Programme Area: Smart Systems and Heat

Project: Value Management

Title: Overcoming barriers to smarter heat solutions in UK homes - Annexe 3c: Factors affecting intervention take-up order

Abstract:

This document was prepared at the time to contribute to ETI internal thinking and planning only.

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

Annexe 3c: Factors affecting intervention take-up order

PREPARED FOR THE ETI

March 2015

1 Introduction

This annexe looks at the order in which interventions are taken up. Whether consumers take up interventions sequentially (and if so in what order) or simultaneously can have important implications for the design of business models and policies. For example, if the majority of factors lead to consumers wishing to carry out simultaneous upgrades, business models and policies which help overcome credit constraints may be more relevant. This is due to the significant up-front costs that consumers would incur when installing multiple interventions at once.

In this annexe, we explore the factors that may affect intervention take-up order for three types of consumer-level intervention: heat pumps, insulation retrofits and HEMS.

All analysis has been carried out under the assumption that consumers face a cost of carbon emissions (produced through both electricity and gas use) based on DECC's shadow price of carbon. This is to act as a simple (and technologically neural) proxy for policies aimed at reducing carbon emissions. As explained in the main report, this is unlikely to be a viable and effective policy in reality, since it does not overcome issues associated with upfront costs and financial constraints.

When we refer to a "cost-effective" intervention in this annexe, we therefore mean one that will pay back over its lifetime in the presence of such a carbon price. Annexe 3b on payback periods shows how, in reality, payback periods may be so long as to deter take up of such interventions.

- First, we use BMET to determine in what order interventions become cost-effective (as described above, this measure of "cost-effectiveness" allows a payback period up to the lifetime of the intervention). Based on the assumptions in the model, we find that **wall insulation (both cavity and internal/external solid wall insulation) and HEMS are cost effective in the next few years for most groups. Heat pumps take longer to become cost effective (except where they are replacing an existing electric-resistive or oil-fired system).**

- We then consider to what extent different interventions may be pre-requisites for each other. This analysis suggests that, **if interventions are not taken up simultaneously, it may be advantageous for consumers to take up HEMS first, followed by any additional insulation (mainly solid wall) they do not already have, followed by a heat pump**.

- Next, we consider the frequency and nature of "trigger points", which may overcome non-financial barriers to interventions. Trigger points are typically infrequent – some only occurring once per lifetime. If intervention installation is tied to such trigger points, this suggests that **interventions may either need to be installed at a similar time to each other, or spread well apart**.

- Finally we look at whether financial constraints may necessitate a sequential take-up of interventions. We therefore examine the relationship between intervention up-front costs and the amount which consumers may be willing to spend on home improvements at any one time. This suggests that, **while consumers might find it straightforward to purchase cavity wall insulation and HEMS at the same time as a heat pump, many may find a combined investment in solid wall insulation and heat pumps too expensive**.

This analysis points to intervention take-up order being a particular problem for consumer groups with uninsulated solid walls and electric resistive or oil-fired heating. Although such groups may find it optimal to take up all three interventions within a short period, credit constraints may mean they need to delay the installation of a heat pump. Given the relative infrequency of trigger points, this could lead to a delay in heat pump installation, with substantial missed financial savings for both consumers and society as a whole (due to higher carbon emissions). This is therefore a customer group that may benefit from tailored business models and policies.

3 Time to intervention cost-effectiveness

We have used BMET to examine when different types of intervention may become cost effective to consumers, in the absence of any other barriers to take-up such as those around customer awareness and attention, or financial constraints.[1] The graph below shows, for each group within BMET, the date at which each technology becomes cost-effective for customers (in the presence of a carbon price, but with no further subsidies). Note that this measure of "cost effectiveness" only requires that the intervention pays back during its lifetime – which is as long as 50 years for internal and external wall insulation.

These results are entirely dependent on the technical characteristics of the interventions and consumers as entered into BMET. In some areas (for example the benefit of HEMS), these are assumptions that have been made in the absence of robust data. We have therefore compared these results to some other available forecasts where possible.

