



An ETI Insights report

HOW CAN PEOPLE GET THE HEAT THEY WANT AT HOME, WITHOUT THE CARBON?

Delivered by:

CATAPULT
Energy Systems

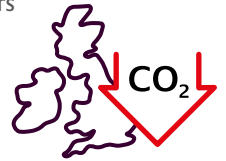
Contents

- 04 Key headlines
- 06 Context
- 08 Introduction
- 10 What do households want from heat at home?
- 14 Why do consumers need to be involved with decarbonising domestic heating?
- 18 Could energy services reveal what consumers want from low carbon energy systems?
- 22 Fair future
- 24 Conclusion
- 26 Further Reading

To tackle climate change, we need to effectively **eliminate the 20% of CO² emissions** that come from how we use heat in the home.

20%

So **low-carbon heating must appeal** to consumers if the UK is to tackle climate change.



HOW CAN PEOPLE GET THE HEAT THEY WANT AT HOME, WITHOUT THE CARBON?



To move consumers to low-carbon heat we need to **rethink the consumer proposition**. The emergence of the “connected home” allows us to look at heat and comfort as a packaged service not simply the purchase of units of fuel.

Decarbonising heat means supplying homes with **something other than natural gas**.



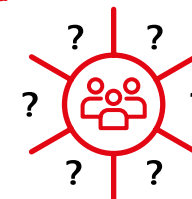
Our consumer research shows **people care more about their experience of using heat** than how it is delivered.



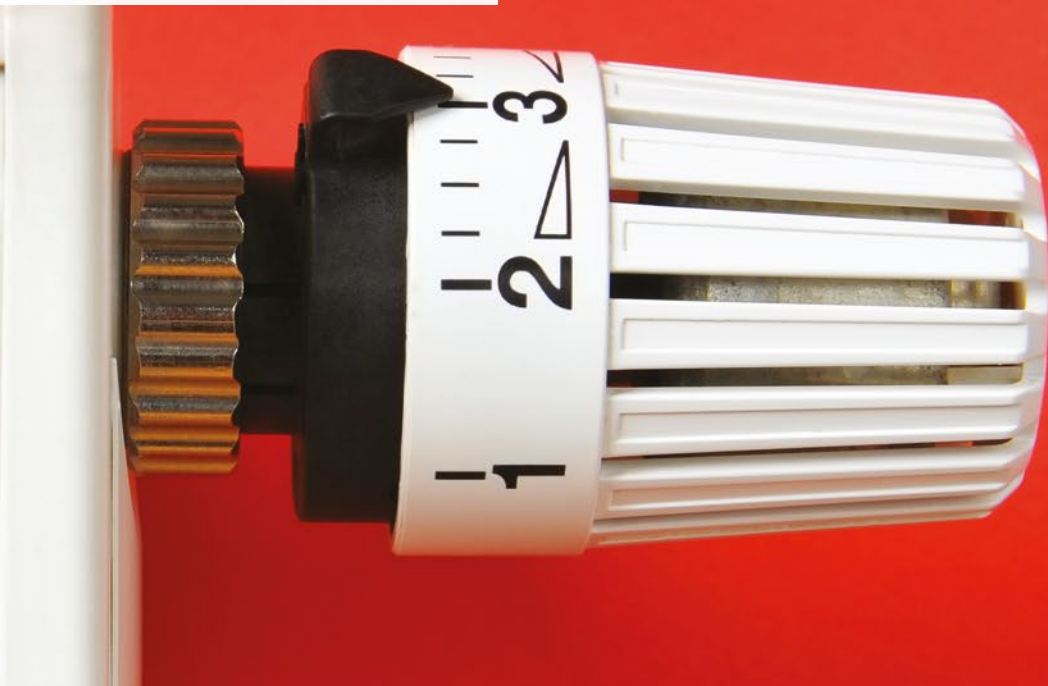
No-one presently knows all of their heating options or which they think are **worth the cost**.



In other consumer centric markets businesses compete to **increase customer satisfaction and loyalty** by **differentiating their offerings** – this does not happen today with heat.



There exists the opportunity for businesses to **utilise the growth** in the Connected Home to deliver appealing, low-carbon consumer heat and comfort.



KEY HEADLINES

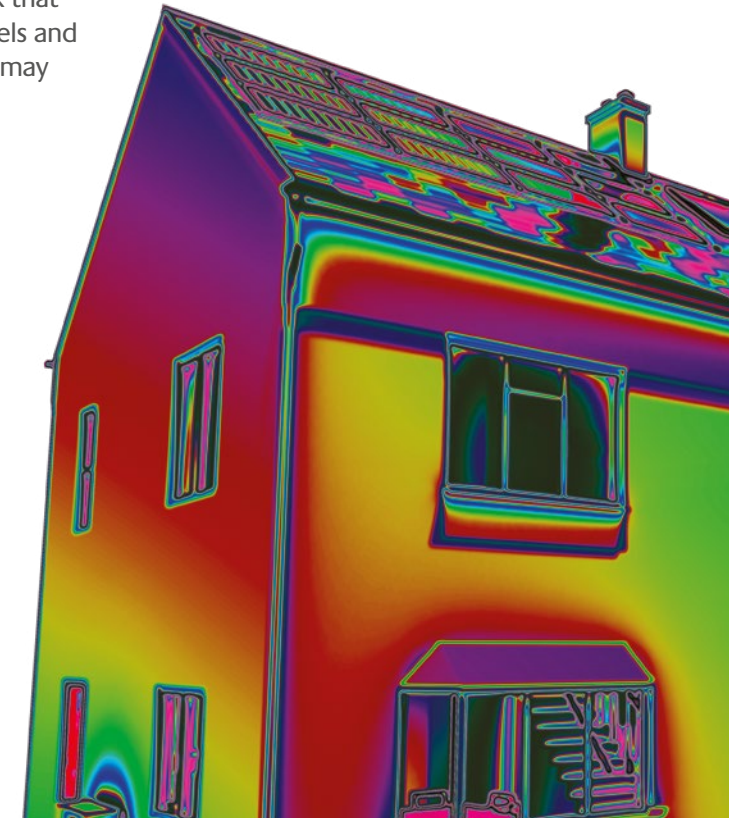
- › Low carbon heating must appeal to consumers if the UK is to tackle climate change. We need to effectively eliminate the 20% of CO₂ emissions that come from how we use heat at home as it is harder and more expensive to decarbonise other sectors. Limited progress has been made even where it is easy, heavily subsidised or mandated. However, as things stand, 90% of consumers would prefer gas central heating to lower carbon alternatives and parliament is unlikely to take action that is widely seen to negatively impact on home life. Progress would be faster and simpler if consumers found low carbon heating designs more appealing. After all, almost everyone with access to the gas grid installed gas central heating, despite the disruption, as it was better than what they had.
- › Consumers might welcome solutions if they enhanced their experiences using heat at home by:
 1. Fixing widespread problems like draughts, damp, mould and overheating (even in winter). We found 2/3 of households report at least one of these problems. Many endure problems to avoid the hassle, disruption and challenge of tackling them.
 2. Helping people get more value from the energy they use to get clean and comfortable at home. We found people care far more about their experiences than how they are delivered. They like the idea of buying services, like a warm home, rather than kWh of fuel and a boiler.
 3. Delighting people with experiences they enjoy but do not expect. We found few realise they value using heat to improve their health, relationships and property. Most rely on heat to relieve aches, host guests or prevent pipes freezing.
- › Consumers will need help to get high quality experiences from low carbon heating solutions. Consumers vary in the experiences they value at home and how much they want to spend on them. Every home needs upgrading in different ways to deliver these experiences without emitting carbon. It is technically challenging to design solutions that will work well, and each home has unique features. Most consumers would prefer to be able to trust someone else to simplify this complexity for them. Businesses who can deliver low carbon energy services that people value could reap huge rewards.
- › Policies could harness the emerging 'smart home' to garner public support for decarbonising heat. Last year we designed and trialled an advanced home energy management system in 30 homes. Participants could compare the cost of heating different parts of their home to different temperatures at different times so that they could get the most value from the money they spent on energy. They liked the idea that they could use these types of system to buy a warm home and leave businesses to deliver that service without any carbon. They were

open to businesses playing a larger role in selecting and installing their heating equipment as long as they could still control their experiences. This could create new ways for government to enable businesses to bring low carbon heating systems to market and reduce the costs of building, upgrading and operating energy networks.

