
Energy bill savings	Reduction in living space
Increased efficiency	Unsuitable physical property orientation for measure
Available financial support through grants	Lack of space or insufficient sunlight for measure
Possible to install in parallel with other works	Simple behaviour option exists as an alternative
	Requires approval (planning department, housing association)

Policy for home energy upgrades has to deal with the great variety of house types, households and their circumstances.

The level of uptake of low-carbon measures is context dependent, varying widely between households (Stern, 2011). It is constrained by the size of upfront costs, household income, availability of financing, and the presence of incentives (Stern, 2011). It also relates to tenure type, cognitive and personality factors, and locational factors (Stern, 2011).

"People may consider an energy efficiency measure primarily for saving energy costs, but also to make them more comfortable. You wouldn't necessarily convince someone who is uninterested and sceptical by providing a moderate incentive. Whereas some people may be positive in their attitude towards energy efficiency improvements but may struggle to find the capital costs"

Interviewee 4

The need for segmentation

Policy also needs to recognise the complexity of the decision-making process for energy-saving upgrades. How people make decisions on what to install is likely to vary between low-cost and high-cost measures, with the decision-making process becoming more complex and extended for higher-cost measures including major home refurbishment. For higher-cost measures, considerations will usually go well beyond the length of the payback period. Given that past experience has been dominated by policies to encourage uptake of low-cost (or free) measures, this may be of limited use in devising policies to encourage uptake of more expensive measures. Policy needs to recognise this multi-dimensional, multi-factorial decision-making process and avoid oversimplification.

To be most effective, research suggests that there is a need to target particular technologies, subsidies, incentives and messages on particular segments of the population (Caird et al., 2008). This can be done to encourage the maximum uptake of upgrades in those segments where there is the greatest potential for energy and carbon savings. It can also be used to try to ensure that all or most households that can benefit from an upgrade are encouraged to commission one, because each will receive the support and encouragement that is appropriate to its circumstances (Rosenow, et al., 2014; Tovar, 2012; Tietenberg, 2009).

To a degree, UK policy already recognises the need for segmentation but further development will be required. The need to avoid incentive schemes which exclude groups of householders, particularly those in lower-income groups, has been argued for in the literature (Rosenow et al., 2013).

There are many different ways of segmenting households but for energy saving upgrades the most important are likely to be based on tenure type, property type (e.g. solid wall, cavity wall), and household income (JR interview). One research group has proposed a number of different possible personas under which householders can be categorised on the basis of their propensity to carry out energy saving home upgrades (Simpson et al., 2015; Haines and Mitchell, 2014). These personas are: restorers, aesthetic pragmatists, functional pragmatists, service seekers, and property leader climbers (Simpson et al., 2015; Haines and Mitchell, 2014). Categorising these householders enables information and incentives to be tailored better to increase effectiveness. However, there are multiple other factors beyond information and incentives which govern uptake amongst the householder population. Further, segmentation may be useful in the marketing of low carbon measures, but could prove less effective in converting interest into adoption (AG interview).

The research on the links between energy upgrades and wider home renovations suggests that a segmentation approach which can identify households considering major renovations early on in their decision making process would be worthwhile.

Homes with solid walls provide a good example of the need for segmentation. There were estimated to be nearly eight million solid walled homes in Great Britain at the end of 2015 (DECC, 2016b). These generally have low levels of energy efficiency and only 4.5% have had insulation applied to their external walls. Consequently, they represent one of the largest opportunities for saving energy in, and reducing CO2 emissions from the housing stock, (Downson et al, 2012). But solid wall insulation is among the most expensive energy-upgrade measures and can also be highly disruptive for households, especially if applied on the interior of the home. There are well-recognised challenges and barriers to solid wall insulation including upfront cost (Jenkins, 2010) as well as technical difficulties (Hopper et al., 2012).

Policies are required to increase the rate of solid wall insulation, but they need to recognise the very different circumstances of households occupying those homes. Many are tenants in privately-rented accommodation. Others are low income and elderly owner occupiers. Some are relatively high-income families living in affluent Victorian and Edwardian suburbs who might have the financial resources to meet the upfront costs of solid wall insulation but no adequate incentive to do so. These very different groups are likely to require different types and levels of incentive and regulatory intervention to make them (or their landlord) likely to install solid wall insulation.

Owner-occupiers with growing families have previously been identified as the most likely group to be planning on undertaking improvement works to their home and able to afford to install low- carbon measures in conjunction with these planned works (Energy Saving Trust, 2011). In contrast, in the private rental sector, landlords have been identified as planning larger-scale refurbishment projects and planning to spend more on each project than owner-occupiers (Energy Saving Trust, 2011) despite this tenure category being the most energy inefficient.

Based on previous research (Energy Saving Trust, 2011), different segments of the population plan different types of improvement works to their homes, each with different principal motivations. Population segments have been suggested as including young couples, families with young or growing children, families with older children, empty nesters, and singles.

Motivations differ between groups. Broadly, motivations include updating and modernising a home, increasing property values, creating more space, ensuring the continued functionality of a home (Energy Saving Trust, 2011), and renovating a property in order to move up the property ladder (Simpson et al., 2015). Increasing thermal comfort levels, reducing energy bills and increasing the availability of incentives can help to encourage uptake of major home improvements, but economic incentives are unlikely to drive this on their own.