It can be seen that:

- **Cavity wall insulation** has already been assumed to have been installed in all bar one ("Transitional Retirees") of the relevant[2] groups prior to the model start period of 2015,[3] and is cost-effective for that group any time from 2015 onwards.

- **Solid wall insulation (SWI), both internal and external**[4] is cost-effective for most of the remaining groups as soon as the modelling period starts. This appears likely to overestimate the potential for cost-effective solid-wall insulation. For example, the CCC estimates[5] that SWI would be cost-

1 To obtain these figures, BMET was used with the £1,000 "additional hassle factor" removed. The "unconstrained" consumer choice of intervention from within BMET (which permits sequential take-up) was then extracted. Note that, in normal operation, BMET constraints customers to take up interventions simultaneously. A separate technical annexe describes the changes that have been made to this aspect of BMET, and the implications of the remaining ordering assumptions.

2 Young Starters, Greener Graduates, Successful Ruralites (gas and oil) and Off-Grid Rural Electric are assumed to have solid walls, while all other groups are assumed to have cavity walls.

3 Consistent with government figures that 72% of the 19.3m houses with cavity wall construction were insulated by June 2014 – DECC (September 2014) *Domestic Green Deal, Energy Company Obligation and Insulation Levels in Great Britain, Quarterly Report*.

4 As explained in annexe 3e, we consider two types of solid wall insulation. The rural groups with solid walls (Successful Ruralites and Off-Grid Rural Electric) are assumed to only consider internal wall insulation, reflecting the way that many older rural properties may have heritage features that make external wall insulation unattractive. By contrast, the urban groups with solid walls (Young Starters and Greener Graduates) are assumed to consider external wall insulation, given the more limited internal space of typical urban homes, and expense of internal insulation.

5 CCC (2014), *Meeting Carbon Budgets – 2014 Progress Report to* Parliament, p174

effective for only one million homes by 2030. It is possible that BMET is overstating the cost-effectiveness of SWI.

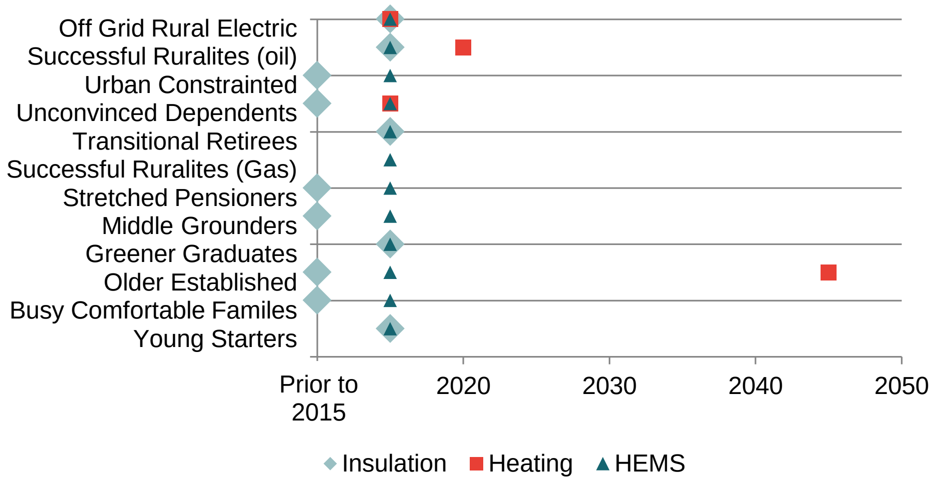
- Due to the long lifetime of SWI, a positive net present value in the near-term may be driven entirely by high carbon prices in the future. Rational consumers may seek to delay the installation of SWI. However BMET does not value this "option value").
- In addition, BMET does not consider heterogeneity within groups – many houses may be particularly hard-to-treat.

- **Replacement heating systems** (an air-source heat pump in all cases here) are cost effective from 2015 for the two groups which already have electric heating (Off Grid Rural Electric and Urban Constrained) as well as the group with oil heating. Heat pumps become cost-effective for two other groups in 2020 and 2045. Heat pumps are never cost-effective for other groups. This is broadly consistent with results from ESME, which suggest that heat pumps will only start to become cost-effective for a significant proportion of households from around 2040: in ESME 3.3 (DC run), the ASHP2 accounts for 3% of space heat production in 2020, 12% in 2030, and 30% in 2040.

