energy technologies institute

Programme Area: Smart Systems and Heat

Project: Value Management

Title: Overcoming barriers to smarter heat solutions in UK homes - final report

Abstract:

This document was prepared at the time to contribute to ETI internal thinking and planning only it should be read in the context of the final reports of the Building Retrofit Project on the ETI website

Context:

This project studied how value can be delivered across a smart energy value chain - in the context of the UK. It built a clear understanding of how smart energy systems can deliver combined consumer value alongside commercial value for market participants - producers, suppliers, distributors. The analysis will help to make the commercial deployment of smart energy systems more likely. This £600,000 project was delivered by Frontier Economics, a leading economic consultancy.

Overcoming barriers to smarter heat solutions in UK homes

FINAL REPORT PREPARED FOR THE ENERGY TECHNOLOGIES INSTITUTE V.1.1

March 2015

Overcoming barriers to smarter heat solutions in UK homes

Contents

Executive Summary

Key points

Businesses can be well placed to make it easier for consumers to choose low–carbon interventions.

- The vast majority of consumers will select familiar heating solutions. Low levels of interest and limited awareness of the benefits of alternatives, coupled with decisions made at the time of heating system failure, may significantly slow the transition to low carbon technologies.
- Businesses can develop propositions which make it easier for consumers to choose low-carbon interventions. These could include contracts which focus on the delivered heat service, bypassing interest and awareness barriers and managing risks for consumers.

Policy support is also required to tackle the fact that some low-carbon interventions currently cost more and in some cases provide fewer benefits to consumers, relative to the incumbent options.

- The overall cost-effectiveness of the measures matters, but the research suggests that consumers are also highly sensitive to upfront costs. Most consumers require payback periods well below 10 years, and often as low as 2 years.
- Cavity wall insulation and sophisticated Home Energy Management Systems have the potential to provide benefits with reasonable pay-back. However heat pumps and solid wall insulation are not cost-effective for most consumers (absent policy intervention), even assuming that the heating service provided meets the consumers' needs.
- Subsidies, of around £8k per household for heat pumps, and around £10k per household for external solid wall insulation would be required to ensure these technologies pay back within 10 years for consumers[1]. Achieving uptake consistent with CCC carbon targets to 2030 would entail providing at least **£25bn of subsidies, to deliver carbon savings worth £6.7bn.**

Whether subsidies in excess of the carbon price would be justified, depends on the extent to which we believe:

1 The results of the cost benefit analysis quoted in this report are in 2015 prices.

- **there are wider benefits from low-carbon heating interventions, such as improvements to health and wellbeing;**
- **the costs of heat pumps and solid wall insulation will be driven down by the growth of the UK market (rather than global growth); and**
- **there are no alternative, more cost-effective options across the energy system for meeting carbon targets.**

These issues would need to be examined further, before a case could be made.

District heat will also require policy support.

- Given the high level of sunk costs associated with district heat, and the fact that some of the risks faced by developers are policy driven, there is a role for policy intervention to help manage risks for developers.
- Policy support is still likely to be needed to reward developers for the value of the carbon savings their schemes deliver. This could be achieved by providing grants. The level of these grants could be set in line with DECC's projected carbon price[2].
- Regulation of local district heat monopolies is also likely to be important to protect consumers, and its early introduction will help reduce uncertainty for investors.

The ETI Smart Systems and Heat programme aims to demonstrate how to better heat existing UK homes, while reducing CO_2 emissions. To achieve the 2050 climate change targets, major reductions in emissions from the heating sector will be required. However, interactions between the features of the market for low carbon heat; the way consumers behave in relation to the heating market; and the characteristics of the interventions themselves, create a complex set of barriers to achieving uptake of low-carbon heating interventions (Figure 1).

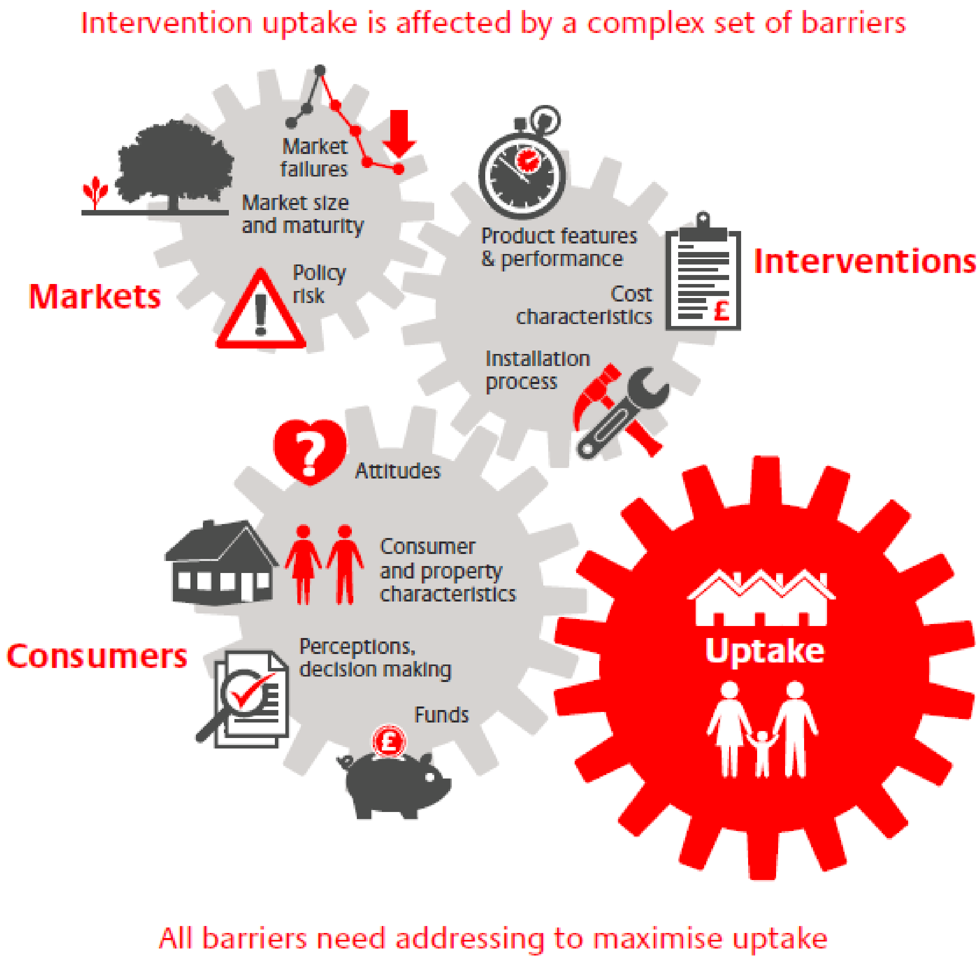
This report aims to understand how these barriers could be overcome to support low carbon deployment, with a focus on the period from 2020 to 2030. One of the key assumptions throughout this assessment is that the transition is more likely to be effective if driven by consumer demand within a constructive policy environment than via a top down implementation. Our approach therefore focuses on understanding value propositions that could encourage market pull, and then identifies features of the policy and regulatory framework that could

2 DECC (2014), *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal*

help support uptake in the transition. We have found that business model and policy solutions need to:

- make it easier for consumers to choose the low-carbon options;
- tackle upfront costs, or develop compensating benefits; and
- for district heat, manage risks and protect consumers.

Figure 1. The features of the market, the way consumers behave and the characteristics of the interventions



Source: Frontier Economics

Make it easier for consumers to choose the low-carbon options.

Consumers' decisions are stacked against low-carbon interventions. The vast majority of consumers will select familiar heating solutions. Low levels of interest and limited awareness of the benefits of alternatives, coupled with decisions made at the time of heating system failure, may significantly slow the transition to low carbon technologies.

This is where businesses can have a significant role. **Businesses are well placed to develop propositions which make it easier for consumers to choose low-carbon interventions**. Examples include contracts which focus on the delivered heat service. These can help bypass interest and awareness barriers, manage risks associated with the heating system and can engage consumers before their existing system fails[3].

Policy can also be designed in a way that reflects what is known about how consumers make heating decisions. Policy interventions could be tied to investment triggers, such as moving house. Financial incentives can be tagged to existing well known taxes to attract attention. **Financial incentives should in general be delivered through upfront rather than ongoing payments,** given consumers' tendency to focus on upfront rather than lifetime costs and benefits.

Tackle costs, particularly upfront costs, or develop compensating benefits

Businesses can make it easier for consumers to choose low–carbon interventions. However, we cannot ignore the fact that many consumers are largely content with their existing heating systems, and that not all low-carbon interventions will make them better off, either financially or in terms of the heating service they receive.

Costs

Consumers focus on near term costs and benefits in their decision making, while businesses face limits to the extent they can spread costs for consumers[4]. This means the two most **important cost elements to consider are the level of the upfront costs and the payback period, with most consumers requiring a payback period well below 10 years, and often as low as 2 years**. Figure 2 shows how these vary across the low-carbon technologies we are focussing on in this work[5].

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3 A heating system that was broken or near the end of its life drove the decision of 61% of homeowners to invest in their heating system. DECC (2013), *Homeowners' willingness to take up more efficient heating systems*

4 This is because investments in these interventions are largely sunk and therefore spreading costs is akin to offering an unsecured loan.

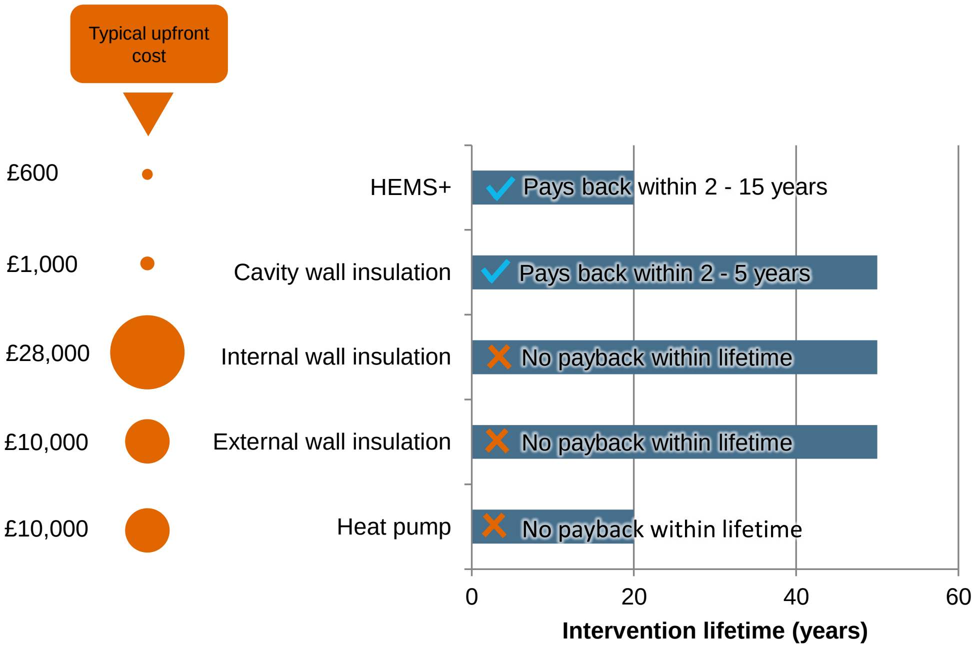
5 We do not have comparable cost estimates for district heat as part of this project.

- Cavity wall insulation and sophisticated Home Energy Management Systems (HEMS Plus)[6] have the potential to save money for consumers, with a relatively low upfront cost and a payback period of less than 10 years for the majority of customers.

- However, the upfront costs of heat pumps and solid wall insulation (internal and external) are an order of magnitude higher, They will never pay back for most consumers within the lifetime of the technology, (absent policy interventions, or other developments such as increases in the efficiency of these interventions).

6 HEMS Plus is a sophisticated Home Energy Management Controller with zoning and hot water management

Figure 2. Upfront costs and payback periods for key in-home technologies in 2025, with no carbon price or other policy support



Source: Frontier Economics

Notes: A high temperature heat pump is assumed. The payback period for heat pumps is calculated relative to gas boilers (that is, the chart shows that the difference between the ongoing costs of heat pumps and gas boilers do not compensate the typical household for the additional upfront costs of the heat pump). Payback period figures are based on averages over typical households in 2025. A minority of households will fall outside these ranges. For example, internal wall insulation does pay back within 50 years for a small proportion of households, while households with electric resistive storage heaters may find that heat pumps pay back. Internal wall insulation costs are based on larger (rural) properties, which will increase its cost. All figures assume no policy support for low-carbon technologies (e.g. RHI or a carbon price). A 3.5% discount rate is used.

Developing compensating benefits

While costs are important, the benefits consumers perceive are also crucial, and will determine their willingness to pay.

As well as having the potential to save money for many consumers, HEMS Plus and cavity wall insulation will also improve the heating service for consumers.

The compensating benefits of heat pumps and solid wall insulation are less clear. Our analysis indicates that businesses may improve the heat pump proposition relative to gas boilers by managing risks on behalf of consumers or delivering electricity demand side response services. They could also focus on compensating benefits that incumbent technologies cannot provide. For example, heat pumps can provide air conditioning and dehumidifying services and in some cases, external solid wall insulation could improve the appearance of properties. However, these types of benefits alone are unlikely to increase most consumers' willingness to pay enough to generate the uptake required to meet carbon targets. **Policy intervention is therefore required to help tackle remaining barriers and enable uptake of these interventions.**

Policy solutions are required for solid wall insulation and heat pumps

We assume that in the transition, policy solutions will not involve mandating take-up or increasing taxation on more carbon-intense heating systems, not least because of concerns about maintaining consumer choice and the affordability of energy. We therefore look at the level of subsidy necessary to generate take-up at a level consistent with being on a path to meet the 2050 carbon targets.

DECC has published a carbon price which represents the estimated marginal cost over time of meeting carbon targets[7]. In theory, applying this carbon price as a subsidy should deliver the take up consistent with meeting the targets. Indeed, applying **a subsidy, in line with the carbon price, makes these interventions cost-effective for many consumers over the lifetime of the interventions. However, it will not be enough to bring payback periods down to a level which they are likely to find acceptable**. For some consumers, the payback on these interventions will be very long, up to 50 years, even with a subsidy in line with the carbon price.

Evidence from sectors, including the energy sector, suggests a 10 year payback period is the maximum consumers are likely to accept. To get payback periods down to this level would require subsidies, at around £8k per household for heat pumps and around £10k per household for external solid wall insulation. **To achieve 1m solid wall installations and 2.5m heat pumps by 2030 (consistent with meeting 2050 carbon targets)[8], our analysis suggests that £25bn of subsidies for these measures alone would be required**. This estimate may be a lower bound: it is enough to ensure these technologies pay back financially for consumers, but it does not compensate them where the new heating system is associated with different performance when compared to the incumbent option. These uptake figures also assume that other barriers, such as those related to interest and awareness, can be overcome through innovative business offerings. This level of subsidy would deliver £6.7bn of carbon savings.