There has been a positive association identified between the amount of time spent at home and the uptake of low-carbon measures (Tovar, 2012). This could be explained by such households adopting these measures because they need affordable warmth and comfort in the context of rising fuel prices and limited disposable incomes. Those who spend most time at home are adults with dependent children and those over 60 years old. Segments of these two groups have previously been eligible for grants and help with installing low-carbon measures, so this could also explain the higher frequency of low-carbon measures in these households (Tovar, 2012). Successive programmes and policy for tackling fuel poverty may explain the finding that those on lower household incomes are more likely to have a higher number of measures installed (although the association with income level is weak across all tenures) and why householders in the lowest income, most deprived wards were more likely to have a greater number of measures (Hamilton et al., 2014). Lone parents are likely to have lower levels of low-carbon measures (Tovar, 2012). Measures such as photovoltaic panels have lower adoption rates amongst lower-income groups than more affluent householders, reflecting the fact that the installation of rooftop PV panels has largely been financed by householders (DECC, 2012).

"Market segmentation are useful for broadly calibrating marketing schemes, but we also know that every person is different and every person will have slightly different reason for not doing retrofit or not changing their behaviour. It really becomes an individual scheme. The policy has to be calibrated to each and every individual if you want to convince them to change...the way you do that is by allowing programmes to adapt to its own market and see what works over time."

Interviewee 2

Tenure type is important in relation to the uptake of low-carbon measures. Typically there are fewer measures installed in private rented accommodation in comparison with owner-occupied housing (Hamilton et al., 2014). This has been interpreted as reflecting the greater degree of control owner-occupiers have over their properties, but it also reflects the well-known and intractable 'principal/agent' issue (Croucher, 2011; Tietenberg, 2009); the misalignment of interests whereby if a landlord invests in energy-efficiency improvements the tenant reaps the benefits of improved comfort and reduced energy bills.

Under the Private Rented Sector Energy Efficiency Regulations (Domestic) 1915, tenants in England and Wales have had the right to request the installation of energy-efficiency measures by their landlord since April 2016 – although the tenant rather than the landlord has to find the finance to cover the improvements. Furthermore, from April 2018 landlords will not be permitted to rent out properties which fall below an E rating in their Energy Performance Certificate with penalties for non-compliance, with the aim of compelling them to deliver energy-saving upgrades to the least energy-efficient homes for rent.

There are, however, various exemptions and the Government's intention is that neither landlords nor tenants should have to provide upfront finance in making improvements to properties under these regulations; instead they would use grant, subsidy and loan schemes including ECO and the Green Deal. The withdrawal of Green Deal finance has therefore undermined these regulations and DECC has yet to announce how it will fill the financing gap.

There are big differences in the potential for energy upgrades between different types of housing and different parts of the country. Housing in London has been identified as being less likely to have low carbon measures such as cavity wall insulation and double glazing than in other areas of the South of England (Leicester and Stove, 2013). It is not clear why this is the case but a range of interpretations exist; the significant number of flats and hard-to-treat homes in the city, the potential higher installation costs (such as higher labour costs) and the higher proportion of private rental homes and conservation areas in the capital (Greater London Authority, 2010). Energy suppliers obligated to improve the energy efficiency of homes are more likely to focus on locations where installation of low carbon measures 'can be done more cheaply' (JR interview).

There is also a higher proportion of solid-walled properties in London in comparison with other urban areas (Baker et al., 2008). In contrast, housing in the North and Midlands has been reported to be more likely to have cavity wall insulation and higher levels of loft insulation than areas in the South (Leicester and Stove, 2013). Differences between northern and southern regions of England have been indicated as nominal for some measures such as double glazing (Leicester and Stove, 2013).

Rural, suburban and urban

Differences in uptake levels of low carbon measures can also be detected for rural, urban and suburban locations. Rural areas are less likely to have cavity wall insulation in comparison with suburban areas while city centre housing is less likely to have double glazing than rural locations (Leicester and Stove, 2013). Rural locations are more likely to have a greater proportion of older housing (DCLG, 2014), which is more likely to be of solid wall construction (Baker et al., 2008) and are therefore more likely to have a greater proportion of the least energy-efficient housing (DCLG, 2014). Rural homes are also most likely to be off-mains gas, leaving them dependent on more expensive and higher-carbon fuel for heating, so there is a strong case for focussing support for low and zero-carbon measures on rural areas. In contrast, around 62% of English housing is located in suburban areas (DCLG, 2014), with comparatively lower levels of older properties (DCLG, 2014). Incentivising solid wall insulation in all locations, where the application of this measure is technically and architecturally appropriate, should be made a priority. Where properties do not have access to mains gas, providing incentives for low-carbon heat in rural properties and/or communities would be one approach to the high-carbon and high-energy cost penalties that households living in such homes face; this is something the Renewables Heat Incentive is addressing.

More than 10% of households in England were experiencing fuel poverty in 2013, according to DECC's most recently published statistics – some 2.35 million homes (DECC, 2015g). The Government's new 'high cost, low income' definition of fuel poverty for England is that a fuel poor home is one in which the energy costs required for reasonable warmth are above the median average, and if the family occupying it paid those costs their residual income would put them below the national poverty line.

For the UK as a whole, it is estimated that 17% of households were living in fuel poverty in 2013 (DECC, 2015g). However, this is based on the previous definition which the devolved administrations have retained; a family which has to spend 10% or more of its income to keep its house reasonably warm is defined as fuel poor.