- › Decarbonisation could help the vulnerable access basic energy services, but there are also risks. Today, as with other services, vulnerable households face a serious challenge accessing energy. There could be opportunities for policy makers to harness emerging technologies to reduce fuel poverty. There is a risk that new energy service business models and decarbonising the energy system may

harm some groups, like those without the internet or those living in rural areas with fewer energy network options. Work is required to ensure the benefits of technology reach all members of society.

The Energy Technologies Institute (ETI) has developed its Smart Systems and Heat programme to help create future-proof and economic local heating solutions for the UK. The Energy Systems Catapult (ESC) are delivering the first phase of the programme to the ETI, with the ESC taking on phases two and three of the programme which will see large scale demonstration of the methodologies and technologies developed in phase one.



Context

Climate change

Humanity needs to radically reduce carbon emissions to minimise the impacts of climate change. Successive UK parliaments have agreed a sequence of carbon budgets to deliver the cuts required. Although challenging, there is widespread consensus that it is cheaper and easier to decarbonise domestic heating than other sectors, such as heavy goods vehicle transport and international aviation.¹

Progress so far

The energy we use on heating and hot water at home produces about 20% of UK carbon emissions. Reductions have been made, but progress is slower than required and may become more challenging. Previous cuts have been relatively simple and cheap. Deeper cuts could prove more disruptive, complex and costly (see Figure 1).

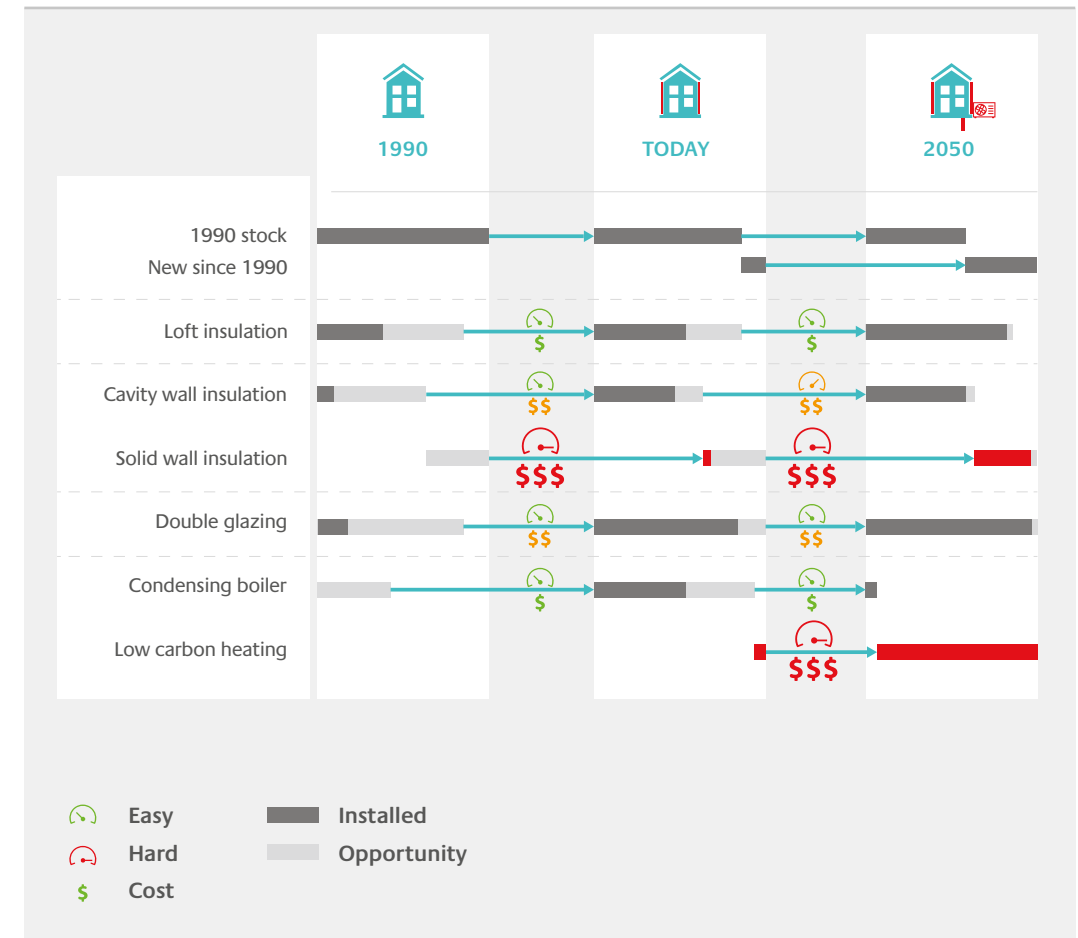
We cannot succeed by using less energy more efficiently unless everyone agreed to use none. Instead we need to find a way for people to get the heat they want at home without emitting any carbon. This means replacing the natural gas central heating in around 90% of homes with something else. Public support will falter unless people can get the experiences they value from the alternative.

Reasons for optimism

There are reasons for hope. The vast majority of people paid to install central heating, despite the disruption, because they believed it was better than what they had. That energy system transformation took around 30 years, created many jobs and delivered healthier homes. We have around 30 years to make another energy system transition with far better tools available and greater rewards to reap.

Figure 1

We need to deliver disruptive, complex and costly measures to tackle climate change²



¹ Analyses by the Energy Technologies Institute, Committee on Climate Change, Department of Energy and Climate Change, University College London and others draw similar conclusions.

² The data underlying this picture comes from official government statistics and strategies.

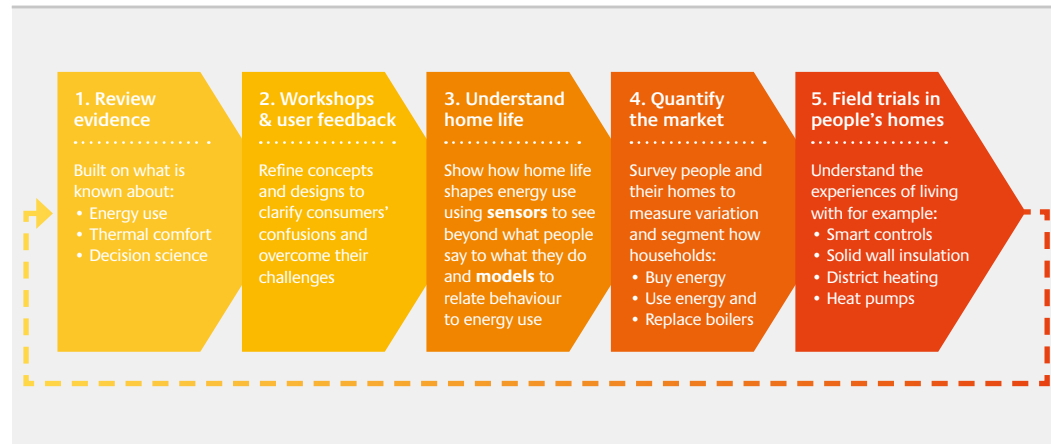
Introduction

The ESC has conducted extensive consumer research for the ETI to understand how to put consumers at the heart of decarbonising heat (see Figure 2). This bespoke blend of studies has:

- › Applied iterative user-centred design to co-create solutions with consumers;
- › Used sensors to see beyond what people say to understand what they do;
- › Deployed data science to relate household behaviour to energy use;
- › Surveyed buildings to measure relevant aspects of people's homes;
- › Ran field trials to understand the experience of living with low carbon heating systems.

Figure 2

Overview of the consumer research this report is based on



Early work highlighted how to improve low carbon heating solutions

There were three important findings from early work.³

First, households value the experiences they get from energy more than how they are delivered.

Most people realised they use heat to get clean and comfortable. However, many underestimated how much they also valued using heat to enhance their health, enrich their relationships and protect their property.

Second, most households endured problems rather than face the hassle, disruption and uncertainty of trying to tackle them. Around 2/3 of households reported draughts, damp or mould in their homes. Similarly, 2/3 had to act to prevent overheating, even in winter.

Third, only a tiny minority chose low carbon heating when they upgraded their heating. Those who had installed heat pumps were more likely to be affluent technical people already renovating their homes who were more able to afford the high initial cost, oversee the work and handle the relatively small increase in disruption.⁴ Given the choice available today, 90% preferred gas central heating as it was simpler to install, cheaper and more familiar.⁵

People will be more open to lower carbon solutions if they enhanced their home lives, solved common problems and were simpler to install.

Recent work is exploring how energy services could improve low carbon heating

The logic is that if consumers bought the outcomes they wanted – a warm home rather than kWh of fuel – their service provider could deliver those outcomes using any heating system. If policy makers set the sector carbon targets, then consumer feedback would drive energy service providers to improve the design, marketing, installation and pricing of low carbon heating solutions.

To test this logic, we designed and trialed a zonal Home Energy Management System (HEMS) in 30 homes using off-the-shelf components to simulate the levels of data and control that will be possible in the 2020s. This HEMS controlled each radiator with wireless radiator valves and monitored room temperature, room humidity, radiator temperature, water pipe temperature, electricity and gas consumption. The user interface enabled trialists to discover the costs of heating their home in different ways to see if this converted them from passive bill payers into more discerning customers. Only one of the thirty homes dropped out partway through the trial.

In parallel, we have been learning how to design and deliver delightful energy services. Standard co-creation exercises show that consumers like the idea, but need to understand how it would work for them and what it might cost before they can really judge the appeal. To that end, we have converted subjective experiences, like comfort, into a draft definition of a heat service that consumers can understand and businesses can price. We are in the process of trialling the experience of buying this heat service with 100 homes over the winter of 2017-18 and quantifying the relative appeal of different levels of heat service with 1,000 households. Finally, we are surveying 3,000 consumers at home to develop a segmentation that can guide efforts to design a range of appealing energy services.

This report considers how to make low carbon heating the natural choice for the vast majority.

1. It draws on existing evidence to describe **what experiences people want from heating**;
2. It explains the need to **engage consumers effectively** to decarbonise their energy supply;
3. It explores if **energy services could help** decarbonise, drive growth and protect the vulnerable;
4. It describes some of the **risks and opportunities** that could come from decarbonising heating.

This report draws extensively on ETI research. In order to improve readability this has not been referenced in detail. Published ETI work is available on our website at www.eti.co.uk and also in the Smart Systems and Heat knowledge zone, a collection of reports and datasets from the first phase of the Smart Systems and Heat programme <http://www.eti.co.uk/programmes/smart-systems-heat>

³ ETI (2015) Consumer challenges to low carbon heat.

⁴ DECC (2013) Analysis of customer data from phase one of the renewable heat premium payments scheme.

⁵ DECC (2013) Home owners' willingness to take up more efficient heating systems.

What do households want from heat at home?

If we want to deliver heating experiences people enjoy, it is vital we understand what people want.

People are very different

It is tempting to generalise from our own experience to try to understand others'. The trouble is this assumes we're all the same, but we're not. One heating study of 290 identical homes found that the highest used twenty times as much heat as the lowest.⁶ This is because, although practically everyone uses energy to enhance their home lives, they aspire to lead very different lives and prefer to use heat in very different ways. Some want to make their home a haven, others a social space, others an asset and many some combination. Around a third try to conserve how much heat they use; a third use heat to make sure they, or someone else, feel(s) comfortable, whatever the cost; and a third are relatively disinterested.

People do not know what they want

It is difficult to learn much merely by talking to people about energy. Public debates relating energy to climate change and resource scarcity can make people less candid if they feel judged. People struggle to report how they use energy because they do so as a by-product of daily life, not as an active choice. Someone who opens a window to remove cooking smells may not know it changes how heat flows.

In our trials, we found that people did not realise how much they enjoyed using radiant heat to take the edge off the cold, or relied on hot radiators to dry their laundry. We found that people's priorities and choices also varied with their situation.

Someone who lives alone and normally uses a timer to control their heating to save money, may choose to leave it on all day to make a guest feel welcome.

When it comes to understanding energy use, it is key to combine questions with sensors so that people can answer accurately and thus reveal what they actually do.

People cannot say what they will like

Few know exactly when they will want to use different rooms or what air temperatures their household will like when they do. People who use zonal heating controls mistakenly set up each room to the temperature on their home's room thermostat only to find it uncomfortable later on.

People cannot say how they will react to things they have never experienced. Trialists who expected to use remote heating controls to turn heating down to save money when they were out, often discovered they turned it up from their couch to get more comfortable.

When it comes to understanding the potential of new technology, it is critical to test it out in real life.

Not everyone is focused on their bill

Surprisingly, given the emphasis on switching to save money, only 15% change their energy supplier each year⁷ and only 1/3 worry about paying their energy bills. Indeed, 50% find it more important to keep their home at a comfortable temperature than to save money on their energy bills.⁸

Part of the reason for this is that people have no way of knowing how much they spend using energy for different things. Participants in a study of the highest and lowest 10% of gas consumers did not even know if they used more or less than average.⁹ Only 50% know they use most of their energy for heating. Many are surprised to discover it costs more to heat their home on a cold day, perhaps because their bills are spread across the year so their direct debit remains the same.

People find it empowering to understand their options

In contrast to so many other parts of their home life, like what they eat or how they relax, when it comes to energy, people do not know what options they have, or which they think are worth the cost.

Our HEMS trialists were fascinated to discover what it cost to heat their home in different ways. Some who worried about cost relaxed when they realised how little they spent. Others who had not really considered the cost were surprised by how simple it was to save. All enjoyed feeling more in control of how they used heat to get what they wanted. They found it enlightening to see how much money was at stake and what made most difference to the cost of heating their home: the times, temperatures or number of rooms.

(Almost) everyone wants to use heat to get clean and comfortable

Most people use heat to get comfortable at home, though 5% report using no heating at all. There is huge diversity in the amount of time people spend at home, what they find comfortable and how they combine heating with other things to get comfortable. Around one in five households spend nearly all day at home every day, whilst half spend only one day a week at home all day. One study found that whereas one person found a change of less than 1°C uncomfortable another put up with a change of 10°C.¹⁰ Half of homes with central heating use secondary heating, like gas fires or portable electric heaters, to top it up.

