

Public awareness of and attitudes to low-carbon heating technologies:

An evidence review with primary focus on domestic consumers in Scotland

Danica Caiger-Smith and Amal Anaam, Energy Systems Catapult
July 2020

DOI: <http://dx.doi.org/10.7488/era/724>

1 Executive summary

1.1 Aims and findings

The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 commits Scotland to reducing greenhouse gas (GHG) emissions to net zero of the 1990 baseline by 2045. Emissions from buildings account for around 20% of Scotland's GHG emissions¹. Achieving Scotland's emission reduction targets is therefore likely to require changes to the heating and hot water systems of nearly all homes and non-domestic buildings.

While growing, the proportion of non-electrical heat demand met by renewable heat sources in Scotland is low, reaching 6.3% in 2018². Deployment of low-carbon and renewable heating needs to increase significantly to meet our net-zero targets. To inform this transition, this evidence review sets out to understand Scottish consumers' awareness of and attitudes towards low-carbon heating technologies and the consumer drivers and barriers to their take-up.

However, we found very little Scotland-specific evidence. Reports that covered Great Britain or the United Kingdom rarely offered country-specific insights. To fill this gap, we analysed existing datasets from Energy Systems Catapult research to compare Scotland with the rest of GB (i.e. England and Wales, combined). We found the attitudes and behaviours reported in Scotland were largely similar to those in the rest of Great Britain. We report on the few differences found below.

Key differences between Scotland and the rest of Great Britain:

- Awareness of biomass boilers and ground source heat pumps (GSHPs) is significantly higher in Scotland, but this does not seem to be driven by higher proportions of people having these technologies in their homes (although other systems like oil and liquified petroleum gas (LPG) heating are significantly more common in Scotland).
- Those living in Scotland are less likely to wait until their heating system is broken beyond repair before replacing it, although in both Scotland and the rest of GB the majority (65% and 71% respectively) say they would do this. This difference between countries is small but statistically significant.
- A smaller proportion of those living in Scotland than those living in the rest of GB said they would use savings to fund a new heating system in the event that their current system breaks down.
- Openness to considering different kinds of heating systems is significantly lower in Scotland: 26% said they would consider other kinds of heating systems (compared to 36% in GB), while 35% said they would be resistant to changing the type of heating system they have (compared to 21% in GB).
- The distribution of property types differs: those living in Scotland are significantly more likely to live in flats in large blocks and significantly less likely to live in semi-detached homes, compared to the rest of GB.

The main findings of the report are as follows:

- **Broad concern about climate change is not driving widespread uptake of low-carbon heat.**
Reported concern about climate change and the environment is high and widespread, with the majority saying they recognise the need to address it. However, this concern does not necessarily translate into heating system transitions. In some cases, people do not recognise the link between home heating and carbon emissions, so the motivation to reduce emissions is not factored into decisions about alternative systems.
- **Raising awareness of low-carbon systems may not be enough to drive uptake.**
Awareness of low-carbon heating systems differed between technologies and countries. However, most people who are aware of low-carbon heating systems decide not to switch to them when replacing their heating system.
- **People can be put off switching to low-carbon heating systems.**
The most likely time for people to learn about alternative heating systems is when replacing their existing system. They may decide not to install one even if they believe it is better for the environment. They cite practical factors like not having enough space for a heat pump or water tank. Noise or unattractive appearance may also put some people off.
- **There are two main factors that put people off low-carbon heating systems: the expected cost and uncertainty about performance.**
Those without low-carbon heating systems raise general concerns about the cost (particularly upfront cost) and performance of these technologies and would prefer to opt for the familiarity and convenience of a gas boiler. Although they do not appear to know for sure that these technologies will cost more to run or be less reliable, the uncertainty

of being able to get warm easily and affordably is off-putting. The cost of heating is higher for homes off the gas grid using LPG or oil instead of natural gas. This could strengthen the financial case for switching to low-carbon heating, something that may be particularly relevant in Scotland where a higher proportion of homes are heated with oil and LPG compared to the rest of GB.

- **The minority who have installed low-carbon heating tend to be motivated by environmental benefits.**

Among the small number of people who have installed low-carbon heating, most cite environmental benefits as a reason for switching – they may be more strongly motivated by ‘green’ factors than the general population. They also perceive low-carbon systems to deliver satisfactory warmth and comfort benefits, although it is common that satisfaction builds over time as people learn how to use what are often more complicated systems.

- **Financial support persuades some to adopt low-carbon heat but is not key for all.**

Financial support is important, if not critical, for some people to install low-carbon heat. However, current levels of funding can be too low and schemes that reimburse people over time may not help tackle the upfront costs needed to install low-carbon systems in the first place. There are also reports that funding is complicated to apply for and difficult to access.

- **Financial support alone is not enough to drive mass uptake of low-carbon heat.**

People also have non-financial reasons for choosing not to install low-carbon heating. Uncertainty about performance, a lack of available space and concerns about noise and aesthetics also put people off these systems. Support would drive more uptake if it could overcome these various other reasons people have for deciding not to replace their heating with low-carbon alternatives.

- **The heating trade is an important source of information about heating systems.**

About a third of Scottish consumers say they would ask members of the heating trade (e.g. ‘gas fitters’ or ‘plumbers’) for advice about heating systems. About a fifth of those in Scotland say that they would ‘probably just choose the heating system their plumber recommends’. Most people service their boilers annually, providing regular contact with these trades.

1.2 Recommendations

- **Reduce the inconvenience and uncertainty of switching to low-carbon heat.**

Providing relevant and accessible information about low-carbon heating systems and the benefits they offer at a time when people are actively looking to replace their systems could encourage them to consider low-carbon alternatives. Offering ways that these alternative systems can be installed quickly, reliably and with minimal inconvenience could trigger greater uptake of these systems.

- **Help consumers discover what low-carbon heating options are suitable for them.** People who install and maintain heating systems are a key source for sharing this information. For the fifth of Scottish people who feel they would ‘probably just choose the system their plumber recommends’, plumbers may even be their *only* source of information. Upskilling the heating trade and encouraging it to promote these systems over conventional alternatives could help boost confidence in and uptake of these systems.
- **Proactively introduce the idea of low-carbon heating options.** The majority of people in Scotland who have gas heating systems have their boiler serviced annually. This regular moment of contact could provide an opportunity to raise awareness and inform people about low-carbon heating systems, encouraging them to consider these technologies when they next replace their system.

- **Give consumers confidence they will be able to get the comfort they want for a predictable price.** Low-carbon heating systems could be offered as part of a 'packaged solution' that gives people this confidence. For example, a solution might include options that make it easy for people to control and manage their system. Solutions which require the supplier, rather than the consumer, to be responsible for ensuring homes are comfortably and affordably heated may also increase uptake of low-carbon systems. Home upgrades, for example insulation or a hot water tank, may be needed alongside a new heating system. The extent of these measures will vary between homes depending on their thermal efficiency. Consumers are unlikely to know how to combine home energy efficiency measures effectively with low-carbon heating systems by themselves. Therefore, it might help to offer them as part of a packaged solution or service.
 - **Start with homes that are already suited to low-carbon heating systems,** because they will need less work. Positive early experiences of these systems could promote them more widely as desirable alternatives.
 - **Encourage less suitable households to prepare their home for low-carbon heating.** This will mean they can replace their heating systems with a low-carbon alternative more quickly, when they come to replace their current system.

- **Simplify the application process for financial support.** Access to funding or other financial support is an important motivator for many who install low-carbon heating systems and is critical to the decision for some. Not everyone finds the application process easy or quick to navigate. Simplifying the process for applying for financial support could encourage uptake and boost satisfaction with the process.

The sources reviewed and research questions are detailed in a separate worksheet which can be found at: <https://www.climateexchange.org.uk/research/projects/public-awareness-of-and-attitudes-to-low-carbon-heating-technologies/>

Contents

1	Executive summary	1
1.1	Aims and findings	1
1.2	Recommendations	3
2	Introduction	7
2.1	Background	7
2.2	Objectives	7
2.3	Gathering evidence	7
2.4	Assessing evidence	8
2.5	Available evidence	8
2.6	Additional analysis	8
3	Public awareness of low-carbon heating technologies	2
3.1	Public awareness of low-carbon heating technologies	2
3.2	People hear about low-carbon heating from different sources	4
3.3	Awareness does not mean knowledge or understanding	6
3.4	The importance of situational factors	7
3.5	Awareness: conclusions and recommendations	9
4	Attitudes towards low-carbon heating	9
4.1	Concern about climate change does not necessarily translate into heating system choices	9
4.2	Gas boilers are the default preference for many	11
4.3	Attitudes: conclusions and recommendations	12
5	Perceived benefits and drawbacks of low-carbon heating	12
5.1	Motivations to install low-carbon heating	13
5.2	Satisfaction varies, but is strongly associated with ability to get warm and comfortable	13
5.3	Those who have rejected low-carbon heating systems cite more practical factors	17
5.4	Those without low-carbon heating perceive more drawbacks than benefits	18
5.5	Perceived benefits and drawbacks: conclusions and recommendations	21
6	Perceptions of incentives and financial support	22
6.1	Financial support schemes increase switching	22
6.2	Schemes can be seen as complex and difficult to navigate	23
6.3	Incentives and financial support: conclusions and recommendations	24
7	Conclusions and recommendations	25
8	References	Error! Bookmark not defined.
9	Appendices	28

Contributors and Acknowledgements

Energy Systems Catapult

Lead researchers: Danica Caiger-Smith and Amal Anaam

Data scientist: Irene Garcia

Contributors: Ian Jones, Tim German, Matt Lipson, Richard Halsey

Energy Systems Catapult would like to thank all those who responded to the call for evidence issued as part of the evidence-gathering stage of this report.

We would also like to thank the following individuals for their time and input during the expert interviews:

Aoife Deery, Senior Energy Policy Officer at Citizens Advice Scotland

Prof. Jim Watson, Professor of Energy Policy and Research Director at University College London (UCL) Institute of Sustainable Resources

Joanne Wade, Deputy Director at the Association for Decentralised Energy (ADE)

Zoe Guijarro, Policy Manager at Citizens Advice Bureaux (CAB)

We would also like to thank **Dr. Val Mitchell, Senior Lecturer in Experience Design at Loughborough University**, for her input and support with gathering and assessing evidence and reviewing the draft report.

2 Introduction

2.1 Background

In 2019 the Scottish Parliament passed the Climate Change (Scotland) Act 2019. This Act sets statutory targets for the reduction of greenhouse gas (GHG) emissions across Scotland. These ambitious targets set a 75% reduction in emissions by 2030 against the 1990 baseline, 90% by 2040 and net-zero emissions by 2045, five years earlier than the rest of the UK. Achieving these emissions reductions is likely to require significant changes across all sectors.

Emissions from buildings account for around 20% of Scotland's greenhouse gas emissions¹. Achieving Scotland's emissions reduction targets is therefore likely to require changes to the heating and hot water systems of nearly all homes and non-domestic buildings.

The proportion of non-electrical heat demand being met by renewable heat sources in Scotland in 2018 was 6.3%², up from 5.5% the previous year. Renewable Heat Incentive (RHI) data suggest that around 9,530 heat pumps have been installed in Scotland through the GB-wide Domestic RHI scheme, since the inception of the scheme in 2014. Air-source heat pump installations in Scotland rose by 11% in the 6 months between December 2018 and July 2019, and ground- source heat pump installations increased by 8% for the same period.

While this growth is welcome, deployment of low-carbon and renewable heating needs to increase significantly to meet Scotland's net-zero targets.

To inform this transition, we need a better understanding of how aware the public is of low-carbon technologies, what citizens' attitudes are towards those technologies, and what the consumer drivers and barriers are to their take-up.

2.2 Objectives

This report has been prepared by Energy Systems Catapult (ESC) on behalf of ClimateXChange to address research questions posed by the Scottish Government.

The report has two aims:

- To review the public's awareness of and attitudes towards low-carbon heating technologies, focusing on domestic consumers and households in Scotland where possible, otherwise in the UK.
- To examine differences according to whether households currently have a low-carbon heating technology or not.

2.3 Gathering evidence

Three approaches were used to gather evidence.

- 1) A call for evidence (see Appendix 1) was issued to relevant contacts of and subscribers to Energy Systems Catapult. This call was also published in the ESC newsletter, on the ESC website, and was shared on LinkedIn and Twitter by the ESC and individuals within its network.
- 2) A structured search was run via an academic database to identify relevant journal articles, conference proceedings and other papers. Details of search terms can be found in Appendix 2.

- 3) Four experts were interviewed by members of the project team. These experts were asked to signpost relevant research and findings as well as provide a summary of their perceptions about the available evidence relating to the research questions.

- **Aoife Deery**, Senior Energy Policy Officer at Citizens Advice Scotland
- **Prof. Jim Watson**, Professor of Energy Policy and Research Director at University College London (UCL) Institute of Sustainable Resources
- **Joanne Wade**, Deputy Director at the Association for Decentralised Energy (ADE)
- **Zoe Guijarro**, Policy Manager at Citizens Advice Bureaux (CAB)

2.4 Assessing evidence

Sixty-five pieces of evidence were assessed for quality and relevance to the research questions. Due to the volume of evidence, two ESC researchers assessed half of the available evidence each. To establish confidence that assessments were being executed similarly, a calibration activity was included: the ESC researchers also assessed three randomly-selected items from each other's lists. This allowed discrepancies to be identified and diagnosed and, where it was felt there might be implications for other assessments, adjustments could be made.

Finally, a third individual assessed four items from the calibration activity, again allowing for any discrepancies to be identified and diagnosed.

Assessment criteria and the outcomes of the calibration activity can be found in Appendix 3.

2.5 Available evidence

Fifty-two pieces of evidence were reviewed in compiling this report. However, it is important to note that we identified limited evidence which was specific to Scotland. Some evidence based on the United Kingdom or Great Britain as a whole offered limited breakdown or comparison of findings by individual country. The majority of evidence identified findings from the wider UK or GB population with no country-specific breakdown available. Where possible, learnings specific to Scotland have been highlighted.

Some pieces of evidence were highlighted in response to the call for evidence, but unavailable at the time of writing. Details of these have been shared with ClimateXChange separately from this report.

A spreadsheet identifying reviewed evidence can be found in Appendix 4.

2.6 Additional analysis

In addition to analysing evidence gathered through the approach outlined in section 2.2, ESC conducted some further analysis to enhance applicability of this report's findings to Scotland specifically. Datasets from existing ESC research were broken down by country to compare attitudes towards low-carbon heating between Scotland and the rest of Great Britain (i.e. England and Wales combined). Where original datasets were based on the UK, data from participants in Northern Ireland was excluded, for two reasons:

1. For consistency in comparing Scotland to the rest of Great Britain only.
2. Northern Ireland has lower penetration of the gas grid than the rest of the UK.

The sources of these datasets and the size of their total and Scotland-based samples are shown in the table below.

Source	Original sample size	Great Britain sample	Scotland sample
Consumer segmentation (2018) ³	3000 (UK)	2732	167
Market Transformations: consumer reactions to future market scenarios ⁴	2166 (GB)	1990	176
Market Transformations: consumer reactions to heat pumps with and without Heat as a Service ⁴	1200 (GB)	1099	101
Innovating to Net Zero ⁵	2043 (UK)	1813	179

Due to the relatively small samples of Scottish consumers, caution is recommended when interpreting differences between countries.

Identifying significant differences:

The analysis approach sought to test the null hypothesis that, for a given survey question, the distribution of responses is *independent* of the country, i.e. responses do not vary significantly depending on whether respondents are in Scotland or the rest of Great Britain. Chi square values were calculated for each question*.

Questions for which the distribution of responses *does* vary significantly depending on the country (and therefore null hypothesis can be rejected) were selected on the basis of $p < 0.05$, i.e. the probability that the difference found is due to chance is less than 5%. These were identified by selecting those questions where the derived Chi square statistic exceeded that which would be expected for $p < 0.05$.

Identifying what contributes to significant differences:

Graphs were plotted to show the relative contribution of each response for each country to the total derived Chi square statistic. These were used in conjunction with the frequency distribution of the responses to determine which particular question responses were different between countries.

Findings from these comparisons are incorporated into this report alongside findings of the evidence review.

* Chi-squared values are used to determine whether there is a statistically significant difference between the frequencies of responses *observed* in a population and the frequencies that would be *expected* if there were no relationship between the responses and the population (i.e. they are independent).

3 Public awareness of low-carbon heating technologies

3.1 Public awareness of low-carbon heating technologies

Reported public awareness of low-carbon heating technologies varies substantially. Sometimes awareness is described as low, as by Parkhill, Demski, Butler, Spence & Pidgeon (2013)⁶ and as in the 2016 report by the Committee on Climate Change (CCC; 2016)⁷, though these do not refer to specific statistics.

Where statistics are highlighted, awareness appears to be fairly high, for example a regular attitudes tracker run by the UK government's Department of Business, Energy and Industrial Strategy (BEIS)⁸ found the majority (57%) of those surveyed in 2019 were aware of renewable heating systems. In that research, awareness is defined as those who say they 'know a lot' or 'know a little' about a technology, as well as those who say that they are 'aware of it but don't really know what it is'. Conclusions of 'low' awareness may be based on more conservative definitions, for example defining awareness as having heard of a technology *and* understanding what it is⁹.

Within surveys, reported awareness differs between technologies and countries. For example, awareness of biomass boilers and heat pumps tends to be higher than awareness of heat networks, and awareness varies between British countries. These points are illustrated in **Figure 1**, which shows data from the BEIS Public Attitude Tracker⁸, the BEIS Future of Heat survey (publication in progress)¹⁰ and ESC's Market Transformations research (2018)⁴ distinguishing between those in Scotland and those in the rest of Great Britain (or UK, in the case of the BEIS Public Attitudes Tracker).

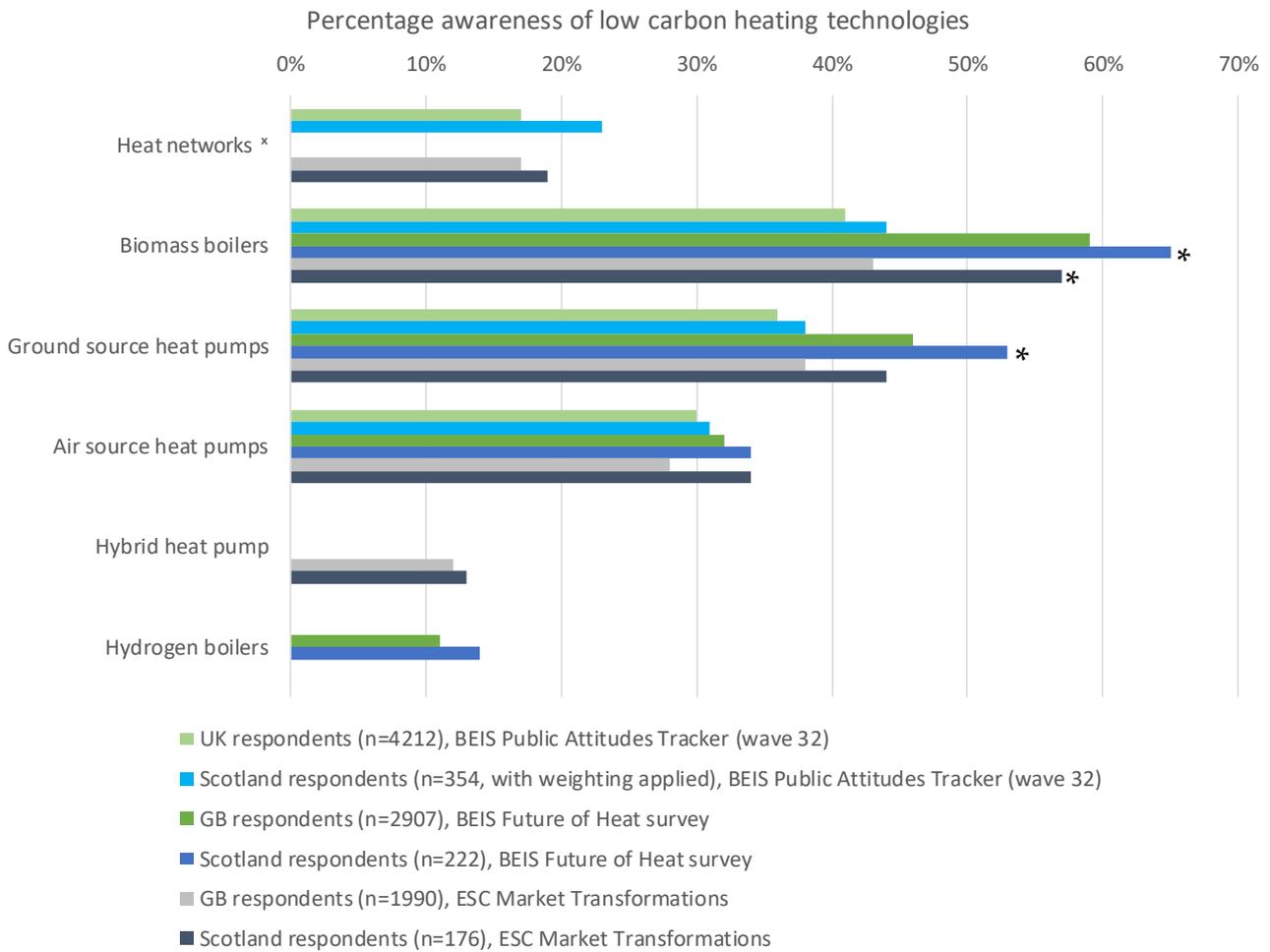


Figure 1: percentage awareness of low-carbon heating technologies.

* denotes a significant difference between Scotland and the rest of GB/UK within each survey.

BEIS Public Attitudes Tracker: awareness based on those who 'know a lot', 'know a little' or 'are aware of the technology but don't really know what it is'. Note that no statistical testing for significance was undertaken for the BEIS Public Attitude Tracker. * Awareness of heat networks is based on those who 'have heard of' this technology.

BEIS Future of Heat survey: awareness based on those who 'have heard of' the technology. Note that statistical testing for significance calculated z-scores; only differences where $p < 0.05$ are reported.

ESC Market Transformations survey: awareness based on those who 'have heard of' the technology. The approach to statistical testing for significance is outlined in section 2.5 of this report.

Awareness of low-carbon heating technologies is marginally higher in Scotland than across GB and the UK more widely, although these differences are only statistically significantly different in some cases: awareness of biomass boilers appears to be significantly higher in Scotland than in GB and one survey (BEIS Future of Heat) indicates that awareness of GSHPs is significantly higher in Scotland than in GB. This does not appear to be driven by significantly different proportions of these populations having these technologies in their homes, suggesting other factors may be at play.

While awareness is often measured, there is little exploration of what a 'good' level of awareness might be. Awareness does not necessarily mean that people will pay attention to low-carbon heating options, let alone consider or install them. Understanding when and how awareness might trigger consideration of low-carbon heating and lead to installations may help understand which routes to awareness are most effective in bringing about change.

3.2 People hear about low-carbon heating from different sources

Surveys often quantify awareness but may not explore where awareness has come from. Indeed, people who are 'aware of' something but have little further knowledge of it may not be able to identify where they came to hear of it. However, these surveys have looked at what sources people would turn to for further information.

The BEIS Public Attitudes Tracker⁸ reports that over a third of those surveyed in Scotland said that they would trust a tradesperson for advice on heating systems. The BEIS Future of Heat survey¹⁰ asked people which sources they would trust for information about greener heating systems, specifically, and found that a similar proportion (29%) said they would trust a tradesperson or professional (see **Figure 2**). ESC's consumer segmentation (2018)³ found that a substantial minority (19%) of those in Scotland would probably just choose the heating system their plumber recommended, suggesting that not only are these professionals a trusted source of information but for some they are also a key influence in decision-making.

What information might these sources be able to offer? The CCC (2016) suggests that installers may be more likely to recommend familiar systems like gas boilers rather than relatively novel alternatives⁷. Furthermore, Consumer Focus Scotland (2012) reported that some tenants had flagged installers' apparent lack of expertise in installing low-carbon heating, feeling that the installers themselves were also 'novices'¹¹. If installers do not have, or are perceived not to have, expertise in alternative heating systems, this may further reinforce decisions to opt for conventional alternatives. Providing heating system installers and engineers with the knowledge and tools to advise on, install and maintain low-carbon heating systems may encourage more confidence in low-carbon heating and support more widespread transition towards these systems. Installers may also need encouragement to recommend low-carbon systems – they may not recommend them if they feel the business opportunity is smaller, or if they are substantially less convenient to install and maintain. Professionals may also be able to keep people updated on alternative systems at other touchpoints, such as routine servicing – building and reinforcing consumers' awareness of low-carbon heating systems over time may encourage consideration of these systems when they come to replace their current one. Research indicates that the majority of those in Scotland have their boiler serviced annually: the ESC's consumer segmentation found 82% of those in Scotland reported annual servicing (mostly but not always as part of an ongoing boiler care plan)³, suggesting that there is a very substantial population who have regular contact with heating engineers.

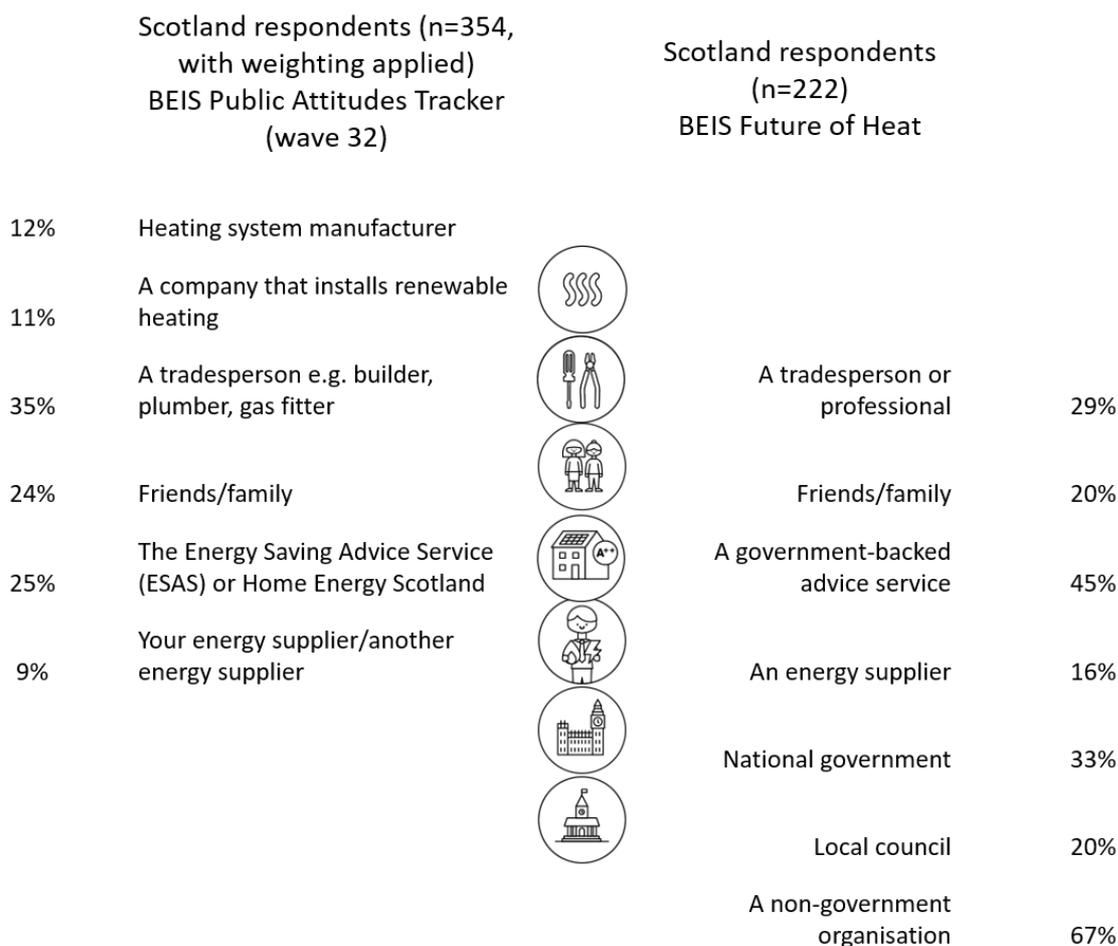


Figure 2: Trusted sources for information about heating systems, among Scottish consumers

BEIS Public Attitudes Tracker: “Which of the following would you trust to provide advice about which heating system to install in your home? Select all that apply.”

BEIS Future of Heat survey: “Which of the following would you most trust to provide information, advice or recommendations about installing a greener and more energy-efficient heating system in your home? Select up to three.”

Word of mouth and other social factors can be powerful for raising awareness. The BEIS Public Attitudes Tracker⁸ found that about a quarter of those in Scotland said they would ask friends and family for advice on which kind of heating system to install. Again, given the vast prevalence of gas heating systems, it is likely that these kinds of queries would lead to other gas boilers being suggested, but there is evidence that social factors can prompt people to explore renewable technologies too. De Wilde (2019) suggests that some are prompted to make inquiries by seeing that neighbours have installed new technology, or by spotting a contractor’s van in the street, and that neighbours with installed technology were also called upon to verify advice from professionals¹². BEIS found that about a third of those who had installed a new heating system got information from family and friends⁸.

Domestic Renewable Heat Incentive (RHI)[†] applicants often got information about heating systems from family and friends¹³, with some particularly valuing first-hand feedback from those who already had these systems.

Word of mouth and social factors may have a greater influence over heating system choices in Scotland compared to the rest of Great Britain. The ESC's consumer segmentation³ found that 44% of those in Scotland said they would prefer to get a heating system they knew other people had, while 13% said they wouldn't care what system others had. This contrasts with the rest of GB, where there was a much more even spread (30% said they would want a system they knew others had and 31% said they wouldn't care what others had). Understanding the role and influence of word of mouth and social factors may help identify routes to encourage uptake that aren't as easy to structure or control as more formal routes like policy changes or commercial propositions.

It is important to bear in mind that word of mouth may not always be positive, though. For example, one report found that negative feedback from those who had heat pumps but didn't know how to use them could contribute to negative perceptions of these technologies¹⁴.

Lack of awareness doesn't necessarily reflect a lack of available information. A paper by Scottish organisation Common Weal (2019)¹⁵ reports that "options such as electric heating, biomass boilers and heat pumps are established technologies and substantial volumes of information and guidance are available to the public" through local authorities, housing associations and organisations like Citizens Advice Scotland and Home Energy Scotland (though the report acknowledges that information can become quickly outdated, given the pace of development). With the BEIS Future of Heat survey¹⁰ showing that nearly half (45%) of Scottish consumers would trust government-backed advice services for information about greener, more efficient systems and this information readily available from such sources to those who seek it out, the impact of this information may be strengthened through further understanding of what types of information consumers would value as part of the decision-making process and in what form they would prefer this to be delivered.

3.3 Awareness does not mean knowledge or understanding

Those who are aware of low-carbon heating may only have limited knowledge and understanding of these systems. BEIS (2019) found that among those who were aware of renewable heating systems, only a small minority felt they knew a lot about them⁸. Illustrating this point, when asked to what extent they agreed or disagreed with statements about the cost and performance of renewable heating, a large proportion of the sample said they neither agreed nor disagreed with statements, or that they didn't know.

People do not necessarily need to understand how something works to buy it – the vast majority of the population will not understand how the internet works or how a car's engine works, for example. However, people will need confidence that something they buy will give them what they want. Awareness alone does not always translate into confidence. Citizens Advice (2016) found that while some were aware of heat pumps, few understood what they were or how they worked – the way that they generate heat wasn't felt to be logical, leading to uncertainty about their performance¹⁶. This lack of credibility can lead to doubt that these technologies will work at low temperatures, a concern particularly among those living in colder parts of Britain¹⁷, which may include parts of Scotland. Consumer Focus Scotland (2012) found a similar lack of understanding about how microgeneration systems work amongst social landlords and tenants in rural Scotland, with this representing a barrier to installation¹¹.

[†] The Domestic RHI scheme offers payments over time towards renewable heating costs for biomass boilers, solar water heating and some heat pumps.

A lack of confidence in the technology may reflect the type of information available to consumers. Information may be overly technical and/or place more emphasis on how the technology works rather than the benefits it can deliver. It may not highlight the consumer-relevant benefits on offer. The former may confuse people or introduce doubts about performance, whereas the latter is likely more important when evaluating a technology's suitability. This perception was reported by a Scottish housing association¹⁸ who said that much of the information it received was technical and irrelevant to decision-making processes.

Scott and Powells (2019) suggest lack of awareness and knowledge can be viewed with optimism¹⁹. They reported low levels of awareness and knowledge of blended hydrogen as a fuel for homes, but also found no sense of strong acceptance or rejection of it. They suggest this represents a 'blank slate', an opportunity to highlight the benefits the technology can offer. With clear and effective communication that highlights consumer-relevant benefits and factors important in decision-making, there may be opportunity to build understanding of low-carbon heating. Working with a 'blank slate' may even be easier than overcoming existing negative perceptions of low-carbon heating.

3.4 The importance of situational factors

Although the limited awareness and knowledge of low-carbon heating systems may be discouraging initially, it's important to consider that people are unlikely to research heating systems at all until they need to. At other times, people may pay little or no attention to information even if it's readily available.

Most people say they would only replace their heating system when their current one breaks down or is becoming difficult to maintain. 65% of those in Scotland said they would not replace their heating system unless it had broken beyond repair³ (this is slightly but significantly lower than for the rest of GB, where 71% said they would not replace their heating system unless it was broken beyond repair). Across the whole of the UK, BEIS (2019)⁸ found that 64% of people said they would only replace their current heating system when it breaks down or starts to deteriorate. This is consistent with previous research by DECC (2013)¹⁷ which found that 61% of those who had replaced their heating system had done so because it had broken down or was nearing the end of its life.

Targeting people who might be open to alternative heating systems could increase consideration of low-carbon heating, but timing and convenience are important. The need for a quick and trusted replacement might mean people simply turn to familiar technologies, typically gas boilers. This 'default' decision may be further reinforced if, as mentioned earlier, heating engineers or installers recommend a like-for-like replacement system. Unless low-carbon systems are already front-of-mind they may be overlooked. Where they are considered, they may not be chosen over conventional systems if other barriers make them less appealing or impractical (as discussed more fully in sections 4 and 5).

A substantial minority, however, say they would consider replacing their heating system at other times and some had already done so for non-emergency reasons. For example, some said they had replaced or would consider replacing their system as part of a home renovation project, or with a system that was more economical, environmentally-friendly or reliable^{8, 17}. About half of the recipients of the Home Energy Scotland loan scheme who were surveyed as part of its evaluation²⁰ were using the loan to support a wider renovation project: 22% said that the measures they were installing were part of a project to build a new house or extension while 29% said measures were being installed as part of refurbishing their home.

These more proactive, less urgent scenarios also represent good opportunities to install other energy efficiency measures like insulation, which may improve the home's thermal efficiency and the performance of a low-carbon heating system. This could be particularly relevant for Scotland's rural and island areas where there is a greater prevalence of 'hard to treat' buildings¹⁴.

It may be worth encouraging people who are planning home renovations to improve the energy efficiency of their home as part of this work, making it easier for them to switch to low-carbon heating when they do replace their current heating system. Otherwise, people may defer to gas boilers to avoid costly and time-consuming energy efficiency upgrades needed alongside a new system. ESC's consumer segmentation (2018)³ found that 20% of those in Scotland said they planned to make their home more energy efficient in the next year. Although this could cover a range of measures from substantial upgrades like installing insulation through to minor changes like changing lightbulbs and appliances (the research did not explore what measures people expected to take) it is important to recognise that some people are proactive about improving energy efficiency. Targeting such individuals with information that helps raise awareness of low-carbon heating systems and other measures like insulation that could help improve a home's thermal efficiency could be particularly valuable. While people may not necessarily need or want to replace their heating system at that point, changes they do consider could set the home up well for a future transition to a low-carbon heating system and increased awareness of alternatives may encourage transition in the future.

3.5 Awareness: conclusions and recommendations

- Awareness of low-carbon heating systems varies between studies, between technologies and between countries. Awareness is marginally higher in Scotland than in GB and the UK more widely, and significantly so in some cases: evidence suggests awareness of biomass boilers and GSHPs may be significantly higher in Scotland.
- It may help to tailor information campaigns for different audiences. For example, campaigns could encourage people in poorly-insulated homes to improve efficiency when they renovate, or highlight the benefits of low-carbon heating to people who are looking to replace their heating systems.
- There is currently no indication of what a ‘good’ level of awareness might be. If the overall intention is to increase uptake of low-carbon heating systems, more understanding is needed to establish what level of awareness might facilitate that, and how. For example, what level of knowledge and understanding do people need to have about low-carbon heating before they take certain actions, like identifying an installer or installing a system?
- Awareness does not necessarily reflect the availability or accessibility of information about low-carbon heating, but rather the extent to which people pay attention to it or seek it out. Regular boiler servicing could represent an opportunity to raise awareness of low-carbon heating alternatives: 82% of those in Scotland reported that they service their boiler annually, an event that involves interacting with the heating trade, a trusted source of information for some.
- Awareness of a system does not necessarily mean people trust that system. People will want confidence that the technologies will give them what they want (warmth, comfort and affordability). It is important to communicate consumer-relevant benefits that are likely more relevant to decision-making.
- Timing is important: boosting awareness of low-carbon heating at or near to key trigger points, like the end of a current system’s life or a home renovation, could encourage uptake of low-carbon systems in both emergency and non-emergency situations.
- The heating trade is a valued and influential source of information: a substantial minority of those in Scotland say they would ‘probably just choose the heating system their plumber recommended’. Upskilling tradespeople and encouraging them to promote low-carbon heating could help boost uptake of these systems.
- Lack of knowledge is not necessarily a bad thing – it could represent a ‘blank slate’ on which understanding can be built in a way that encourages positive perceptions.

4 Attitudes towards low-carbon heating

4.1 Concern about climate change does not necessarily translate into heating system choices

There is generally a high level of reported concern about climate change and related topics. For example, the vast majority of those surveyed by Parkhill et al (2013) believed the UK should

reduce its use of fossil fuels and felt it would be unacceptable for a future energy system to rely mostly on fossil fuels⁶. A 2018 YouGov poll reflected these findings with a sample of Scottish participants, 73% of whom said they felt climate change needs to be addressed now²¹. ESC's Net Zero research (2020)⁵ found that 75% of Scottish participants reported being concerned about climate change and 75% felt it was a global emergency, views represented in similar proportions across the rest of GB.

Beyond personal views, the BEIS Future of Heat (publication in progress) survey¹⁰ found that, among those surveyed in Scotland:

- The vast majority (90%) said they were aware of the UK having legally binding targets to substantially reduce carbon emissions by 2050.
- 72% said they were aware of the government's ambition to eliminate nearly all emissions from heating buildings as part of meeting these overall targets.
- 89% thought it was important for the UK to make a full transition away from heating systems which use fossil fuels towards greener and more environmentally-friendly technologies by 2050.
- 59% were supportive of the idea of phasing out the sale of gas boilers in favour of more environmentally-friendly heating systems (19% opposed this idea).

However, the extent to which people associate home heating and energy use with climate change varies. There seems to be an established association between general home energy use and the environment. For example, over the past few years, ESC research has reported that approaching two-thirds of Scottish participants agree that everyone should try to reduce their home energy use to help the environment (62%³, 62% and 65%⁴). But does this extend as far as thinking about the systems that are used to heat homes?

In some cases, concern about climate change and the environment appears to influence people's perceptions of and decisions around energy-related installations. In a review, Balcombe, Rigby and Azapagic (2013) found that some homeowners' decisions to install energy efficiency measures (including heating and hot water systems but also insulation and window or door upgrades) were motivated by wanting to help the environment and wanting to demonstrate their environmental commitment to others²². A 2020 survey of residents in Levenmouth in Scotland found that nearly half (46%) wanted to reduce their carbon emissions from household heating to help tackle climate change and suggested that a further 48% might be interested in doing so if they were confident other needs would still be met, such as affordability (which may be a particularly relevant need for this area which has high levels of poverty)²³. However, this area of Scotland has also received a lot of attention for low-carbon projects so it is possible that residents' awareness of energy and environment-related topics is higher than in other areas, and their perceptions may differ.

Some may know little about what causes climate change and many do not think of home heating as something that impacts the environment⁵. BEIS (2018) reported low awareness of the need to transition to low-carbon heating²⁴. Citizens Advice Scotland (2018) reported that few Scottish citizens linked reducing their household energy consumption to reducing climate change and suggested that consumer engagement would be needed to help people understand the need to decarbonise the way they heat their homes²¹. While ESC (2020) found that approaching half (46%) of those in Scotland thought that emissions from gas central heating contributed to climate change, this fell far behind other factors such as industrial pollution (78%), emissions from transport (77%) and other human activity that puts CO₂ and greenhouse gases into the atmosphere (70%)⁵.

Having a low-carbon heating system certainly seems to appeal in principle, with about half of those in Scotland saying it would be essential that their 'ideal' home heating system should have very low carbon emissions, so be truly environmentally friendly (52%³, 51% and 48%⁴), but when it comes to choosing a new heating system, other factors may take priority. A Royal

Society of Edinburgh (2011) review about opportunities and barriers for Scotland as it moves towards a low-carbon future suggested people worried that steps that could address climate change would lower standards of living²⁵.

4.2 Gas boilers are the default preference for many

When asked what kind of heating system they would replace their current system with, the vast majority of British homeowners say they would choose a conventional system: 90% of those who are on the gas grid say they would install a gas boiler, while those not on the gas grid were most likely to say they would choose an oil boiler (40%)¹⁷. The ESC's Market Transformations research (2018)⁴ found a similar proportion (93%) of those living in Scotland expected to replace their heating systems with a gas boiler, the same proportion as seen across the rest of GB.

Gas boilers are familiar and tend to be the preferred technology for most people. Gas central heating is seen as controllable, responsive, safe, effective and cheap. This contrasts with electric heating which is often thought of as expensive, ineffective due to lack of responsiveness and control, and as creating undesirable 'dry' heat – perceptions often driven by associations with storage heating⁶.

Mains gas systems are often the preferred choice among social housing providers, due to lower running costs, maintenance requirements, ease of use and control. Some also mentioned that in areas not connected to the mains gas network, they often look first at the feasibility of connecting to the gas mains²⁶.

Communicating that low-carbon heating can compete with the performance, cost and other benefits offered by conventional gas heating systems may encourage people to consider these systems when they come to replace their heating system. For example, Parkhill et al (2013) found that the proportion of people willing to use electric heating systems increased from 42% to 61% when the systems were said to perform as well as current systems, and to 85% when the systems were posed as being cheaper than current systems⁶.

One way to give consumers confidence that low-carbon heating systems can compete with conventional gas systems in terms of performance and cost might be to sell energy as a service. In this new business model, consumers buy the outcome they want and their service provider is responsible for delivering it. For instance, consumers could use smart heating controls to choose how warm they want their home to be and providers would sell that heat-as-a-service. Providers could sell one service with a gas boiler and another with a low-carbon heating system to show consumers exactly what it would cost to get the level of heating they wanted with each system²⁷. There is some early evidence that this service-based model can increase consumers' confidence in low-carbon heating and drive uptake of heat pumps²⁸.

Although they may tend to defer to gas by default, people are not necessarily opposed to different kinds of heating systems. The ESC's segmentation research (2018)³ found that 26% of those in Scotland said they would consider different types of heating systems. It is worth noting that this research found those in Scotland to be significantly less open to considering other kinds of systems than those in the rest of GB (of whom 36% would consider other systems) and more resistant to changing the type of system they have (35% of those in Scotland vs 29% of those in the rest of GB). Nevertheless, that a substantial minority are open to considering different kinds of systems is encouraging.

Research that introduces and explains low-carbon heating systems to participants indicates that people are often positive towards these systems. For example, ESC's Market Transformations (2018)⁴ research introduced three alternative heating systems to participants: heat pumps, district heat and hydrogen. After reading a brief explanation of each of these technologies, people were asked how positive or negative they felt about them. 65% of those in Scotland were positive towards heat pumps (9% were negative), 49% were positive towards

district heat (22% were negative) and 41% were positive towards hydrogen (18% were negative). These proportions were similar to those seen for the rest of GB. DECC (2013) also reported that 38% of those living in properties with outside space were positive about GSHPs, with this higher (53%) among those who were off the gas grid¹⁷.

Is positivity towards low-carbon heating systems enough to encourage uptake, though? Uptake rates of low-carbon heating remain incredibly low: the BEIS Public Attitudes Tracker (2019) found that of those who had installed a heating system in the last 3 years (21% of the sample), 94% had installed a gas system (and 2% an oil system)⁸. ESC's Net Zero research (2020)⁵ found that the majority of those in Scotland said they would be unlikely to consider replacing their heating systems with low-carbon alternatives, although a substantial minority would consider them. Understanding the perceived benefits and drawbacks these systems offer is important in identifying barriers to uptake – this will be covered in section 5.

4.3 Attitudes: conclusions and recommendations

- High levels of reported concern about climate change do not necessarily translate into installations of low-carbon heating systems. Some may not see heating as something that contributes to climate change. Others may recognise that switching heating systems could provide an environmental benefit but choose not to do so.
- If people considered low-carbon heating to be as good as or better than conventional systems, these technologies would be the natural choice when people replaced their systems. Some people do choose low-carbon systems for their environmental benefits but for others these benefits may be outweighed by concerns or perceived drawbacks.
- Gas boilers are often the 'go to' when replacing a heating system. They are familiar, easy to use and known to give people the warmth and comfort they want. Unfamiliar low-carbon heating systems will not be able to compete if they are more complicated to use or cannot easily or affordably deliver the same comfort.
- Many consumers will need to feel confident that they will be able to get the warmth they want for a price they can afford before they install low-carbon heating systems. New energy-service business models may be able to help build this confidence. These could give consumers control over how much they spend getting the level of heating they want and leave their service provider responsible for delivering it.

5 Perceived benefits and drawbacks of low-carbon heating

People know more about the advantages and disadvantages of low-carbon heating systems if they have lived with one or considered installing one, but the vast majority (89%) of those in Scotland heat their home with gas central heating and a further 7% heat with oil or LPG central heating³. For the most part, those people are unlikely to have seriously considered installing a low-carbon heating system. Their perceptions can help gauge general assumptions about low-carbon systems and perceptions of what they can or cannot offer people on the basis of (perhaps limited) knowledge.

5.1 Motivations to install low-carbon heating

Only a tiny proportion (c. 5%) of households in the UK have low-carbon heating. Research based on samples taken from this small population may have certain biases. For example, there may be disproportionately high representation of ‘early adopters’ or wealthier households²⁴, particularly when research samples draw from those who have self-funded installations.

Learnings about what motivates households to install low-carbon heating focus largely on heat pumps. These motivating factors may be similar to the benefits that district heat users feel they get from heat networks, but individual homes can’t choose to install district heating at present.

BEIS (2016) found that those who were driven by a single factor to install renewable heating were motivated by either financial factors, such as lower running costs, or by environmental considerations¹³.

However, this BEIS research also identified that some people who had applied for the RHI were motivated by multiple factors. For these individuals, financial factors were still key but practical considerations also came to the fore – these individuals wanted to know that their system would keep them warm, as well as being affordable to install and operate.

A 2019 evaluation of Scotland’s Home Renewables Specialist Advice Service asked people what their main motivation was for looking into renewable energy or energy efficiency (though not specifically heating technologies): 42% said their primary motivation was wanting to reduce energy costs, 26% said they wanted to be warmer and more comfortable in their home and 18% said they wanted to reduce their impact on the environment²⁰, illustrating the variety of primary motivations for exploring low-carbon heat.

Schemes like the RHI help reduce barriers in terms of the running costs of a low-carbon heating system but the extent to which this drives the decision to install low-carbon heating varies. For some, cost was the key factor and it is possible that without the RHI conventional systems may have been chosen instead. Others were influenced more by non-financial factors, such as the environmental benefits. The RHI supported their decisions to install low-carbon heating but was not the driving force²⁹.

5.2 Satisfaction varies, but is strongly associated with ability to get warm and comfortable

Many factors influence the performance of a heating system: the power (i.e. how much energy it produces), the heat emitters, the pipework, heat losses through the fabric of the building and, of course, the temperatures that people want at different times in different rooms. A detailed review of the relative performance of different heating systems is beyond the scope of this report. Instead, it summarises key findings from field trials of different systems.

There is a wealth of evidence that models the technical performance of low-carbon systems and demonstrates their capability to perform well. However, this evidence is not considered in this review as modelling of technical factors alone cannot account for the vast differences in what people want from their heating systems – not just in terms of comfort, but in terms of hygiene, wellbeing and relationships³ - nor how they will use their heating systems to get what they want.

Satisfaction is predominantly reported in terms of satisfaction with the warmth and comfort a system provides. It may vary with the type of system installed and the level of disruption involved. It also seems to be influenced by how performance compares to the previous system, particularly whether people can get the same or a better level of comfort, for the same or lower running costs¹³.

People can have good experiences with low-carbon heating. For example, Caird et al (2012) found that 75% of users rated their heat pump as better than their previous system – most of these individuals were not on the mains gas network so had typically moved from oil central heating or electric heating³⁰. BEIS (2016) has also found good levels of satisfaction across different types of heat pumps: high temperature heat pumps, hybrid heat pumps and gas heat pump technology³¹.

Many households will need to improve the thermal efficiency of their home to get the comfort they want from a heat pump – a heat pump installed without these additional measures may not give a satisfactory level of comfort. The majority of homes interviewed as part of the Energy Saving Trust (2013) heat pump field trials³² reported that they were satisfied or very satisfied with their heat pumps, liking the stable air temperature the technology provided, with no significant differences noted between air- and ground-source systems. It is worth noting that between the first and second phases of this trial, technical interventions were carried out to improve the systems' performance. In some cases, this involved replacing the heat pump with a correctly-sized one, while other interventions included installing low-temperature radiators and heat emitters. The findings of this field trial therefore show that users are satisfied with the performance of heat pumps, though in some cases that may be the result of specific technical actions to improve this.

Differences in expectations or preferences may be due to differences in previous heating experiences. For example, one homeowner who was extremely satisfied with his system had moved from a farmhouse mainly heated by the kitchen cooker to a new-build with underfloor heating. Very few people with gas boilers have switched to low-carbon heating. The potential of low-carbon heating to improve heating experiences should not be overlooked though: Citizens Advice Scotland (2018) pointed out that dissatisfaction with electric heating systems was significantly higher among those with electric heating than those with gas heating – 22% of those with electric heating said they were 'only sometimes' warm enough during the winter and 11% said they were never warm enough³³. ESC's segmentation found that 30% reported rooms getting too cold and 25% said their home felt draughty (sometimes, often or always/every day)³. Low-carbon heating alternatives may be particularly well-suited to circumstances where they can substantially improve a poor heating experience.

This satisfaction with heat pumps comes despite the disruptive installation process⁷ – it may be that the one-off inconvenience or disruption of installation is perceived as 'worth it' to get the benefits that a heat pump can offer. However, the scale of disruption will depend on what other measures might need to be installed alongside the heat pump, for example insulation or new radiators and pipework. Different levels of disruption may be more or less acceptable to different households.

Satisfaction with heat pumps is also high despite reports that early difficulties in understanding how to use the technology are common³¹. However, it is important to note that some of this evidence comes from trials in which new users have been introduced to the technology and given advice on how to use it. This support might not always be offered. Caird et al (2012) found that more social housing tenants than private households were uncertain of how to use their heating system's controls (50% vs 30%)³⁰. Some users found it difficult to work out how to use new controls, which are often more complicated than those for conventional heating systems, and reports of 'teething problems' are common early after switching.

Satisfaction tends to improve as people get used to the systems over time. BEIS (2016) recommends that new users should be actively involved in the installation process so that they have a good understanding of how to operate the systems, highlighting that this is particularly

the case for tenants who may not have been involved in choosing the technology³¹. Abdel-Wahab, Moore and MacDonald (2011) report feedback from one Scottish housing association that tenants seemed to be trying to use low-carbon heating systems like conventional heating systems, without getting the results they want, and suggested that training for end-users was important to avoid misuse resulting in poor performance¹⁸.

Heat pumps need longer running times to warm homes up because they are lower-powered than gas and oil boilers. However, people may need reassurance that their bills will not rise before they are persuaded to run them for longer periods of time than their previous system. Caird et al (2012) found that fewer social housing tenants than private homeowners ran their systems overnight and when the home was unoccupied, with qualitative feedback suggesting that they remained to be convinced that it was more economical to run their heating system continuously³⁰ (although they were also more likely to have radiator-based systems, whereas private homeowners were more likely to have underfloor heating, which may have contributed to differences). EST (2013) reported that both those who ran their systems constantly and those who ran them non-continuously were satisfied with their comfort and the running costs³². Consumers consider different things when heating their homes³ and some might not want to run a heat pump continuously. For example, some may feel it is wasteful to run the heat pump at times when there is nobody at home, even if this is the most 'economical' way of running it and does save them money. These individuals may be reassured that satisfactory comfort can still be delivered without the system running constantly, although whether this is true will vary from house to house depending on the system itself, the building's energy efficiency, the temperature the heat pump is run at and other factors.

Satisfaction with comfort seems to be more varied among those with district heating but other issues are reported too, such as with problem resolution and costs, resulting from how heat networks are owned and managed. In research with heat network consumers and operators, BEIS found that many consumers appreciated the reliability of their heating but that there were exceptions among those who had experienced prolonged or recurrent issues with delays and confusion about responsibility in resolving these. These issues were found across both public- and private-led schemes. Some also reported issues with overheating, which was sometimes tackled by opening windows or dressing lightly³⁴. Some people felt that the information they were given about how district heating works and what to expect painted a different picture to what they went on to experience. Many households with district heat have experienced service outages and confusion about who is responsible for resolving problems, as well as feeling that they have less control than with gas central heating³⁴.

Citizens Advice Scotland (2018) has pointed out that studies focusing on Great Britain as a whole have indicated the problems that district heat consumers can face without appropriate consumer protection measures, though points out that Scotland-specific evidence is limited³⁵. It acknowledges the progress the Heat Trust has made in ensuring protection for heat network consumers, although there are only three member sites in Scotland (as of July 2020) and Citizens Advice Scotland reported that at least 50% of Scottish suppliers had no plans to join the scheme. One of the Scottish networks registered with the Heat Trust is the Wyndford estate in Glasgow, highlighted by the CCC (2016) as a successful example of positive consumer experiences⁷. However, other networks that are not Heat Trust members are also very well-regarded. For example, Aberdeen Heat and Power, which has networks across Aberdeen, is regarded as exemplary on the basis of its growth³⁶ and its innovative approach to combining low-carbon and fuel poverty objectives³⁷, although direct evidence of consumer experiences and satisfaction appears to be limited.

We have discussed satisfaction with the warmth and comfort that low-carbon heating can give, but these factors may have a knock-on effect on other lifestyle factors. For example, BEIS (2016) found that those whose renewable heating systems heated to higher temperatures and warmed rooms around the home more evenly tended to use more rooms in their home and invite friends round more¹³. Citizens Advice Scotland suggests heating systems can deliver a range of positive benefits including physical health, mental wellbeing and community benefits,

as well as the more 'direct' benefits of improved comfort and savings over time²¹. Researching and communicating the holistic benefits that improved warmth and comfort might bring could enhance the appeal of these technologies and the case for installing them more widely, among both homeowners and landlords or housing providers.

The performance of low-carbon heating will depend on the home it is installed in, with the size, layout and building fabric all playing a role as well as user behaviour³². So far, we have highlighted that lack of understanding of how to use heating systems can impact on experiences, but technical factors may also play a contributing role, for example in instances where systems are not correctly sized or installed.

A 2016 study explored the performance of a small number of passive houses in Scotland³⁸. Passive houses are designed to offer a high degree of energy efficiency – indeed, the occupants in this study felt these homes were more energy efficient than their previous homes and largely enjoyed their environment and comfort. However, they reported some issues with both under- and over-heating. These were found to be contributed to both by technical issues with system commissioning and installation and by user behaviour (occupants did not understand how to use the systems).

In diagnosing performance issues, it is important to consider that these might be down to user behaviour, technical issues such as wrongly-sized equipment or incorrect installations and various combinations of these and other factors. Currently, businesses are responsible for installing technologies but not for ensuring they deliver a good outcome: where performance is unsatisfactory users may be left unsure how to resolve problems. Services that require businesses to install technologies and ensure satisfactory performance may help deliver better outcomes for consumers and facilitate increased uptake of low-carbon heating.

Illustrating this, 21 homes in ESC's Living Lab³⁹ who were used to using smart controls and zonal heating to control their heating and comfort at home were offered a heat pump. Eleven of these homes were interested enough to arrange a survey of their home's suitability for a heat pump⁴⁰ – a far greater proportion than express interest in any low-carbon systems among the general population. It may be that some of their interest was driven by familiarity with and trust in the ESC and confidence that any issues would be satisfactorily resolved, though that caveat itself also reinforces the same point.

The previous section highlighted that a desire to reduce bills is a reason people give for installing low-carbon heating systems. Some research suggests that tenants in rural Scotland felt the running costs of their ASHPs were lower than the running costs of the systems they had replaced, but some still raised concerns about unknown future costs or the high costs that might be incurred if there was a technical fault¹¹. Other evidence highlights increases in electricity costs as a result of running different types of electric systems but reports that most individuals seem satisfied with the running costs of these systems. It is possible that reduced gas costs counteract higher electricity costs for those who have switched from gas central heating. On the other hand, some people (particularly social housing tenants) in the BEIS (2016) trial of high temperature, hybrid and gas-fuelled heat pumps were dissatisfied with the running costs of these systems. However, the report notes that the trial coincided with a substantial rise in fuel costs, which may have played a part in pushing up running costs³¹. There are few studies exploring how and why bills change and how those changes compare with expectations.

The costs of district heating are a source of dissatisfaction in some cases. BEIS (2018) found that consumers of two private-led district heat networks felt they had been mis-sold their properties – they had moved in believing that their standing charges would decrease, but in reality found these had gone up³⁴.

Comparisons of running costs are typically made with gas central heating systems and may be less relevant to those living off the gas grid and/or using non-gas heating. This is important to consider for Scotland, where non-gas systems like oil or LPG are significantly more common

than across the rest of GB³. Those living off the gas grid could potentially save even more than those on gas systems, especially if they're using older, less efficient electric systems. Highlighting the extent of possible cost savings for those switching from different types of systems may help increase the relevance of communication about financial benefits. That said, it should be highlighted that not everyone will be motivated to reduce their energy bill: indeed, 47% of people surveyed in ESC's consumer segmentation agreed or strongly agreed that keeping their home at a comfortable temperature is more important than saving money on their energy bills³.

Citizens Advice Scotland (2016) interviewed 30 tenants in rural areas about their experiences with various heating systems (including heat pumps, biomass boilers and 'smart' storage heaters). Considering factors like ease of use, how comfortable people were able to get, affordability to run and experiences compared to previous heating systems, the report concludes that no system is a clear winner. Rather, different heating systems have different characteristics that will suit individuals' preferences in different ways⁴¹. The report emphasises that strong conclusions cannot be drawn on the basis of the small sample size, but the point that different technologies will suit different people is an important one – as the ESC consumer segmentation (2018) highlights, people use heat in very different ways, value different features and functionality and vary in how open they are to change and new technology³. That there is no 'one-size-fits-all' solution feels a very logical, reasonable conclusion. Add to that the complexity of varying types and sizes of homes and differences in thermal efficiency and the conclusion becomes even more fitting.

Environmental factors were a motivation for some people to install low-carbon heating, yet there is very little discussion of satisfaction around this factor post-installation. That may be because environmental benefits are far less important to consumers than being able to get

Very little research explores the motivations and barriers to installation among those who have considered installing low-carbon heating but decided not to, although some reports touch briefly on learnings from such individuals. This population may provide valuable learnings about their perceptions of the benefits and drawbacks of these systems, the research and considerations involved in the decision-making process and, when compared to those who *have* installed these systems, insights about how different factors are weighed up and traded off against each other – for example, what makes a barrier insurmountable for some while others overcome it?

A couple of the references in this section refer to findings from consumer workshops. Participants in this research had not necessarily considered low-carbon technologies before but these qualitative methods allow for thorough learning and discussion around the benefits and drawbacks of different systems. While not the same as going through the decision-making process that could lead to an installation, we feel these methods are worth including in this section as they encourage participants to consider the weight they would place on different factors when evaluating alternative heating systems.

comfortable and, for some, controlling how much they spend on heating their home. However, there are some reports of the positive impact of environmental benefits. For example, DECC (2013) found that the concept of GSHPs using readily-available and 'free' energy from the ground was appealing, while the idea of a community heat network appealed at an emotional level as well as a practical one¹⁷. These kinds of benefits may be harder to discover with some questionnaire or interview designs – methods like in-depth interviews that help elicit less-tangible benefits may help. Those who have rejected low-carbon heating systems cite more practical factors

Where low-carbon heating systems have been considered but rejected, the barriers often tend to be practical, for example the need for space or increased maintenance.

Heat pumps in particular require space for the heat pump itself as well as indoor space for a hot water tank if the property doesn't already have one. This is a major barrier for some properties and locations³¹ and may be particularly so for Scotland, where the distribution of property types is significantly different to the rest of Great Britain³: those in Scotland are more likely to live in flats in large blocks (14% compared to 3% of GB) and less likely to live in semi-detached homes (26% compared to 42% of GB). The lack of outside space and the relative size of flats will limit opportunities for installing technologies like heat pumps.

The type of heat pump considered also matters. For example, research with social housing providers notes that GSHPs are often not considered practical for individual properties because of the land area required, although it does note that communal GSHP systems are a more practical option²⁶, dependent on their scale and financial viability.

Participants who considered different technologies in a workshop environment (encouraging more detailed evaluation of the benefits and drawbacks than other survey methods) were keen to see information about how much indoor and outdoor space was needed for different technologies, both for the system itself and any fuel storage, as well as whether they would need a hot water tank¹⁷. In rural areas and larger homes, space may not represent as big a barrier.

High-density housing like blocks of flats may be well suited to network-based heating systems like district heat or, in the future, hydrogen. However, the installation of these technologies is not down to individual homeowners.

There was a small amount of evidence that noise and aesthetics represent barriers. Cherry, Hopfe, MacGillivray and Pidgeon (2017) found that workshop participants exploring and evaluating the benefits and drawbacks of low-carbon homes raised concerns about the noise created by mechanical ventilation with heat recovery (MVHR) systems, feeling that the noise was intrusive (unlike the noise of existing boilers) and that this would have a negative impact on the home's atmosphere and comfort⁴². DECC (2013) also found that people were less positive towards ASHPs and biomass boilers than towards some other technologies, with some saying they were put off by the unattractive appearance of these systems¹⁷.

Finally, a finding specific to social landlords is worth highlighting. A report from Consumer Focus Scotland (2012) mentioned that some social landlords struggled to find trusted, local traders to install and maintain microgeneration systems, a particular problem for rural areas¹¹. If this extends to low-carbon heating systems too, and social landlords who may be better networked²⁶ than consumers find it difficult to access suitable traders, then homeowners who want to install low-carbon heating may well experience this difficulty, perhaps to a greater degree.

5.3 Those without low-carbon heating perceive more drawbacks than benefits

Those who do not have low-carbon heating systems tend to think that these technologies do not offer substantial consumer benefits. On the other hand, expected drawbacks are commonly mentioned, with these largely related to concerns about cost and performance.

People often expect that low-carbon heating systems will have higher upfront costs than conventional heating options. It is these upfront costs, rather than ongoing running costs, which are often cited as a key drawback of these systems, although it may be that people have not really thought about the running costs. These perceptions are nicely illustrated by the BEIS Public Attitudes Tracker (2019), which finds that the majority (60%) of owner-occupiers who are aware of renewable heating think these systems would be expensive to install, but that only a small minority (9%) seem to think they would be expensive to run⁸.

Some people have money set aside that could be used if they needed to replace a broken-down system. When asked how they would fund a replacement system if their heating broke

down soon, 21% of those in Scotland said they would use savings set aside specifically for this purpose (suggesting they think ahead and prepare for a system breakdown) and 23% said they would use general savings (not specifically set aside for this purpose)³. It is worth noting that a significantly higher proportion of those in the rest of GB said they would use general savings (39%), although it is not known whether this was due to availability of general savings or differences in preferences about using them to fund a heating system.

This perception that low-carbon heating systems cost more than conventional alternatives is not wrong, especially if additional measures like insulation, a hot water tank or larger radiators are needed alongside the new system. Indeed, the Scottish Government (2019) recognises that low and zero carbon technologies are more expensive upfront than their 'traditional' counterparts and that the greater capital investment is a substantial barrier for consumers¹⁴. It also highlights that experts feel unrealistic cost estimates from installers can lead to negative perceptions or 'bad press' around some technologies.

Upfront costs could be more prohibitive for some than others. DECC (2013) flags that those with lower incomes or without available savings would need information about support available to help with upfront costs¹⁷. Citizens Advice Scotland (2018) points out that those on the lowest incomes may be doubly disadvantaged – not only do they have less disposable income, but they tend to be more likely to live in homes which are not energy efficient²¹. These homes might need additional upgrades alongside low-carbon heating to achieve satisfactory performance. Frerk and MacLean (2017) point out that schemes like the RHI that help in the longer term do not facilitate access to low-carbon heating for fuel-poor consumers who need help with upfront costs⁴³. At the time of writing, BEIS are consulting on providing financial support up front.

Although upfront cost was more commonly mentioned, long-term running costs may represent a barrier for some. DECC (2013) reported that both purchase and running costs were important but that more focus seemed to be given to long term costs, such as low energy bills and the system being cheap to run¹⁷. Cherry et al (2017) found that when considering low-carbon homes generally, payback times were a key concern and payback times of more than 10 years were considered unreasonable. This reflected concerns about how personal, family and financial circumstances could change given the unpredictability of modern life⁴². In reality, people will differ in how they evaluate costs – not only will they have different circumstances but they will consider upfront and running costs in different ways.

However, addressing just the costs of low-carbon heating will not be enough to encourage uptake. ESC found that only 9 of 15,000 who saw an online advert for a *free* heat pump signed up for the offer. People who turned down the offer cited various reasons. Some worried their running costs might rise or that they might not be able to use the heat pump to get comfortable. Others complained about the appearance, or disliked the idea it would make a noise⁴⁰.

Concerns about performance of low-carbon heating are often mentioned. Many are hesitant to switch from familiar, convenient systems (mainly gas boilers) to something where the performance is relatively unknown³¹. They might not know if low-carbon heating systems will give them the comfort they want or are used to. For example, people value responsiveness in a heating system¹⁴ – they know that gas boilers can quickly heat a home but may not know how alternatives perform. Some are concerned that technologies like heat pumps might provide too low a level of heat to effectively heat a home³¹. Others may have investigated installing a low-carbon system but found that they are unlikely to get the comfort they want from it, in which case they may prefer to stick with a conventional system.

Parkhill et al (2013) reported that people do not see low-carbon technologies, including heating systems, as being 'as good' as current models⁶. However, when electric heating systems were described as being able to match the performance of current systems, willingness to use these systems substantially increased, suggesting that it is the *uncertainty* of performance which is a drawback, not necessarily *known* poorer performance. Further illustrating this point, BEIS (2019) found that owner-occupiers were divided in their expectations about the performance of

these technologies – equal numbers agreed and disagreed that renewable systems would heat their home better, suggesting there is no consensus on the performance of these systems⁸.

One other consumer need worth mentioning is the experience of 'cosiness'. As well as warmth, the appearance of a real fire is often highly valued – it is an important motivator for installing wood-burning stoves⁴⁴. These benefits are so important to some people that they spend substantial amounts of money on stoves and similar systems to create this atmosphere and often use them as secondary heating systems alongside their main heating system, suggesting that they are not being used to minimise running costs. Low-carbon heating may appeal more if it can deliver these benefits where conventional systems cannot.

5.5 Perceived benefits and drawbacks: conclusions and recommendations

- Perceived benefits and drawbacks vary depending on how 'close' people have come to switching to low-carbon heating. Those who have low-carbon heating or have considered it but decided against installing it tend to cite more specific benefits and drawbacks, while those who do not have and likely have not considered low-carbon heating tend to voice more general concerns.
- Those who have installed low-carbon heating systems are most commonly motivated by financial or environmental factors. However, people also want to know that they would be able to get comfortable with a low-carbon system.
- Satisfaction with low-carbon heating tends to be based on experiences of warmth and comfort. On that basis, satisfaction is often high but can take some time to achieve as people overcome 'teething problems' learning how to use a new system.
- Those who have a good understanding of how to use their system tend to be more satisfied than those with less understanding. Systems that are designed so that people can easily use them to get what they want may lead to greater satisfaction.
- A large amount of the research is focused on heat pumps. Satisfaction with other systems may be different, for example it seems more varied with district heating, with some reporting a different reality compared with what they had expected.
- Satisfaction depends on how the new heating system compares to the one it replaced, too, so people with similar low-carbon systems may have different levels of satisfaction.
- There is little evidence that covers asking people about satisfaction with the running costs of their new low-carbon heating systems.
- Environmental benefits are rarely referred to when considering satisfaction. That may be because these benefits are not reinforced on an ongoing basis, or because satisfaction from using a more environmentally friendly system is harder to articulate. It may also be that these benefits are recognised but not valued as much as other benefits.
- Those who considered but rejected low-carbon heating systems often did so on practical grounds, particularly a lack of available space.
- Those without low-carbon heating perceive few if any benefits but raise broad concerns about cost and performance.
- Low-carbon heating is perceived as expensive to install, but it is unclear if the expected costs are accurate. Verifying the accuracy of people's expectations could help determine if cost barriers are based on correct assumptions.
- Running costs of low-carbon heating systems are often compared to gas systems, but such comparisons may not be relevant to those living off the gas grid and/or using non-gas heating systems. With non-gas heating like oil and LPG more common in Scotland than in the rest of GB, it may be important to make comparisons against these systems too.
- The performance of low-carbon heating systems is an unknown for many people, with some expecting that these systems will not match the performance of current systems.

6 Perceptions of incentives and financial support

Previous sections of this report have covered perceptions of cost and the implications for financial support. This section looks specifically at perceptions and experiences of incentives and financial support.

6.1 Financial support schemes increase switching

Funding is important and incentives and financial support do encourage uptake. EST (2019) reported that Home Energy Scotland loans were very influential in encouraging uptake of renewable technologies: nearly half (46%) of installations would not have taken place without the support and the majority (88%) of installations were at least partly driven by it²⁰. An evaluation of the RHI found that it had a greater impact on the decision to install technologies among Scottish applicants – 72% said they would not have installed their technology without the incentive, compared to 63% across England and Wales²⁹.

The same report suggested that the appeal of the RHI might differ depending on people's motivations. Those who installed a renewable system for environmental or efficiency reasons or were replacing a broken-down system were less likely to be influenced by the RHI than those who were installing their system for financial reasons. Some of those whose decisions were not strongly influenced by the RHI were also sceptical of the long-term stability of the tariff. However, this may not have been perceived as a significant disadvantage: the majority (74%) of RHI applicants said they were aware that the value of the RHI tariff might drop over time, but rather than have a negative impact this was a trigger for many applicants to install their technology sooner.

There is some concern from stakeholders, rather than consumers themselves, that schemes like the RHI or the Feed-in Tariff (FiT) disproportionately benefit those who can already afford the upfront installation costs²¹. While loan options are available to help cover upfront costs these are not always appealing. For example, some who had heard of the Home Energy Scotland loan scheme had decided not to apply for it as they did not want to take on debt²⁰. Studies in Orkney and Fife illustrate this with solid wall insulation – findings suggest households might prefer to use grant support or their own savings rather than get into debt (EST, 2013, as referred to by Gilchrist & Craig, 2014⁴⁵).

For buildings that are not energy efficient, upgrades like insulation or double glazing might be needed to ensure low-carbon heating can deliver comfort. Such installations increase the cost of effective renewable heat installations compared with more efficient buildings. Where non-energy efficient homes are more prevalent, such as in rural areas of Scotland, lack of support with upfront costs likely represents an even bigger barrier. The barriers in these scenarios are also reflected by social landlords – Consumer Focus Scotland (2012) point out that given the high capital cost of renewable heating systems and insulation for hard-to-treat homes, many social landlords feel more grant funding should be available¹¹.

However, even where grants can reduce upfront costs this does not guarantee action. Scottish homeowners who had applied for and received a £400 voucher as part of the UK's boiler scrappage scheme often still let this voucher expire as they felt replacing their system was still too expensive⁴⁵. The size of the upfront grant and the proportion of the total installation it covers needs to be enough to trigger or at least encourage a transition. This is reinforced by a choice experiment in research by DECC (2013) that showed that the provision of an upfront grant was a greater influence on homeowners' choice than the upfront installation cost, annual fuel bill or annual tariff payments¹⁷ and that as the value of the grant increased, so did homeowners' likelihood of taking up a renewable system.

6.2 Schemes can be seen as complex and difficult to navigate

Schemes offering financial support can be seen as complicated to manage. This may be a particularly salient barrier in situations where households need an urgent replacement for a broken-down system. For example, Snape, Boait and Rylatt (2015) speculate that the instructions and conditions for the RHI might put people off renewable heating systems when their current system has failed and predictability and speed are critical. They recommend that package deals could help in such situations by recommending a suitable system that can be quickly installed with confidence that it will satisfy RHI requirements⁴⁶.

In addition, evaluation of the RHI has suggested that when applicants are prepared with all the information needed for the application and/or they can get appropriate support, they have positive experiences of the application process, also noting that the process is quicker and easier online. Less positive experiences were reported by those who were less digitally literate or had technical issues with the application process, or those who did not have the right or timely information from suppliers¹³. Processes that require people to gather lots of information, some of which may be unfamiliar, and rely on others to deliver accurate information on time are only as easy as their various components make it. Applicants only have so much control over the information they receive and, not being experts themselves, may not spot errors until these are flagged as part of the application process, adding delays. This has also been reflected in social housing providers' evaluations of the RHI, with some saying that they often had to wait a long time to be told when their applications contained errors²⁶.

On the other hand, Consumer Focus Scotland (2012) ran focus groups with individuals who had installed energy efficiency measures (though not specifically low-carbon heat) through schemes such as the Universal Home Insulation Scheme (UHIS). They found that almost all considered the process 'easy' or 'very easy', with this partly because paperwork was managed by the surveyor⁴⁷. In these instances, though, opportunities to improve earlier communication were highlighted – some said they had been unclear about whether or not they were eligible for the scheme and, among others who were looking for additional information about the scheme, found the initial communication slow, with requests for more information about the scheme sometimes receiving delayed responses.

Participants may be aware of different schemes available to them but find it difficult to identify the most appropriate way to make use of them. Making the most of the available schemes may require some financial savviness. For example, some RHI applicants had received advice from financial experts who recommended taking out low interest loans to cover the upfront costs of renewable heating systems and then using RHI payments to cover loan repayments¹³. More than a quarter (28%) of Home Energy Scotland loan recipients said that using the loan had freed up money that they could then spend on other energy technologies²⁰. Not all consumers may think to combine different types of financial support as some RHI applicants did, or look into installing additional energy measures at the same time as those they have already planned.

6.3 Incentives and financial support: conclusions and recommendations

- Schemes, incentives and financial support encourage switching to low-carbon heating, although the extent to which they do varies from person to person. Some people are highly motivated by these initiatives and may not consider a transition to low-carbon systems without the support. Others are less motivated, especially those who feel that low-carbon heating itself offers financial benefits or where environmental factors are the key driver.
- Some reviews of stakeholder feedback suggest that schemes like the RHI and FiT disproportionately benefit those who can already afford the upfront installation costs of low-carbon heating. Those who are fuel-poor or have low incomes may even be further disadvantaged if they live in homes that are not energy efficient – the cost of upgrading the home to make it suitable for a low-carbon system would increase the upfront capital needed.
- Upfront costs are a bigger barrier than ongoing running costs and grants are the preferred way of meeting these. However, the size of the grant is important – if the new technology is still deemed too expensive after the grant has been taken into account, people will be unlikely to go ahead with the installation.
- Perceptions that an application process is complex and time-consuming to navigate may put people off applying for incentives and financial support, particularly in emergency situations where speed and predictability are critical.

7 Conclusions and recommendations

Reports describing awareness of low-carbon heating systems are easy to find, though using these to reach a conclusion about general levels of awareness is not as straightforward. Some technologies, such as biomass boilers, are more familiar than others, like district heating. Also, while awareness of some technologies is similar across Britain, consumers in Scotland do seem to have higher levels of awareness of some technologies (particularly biomass boilers) than those in England and Wales. However, it is unclear why awareness varies – certainly, awareness does not seem to reflect the spread of different system types installed in homes.

However, the usefulness of ‘awareness’ as a metric is unclear. Despite substantial proportions of those in Scotland saying they have heard of low-carbon heating systems and many people knowing where they would go for more information, uptake is still very low. Exploring how levels of awareness might prompt certain behaviours at key points (e.g. the decision to look into low-carbon heating systems) or among certain populations (e.g. those anticipating home renovation work), could help illustrate the role of awareness in transitions to – or at least consideration of – low-carbon heat.

People want confidence that heating systems will give them what they want, especially in terms of warmth and comfort. Even if people are aware of and look into low-carbon heating as a replacement, a lack of familiarity and experience with low-carbon systems might mean they are overshadowed by conventional alternatives. This may be exacerbated if sources of information do not highlight relevant benefits of low-carbon heating. Common sources such as heating system engineers and installers may well not recommend low-carbon systems, perhaps out of their own lack of understanding. This may further reinforce conventional systems as a more suitable choice – indeed, about a fifth of those in Scotland say they would probably just choose the heating system their plumber recommended.

Lack of awareness and knowledge is not necessarily a negative: it could represent a ‘blank slate’ on which to build consumers’ knowledge of and confidence in low-carbon heating, such that it is front of mind and desirable when they come to replacing their heating systems. With nearly half of Scottish consumers saying they would trust a government-backed advice service for information about greener, energy-efficient systems, there is an opportunity for Scottish Government to help shape campaigns that provide consumers with relevant information about the benefits of low-carbon heating and build consumer confidence in these systems.

Despite Scottish consumers’ high levels of reported concern about climate change and awareness of the need to address carbon emissions, not everyone recognises or is motivated by the need to transition to low-carbon heating systems. While environmental benefits might motivate some to switch to low-carbon options, others may not recognise these benefits or may not value them enough to move away from familiar, trusted alternatives like gas central heating, especially if there is any doubt about the ability of these alternatives to deliver more warmth, comfort and affordability.

Packaging and selling low-carbon heating systems into solutions that deliver comfort and foster confidence in consumers that they will get what they want for a predictable price, for example selling Heat as a Service, could help encourage installation of these technologies.

Those who have low-carbon heating systems are often satisfied with them on the basis of being able to get warm and comfortable (although it may take some time to learn how best to use a new system). This suggests that these technologies can and do deliver the warmth and comfort that people want. Satisfaction may be higher, or quicker to achieve, where systems are designed in a way that makes them easy to use, or perhaps sold as part of a wider solution or service that helps people warm their homes in the way they want.

Indeed, those that have considered but rejected low-carbon heating systems tend to cite practical factors as reasons not to install, rather than doubts that they would be able to warm

their homes sufficiently. Barriers such as space are particularly salient – and may be even more so in Scotland where a higher proportion live in flats.

Those who do not have low-carbon heating systems typically perceive them as expensive to install and raise concerns about performance. Certainly, low-carbon systems can be expensive to install, especially where additional measures like insulation are also needed. Financial support schemes may not help overcome these barriers, particularly where they are structured in a way that reduces the ongoing rather than the upfront costs.

Concerns about performance seem to be based on *uncertainty* about whether low-carbon alternatives can really deliver comfort, rather than a perception or knowledge that they cannot. It will be important to highlight that these systems can perform as well as conventional systems. In some cases, low-carbon heating may offer an opportunity to improve heating experiences.

Even when people feel that low-carbon systems offer equivalent or perhaps superior comfort benefits, these can still be overridden by financial factors. If a system is perceived as unaffordable, people are likely to choose a cheaper option.

Highlighting relevant comparisons of the performance and running costs of low-carbon heating is important. Comparisons are often made against gas central heating systems which may be relevant to the majority of the population, but with non-gas systems like oil and LPG significantly more common in Scotland than the rest of GB it may be important to highlight the relative benefits of low-carbon heating compared to these technologies too.

For those who place a lot of weight on financial factors, financial support seems to play an important, often critical role, in encouraging switching. However, these schemes may be more suitable for some populations than others. For example, schemes that reduce the running costs of low-carbon heating but not the installation costs may not be relevant to those for whom upfront costs represent a substantial barrier. However, loans to cover upfront costs will not appeal to everyone – some individuals chose not to apply for the Home Energy Scotland loan scheme as they didn't want to take on debt. Using existing savings or grant support may be preferable. However, if grant support is not felt to sufficiently reduce the barrier of upfront costs, it will not encourage a transition.

Where financial schemes and support are used, application processes should be simple and straightforward for people to navigate. This is even more important when heating systems need to be replaced quickly – people may value speed and convenience and if installing a low-carbon system cannot be done quickly and simply, they may opt for conventional systems instead.

8 References

- ¹ Protecting Scotland's Future: The Government's Programme for Scotland 2019-20, Scottish Government, 2019
- ² Renewable Heat in Scotland, 2018: A report by the Energy Saving Trust for the Scottish Government, Grillanda, A. & Khanal, P., 2019
- ³ Smart Systems and Heat: Consumer segmentations, Energy Systems Catapult, 2018
- ⁴ Consumer perceptions of low-carbon heating systems in hypothetical future energy market scenarios, Energy Systems Catapult, 2018
- ⁵ Innovating to Net Zero, Energy Systems Catapult, 2020
- ⁶ Transforming the UK Energy System: Public values, attitudes and acceptability – Synthesis Report, Parkhill, K.A., Demski, C., Butler, C., Spence, A. & Pidgeon, N., UKERC, 2013
- ⁷ Next steps for UK heat policy, Committee on Climate Change, 2016
- ⁸ Public Attitudes Tracker (wave 32), BEIS, 2019
- ⁹ Pathways to high penetration of heat pumps, