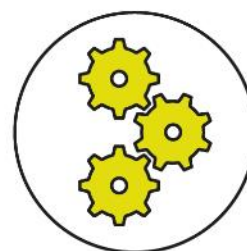


Fuel poverty in a smart energy world

How vulnerable energy consumers could benefit from smarter heating controls

July 2020



Executive summary

Smart Local Energy Systems often propose to use smart heating controls to maximise the use of local energy, whilst providing services to the local network. Some consumers like the idea of using electricity generated [locally](#). This might also reduce the costs and energy losses created by transmitting electricity across the network. By passing on a fair proportion of the resulting network savings, smart local energy systems could help vulnerable households afford the energy they need to be safe, healthy and comfortable.

Although growing in popularity, smart heating controls are not yet commonplace in UK homes. They may fail to deliver consumer benefits, or they may change energy consumption in unpredictable ways. The best way to make sure they deliver positive changes is to design and test them *with* households. [Some studies](#) have explored how consumers use smart heating controls. However, those studies did not include vulnerable households.

The research presented in this report fills that gap. It explores how vulnerable households used smart heating controls and how they could benefit from future smart energy services (e.g. room by room control and advanced information about the cost of different ways of heating their home).

This is what you should know:

- Vulnerable households are not all the same. We may use one term to describe them, but their behaviours, needs and attitudes vary as much as those of other consumers.
- Vulnerable households may struggle to afford the cost of energy, but they have the same fundamental needs as everyone else. We found that they wanted the same things from heating as everyone else: to protect their home, to enrich their relationships and to enhance their health.
- They may be less able to afford their energy bill, but they did not want to minimise what they spent. Instead they wanted to manage how much they spend whilst getting the heat they wanted.
- They enjoyed using smart heating controls to manage their heating. They had previously found managing their heating difficult, time consuming and complex.
- Most people thought it would be useful to understand the cost of their heating. We found that people wanted peace of mind that they could afford to heat their home in future.

This is what you can do about it:

- You can support vulnerable households by designing your smart local energy system to enable them to choose how to use the energy they buy in ways that are important to them (e.g. to stay healthy).
- Vulnerable households could find information about the cost of heating helpful but they will want to be able to use it to decide how much to spend (e.g. getting warm and healthy).
- You can maximise the benefits your smart local energy system will deliver to vulnerable households by involving them in the design of innovations.
- New energy innovations that are based on incorrect assumptions about what consumers want to use energy for could accidentally harm consumers. [This manual](#) can help you test any assumptions you are making about vulnerable households.

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1. Introduction

Decarbonisation and digitalisation will change the way that consumers use and buy energy, creating an opportunity to harness these changes to bring real and lasting benefits to consumers and local communities. In the race to decarbonise home heating, smart energy systems can tailor solutions to the needs of different households, giving them the ability to choose how to use their energy to achieve the outcomes they want.

Households in vulnerable situations, or at risk of fuel poverty, are rarely thought of as consumers of new energy services and products. This trial addresses this gap by specifically exploring the potential impact of low carbon energy technologies for vulnerable energy consumers.

For the purposes of this report, we use the term 'vulnerable households' to refer to households that are at risk of fuel poverty. The criteria we used to determine whether households were vulnerable are shown in the Appendix. Broadly, our criteria mean that the households in this trial were those on a low income and either suffering from a health condition made worse by the cold, or are more likely to be exposed to high energy costs. Here, 'high energy costs' means they potentially pay more for their energy because they have a prepayment meter, they pay on receipt of a bill, or they have debt on their energy account.

For the first time in the UK, we have explored how smart heating controls can bring benefits to vulnerable households. We conducted qualitative and quantitative research with people living with room-by-room smart heating controls and sensors over the winter period of 2019-2020. These people lived across England and Wales and were identified as being at risk of fuel poverty using the criteria outlined above.

All homes were part of Energy Systems Catapult's Living Lab: a 100-home test-environment, where businesses can trial new heat products and services in real homes, with real people. In this trial, each vulnerable household's home was provided with room sensors and smart heating controls. These controls allowed residents to choose the temperature in each room of their home at different times of day and days of the week.

In this trial, we combined qualitative data from interviews with participants, with quantitative data on how they used their central heating and from sensors in their home. We used this data to explore:

- How vulnerable households experienced improved heating control.
- Their motivations for using their central heating and smart controls.
- How cost impacted the way that they heated their homes.
- Their reactions to information about how much it cost to heat their homes.