There is limited understanding of what environments people want in their homes. Most studies of thermal comfort have been done in controlled or extreme environments like the laboratory, the Arctic or inside a car. Focusing on thermostat set points is misleading as people find the same temperature feels cooler in a draught and warmer in the sun as comfort is influenced by air flow and radiant heat amongst other things.

People are, on average, more likely to shower in the morning and bathe at night though timing varies across households, some prefer one to the other and most do both more in summer. Around one in six prize cleanliness particularly highly, taking more than one shower or bath a day and being more likely to say they use heat to prevent damp and hot water to make their home smell nice. Conversely, one in six report showering or bathing only four times a week. Showers can last anywhere from 1 to 30 minutes. One indication of how highly people prize hot water is that many miss showers more than warmth if their boiler breaks.

Many might pay more for something better

Around 2/3 of households report damp, draughts, or condensation and acting to prevent overheating, even in winter. These are strong signals of dissatisfaction that could motivate households to integrate energy within their home improvements, if they only knew how. Instead, they are so used to overcoming frustrations they do not realise that they would prefer something better.

Few realise they value heat for many other things

However, people are far less aware of how much they value using heat to enhance health, enrich relationships and protect property.

Few realise how heat relates to their health until they fall ill. Those who do fall ill often prioritise using heating to enhance their health above all else. The 30% who often use heat to relieve pain may use exceptional amounts of energy.¹¹ When given examples, 61% report health as a key factor in how they use heat and 19% say they live with someone suffering a heat-related health concern. About half feel it is important to turn water temperatures down to prevent scalds and 80% open windows in winter to get fresh air. Physiologically, cooling down drives the sleep cycle¹², which would help explain why heat can keep some people awake.

6 Andersen (2012) The influence of occupants' behaviour on energy consumption investigated in 290 identical dwellings and in 35 apartments. Healthy Buildings 2012.

7 Ofgem (2016) Consumer engagement in the energy market since the Retail Market Review.

8 BEIS (2017) Energy and climate change public attitudes tracker and our own research.

9 DECC (2012) Domestic energy use study: to understand why comparable households use different amounts of energy.

10 Jacquot et al. (2014) Influence of thermophysiology on thermal behaviour: the essentials of categorization. *Physiology and Behavior*, 128, 180-187.

11 DECC (2012) Domestic energy use study: to understand why comparable households use different amounts of energy.

12 Kräuchi (2007) The human sleep-wake cycle reconsidered from a thermoregulatory point of view. *Physiology and Behavior*, 90(2-3), 236-45.

What do households want from heat at home?

Continued >

Three quarters of people live with others and most who live alone host guests. Just over half of people report actively using heat to care for others. People enjoy using zonal heating controls to make others feel comfortable around their home. Households with a dependent infant or someone who is unwell are more likely to prioritise the needs of that person. Others fail to find a compromise: many adults report arguing about their heating.

Many also use heat to protect their property, for instance from pipes freezing or damp damaging walls. Just over 40% selected these as significant factors in how they used heat at home. Around half of homes hold some form of home emergency insurance. Around a third say they would like to open their doors or windows to keep cool, but do not because of concerns about security.

People value convenience

Finally, it is worth emphasising that it is not just these outcomes – comfort, cleanliness, well-being, harmony, safety – that people value, but also how they are achieved. With experiences, the journey is

also important, not just the destination. That is why 80% agree they would *want the convenience of immediate hot water* in their next heating system: smart controls trialists relish the *simplicity of adjusting their heating* with their phone, and 70% pay for their energy by direct debit at least partially so that they can enjoy the *predictability of a fixed bill*.¹³ Conversely, people with old storage heaters that charge overnight and gradually release heat during the day lament their inflexibility.

There are clear patterns, they are just hard to see

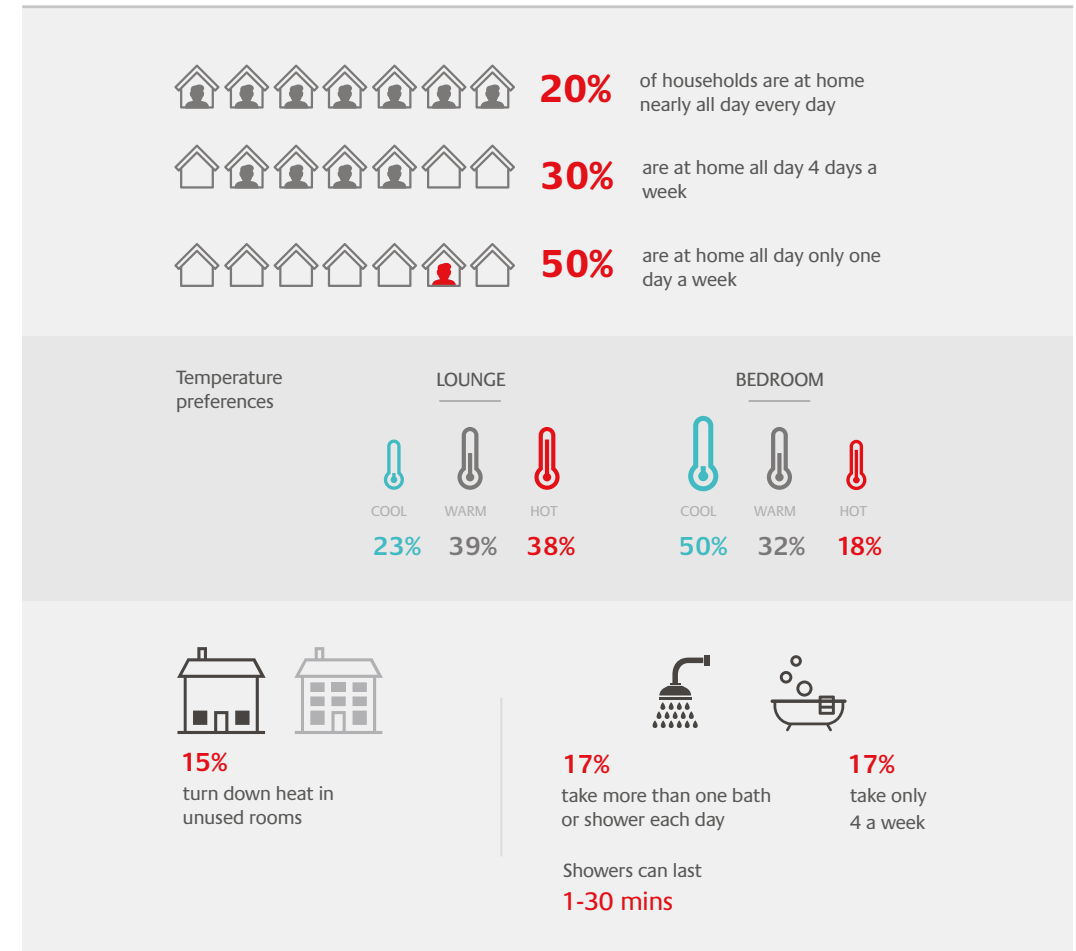
When it comes to how people use heat, there is no simple relationship between where people live, the priorities they hold and the experiences they will enjoy. Instead the links are complex and dynamic. People with varying priorities can live in any home and households vary hugely in how they use heat. What is clear, as Figure 3 shows, is that households will need to be able to pick from a range of plans if they are to find a level of energy service that meets their needs.



¹³ Ofgem (2016) Consumer engagement survey.

Figure 3

Different levels of heating service will meet different household's needs¹⁴



¹⁴ Data for this figure comes from our own research and Pullinger et al. (2013) Patterns of water.

Why do consumers need to be involved with decarbonising domestic heating?

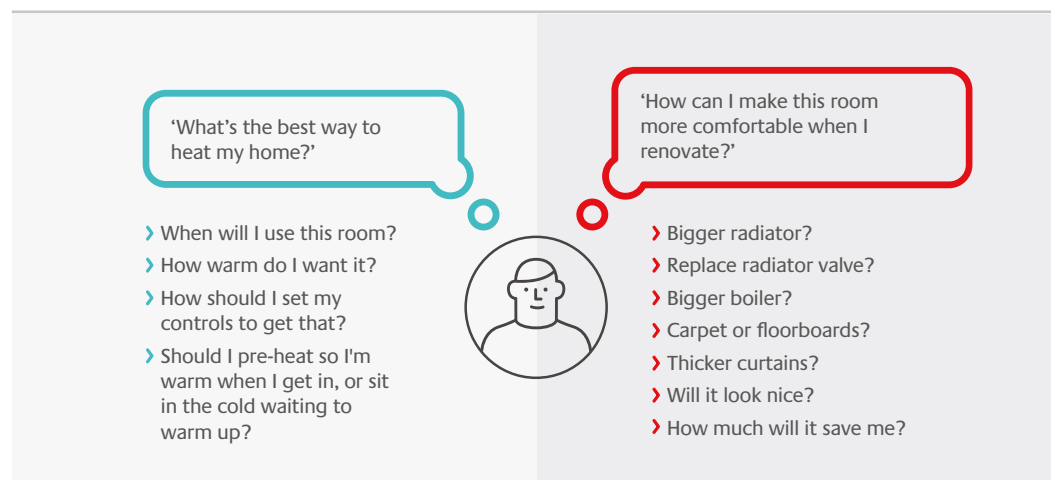
Today we can get by with gas without knowing how to deliver great experiences

It is hard for households to understand how to get the most out of their heating system. Is it worth spending time, effort and energy setting controls to pre-heat your home so it is warm when you get in, or turning it on when you arrive and sitting in

the cold waiting for it to warm up? They face a similar problem in deciding how to factor heating into home improvements. What's the best thing to do if you want a cosier room? It is hard to know how upgrading any part of the home will influence the final integrated experience (see Figure 4).

Figure 4

What is the best way to heat the home or include thermal factors in home improvement?



Today, we muddle through without knowing how our homes limit our choices, or which choice is best. People heat their home without knowing the cost of the alternatives and renovate their home without taking opportunities to improve its thermal performance. This works with powerful boilers burning plentiful, cheap gas that can warm up cold homes or cold water quickly when needed. It could prove fatal to ambitions of delivering low carbon heating.

We will need new ways to involve consumers with decisions about how to decarbonise heat

Decarbonising heating means changing how

we generate, move around and use energy at home. There are complex choices to make about how to spend large sums. Consumers will be more supportive of decisions that enable them to get the experiences they want from using heat at home. This section discusses some of the challenges involved.

Around 80% of today's homes will still be standing in 2050. They were designed to be heated by burning fossil fuels. Older homes were heavily ventilated to remove particulates and carbon monoxide from open fires. Now around 90% use gas boilers to pump hot water through small radiators and to bathrooms.

Tackling climate change means heating these homes with something other than natural gas. Many analyses highlight a role for three options:¹⁵

1. Electrifying heat in individual homes,
2. Connecting neighbourhoods to new district heat networks distributing hot water, or
3. Repurposing the natural gas grid to transport hydrogen or biogas instead.

They all come with significant challenges.

In each case, households will need to replace or transform their natural gas appliances to work with a different source of energy. This means they will need to break out of the gas boiler replacement cycle in Figure 5 and install an alternative. Around 40% are open to low carbon heating, drawn by new technologies or environmentalism, but few have heard of heat pumps (38%) or district heating (17%).¹⁶ In the end, 90% install a new gas boiler instead when they replace their system.

Electrifying heating means generating more low carbon electricity, upgrading networks to transport these higher loads and replacing gas boilers with electric heaters, like heat pumps. Heat pumps are more efficient than boilers but less powerful, so millions of buildings will need renovating to warm up on cold days and space to install a hot water tank. However, people do not know how to include thermal factors in their home improvements, or the best way to heat their home (see Figure 4). They may not welcome the complexity, expense and disruption of installing some combination of insulation, draught-proofing and a new water tank, just to match heating experiences they can already get from gas boilers. After all, most simple steps have already been taken (see Figure 1) and only half of homes now have hot water tanks. Indeed, people often remove water tanks and use the space for something else when replacing their

boiler. Households will need help making suitable upgrades, or electrification could make it harder for them to use heat to get clean and comfortable at home.

Connecting neighbourhoods to new heat networks or repurposing the gas grid present different challenges. Local areas will need to find a way to decide what type of network they want in order to avoid paying for several in the same place. Those that build heat networks will need to persuade enough households to connect to recoup the construction and operating costs. Those that repurpose the gas grid will need to co-ordinate households to switch from natural gas to a new fuel in a short period, of perhaps a few weeks. Local areas may need to develop new processes to make these decisions and organise these activities.

Whichever option is taken, there is a question about how much capacity to build. Today we store enough gas to heat the nation's homes for many days. Tomorrow, with future energy systems, we will need to decide if we want to pay for capacity to use on rare occasions. Some may value the freedom to do what they want when they like; others may prefer to save some money to accept some limits, as they do with train tickets, mobile plans or broadband packages for instance. Clearly, we will need effective ways to garner strong public support for the capacity we build.

Standard market research can only provide limited input into these sorts of decisions as consumers will struggle to say which future they would prefer, from alternatives they can barely imagine. The next section explores the potential for energy services to reveal consumers' preferences instead.

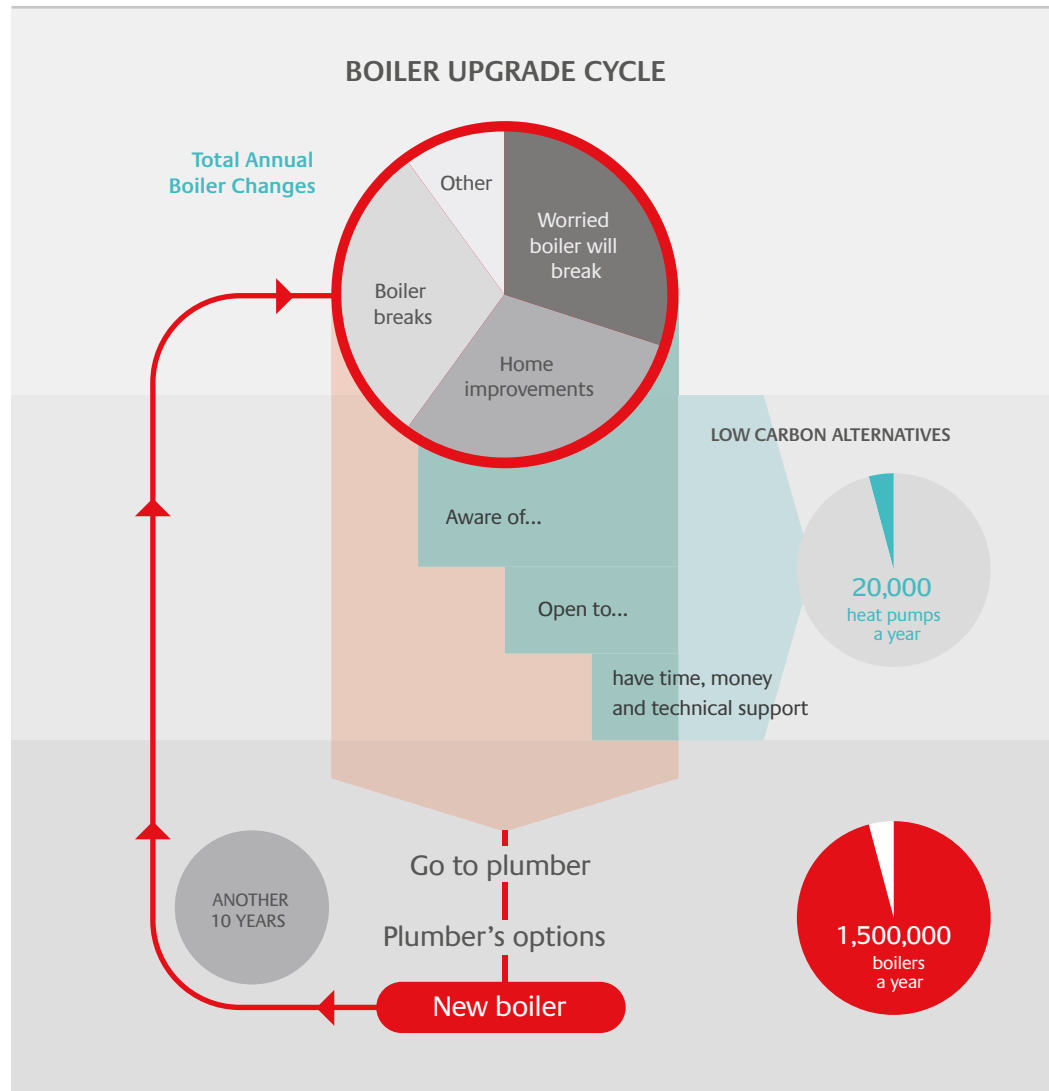
¹⁵ BEIS (2017) The Clean Growth Strategy: Leading the way to a low carbon future.

¹⁶ BEIS (2017) Energy and climate change attitudes tracker.

Why do consumers need to be involved with decarbonising domestic heating?

Continued >

Figure 5
The challenge of breaking out of the boiler replacement cycle¹⁷



¹⁷ Reasons for boiler replacement come from DECC (2013) Home owners' willingness to take up more efficient heating systems. Estimates of the number of boilers installed each year come from the Energy and Utilities Alliance: <https://www.eua.org.uk/hhic-sees-the-devil-in-the-detail>. Estimates of the number of heat pumps installed each year come from CCC (2017) Meeting Carbon Budgets: Closing the policy gap, p76.

Decarbonising domestic heat is a very complex systems integration challenge... but remains one of the more cost-effective ways to tackle emissions in the UK

Could energy services reveal what consumers want from low carbon energy systems?

It is hard to imagine a different energy future. Looking back can make it easier to see ahead. 35 years ago, almost no one had a mobile phone, PC or used the internet; now these things underpin our lives. Today almost everyone burns natural gas to get comfortable at home; in 35 years' time, if the UK is to decarbonise, practically no one will.

What if, in future, people bought energy services rather than fuel and boilers? Their energy service provider would have to integrate 'smart' connected components from many device vendors and energy resources from many producers, distributors and 'storers' to deliver this service.

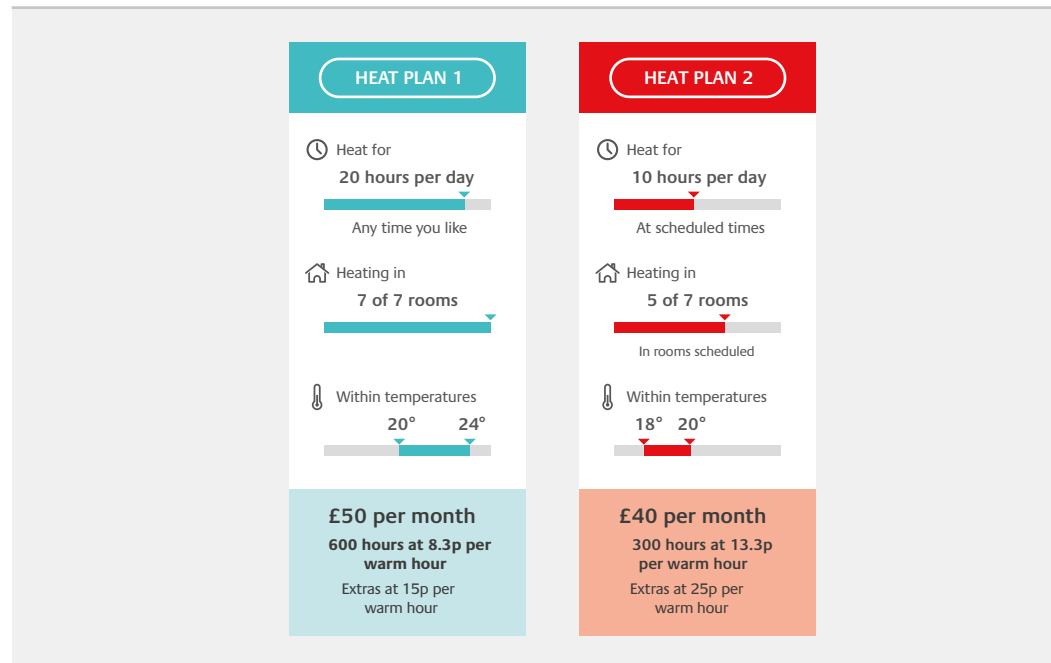
The promise of ubiquitous, invisible computers enabling the smart home was also born 35 years ago.¹⁸ Now – with the advent of cheaper, smaller,

wirelessly connected sensors – the connected home appears to be coming of age. This section discusses how policy makers could harness market forces to exploit this as an opportunity to deliver affordable, low carbon energy that consumers want to buy.

Why might households want energy services?

Consumers only buy electricity, gas, boilers, radiators and so on to get the experiences they want. They are more interested in buying a warm home than units of fuel and a heating system and like the idea of buying services from someone responsible for delivering the outcomes they want. They realise that every household would want a different level of service and that the cost would depend on their home, heating system and how they used it.

Figure 6
Heat plans comparing two different levels of heat service



Today, it is hard to decide how much to spend getting the energy experience you want without knowing the cost of the alternative options. People can imagine living in smarter homes and sharing data about their boilers, radiators, room temperatures and so on, to access a world of energy services. In that world, households would be able to choose between the sorts of options shown in Figure 6: heating the whole home all day to high temperatures for one price, or only heating parts to lower temperatures for some of the day for another price. Their choices would reveal what they were willing to pay for different levels of service, both to them, but also to their service provider. HEMS trialists, who experienced this possibility, **were transformed from passive bill payers into discerning customers who knew what level of service they would buy in their home.**

Today, people upgrade their gas boilers with a newer model when they replace them. In a world of energy services, providers would need to know enough about each home to estimate the cost of delivering energy services with any type of heating system. If households were satisfied with their service, they would not care if it was delivered by a gas boiler or a low carbon alternative, providing an opportunity to break out of the gas boiler replacement cycle in Figure 5. Indeed, most say they are open to a lower carbon option, unless it cost more or delivered a worse experience.