Whether subsidies in excess of the carbon price would be justified, depends on the extent to which we believe:

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7 DECC (2014), *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal*

8 CCC (2014), *Meeting Carbon Budgets: 2014 Progress Report to Parliament,* Frontier Economics and Element Energy (2013), *Pathways to high penetration of heat pumps*

- **there are wider benefits from low-carbon heating interventions, such as improvements to health and wellbeing;**
- **the costs of heat pumps and solid wall insulation will be driven down by the growth of the UK market (rather than global growth); and**
- **there are no alternative, more cost-effective options across the energy system for meeting carbon targets.**

These issues would need to be examined further, before a case could be made.

We note that policy supporting innovation may also help to reduce costs and increase compensating benefits.

District heat requires different intervention

District heat can already deliver a heating service that is comparable (or better) than the main incumbent, gas boilers, although policy support is still likely to be needed to ensure developers are rewarded for carbon savings their schemes will deliver, for example through grants. This would allow district heat to compete with incumbent technologies on cost.

Given the high level of sunk costs, one of **the key challenges is around helping developers to manage risk around future heating demand (especially risk that is policy driven) while not removing choice from consumers.** This can help reduce borrowing costs for developers, and thereby increase the number of schemes that are potentially viable. One important way for local and national Government to manage risk may be to identify the local characteristics that would make an area most suitable for district heat. Research for DECC found that managing risk was crucial, and in combination with a carbon price signal, could ensure that district heat meets between 6-14% of UK heating needs in 2030[9].

Part of managing policy risk is to ensure that national policy is aligned with local plans for district heat development. It is critical that incentives (financial or other) applied at a national scale are aligned with local efforts to roll out low-carbon interventions, and vice versa. This topic is complex with a number of key stakeholders to consider. The ETI has identified the following questions as important:

- how to identify local area optimal solutions?

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9 Pöyry and Faber Maunsell (2009), *The potential and costs of district heating networks, A report to the Department of Energy and Climate Change*

- how best to provide consumer choice while trying to ensure adoption of the most effective interventions within each local area?
- how to ensure the policy framework is seen by consumers as fair and equitable across UK?

Regulation of local district heat monopolies is also likely to be important to protect consumers, and introducing it sooner rather than later will reduce uncertainty for investors.

1 Introduction and scene setting

The ETI Smart Systems and Heat programme aims to demonstrate how to better heat existing UK homes, while reducing CO_2 emissions.

Previous ETI work considered how value can be delivered across the smart systems energy value chains and identified some initial business models and policy requirements[10]. This report builds on this work to further understand barriers within the transition to new approaches to heat supply and demand management and to describe solutions which could overcome barriers to take up.

This work is focussed on the period 2020 to 2030.

1.1.1 The scale of the challenge

The UK has signed up to legally binding targets to reduce greenhouse gas emissions by 80% over 1990 levels by 2050. To meet 2050 targets cost-effectively, tackling emissions from heating in UK homes will be crucial: domestic heating accounts for almost 20% of CO_2 emissions, and these emissions will need to be almost completely eliminated by 2050[11].

Almost all of the current housing stock will still be in place in 2050, which means the challenge is around installing low-carbon interventions in existing homes. ETI analysis suggests that the most cost-effective path to meeting this target will require around **7 million homes** to be fitted with a comprehensive insulation package. Further, **almost all households will need to switch from their current heating system to a low-carbon option**. This is radical, and therefore extremely challenging. The implications for take up of key low-carbon heating interventions to 2030 are shown in Figure 3. This shows that a step change in the installation of heat pumps, solid wall insulation and district heat will be required, alongside continued strong progress with cavity wall insulation.

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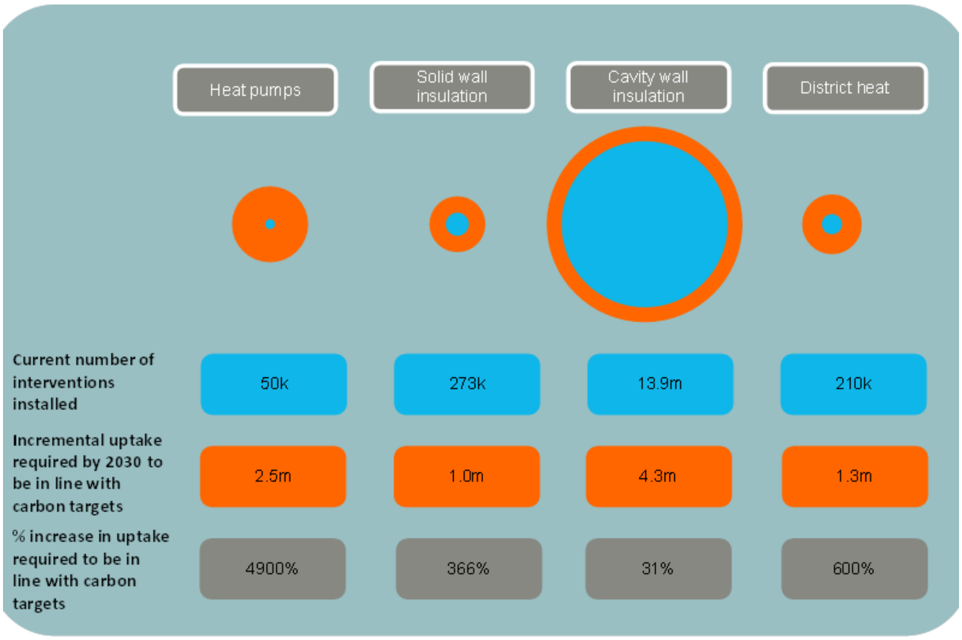
10 Frontier Economics for ETI (2013), *Future business models: options and analysis*. This work identified that the credibility and stability of climate change policy will be crucial, both for overall climate targets to be met, and for innovative business models to emerge. It also identified a number of more specific requirements, for example policy reform to ensure tariff innovation is possible, energy wholesale markets to be liquid and DNOs to be able to trade services from storage.

11 ETI, DECC and CCC analysis suggests that the heating sector will need to be almost completely decarbonised by 2050.

Figure 3. What is required by 2030?



Notes: This figure aims to give a high level picture of the scale of the challenge. The current level of uptake of interventions was not taken from a single source and therefore corresponds to slightly different time periods. For solid wall insulation and cavity wall insulation, the current level of uptake relates to September 2014 and the figures are taken from DECC (2014). For district heat, current uptake levels correspond to home connections in 2013. Heat pump current uptake levels correspond to the estimated sum of installations installed in 2010 up to 2012. Incremental uptake required by 2030 is also taken from a number of sources. For cavity wall insulation, the figure refers to incremental amount required to meet the fourth carbon budget in 2027. For solid wall insulation, the figure is taken from the CCC (2014) report that shows the number of installations estimated to be cost effective by 2030. Solid wall insulation covers both internal and external insulation. The base year for the incremental calculations for both types of insulation is 2013 (based on the CCC report). For district heat the uptake of interventions required in 2030 represents the estimated additional number of households that could be cost effectively served by district heat networks by that time, less existing connections in 2013. For heat pumps, the 2.5m figure represents the number of additional heat pumps required by 2030 in order to make meeting the carbon targets possible, as indicated by the analysis of Frontier Economics and Element Energy (2013) for the CCC. We note that the CCC's analysis for the Fourth Carbon budget recommends exceeding this minimum and aiming to invest in around 4 million residential heat pumps by 2030.

1.1.2 Methodology and structure

This report is structured as follows.

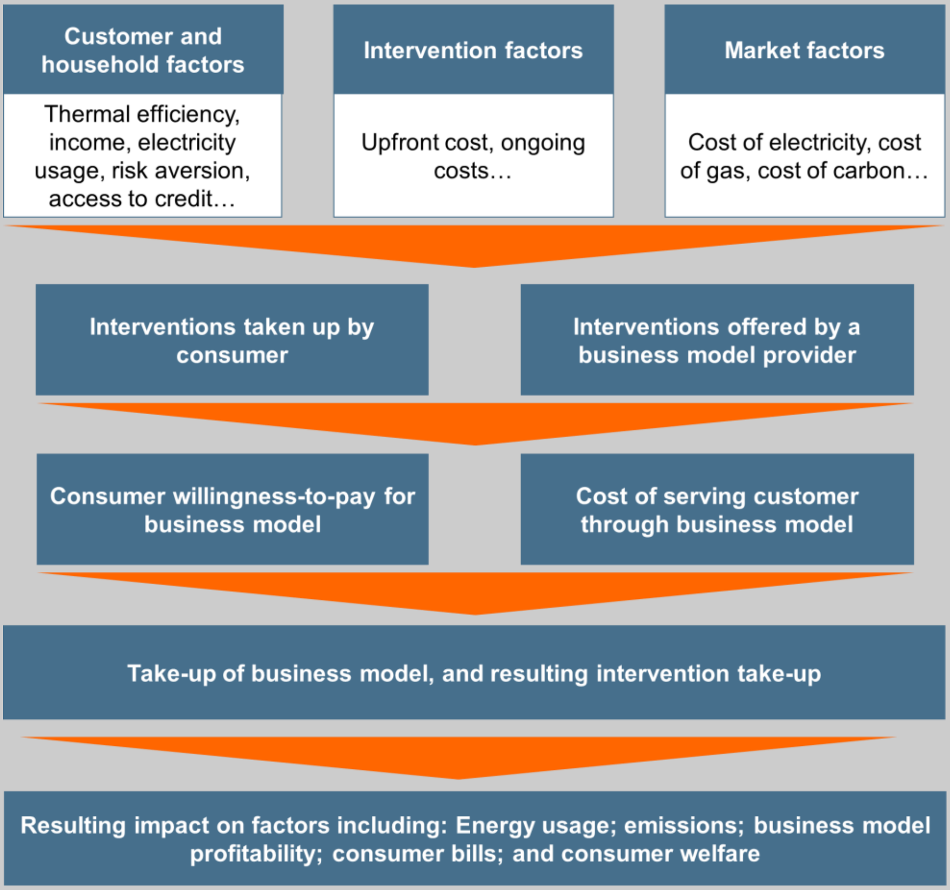
- Section 2 gives an overview of the key barriers.
- Section 3 describes potential business model solutions to these barriers.
- Section 4 sets out some options for policy and describes the associated challenges.

Throughout the analysis, we draw on insights generated by the ETI's Business Model Evaluation Tool (Box 1), case studies from other sectors and the wider literature on behaviour in the energy efficiency and low-carbon heating sector.

Box 1: Business Model Evaluation Tool (BMET)

Frontier Economics developed BMET for the ETI in 2013. This tool allows testing of the long-run cost effectiveness and affordability of low-carbon heating interventions and business models against a range of customer groups and assumptions. For this report, we have populated the model using data on the cost of interventions from ETI, alongside DECC assumptions on fuel and carbon prices.

Figure 4. Overview of BMET



Source: Frontier Economics

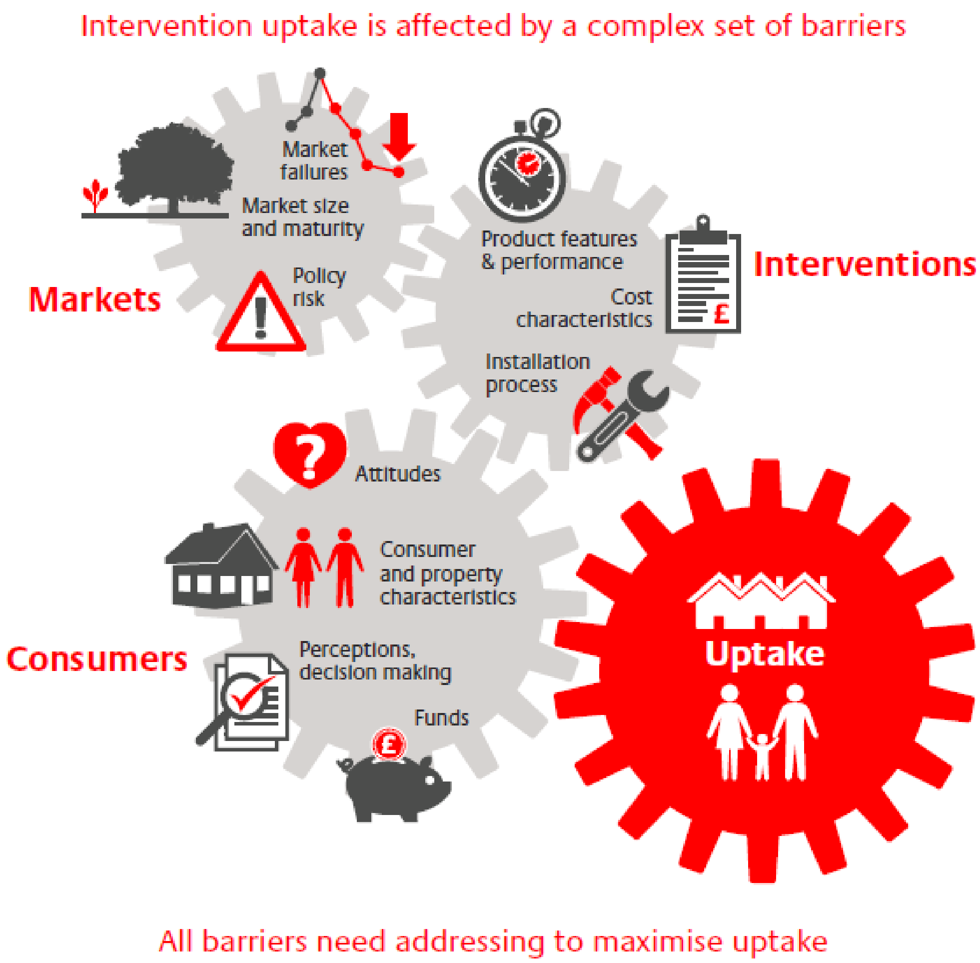
2 Why has uptake of some low carbon heating interventions been so low?

Radical changes will be required in the heating sector to meet 2050 targets. To date, despite a range of ambitious policy interventions, uptake of some low-carbon heating interventions, such as heat pumps and solid wall insulation has been low.

For low carbon heating interventions to be taken up, they must be seen as a better choice for the consumer than the alternative options. For businesses to offer these low-carbon interventions, they must be able to develop financially viable propositions.

In this section, we consider how the interactions between the features of the market for low carbon heat, the way consumers behave in relation to the heating market, and the characteristics of the interventions themselves drive barriers to uptake (Figure 5). This provides us with a framework for thinking about solutions to overcome these barriers during the transition period from 2020 to 2030.