The fact that a significant minority of the population struggle to afford the heat and electricity they need in their day-to-day lives increases cardiovascular and respiratory illnesses and is a significant burden on national mortality and health (Hills, 2012). There is a potential tension between fuel poverty and climate change policies in that by increasing internal living temperatures in cold homes, the carbon emissions generated from those homes can increase (Hills, 2012). Energy efficiency measures have been identified as the most effective way of addressing fuel poverty (Hills, 2012). Importantly, although energy efficiency improvements have decreased fuel poverty, this has been offset since 2004 by rising energy prices (Hills, 2012). Better insulated housing has been reported to deliver a variety of health benefits; for example less condensation may reduce mould growth and thereby the incidence of asthma (Hills, 2012). However, greater understanding is needed about the effect of summer overheating on health which may result from increased levels of insulation as the climate changes (Shrubsole et al., 2014; Gupta et al, 2015).

Private rented accommodation has been identified as having a higher incidence of fuel poverty (DECC, 2015g), with the likelihood of being in fuel poverty notably increasing with lower SAP ratings (DECC, 2015g). Low-income households are most likely to be in fuel poverty, with 40% of all households in the lowest-income decile being designated as in fuel poverty (DECC, 2015g). These groups need to be prioritised for assistance in improving the energy efficiency of their homes as they cannot afford to contribute to improvements themselves (Hills, 2012).

"For the more complex measures there are all those other considerations [beyond simple the economic aspects] that go alongside any renovation project – when would you install a new kitchen? Before you move in would be ideal, or when you're away for a longer period of time so you don't have to deal with all the dust"

Interviewee 4

Timing is critical in targeting households to encourage greater adoption of low carbon measures (Caird et al., 2008). Research has indicated that low carbon measures are more likely to be installed when moving house or when forming part of a wider programme of improvements (Caird et al., 2008) and that householders are less likely to install measures if intending to move home (Tovar, 2012; Wilson et al, 2013)). Recent movers may be more suitably placed and receptive to undertaking improvement works to their home to reduce the inconvenience of the works (Leicester and Stoye, 2013). Therefore it may be possible to target this segment of the population to encourage the uptake of low carbon measures.

There are a number of 'trigger points' which have been identified as promoting greater uptake of low carbon measures in households.

An Energy Saving Trust (EST, 2011) report on trigger points highlighted that householders are more likely to adopt low carbon measures gradually in conjunction with other refurbishment works, rather than in a 'whole house' approach. This also enables householders to save up for works or to manage the investment costs in conjunction with other costs such as holidays (Simpson et al., 2015). The sequencing of works can be critical (Raw and Varnham, 2010); householders and/or landlords need to understand how to effectively sequence works in order to avoid additional costs and disruption and closing off opportunities for installing other low carbon measures later on. Table 3 outlines the 'trigger points' identified by the Energy Saving Trust (EST, 2008) which could be targeted to increase the uptake of low carbon measures in households.

Table 3: Trigger points for uptake of low carbon measures in households

Source: Energy Saving Trust (2008)

Trigger points		
Change of residence	Element alterations	Structural alterations
Moving home	New kitchen	Extension
Change of tenancy	New windows	Loft conversion
	New bathroom	Large-scale refurbishment
	New heating system	
	Re-roofing	Scaffolding
	Re-flooring	

Policy should recognise the critical role architects, surveyors, and builders have in home refurbishment decisions, and target these professionals to also help encourage householders to adopt low carbon measures. Currently, there is a skills and knowledge shortage in industry around new technologies and practices, such as solid wall insulation. In France, engaging small building firms in offering energy-saving upgrades is seen as one way of encouraging the uptake of the 'eco loan' initiative and the adoption of specified low carbon measures (Killip et al., 2014). Research has shown the need for both the supply and demand sides of the home energy-upgrade market to grow in parallel (Research Into Action, 2012)

Well-designed policy is essential to ensure greater certainty over government-backed initiatives. A 'stop-start' situation potentially resulting from drying up of incentives and grant funding would significantly affect the construction industry. It is essential to avoid this.

"People with those [whole house energy retrofit] skills are very hard to find and the different kinds of funding system for home improvements doesn't support the development of people with those skills. The funding has been all about throwing money at the cheapest interventions; you have someone who comes in and installs a boiler or someone who comes in and rolls out some insulation and you don't have that whole house thinking happening very often."

Interviewee 3

France's eco loan

The Éco-Prêt à Taux Zéro or Éco PTZ is a zero-interest eco loan directed at owners of both owner-occupied and rented homes constructed before 1990. The loan can be used to fund energy works in the home comprising at least two of:

- High performance roof insulation;
- High performance wall insulation;
- High performance external windows and doors;
- Replacement or upgrades to heating or ventilation systems; and
- Installation of a water-heating system fuelled by renewable energy (e.g. solar, geothermal).

Under the Éco PTZ, a maximum of €30,000 can be loaned. Only one loan can be awarded per house/building but it can be used in conjunction with a specified energy efficiency tax credit (Crédit d'impôt pour la transition énergétique) and a green tax allowance (l'Aide à la solidarité écologique).

To qualify, the overall refurbishment works must bring energy consumption down to 150 kWh/m2/year or less where pre-work levels were equal to or greater than 180 kWh/m2/year, based on modelled consumption. For homes where the pre-work energy consumption was under 180 kWh/m2/year, the refurbishment must reduce it to 80 kWh/m2/yr or less. Works must be undertaken by a certified company registered under the Reconnu Garant de l'Environment scheme.