Why would businesses want to sell energy services instead of units of fuel?

The energy supply market is challenging. Attracting new customers is expensive and those who do not switch cannot be expected to subsidise those who do. Those who switch to join, may be more likely to switch to leave. The number of suppliers has

grown from 12 in 2010, to 60 as of June 2017. New entrants, some facing lower overheads and seeking lower profits, can make very attractive offers.

The energy market encourages customers to switch between suppliers offering the same proposition. Other markets increase customer satisfaction and loyalty by differentiating their offers.¹⁹ Far fewer switch landline (3%) or mobile phone provider (8%) than energy supplier (15%).²⁰ Commercial decision makers also face risks from policy uncertainty: energy bills were discussed 4,637 times in parliament since 2010, compared with only 983 references to mobile and landline phone bills combined.²¹

It is harder to deliver energy services than units of fuel. Providers need to understand their customers' expectations, help them understand what is possible and explain the limits of any service. They will need to work across the supply chain to integrate different components – heat pumps, radiators, smart thermostats – to deliver experiences people want to get from using energy. They will need to learn how to price services to attract customers without charging less than they cost to deliver.

It is worth taking the trouble. Businesses who sell energy services will find it easier to attract customers and keep them happy. Satisfied customers will pay more for services they value, complain less and be more loyal. They would be delighted if services met needs they did not even realise they had. Customers' preferences would be revealed by the levels of service they chose. Those able to interpret this to design and deliver energy services could also access a set of other commercial opportunities described below.

19 Ofgem analysis of DNO, Xoserve and supplier reports show that 357,822 electricity and 272,759 gas customers have switched supplier each month, on average, since 2003.

20 Ofcom (2016) Access and inclusion in 2016, Annex. Available at: https://www.ofcom.org.uk/_data/assets/pdf_file/0029/98615/access-inclusion-research-annex.pdf
Ofgem (2016) Consumer engagement in the energy market since the Retail Market Review.

21 Hansard search (1st August, 2017) at: <https://hansard.parliament.uk/>.

18 Mark Weiser describes Xerox's seminal 1980s work on this in Weiser (1991) The Computer for the Twenty-First Century, Scientific American.

Could energy services reveal what consumers want from low carbon energy systems?

Continued >

Could energy services enable government to decarbonise?

Today's policies use incentives to persuade households to decarbonise their heating. This presents households with a highly technical challenge without a mature supply chain to buy solutions from. Mandating that people decarbonise their homes could prove unpopular if they end up with bad experiences. Subsidies could be criticised if they raise everyone's energy bills to reward the minority who are willing and able to upgrade their homes.

In the future, could government introduce a long-term, technology-neutral, carbon target to persuade energy service providers to decarbonise instead, as they have for car manufacturers? Might that motivate businesses to invest in R&D, driving economic growth, and improve consumers' welfare by removing subsidies from their energy bills?

Consumers are open to their energy service provider decarbonising their energy supply as long as they can get the heat experiences they want: people who enjoy their meal do not care what oven it was cooked in. Many consumers would be pleased to be able to trust someone else to select the components they need, install them correctly, maintain them effectively and operate them efficiently.

Could energy services increase sales of low carbon heating systems?

Today the gas boiler replacement cycle locks out low carbon heating systems (Figure 5). Households go to a plumber to repair or upgrade their heating system. Plumbers only invest in learning how to install a limited number of gas boilers. By calling a plumber, households often end up choosing the gas boilers they install, without even realising it.

If energy service providers were mandated to decarbonise over time, could they become a channel to market for low carbon heating systems

like heat pumps? Might device vendors allow service providers to control their equipment in exchange for a share of the value their device delivered? Could usage data drive a roadmap for improving existing products and developing new ones? Would an industry capable of delivering consumers better, lower carbon, energy services create new, high-skilled jobs?

Could energy services unlock investment in energy networks?

Today it is challenging to invest in energy networks. District heat schemes must supply lots of nearby buildings to be commercially viable; as costs of pipes and heat loss, rise the further heat is transported. Similarly, electricity networks will need upgrading if they are to power heating and charge vehicles in people's homes. The more heat or electricity required, the more expensive the infrastructure will be.

However, it is hard to discuss new heating options with many households, never mind persuade them to commit to buy a system they are unfamiliar with.²² This increases the risk that investors will not recover their investment, thereby raising the cost of loans.

Might investors find it simpler to work with a small number of energy service providers, each representing a large number of households? Is it possible that parts of the country may prefer to pay more for unlimited use as they have with broadband and mobiles, rather than minimising the cost?

Could energy services reduce the costs of operating networks?

Operators could spend less upgrading their electricity networks if they found ways to reduce peak demand. One popular concept with distribution network operators is to reward consumers who use less electricity during peak hours (demand side response). However, it may

prove hard to convince 26m households not to use electricity when they want for small sums of a few pounds a week. After all, only 15% spend far less time taking the trouble to switch each year for much larger savings.²³

Might district network operators find it easier to persuade a smaller number of providers to learn how to deliver the energy services consumers want, without using electricity at peak times? The incentive would be far higher for an energy service provider with a million customers (a few million pounds each week), than any individual household. If so, market forces might drive energy service providers to find the most cost-effective way to use networks, reducing the costs of upgrades to society overall.

²² DECC (2013) Home owners' willingness to take up more efficient heating systems.

²³ BEIS (2017) estimate many households could save £200 per year by switching supplier. <https://www.gov.uk/government/publications/household-energy-savings-through-switching-supporting-evidence/many-households-could-save-around-200-per-year-through-switching-energy-supplier-basis-for-claim>

Fair future

Today millions of households struggle to get a basic level of energy service

Millions of UK households are classified as fuel poor.²⁴ As a nation, we spend billions every year trying to assist. However, it has proved hard to identify and deliver effective support. The numbers in fuel poverty fail to fall²⁵ with costly consequences to society and the economy.²⁶

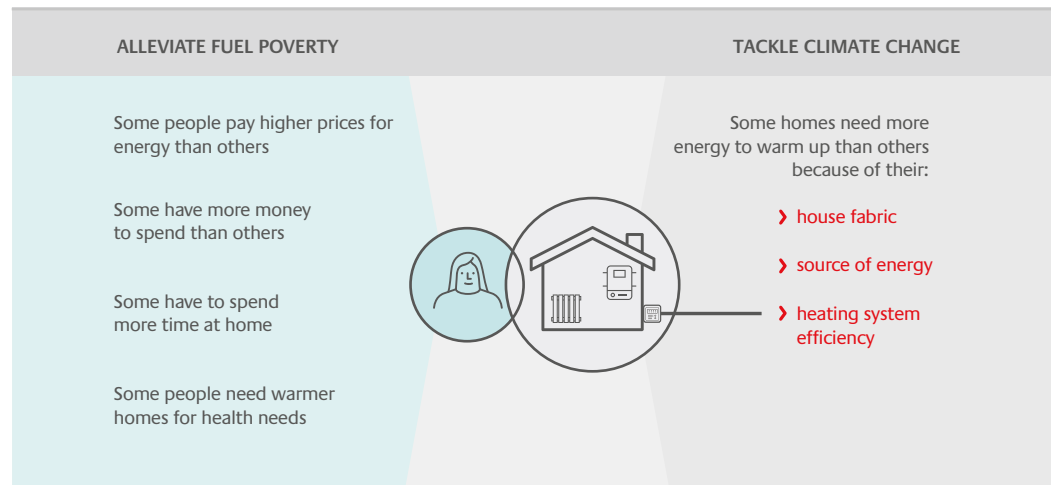
Figure 7 shows that the problem is highly complex. Some need higher levels of warmth than others. The same level of warmth costs more to deliver in some situations than others. Common

life events – like childbirth, illness and retirement – can mean people spend more time heating their home as their incomes fall. Those with more savings, or healthier constitutions, may be more resilient than others.