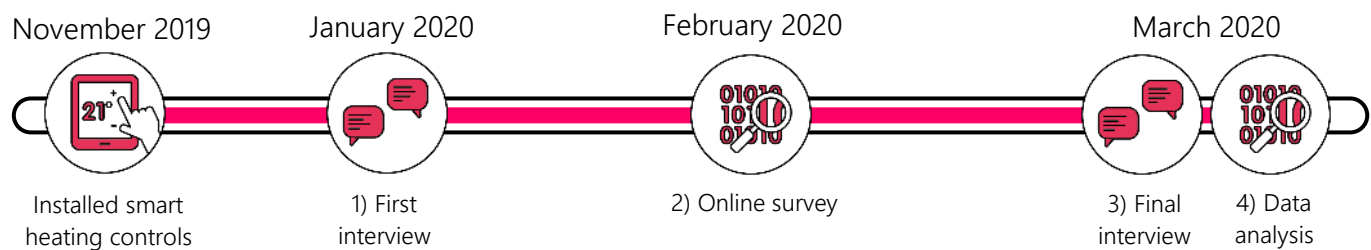
This report presents findings on three overarching themes:

- Vulnerable households are not all the same: they are different in what they want to use heat for, their heating experiences and what they want to spend.
- Vulnerable households do not just want to minimise cost: they are constantly trying to manage the relationship between the cost of energy and the heating experience they want.
- Vulnerable households could become empowered consumers in a future energy system: Showing them the cost of different heating experiences could enable them to choose what they want at the cost they want.

2. Methods

Our Research

We used four methods to collect and analyse data between December 2019 and March 2020.



1) First interview

We conducted a semi-structured telephone interview with participants soon after the installation of smart heating controls. This interview aimed to explore:

- How they controlled their heating before smart heating controls were fitted.
- How they heated their home and why.
- Any benefits of improved control.

2) Online survey

Participants completed an online survey to explore their motivations for heating their home. This distinguished whether their key driver for heating their home was cost, comfort or value for money. Scores for each of these factors were calculated for each participant, based on their answers to the survey, and participants were classified according to the factor they scored most highly on.

3) Final interview

We telephoned participants at the end of the study to investigate:

- Any change in their heating experiences since smart heating controls were installed.
- Their motivations for heating their home now that they have smart heating controls.
- Their understanding of the cost of heating their home.
- How smart heating controls and cost information could affect their heating decisions.

We also showed participants pictures of different ways that their smart heating controls could display the cost associated with different heating schedules.

4) Data analysis

We used top-down thematic analysis to understand:

- The participants' motivations for heating
- Their use of smart heating controls to meet their heating needs.
- The impact of cost on their heating decisions.
- Their perception of information about the cost of heating their home.

This qualitative data was combined with data from indoor environment sensors and the smart heating controls for four weeks, over the month of February 2020. This data included the target

temperatures each household set each individual room to at different times of day and night. We extracted and analysed this data to calculate:

- The average number of hours each household wanted their home warm for each week.
- The average percentage of rooms they heated in their home.
- The average target temperature they set.

We analysed the interviews and online surveys to explain the heating patterns we observed. This allowed us to gain deeper insight into the benefits of smart heating controls for these vulnerable households.

The sample of households in this trial

Vulnerable households may struggle to afford to heat their home but are diverse in the homes they live in and their everyday lives.

Households were recruited to this trial if the household and house were identified as being at risk of fuel poverty. We did not specifically recruit to create a diverse group of households within this sample. Nonetheless, the trial includes people living in a diversity of houses, households and everyday situations (Figure 1). All homes had gas central heating.