- **HEMS**, by contrast, is cost-effective as soon as the model starts for all groups. This is driven by the assumptions within BMET around the low cost of HEMS, its efficiency in shifting and reducing demand, and the present of time-of-use tariffs.[6]

[6] With time-of-use tariffs, HEMS may be able to produce value for customers by shifting demand from peak periods to off-peak periods. As a long-run model, BMET assumes that all customers have smart meters and are exposed to half-hourly static time-of-use tariffs, which provide this benefit.

Figure 1. Unconstrained intervention take-up within BMET



Source: Frontier analysis using BMET.

For most groups, this analysis is indicative of HEMS and improved insulation (where not already present) being installed in the near future, with heat pumps following some time later, if ever.

The exceptions to this are groups which currently have electric resistive heating. Such groups may benefit from a simultaneous upgrade of insulation (where this has not already been done), together with the installation of a heat pump and HEMS.

5 Prerequisites between interventions

Interrelationships between the interventions may affect the order in which they are taken up.

As discussed in annexe 4c, adequate insulation is required for heat pumps to be cost-effective. Insulation retrofits, where required, must therefore occur before or at the same time as heat pump installation (the analysis above takes this effect into account). Note that, based on the assumptions in annexe 3e, we believe that the majority of cavity-walled houses may already have an adequate level of insulation. This ordering is therefore more likely to be an issue for solid walled houses.

Although not physically required for a heat pump in the same way, there are a number of potential advantages to installing HEMS before or at the same time as a heat pump.

- As described in annexe 3d, heat pumps may be able to provide value to customers through the provision of DSR services to entities such as suppliers and networks. The level of control provided by HEMS may be a pre-requisite for such services.

- HEMS can also provide data that businesses model providers can use to better tailor services to customers and reduce business and customer risks associated with future interventions. For example, any offer to fix energy bills require an accurate estimate of a consumers' baseline energy consumption. Installing HEMS prior to a contract provides one way of doing this.

We therefore think that it is likely that a consumer (or business model provider) would wish to install HEMS before or at the same time as a heat pump, and potentially in advance of insulation too.

6 Awareness, interest, perceptions and decision-making

Even if an intervention offers benefits, consumers will only take it up if they are aware of it, and are in a position to make a purchasing decision. A wide range of barriers – for example a lack of consumer awareness – may contribute to interventions not being taken up at the point when they become cost-effective.

Various "trigger points" can act to reduce these barriers. For example, if a consumer is carrying out significant refurbishments to their house, this may prompt them to consider improvements to their heating system. It may be less hassle to carry out multiple interventions at such a time, rather than spreading them all out. **Table 1** below summarises some possible trigger points, and provides rough estimates of the frequency with which they occur. This shows how trigger points potentially infrequent, which suggests that intervention take-up may need to be either simultaneous, or widely spread out.

If different trigger points only applied to specific interventions, then they could feasibly lead to sequential take-up. However, most of these trigger points could apply equally across all interventions. The main exception is the need to replace an existing heating system, which is also one of the more common triggers. However, as discussed above, insulation and HEMS may well be prerequisites for a new heat pump. A customer considering a heat pump is therefore likely to be prompted to look at these other interventions during the purchasing process. It therefore seems unlikely that trigger points would lead to sequential take-up of these interventions.

Table 1. Triggers

	Possible applicability to…			
	ASHP[7]	HEMS	Insulation	Frequency
Needed to replace or repair existing heating system	**High** Homeowner forced to purchase a replacement (although urgency may lead them to consider a familiar technology if the incumbent system has already broken down).	**High** Homeowner may consider new controls as part of the entire heating system package.	**Some** Consideration of heating running costs may prompt consumer to consider wider changes.	ESME includes a boiler lifetime of 15 years, which would imply that, at the moment where most have gas boilers, nearly **7%** of households replace their heating system every year. This is likely to be an underestimate since heating systems may exhibit problems before they become uneconomic to repair and therefore there may be more than one trigger point before the system is actually replaced.

