

November 2018

Public acceptability of the use of hydrogen for heating and cooking in the home

Results from qualitative and quantitative research in UK

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Acknowledgements

We would like to thank the Committee for Climate Change for commissioning this research and David Joffe, Ellie Davies, Rachel Hay and Sarah Livermore for their dedicated steer and input throughout.

We would also like to thank Sam Foster and Foaad Tahir from Element Energy for their key role in providing the technical expertise required to help communicate the complex subject matters discussed within the project.

Additionally we would like to thank Samantha Brannan and the Creative Team at Madano for their work in developing the visuals and stimulus used in the research.

Thanks also must go to all research respondents who took part in the project.

Executive summary

This report presents findings of a combined qualitative and quantitative research study that aimed to assess the public acceptability of two alternative low-carbon technologies for heating the home: hydrogen heating and heat pumps. These technologies could potentially replace natural gas in many UK households as part of the government's efforts to decrease carbon emissions in the UK. Commissioned by the Committee on Climate Change, the research was designed and conducted by Madano, in collaboration with Element Energy, a specialist energy consultancy, focusing on the low-carbon economy.

The next section provides a summary of the project, including an overview of the rationale for the research, the methodology and research findings.

Research rationale

Background, objectives and aims of the research

In order to meet legally-binding targets set by Parliament under the 2008 Climate Change Act, emissions from heating and cooking in homes need to be reduced by 20% by 2030. Heating and cooking need to be almost completely decarbonised by 2050¹. This will require a combination of improved energy efficiency and a large-scale shift from natural gas boilers to a low-carbon heating technology. This study looks at two of the main alternative options to replace natural gas: electrification through the use of highly efficient heat pumps, or potentially by switching the gas supply over to hydrogen.

There is already an existing body of research on the acceptability for heat pumps. Research was therefore required to understand household preferences and to assess public acceptability of the use of hydrogen heating in homes, relative to that of heat pumps. Specifically, this research looked to understand key barriers to acceptability, so that recommendations could be made as to how these could be overcome.

This research is a first step to understanding the challenges around public acceptability to alternatives to natural gas heating in general, and to hydrogen heating and heat pumps in particular. Findings from the research will support the Committee on Climate Change in making further recommendations about the use of these two alternative heating technologies and enable them to inform how government might begin to establish a programme of research on hydrogen.

Research approach

Method and sample

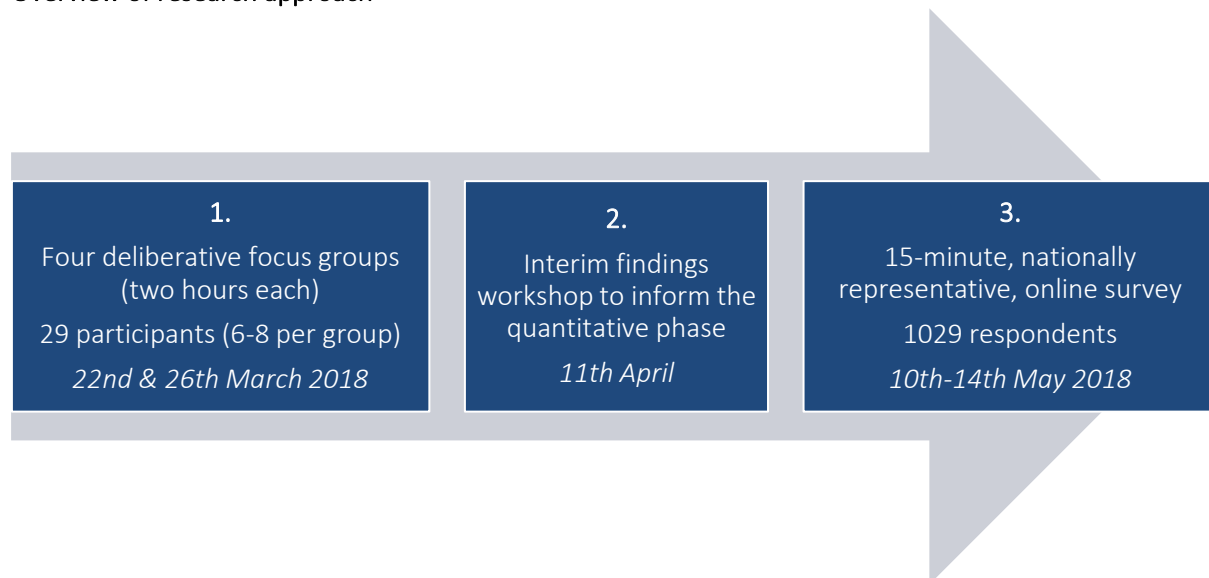
The research involved discussion of a complex and technical subject matter with members of the public, whose knowledge and awareness of the heating technologies was likely to be low. A socio-technical approach was therefore adopted in order to ensure clear, accurate articulation of the heating technologies alongside best practice social research techniques and expertise in order to understand and interpret human reactions to new material.

The approach also sequenced qualitative and quantitative data collection. The qualitative phase allowed understanding of the broad range of attitudes to different aspects of the technologies. It also acted as a medium to gauge the public's ability to understand implications of the heating technologies based on receiving a small amount of information. Results from this phase then informed the design of the method,

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questions and research materials used to describe heating technologies in the quantitative phase, which looked to measure the prevalence of these attitudes.

Overview of research approach



Both the qualitative and quantitative samples were designed to be as nationally representative as possible, in order to capture a range of opinions from people with a diversity of backgrounds in the qualitative phase and be proportionally representative in the survey sample. Three primary sample criteria defined the split of focus groups and survey quotas: housing tenure, level of education and location. These were chosen as they were perceived to be key characteristics likely to influence overall views on the switchover from natural gas and associated heating technologies.

Key findings

Overall understanding of the need to reduce carbon emissions and the role of heating technologies

Carbon emissions reduction is viewed as an important issue, but there is limited awareness of the need to decarbonise household heating or the implications of switching over to low-carbon heating technologies.

The majority of the public are concerned about climate change and feel it is important for actions to be taken to mitigate against it. This research suggests that the public would be open to switching from natural gas to alternative low-carbon heating technologies in their homes, in order to help reduce carbon emissions and mitigate against climate change.

However, awareness amongst the public of the need for switchover is low, and knowledge of hydrogen heating and heat pumps even lower. Just over half (51%) of survey respondents had never heard of hydrogen fuel boilers, with 42% stating they had never heard of either ground source or air source heat pumps. Even once respondents receive further information about each heating technology as part of the focus groups or survey, understanding of both heat pumps and hydrogen heating remained low. At the end of the survey, less than half of respondents reported that they understood the impact and workings of the heating technologies.

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There are therefore significant communications and educational challenges to overcome in order for the public to support the switchover from natural gas, especially in terms of how they would work in practice for households.

Public acceptability towards hydrogen heating and heat pumps

Acceptability of both heating technologies is limited by a lack of perceived tangible consumer benefit, which has the potential to drive scepticism towards the switchover more generally.

Both heat pumps and hydrogen heating are perceived to offer no, or limited, additional consumer benefits when compared to current natural gas heating systems. Additionally, there are significant concerns about the effort and costs that will be required by the public to install and use the new heating technology. This magnifies the need to be clear about the consumer benefits of these technologies; without this clarity it will be difficult to encourage willingness and motivation for the switchover based purely on the more abstract environmental benefits.

In the absence of clear consumer benefits, preferences towards the heating technologies tended to be driven by which had the fewest perceived drawbacks. People typically preferred the least-worst option rather than drawing on any positive factors attached to a given heating technology. However, the potential utility for heat pumps to cool homes, as well as heat them, was seen as advantageous and had some positive impact on preferences vs. hydrogen heating.

Therefore, whilst the need to reduce carbon emissions in the UK and switch to alternative low-carbon heating technologies was felt to be important amongst the majority of the respondents, the acceptability of currently available options was tempered once they learned more about the limited improvements to their lived experience in their home and the burdensome installation process.

Overall heating technology preferences

Results show that heating technology preferences are not fixed at this stage, although heat pumps appear to be the favoured option in this research study

Once provided with detailed information about the installation and lived experience of both technologies, heat pumps were the preferred heating technology amongst survey respondents. When forced to make a selection of their preferred heating technology at the end of the survey, 63% selected heat pumps and 37% chose hydrogen heating. The main reason for this was the perceived installation burden associated with hydrogen heating. However, until the end of the survey, a large minority of respondents had no preference towards either heating technology.

Ultimately, however, the research suggests that preferences are heavily influenced by how the information on alternative heating technologies is communicated. Knowledge of low-carbon energy alternatives is low and public opinion is certainly not fixed. Even within this study, changes made to explanatory materials between each phase and methodological differences appears to have had an impact on heating technology preferences.

Factors influencing heating technology preferences

Three overarching factors were identified as influencing preferences for heating technologies (described in the table below). These factors manifested differently for different people, meaning that the same factor could lead one person to prefer heat pumps and another to prefer hydrogen depending on their overall heating preferences and understanding of the two technologies.