Figure 5. The features of the market, the way consumers behave and the characteristics of the interventions

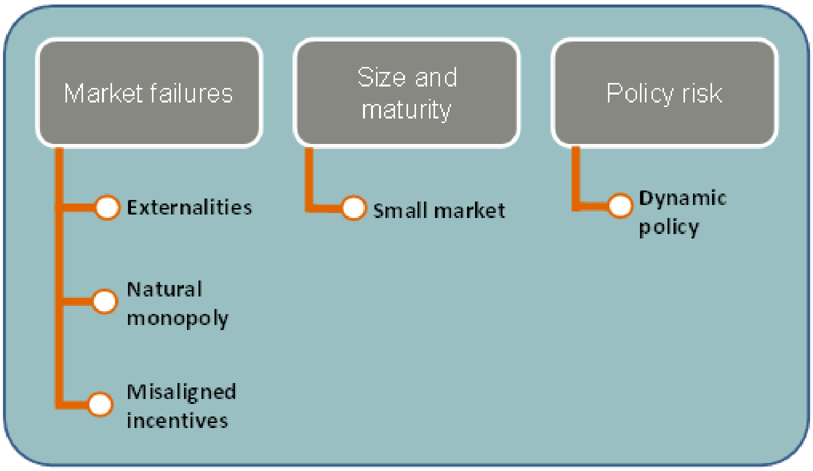


Source: Frontier Economics

2.2 Markets

The features of the market for low-carbon heating technologies drive barriers (Figure 6).

Figure 6. Features of the market for low-carbon heating interventions



Source: Frontier Economics

There are market failures in the low-carbon heating market. This means that without policy intervention the market for low-carbon heating interventions would not be expected to deliver an efficient outcome for consumers.

- *Externalities.* There is no carbon price currently on gas use, and a very low and unstable price (through the EU ETS) on electricity use. This means that consumers and businesses will not take the full cost of carbon emissions into account in their decision making. In practice, in the absence of policy intervention, this puts the low-carbon alternatives at a cost-disadvantage relative to the incumbent alternatives, which means significant compensating benefits would be required for them to be taken up. For example, the lifetime carbon savings associated with installing internal solid wall insulation in 2025 could be as high as £3k-£12k [12,13].

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12 Based on BMET analysis. The bottom of the range relates to customers on electric resistive heating with poor existing levels of insulation and the top of the range relates to customers on oil with poor existing levels of insulation.

13 Carbon price based on DECC projections. DECC (2014), *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal*

- *Natural monopolies.* The fixed costs of establishing a district heat network mean that a necessary (but not sufficient) condition for schemes to be viable is that they can connect many hundreds of customers in the same area at once[14]. This cost structure makes it difficult for multiple firms to compete to supply the same customers, and therefore district heat networks will tend to be monopolies in the local areas that they serve. As we describe in more detail below, these resulting monopolies will require policy intervention to protect consumers.

- *Misaligned incentives.* In the private rented sector, the costs of heating improvements are borne by landlords, while the resulting lower energy bills accrue to current or future tenants. This would tend to encourage landlords to underinvest in low-carbon heating interventions. This barrier is growing in importance, as the size of the private rental sector has increased in recent years. The most recent figures available show that 18% of UK dwellings were privately rented in 2012, compared to 10% in 2002[15]. This is a particular problem as privately rented homes are often in worse condition than average, and therefore could benefit most from heating system investments[16,17].

These issues are well known, but they have not yet been fully addressed by policy intervention.

The small size and immaturity of the market for some low-carbon heating technologies is also relevant. This is particularly the case for heat pumps and district heat. There are around 1.6 million gas boilers installed per year[18]. This compares to fewer than 2,400 new installations of heat pumps in the first seven months after the introduction of Renewable Heat Incentive (RHI) in April

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14 Research for DECC found that energy service providers had a minimum scheme size (circa 300 dwellings) below which they were not interested in delivering. For one provider this was as high as 500 customers. BRE, University of Edinburgh and the Centre for Sustainable Energy for the Department of Energy & Climate Change (2013), *Research into barriers to deployment of district heating networks*

15 DCLG, 2014, Table 101: Dwelling stock: by tenure, United Kingdom.

16 In 2012, 4.9m homes in the UK failed the Decent Homes Standard. Privately rented accommodation made up 28% of this total, though it makes up only 18% of the total population of dwellings DCLG (2010), *What is the Decent Homes Standard*

17 The Decent Homes Standard applies to social housing in England and it consists of four aspects: (1) There are no category 1 hazards under the HHSRS, (2) Reasonable state of repair (3) Relatively modern facilities and services in the home (4) Acceptable degree of warmth provision for comfort. English Housing Survey (2014), *Dwelling condition and safety.*

18 DECC (2012), *The Future of Heating: A strategic framework for low carbon heat in the UK*

2014[19,20]. District heat currently heats only 2% of UK homes[21]. This means there may be issues in the transition. If a technology is more expensive initially, but cheaper at scale, it may never grow to replace an inferior incumbent technology. A critical mass of take up may be required before it is viable to invest in developing skills. In addition, emerging technologies may be more complex and less easy to install. A small market will also mean that the technology is less familiar to consumers.

Finally, as with any sector characterised by a high degree of political interest, **policy uncertainty** is an issue. For example, changes to ECO, announced in late 2013, were challenged in part because of the uncertainty they caused for businesses[22]. Policy uncertainty may be of particular concern for district heat, because of the high sunk costs and the potential for Government incentives for alternative heating systems (e.g. heat pumps) to change the business case for district heat schemes.

2.3 Consumers' relationship with the heating market

For low carbon heating interventions to be taken up, they must be seen as a better choice for the consumer than the alternative options. How consumers think (or do not think) about low-carbon heating interventions is therefore crucial. Of course consumers must also be able to pay for the interventions, so their ability to access funding is also important.

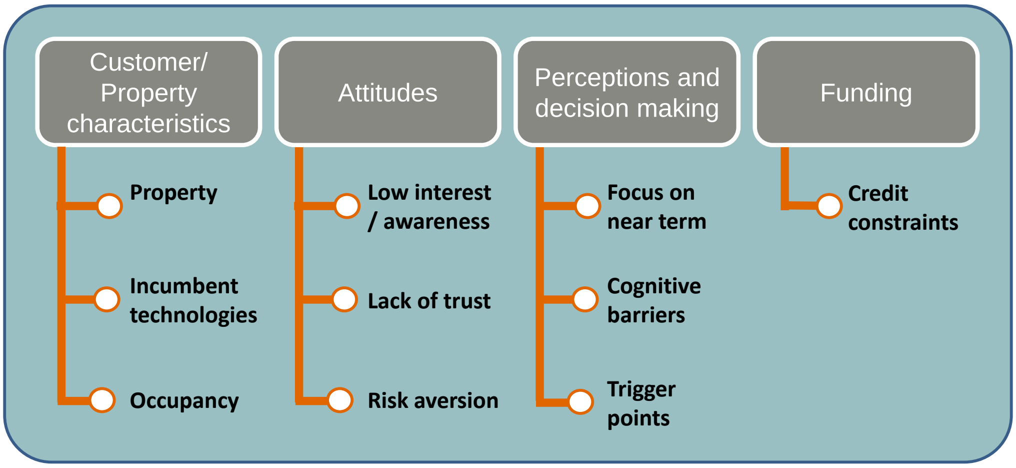
19 There were 2,402 new domestic renewable installations accredited under the RHI in this period. 37% of accredited installations (both legacy and new) were air source heat pumps. Ofgem (2014), *Domestic Renewable Heat Incentive Quarterly Report Update*

20 DECC research suggests that the main triggers for installation of air source heat pumps under the RHI are: needed to replace heating system (43%), upgrading/refurbishing a home (24%), Could get grant or funding (27%), building a new home (17%). DECC (2014), *Evaluation of the Domestic Renewable Heat Incentive: Interim Report from Waves 1–4 of the domestic RHI census of accredited applicants*

21 DECC (2013) *The Future of Heating: Meeting the challenge*

22 For example, National Insulation Association: http://www.nia-uk.org/media-and-information/index.php?mact=News,cntnt01,detail,0&cntnt01articleid=305&cntnt01returnid=16

Figure 7. Consumers' relationship to the heating market



Source: Frontier Economics

Heating requirements will vary, depending on the building **characteristics**, such as property size and type, the incumbent technologies, and the existing level of insulation. We have used BMET to analyse the importance of some of these factors on the cost-effectiveness of interventions. This analysis shows the critical importance of property-related characteristics, and how these can interact between technologies to create barriers to uptake. For example, without policy support, heat pumps are only ever cost-effective for groups with particularly inefficient incumbent heating technologies (such as oil boilers). Further, the reliance of heat pumps upon adequate insulation can act as a barrier to uptake for households with solid walls, even if the incumbent heating technology is inefficient.

Attitudes are important. At the very basic level, *consumers may not be interested* enough in heating systems to proactively spend the time considering a change to a new technology. For example, DECC research found that most consumers who had not replaced a heating system to date, had never considered doing so[23]. Evidence from how heating systems are marketed suggests that consumers see them as functional rather than aspirational items[24]. This sets heating systems

23 DECC (2013) *Homeowners' Willingness to Take up More Efficient Heating Systems*

24 For example, kitchens are marketed using phrases such as "buy the kitchen of your dreams, " or "be inspired. This is in contrast to boiler marketing which tends to focus on finance, safety and efficiency. See for example: http://www.sainsburysenergy.com/products-and-services/boilers/new-boiler-fixed-price-quote.html, http://www.swaleheating.com/new-boiler-installation.aspx, http://www.markgroup.co.uk/homeowners/heating/boilers and http://www.ikea.com/gb/en/catalog/categories/departments/kitchen/, http://www.magnet.co.uk/, http://www.wickes.co.uk/Products/Kitchens/c/1000916).

apart from other major items of household expenditure such as kitchens and cars. *Low awareness* of low-carbon heating systems also poses a barrier. Again, DECC research found 68% of people were unaware of air source heat pumps and 69% had not heard of district heat[25]. Related to awareness, a lack of social norms around low carbon heating interventions may also limit their uptake, with consumers having more confidence in technologies with which they are familiar[26].

Consumers' perceptions will also be affected by *lack of trust*. Trust in energy companies has been low in recent years, with only around half of the population trusting these companies to give them a fair deal[27]. Relationships with installers are also sometimes characterised by low levels of trust,[28] though they can also be important sources of advice on new heating systems[29]. Taken together, this evidence implies a need to improve trust in low carbon heating technologies and the competence of installers.

Consumers also tend to be *risk averse* in their relationship to the heating market. For example, it has been estimated that 36% of households have boiler insurance,[30] while the wider home emergency insurance market has grown significantly, from 4.5m contracts in 2004 to 13.9m in 2012[31]. This demonstrates that consumers can be willing to pay a premium for peace of mind. Perceived risk will affect decisions in different ways[32]. For example a consumer whose boiler has just broken and is deciding whether to purchase a heat pump may weigh up uncertainty very differently to a consumer about to build a house.

Consumer **perception and decision making processes** may also result in outcomes that are not optimal. *A focus on near term costs and benefits,* combined with high upfront costs, can mean consumers systematically underestimate the net

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25 For DECC (2013) *Homeowners' Willingness to Take up More Efficient Heating Systems*

26 For example, research for DECC found that gas condensing boilers were perceived most positively (80% of participants had positive perceptions, compared to 34% for heat networks and 28% for air source heat pumps), and reasons for this included their familiarity and that they were trusted.

27 DECC (2014), *Public attitudes tracking survey: wave 11*

28 Consumer Focus (2012), *What's in it for me? Using the benefits of energy efficiency to overcome the barriers*

29 DECC (2013) *Homeowners' Willingness to Take up More Efficient Heating Systems*

30 Uswitch survey 2013, http://www.uswitch.com/media-centre/2013/10/boiler-bother-leaves-householders-facing-314-bill/

31 Data Monitor (2012) *UK Home Emergency Insurance 2012: An analysis of the UK home emergency insurance industry*

32 Kahneman, Tversky, Prospect Theory: An Analysis of Decision under Risk, Econometrica (1979), Barberis (2013)

benefits that they would gain from the low-carbon interventions[33]. This is a very prevalent feature of consumer decision making[34], and can be seen in the pensions and mortgages market, among others[35,36].

While sometimes this focus on near term costs and benefits can be seen as a bias, it is also important to accept where it may be rational. Figure 8 shows the projected typical monetary savings from low-carbon interventions compared with house prices in 2020 for different property types. For the majority of property types these savings are very small compared to the overall cost of the property, and therefore are unlikely to affect purchasing decisions. This means that it may be rational for consumers not to invest in these technologies, if they expect to move house during the lifetime of the measure, as they are unlikely to be able to recoup their investments when they sell their properties[37].

33 Very high discount rates are implicitly used in the decision making. Pollitt, Shaorshadze (2011): *The Role of Behavioural Economics in Energy and Climate Policy*

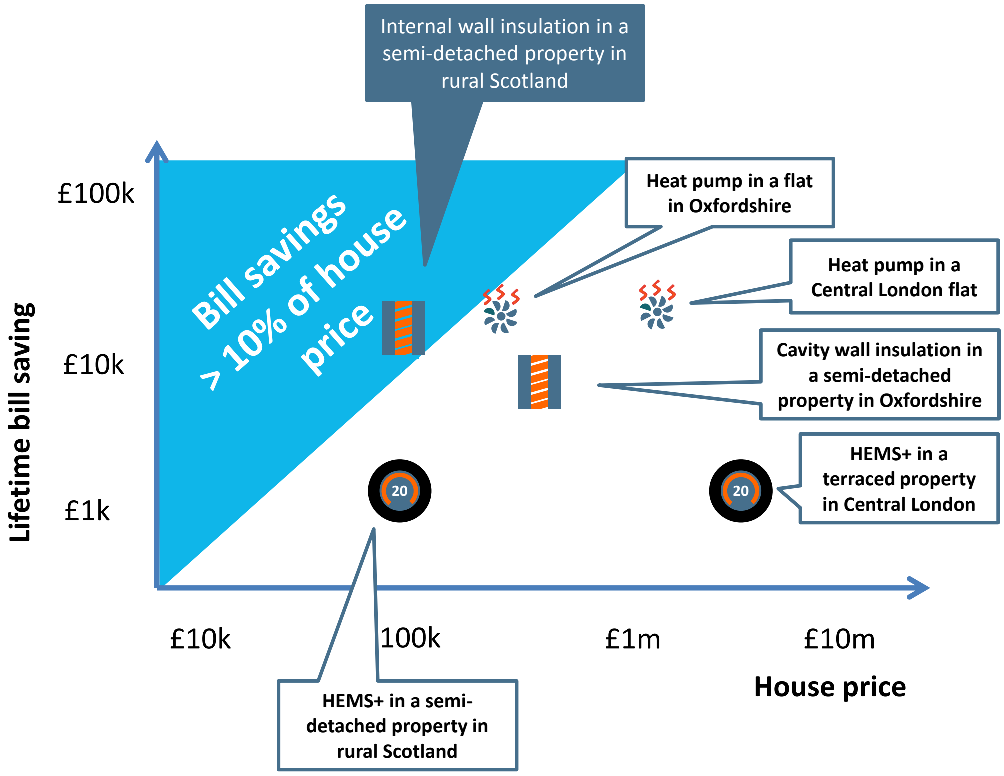
34 For example, Laibson, D., 1997, Golden eggs and hyperbolic discounting, The Quarterly Journal of Economics, May 1997

35 'Present bias' means people under-save for retirement and regret it later. Financial Conduct Authority, 2013, Occasional Paper No. 1, Applying behavioural economics at the Financial Conduct Authority

36 In the mortgage market consumers are often drawn in at teaser rates without looking at the long term rates FPC, the Bank of England (June 2014) 35: Financial Stability Report

37 It is also notable that the energy savings associated with the interventions are only significant in relation to the house price in low price areas, where affordability constraints are most likely to bite.