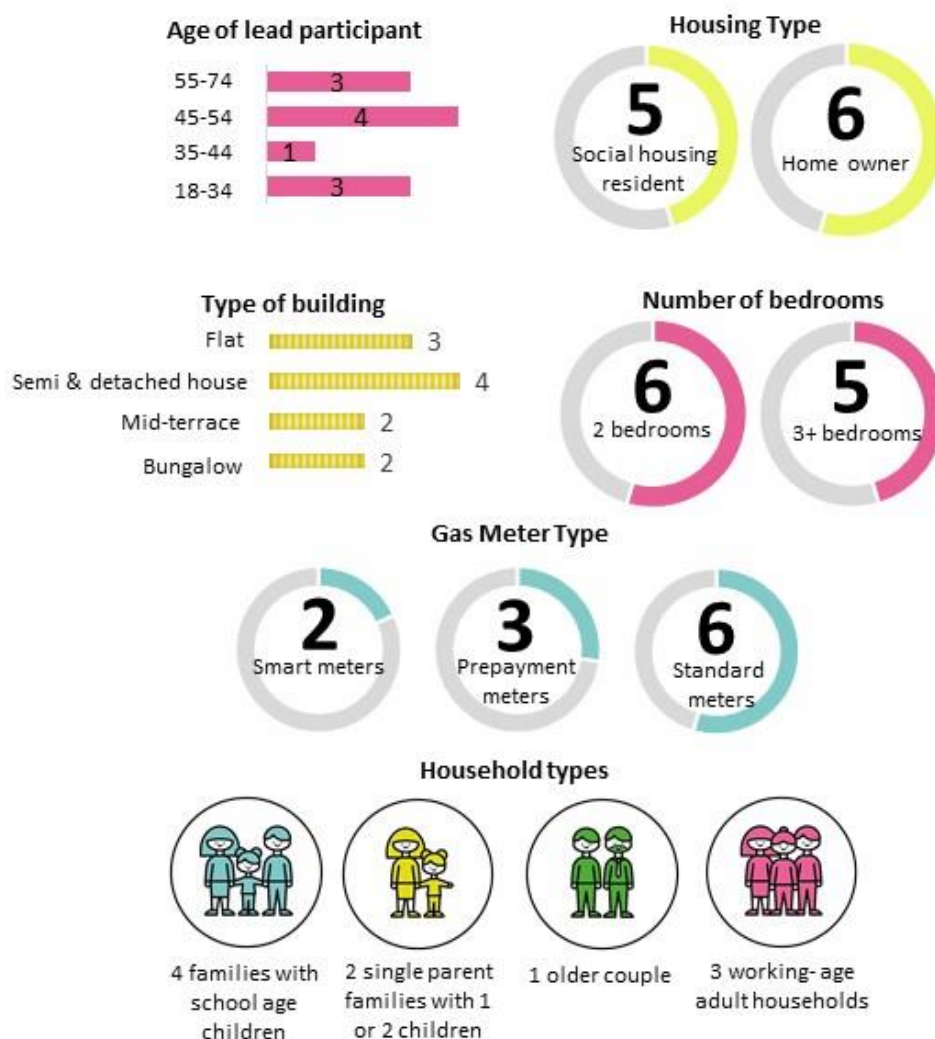


Figure 1. The profile of households in this trial.

Recruitment for the trial

Finding households at risk of fuel poverty is widely acknowledged to be difficult. Those offering support and advice (such as energy suppliers and consumer advocates) spend a significant amount of time and money trying to reach the 'right' households for the support they have to offer.

We worked with a social housing provider, Bromford Housing, and an energy supplier, Bristol Energy, to try various traditional and innovative approaches for finding people to take part in this research.



Figure 2: Recruitment methods used to recruit homes at risk of fuel poverty to join this trial

All six recruitment methods (Figure 2) invited potential homes to register their interest in the trial via a website. The smart heating controls were then installed once homes had passed a survey to see that they were technically suitable.

As a result of these recruitment channels, 84 homes registered their interest in the trial via the website. Approximately half of the households in this research were engaged through their social housing provider and the remaining households from the focus groups, their energy supplier and existing homes in the Living Lab.

Key learning: We found that the best methods to find and engage people at risk of fuel poverty was through **existing relationships** that their households had with organisations that they already knew. This included housing associations, energy suppliers and research agencies.

If you're looking to conduct research or test your innovation with vulnerable households, you should work with a **trusted partner** that can unlock these relationships for you.

3. Findings

Key Learning: People wanted to control how much they spend using heat to get comfortable, care for others and protect their building.

Whilst participants were influenced by cost, they reported various motivations for heating their home. These included meeting their needs for personal comfort, caring for others and protecting their home.

Heating to optimise comfort and well-being

Even the homes that reported being cost-conscious also valued being warm in their homes. Whilst a few told us putting on the heating was not always the first thing they would do if they were too cold (some take extra measures such as wearing extra layers, using blankets or having hot drinks to warm themselves up) the majority of our participants said that they would usually put on the heating, or use another heat source, rather than be cold.

"I'd rather be warm than cold and worrying about the bill"

A few homes said that thermal comfort is important to them and that they like the feeling of sitting near a hot radiator. These homes reported standing next to the radiators, putting on electric fans, or using log burners to feel comfortable.

"I like it when I get up and its warm and I also put my uniform on the radiator, so it is warm when I put it on... I like to feel the warmth"

Heating to avoid health issues worsening in cold weather

Some homes include a resident that has a health condition that is worsened by the cold. They were also often at home during the day and want their home to feel warm. As a result, they tended to heat their home for longer periods of time than other homes (Figure 3).