[7] Or another form of low-carbon heating, such as an electric resistive system.

Table 1. Triggers

	Possible applicability to…			Frequency
	ASHP[7]	HEMS	Insulation	
Upgrading or refurbishing a home	**Some** Major works (e.g. extension) may require changes to the existing heating system or building fabric. For example, if scaffolding is already present, it may reduce costs of installing SWI.[8]			In 2012, 165,896[9] "householder development" planning permission applications were granted in England – around **0.7%** of English households. This represents a lower bound, as many minor developments do not require planning permission.
Building a home	**High** Homebuilder must purchase a heating system, and is likely to have time to investigate alternatives.	**High** Homebuilder must purchase controls for heating system.	**High** Insulation measures typically intrinsic to building fabric (e.g. type of windows, walls).	Construction started on 139,500 English homes in the year to September 2014 (24% down from the peak in 2007).[10] This represents around **0.6%** of the total stock of approximately 23m English houses.[11]

8 CCC (2014), *Meeting Carbon Budgets – 2014 Progress Report to* Parliament, p174

9 89% of 186,400 decisions, according to planning *Planning Applications: October to December 2012 (England)* - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/184968/Planning_Applications_October_To_December_2012_England.pdf

10 House Building: September Quarter 2014, England (https://www.gov.uk/government/statistics/house-building-in-england-july-to-september-2014)

Awareness, interest, perceptions and decision-making

Table 1. Triggers

	Possible applicability to…			
	ASHP[7]	**HEMS**	**Insulation**	**Frequency**
Moving home	**Potentially some** There is evidence that moving home lead to refurbishment[12] (whether an owner-occupier improving the house, or a landlord taking advantage of a vacant periods to carry out works) – see row on refurbishment above.			According to the English Housing Survey, 2.3m English households moved during 2012, roughly **10%** of the total. Note that a small proportion of these will be new-build houses, covered in the trigger discussed above.

11 English Housing Survey 2012

12 http://www.sustainablelifestyles.ac.uk/projects/change-processes/habits accessed on 07/01/2015

Awareness, interest, perceptions and decision-making

Table 1. Triggers

	Possible applicability to…			Frequency
	ASHP[7]	HEMS	Insulation	
Change in life stage (e.g. retire, start a family)	**Potentially some** It has been suggested that these events may lead to increased environmental awareness,[13] although this may not be a trigger in itself. Changes in occupancy could feasibly prompt dissatisfaction with current heating system – e.g. if property is too cold for a child, or a retiree staying at home experiences higher bills.			UK life expectancy is currently 81.5 years.[14] A highly approximate[15] estimate for the proportion of households with a retiree in each year is therefore the reciprocal of this, **1.2%**. During 2013, 263,830 children were born in England and Wales to a mother with no previous children.[16] This suggests that, very approximately, **1.1%** of households may have started a family.

Source: Frontier

13 http://www.sustainablelifestyles.ac.uk/sites/default/files/eventdocs/elicit.pdf accessed on 07/01/2015

14 World Bank

15 For example, this assumes that individuals within multiple-occupancy households retire at the same time, and that all individuals retire.

16 *Characteristics of Birth 2* (http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-327594)

Awareness, interest, perceptions and decision-making

7 Financial constraints

Even if consumers realise that a given bundle of interventions provide best value to them, they will not be able to purchase them all together unless they have readily available finance (whether as savings or as access to credit). Even if they have access to finance, they may have an aversion to spending large sums of money on multiple expensive interventions simultaneously.

We have used BMET to explore the extent to which credit constraints are likely to stop consumers taking their optimal bundle. Within BMET, groups are assumed to have a maximum spend within a year on interventions[17] of:

- £500 for Young Starters, Greener Graduates and Urban Constrained (30% of BMET households);
- £3,000 for Busy Comfortable Families, Middle Grounders, Unconvinced Dependents, and Off Grid Rural Electric (48% of BMET households);
- £6,000 for Transitional Retirees (7% of BMET households);
- £10,000 for Older Established (10% of BMET households); and
- £18,000 for Successful Ruralites (5% of BMET households).