It is often assumed that tackling climate change will also alleviate fuel poverty. However, differences between the two challenges means that they need different solutions: decarbonising heat to prevent climate change and enabling vulnerable households to get a basic level of heat to tackle fuel poverty.

Figure 7

Influences on the affordability of a healthy home environment. We need to consider the factors on the right hand side to decarbonise heat and tackle climate change. Attempts to alleviate vulnerability to fuel poverty also need to include the factors on the left.



What might aid efforts to solve this problem?

Today there is “a general lack of evidence on the

behaviours and attitudes of households in fuel poverty”.²⁷ There are many types of vulnerable

energy consumer. Each type needs different support. If we had a clearer picture of their problems, it would be possible to tailor what support they received.

Those tackling fuel poverty today can struggle to deliver effective support to those most in need. Support could be targeted and focused more effectively if solutions were co-designed with those able to deliver them and if it was clear how many shared similar problems.

Transforming the energy system creates risks and opportunities

Could a world of energy services reveal new routes to reducing fuel poverty? After all, businesses will need to know what it costs specific households to get warm and clean if they are to sell energy services. One possibility is that government could

target subsidies through performance-based contracts that rewarded businesses for assisting those least able to afford a basic level of energy service.²⁸

On the other hand, decarbonising the energy system changes the costs of energy which could influence who is threatened by fuel poverty (see Figure 8). Today those who use more energy for heating face higher costs. Tomorrow’s energy system might cost a lot to build but little to use. That means it need not cost more, or emit more carbon, to use a lot more heat, but costs could vary during the day depending, for instance, on how sunny and windy it is. So, those with less flexibility about when they use energy may face higher costs. Finding solutions will depend on knowing who will be pushed into and pulled out of fuel poverty if they are to be future-proof.

Figure 8

Decarbonising the energy system changes the affordability of basic energy services

Who struggles to afford basic energy services?		
TODAY		TOMORROW
Those in rural areas and tower blocks cannot get mains gas	NETWORK	Those without access to low carbon energy networks
It costs more to use electricity, oil or solid fuel than gas	FUEL	It costs more if you use fossil fuels
Larger poorly insulated homes cost more to heat	HOME	Smaller homes without off-street parking may pay more to charge their electric vehicle
People at home all day need more energy to get comfortable	PEOPLE	People out all day need to use more energy at peak times when prices are high

²⁴ NEA (2017) UK Fuel Poverty Monitor 2016-2017: a review of progress across the nations.

²⁵ BEIS (2017) Annual Fuel Poverty Statistics Report 2017 (2015 data).

²⁶ Tackling fuel poverty enhances health, improves work productivity and raises attainment at school: see HM Government (2015) Cutting the cost of keeping warm – a fuel poverty strategy for England, p50.

ACE (2015) Chilled to Death: The human cost of cold homes: estimate that cold homes cost the NHS £1.4bn/yr.

²⁷ DECC (2014) Understanding the behaviours of households in fuel poverty. A review of research evidence.

²⁸ There are other examples of how data might help target support for those in fuel poverty.

BEIS (2017) Annex A: Machine learning and fuel poverty targeting.

Ofgem (2017) The Futures of Domestic Energy Consumption.

HM Government (2015) Cutting the cost of keeping warm – a fuel poverty strategy for England.

Conclusion

If people bought energy services, could businesses decarbonise heat?

We face a daunting challenge. We must decarbonise our energy system and change how we use energy in our homes to tackle climate change. With change comes opportunity. Societies, governments and industries need to act together to make the most of this opportunity. Perhaps there is a route for policy makers to create markets where consumers pay businesses to deliver energy experiences, and their energy service providers compete to decarbonise at least cost.

Consumers value the experiences they get from using the energy system, not the system itself. Today problems are widespread: 2/3 report problems like draughts and damp; 2/3 act to prevent overheating; 2/3 put off replacing their boiler if they feel they can. Few realise how much they value heat to enhance health, enrich relationships or protect property.

In other sectors, entrepreneurs read these signs as spurs to innovate. Car manufacturers interpreted discomfort and inconvenience as evidence consumers would pay more for air conditioning, central locking and electric windows. People spend more time in their homes and more money improving them. The way they behave implies that they would pay for better energy experiences there too.

Today, households are unwilling and unable to buy, install, configure and integrate low carbon heating systems into their homes to get the experiences they want. Tomorrow, with the right adjustments, might market forces reward innovators for designing and delivering desirable low carbon energy services instead? Businesses could certainly apply resources, skills and economies of scale unavailable to any single household. Could energy service providers learn how to help households use energy to enhance their home lives and factor heat into their home improvements? If so, consumers might associate low carbon heating with improved energy experiences, driving demand for the scale of transformation needed to tackle climate change.

Conceivably, a world with energy services could bring society far broader benefits. Could consumers' service choices guide decisions about how to upgrade the energy system more accurately than surveys asking people about futures they struggle to imagine? Might service providers increase investment in energy supply and networks by reducing the risk facing investors? Could energy services reduce the cost of operating energy networks by rewarding businesses that aggregated flexibility? Could energy services be extended to help alleviate fuel poverty? It must be worth investing some effort to discover how to tap this considerable potential.

Discovering how to unlock this opportunity

The ETI collected these consumer insights to learn how to decarbonise the energy system effectively for people. With their support, the ESC has created a capability to help others apply these insights so they can decide how to operate in a smarter, more connected world. It consists of a team equipped with tools organisations can use to blend consumer research, data science and design thinking to design delightful products and services, successful strategies and effective policies. These tools include:

- › **Language** to understand, shape and bound consumers' service expectations;
- › **Consumer segmentation** to design appealing services and suitable service plans;
- › **Models and data packs** to price the cost of delivering services affordably;
- › **A platform** to deliver services to real homes and reveal consumer preferences;
- › A **'living lab'** of households to provide feedback on their service experiences.

The ESC is actively working to understand the potential of energy services by:

- › Trialling energy services with 100 households around the UK;
- › Examining how energy services can help areas switch from gas to low carbon heating;
- › Quantifying the relative appeal of different levels of heat service with 1,000 households; and
- › Helping businesses develop consumer heating propositions.

Finally, it is building an alliance of organisations who want to understand how to take the opportunities that come from transforming our energy system to support the most vulnerable. One focus is to understand what people in fuel poverty need from energy, how many households share common needs and how innovation can improve support. Another focus is to highlight who may be harmed by new energy service models, like those without the internet, or by deep decarbonisation, like those with fewer network options, to help mitigate such unintended consequences.

Further Reading



Decarbonising heat for UK homes



Consumer challenges for low carbon heat



Housing retrofits – a new start



Domestic Energy Services

All of these reports are available via the dedicated insights report page of the ETI website – www.eti.co.uk/insights

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The Energy Technologies Institute (ETI) commissioned its Smart Systems and Heat programme in 2012 with the objective of creating future-proof and economic local heating solutions for the UK. In 2015 the ETI's Smart Systems and Heat team transferred to the Energy Systems Catapult (ESC) to become delivery partners for the first phase of the programme. The ESC will take forward phases two and three of the programme independent of the ETI to demonstrate at scale the methodologies and technologies developed in phase one of the programme.



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