Explanation of factors influencing heating technology preferences

Factors influencing heating technology preferences	How this factor impacted on heating technology preference
<p>Perceptions of negative installation burden:</p> <p>The direct implications of the processes of installation for households were a key barrier to acceptance.</p>	<p>Multiple aspects of the installation were seen as burdensome for both heating technologies. The main barrier to acceptability of hydrogen heating was the one to two weeks that households would have to be disconnected from the gas supply during installation. This was seen as the most unreasonable of a number of aspects of the installation of either heating technologies.</p> <p>Other factors that felt burdensome as part of the installation process were the significant amount of new appliances required for both heat pump and hydrogen heating installation. For example, depending on the heating technology, the need to replace or get rid of all gas appliances, as well as requiring new types of appliance in order for the heating systems to work.</p>
<p>Familiarity of the lived experience of using the technologies in home, once installed:</p> <p>Unfamiliar aspects of the heating technologies created uncertainty for the public and required them to consider how they would adopt new heating behaviours and habits.</p>	<p>The difficulty envisaging how heat pumps would work in the home caused great uncertainty. Hydrogen heating, on the other hand, was seen to be a more like-for-like replacement of the current natural gas system and therefore easier to grasp.</p> <p>This unfamiliarity as to exactly how heat pumps would heat the home, whether this would meet their needs and how it would be maintained, generated lots of questions and concern, ultimately acting as a barrier towards public acceptability of heat pumps.</p>
<p>Perceptions of how well technologies would meet modern heating needs:</p> <p>Heat pumps and hydrogen heating were judged by the extent to which they are seen to offer comfort and convenience, as well as their ability to align with the trajectory of a smarter home – that is technologies that are quieter, faster and concealed.</p>	<p>Hydrogen heating was seen as progress to a more modern version of natural gas; views as to whether heat pumps represented a step forward were less clear. The cooling utility of heat pumps meant that this added consumer benefit, which helped the heating technology to be perceived as modern and innovative to an extent. However, the implications associated with certain appliances that are part of the heat pump system took away from this perception, in particular the space needed for the storage tank and the lower responsiveness of the system, which led to the impression that heat pumps were outdated and inconvenient compared to hydrogen and natural gas heating systems.</p>

The findings of this research suggest that those who concentrate on the immediate, short-term burdens of the installation will typically prefer heat pumps. This preference for heat pumps was more prominent in the survey results, potentially due to the shorter time frame in which survey participants had to reflect on all of the elements of the technologies and their installation and consider what it might be like to live with them. Alternatively, others were willing to overcome the short-term installation burden of hydrogen for what they perceived as a more familiar, modern and convenient technology. This perspective was more prominent when focus group participants had longer to reflect on the implications, often opting for what they viewed as beneficial in the longer term.

Remaining challenges to public acceptability

Both hydrogen heating and heat pumps face significant challenges to secure public acceptability.

This research does not provide a definitive conclusion about public preferences for either hydrogen heating or heat pumps. While heat pumps were ultimately preferred in the quantitative survey, it is clear that knowledge of the two technologies remains low and preferences are not fixed or embedded.

This research does allow strong conclusions to be drawn around the specific factors that drive public acceptability of alternatives to natural gas. The way in which different aspects of each heating technology are framed can influence views and ultimately swing opinion. Installation burden is of most immediate concern to the public, whilst longer-term concerns relating to system familiarity and meeting heating needs are also influential and require more considered thought.

Overall, while public acceptability of the need for the switchover is relatively high, in order for the public to accept the unavoidable burden of installation, challenges remain in explaining how heat pumps and hydrogen heating work in practice, how they contribute to reducing carbon emissions and most importantly what extra utility they provide the consumer.

Raising awareness of the need for a switchover to lower carbon heating technologies should therefore be a priority for government and industry, in order to establish a long lead-time prior to the switchover itself. This would allow educational challenges to be addressed, as well as providing the public with time to prepare for and come to terms with burdens and the benefits associated with the switchover.

1. Introduction

This section provides some background to the research and details of how it was carried out. First, the policy context and rationale for the research are described, along with details of the two heating technologies which were assessed as part of the research. This is followed by the aims and objectives of the research and the methodology designed to address these objectives.

1.1. Background and project rationale

Heating and hot water for buildings made up nearly a fifth of greenhouse gas emissions in the UK in 2017¹. In order to contribute to the legally-binding targets set by Parliament under the 2008 Climate Change Act these emissions need to be reduced by over 20% by 2030, with a near complete decarbonisation by 2050². This reduction requires a combination of improved energy efficiency and a large-scale shift from gas boilers to low-carbon heating.

The most significant challenge in meeting this obligation will be to decarbonise the heating of the 23 million homes currently connected to the gas grid. For many households, two of the main options for a switch away from the use of natural gas are:

- 1) Electrification through the use of highly efficient heat pumps
- 2) Switching the gas supply over to hydrogen

(More information about heat pumps and hydrogen heating, and the implications of their installation are detailed in section 1.2).

Where heat pumps have been installed correctly, satisfaction levels appear to be high, even though installations are often perceived as disruptive and heat pumps offer a different customer experience from gas and oil boilers. Hydrogen for heating would, in some ways, require less change in behaviour by consumers since it shares many characteristics with natural gas heating. However, the public will likely need reassurance that the change will be safe, affordable and involve minimal disruption.

There is already an existing body of research on public acceptability of heat pumps³. Research was therefore required to assess public acceptability of the use of hydrogen heating in homes, prior to the Committee on Climate Change making further recommendations about the use of hydrogen heating and heat pumps. Heat pumps were used as a comparator in the research.

1.2. What is hydrogen for heating and heat pumps?

This section provides a summary of the two heating technologies, using some of the explanatory visual material presented to the research participants (full details of the stimulus used can be found in the appendix). An overview of the technology and a summary of the appliances required, the installation process and experience of living with the heating technology is provided for both hydrogen heating and heat pumps.

Hydrogen for heating

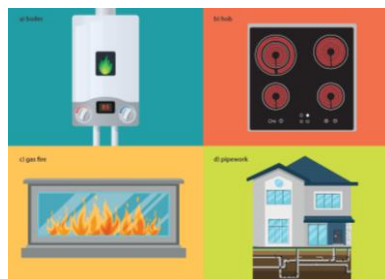
Overview: Hydrogen can be made from renewable energy sources and is virtually non-polluting. It can be produced in various ways, either through using renewable electricity to produce hydrogen from water, or from fossil fuels through processes that capture and store carbon emissions rather than releasing them into the air. Hydrogen would enter households in a similar way to natural gas, via the grid system. However,

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before hydrogen heating can play a bigger role in heating households, structural changes to the existing gas grid would need to be made.

Implications:

Figure 1.1. Appliances required for hydrogen heating



All gas appliances in households would need to be changed to hydrogen compatible versions. This would mean the replacement of:

1. Gas boilers
2. Gas hobs and ovens (if the household does not already use an electric cooker)
3. Gas fires (if present)
4. Some of the pipework within households (if required)

Figure 1.2. The process to install hydrogen heating



The gas supply would have to be turned off for one to two weeks during the period that the local area is switched over in order for the natural gas to be drained from the grid.

Figure 1.3. The experience of hydrogen heating post-installation



There would be minimal change in the lived experience, should hydrogen heating be installed, as the way the heating and hot water systems work would be very similar to how a natural gas boiler currently works. Small differences may include:

- The smell of the gas
- The colour of the flame in the boiler and on the cooker
- A need for a hydrogen-specific safety alarm

Heat pumps

Overview: Heat pumps are a renewable technology that take heat energy from the outside air (or the ground) and use this to provide heating and hot water. Heat pumps work like air conditioning 'in reverse', keeping your home at a constant warm temperature, even when it is cold outside. A dedicated heat pump is fixed to each home (or block of homes) and does not require a connection to the gas grid. They are known to be efficient and run on electricity, which can be produced from renewable sources such as wind or solar power. They are already common in many other countries across Europe.

This research focused on air source heat pumps, although there are other types of heat pump, which could potentially be used in households.

Implications:

Figure 1.4. Appliances required for heat pumps



A new heat pump system would require the installation of:

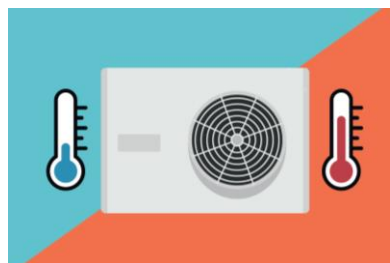
1. Outdoor and indoor units for the heat pump itself
2. A hot water storage tank
3. An electric or induction cooker (if the household does not already use this type of cooker)
4. Larger radiators (potentially)
5. Underfloor heating (potentially)

Figure 1.5. The process to install heat pumps



The gas supply would be switched off completely, and it would take one to three days for the engineers to complete the work to install the heat pump.

Figure 1.6. The experience of heat pumps post-installation



There would be a number of noticeable changes to the lived experience of having a heat pump, compared to how natural gas heating systems work:

- The heating system is likely to be less responsive than a gas boiler, so needs to run more continuously to heat the home
- Hot water is heated and stored in a storage tank (as currently happens in households without “combi” boilers)
- The heat pump would make a faint hum
- The heat pump could also have the potential to cool the home, dependent on the type of heat pump that is installed

1.3. Research aims and objectives

In this context, research was required to understand the public acceptability and consumer preferences towards hydrogen heating in the home in comparison to heat pumps. To meet this overall aim, the research addressed four objectives:

1. To describe and measure the prevalence of different attitudes towards hydrogen heating and heat pumps as energy sources for heating and cooking; identifying overall preferences, as well as differences between different sub-groups
2. To understand attitudinal differences between demographic groups and geographical areas

3. To identify likely barriers to public acceptability of widespread deployment of hydrogen heating or heat pumps, and how significant these will be to overcome
4. Provide recommendations for how government could engage with households to overcome these barriers

1.4. How this research will be used

In order to help build towards a decision on the future gas grid by the mid-2020s, the Committee on Climate Change is recommending that the government puts in place a programme of research on hydrogen. The next stages of future research could include pilots where hydrogen is injected into the gas grid in particular regions, or where the gas grid serving a community, or cluster of users, is fully converted to hydrogen, to understand whether hydrogen heating is a genuine option at a large scale.

This research is a first step to understanding the challenges around public acceptability to alternatives to natural gas heating in general, and to hydrogen heating and heat pumps in particular. Results from this study will inform how this programme develops and more specifically how pilots are communicated to those affected, in order to overcome any current known barriers associated with hydrogen for heating.