Figure 8. Lifetime bill savings and house prices in 2020



Source: Frontier Economics

Notes: Lifetime bill savings for installing different interventions in 2020 are calculated for different BRE archetypes (for instance, pre-1919 mid-terrace properties; 1945-1964 low rise, purpose built flat; 1965-1980 detached; pre-1919 semi-detached, 1919-1944 semi-detached). These archetypes have different characteristics in terms of heating requirements and insulation levels. These assumptions were provided to us from ETI. We matched each of these archetypes in a high price and low price location using house price data from Zoopla and adjusting for real price increases in 2020. We assume that there is no policy support for low-carbon technologies (e.g. RHI or a carbon price).

Other *cognitive barriers* also create hurdles. Consumers can make inaccurate assumptions about future bills when making decisions. They may lack data about their energy usage and total energy-related costs[38]. Or they may use current energy bills to calculate investment decisions, without taking into account that energy prices may change[39]. Indeed, inaccurate assumptions of this kind may be one of the reasons why uptake under the Green Deal has been so low: interest

38 For example electricity and gas bills, plus maintenance, plus the annualised costs of purchasing their heating system.

39 Pollitt, Shaorshadze (2011), *The Role of Behavioural Economics in Energy and Climate Policy*

Why has uptake of some low carbon heating interventions been so low?

rates for the loans were perceived to be high, as consumers compared them to current low interest rates without considering how interest rates may rise in the future. In actual fact, analysis has shown Green Deal loans to be competitive with other unsecured loans[40].

The context in which decisions are being made is also important. Where the intervention involves replacing a heating system with a low-carbon alternative, there is a natural *trigger point* associated with the end of the life of the existing system. Indeed, DECC research found that by far the most important determinant of the likelihood of replacing the current heating system was its age,[41,42] and a heating system that was broken or near the end of its life drove the decision of 61% of homeowners to invest in their heating system[43]. Choices made under "distress" are likely to favour the incumbent option, as it will generally be the easiest and quickest one.

Funding is also crucial. Where the overall costs of low-carbon interventions are higher than the incumbent alternatives, *affordability* will be an issue, particularly for those households already in fuel poverty.[44] Not all consumers have *access to credit*.[45] DECC research found that 10% of homeowners had no way of paying for a new heating system[46] and this will be exacerbated by the fact that low-carbon options tend to have higher up-front costs and lower running costs than the conventional alternative. Of course, as our discussion above illustrates, even if they do have the funding or access to credit they may still prefer to spend it on something else.

For context, Figure 9 shows that the upfront costs of heat pumps and solid wall insulation (internal and external) are comparable or higher to other major items of household expenditure, such as kitchens and cars. At the same time, the benefits that consumers perceive from purchasing a heat pump relative to a gas

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40 UKGBC (2014), *Task Group Report on Green Deal Finance*

41 For example, households with systems older than 20 years are five times more likely to consider replacing than the average. DECC (2013) *Homeowners' Willingness to Take up More Efficient Heating Systems*

42 This work found that key triggers to installing a renewable heating technology included the need to replace a heating system (35%), upgrading/refurbishing a home (28 %) or building a new home (16%) The availability of a grant was only the trigger for 27%. DECC (2014) *Evaluation of the Domestic Renewable Heat Incentive: Interim Report from Waves 1–4 of the domestic RHI census of accredited applicants*

43 DECC (2013) *Homeowners' Willingness to Take up More Efficient Heating Systems*

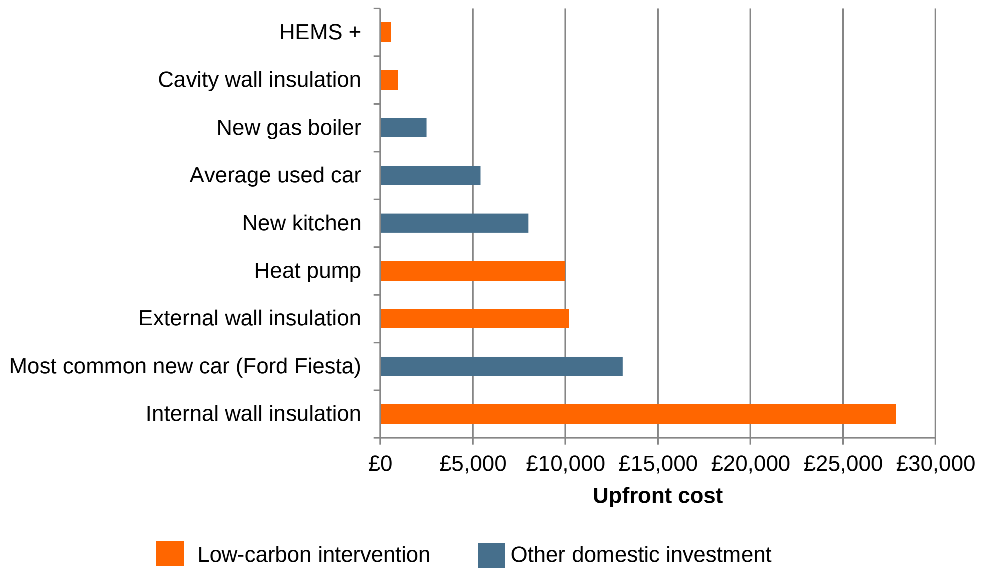
44 10% of households in England are living in fuel poverty in 2012. DECC (2014), *Annual Fuel Poverty Statistics Report 2014*

45 Around 30% of the population do not have access to normal consumer finance (either with no access to finance, or with access only at prohibitively high interest rates). Frontier Economics (2014), *Reducing the cost of capital for household low-carbon investment decisions*

46 DECC (2013) *Homeowners' Willingness to Take up More Efficient Heating Systems*

boiler, or from installing solid wall insulation are likely to be lower than the benefits they perceive from a new car or kitchen[47].

Figure 9. Putting the upfront cost of low-carbon interventions in context



Source: Frontier Economics using data from: ESME version 3.3, Which? [http://www.which.co.uk/home-and-garden/home-improvements/guides/planning-a-kitchen/kitchen-costs/], AM online [http://www.am-online.com/news/2014/6/30/average-used-car-values-hit-5-420-in-may/36326/], Ford [http://www.ford.co.uk/Cars/NewFocus/Brochures-and-Pricelists#primaryTabs], Carbuyer [http://www.carbuyer.co.uk/reviews/recommended/best-selling-cars], Autoexpress [http://www.autoexpress.co.uk/best-cars/85843/best-selling-cars-2014]

Notes: The upfront costs represent current estimates of the upfront costs of different interventions. The costs for the low-carbon interventions represent the costs for a typical consumer based on ETI estimates. The cost of a new gas boiler is taken from ESME version 3.3. The cost of a new kitchen is taken from Which?. The cost of the average used car is taken from Automotive Management. The most common new car was selected based on online sources (Autoexpress and Carbuyer) that ranked Ford Fiesta as the bestselling car in UK in 2014. The cost of the most common new car is taken from Ford's website for the model Zetec. Note that internal wall insulation costs are based on larger (rural) properties, which will increase its cost.

2.4 Characteristics of low-carbon heating interventions

Finally, the characteristics of the low-carbon heating technologies and how they compare to the alternative options for consumers matter. In this work, we are

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47 For example heat pumps may not save consumers money, or provide them with the heating service they desire. Kitchens and cars on the other hand, are often aspirational goods.

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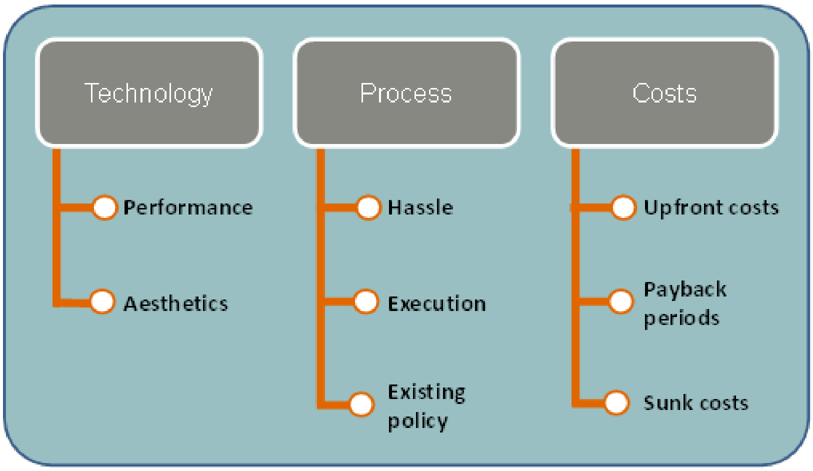
focussing particularly on uptake of heat pumps, district heat, solid wall and cavity wall insulation and HEMS Plus. However our analysis of the attributes of these technologies could be applied to other low-carbon technologies, many of which have similar characteristics.

Figure 10 summarises the characteristics of low-carbon heating interventions which drive barriers to uptake[48].

Figure 10. Intervention characteristics



Source: Frontier Economics

For a low-carbon heating intervention to be taken up, consumers must see it as a better choice. Comparing low-carbon heating interventions with the alternatives therefore provides vital information about the scale of the challenge and likely solutions.

New technologies generally emerge in industries because they provide a better service to consumers. In this case however, the push for low-carbon interventions is based on the fact that they save carbon emissions. Consumers want reliable, responsive heating systems that allow them to get comfortable in their homes[49,50]. The main incumbent technology, the gas boiler, largely provides

48 In the discussion, we focus particularly on how these apply to heat pumps, insulation, HEMS Plus and district heating. However, they also apply to varying degrees to other low-carbon heating interventions, such as solar thermal or biomass boilers.

49 The ETI's representative survey of 2,313 British households found that 85% reported being comfortable as a big factor in how they use their heating at home and this factor featured in the top three most important factors more than any other.

50 DECC (2013), *What people want from their heating controls: a qualitative study*

this service. Not all low-carbon technologies will provide the heating service in the same way. For example, air source heat pumps require more space and are noisier than gas boilers[51]. Low-temperature heat pumps provide a different type of heating by delivering lower levels of heat over longer periods[52]. This means that they will be less responsive than gas boilers.

Insulation on the other hand, will generally improve the comfort experienced by the consumers. However, solid wall insulation can still affect consumer amenity: internal insulation has an impact on space[53] and external insulation can affect how the property looks (either positively or negatively)[54].

Therefore barriers to do with *performance and aesthetics* exist for heat pumps and solid wall insulation. On the other hand, these are not important barriers for cavity wall insulation and HEMS Plus, which would tend to improve heating performance without compromising the property, and for district heat, which can provide a similar service to a gas boiler. Indeed the aesthetics of HEMS systems such as Nest may even have been a selling point.

The **process of installation** also creates barriers. There is likely to be considerable *hassle* as consumers need to find out about options, find an installer, and then put up with the disruption caused by installation, which may involve reorganisation of the home or redecoration. Hassle is exacerbated by the fact that it may be harder to find experienced installers, leading to both perceived and real issues around *execution*[55]. In addition, *existing policy* can create a barrier. For example, because of noise level thresholds, a large number of air source heat pump installations require planning permission[56]. This requirement may not be consistent with widespread roll out of heat pumps, unless technological improvements can reduce the associated noise.

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51 Noise from the external fan and compressor unit of an air source heat pump is a potential source of nuisance both for the occupants of the building served by the heat pump and for their neighbours. Frontier Economics and Element Energy (2013) *Pathways to high penetration of heat pumps*

52 Energy Savings Trust, http://www.energysavingtrust.org.uk/domestic/content/air-source-heat-pumps

53 Energy Savings Trust, http://www.energysavingtrust.org.uk/domestic/content/solid-wall

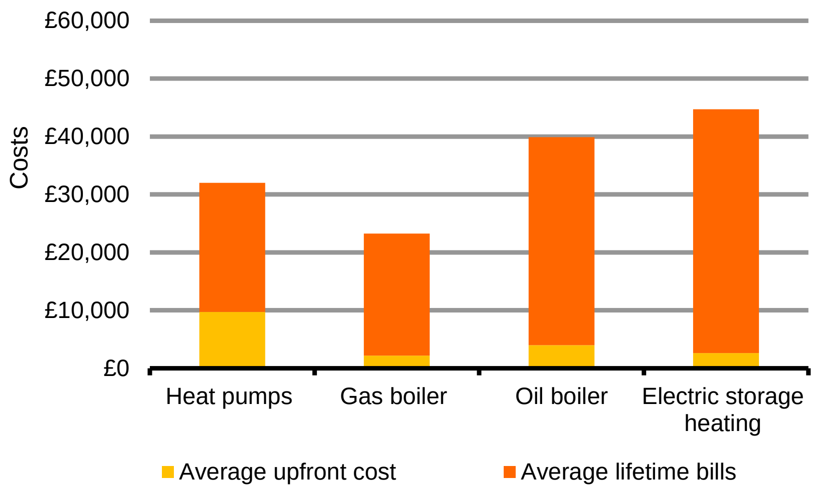
54 Energy Savings Trust, http://www.energysavingtrust.org.uk/domestic/sites/default/files/reports/Solid%20wall%20-%20external%20wall%20insulation.pdf

55 For example in the first phase of the Energy Savings Trust heat pump field trials, many heat pumps were found to have been installed incorrectly. In addition, sometimes installers did not understand proper control requirements. However, it is worth noting that this study was carried out before the Microgeneration Certification Scheme (MCS) was in place. Energy Savings Trust (2010), *Getting warmer: a field trial of heat pumps*

56 Frontier Economics and Element Energy (2013), *Pathways to high penetration of heat pumps*

The **costs** of low-carbon heating technologies also drive barriers. Figure 11 shows the projected lifetime costs of a heat pump installed in 2025, compared to the incumbent alternatives, and the portion of this that is made up of upfront costs. This shows that in 2025 (without a carbon price), heat pumps may be cost-effective relative to oil-fired and electric heating systems, but are unlikely to be cost-effective relative to the most widespread technology, gas boilers (that is, taking into account the difference in upfront and running costs, they will not pay back over the lifetime of the product, even under the conservative assumption of a 3.5% discount rate). This cost disadvantage will be exacerbated where investment in insulation is required first. District heat also has higher lifetime costs than gas boilers[57]. Figure 11 also shows that the *upfront costs* of heat pumps are higher both in absolute terms and as a proportion of the lifetime costs than for the other technologies.

Figure 11. Lifetime costs and upfront costs of measures installed in 2025



Source: Frontier Economics

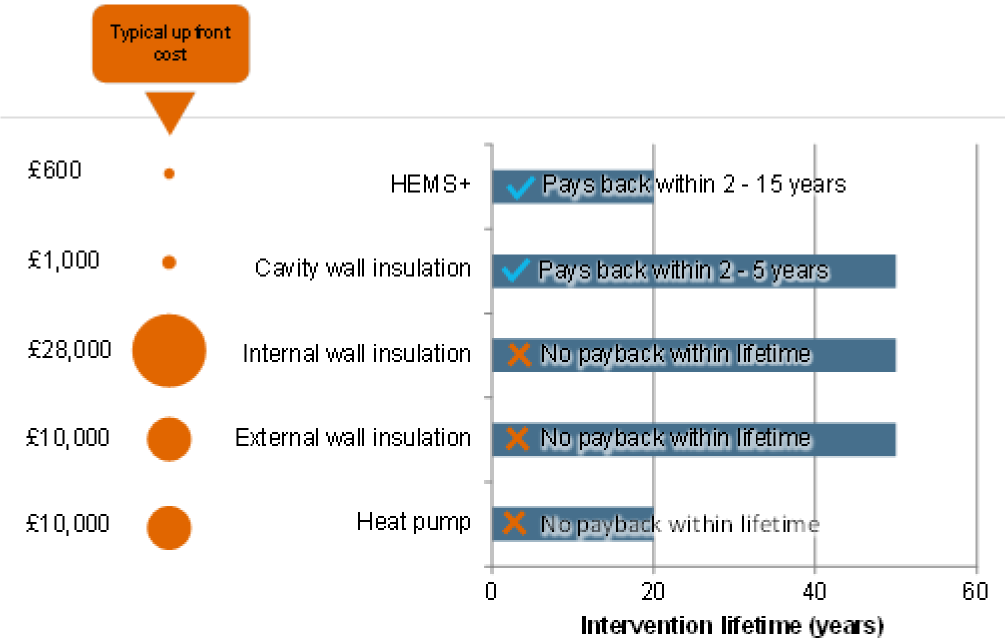
Notes: Average lifetime bills refer to the weighted average of customer's electricity and gas bill in 2025 for different household types (that is, BMET customer groups). Similarly, upfront costs are based on the weighted average cost for different household types in 2025. In this chart we assume no policy support through a carbon tax or RHI. Maintenance costs are not included in these calculations but including these would not significantly change the relativities.

For insulation and HEMS Plus, the consumer will be comparing the purchase decision to the option of doing nothing. The relevant metrics are therefore the upfront costs, and the speed at which the intervention pays itself back through

57 Pöyry and Faber Maunsell (2009), *The potential and costs of district heating networks, A report to the Department of Energy and Climate Change*

lower energy bills. Upfront costs and payback periods (in the absence of a carbon price) are illustrated in Figure 12 for interventions installed in 2025. This shows that without a carbon price signal, the very high upfront costs associated with internal and external solid wall insulation are never paid back, within the expected 50 year lifetime of these measures. On the other hand, cavity wall insulation and HEMS Plus are paid back within 10 years for the majority of consumers.

Figure 12. Upfront costs and payback periods for key in-home technologies in 2025, with no carbon price or other policy support



Source: Frontier Economics

Notes: A high temperature heat pump is assumed. The payback period for heat pumps is calculated relative to gas boilers (that is, the chart shows that the difference between the ongoing costs of heat pumps and gas boilers do not compensate the typical household for the additional upfront costs of the heat pump). Payback period figures are based on averages over typical households in 2025. A minority of households will fall outside these ranges. For example, internal wall insulation does pay back within 50 years for a small proportion of households, while households with electric resistive storage heaters may find that heat pumps pay back. Internal wall insulation costs are based on larger (rural) properties, which will increase its cost. All figures assume no policy support for low-carbon technologies (e.g. RHI or a carbon price). A 3.5% discount rate is used.

The analysis in these figures suggests that even without any other barriers, the costs of heat pumps and solid wall insulation would prevent their take up, where subsidies are not offered[58].

[58] Of course, heat pumps are subsidised under the Renewable Heat Incentive.

Why has uptake of some low carbon heating interventions been so low?

Finally, a large proportion of the costs of interventions **are sunk** – for example around 30% of upfront heat pump costs are to do with installation, (even where the radiator system does not have to be replaced)[59], and 100% of insulation interventions could be considered to sunk. Capital costs also make up 60-70% of the costs of district heating and the majority of these will be sunk in the network[60]. The level of sunk costs are important as it makes it difficult for businesses to offer credit to consumers to install these measures, as to do so is akin to providing an unsecured loan (i.e. businesses cannot reclaim the insulation if the consumer defaults).

2.5 What does this mean for potential solutions?

There are clearly many barriers that need to be overcome to deliver the scale of heat decarbonisation required. As recent policies such as the Green Deal and RHI have shown, addressing only a subset of barriers is unlikely to be sufficient.

Understanding the markets and then recognising how the barriers vary both by the type of consumer making the purchasing decision and by low carbon technology, provides us with a number of insights into how they may be overcome. From this, **we have identified the following five priorities for business model and policy solutions.**

- **Find the added value for consumers, or compensate them.** We cannot ignore the fact that many consumers are happy with their existing heating systems, and that some low-carbon interventions will not make them better off, either financially or in terms of the heating service they receive. While cavity wall insulation and HEMS Plus can improve the heating service and have the potential to save money for consumers, important barriers exist for district heat, solid wall insulation and heat pumps. For district heat, costs need to come down so it can compete with the incumbent gas boilers. For heat pumps and solid wall insulation, it is about reducing costs *and* improving the product features and associated heating service, for example, by tackling issues around performance, aesthetics, risks and hassle associated with installation.

- **Make it easier for consumers to choose low-carbon options**. At the moment, consumers' decisions are stacked against low-carbon interventions. The vast majority of consumers will select familiar heating solutions. Low

59 ETI assumptions.

60 Calculations assuming a 10% discount rate based on cost figures quoted in Pöyry and Faber Maunsell (2009), *The potential and costs of district heating networks, A report to the Department of Energy and Climate Change*

levels of interest and limited awareness of the benefits of alternatives, coupled with decisions made at the time of heating system failure, may significantly slow the transition to low carbon technologies. It is therefore necessary to find ways of making it easier for consumers to choose the low-carbon options for example by engaging with consumers at different times, in different ways, or with a different focus.

- **Manage upfront costs.** The high upfront costs associated with low-carbon interventions result in an important barrier to uptake, when combined with consumers' focus on near term costs and benefits, credit constraints and misaligned incentives between landlords and tenants. Again, this barrier means that even where interventions are in consumers' best interests, they may not take them up.

- **Focus on consumers with the most to gain**. The small size and relative immaturity of the market drives barriers related to cost and lack of familiarity. To overcome these, it makes sense to focus on those consumers with the most to gain– either in terms of financial savings (for example, high energy users), or in terms of health and wellbeing (for example, the fuel poor). Working with the market and not against it can help businesses reach uptake levels that increase viability and reduce policy intervention costs.

- **Ensure natural monopolies deliver for consumers.** Finally, intervention will be required to ensure natural monopolies in district heat can deliver the best possible service for consumers.

3 Business model solutions

Having described the barriers, we now turn to solutions. We start with how business models can help overcome these barriers before looking at where policy may still be needed to achieve the required change.

3.1 What can businesses do best?

Harnessing the initiative of businesses will be crucial to overcoming barriers to uptake. In well-functioning markets, businesses are best placed to understand what it is that consumers want and to deliver on this. Competition between businesses can drive innovation, pushing down costs and improving products and services. Further, allowing businesses to deliver low-carbon heating systems can help maintain consumer choice. We now look at how businesses can lead and deliver in the four of the five key areas identified in the previous section.

- finding the added value for consumers, or compensating them;
- making it easier for consumers to choose the low-carbon options;
- managing upfront costs; and
- focusing on those consumers who have the most to gain first.

We discuss policy's role in ensuring natural monopolies deliver for consumers in Section 4.

3.1.1 Finding the added value for consumers, or compensating them

As set out in Section 2, the costs of district heat, solid wall insulation and heat pumps are higher than the alternatives for most consumers. For heat pumps and solid wall insulation, the performance and aesthetic issues associated with the new technologies creates an important barrier.

What can businesses do about this? Obviously they will look to make **design improvements and cost efficiencies** to make products and services more attractive to consumers.

What we focus on here, is how businesses may be able to bundle various additional elements together with the low carbon technology to make the overall proposition more attractive for consumers. Adding elements to a business model can only help the take-up of low-carbon heating interventions if they are *complementary* to the interventions to a greater extent than to a higher-carbon alternative. In this context, "complementary" means that either the business model element:

- is more cost-effective to provide with the low-carbon intervention than without; or

- adds more value alongside the low-carbon intervention than without.

We used BMET to examine to what extent different business model elements (such as risk management, spreading upfront costs or obtaining services like Demand Side Response (DSR) from consumers) are complementary to the interventions and therefore potentially increase their uptake. Not all consumers value things equally, so these bundles will need to be designed to appeal to different types of consumers.

There were two business model elements in particular that this analysis suggested may improve the proposition provided by heat pumps compared to gas boilers.

- **Managing risk.** For consumers that place a strong value on risk avoidance,[61] a heat pump with a fixed price guarantee may be more attractive than a gas boiler with or without such a guarantee. This is because such a business model may be more suited to a heat pump because:
  - hedging costs may be lower, as it leverages the high upfront cost / low running cost nature of the technology;
  - some elements of risk associated with the unfamiliar technology can be eliminated by businesses – either since they have greater knowledge of the interventions and so have a lower subjective perception of risk, or by contracting with multiple consumers can diversify away risks (such as a heat pump happening to be less efficient in one property); and
  - similarly, while sophisticated systems including predictive monitoring of failure based around HEMS Plus technologies, could equally be introduced alongside gas boilers, they may be more valuable to consumers thinking about investing in new technologies such as heat pumps.
- **Using heat pumps and HEMS Plus to provide DSR services** to entities such as suppliers, DNOs, and National Grid. By sharing the benefits of such contracts with consumers, the value of a heat pump is increased. Again, this business model element is complementary to a heat pump, utilising the way in which a heat pump (and not a gas boiler) is electrically powered and dispatchable.

However, it is far from certain how effective such business models would be. Both the costs and benefits of fixed-bill contracts[62] and the gains from DSR[63] are

61 The high proportion of households with boiler insurance would imply this is a sizeable minority.

62 They will depend on consumer behaviour in the presence of uncertainty and are hard to estimate for a new technology.

currently difficult to quantify, but reasonable estimates would indicate that they are likely to be small in the context of the wider barriers to take-up[64]. Further, these contracts do little to address the barriers to insulation take-up even though this is likely to be a significant problem for many households and is likely to be required prior to installing a heat pump.

Another example, which may be effective but that we have not modelled, is to **focus on compensating benefits that incumbent technologies cannot provide**. In particular for heat pump systems this would be that they can provide air conditioning and dehumidifying services[65]. Consumers are often willing to accept decreases in functionality of a product or increases in its cost, if the compensating benefits are of sufficient value to them. For example, the penetration of underfloor heating, which provides warm floors and a constant level of heat, but does not provide as responsive a service as traditional radiators, has risen significantly in recent years[66].

3.1.2 Disrupting consumers' decision making processes.

In Section 2, we described the way consumers currently think (or do not think) about their heating systems, and how this means that they are more likely to replace existing heating systems with the incumbent option, and delay investing in efficiency improvements. Businesses can help disrupt this situation by engaging with consumers at appropriate trigger points or by offering value propositions that bypass consumers' lack of interest and awareness.

What is notable about trigger points such as breakdown of existing systems, renovation, moving house or a change in life circumstance (such as starting a family or retiring) is that they do not happen very often (Figure 13).

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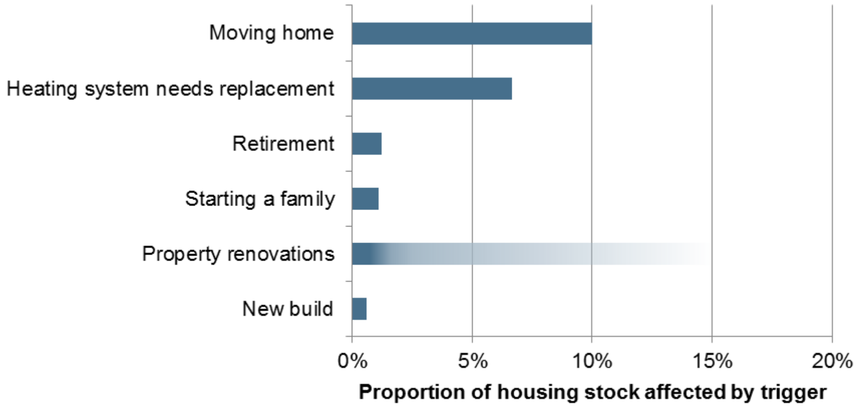
63 Current payments to US customers on the Nest "Rush Hour Rewards" tariff are of the order of £50 per year. We note that the demand for DSR could increase in the future, leading to higher payments – although increased electrification of heat and transport could also increase the supply of DSR, having an offsetting effect.

64 See Annexe 3d for further analysis.

65 DECC, http://energy.gov/energysaver/articles/heat-pump-systems

66 The size of the underfloor heating market is estimated to be £102 million in 2014, up from £87 million in 2010. http://www.amaresearch.co.uk/Underfloor_Heating_Market_14s.html

Figure 13. Frequency of trigger points for pre-emptively replacing a heating system



Source: Annexe 3c bundle ordering and UKERC (2013) *Understanding homeowners and renovation decisions.*

Notes: The figures reflect the analysis carried out in Annexe 3c. For property renovations, the bold area represents the lower bound of the proportion of housing stock affected by the trigger. That is, the bold area represents the c. 1% of the housing stock that was granted 'householder development' planning permission application. This will represent the lower bound as many minor developments do not require planning permissions. According to Tyndall (http://tyndall.ac.uk/sites/default/files/verd_summary_report_oct13.pdf), 15% of the people it surveyed were in the middle of renovations. Even if renovations lasted an entire year, that would be consistent with 15% of the housing stock being renovated every year.

Given this, one option for businesses would be to target consumers *before* the trigger event and sign them up to outcomes contracts that involve the replacement of their heating system with a low-carbon option at the appropriate point in time. This may be particularly important for when the heating system breaks down, at which point it would be helpful to have signed consumers up to an energy only contract first. There are examples of this in Denmark: one Danish district heating company offers connection within five days for new customers where an existing heat network is in place, and, where a new network is being built, paying for spare parts for the customer's existing gas or oil heating until connection can take place[67].

[67] Information provided by the ETI.

Value propositions that **rent the heating system** to consumers, and include maintenance can reduce hassle, and bypass awareness and attention issues. These are already offered in the boiler market[68] and via district heat systems.

Going further, indirect approaches, such as lifestyle contracts that focus on **outcomes aligned to customer needs, for a fixed price** may be particularly powerful. While people feel disengaged when thinking about the technologies that provide warmth, (particularly new and unfamiliar technologies),[69] they do think about the comfort and cost associated with their use of heating. Businesses models could offer a heating outcome (in terms of guaranteed levels of warmth by room, for example). The business could then deliver that outcome in the most efficient way possible**, managing hassle, performance and risk** for the consumer.

The **development of brands** can also be a powerful way of making it easier for consumers to choose low-carbon options. Although trust in energy companies has been low in recent years, some of the increase in mistrust in energy companies is likely to have come from the increased regulatory, political and media interest that has followed rising energy prices. While rigorous challenge of the energy sector is both valid and to be expected, consideration should be given to how this is delivered. Unnecessarily undermining energy sector brands will be counter-productive if it makes them less able to overcome the barriers to a low carbon future.

Partnering with companies with stronger brands may help to introduce new measures into people's homes[70]. For example, the link between Nest and Google has been made much of in the press. There are also a number of premium brands (such as Mercedes) that are affiliating with products in the "smart homes" space. However, given that businesses are extremely cautious about brand damage, the additional barriers around some of the other low carbon heating solutions may mean that partners with strong brands are not willing to be associated with them, at least in the transition.

3.1.3 Managing upfront costs

The low-carbon technologies that we have considered have a higher capital cost than the alternative: heat pumps cost more than gas boilers, while insulation

68 For example, Hassle Free Boilers offer 12 year contracts for boilers, including maintenance in return for a flat monthly fee. Customers moving house can buy themselves out of the contract. See https://www.hasslefreeboilers.com

69 DECC (2013), *Homeowners' Willingness to Take up More Efficient Heating Systems*

70 In 2014, Brand Asset Valuator, a consultancy, found that the AA, the Post Office and Boots are the UK's most trusted brands. The next most trusted brands were: Google, Johnson's Baby, Fairy, RAC, Marks & Spencer, Dulux, and Kellogg's Corn Flakes.

retrofits and HEMS Plus are capital expenditures that a consumer could avoid altogether. District heat is also associated with high setup costs. We have seen that high upfront costs mean that even where interventions are cost-effective for consumers, they may not take them up.

As a result, **business models which spread payments** are also likely to increase the attractiveness and affordability of low-carbon interventions relative to the alternatives. They can do this if their cost of capital is lower than consumers' discount rates (see Box 3).

Box 3: Managing upfront costs: Example

Consider, for example, an intervention that initially costs £5000, and then delivers a bill saving of £1000 for each of the following ten years. This would have a negative net present value (NPV) of -£810 for a consumer with a discount rate of 20%, but a positive NPV of £1140 for a business with a discount rate of 10%.

If the business installed the intervention and kept the resulting bill savings, they would be able to profitably pay the consumer £100 in each year. This would yield a positive net present value for both the business (£710) and the consumer (£520).

In this situation, both business and consumer can be even better off if the business model provider front-loads the benefits.

However, where a lot of the costs of these technologies are sunk and payback periods are long, there will be a limit to firms' ability to spread costs in this way. For example, the payback period for some insulation interventions is as long as 50 years, while the total cost of the measure is sunk. This means that a business model which spread the costs would be akin to providing an unsecured loan. Since over long periods default risks become very high, it is generally not viable for the market to provide them. Indeed, the maximum length of an unsecured loan is typically no more than seven years, although there are examples of businesses managing to secure the right mix of risk and return for loans up to 12 years when secured against a boiler and bundled with an insurance product[71].

3.1.5 Focusing on consumers with the most to gain first

It makes sense for businesses to grow the market by focussing on those consumers most likely to take up interventions first. As described in Section 2, consumers who have the most to gain financially from low-carbon heating

[71] Research for the CCC found no unsecured loans available in the market for terms longer than 7 years. In the boiler market (where the loan can be partially secured against the boiler, 10-12 year contracts are available. Frontier Economics (2014), *Reducing the cost of capital for household low-carbon investment decisions*. See for example Hassle Free Boilers (12 years) and British Gas (up to 10 years): http://www.britishgas.co.uk/products-and-services/boilers-and-central-heating/new-boilers/boiler-costs-and-ways-to-pay.html#payment

interventions tend to be those with the highest heating demand and the most inefficient systems (for example, oil-fired systems). Some businesses offering low-carbon interventions are already explicitly targeting these consumers[72].

How do businesses find the consumers with the most to gain? The early roll out of HEMS Plus technology, which can provide detailed information on consumers' heating patterns and behaviours, may help. Segmenting consumers may also help: research by Consumer Focus has shown that segmenting consumers, based on their priorities (e.g. comfort, home improvement) can allow effective targeting of energy efficiency measures[73].

Once the market starts to develop, businesses may be able to use peer demonstration as an effective way of increasing the familiarity of these measures and raising trust to grow the market further to include other consumers for whom the interventions can deliver benefits[74]. However, in some cases, those who have the most to gain from these interventions will be fuel poor. Affordability constraints will generally prevent businesses from meeting the needs of this group, absent additional policy intervention.

3.2 Policy implications

It is clear that businesses can play a very important role in driving the roll out of low-carbon heating interventions. However, the discussion above shows that there are also clear gaps for policy to fill.

- First, businesses cannot internalise the carbon cost. That is, carbon emissions are currently not priced, and therefore businesses will not receive a return for abating them. Where this causes the lifetime costs of low-carbon interventions to be above the cost of the incumbent alternatives, policy intervention will be required to gain uptake.

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72 For example, Flow Energy are targeting their combined heat and power boiler at customers that already spend more than £2,000 a year on gas and electricity. http://www.theguardian.com/money/2015/jan/17/new-boiler-generates-electricity

73 For example, the Newark and Sherwood WarmStreets project examined in this report had fully adopted a segmented approach and had seen response improve as a result. Consumer Focus (2012), *What's in it for me? Using the benefits of energy efficiency to overcome the barriers*

74 For example, research for DECC found that gas condensing boilers were perceived most positively (80% of participants had positive perceptions, compared to 34% for heat networks and 28% for air source heat pumps), and reasons for this included their familiarity and that they were trusted. Positive perceptions of gas condensing boilers appear to be related to social proof: "They often drew either on their own experiences or those of friends and family – being reassured that it would be reliable and effective." DECC (2013) *Homeowners' Willingness to Take up More Efficient Heating Systems*

- Second, the combination of sunk costs and long payback periods means businesses will not always be able to manage upfront costs for consumers. In these cases, policy may be required to provide upfront incentives, to reduce payback periods and to overcome credit constraints. These incentives would have to be paid for by the tax payer (or through energy bills). We discuss the distributional consequences of this further in the next section.

- Third, clearly businesses need to focus on those who are able to pay for the services they offer. However, whether households can afford to adequately heat their homes affects their health and wellbeing[75]. This means there are equity considerations in the heating sector with a role for policy to protect vulnerable or fuel poor consumers.

- Fourth, policy is required to set a framework within which district heat natural monopolies can deliver the best outcomes for consumers.

Is policy intervention required to support all the interventions? The analysis in Section 2 showed that the barriers to the uptake of HEMs Plus and cavity wall insulation are less acute than the barriers for solid wall insulation, heat pumps and district heat. In particular HEMS Plus and cavity wall insulation are cost-effective, even without a carbon price, and the associated payback periods are less than 10 years for the majority of consumers. Therefore, although there are still uptake barriers, businesses should be able to overcome these. While internalising the carbon price for these measures would be ideal in theory, in practice, given limited Government resources, this may not be a priority. However, though there are fewer barriers to uptake for HEMS Plus, policy intervention may still be required. In particular, the ETI consider this will be important to ensure innovation supports the development of systems that are compatible with low-carbon heating systems and highlight opportunities for consumers to improve the insulation in their homes.

Therefore in the policy section below we focus on solid wall insulation, heat pumps and district heat because they:

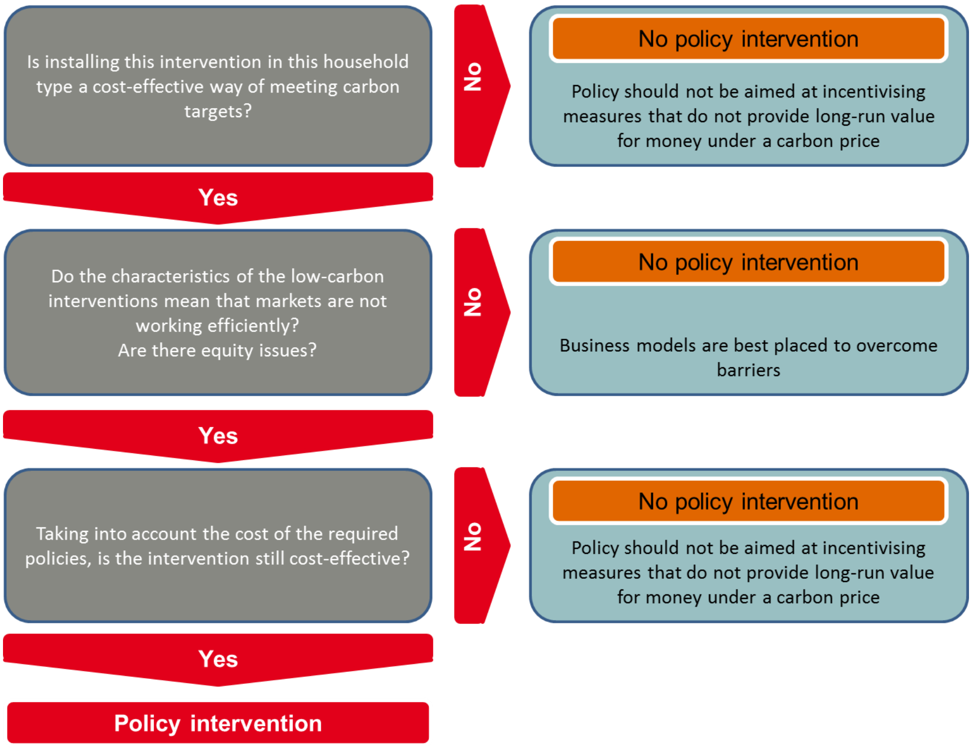
  - are not cost effective, without the application of a subsidy in line with the carbon price;
  - even with a carbon price, they have long payback periods, over which unsecured loans may not be possible; and
  - in the case of district heat, there is a natural monopoly.

75 See for example the discussion in Hills (2012) *Getting the measure of fuel poverty: Final Report of the Fuel Poverty Review John Hills*

4 Some potential policy options

Our starting point for the policy analysis is to focus only on where uptake will bring net benefits to society. In practice, this means policy should only aim to drive interventions that are cost-effective under a carbon price, where this carbon price represents the marginal cost of abatement associated with the 2050 carbon targets (Figure 14)[76].

Figure 14. Determining the role for policy



There are three issues to be borne in mind when considering policy solutions.

- **Local and national policy.** We assume that the policy framework will be set at a national level and will be implemented through legislation and regulation, while local initiatives (such as Local Area Energy Strategic Plans) could help deliver this framework. It is critical that incentives (financial or other) applied at

76 DECC has estimated a carbon price that is consistent with the level of marginal abatement costs required to reach the targets that the UK has adopted The carbon price consistent with meeting targets rises to £67/tonne in 2020 and £78/tonne in 2030. Consistent with DECC advice, we quote non-traded prices here, as applicable to gas use in the domestic sector. DECC, https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

a national scale are aligned with local efforts to roll out low-carbon interventions, and vice versa. This topic is complex with a number of key stakeholders to consider. The ETI has identified the following questions as important:

- how to identify local area optimal solutions?
- how best to provide consumer choice while trying to ensure adoption of the most effective interventions within each local area?
- how to ensure the policy framework is seen by consumers as fair and equitable across UK?

- **Funding.** Some of the ideas for consideration that we describe below involve subsidising the consumer market. This has distributional consequences as these subsidies must be paid for, either by energy consumers through their energy bill (as is the case for most measures in the UK), or by the general taxpayer (as is common in Europe)[77]. Funding through energy bills is consistent with the polluter pays principle and provides an added incentive for efficiency. However, it will generally be less regressive to fund schemes through general taxation[78]. If subsidies are to be funded through energy bills, attaching the costs to both gas and electricity bills (as is done for ECO) would be preferable to focussing the costs on electricity bills only.
- **Misaligned incentives.** Specific policies may need to be put in place to target private landlords. Even high subsidies may not be sufficient to incentivise landlords to take up low-carbon heating interventions, given misaligned incentives. This issue is being partly tackled with proposed new minimum energy efficiency standards for rental properties. Under these proposals, from April 2018, landlords who are re-letting a property must improve its EPC rating to a minimum of E[79]. While we considered additional policies to target private landlords (see Annexe 2a), the cost benefit analysis presented below focusses on the owner-occupier sector.
- **Policy to drive innovation.** There may be a need for specific policy to drive innovation. For example, in the absence of policy intervention, firms may underinvest in innovation since knowledge spillovers mean they cannot

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77 CEER (2015), *Status Review of Renewable and Energy Efficiency Support Schemes*

78 The impact of internalising the carbon price on bills could be large. For example, a carbon tax on gas would add £200 to a typical gas bill in 2020.

79 Landlords would only be required to undertake these improvements where they can do so without incurring net costs – for example by taking out a Green Deal loan, using ECO funding or obtaining grants. DECC (2014), *Private Rented Sector Energy Efficiency Regulations (Domestic) (England and Wales)*

capture all the benefits of their innovation investments. In addition, if future policy around meeting carbon targets is not stable and credible, firms may not see a benefit in investing in technologies suitable for a low-carbon energy system. While there are multiple UK funding sources for low-carbon innovation, availability of funds can be volatile. There are also limited commitments of support beyond 2015 which could, according to some companies, be a hindrance to long-term investment planning[80]. Therefore further action is likely to be needed in this area.

Box 4 describes the policy assessment that we have undertaken.

80 NAO (2013), *Public funding for innovation in low carbon technologies in the UK*

Box 4 Policy assessment

We analysed policies in two stages, starting with the long list of policies, shown in Figure 15. This includes a combination of policies that have been suggested or trialled, and policy measures that have yet to be put forward.