Figure 2 plots these figures against intervention costs from BMET,[18] where interventions have been ordered according to cost (with separate columns depending on the type of wall insulation required).

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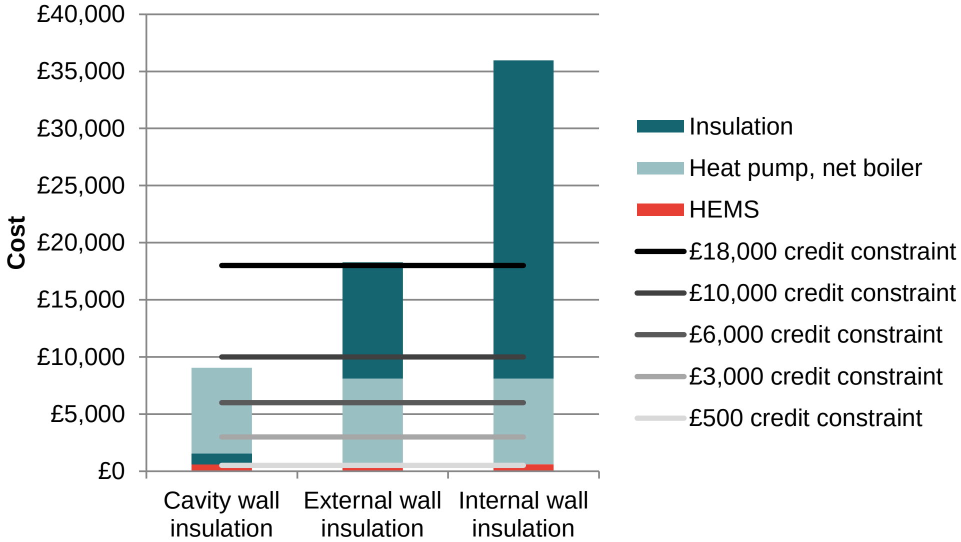
17 These represent estimated total spend on home improvement over a 3-5 year period. The figures are partially based on direct research carried out by a national home improvement business.

18 Intervention costs have been taken for 2015. The BMET average boiler replacement cost of £2,500 has been netted off the heat pump cost of £10,000, as it is assumed that the heat pump is installed instead of a gas boiler. All the other interventions are retrofits rather than replacements.

Figure 2. Credit constraints and intervention up-front costs



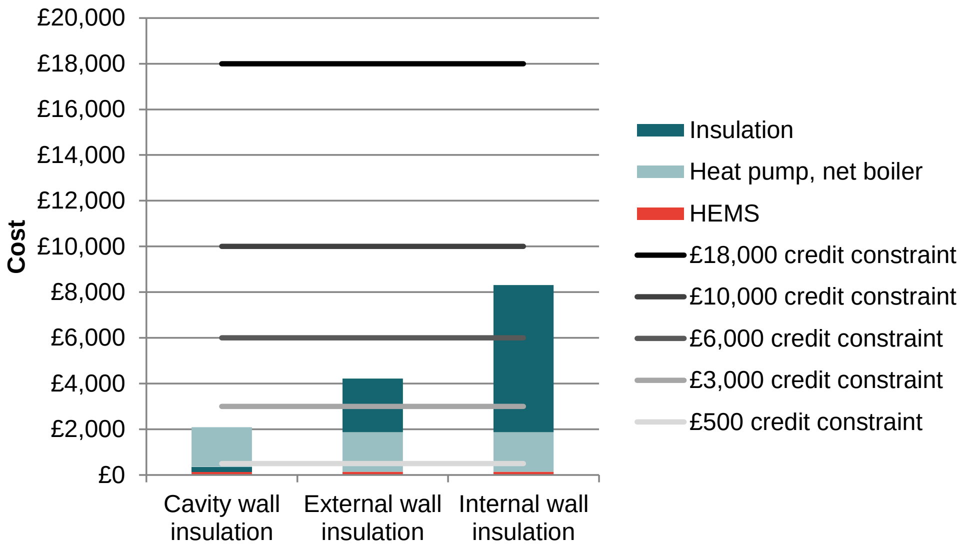
Source: Frontier Economics. Note that interventions have been re-ordered by upfront cost: cavity wall insulation is shown below heat pumps in the first column, and above heat pumps in the following columns.