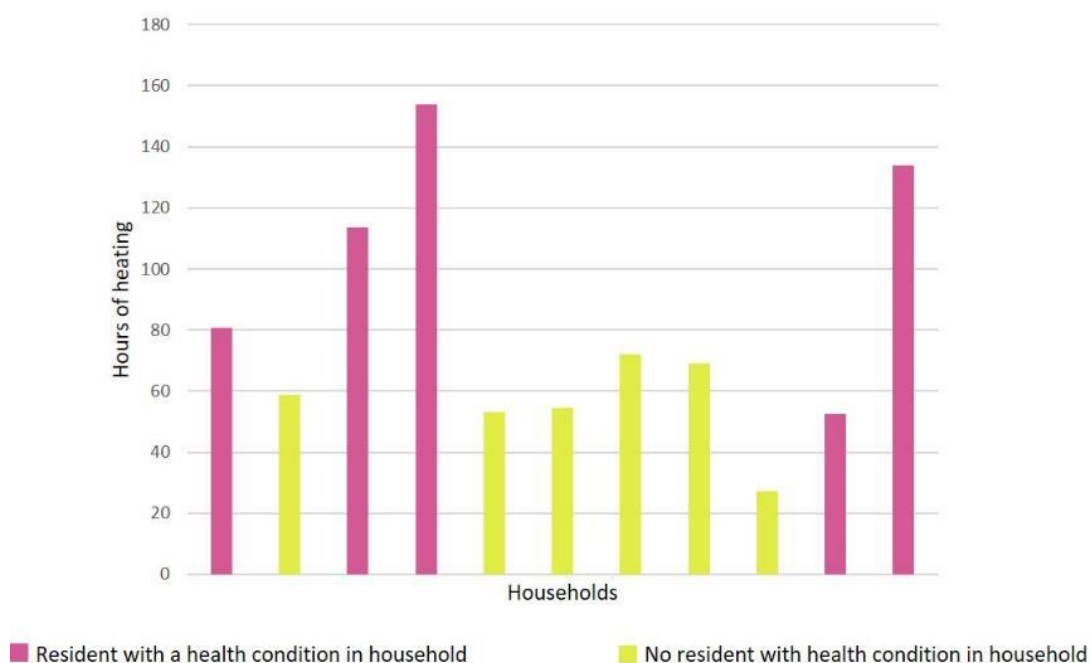


Figure 3: Average number of hours that the household requested heating in their home (this includes scheduled and ad-hoc requests).

These people felt it was worth spending money to use their heating because living at low temperatures could harm their health. They reported setting higher temperatures when they were heating to create a healthy environment.

"19°C is not enough for her [my wife], she had a big operation and has not been fully right since as her immune system is down... a little bit of more warmth keeps her comfortable"

Case study:

Participant #1 lives at home with their partner. They currently spend most of their time at home. The temperature they most often request is 21°C, even though #1 would prefer to set a lower temperature for their own comfort. However, due to their partner's health and sensitivity to cold temperatures, they have decided to set 21°C to accommodate their partner's health needs. They are at home during the day and heat their home on average for 71 hours a week (around 10 hours a day). Whilst they said they think about cost and that they would be interested in exploring ways to save money, this is a much lower priority than the wellbeing of their partner.

Heating to make others feel comfortable

Over half of the participants reported heating to ensure other family members were comfortable. This includes those heating for partners or children with health needs. These participants focused less on their own thermal comfort and emphasised the need to keep others warm.

Case study:

Participant #8 says they are predominantly driven by cost. However, the way they used their heating showed that they were also focused on keeping their family comfortable. #8 lives at home with their partner and two young children. Their home is empty during the day in term-time when the family spend their weekdays at work or school. They heated around a quarter of their rooms for 22-28 hours a week. However, during the week of half-term, when they spent more time at home, they heated more rooms (approximately two thirds) for 15 hours more than usual.

Some participants reported using their heating to keep their children warm when they were at home. These decisions included heating bathrooms in time for bath time and ensuring the spaces used by their children were heated when they were occupied by them. Others told us that the heating was set to come on when their children came home from school or football.

Others talked about heating for their partners. A few participants, whilst conscious of cost, noted that their partner preferred higher temperatures and were more sensitive to cold temperatures. Although these preferences were not shared by the individual person we conducted the research activities with, adjustments were made and schedules were set to meet the preferences of their partner.



"The comfort is the governing aspect... if my wife is uncomfortable, she wants to heat up and I'll go with that every time"

Heating to protect their home against damp

One home reported having the heating set to protect her home from damp. Even though they weren't always in all the rooms that they heated, they liked to heat them to avoid damp.

Case study:

Participant #6 is driven predominantly by comfort and wants to ensure their children are warm when they get home from school. They are conscious of heating their home to protect it. Their home suffers from damp, especially in the bathroom so the heating schedule is set to try and avoid damp.

"My bathroom is always on in the morning, every room is, but the landing... it is pointless heating a few rooms and I find it's better to heat the rest of the rooms. I suffer from bad damp in my house so need the heating on most of the time"

Key Learning: People enjoyed using their smart heating controls to meet their needs in different ways.

We asked participants how they had controlled their heating before the study. More than half told us that they used to turn their boiler on or off and adjust a single room thermostat to control their heating. The others said that they used timers to schedule their home to be heated.

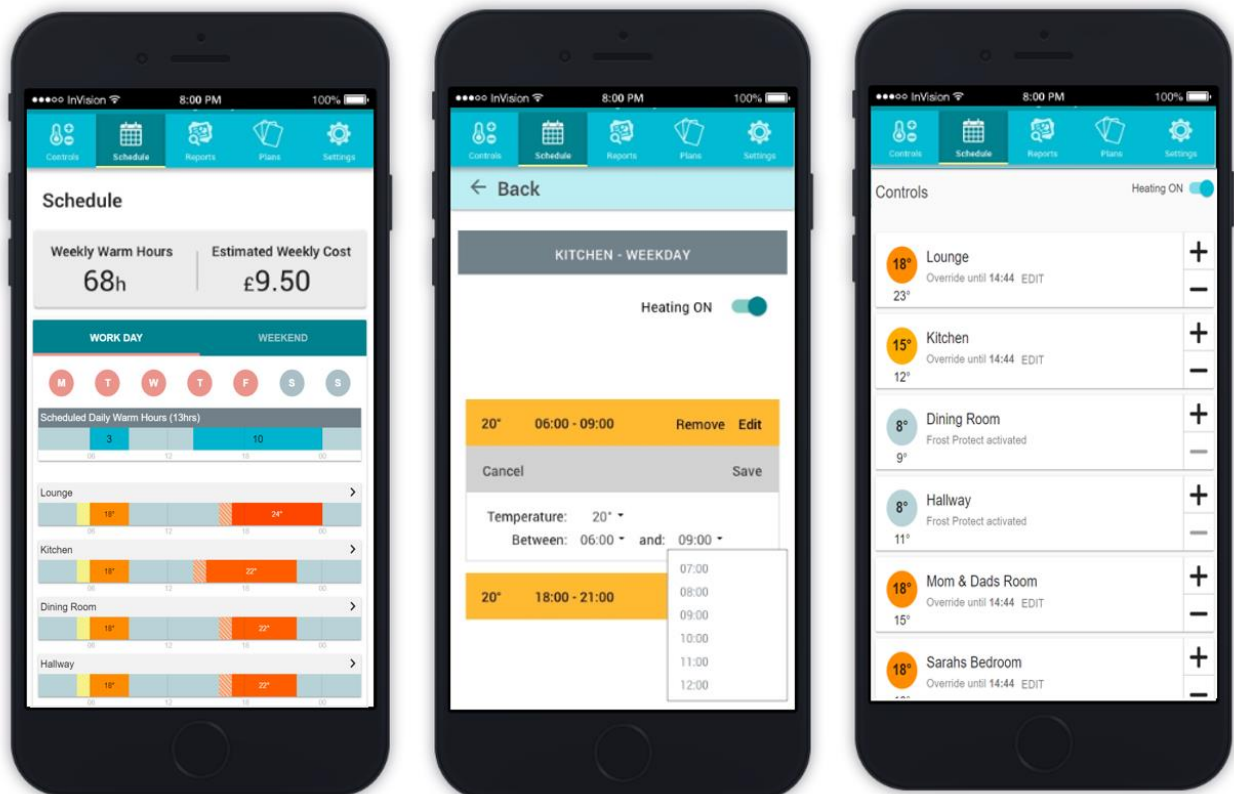


Figure 4: How the SMART HEATING CONTROLS controls look on a mobile phone. Summary of heating schedule programmed (left), interface to make changes to schedule (middle) and to make ad-hoc changes to current heating (right)

After we installed smart heating controls, participants were able to schedule individual rooms to the reach the temperatures they wanted at the times they wanted (see Figure 4). We asked them about their experiences of heating their home with their smart heating controls and explored data about how they heated their home for the month of February 2020.

Smart heating controls allowed people to learn what experience of heating their home they want.

Participants used their smart heating controls in different ways. Some rarely adjusted their schedule, others constantly updated it throughout the week. One home, with a particularly varied working routine, spent time every night setting their schedule for the next day. Most talked about having played around with their settings to get them right.

Most reported that the smart heating controls made it much easier to control their heating. Some said that they were more comfortable now and enjoyed not having to wait for the home to warm up. Participants also liked the convenience of being able to control their heating remotely from their phone rather than having to go to a particular place to adjust it. They described turning the

heating off when they were out to reduce waste and turning it on before they got home, so that their home was warm and comfortable when they returned.

All participants liked being able to easily stop heating some of their rooms when they wanted. Some said that they felt this reduced waste and saved them money.

Households at risk of fuel poverty use their heating in very different ways (see Figure 5), which can be explained by understanding how people were using their home and heat. On average:

- Homes were heated from 36 to 154 hours per week (5 to 22 hours per day).
- Between 23% and 80% of rooms were heated.
- Mean set point temperatures ranged from 15°C to 23°C.

Low carbon services that are designed to deliver one outcome to all households will not meet the diverse experiences that people want, as illustrated in Figure 5. This is a sample of only 11 households, but similar diversity has been observed across the 100 homes in Energy Systems Catapult's Living Lab. Further information can be found in reports [here](#).

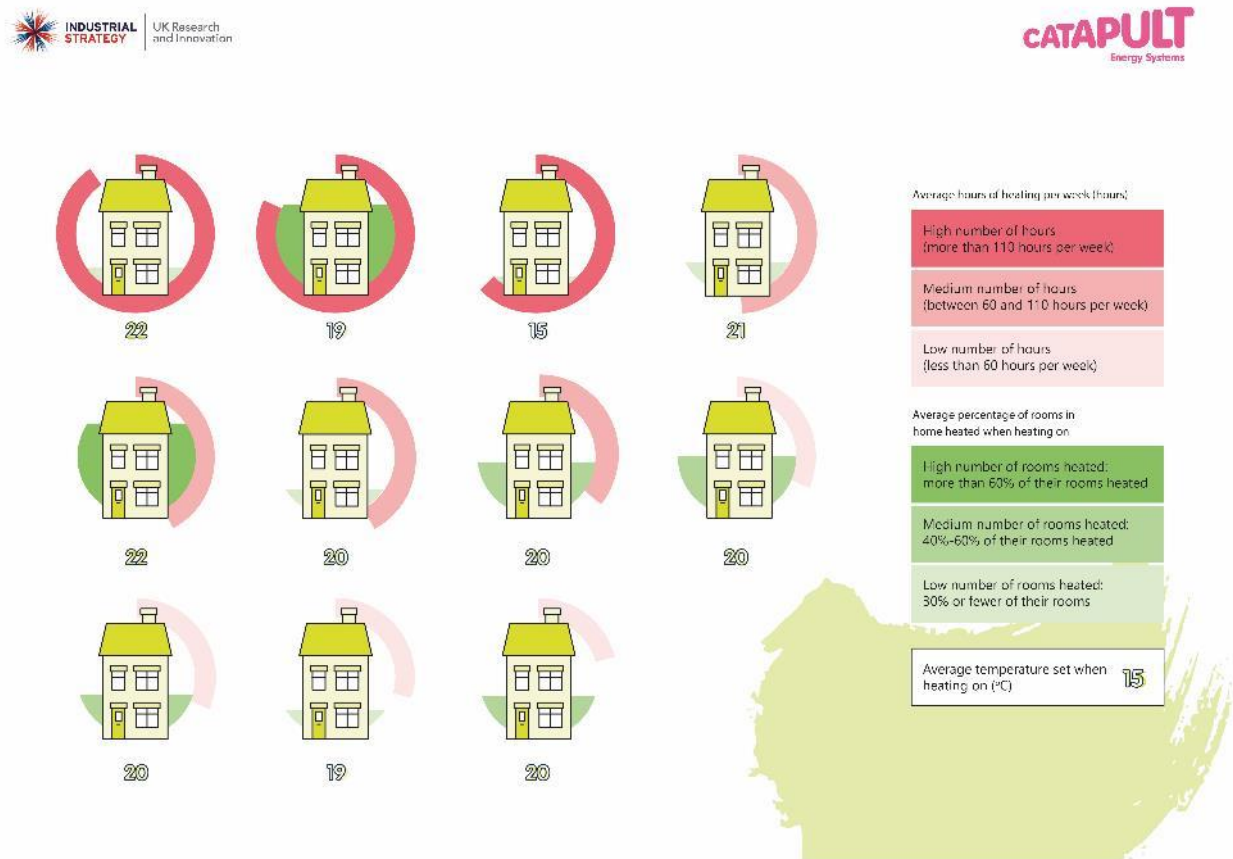


Figure 5: Average weekly hours of heating, space in the home heated and temperatures scheduled by the participating households during February 2020

Most people adjusted their heating to suit how they used different rooms at different times

People set their heating to suit their own household routines. For example, they set their heating around daily activities, like getting up in the morning, coming home from work, the children coming home from school, getting ready for bed, going to bed. These times varied between households. A few homes included people working shifts, so they set heating times to suit their shifts.

Most households used their smart heating controls to only warm the parts of their home they were using at the times they used them. For example, participants described thinking about exactly where they needed to heat:

"My youngest son goes to school... in the morning the hallway, kitchen, landing and his bedroom will come on... This is basically his walkway... This is to ensure he is warm wherever he lands."

Most households chose not to heat spaces when they knew they would not be using them. They did not heat their home when they were in bed or had gone out. Sometimes, if there was only one person in the home during the daytime, they chose to wear extra clothes or wait until they felt uncomfortably cold to turn their heating on. Most heated fewer than half their rooms at any time.

People wanted their home warm whenever it was occupied if it helped to keep someone well

Some of our homes had someone living in them with a health condition that was made worse by the cold. These households suffered from a range of health conditions including poor circulation, auto-immune diseases, reduced mobility and respiratory illnesses. These homes were often occupied during the day.

These households set their homes to be heated for extended periods of time. Participants #3 and #4 set their heating to maintain at least a minimum temperature for most of the day and (unlike other homes in this study) also at night, but only heated on average 25% of the rooms in their home at time. This was to ensure that there was always a warm space in the home. In contrast, participant #11 heated most of their home.

They all set different target temperatures to meet their needs in different ways: either setting a minimum temperature so that the home never got very cold, setting a moderate temperature across the home so it was uniformly warm, or setting a higher temperature in a limited portion of the home.

Case study:

Participant #4 heated their home, on average, to 22°C for 154 hours per week, but only heated a quarter of the rooms in their home. For most of the time, they only heated one or two rooms in the house.

#4 used their heating to make sure their unwell, elderly parent always had a warm space to use, day and night. They heated their home for more hours than other participants, but heated fewer rooms. They also often used a log-burner to add extra warmth.

Key Learning: People were constantly trying to manage how much they spent on the heat they wanted.

People did not compromise on why they wanted to use energy (for example: for health). People did, however, try and negotiate or manage the relationship between the cost of energy and the heating experience that made them feel that they were meeting their needs.