Figure 15. Long list of policies

Externalities, lock-in, upfront costs and interest	• Stamp duty rebate • Council tax rebate • Grants to consumers • Grants to district heating developers • Variable council tax • Energy efficiency feed in tariff (FIT) • Economy-wide carbon price • Technology tax • Providing information on consumers in a community that have switched to low-carbon heating • Requirement that calculation of future heating bills is factored into mortgage decisions • Minimum EPC at sale • Mandating energy efficiency improvements
Misaligned incentives	• Including information on energy bills in headline rental prices • Variable tax on landlords
Coordination, natural monopolies and lock-in	• Regulatory framework that shares district heating risks • Consumer protection for district heat • Mandating district heating connection • Standardised district heat development contracts • Building skills and capabilities
Upfront costs and affordability	• Lower interest on Green Deal loans • Reducing the term of Green Deal loans

Source: Frontier Economics

We first qualitatively assessed whether policies may be effective, using the criteria in Figure 16.

This process allowed us to identify policies that may be effective. The next st was to take the potentially effective policies to a more detailed analysis. The policies were:

- Stamp duty rebate;
- Council tax rebate;
- Grants to consumers;

Some potential policy options

- Grants to district heat providers;
- Consumer protection for district heat; and
- Regulatory framework that shares district heat risks.

The more detailed analysis of these policies is presented in the next sections.

Figure 16. Qualitative assessment criteria for policy analysis

	No.	Criteria	Description
Impact	1	**Effectiveness in addressing barriers**	Which barriers does the policy address? Would businesses overcome the barriers the policy is addressing anyway? What's the effect on uptake? Are there interactions with other barriers?
	2	**Cost**	How costly is the intervention to government/ consumers/ businesses and others? What is the cost over time (e.g. will a policy drive down costs of an intervention in future?)?
	3	**Distributional impacts**	What are the distributional impacts of the policy? What are the impacts on consumer bills and how do these differ by consumer income?
	4	**Impact on government, supplier, investor and consumer confidence**	What impact is the policy expected to have on confidence in the developing UK energy market?
Risk & uncertainty	5	**Risks/unintended consequences**	What unintended consequences could the policy have? How could the positioning of the policy affect its impact?
	6	**Evidence base**	Is there evidence that the policy works? E.g. are there international or past precedents, and has the policy been trialled?
	7	**Flexibility**	Is the policy robust to different scenarios for decarbonisation? How flexible is it in the face of uncertainty over future conditions?
Implementation	8	**Transition**	What transition is required to implement this policy? E.g. how long would it take to implement, what are the transition costs, does it require replacement of other policies?
	9	**Political acceptability and communication to consumers**	Does the policy create new winners and losers? Are those losing out likely to oppose the policy? Are there risks around a negative public reaction? How easily could the policy be communicated to consumers?
	10	**Compatibility**	Is the policy compatible with other policies already in place? How does the policy interact with other policies (e.g. are potential policies complements or substitutes?)?

Source: Frontier Economics

4.2 Potential policy options to incentivise solid wall insulation and heat pumps

In this section, we estimate the level of financial payment required to incentivise solid wall insulation and heat pumps. We first look at likely uptake under a financial incentive set at a level that is consistent with DECC's projected carbon price (which represents the marginal cost of abatement of meeting the 2050 carbon targets)[81]. We find that payback periods for consumer investments in heat pumps and internal and external solid wall insulation would still be over 10 years if the financial incentive was set at this level. We then estimate how high a financial incentive would need to be to reduce the payback periods to below 10 years, and to achieve take up of 2.5m heat pumps and 1m solid wall installations

81 DECC (2014), *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal*

(which are the levels required to be consistent with being on a path to meeting 2050 targets)[82].

4.2.1 Incentives in line with the carbon price

At present, consumers do not gain any financial benefit from saving carbon emissions. To incentivise the cost-effective uptake of solid wall insulation (internal and external) and heat pumps, policy needs to be put in place which delivers a financial benefit for consumers in return for the carbon savings associated with these interventions. As set out in Figure 14, this financial benefit should in theory be set at a level that is consistent with the carbon price, where the carbon price represents the marginal cost of abatement to meet 2050 targets.

To deliver this price signal in a way that increases uptake, the incentive should be applied so it manages upfront costs, has limited adverse distributional impacts, doesn't create policy risk, and focusses on trigger points. We have considered a range of options (Box 5).

[82] CCC (2014), *Meeting Carbon Budgets: 2014 Progress Report to Parliament.,* Frontier Economics and Element Energy (2013), *Pathways to high penetration of heat pumps*

Some potential policy options

Box 5: Incentives in line with the carbon price

There is an important unpriced externality in the market for low-carbon heat: there is no carbon price on domestic gas use.

This unpriced externality is a market failure: without a price on carbon, consumers and businesses will not factor carbon emissions into their decisions. In practical terms, this means that some interventions that have net benefits to society will not be taken up.

DECC has estimated a carbon price that is consistent with the level of marginal abatement costs required to reach the targets that the UK has adopted. The carbon price consistent with meeting targets rises to £67/tonne in 2020 and £78/tonne in 2030[83].

We looked at a wide range of options for providing an incentive in line with the carbon price, including measures proposed by the Green Building Council.[84] The detailed analysis of these options is presented in Annexe 2a.

We considered two tax options: **a carbon tax on domestic gas use** and a **technology tax** targeted at high carbon heating technologies, and payable on the purchase of a new heating system.

We also considered five subsidy options: a **one-off rebate on stamp duty,** payable when low-carbon heating interventions are installed in the home up to twelve months after purchase; a **council tax rebate** for households on the production of receipts for the installation of energy efficiency measures; **variable council tax**, where rates would be based on the energy efficiency of the home; **grants** or upfront payments for the installation of low-carbon interventions; and an **energy efficiency feed in tariff** (FiT), which would reward households with payments for installing measures which reduce their energy consumption.

We first assessed each of these measures against the criteria, described above in Figure 16.

Stamp duty rebates, council tax rebates and grants warranted further analysis and are discussed below.

The carbon tax on gas use, the technology tax, the variable council tax and the energy efficiency FiT did not perform well against our assessment criteria.

- These measures do not address barriers associated with the high upfront costs of the low-carbon heating interventions. This means they will fail to overcome consumers' focus on near term costs and benefits.
- The carbon tax and the variable council tax measure, may also put more policy risk on to consumers. It is very difficult to apply a tax in a way that gives long

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83 DECC (2014), *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal.* Consistent with DECC advice, we quote non-traded prices here

84 Green Building Council (2103), *Retrofit Incentives: Boosting the take-up of energy efficiency measures in domestic properties*

term certainty to consumers over the future gains associated with avoiding carbon emissions.[85]

- There may also be an impact on equity. Applying a carbon price would increase annual gas bills in 2020 by £200 for medium gas users and £278 for high gas users.
- The technology tax measure has the additional downside of potential unintended consequences associated with households holding on to older, inefficient technologies.

Of the long list of options considered, three merited further quantitative analysis: a stamp duty rebate, a council tax rebate and upfront grants.

- **Stamp duty rebate**. This policy would offer a one-off rebate on stamp duty to new homeowners, payable when measures are installed in the home. Buyers could claim this either at the point of sale or in the first twelve months after it. The discount could be calculated using the Standard Assessment Procedure (SAP)[86] or EPC framework, and could be based on the value of the carbon savings associated with each measure. In some cases, the rebate will be greater than the stamp duty the new homeowner would have paid. In these cases, new home owners would receive a net payment under this policy. A stamp duty rebate could be an effective way of driving uptake of energy efficiency measures, covering their upfront costs at a key trigger point for renovations, and attracting consumers' interest and attention by tagging the incentive to a well-known tax[87].
- **Council tax rebate.** The policy is effectively a type of one-off cash-back scheme for households which install measures. Households would qualify based on providing receipts for the improvement measures. Accreditation for installers undertaking these interventions and auditing of selected properties could help ensure high standards are maintained. As with the stamp duty policy, where the rebate is greater than the council tax that would have been paid, homeowners will receive a net payment. Again, this tackles

85 There is always a material risk that subsequent governments will change taxes as priorities change This type of policy risk was a key driver for the Government's reliance on contractual mechanisms to incentivise low-carbon generation in the recent Electricity Market Reform package of measures.

86 https://www.gov.uk/standard-assessment-procedure

87 Government has considered this policy before: in 2013, DECC announced that they would introduce a stamp duty rebate of up to £4,000 for homebuyers installing energy efficiency measures, including those that don't have to pay stamp duty. The rebate was also set to be limited to three years. It is not clear what has happened to this plan. DECC, 2013, Press release, Government action to help hardworking people with energy bills, available at: https://www.gov.uk/government/news/govt-action-to-help-hardworking-people-with-energy-bills.

upfront cost barriers, and attracts consumers' attention through the link to a well-known tax. Given local authority funding, additional central Government funding is likely to be required. Some council tax payers may see council tax as a means for paying for local services, and could be unhappy with its use to fund low-carbon interventions. On the other hand, local authorities may want to be seen as leaders in this area.

- **Grants.** Grants would provide a similar incentive to council tax rebates and stamp duty, though this policy differs in that it is not tagged to an existing policy structure. However, experience from existing grants such as the Green Deal Home Improvement Fund (GDHIF), suggest that they may be effective even without this.

For each of the policies considered, the cost of incentivising each intervention is set at a level that internalises the *average* value of carbon savings associated with that intervention, where the carbon savings are valued using DECC's carbon projections. Therefore the level of the financial incentive offered for each intervention is the same under each policy (Table 1).

Table 1. Value of the financial incentive

	Heat pumps	Solid wall insulation (internal and external)
Value of the rebate in 2020	£2k	£4k[88]

Source: Frontier Economics

The policies differ only in terms of *how* the financial incentive is offered. Offering a financial incentive through a stamp duty rebate, means that only 3% of households are likely to take it up per year (around 0.7m households buy a home each year in the UK)[89]. On the other hand, grants and council tax rebates could be taken up by most households in the private rented or owner occupier

88 This figure differs from the figure included in Table 3 for two reasons: First, Table 1 is a weighted average of carbon savings across all customer groups that are eligible to take up an intervention. In contrast, Table 3 reflects the weighted average carbon saving of only the groups that are required to meet 1m insulation and 2.5m heat pumps. Second, Table 3 reflects carbon savings for only external wall insulation while Table 1 reflects both external and internal wall insulation.

89 3% of households buy a home each year, according to data from the English Housing Survey 2012-13, which collects data from households in England. To calculate the number of households that will buy a home each year in the whole UK, we have assumed that the 3% will also hold when looking at the whole UK housing stock. The number of UK households is 26m according to ONS data.

sector in any year. In practice however, because of misaligned incentives between landlords and tenants, they are likely to only apply to the 65% of households that are owner occupiers (with council tax rebates only being applicable to those 61% of households that are both homeowners and pay council tax) [90].

Results of the analysis of these policies

The results of our quantitative analysis are shown in Table 2. This shows that the application of each of these policies would mean that heat pumps would become cost-effective and affordable for just 0.3-0.4m households, while for solid wall insulation the numbers would be just 0.6-0.9m households (all taking up internal insulation)[91]. If consumers responded to the incentive, this would create net benefits for society (due to the carbon and fuel saving), but would come at a cost to Government of up to £4bn to 2030.

90 We consider that 94% of households are council chargeable, excluding households that are exempt from council tax or demolished (i.e. students), empty dwellings, second homes, and properties that are disregarded for council tax purposes. DCLG (2014), *CT Return*

91 The total additional customers that are modelled as taking up any intervention (either heat pumps or solid wall insulation) will also be either 0.6m or 0.9m. This is because all of the customers that are modelled as taking up heat pumps will take up solid wall insulation (internal) as well.

Table 2. Results of the cost benefit analysis of subsidies set in line with DECC's carbon price (2015-2030)[92]

	Stamp duty rebate	Council tax rebate	Consumer grants
Proportion of all UK households that could take up rebate in any one year [93]	Limited to when homeowners move house – around 3% of households are estimated to buy property each year[94]	61%	65%
Number of households for whom heat pumps are cost-effective and affordable to 2030 under the policy	0.3m	0.4m	0.4m
Number of household for whom solid wall insulation is now cost-effective and affordable to 2030 under the policy[95]	0.6m	0.9m	0.9m
Payback period for measures to consumers	>10 years	>10 years	>10 years

92 The cost-benefit analysis was carried out for uptake that occurs over the period 2015-2030, but assesses the costs and benefits over the lifetime of the measures associated with that uptake (that is, the analysis is not truncated at 2030).

93 As explained in Annexe 2a, these policies would only function for owner-occupied households. Additionally, the council tax policy would only target the 94% of such households paying council tax.

94 English Housing Survey 2012-13

95 Under a subsidy in line with the carbon price, internal solid wall insulation becomes cost-effective for these consumers. Within BMET, internal wall insulation has higher upfront costs than external wall insulation, but often has higher carbon benefits over the long run (since it is assumed to be installed in off gas-grid houses reliant on inefficient heating technologies). Table 3 focusses on a short (ten-year) period, during which the subsidies required for external wall insulation to pay back are lower than those required to install internal wall insulation. We therefore present figures for external wall insulation. This is in contrast to the results in Table 2, which take into account costs and benefits over lifetime of the interventions. When looking over the lifetime of the intervention, internal wall insulation can offer greater benefits for off-grid houses, and so the various policies listed above lead to the take-up of internal wall insulation.

	Stamp duty rebate	Council tax rebate	Consumer grants
Present value of cost to Government if uptake is realised to 2030[96,97, 98]	£2.7 bn (£4.5k per household)	£3.8 bn (£4.5k per household)	£4.1 bn (£4.5k per household)
Net present value of benefit to consumers if uptake is realised to 2030[99]	£3.2 bn (£5.3k per household)	£4.5 bn (£5.3k per household)	£4.8 bn (£5.3k per household)
Net present value of benefit to society if uptake is realised to 2030[100]	£5.5 bn (£9.2k per household)	£7.9 bn (£9.2k per household)	£8.4 bn (£9.2k per household)

Source: Frontier Economics

However, our analysis suggests that financial incentives at this level may not incentivise uptake, even for the relatively small number of consumers identified in this modelling. This is because the payback for heat pumps and solid wall insulation with this level of subsidy remains above 10 years. Essentially, despite the upfront grants, these policies are unlikely to be successful in managing the upfront costs. Consumers' focus on near term costs and benefits means that few would take up measures with payback over 10 years, and

96 The cost to Government is the financial incentive multiplied by the number of consumers taking up the interventions. The size of the financial incentive is calculated based on the average emissions savings associated with each intervention, valued using the DECC carbon price projections. The cost included in this table is the present value of the cost associated with interventions to 2030.

97 For each of the policies considered, the cost of incentivising each intervention is set at a level that internalises the average value of carbon savings associated with that intervention, where the carbon savings are valued using DECC's carbon projections. Therefore the level of the financial incentive offered for each intervention is the same under each policy.

98 The average discounted cost per household has been derived by dividing the total discounted cost by the number of households taking up any intervention over the period 2015-2030. The total number of households modelled as taking up *any* intervention is equal to the number taking up solid wall insulation (either 0.6m or 0.9m). Note that all figures in this table are rounded, therefore multiplying the per-household figure by the number of households will not necessarily produce the same exact number we give for the overall costs. This also applies to the benefit to customers and society.

99 The net benefit to consumers equals the financial incentive received *plus* the value of the change in energy use due to the interventions *minus* the upfront cost of the interventions.

100 The net benefit to society equals the value of the carbon and energy savings from the policy *minus* the cost of the interventions. The financial incentive is not included in this calculation as it is a transfer from Government to consumers.

businesses would be unlikely to intervene to spread the costs for them, given the barriers to offering unsecured loans over such periods.

What level of subsidy would be required to incentivise uptake? Table 3 shows the level of subsidy required to bring the payback period down to below 10 years for 1m external solid wall interventions[101] and 2.5m heat pump interventions (i.e. the levels which may be required to meet 2050 targets)[102].

101 External wall insulation is typically much less expensive than internal wall insulation. To insulate 1m solid-walled properties, it would be most cost-effective to focus on external wall insulation.

102 CCC (2014), *Meeting Carbon Budgets: 2014 Progress Report to Parliament.,* Frontier Economics and Element Energy (2013), *Pathways to high penetration of heat pumps*

Table 3. Total value of subsidy required to bring payback down to 10 years and value of the carbon saved[103]

	Heat pumps	Solid wall insulation (external)
Size of subsidy to reduce payback period to 10 years in 2020, per intervention[104]	£8k	£10k
Value of carbon savings over the lifetime of the intervention, per intervention[105]	£2k	£3k
Uptake up to 2030	2.5m	1m
Total present value of cost of subsidies for interventions installed to 2030	£16.5bn	£8.5bn
Total present value of carbon savings for interventions installed to 2030	£4.1	£2.6

Source: Frontier Economics

This shows that £25bn of subsidies for these measures alone would be required, to deliver £6.7bn of carbon savings. This estimate may be a lower bound: it is enough to ensure these technologies pay back financially for consumers, but it does not compensate them where the new heating system is associated with different performance when compared to the incumbent option.

103 Based on DECC's carbon prices, DECC (2014), *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal*

104 This is the total subsidy required to bring the payback down to 10 years for each intervention. Further subsidy in line with the carbon price would not be required.

105 This assumes interventions are taken up in 2020. The value of carbon is calculated using DECC's non-traded carbon price.

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These uptake figures also assume that other barriers, such as those related to interest and awareness, can be overcome through innovative business offerings.

Since the carbon price represents the marginal cost of meeting carbon targets, offering a subsidy in excess of the carbon price implies that this measure would not be as cost-effective as other available options. This might be justified if the subsidy was expected to address market failures in the transition – for example the risk that without intervention, the heat pump and solid wall insulation markets in the UK will not reach the scale needed to bring costs down to a competitive level.

Whether subsidies in excess of the carbon price would be justified, depends on the extent to which we believe:

- there are wider benefits from low-carbon heating interventions, such as improvements to health and wellbeing;
- the costs of heat pumps and solid wall insulation will be driven down by the growth of the UK market (rather than global growth); and
- there are no alternative, more cost-effective options across the energy system for meeting carbon targets.

These issues would need to be examined further, before a case could be made.

Box 6: How do these subsidies compare to Government's current policy?

The subsidies shown in Table 3 are much higher than those currently offered by Government: £8k for a heat pump compares to payments under the RHI of £500 each year for seven years (for a house with heat demand of 10MWh/year)[106], while £10k for external solid wall insulation compares to £4k cashback available through the Green Deal (for internal or external insulation).[107]

This is because the subsidies shown in Table 3 are aiming at a higher level of uptake than current Government policies such as the GDHIF and the RHI.

- The GDHIF gave around 6,000 grants out for either internal or external solid wall insulation in December 2013. Our analysis is aimed at securing 1m installations by 2030[108].
- The RHI aims to incentivise 350,000 air source heat pumps to 2020/21 and has therefore been set at a level that would incentivise a consumer with an oil-fired system (which is a sensible strategy in the early years of heat pump uptake), while our modelling has calculated the level of subsidy required to gain a response from 2.5m consumers by 2030. To gain uptake at this level, the subsidy would have to attract some consumers that are currently on gas boilers, and therefore require a high payment to make it worth their while. Separately, we note that the RHI could be more cost-effective, if paid as an upfront incentive rather than an ongoing payment.

An alternative to subsidising take-up would be to mandate take up. However, that comes at the cost of consumer choice (Box 7). Additional costs would be associated with identifying consumers for whom these measures would be cost-effective (e.g. through mandatory assessments). Further, the policy would need to be accompanied with a grant covering the carbon externality, and a Green Deal type mechanism to allow consumers to spread the cost. The high costs associated with heat pumps and internal and external solid wall insulation therefore make delivering them a very challenging policy proposition for the transition period.

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106 DECC (2013) *Domestic RHI Impact Assessment*

107 https://energy-saving-home-improvement-fund.service.gov.uk/Downloads/GDHIF2_TermsAndConditions.pdf

108 80% of the £30m funding in December was for SWI. The figure of 6,000 households is based on the assumption that each household claimed the highest amount possible of £4k.

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Box 7: Why would mandating solid wall insulation (internal and external) and heat pumps be so much more radical than mandating condensing boilers?

Condensing boilers were mandated in the UK from 2005, through building regulations. Could this set a precedent for mandating solid wall insulation?

The price for a typical condensing boiler is around £1,250 and for a typical non-condensing boiler it is £850.[109] This higher cost is recouped through lower running costs (saving around £95 a year).[110] Payback for the higher upfront costs occurs therefore within 5 years.

Heat pumps and solid wall insulation imply a much higher outlay for consumers – £10k for heat pumps, £27k for internal solid wall insulation and £10k for external solid wall insulation, with payback periods of well in excess of 10 years for most consumers.

4.3 Potential policies to incentivise district heat

For district heat, the key challenges relate to the high costs, the high level of sunk costs and the fact that district heat networks are natural monopolies. As with the experience of district heat in European countries, it is a range of policies that are required, rather than an individual one.

Box 8: European policy: there is no silver bullet

Uptake of district heat has been much higher in Europe, but this has necessitated multiple policy interventions.

Experience from Denmark, Germany and Sweden suggests that a wide range of policy measures are required to support district heat development – with measures including provision of financial incentives, establishing a supportive planning process, use of long-term contracts, credit provision, and mandating. The relative importance of the range of interventions used is not clear. Recent experience of district heat also highlights the importance of having suitable supply side policy (to incentivise low-carbon generation of heat) and competition policy (to protect consumers) in place.

We have looked at three policies: grants to internalise carbon costs to deal with the high costs, risk sharing between Government and developers to deal with high sunk cost and policy risk; and licensing and regulation to manage the issues associated with natural monopoly.

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109 See for example: http://www.servicemagic.co.uk/resources/cost-guides/boiler-replacement-costs-prices/

110 HM Government (2011) *The Carbon Plan: delivering our low carbon future*

4.3.2 Grants

Cost barriers are higher for district heat in the UK than in other parts of Europe To the extent that this is due to a lack of experience, UK costs would be expected to fall with greater roll out[111].

In the meantime, financial support is likely to be required to deliver roll out. Once again, to deliver an efficient outcome for society, the level of this financial support should be in line with the value of the carbon savings delivered.

Based on the estimated carbon savings associated with district heating, we estimate that a grant paid to district heating developers would need to be between £2,000 and £10,000 per household connected, to reward developers for the carbon savings their schemes deliver[112]. The variation between the upper and lower end of the range is driven by the variation in fuels used in district heating systems, and by a range of assumptions on the future carbon intensity of the electricity grid.

4.3.3 Dealing with high sunk costs and policy risk

Government can also intervene to reduce risks for developers. The level of sunk costs means that the regulatory framework may need to provide for risk sharing between government and developers. Many of the risks faced by district heating networks are driven by policy (for example the extent to which alternative heating technologies will be supported by policy in the future). This is an argument for the Government to bear some of the risk associated with developing district heating, for example providing long-term heat demand guarantees or loan guarantees, or acting as a 'quasi-regulator'. Existing agreements already include these types of risk sharing between project sponsors and ESCOs for some heating networks[113,114]. In addition, government could contribute resources such as land or planning expertise. This is already used in some cases. Local Development Orders are also helpful, in that they streamline the process of getting planning permission. There is also a potential role for local or national Government in identifying the areas most suitable for district heat.

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111 Research for DECC found that the main reasons for higher costs in the UK were related to: lack of experience; the need for wider and deeper trenches compared to other services; the pricing in of construction risks which may be overestimated; and traffic management costs which may be higher than elsewhere. Pöyry and Faber Maunsell (2009), *The potential and costs of district heating networks, A report to the Department of Energy and Climate Change*

112 Calculated by multiplying estimated carbon savings from Pöyry and Faber Maunsell (2009) for DECC, by DECC carbon prices. Note: Assumes a 25 year lifetime and a base year of 2025. Projected central non-traded carbon price was applied.

113 Roger Cotton, Brodies LLP (2011), *Governance and business models for district heating*

114 ARUP (2011), *District heating manual for London*

Following this, the big question is the degree to which you require consumers to sign-up to a district heat network, if one becomes available. Experience in other countries, such as Germany, has shown that district heat networks can thrive without such requirements[115]. Whether this will be possible in the near term in the UK, when experience of district heat is limited and its cost may be in excess of the alternative incumbent heating options, is something that would benefit from further research.

Policy signals should not reduce the choice that consumers face in particular locations. If a heat network is available in an area and, overall, offers the most cost-effective way of meeting lower carbon targets, then offering consumers in this area subsidies to adopt a different technology will require very careful consideration.

4.3.4 Regulating natural monopoly

At a minimum, a regulatory framework to **licence developers** is required. This could involve a tender for the option to develop a network in a particular area. It could also be built into the planning regime so that Local Authorities could require individual developers to engage with and use potential district heat schemes. Licencing could be introduced alongside a target for take up of district heat by 2020 and/or 2030. A target is already in place in Scotland, and was put forward by the CCC in its most recent progress report[116].

The regulatory framework would need to ensure **good outcomes for consumers.** Evidence from countries with unregulated district heat networks shows that outcomes can be adverse in the absence of ex-ante regulation. There have been repeated competition investigations in Sweden, and an ongoing investigation in Germany[117]. This suggests that regulation may be needed to provide sufficient consumer protection both in terms of price and quality of service. This is because heating networks are natural monopolies, and consumers have limited alternative heating options after connecting to a heating network. Regulation could potentially be applied along with unbundling and in some cases it may be possible to introduce competition between sources of heat supply to

115 In Germany in 2008: 65% of network areas did not require consumers to use the heating network, 29% used partial purchase obligations (which are not clearly defined, but appear to be a time limited requirement that consumers connect, to incentivise large investments in district heating) and 6% required compulsory connection and usage. German Federal Cartel Office (2012), *Sector Inquiry District Heating*

116 CCC (2014), *Meeting Carbon Budgets: 2014 Progress Report to Parliament*.

117 The investigation in Germany indicated that some district heat consumers pay less than 4c/kWh, with others paying more than 18c/kWh.[117] This has resulted in the German Federal Cartel Office instituting proceedings against seven district heating suppliers on suspicion of their charging abusively excessive prices.

the network. However, for most heat networks retailers wouldn't have choice on where to purchase heat from and this would limit the dimensions of competition (e.g. to customer service and billing). Introducing competition on small district heat networks may therefore not be worthwhile. This is consistent with the water sector where a decision has been made to limit retail competition to non-domestic consumers[118].

Impact of policy on uptake

Research for DECC found that managing risk was crucial, and in combination with a carbon price signal, could ensure that district heat meets between 6-14% of UK heating needs in 2030[119].

4.4 Implications

Policy can have a role in correcting market failures, particularly around carbon externalities and natural monopoly, and to protect vulnerable consumers.

In doing so, the design of policy can reflect what is known about how consumers make heating decisions. Where policy interventions are planned, they can be tied to investment triggers, such as moving house. Financial incentives can be tagged to existing well known taxes to attract attention and given the importance of upfront costs as a driver of barriers, financial incentives should in general be delivered through upfront rather than ongoing payments.

Required policy intervention varies, according the characteristics of the interventions.

Cavity wall insulation and HEMS Plus

Cavity wall insulation and HEMS Plus have the potential to save money and improve the heating service for many consumers. They have a relatively low upfront cost and a payback period of less than 10 years for the majority of customers. The role for policy in relation to these interventions is likely to be focussed on ensuring that fuel poor or vulnerable customers can also benefit from these technologies, and in driving innovation to further improve these interventions.

118 Defra (2014), *Reforming the water industry to increase competition and protect the environment*

119 Pöyry and Faber Maunsell (2009), *The potential and costs of district heating networks, A report to the Department of Energy and Climate Change*

Solid wall insulation and heat pumps

The high costs of solid wall insulation and heat pumps will mean that policy is required to drive their uptake.

To achieve 1m external solid wall installations[120] and 2.5m heat pumps by 2030 (consistent with meeting 2050 carbon targets)[121], our analysis suggests the costs of these subsidies would be over £25bn.

Whether subsidies in excess of the carbon price would be justified, depends on the extent to which we believe:

- there are wider benefits from low-carbon heating interventions, such as improvements to health and wellbeing;
- the costs of heat pumps and solid wall insulation will be driven down by the growth of the UK market (rather than global growth); and
- there are no alternative, more cost-effective options across the energy system for meeting carbon targets.

These issues would need to be examined further, before a case could be made.

District heat

District heat can already deliver a heating service that is comparable or better than the main incumbent, gas boilers, although policy support is still likely to be needed to ensure developers are rewarded for carbon savings their schemes will deliver, for example through grants. This would allow district heat to compete with incumbent technologies on cost. The challenge is around helping developers to manage risk (especially risk that is policy driven) while not removing choice from consumers.

Part of managing policy risk is to ensure that national policy does not conflict with local plans. Regulation of local district heat monopolies is also likely to be important to protect consumers, and introducing it sooner rather than later will reduce uncertainty for investors.

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120 The figure for solid wall insulation refers to external wall insulation, which is typically much less expensive than internal wall insulation. To insulate 1m solid-walled properties, it would be most cost-effective to focus on external wall insulation.

121 CCC (2014), *Meeting Carbon Budgets: 2014 Progress Report to Parliament.,* Frontier Economics and Element Energy (2013), *Pathways to high penetration of heat pumps*

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