It can be seen that HEMS and cavity wall insulation are far cheaper interventions than either a heat pump or solid wall insulation. This makes it more credible that they could be "added-on" to the cost of more expensive interventions. Further, for all but the groups with the lowest credit constraint, the combination of HEMS and cavity wall insulation is affordable.

However, the cost of a heat pump or solid wall insulation by itself is above the credit constraint for 85% of households. This suggests that households will be likely to need to pay for these interventions through loans. **Figure 3** therefore considers the annual repayments that would be required if interventions were financed at a real interest rate of 10%[19] over five years. As annexe 3b suggests, this is a period over which consumers may be willing to sign into a long-term contract (and for which business model providers may be willing to supply it). The credit constraints have been kept at the same levels (BMET assumes these refer to the maximum yearly spend on interventions).

19 The analysis would not be substantially different for a real interest rate of 5%.

Figure 3. Credit constraints and yearly intervention loan repayment costs, spread over five years at a real interest rate of 10%



Source: Frontier Economics. Note that interventions have been re-ordered by upfront cost: cavity wall insulation is shown below heat pumps in the first column, and above heat pumps in the following columns.

Most groups would be able to purchase a heat pump and HEMS together. However consumer groups accounting for 78% of households are modelled as not being able to afford payments for external wall insulation and a heat pump at the same time.

This suggests that credit constraints may prevent a significant proportion of households from purchasing a heat pump and solid wall insulation together, but are unlikely prevent take-up of a heat pump alongside either HEMS or cavity wall insulation.

9 Conclusions

Based on this analysis, we believe that the main determinants of optimal intervention take-up are building-specific factors. In particular, the presence of adequate insulation and less efficient heating systems such as electric resistive or oil-fired boilers are likely to lead to a different order of take-up. Credit constraints and trigger points may then dictate whether the optimum take-up order is possible.

This is summarised below and in **Figure 4**.

1. Consumers who **already have adequate insulation**, with **an existing gas boiler**. HEMS is likely to be a worthwhile early investment for such groups, but it will be a long time before heat pumps are viable. This form of sequential take-up is compatible with infrequent trigger points (given the long time between HEMs and the heat pump becoming cost-effective) and will fit into most credit constraints.

2. Consumers who **already have adequate insulation**, with **electric resistive or oil heating**. These consumers may find it optimal to install a heat pump in the near future (e.g. when they next experience a trigger point), with HEMS installed at the same time or shortly before. Given the low cost of HEMS, this simultaneous take-up is unlikely to breach credit constraints.

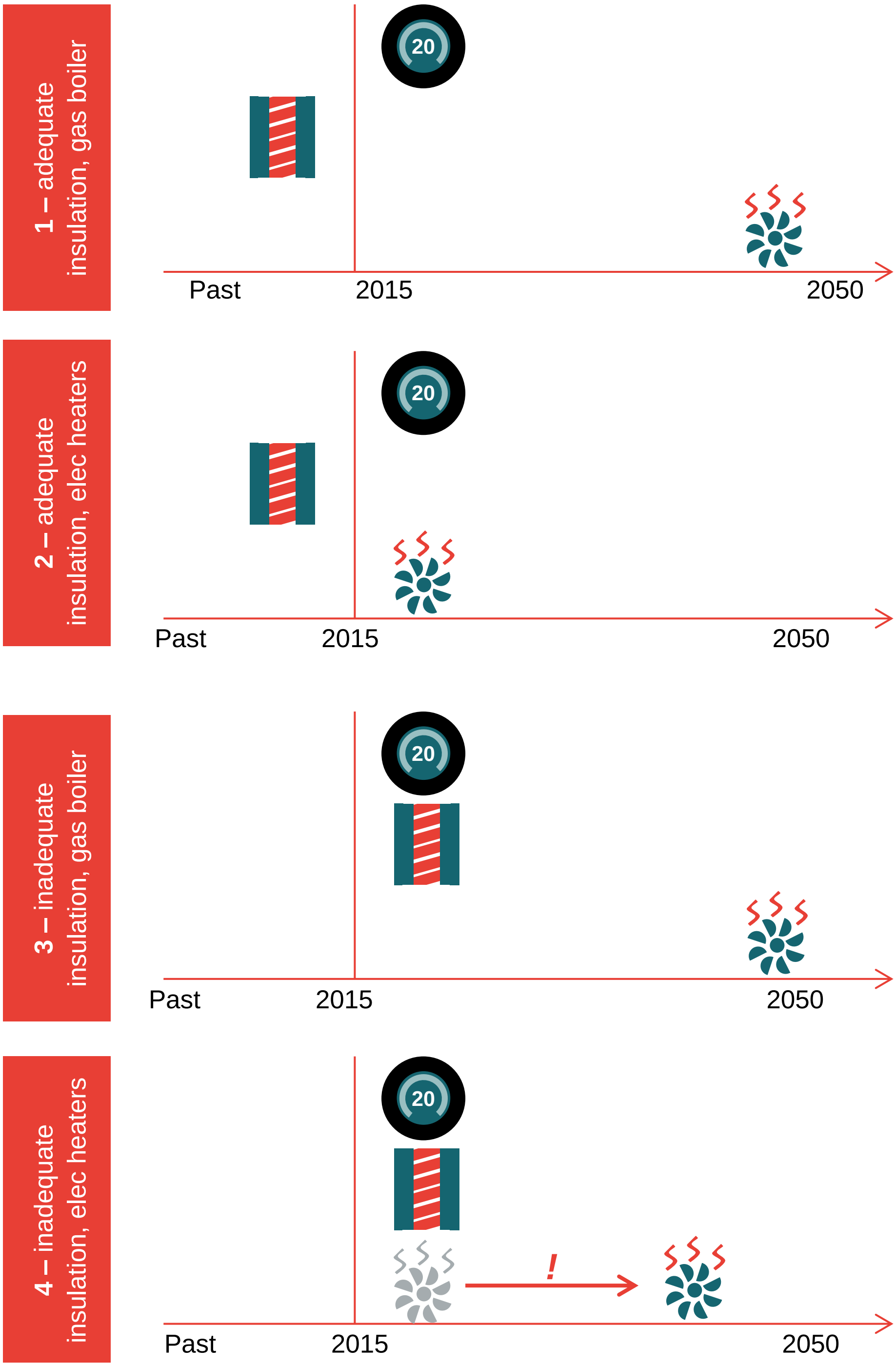
3. Consumers who **do not have adequate insulation**, with **an existing gas boiler**. Such consumers may wish to install both HEMS and insulation in the near-term, and heat pump in the more distant future. Given many such customers may have solid walls, credit constraints may prevent take-up. However, where customers are able to afford solid walls, the addition of HEMS is unlikely to prove problematic.

4. Consumers who **do not have adequate insulation**, with **electric resistive or oil heating**. Such consumers may find it optimal to install all three interventions within a short time period. However, the combined cost of solid wall insulation and a heat pump may be too expensive. If this forces the consumer to delay taking up a heat pump until the following trigger point, the costs to both the consumer (as well as society, through higher carbon emissions) could be significant.

   - Using BMET, we estimated the costs if such a consumer (the "off-grid rural electric group in the model) was forced to delay take-up of a heat pump for ten years. For each year where the consumer continued to use their incumbent technology (electric resistive heating in a poorly insulated property without HEMS), they would forego benefits of around £2,200 in bill reductions.

- One of the main benefits of solid-wall insulation for this type of group is that it enables a heat pump to be installed. If consumers place a low value on future benefits, they may be less willing to install solid wall insulation at all if they need to wait many years until the benefits from a heat pump can be realised. If this group failed to ever take up both solid wall insulation and a heat pump (and only took up HEMS), they would forego benefits of around £2,000 every year.

Figure 4. Possible intervention take-up orders



Source: Frontier Economics

Conclusions

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