Households knew how much they spent on energy, not the cost of their heating

Most people knew how much they were paying for their energy, but most people were not confident on understanding the relationship between how much they were paying for energy and the heating outcome they were getting.

More than half of these homes paid their energy bills by monthly direct debit (proportionally comparable to all UK households). Whilst people often knew exactly how much their direct debit was, they were not confident on how much of what they paid was for gas and how much was for electricity. Furthermore, they were not confident on how the amount of heating they were using related to the amount of gas they used in a month and how this related to their bill.

For households that were paying for their energy via a prepayment meter, most of them checked their meter weekly or paid money onto their energy account at irregular times. These households were confident on how much they spent on using gas. However, they were not clear on how much of the gas they used was for heating their home. One household was not confident how often they topped up their account or how much their energy was costing them.

Overall, all households were not confident on how much of their energy costs were associated with heating their home. Only one participant said they noticed a difference in the amount they paid for their gas when they heated their home differently.

Participants did not want to go without heating to save money

Participants used their smart heating controls to get the basic, essential level of heating they needed. They used their heating to get comfortable, care for others and protect their home.

None wanted to use less heating to save money, as it would prevent them getting what they needed. Only one said they could not afford their heating and sometimes went without, even when they were feeling cold. Indeed, two said they would make sure their home was warm whatever it cost, as they wanted to keep healthy.

We discussed how people would choose to heat their homes if money was no object. They explained that they would heat rooms for more time when they were being used. Most felt higher temperatures would be uncomfortable and heating empty rooms was a waste.

Smart controls helped people learn what they wanted from their heating. They had all developed a heating schedule that gave them the outcome they wanted. They said that they were not willing to compromise on this to reduce their energy bill.

Most people think it would be useful to understand the cost of their heating

Most participants said they thought that information about how much it costs to heat their homes would be useful and might influence how they used their heating. The only two participants who did not think it would be useful explained that they would use their heating to stay healthy, whatever the cost.

Some people thought that real-time feedback on the cost of their heating might help them decide whether to use it at a point in time (see Figure 6a). They explained that this might help them worry less about using one or two extra hours when needed. Others did not want to know the cost of adding or removing one or two hours as the costs involved were small.