Based on research by Killip et al. (2014), the five French firms interviewed used the opportunity of household requests for major home renovations as a 'foot in the door' for offering additional low-carbon measures, in effect upselling the Éco PTZ.

The business case for this scheme is still under development and its success is not currently known. However, the innovative elements of the programme are that it is designed to engage households "in managing their own energy use", as well as the provision of guarantees without exposing refurbishment firms to unacceptably high degrees of risk (Killip et al., 2014, p.122). It also demonstrates the potential for using contractors to encourage the installation of low carbon measures resulting from initial work requests.

There has been a marked improvement in the energy-efficiency and carbon-saving performance of UK housing over the past decade, in large part attributable to policy. But this now needs to accelerate in order for carbon budgets to be met, fuel poverty to be tackled and energy security enhanced.

Householders adopt low carbon measures for multiple reasons. However, the literature has highlighted that the market alone will not drive the uptake of low carbon measures in households. For uptake, incentives are required, but these must be aligned with the existing motivations, values and beliefs of householders to effectively encourage the adoption of these measures.

Although economic aspects will have a strong influence on the decision to adopt low carbon measures, economic reasons alone will not motivate uptake. Adopting low-carbon measures which reduce energy demand also depends on the full range of resources available to a household (over and above financial resources), values, beliefs and attitudes about the environment and prevailing regulations. Comfort and social aspects will have an influence, as will attitudes towards aesthetic improvements. Different low carbon measures may be driven by different motivations. Motivation types can be used to frame information to appeal to multiple segments of the population, but tenure should also be considered in how the information is framed.

Relevant information, tailored to various motivation types and general values and beliefs should be readily available in a vivid format at the times when the householders are most likely to undertake works. This should be based on key 'trigger points' such as when they move into a new home. If information is not presented at this time, or is not sufficiently relevant, householders will not engage, and the take up of low carbon measures is unlikely. Information can also be provided to encourage adoption of low carbon measures through phased works, since this type of work holds greater appeal for householders, but increasing effectiveness and value for money through appropriate sequencing of works must be provided.

Mixed messages in information and policy must be avoided. Mixed messages within policy can delay or deter the adoption of low carbon measures, with householders and suppliers waiting for greater certainty and/or for perceptibly preferable incentives. Although long running and certain incentives may lead to increased likelihood of free-ridership, in the absence of an incentive many householders may still favour the status quo and not take action, particularly when incentives have previously been available. Mixed messages have already occurred through the delays in the introduction to the Renewable Heat Incentive and the Green Deal energy saving loan scheme, which was abandoned less than three years after its launch. A consistent, well-designed policy is essential.

Households are most likely to undertake works incorporating low-carbon measures at a time when inconvenience and cost can be minimised. Therefore the adoption of low carbon measures is likely to be done in parallel with other improvement works. An intention to move home will reduce the likelihood of adopting low carbon measures in the existing property, whereas moving into a new home increases the likelihood of undertaking works. This provides the possibility of targeting 'movers' in relation to information and incentives to encourage uptake. Those in a period of life transition, such as young or growing families, or where householders spend more time in the home, also increases the likelihood of adopting low carbon measures. This is interpreted as resulting from the need for affordable comfort amongst these groups. Lower-income households have been identified as more likely to have a greater number of low carbon measures than other household types, which could reflect support from previous policy but also the need for affordable warmth.

Serious difficulties arise in relation to adoption of low carbon measures in rental accommodation. If the landlord invests in such measures s/he may not be able to recoup that investment or benefit from it; tenants lack the resources and the authority to improve the homes they rent, and lose any benefit in reduced energy bills and/or improved comfort levels when they move out. New energy efficiency regulations for the private rented sector had promised to tackle this issue, but the withdrawal of Green Deal finance had undermined these.

Various government incentives and regulation have succeeded in promoting uptake of energy-saving measures by households. These have typically been focused on lower-cost measures such as loft and cavity wall insulation. This approach risks an uneven geographic spread of energy-saving improvements, because rural and city centre/ inner city locations are more likely to have a high proportion of older or harder-to-treat properties – particularly solid-walled houses, or those not served by mains gas. Solid wall insulation in all locations should be incentivised where technically possible and where there are not over-riding objections on conservation grounds. Policy should enable those properties not receiving mains gas to have individual and/or community low-carbon heating systems introduced. These and other types of energy-saving upgrades may be more readily or effectively delivered through community-led projects. This approach to energy supply has begun to be recognised as having the potential to be transformative. The Government has highlighted the benefits of community energy as including maintaining energy security, tackling the issue of climate change, saving money on energy bills, and potential for social and economic benefits (e.g. income streams, community cohesion, skills) (DECC, 2015f).

Communities and community groups can also be of use in relation to shared knowledge and skills. They can encourage greater uptake due to sharing of information through word-of-mouth, reducing the mistrust households tend to have towards institutions and organisations delivering low carbon measures. They can also encourage adoption and sustained use through social norms and comparisons. However, to date community groups attempting to encourage greater uptake of low carbon measures tend to be under-resourced, driven by a few passionate volunteers.

Another way to encourage the adoption of low carbon measures and more importantly, the sustaining of behaviours to reduce energy use, are the use of smart meters. This technology, now being rolled out in the UK, can increase awareness of household energy use, but its effectiveness will depend on the extent to which and the ways in which householders are encouraged to engage with the technology. Comparisons with neighbours, friends, family and/or similarly sized households may encourage sustained use and reduction in overall energy use. It may also potentially motivate action to install low carbon measures amongst some householders.