This research has been designed to best capture reported attitudes and behaviours relating to future (and hypothetical) heating options and is therefore subject to biases and limitations. As heat pumps are deployed more widely, and as hydrogen heating technology is developed and begins to be trialed in pilot locations, further experimental research is recommended to observe actual in-situ responses and behaviour to installing and living with each heating technology.

2. Methodology

2.1. Summary of approach

A sequenced, socio-technical approach

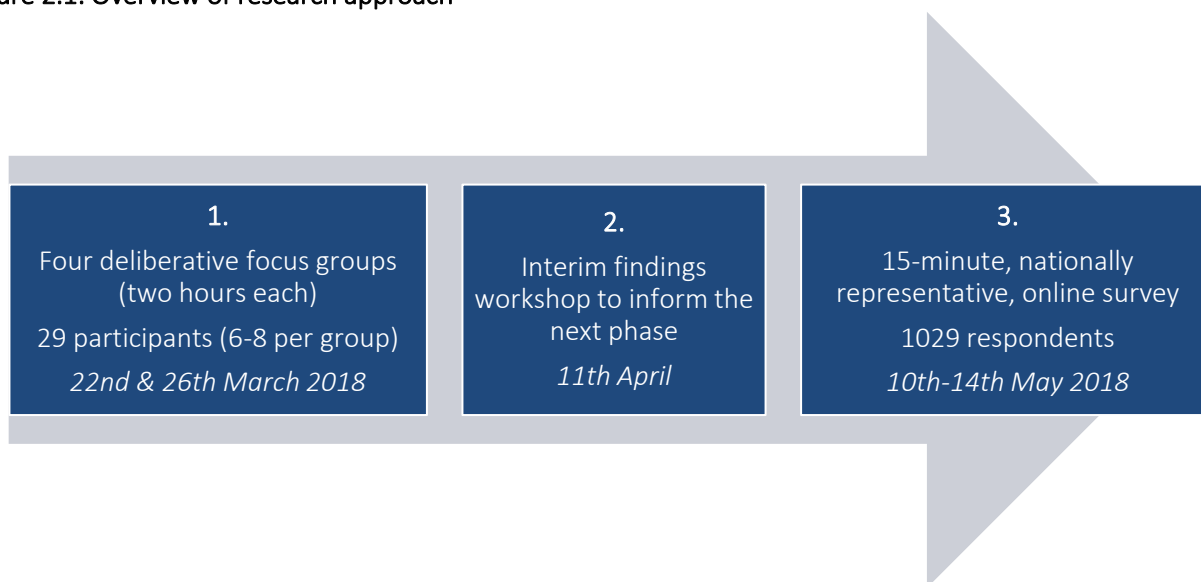
This research study required the discussion of a complex and technical subject matter with an uninformed general public. A socio-technical approach was adopted, drawing on technical experts from Element Energy, as well as specialists in social research at Madano.

A socio-technical partnership ensured clear articulation of the heating technologies, alongside best practice social research techniques, with the ability to understand and interpret human reaction. This meant that insights from the research were generally valid as well as meaningful for the specific issues of alternative low-carbon heating technologies. This collaborative approach was especially vital given that knowledge and awareness of the energy sector amongst the public tends to be low.

As part of the socio-technical approach, technical stimulus materials were developed. These explained the heating technologies in simple terms, using real life scenarios. This facilitated the public's understanding of the various implications associated with each heating technology and helped them consider the implications in-situ, despite the actuality of the switchover being in the future (if at all). Responses are therefore situated within a constructed reality, resulting in the identification of genuine, everyday concerns that are specific to hydrogen heating and heat pumps.

Additionally, in order to assist understanding of the switchover and heating technologies amongst research respondents, this study also sequenced qualitative and quantitative data collection (described in more detail in sections 2.2 and 2.3). Results from the qualitative research informed the design of the quantitative phase, supporting the development of valid response categories for survey questions, as well as testing how the public responded to the visual explanations of the technologies.

Figure 2.1: Overview of research approach



2.2. Qualitative rationale and approach

There were two key reasons for having an initial, qualitative phase to the research:

1. To assess the ability of the public to understand and deliberate the complex information being shown, in order to inform the quantitative phase, in terms of the method, questionnaire design and development of explanatory materials.
2. To understand the range of attitudes towards different aspects of the switchover, to provide rich and detailed context, in order to both inform the design of the quantitative phase, and the analysis and interpretation of the results.

Focus groups were chosen to achieve the two objectives outlined above, because they would facilitate a more dynamic discussion around a complex subject in a way that interviews would not. This enabled understanding on how conversations amongst the public might play out in a real-life context, which meant that a broad range of perspectives on the issue were heard. A variety of concerns could therefore be captured and be reflected in the research instruments for the quantitative stage.

Prior to the focus groups, participants were asked to keep a diary of their heating use within their household. These behaviours are often sub-conscious, so this task helped to bring some of the issues to be discussed to the front of participants' minds before the focus group. The focus group discussion could then address questions related to general energy preferences, behaviours and frustrations in the home from the outset, as well as attitudes towards switching to the alternative heating options.

The focus groups followed a deliberative design, with information on the switchover and the heating technologies released incrementally throughout the discussion. This allowed us to capture both uninformed and informed responses to the concept of the switchover, as well as to identify the different elements associated with each of the heating technologies and stages of the switchover.

Qualitative focus groups took place on 22nd March 2018 in London and 26th March 2018 in Edinburgh. Average temperatures recorded for this month were between 3 and 9.8 degrees Celsius⁴.

2.3. Quantitative rationale and approach

Following the qualitative phase, an online survey was conducted in order to measure the prevalence of attitudes towards heat pumps and hydrogen heating, identify any differences between sub-groups, as well as assess assumptions made in the qualitative phase.

Following the review of the responses of focus group participants to the information provided on the switchover and the heating technologies, it was decided that an online survey, rather than a telephone survey, would be the optimal way to assess public opinion in the quantitative phase. This is because the stimulus materials were felt to be sufficient in explaining the heating technologies, and having a moderator would only take away from the validity of the results by introducing additional researcher bias. A larger sample size was also possible by carrying out the survey online.

Within the survey, heating behaviours and attitudes were also captured and used as analysis variables. The survey was fielded between 10th and 14th May 2018. Average temperatures recorded for this month were between 6.9 and 16.6 degrees Celsius⁵.

2.4. Qualitative and quantitative sample framework

Both the qualitative and quantitative samples were designed to be as nationally representative as possible, in order to capture a range of opinions from people with a diversity of backgrounds in the qualitative phase and be proportionally representative in the quantitative survey. This would allow any differing views to be captured amongst the sub-groups, should certain characteristics have an impact on attitudes.

The study population was the general public living in households connected to the gas grid. Within this population, four primary sample criteria defined the split of focus groups and survey quotas:

- *Housing tenure*: social renters, private renters, or home owners
- *Education*: varying levels of formal qualification
- *Location*: devolved nations across the United Kingdom (England, Northern Ireland, Scotland, Wales)
- *Age*: various ages above 18 years old

A range of secondary sampling criteria were also considered as part of the sample design, including household composition and income.

Table 2.1: Qualitative sample table

Four, two hour focus groups with six to eight participants in each were conducted:

Group	Location	Age	Education	Housing Tenure
1	London	18-35	Up to A Level	Mix of private and social renters
2	London	36-65	Degree Level	Mix of private renters and owner occupier
3	Edinburgh	18-35	Degree Level	Mix of private renters and owner occupier
4	Edinburgh	36-65	Up to A Level	Owner occupier only

Table 2.2: Quantitative sample table

A fifteen-minute, nationally representative online survey with 1029 completed responses was conducted. Only results that were statistically different are provided within this report.

Respondent Characteristic	Number of respondents	% of respondents
AGE		
18-34	305	30%
35-54	363	35%
55-74	284	28%
75+	77	7%
COUNTRY CURRENTLY LIVING IN		
Northern Ireland	100	10%
Scotland	104	10%
Wales	101	10%
England	724	70%
HIGHEST LEVEL OF EDUCATION		
No formal qualification	38	4%
GCSE or equivalent	231	22%
A-Level or equivalent	261	25%
Undergraduate degree	297	29%
HOUSING TENURE		
Social rent	100	10%
Private rent	164	16%
Home-owner	765	74%

A detailed breakdown of the sample framework for both qualitative and quantitative phases is outlined in the technical appendix.

2.5. Further research considerations informing the approach

The project team was aware during the design of the research approach that factors related to cost and safety could influence the reactions to the heating technologies. Future costs are uncertain at this early stage of technology development and are likely to change, meaning it is not possible to say which heating technology would be more cost effective for the consumer. Further to this, introducing ideas around safety within a research setting is also a challenge, as these tend to only raise concerns and distract from having meaningful conversations around other elements of the heating technologies.

It was therefore decided that the research would not investigate the public reaction to the cost of the technologies or concerns around safety. The aim was therefore to avoid the cost and safety issues distracting from the reactions to other aspects, which were the focus of this research.

It was therefore important to consider how both these factors would be framed within the focus groups and survey. Firstly, the cost of each heating technology was described as equivalent. Secondly, participants were asked to assume that full installation of either heating technology would come with assurances that the level of safety would be at least equivalent to current safety standards of natural gas.

Where comparative cost and safety issues were raised spontaneously, there were systematic attempts to capture what was discussed, but these were not representative and are therefore not included as part of the analysis and report development.

2.6. Interpreting the results

Methodological differences between the focus groups and the survey should be taken into consideration when interpreting results of this research. Two issues are important here:

- **Changes to the explanatory materials, describing the switchover and heating technologies:** Some descriptions were altered after the qualitative stage. Some aspects of the heating technologies, which are at this stage still uncertain dominated discussion, for example the potential size of heat pump units, or storage tanks. These elements were not emphasised in the survey materials to avoiding biasing attitudes towards the heating technology as a whole. It was also felt that it would be valuable to explore additional qualities of the heating technologies that had not previously been mentioned (such as cooling for heat pumps), in order to see how these influenced attitudes.
- **Different respondent mind-set:** Focus groups are face-to-face and last two hours allowing more time to digest and consider new information and take a longer term view. The online survey is taken via a digital interface and takes approximately 10-15 minutes meaning that responses may be more instant reactions than deeply considered attitudes.

Details of the refinements made can be found in the technical appendix.

3. Understanding public acceptability of hydrogen heating and heat pumps

This section describes the key findings of the research. It starts with an explanation of the overall heating technology preference, before describing the rationale behind this choice. A description of the key factors that influence preference for a heating technology follow, drawing on survey results and participant responses within the focus groups.

3.1. Overall heating technology preference

Having been provided with detailed information about the installation and lived experience of both technologies, heat pumps were the preferred heating technology amongst survey respondents. When forced to make a selection of their preferred heating technology at the end of the survey, 63% selected heat pumps and 37% chose hydrogen heating. While not a direct comparison, the overall preference of focus group participants was for hydrogen heating. The rationale for these preferences was consistent, with well-defined factors influencing why an individual might choose one alternative low-carbon heating technology over another.

In general, these preferences were driven more by perceived drawbacks than any positive factors attached to a given heating technology. The only counter to this trend was a small upsurge in support for heat pumps when survey respondents were informed that some types of heat pumps could also cool their homes. Three overarching barriers, discussed in more detail in section 3.4, were identified:

- **Installation burden: the direct implications of the processes of installation for households.** These included structural changes to the home, new appliances required, how long the installation will take, as well as the ability to use heating systems during the installation process. The greater the installation burden is felt to be, the greater the barrier for that particular heating technology.
- **Familiarity of the lived experience: the similarity for the user of using the new heating system.** This included considerations about the operation of new appliances and how the system and appliances fit into existing energy routines and behaviours. If they are seen as very different, this is a greater barrier, as this difference creates uncertainty for the public and requires them to adopt new heating behaviours and habits.
- **Meeting modern household heating needs: the need to meet heating preferences and align with a future vision of the smarter, modern home.** Heat pumps and hydrogen heating were judged by the extent to which they are seen to offer comfort and convenience, as well as aligning with the trajectory of a smarter home; one that is quieter, faster and with technology that is more. If a heating technology is perceived as less modern in this regard, then this will create a greater barrier to acceptability.

Ultimately, however, what the overall results also demonstrate is that people's attitudes and preferences are heavily influenced by how the information on alternative heating technologies is communicated. Knowledge of low-carbon energy alternatives is low and public opinion is certainly not fixed. Even within this study, changes made to explanatory materials between each phase and methodological differences had an impact on their heating technology preference.

The next section describes participants' levels of knowledge and awareness of the technologies and the switchover in more detail.

3.2. Knowledge and awareness of the switchover

In both the qualitative and quantitative phases, consideration was given to attitudes towards climate change, knowledge of the causes of climate change and how respondents viewed the rationale and necessity for the switchover from natural gas to a low carbon heating technology. This section describes supportive and sceptical views, as well as illustrating knowledge and awareness related to specific heating technologies.

Attitudes towards climate change

The majority of survey respondents felt it was important that actions are taken to mitigate against climate change. Over three-quarters, (76%) of respondents, stated that they were fairly concerned or very concerned by climate change, and only 5% stated they were not at all concerned.

There were mixed views as to where responsibility lies for tackling climate change. There was a definite sense that the government should play a leading role. Over three-quarters of survey respondents (78%) felt it was quite or very important that the government legally binding targets have been set in order to reduce carbon emissions. Additionally, many felt the idea of the switchover was right, as 76% of survey respondents reported that it was quite, or very important, that every home in the UK switches to alternative low-carbon energy sources for heating. The importance placed on switching over by the public therefore suggests that there is an openness to the need to switch, to help decrease carbon emissions.

Equally, it was thought to be very important that the public are involved, as over four in five respondents reported that they felt it was quite or very important that the public have a say about the options for alternative low-carbon energy sources for heating their homes. The public's responsibilities was also emphasised by some participants in the qualitative research:

"[It is important that] we do it for ourselves, for the next generation. It should come naturally to us because I mean it's getting worse and worse. I don't think about it every day, but I'm aware that it's a big problem that needs to be addressed, so, if we don't address it now it will have to be addressed later."

(36-65 year old, Degree level, London)

In general, there was positivity and support for the problem being tackled collectively, with participants in the qualitative research viewing it as a progressive step to take.

"I'm all for it. It probably should have happened a long time ago ultimately."

(18-35 year old, up to A-Level, London)

Despite this general support for the switchover, only one in ten of those who reported that they paid attention to the amount of energy used to heat their home stated that they do so in order to minimise the environmental impact of the heat used. Comfort levels and associated costs have much greater influence on people's interest in energy use for heating. Therefore, while there may be an emphasis on the individual to take action, this cannot be at the expense of them meeting their heating needs.

A small minority remain sceptical about climate change. Just over one in ten (13%) respondents stated either that they do not believe in climate change, or that they believe it is entirely or largely the result of

natural processes. However, from the qualitative research, it was clear that even when participants were not sceptical about the concept of climate change itself, there was still cynicism about the efforts that could be made mitigate against it, on three levels:

- **Global:** Uncertainty around the role the UK can play in what is seen as a global issue, especially if other countries are seen to be more polluting.
- **National:** Wariness over the government's role in reducing carbon emissions.
- **Personal:** Difficulty in understanding to what extent a viable difference can be made, through individual actions day-to-day.

In terms of the government's role, there is distrust towards the latest advice about what is good or bad for the environment, given that new evidence means these viewpoints can change. Some of the participants in the focus groups referred to the government's previous promotion of diesel cars, which the government is now strongly discouraging, in order to demonstrate that the government does not always make the right decisions in this area:

"I just feel the goalposts might change in a couple of years. A couple of years ago they told us to buy diesel cars and now they're telling us they're going to be worthless in a couple of years."

(36-65 year old, up to A-Level, Edinburgh)

Therefore, those who are already sceptical about the topic will be harder to engage, as they question the effectiveness and the real need of switching from natural gas. A further challenge in addressing this will be the difficulty in making the benefits to the environment tangible, rather than part of a green, or eco movement.

"I'm not that eco-friendly, I'm not bothered. I just want to make sure it's cost-efficient and comfortable."

(36-65 year old, up to A-Level, Edinburgh)

Knowledge of the switchover and potential alternative low-carbon energy sources

Despite the importance placed on reducing carbon emissions by the majority of respondents, there was a low level of knowledge and awareness of the specific need to switch from natural gas to alternative low-carbon energy sources for heating homes. Over half (57%) had never heard of it, or stated they had heard of it, but did not know much about it.

Knowledge and awareness of alternative low-carbon heating technologies was also low. Although references to solar power and wind energy in the qualitative research suggest awareness of some renewable energy sources, heat pumps and hydrogen for heating are much less well known. Just over half (51%) of survey respondents have never heard of hydrogen fuel boilers, the lowest awareness of all the technologies asked about. Respondents reported similarly low levels of knowledge of heat pumps, with 42% stating they had never heard of either ground or air source heat pumps.

Summary: Support for the concept of the switchover

Results from the research therefore suggest that the public would be open in principle to switching over from natural gas to alternative low-carbon heating technologies in their homes, in order to help reduce carbon emissions. However, as the public reported low levels of knowledge on the topic, their understanding of how this would work in practice is also likely to be low. Therefore, on learning about the specific implications of the switchover on their household, this openness tended to lessen, due to the three key barriers, described in section 4.4.

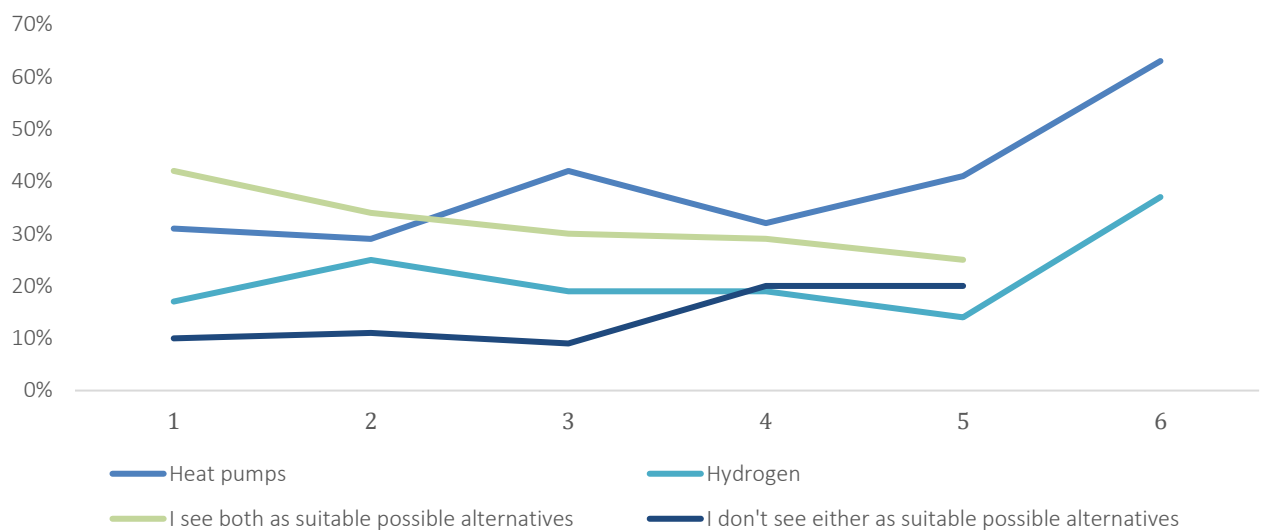
"It's a good idea, but how will it be implemented? At what cost to the consumer and how long to actually do it?"