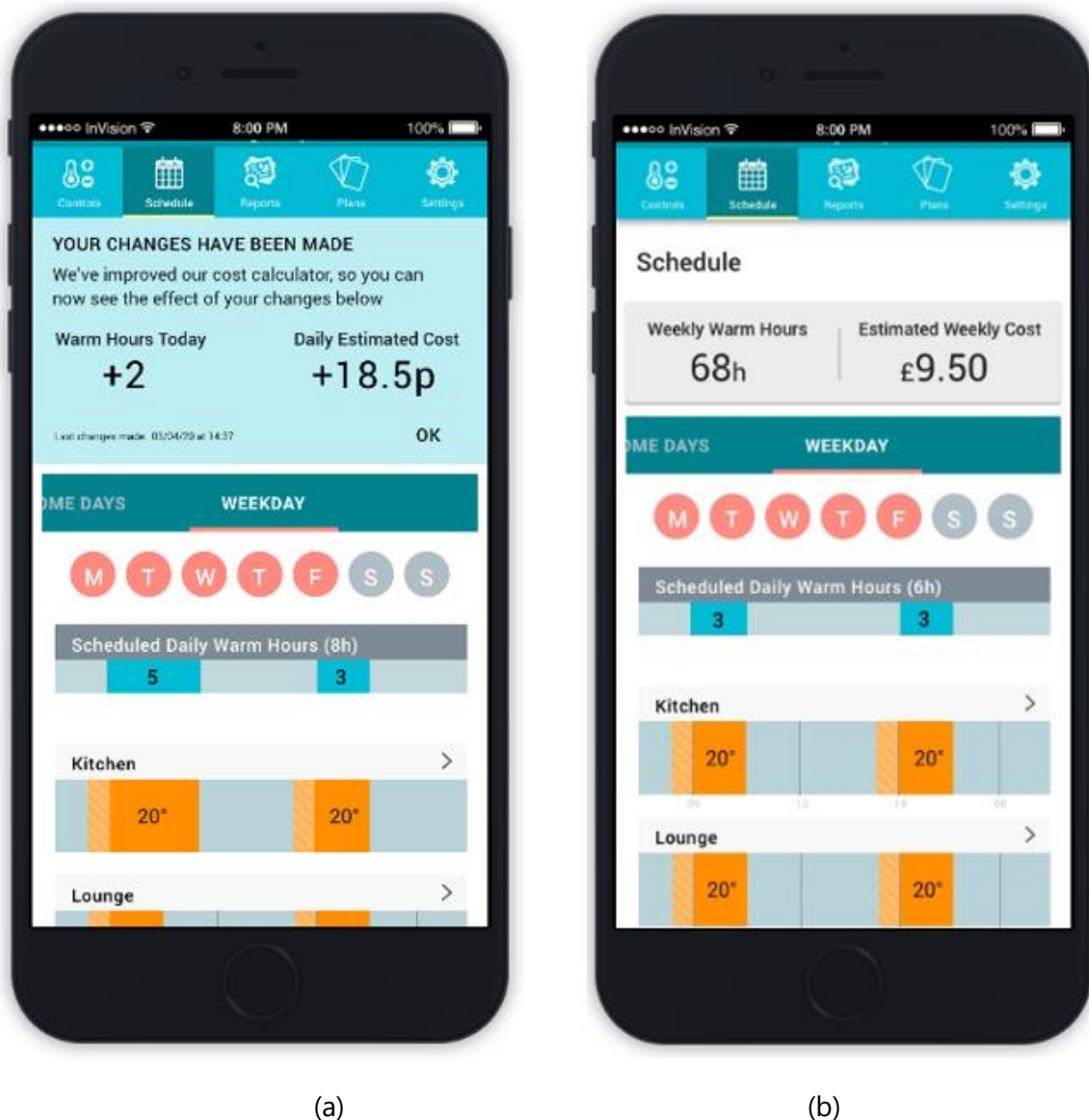


Figure 6: (a) Feedback about the cost of heating schedule changes and (b) estimate of weekly cost of heating

Many people knew how much they were paying for their energy. Most told us they could afford these regular payments. They were more worried that this cost could rise. They wanted to understand the costs of larger changes over weeks or months to help them budget for their heating.

Information will only be useful if it is relevant to people and they can trust it

We explored what other information might be useful. For instance, we showed participants estimates of what their heating would cost over the week (see Figure 6b). Many found it confusing that this estimate varied with the weather. Most could not easily relate the estimated cost to the amount they were paying for their energy. A weekly estimate was less relevant to participants who frequently changed their schedule.

Participants need to know more than the cost of the energy they will use to get a heating schedule. They wanted to be confident they would be able to afford this energy and they did not want to be surprised that their bill had increased. Their energy bill could rise for lots of reasons that are outside of their control: the weather could get colder, energy prices could rise, they may need to spend more time at home (for example, because they become ill).

Fundamentally, they wanted the peace of mind that they could afford their heating in future. Information about what their heating might cost next week did not make them feel in control, especially as it drew attention to the complexity and uncertainty of predicting the cost.

However, there appears to be an opportunity for innovation to empower vulnerable households. Providing them with accurate heating cost information could reduce anxiety and enable them to spend their limited budget on staying healthy, caring for others and protecting their homes. This could be particularly useful for households who struggle to afford the heating they need.

4. Conclusions

Smart local energy projects often hope to deliver benefits to vulnerable households in particular. To deliver on this aspiration, innovators need to design their offers around the needs of those people they want to benefit.

We found that vulnerable households want to use heat in the same ways as other households. However, there can be serious ramifications for vulnerable households if their heating costs are more than they are expecting. They may end up unable to afford other basic household necessities: In other work (e.g. [O'neil et al. 2006](#)), some people end up being forced to choose between "heating or eating", between paying for their energy and buying food. Our research has shown that giving people better control over their heating can help them to negotiate between getting the heating experience they value at a cost they are comfortable with.

Energy system innovators can apply this insight to enable vulnerable households to make informed choices about how to get the most benefit from the money they spend on their energy. Smart local energy systems could benefit vulnerable consumers by:

- Using innovation to help people get the heating experiences they value (e.g. wellbeing), rather than focusing only on minimising what they spend.
- Using technology to give people better control of their heating system for the experiences they want.
- Providing information on the costs of using energy to help people choose how much to spend on getting the heating experiences that they want.

Involving vulnerable consumers in the design of innovations will help ensure they deliver benefits. New energy innovations based on incorrect assumptions of what consumers want to use energy for could accidentally harm consumers. For instance, leaving people living in a cold home because it is assumed they want to minimise their energy bill above everything else.

5. Appendix: Recruiting households at risk of fuel poverty

We aimed to recruit homes at risk of fuel poverty according to [guidance from BEIS for providing on-the-ground support to vulnerable households](#). We also captured behavioural indicators of a household being at risk (e.g. only heating one room, or not heating their home during the winter).

Low income

A household is classed as meeting the 'Low Income' category if:

1. They answer that their income is less than £900
Or
2. They answer that they are using a prepayment meter and they are struggling to pay for their energy bill or are concerned that they may not be able to afford it
Or
3. They answer that they are struggling to pay for their energy and they have energy debt

Further investigation is needed if they answer that they would require support if the bills went up but haven't given any other answers indicating the 'Low Income' category.

Vulnerable to the cold or high potential energy costs

In the Living Lab, those that are vulnerable to the cold are those people who have a long-term illness or disability made worse by cold temperatures. We asked existing and new participants this question directly.

Households that are likely to have high energy costs in the Living Lab include those with any of the following:

1. Using a prepayment meter.
2. Paying energy on receipt of a (quarterly/monthly) bill.
3. Repaying energy debt.

Behavioural characteristics that could also be used, but weren't in recruitment for this trial, are those households only heating one room, self-disconnecting via their prepayment meter and being in the house for 20+ hours a day, every day.