Most importantly, policy should be sufficiently flexible to enable a more holistic approach to enable greater uptake amongst all segments of population, and household and housing types. It must make provisions for all types of tenure and all income groups, including those suffering fuel poverty.

The most important policy objective for reducing the energy consumption of UK housing, and its carbon emissions, is to increase the number and depth of home energy-saving upgrades. This is likely to deliver greater and more sustained savings than policy focused on changing people's shorter term energy behaviours.

Policy should focus on harnessing energy efficiency upgrades to the large and sustained market in wider home renovations.

The local/community level is very important for increasing the number of upgrades, with community energy groups and local authorities having a leading role to play in facilitating and encouraging these. But they are not a panacea, and they can only be effective against a background of national policy which promotes upgrades and provides them with the resources required.

Households which are interested in, or might be interesting in, having an energy-saving upgrade could often benefit from face-to-face contact with a facilitator who understands energy saving upgrades in general and the households' own circumstances. Such sustained contact, taking the household from an energy audit/assessment through to commissioning an upgrade, can make it more likely that they will in the end opt for an upgrade.

Incentives work, as has been seen with measures such as the boiler scrappage scheme and Feed-in Tariffs. They are essential for driving up the number of upgrades - information, campaigns, advice and exhortation will not suffice.

Government should learn and share lessons from the now abandoned Green Deal energy saving loan scheme. It needs to understand why it did not meet early expectations and has not had a significant positive impact on either the supply or the demand sides of home energy upgrades.

Policy has to be integrated so that supply and demand grow alongside each other in a sustained way, with competent and qualified local contractors able to meet local requirements for upgrades. Polices that work at the local/community level can contribute to that in local upgrade markets.

Policy should aim to evoke the maximum response from the able-to-pay market with the minimum of incentive/subsidy. To succeed in this, it will have to be based on a good understanding of the factors motivating people to have home energy upgrades, including trigger points, and the barriers that stand in their way. Segmentation studies can help with this, targeting different incentives, messages and information at different audiences.

Policy should continue to target reductions in fuel poverty, but recognise that this may not deliver large reductions in energy demand.

Successful policies are likely to involve several approaches such as financial incentives, improved information and advice and regulations which help to drive up the number of upgrades. They need to be carefully integrated.

The role of community groups and local authorities in home energy efficiency retrofits

Community and local-authority based interventions are well placed to play a leading role in improving the energy efficiency of the UK's housing stock.

- Because major energy-saving upgrades are an unfamiliar and difficult to understand product, few households will opt for them in response to information, general advice and moderate financial incentives.
- Local and community based initiatives offer advantages in overcoming these barriers and in providing the personal advice and assurance to convert initial householder interest into upgrade decisions.
- These may also offer better ways of directing subsidies and incentives cost-effectively towards homes, and better integration between measures to increase demand and supply.
- Government should carefully evaluate emerging UK and overseas evidence, particularly US experience, on the potential of local and community approaches in stimulating energy saving upgrades.

Background

A key overall policy aim is to achieve the maximum possible number and level of carbon and energy saving home upgrades financed by the "able to pay" majority of households in return for the minimum level of subsidy and/or regulatory intervention.

Household energy efficiency upgrades are a new and different kind of product. Simply raising people's awareness and providing information and financial incentives about them will not be enough to increase both supply and demand and move the market for deeper upgrades beyond a small number of early adopters..In the UK, the most cost effective upgrade measures such as loft insulation, cavity wall insulation and higher efficiency boilers have already been widely adopted. A market for further low carbon products which are high cost and less cost effective, notably solid wall insulation, is unlikely to develop in the absence of support. It was hoped that the Green Deal would combine with the CERO (Carbon Emissions Reduction Obligation) element of the ECO (Energy Company Obligation) to provide the financial support required to bring about a market transformation for solid wall insulation but this has not succeeded.

Research and theory has demonstrated several obstacles to domestic energy efficiency upgrades:

- Affordability
- Households not understanding or valuing the benefits,
- Not trusting that the claimed benefits will be realised, or
- Worrying about disruption.

While households may be familiar with loft and cavity wall insulation, there appears to be little understanding of what wider energy efficiency upgrades are available, how they work and what they can deliver. Part of the problem is that they cannot be offered as a standard product. An effective upgrade usually has to be tailor made for an individual property.

Lessons from the Better Building Neighbourhood Program in the USA

As in the UK, the United States federal and state governments have long experience in promoting upgrades, often in association with utilities, to households but with limited success. The large scale of recent US effort and a concerted attempt to learn lessons suggests the UK could usefully study this.

The US Department of Energy's (DoE) Better Buildings Neighborhood Program ran from 2010-13, deploying $508 million (£350m) of post-financial crisis stimulus funding (DoE, 2016). The BBNP funded 41 local initiatives with grants ranging from $1.4m to $40m, used to set up, promote and subsidise locally-devised retrofit programmes using local installation contractors. As well as delivering energy saving upgrades mainly for middle and low-income housing but also for some commercial, industrial and agricultural buildings, BBNP's other main objectives were to:

- Demonstrate more than one sustainable business model for providing energy upgrades to a large percentage of buildings in a specific community;
- Identify and spread the most effective approaches supporting the development of a robust retrofit industry.