(36-65 year old, Degree level, London)

3.3. Reactions to specific aspects of the installation

This section describes the responses given on the preferred heating technology following the provision of information on each stage of the installation process and consumer experience for each heating technology. The information provided to research participants on each technology was released incrementally, allowing the assessment of the impact each factor had on preference. The remainder of this section describes how this preference changes at different stages of the quantitative survey, as illustrated in Chart 3.1. below.

Chart 3.1.: Preferences of heating technologies after receiving different pieces of information about heat pumps and hydrogen heating



The numbers on the horizontal axis mark different points at which each piece of information was provided to the respondents:

1. Initial reaction: A brief summary of each heating technology and how it works
2. Lived experience: Description of what the experience of heating and cooking would be like in home, post the installation of each technology
3. Heat pumps and cooling: Explanation that heat pumps could also potentially cool homes
4. Appliances required: Identifying what appliances would need to be installed as part of the process
5. Disconnection from the gas grid: Explanation of how long the installation process would take and implications on heating and cooking ability in this period
6. Final preference: After hearing all information described in 1-5, respondents were asked to choose between the technologies (the two alternative options which allowed respondents not to make a definitive choice between the technologies, as shown in Chart 3.1., were removed at this final stage)

1. Initial reaction

The low level of public knowledge around alternative, low-carbon energy sources means that the public have little to judge each of the heating technologies on initially. Even when provided with initial information on heat pumps and hydrogen heating, this did not drive a definitive preference for one heating technology over the other in most cases.

Initially, therefore, little appears to help differentiate preference between the two heating technologies. The largest group of respondents (42%) saw both heat pumps and hydrogen heating as suitable alternatives to natural gas. However, heat pumps (31%) were already preferred to hydrogen (17%) prior to any implications being explained.

2. Lived experience

When provided with information describing the consumer experience of living with each heating technology, preference for hydrogen heating slightly increased (by 8 percentage points), whereas preference for heat pumps slightly decreased overall (by 2 percentage points). However, over half of respondents felt that the lived experience for hydrogen heating (55%) and heat pumps (52%) was between 'somewhat reasonable' and 'extremely reasonable', suggesting that the differences between the lived experience of the two heating technologies is not a decisive factor in driving technology preference.

3. Heat pumps and cooling

Heat pumps became more attractive to respondents when respondents were provided with information about the cooling capabilities of heat pumps. Preference for heat pumps increased by 13 percentage points at this stage. This illustrates the potential importance of demonstrating the additional utility that each technology can provide in order to improve public acceptability.

4. Appliances required

Respondents were then provided with information about a range of aspects of the installation process. New appliances required as part of the installation process were a concern for both technologies. The number of respondents who reported that they did not see either heating technology as a suitable alternative to natural gas doubled at this point, increasing by 11 percentage points from 9% to 20%. Qualitative research suggests that the large number of appliance replacements and structural changes to the house required are a major concern due to negative perceptions of the cost and time implications, as well as perceptions of waste generation.

Those concerned about new appliances felt the effort the public were expected to go to in order to be ready for the switchover was surprising and in some case unacceptable:

"Again, I think it has cost implications for individual families and you need to know that. You need to know, and you need to have plenty of warning, ten years, whatever, so that you can plan your life accordingly. I mean you might want to leave wherever and go and live on the islands of Scotland or somewhere like that and not bother with the whole thing."

(36-65 year old, Degree level, London)

The number of changes needed also raised questions on the waste generated. This appeared to contradict the objectives of the switchover, with the appliance changes being cited as particularly wasteful.

"Disposing of 25 million radiators, that's not going to do the planet much good."

(36-65 year old, Degree level, London)

5. Disconnection from the gas grid

The biggest impact on heating technology preference was the time disconnected from the gas grid during the installation process. Preference for hydrogen heating fell to the lowest level at this point in the survey in response to the one to two week period of disconnection: fewer than one in five (17%) reported that they would prefer hydrogen heating at this stage. Respondent preference towards heat pumps, over hydrogen, also increased at this point to 41%, seemingly due to the fact that the time the public would be without cooking and heating capabilities is likely to be a lot shorter.

6. Final preference

Throughout the stages of the survey described above, between 39% and 52% of respondents stated that they did not have a preference for either heating technology, either stating that they saw both options as suitable alternatives (25%), or that they didn't see either option as a suitable alternative (20%). As more information was provided on the two technologies, the share of respondents who stated that they did not see either option as a suitable alternative increased from 10% of respondents at stage 1, to 20% at stage 5.

When respondents were forced to make a choice between heat pumps and hydrogen heating at the final stage, a fairly equal number of previously undecided respondents chose heat pumps and hydrogen. This resulted in 63% of respondents selecting heat pumps and 37% selecting hydrogen.

How the decision to switch is made

Respondents were also asked whether they had any preferences or concerns around whether the decision to switch was made on a local or national level. Respondents showed no particular preference as to whether a decision to switch from natural gas was made at a local or national level. Around two in five felt that both a local decision (42%), or a national decision (43%), would be 'somewhat reasonable' to 'extremely reasonable'. Furthermore, around a third stated that they were neutral about the decision-making process in both cases (33% for the national decision and 32% for a local decision).

A similar number of respondents, at around one in five, felt that the decision was between 'somewhat unreasonable' and 'extremely unreasonable' in either case (22% for the national decision and 24% for the local decision).

There were, however, negative views raised in the qualitative research around a decision being made at a local level and there was more appeal for a decision to be a national one. This was chiefly because the potential for different regions to be using different systems also raised concerns of a postcode lottery for energy:

"Like you're saying if one area was getting it and one area wasn't, you'd want to know why if you were or you weren't. You'd feel like the guinea pig a little bit, you'd be like why are they testing it on us? Are they not sure it's going to work if they're not rolling it out nationally?"
(18-35 year old, Degree level, Edinburgh)

There was also concern about how a switchover might be organised at a local level. Participants felt that if the switchover was rolled out nationally it would be more streamlined, in comparison to one managed locally, which was imagined to be disorganised and slow:

"I feel like if it's a national roll-out, there's less room for screw-ups, because when you leave it to individual councils or communities, everyone wants to do it different with contracts and stuff like that."

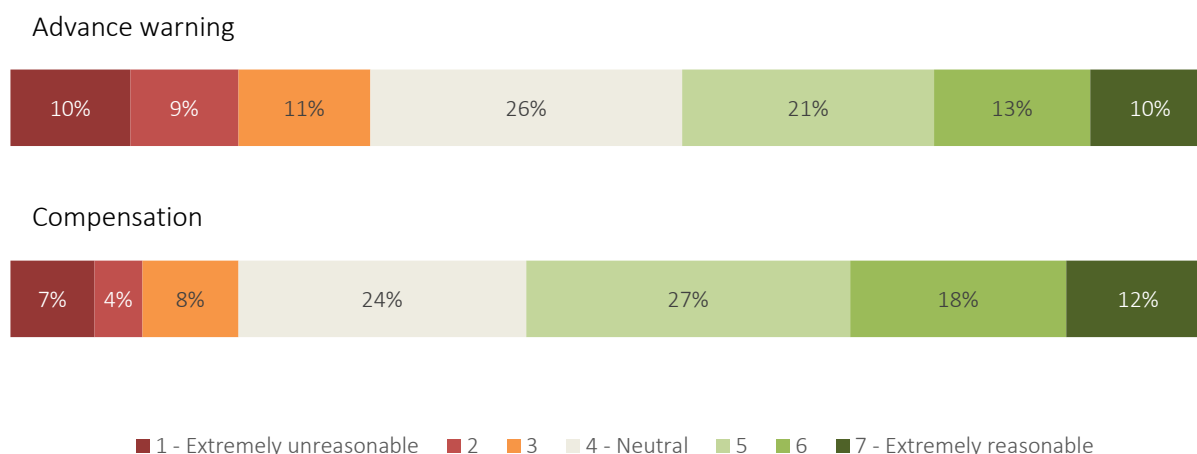
(18-35 year old, up to A-Level, London)

Supporting purchases of new appliances that are required for the switchover

Respondents were provided with two different scenarios for replacing existing appliances with new ones compatible with the new heating technologies. Overall, survey respondents felt that it was more reasonable for the government to introduce a compensation scheme to help pay for new appliances required as part of the switchover, rather than expecting households to factor in new appliances as part of routine replacement cycles. Over half (57%) felt that a compensation scheme (in isolation) was between 'somewhat reasonable' and 'extremely reasonable'; compared to just under half (41%) thinking a long lead time (in isolation) was either between 'somewhat reasonable' and 'extremely reasonable'. However, neither of the scenarios described were seen to be of huge concern, as only around one in ten, or less, stated that they felt the idea was extremely unreasonable.

Chart 3.2.: Reasonableness of approaches to support new appliance purchase

How reasonable do you feel the following ways to pay for the new appliances required are?



BASE: 1029

Findings from the qualitative research suggest that the preferred solution would be a combination of both scenarios; three areas where participants would expect to be supported were identified and are described in detail below.

Feasibility is dependent on dual-fuel appliances

A key point for the hydrogen heating scenario was whether appliance replacements would work for both natural gas and hydrogen. In this scenario, dual-fuel appliances are seen as vital for the switchover to be practical and allow for staggered appliance replacement.

"This cooker you are buying, will it be dual, so it works off the current system... because otherwise you'll have a cooker sitting in the corner not being used?"

(36-65 year old, Degree level, London)

Payment towards appliances should compensate for the installation burden

Where participants preferred compensation, this was felt to show recognition for the effort required of households to purchase and install numerous appliances.

"I think as long as you're compensated to some extent that's fine... then it's up to you, if you want to upgrade."

(18-35 year old, Degree level, Edinburgh)

The idea of the government providing compensation was more important for those who were more sceptical of the switchover in general. This is because they believed that the main beneficiary of the switchover was the government, who would be able to meet carbon emissions reduction targets.

"I think this benefits the government, doesn't it? It helps them reach their targets, so if they're going to force us to switch over then they have to [provide compensation] because it benefits them."

(18-35 year old, up to A-Level, London)

A long lead time is acceptable and should be built-in, even if compensation is given

Having a sufficiently long lead time was also understood and seen to be another way the public can be supported during the switchover. This is because participants can relate it to other switchovers that they have previously experienced, such as the digital switchover, although this is viewed as more of a major change, given the necessity of heating and cooking in home.

"Didn't they do that with TV when they switched to digital TV? They didn't give anyone money for that. They just said, you've got to get a digital TV by this time."

(18-35 year old, up to A-Level, London)

3.4. Factors affecting heating technology preference

Having described the reactions of survey respondents following their exposure to information about different aspects of both heating technologies in the previous section, this section explores in more detail the three main factors that appear to influence heating technology preferences. The factors are:

- Installation burden
- The lived experience of using the technologies
- How well technologies would meet modern heating needs

These are common factors effective at each stage of the journey on which we took research participants; yet they manifest in different ways for different people. These factors also played a role in shaping overall attitudes towards the switchover, as well as attitudes towards the heating technologies.

Factors affecting heating technology preference

The top three reasons reported by respondents for choosing heat pumps over hydrogen heating as their preferred heating technology, after receiving all information on the heating technologies, were all negative perceptions of the installation process: three in five (60%) identified the possibility of being without gas for 1-2 weeks; over half (55%) selected the possibility of needing new piping and just over half (51%) selected the need to replace their gas appliances.

Factors relating to the lived experience of the technologies and meeting the heating needs of a modern household were more prominent for respondents who preferred hydrogen heating to heat pumps.

Installation burden

When provided with a new piece of information about the heating technologies, respondents were asked how reasonable they felt that particular implication was. Of all the elements of the switchover described to respondents, being asked to live without access to the gas grid for one to two weeks was seen as the most unreasonable ask of the general public (see Chart 3.3.). One in five (20%) survey respondents stated that this was extremely unreasonable,= and just under half (48%) reported that it was 'somewhat' to 'very unreasonable'. No other individual aspect of the switchover was seen as extremely unreasonable by more than 11% of respondents.

In the qualitative phase, participants articulated exactly why being disconnected from the gas grid for one to two weeks was such a major concern. In particular, participants emphasised the impact on a household's ability to shower, cook and use the heating in the way that facilitates their daily routines:

"I don't understand how you would live for one to two weeks without it - are people expected to move out and... Just no."

(18-35 year old, Degree level, Edinburgh)

Many felt disbelief that it was even feasible for government to expect or ask this:

Focus group participant 1: "Surely they couldn't do that."

Focus group participant 2: "You wouldn't get people to buy into that."

Focus group participant 3: "They would kick up a stink."

Focus group participant 4: "Yes, the impact's too much."

(Group of 18-35 year olds, Degree level, Edinburgh)

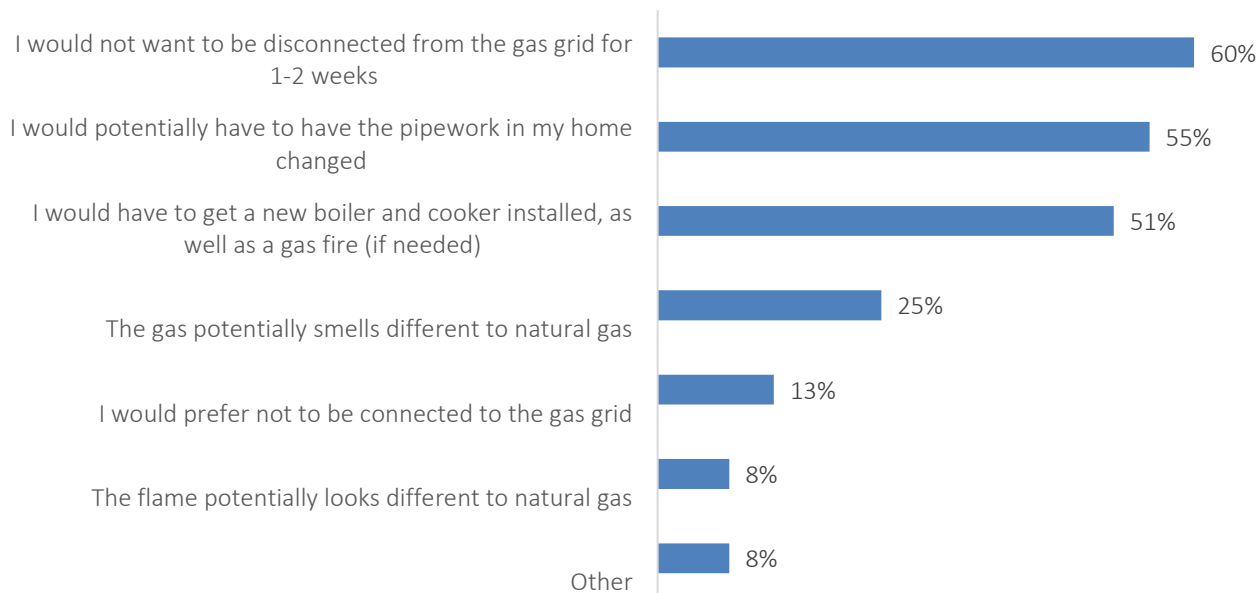
Some measures that could be put in place to support the public during a disconnection from the gas grid, were suggested within both phases of the research. These included:

- Explanation that summer would be the only time of year this would occur
- A reminder that all household electric appliances would still work during this period (e.g. kettles, microwaves, electric showers)
- Portable facilities, such as gas stoves and showers, could also be made available

These support measures did not, however, minimise concerns raised. Disruption caused by being disconnected from the gas grid was still felt to be a significant inconvenience and will therefore be one of the greatest challenges to public acceptability for a switch to hydrogen heating technology.

Chart 3.3: Reasons for heat pump preference

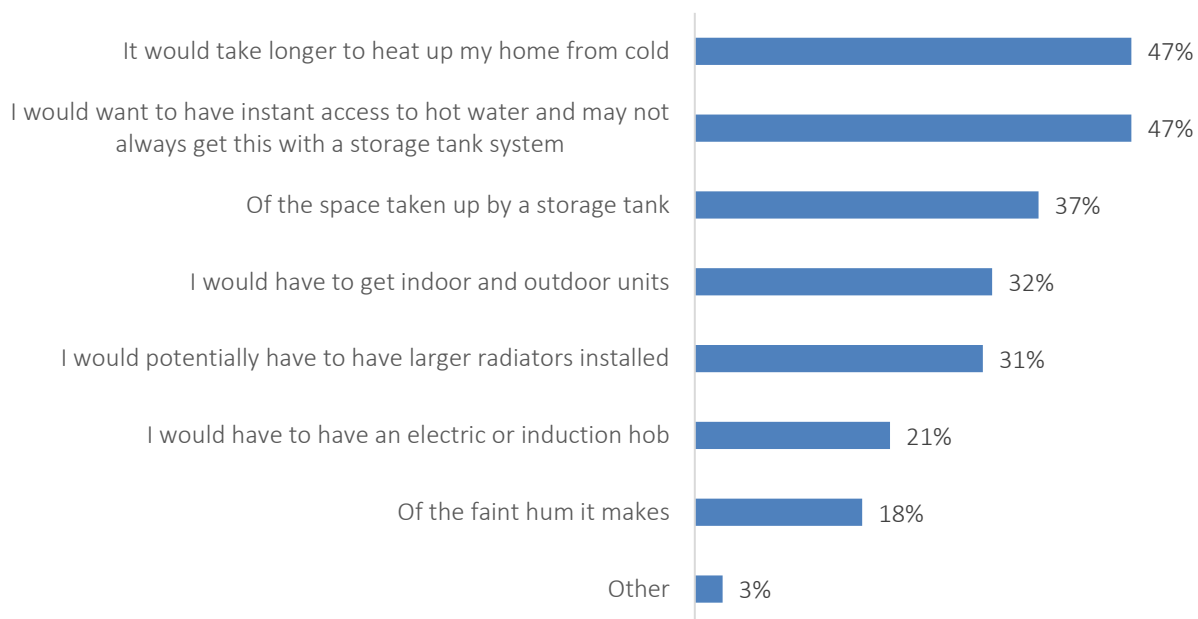
You say you would prefer not to have hydrogen heating in your home. What are the main reasons you would not want hydrogen heating? I do not like the sound of hydrogen because...



BASE: 685

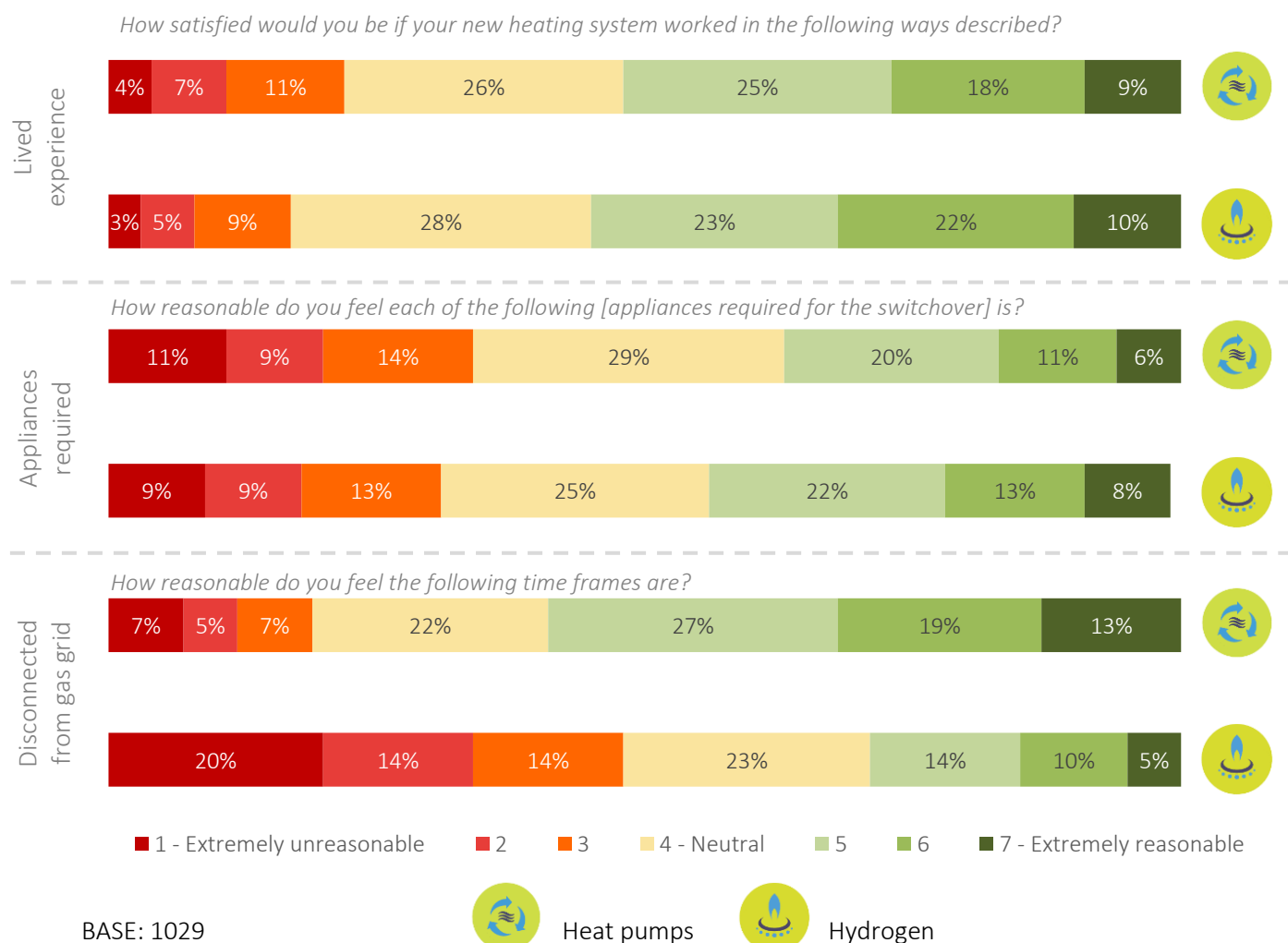
Chart 3.4.: Reasons for hydrogen heating preference

You say you would prefer not to have heat pumps in your home. What are the main reasons you would not want heat pumps? I do not like the sound of heat pumps because...



BASE: 384

Chart 3.5.: Reasonableness of various elements associated with heating technologies



Lived experience of using the heating technology

Elements associated with the lived experience of hydrogen heating were viewed as less problematic and easier to adapt to by qualitative research participants, whereas the perception of more significant differences with heat pumps created more uncertainty. The impact of this on the choice between technologies was, however, minimal; just over one in five (22%) perceived that the lived experience of heat pumps was 'somewhat' to 'extremely unsatisfactory', only a little higher than those who perceived the lived experience of hydrogen heating was 'somewhat' to 'extremely unsatisfactory' (17%).

Within the survey results, however, lived experience was more of a barrier to the acceptability heat pumps, (see Chart 3.5). Only a small minority of respondents cited reasons related to lived experience for preferring heat pumps over hydrogen, with only one in four (25%) selecting the different smell of the hydrogen gas and fewer than one in ten (8%) concerned about the hydrogen flame looking different.

Participants in the qualitative phase provided some explanation for why the lived experience of heat pumps was seen as a significant barrier. Overall, living with heat pumps felt much more challenging to imagine in reality. Hydrogen heating was felt to provide a 'like for like' replacement of the what they are used to, whereas heat pumps were viewed as a completely new heating system with many new aspects to learn about. This greater sense of change and uncertainty was expressed in relation to three key changes:

Uncertainty about the operation of new appliances

Outdoor and indoor units, a new storage tank, as well as (potentially) larger radiators would be required if heat pumps were installed. More specifically, questions were raised about the maintenance of the appliances in terms of how reliable they were, how often they might need replacing and who would be qualified to repair them. With fewer new types of appliance needed for hydrogen heating, maintenance was assumed to be similar to that of natural gas heating systems.

"It can't just be a case of something being on all the time and not breaking down. What is the life span of a pump?"

(36-65 year old, up to A-Level, Edinburgh)

Requirement for new heating and cooking behaviours

Heat pumps are less responsive than hydrogen and natural gas systems, so heating would therefore need to be switched on more continuously to keep the home warm. Participants were concerned about how they would make this work in practice, particularly where household routines are inconsistent. Concern over this prospect led participants to exaggerate or misinterpret how long and inconvenient this time might really be:

"You have to plan it and I feel like, [now] you can get those smart home things and you control it with your phone and you can turn up the heat before you get home and I would assume they'd use those instant boilers where it just sends heat through instantly. Whereas, this would take 24 hours to heat up."

(18-35 year old, up to A-Level, London)

Furthermore, participants also disliked the idea of cooking on electric cookers, with a preference for gas cookers. In some cases, induction cookers were felt to also meet cooking needs, however, many had not necessarily experienced cooking on this type of cooker and remained sceptical.

"It's a massive pain in the arse. They take so long to do anything. They don't have the pots as well, the electric ones, do they?"

(18-35 year old, up to A-Level, London)

Misunderstanding around shifting responsibility for heating from the grid to the individual

Participants understood that their current ability to heat and cook in their homes is reliant upon the gas grid. Many therefore found it easy to understand the way that hydrogen heating works, as it would also be reliant upon the same grid system. In contrast, although heat pumps rely on an electricity grid in a similar way that gas boilers rely on a gas grid, this is not always understood, leading to a greater lack of understanding in the case of heat pumps.

The bigger perceived change in this regard for heat pumps, versus hydrogen, led some participants to presume that the lack of a gas grid would mean homes would be responsible for their own energy production. This raised concern as to who would be responsible to ensure households have a consistent, reliable heating source:

"Who would be responsible for the unit with the heat pump? I feel like hydrogen comes through the pipes like it does just now... you don't really think about what happens out there. When the heat pump is on your property, it's there; it has to work for you to get your electricity, your hot water and whatever."

(36-65 year old, up to A-Level, Edinburgh)

In all cases, however, whether heat pump, hydrogen boiler, or natural gas boiler, heating relies upon the proper operation of both the relevant gas, or electric, network and of the appliance within the building. The responsibility of operation is therefore potentially a source of misunderstanding, which could be a barrier to the implementation of heat pumps.

Meeting modern household heating needs

The ability for a heating system to achieve desired comfort without inconvenience is important for households. However, the number of structural changes required to install heat pumps means people are less likely to feel that this technology would be able to meet their current heating needs.

Respondents who selected hydrogen heating as their preferred heating technology were more confident that hydrogen heating would be able to meet current heating needs, being seen as a simple progression from natural gas and having a similar lived experience.

Participants in the qualitative research viewed heat pumps as less modern. The greater use of space, lack of responsiveness, additional noise generated by the pump, and the overall look of heat pumps that was envisaged, did not tie in with perceptions of a smart home. These are discussed in detail below.

Lack of responsiveness

Participants are used to and appreciate being able to turn the heating on and off as desired and being able to feel the results quickly, especially if they have smart heating controls that further emphasise this lack of responsiveness. Therefore, as heat pumps would mean homes would take longer to heat up, they were seen as a backwards step. Furthermore, the potential that hot water might run out and may not always be available at the touch of a button, was also a concern:

“So, to me that would be like a step back... like okay it might be more energy efficient, but it's not going to be any more efficient to my life, so I'm not interested. Bin it.”
(36-65 year old, up to A-Level, Edinburgh)

A step back in time to older, less space-efficient hot water systems

Having to install or re-install a storage tank causes further concern, because they are known to be large, therefore taking up space, which could be used in other ways. Given that storage tanks were also used in older heating systems, they are also seen as outdated and suggest a step back in time.

“My concern is how big the storage tank is because... if you've got a small kitchen, not everyone has got a mansion, where are you going to put it in?”
(18-35 year old, up to A-Level, London)

An outdated outdoor unit that adversely impacts the aesthetics of the home

Concerns were also raised about the aesthetics of the outdoor unit, particularly in Edinburgh, where many city centre buildings are listed. Additionally, the noise of the fan added to the perception of a less modern system.

“A big massive box making a noise that stands in front of the house making your house unattractive - who would want that?”
(36-65 year old, up to A-Level, Edinburgh)

Despite these concerns, survey results suggest that a clear consumer benefit or added utility from the new heating technology can sway opinion. The cooling capability of some types of heat pumps is seen to reflect a more modern heating system: the largest peak in support for heat pumps was observed after survey

respondents were provided with the information about the cooling functionality of some types of heat pumps (preference increased by 13 percentage points).

In the qualitative research, participants were not informed of the cooling capability of heat pumps. Given the perceived burden of the installation, it is clear that the public will look for additional personal utility and not just the environmental benefits in choosing alternative heating technologies.

"Everything is pretty much changing because of this technology and I'm still not seeing what the actual benefits are. What am I saving? What are the savings to me? If I'm spending all this money to have this technology, then I need to be getting [something] back out of it, and I can't see that."

(36-65 year old, Degree level, London)

Short-term and long-term perspectives

The way these factors drive preference manifests differently between individuals. Those who concentrate on the immediate, short-term burdens of the installation will typically prefer heat pumps. Alternatively, others are willing to overcome the short-term installation burden associated with hydrogen heating for what they perceive as a more familiar, modern and convenient technology.

However, any additional consumer benefit a heating technology can provide will have a positive impact on how a heating technology is viewed, and better enable it to overcome other burdens associated with the installation and lived experience.

3.5. Informed understanding and remaining knowledge gaps

Educating the public on the heating technologies will be a key challenge

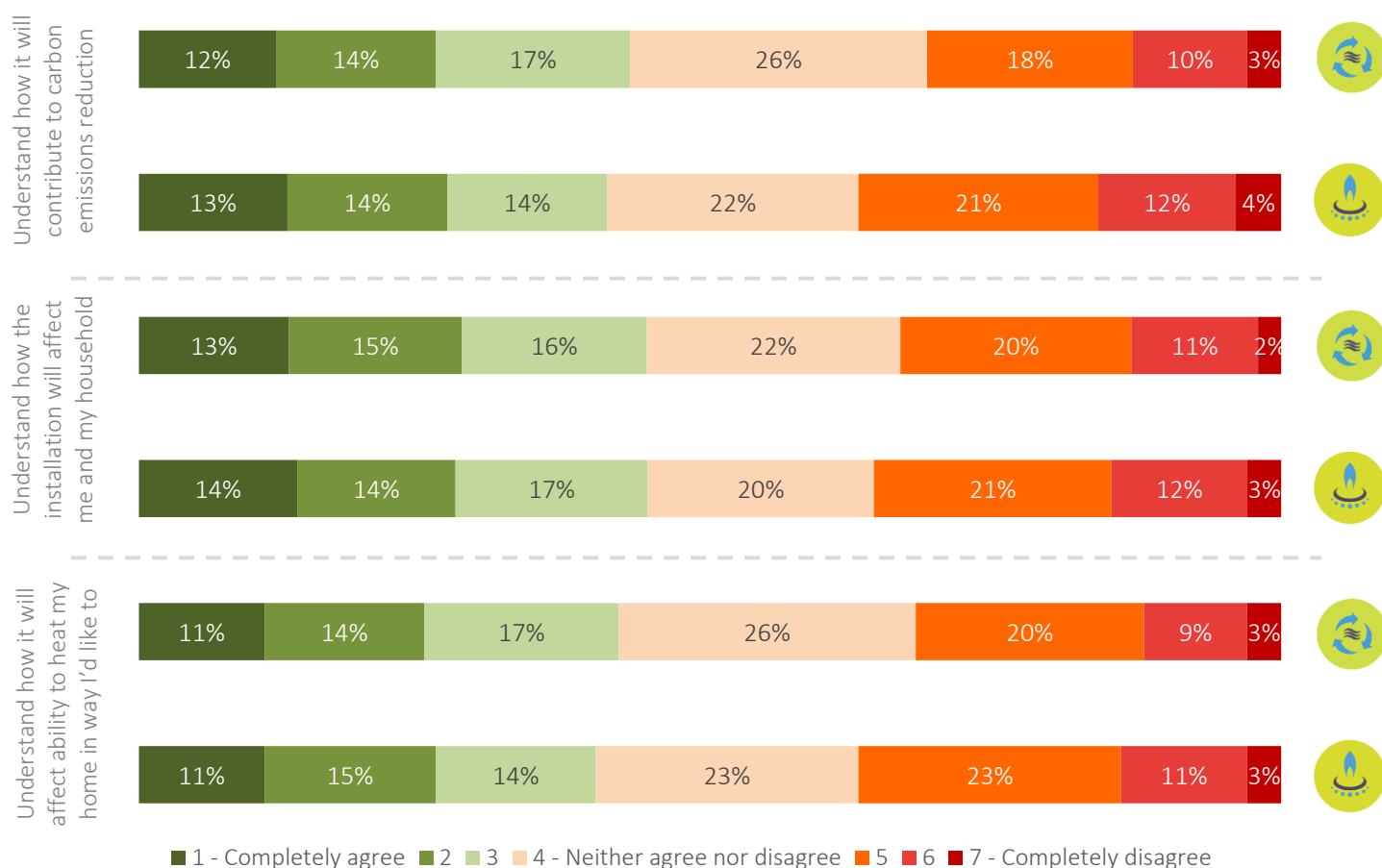
At the end of the quantitative survey, once respondents had received information about each heating technology and the installation processes, knowledge and understanding of both hydrogen heating and heat pumps remained low. Less than half of respondents felt they understood the impact and workings of the heating technologies. This was in terms of understanding how either technology would:

- Contribute to carbon emissions reductions (heat pumps 43%; hydrogen 41%);
- Affect their household (heat pumps 43%; hydrogen 45%), or
- Affect their ability to heat their home in the way that they would like it to (heat pumps 42%; hydrogen 40%).

Public acceptability of the use of hydrogen for heating

Chart 3.6.: Level of understanding the heating technologies after all information has been provided

Thinking about all the information you have heard about hydrogen and heat pumps, to what extent do you agree with the following statements



BASE: 1029



Heat pumps



Hydrogen

Respondents were also asked which elements of the heating technologies they would like to know more about. Nearly two thirds (64%) stated that they would like to know more about how heat pumps work in their home; over half (56%) stated the same for hydrogen. Three in five (61%) also stated that they would want to know more about how and when hydrogen heating and heat pumps would be installed. In contrast, only around one in three (31% heat pumps; 28% hydrogen) were interested in knowing more about the impact of the heating technology on reducing carbon emissions.

The implied lack of understanding was reflected in the qualitative research, where the low levels of knowledge meant that a multitude of questions were asked throughout and at the end of the focus groups. This lack of knowledge prompted varied questions, with the most pressing related to direct implications for households:

"The cost of having it done, the impact on the home, the efficiency of how it all works, they're all questions that I'd really like the answers to."

Public acceptability of the use of hydrogen for heating

(36-65 year old, Degree level, London)

There was also difficulty in participants' ability to understand how this would work in practice, and visual illustrations were requested.

"To see a picture of the house with that thing installed already and just to see what it actually looks like in real life. Maybe it's not as bad as we think it will be or maybe it's worse."

(36-65 year old, up to A-Level, Edinburgh)

In addition, however, further explanation would be required in relation to the need for and the benefit of reducing carbon emissions, particularly given the perceived burden of the installation. This concern could be alleviated to some extent by coordinating a smooth transition.

"I'd like to know what the overall effect would be on the ozone layer, or whatever. Is it going to eliminate global warming in this country? Is it going to cut it by 50 per cent et cetera, et cetera? Now, you need more information."

(36-65 year old, Degree level, London)

Finally, rationale around why the specific heating technology has been chosen to replace natural gas, over others, will be required. This is due to public awareness of other renewable technologies (e.g. solar and wind), which are more familiar and perceived as easier to implement, than both hydrogen heating and heat pumps.

"Are these two options that have already been decided by the government? I would like to find out if we could have the same benefit via having a wind turbine or having solar panels that we can get from the UK. I don't know what other options there are, why we're not using them. It would seem a lot more simple."

(18-35 year old, Degree level, Edinburgh)

Due to having limited knowledge initially, there are significant educational challenges to overcome in supporting the switchover and what living with the alternative technologies means in practice.

4. Conclusions and implications

This research does not provide a definitive conclusion about public preferences for either hydrogen heating or heat pumps. While heat pumps were ultimately preferred by 63% of the respondents at the end of the survey, it is clear that knowledge of the two technologies remains low and preferences are not fixed or embedded.

The way in which different variables are framed can influence views on each heating technology and ultimately swing opinion. Until forced to actually make a choice between hydrogen heating and heat pumps at different stages of the survey, between 45% and 55% of respondents could not choose between the two. When forced to choose, these undecided respondents chose hydrogen heating and heat pumps in roughly equal numbers.

The research does allow us to draw stronger conclusions in relation to the specific factors that drive public acceptability of alternatives to natural gas. Installation burden is of most immediate concern to the public, with longer-term concerns relating to system familiarity and meeting heating needs as influential. Overall, while public acceptability of the need for the switchover is relatively high there remains a need to emphasise additional benefits of any alternative technologies and reduce the installation burden as much as possible. A series of specific implications for policy and industry emerge from these conclusions:

- **For both technologies, effective public engagement on the switchover will need to be built around a narrative that makes tangible the long-term need for the switchover, the collective nature of the burden that this will impose, as well as the household level benefits. Specifically, this means:**
 - Starting early to incorporate a long lead time and an incremental approach, establishing the need and public acceptability for the switch over in general before explaining options and the burden and benefits of the switchover at a household level
 - Communicating the additional consumer value and benefit of the new technology in a way that addresses the core drivers of household heating preference: cost, convenience, control and comfort
 - Ensuring that detailed descriptions include easy to understand as well as equitable support or compensation packages for replacing appliances
- **If hydrogen for heating is the selected solution, specific consideration should be given to:**
 - Articulating how the heating technology adds value or utility for the consumer in order for a switchover period of up to two weeks to be seen as acceptable
 - Providing workable solutions and support for households during the switchover period, particularly where members of the household are vulnerable or immobile
 - Providing a simple explanation of how the hydrogen is produced

To inform the development of these communications activities and also wider policy development in this area, further experimental research is likely to be required. In particular there would be value in verifying the *reported* attitudes and behaviours in this report with research that aims to uncover *actual observed* attitudes and behaviours in a real-life setting. Piloting hydrogen heating or heat pumps in dedicated local areas would facilitate this data collection, as well as enabling the testing of communications materials and the identification of unforeseen practical considerations and barriers that only emerge when these technologies are installed in-situ and at scale.

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