The extensive, six volume evaluation of the programme has found some impressive results (Research into Action, 2015). The BBNP succeeded in:

- Contributed about $2 billion and 13,000 full time equivalent jobs to the economy that would not have occurred in the absence of this stimulus programme, with a benefit-cost ration of 4.7.
- Carried out energy saving audits in 225,065 residential buildings (approximately 300,000 individual homes), the great majority single family or detached houses.
- Converted these audits into verified energy saving upgrades in 99,071delivered buildings, most of them single family homes. Since the upgrades also covered thousands of apartment buildings, well over 100,000 homes received upgrades. This is a far higher conversion rate than was achieved following Green Deal assessments of UK homes.
- Achieved verified energy savings in retrofitted homes of 15%, with the total annual energy bill savings for natural gas, electricity, LPG and heating oil across these homes worth $29.2m a year. Annual carbon savings were 245,000 tonnes of CO2 a year.

BBNP also generated 5.6 million hours of paid work and trained several thousand people in energy efficiency audit and upgrade work.

The program was designed to fund a wide variety of delivery models in order to discover what works. Building on studies of previous upgrade programs, the DoE had defined four pillars of success:

- Creating demand for energy saving upgrades
- Ensuring finance is available for households
- Developing a workforce and capable contractors who can meet the demand for audits and upgrades
- Collecting and reporting all of the data required to document the program and then evaluate its success

The DoE was looking for initiatives and innovations to stimulate integrated local markets for energy efficiency upgrades, in which growing supply and demand were well matched and, ideally, would continue once BBNP expired. It wanted to ensure it would have the data needed to identify success among a diversity of models and spread the lessons about what works.

The 41 grants mostly went to state, city and county governments, but also to NGOs, utilities and public bodies. The initiatives all relied heavily on partnerships and contractors for outreach and delivery, with several linked to existing energy efficiency upgrade programmes run by, or for, utilities obliged to achieve reductions in electricity demand. Grants were used to offer a wide range of subsidies, rebates and loan finance to households including free audits and loans with reduced interest rates. While the initiatives varied greatly in their success, most continued to run through 2014 after BBNP closed. Some should be self-sustaining in the longer term.

The evaluation found some evidence of local market effects, indicating that both the capacity to supply energy-saving retrofits and the demand for them had risen in areas reached by the BBNP.

But it was too early to conclude that there had been a permanent market shift. And while there was a wide variation in the success of the 41 initiatives, the evaluators were not able to demonstrate that any specific program design worked better than other designs. There were many success factors. What was most important for success was for activities and planning under these four pillars to be complementary and coherent.

Among these success factors were:

- The degree of training of installation contractors, particularly in engaging with householders and selling them retrofits;
- Having a large pool of eligible or pre-approved contractors available to carry out retrofits;
- Quality control and quality assurance mechanisms;
- Having finance packages available to offer to households, although only 16% of households took out loans to cover their upgrades.

The evaluation also found that local community based organisations could play a strong role in recruiting households for retrofits.

Engaging credible messengers – such as respected local governmental personnel or homeowner association presidents – in program promotion influenced individuals in those messengers' social networks to undertake upgrades…canvassing (cold calling) was rarely an effective approach
(Research into Action, 2016)

One or more meetings with someone who understands domestic energy saving and can discuss that household's circumstances, needs and concerns can be important in converting audits into delivered upgrades. Several successful BBNP programs used facilitators independent of the contractors to provide advice and support to interested households throughout the process.

UK potential for local and community-based upgrade initiatives

This US learning and experience should resonate with UK policy and industry audiences. There may be an important role for local authorities, local community energy groups and other local organisations in encouraging "able to pay" consumers to opt for energy efficiency upgrades with minimum levels of subsidy. Locally and community based approaches could succeed in this because:

- It may be easier to build the necessary 'critical mass' of interested households and capable contractors at a local market level, with local demand and supply growing in tandem.

- Households may be able to achieve economies of scale by grouping to purchase upgrades for properties which are of the same type and/or in the same neighbourhood. Local contractors may be able to offer more attractive prices if there is sustained local demand.

- Local authorities and community energy groups working with contractors may be able to overcome trust barriers because of their established local identity and status. They may be better positioned than large energy companies or other nationally-based organisations to provide the face-to-face contact and trusted advice needed to convert household awareness and interest into an upgrade decision.

- Local approaches may offer a promising way of 'bundling up' reductions in demand, thereby facilitating the financing of upgrades. This could be of interest to the national market for capacity/guaranteed demand reductions and to DNOs managing local grid capacity constraints. Local upgrades could be part of 'smart grid' initiatives in which homes store and share electricity generated by rooftop photovoltaic panels.

UK experience in local and community-based upgrade initiatives

Several local authorities, most notably Kirklees in West Yorkshire, have extensive experience in domestic energy efficiency upgrade programmes, although these have mainly concentrated on delivering free measures and tackling fuel poverty (Webber, 2015). There are also a growing number of community energy groups offering advice to households on upgrades, and in some cases delivering these.

DECC has been developing policy to support community energy approaches, seeing these as having an important role in unlocking opportunities for lower energy bills and carbon emissions that would otherwise be missed. It published its first Community Energy Strategy at the start of 2014, with an update in March 2015 (DECC 2014b and 2015f). The strategy divides community energy into four strands – generating heat and electricity, reducing energy use, managing energy demand and purchasing energy. The 'reducing energy use' strand is most closely linked to upgrades, but they also link to generation and managing demand.

Two programmes aimed at stimulating Green Deal uptake, Green Deal Pioneer Places and Green Deal Communities, have given opportunities to local authorities working in partnership with others, including community groups, to develop local domestic upgrade programmes. The latter had significant funding of £80m. Several other UK government and devolved administration programmes have funded local energy initiatives which can be used to promote domestic energy efficiency upgrades.

There are also independent research and evaluation projects examining the outcomes from various local and community based energy initiatives. The Energy and Communities Collaborative Venture, part of the Research Councils' UK Energy Programme has funded seven separate projects concerned with how individuals and communities use, understand and manage energy aiming to help them to find ways to reduce energy demand. One of these was a four year investigation and evaluation of the changes in energy use in six 'Low Carbon Communities' funded under DECC's 2010 Low Carbon Communities Challenge.

The findings of this EVALOC (Evaluating the impacts, effectiveness and successes of low carbon communities on localized energy behaviours) research project by Oxford Brookes University and the University of Oxford support a strong role for local communities and local authorities. Such local initiatives should be seen as an important complement to business and government in increasing the rate of domestic energy saving upgrades, not a substitute.

Integrating energy efficiency with home renovations

Energy efficiency improvements are frequently part of wider home renovations, but saving energy and cutting fuel bills is rarely the main or a leading motive for a home renovation.

There market for home renovations is large and sustained and the average owner-occupied property is highly likely to undergo a major renovation within a 10-20 year period.

Households contemplating and planning a renovation are generally open to the idea of using a renovation to save energy and potentially reduce their energy bills, especially if they believe it will make their home more warm and comfortable.

However, there are multiple barriers on both the supply and demand side which prevent major energy efficiency improvements from becoming part of most home renovations. In particular these concern upfront costs, inconvenience, lack of information and advice and lack of trust.

There is scope for renovations primarily funded by households to deliver large energy and carbon savings from the UK owner-occupied housing stock. The policy challenge is to devise a package of incentives, disincentives and regulation which will secure this, learning lessons from the Green Deal's failure, to impact on the demand and supply sides of the renovation market.

Findings from recent research suggest a need for energy efficiency and carbon reduction policies to focus on the large proportion of owner-occupied households considering or undertaking home improvements and refurbishments – and on the industries and supply chains that serve them.

Although the proportion of owner-occupied homes is falling, they still comprise a substantial majority of UK housing stock – 63% (DCLG, 2016b). There is a large potential to improve their energy efficiency and reduce associated carbon emissions cost effectively, or near cost effectively, with their occupants having both the resources and the ability to make these improvements to heating systems and building fabric. The resulting energy savings can be large when compared to those achieved by changes in household behaviour and purchasing more efficient appliances; they are also sustained.

Such changes are often made as part of wider home improvement projects. Conversely, only a small proportion of home improvement projects are devoted primarily to improving energy efficiency and making energy savings.

At an estimated £27bn a year, the market for home improvements and refurbishments is much larger than that for home energy efficiency improvements. At any one time, a large proportion of owner occupiers (as large as half) are considering, planning or implementing significant home improvements. Given that the mean length of tenure for owner occupiers is 17 years, every home will eventually become a candidate for improvement. And since homes change their owners, every home will eventually become a candidate for improvement.

Would be amenity renovators should be seen as a giant 'foot in the door' for energy efficiency service providers, and represent a largely unexploited opportunity to introduce energy efficiency measures into homeowners' decision to renovate.

Findings of the VERD Project

What the research finds

The largest and most recent UK study on this topic is the University of East Anglia's VERD Project (Value propositions for Energy efficient Renovation Decisions), which surveyed a representative sample of 1,028 UK homeowners (Wilson et al, 2013). It also interviewed household members considering and planning renovations, researched their preferences in order to find out what mattered most to them and reviewed the literature on home renovations.

Several of these findings overlap with those of a similar 2011 study by the Energy Saving Trust, although this found a somewhat lower proportion of households (22%) considering refurbishments in the next three years (Energy Saving Trust, 2011).

Both studies support the established view that saving energy, cutting energy bills and reducing carbon emissions are rarely the main or a leading motive for home renovations.

The EST study arrives at the same conclusion as several others; that while households may be interested in the possibility of cutting their energy bills by installing energy efficiency measures several barriers prevent them from doing so, particularly high upfront costs, worries about disruption and inconvenience and a lack of confidence that the promised savings will be realised. As the budget for a renovation project increases, the extra proportion (or budget 'stretch') that households are willing to spend on energy saving measures falls.

The VERD study's finding that financial constraints do not act as barrier to renovation decisions would appear to conflict with this. Simply put, it maintains that if households decide they really want or need a renovation they find a way of affording it.

However, this finding applies to all types of renovation rather than renovations linked directly to energy saving. Another VERD finding that energy saving renovations tend to fall back and amenity renovations increase as households move into planning and finalising their projects suggests that non-energy efficiency improvements gain a higher priority as householder intentions and aspirations move towards actions.

Key findings were:

- Households move through a process of first thinking about, then concretely planning, finalising and implementing renovations. About half of households are at some point in this process, with the other half not thinking about renovations. The process varies widely in length between households, usually takes several months and often longer than a year.

- Only 11% of those households considering a renovation were planning one which was related directly to improving energy efficiency – such as insulation, heating systems, windows and doors. Just over half (54%) were planning an 'amentiy' renovation unrelated to energy efficiency; for example a new bathroom, kitchen or extension. The remaining 35% were planning 'mixed' renovations with some energy efficiency elements.

- As households moved through the process towards implementing a renovation, they appeared more likely to opt for amenity renovations and less likely to opt for energy-efficiency renovations.

- There are multiple and complex motivations for – and barriers against - households contemplating, planning and implementing renovations, but about one in four are triggered by something in the home needing fixing or replacing, such as a broken down boiler.

- The longer occupants have been in their current home, and the shorter they expect to stay, the less likely they are to be considering renovations.

- Financial constraints do not act as a barrier to renovation decisions or strengthening intentions, but they may lengthen the time spent moving to a final decision.

- In selecting and implementing renovations, households prefer to rely on personal recommendations and advice, on small local companies and on face-to-face customer support.

- When finalising their renovation plans, the most important features of an "attractive value proposition" were:

    1) lower upfront costs
    2) reliable contractors and
    3) less disruption to domestic life.

The case for linking home energy efficiency upgrades to home renovations

These research studies were founded on the concept that the established home renovation market can provide an opportunity or "foot in the door" for major improvements in the energy efficiency of the UK's housing stock, at least for owner occupied housing. There are several reasons for this:

1. Home renovation is a very large, established market with very many existing suppliers, mostly small, locally based businesses. There are well established ways of financing home improvements through personal saving and borrowing; upfront costs are not a barrier.

2. Home renovations are already routinely delivering large quantities of unsubsidised energy efficiency improvements to homes, such as more efficient boilers, heating controls, double glazing and insulation. Householders are open to considering improvements which make their homes more comfortable and cut their energy bills.

3. Households are willing to face significant disruption and inconvenience in order to have a home renovation. The disruption associated with energy efficiency measures may be a small or negligible part of the wider disruption caused by a renovation.

4. There are potential economies in making energy efficiency work part of a wider renovation project, although there appears to be little published evidence for this.

5. One motive for renovating a home is to increase its value (although it is often not a primary motive, and these research studies did not consider this). There is evidence that improving houses' energy efficiency level does raise their value (Fuerst el al, 2013).

If this case is accepted, then energy efficiency policy should be designed to encourage both the demand and supply sides of the home renovation market to opt for more energy efficiency measures.

The Green Deal attempted to do this, by making finance for energy saving measures more readily available – especially for lower and medium income households – and by providing an accreditation system for energy saving audits and installations. However, it had little impact on the market and the Government withdrew financial support on 2015, two and a half years after it was launched. The policy challenge is to understand why it did not succeed and what more could be done.

It is potentially far simpler to introduce energy efficiency measures into amenity renovation decisions than it is to try and initiate efficiency renovation decisions from scratch.

Findings of the VERD Project

Policies to integrate energy efficiency with home renovations

Drawing from the research findings, it seems likely that some combination of incentives, disincentives, regulation and public information and advice will be required to significantly increase the energy efficiency purchase of the existing home renovations market. A key consideration is that policies should not act to reduce this market.

Experience in the UK and overseas suggests such policies can have an impact. Regulation has already improved the performance of boilers, windows and insulation incorporated in home renovations. When incentives such as the boiler scrappage scheme and the Green Deal Home Improvement Grant are available, they are rapidly taken up.

Incentives, such as grant and subsidies, should be large enough to evoke a response which levers in household (able to pay) spending but not so large that the funds set aside for them rapidly expire and the grant is withdrawn. They should target some combination of the most cost effective energy saving measures and the least energy efficient properties. In Germany, a combination of low interest rate loans, repayment bonuses and grants offered by the KfW bank is targeted on increasing the energy efficiency element of home renovations (as well as new build). It has substantially improved the energy efficiency of millions of existing homes and the great majority of the finance required has come from the private sector (Schröder et al, 2011).

Disincentives: If an incentive is available to all home owners to raise the energy efficiency of their homes, then there is a case for disincentives to eventually be targeted on those homes which are shown, through energy labelling, to have low levels of energy efficiency. Households could be given a period of several years in which to take action before the disincentive entered into force, as is currently the case for the private rental sector. Disincentives could be financial and applied through existing tax systems (stamp duty tax or council tax) which could also have an incentive element supporting energy efficiency improvements. Alternatively, they could take the form of regulation mandating higher energy efficiency standards.

Regulation: The most obvious form regulation could take is 'consequential improvements', with Building Regulations approval for a home renovation also requiring energy efficiency improvement of the entire property. This has been proposed by UK governments on more than one occasion, but subsequently rejected following consultation.. Here, too, if incentives are available to all households then it is easier to justify this regulatory intervention. In Berkeley, California minimum energy standards are required in all existing private housing with improvements triggered by the sale or transfer of a property or a major refurbishment (CAG Consultants, 2010). These improvements are set within limits on the amount of money the property owner is required to invest in the prescribed measures.

Such policies need to be applied against a background of improved information and advice to households and suppliers and increased visibility and salience for properties' Energy Performance Certificates. Local authorities can play an important role, with this information and advice linked to applications for planning permission for home renovations and to building control.

It will also be important to ensure that policies give the suppliers, mainly small building firms and local tradespeople, an incentive to include energy efficiency within home renovation works and that they develop the required knowledge and skills and can advise households or point them to sources of sound, easily understood advice.

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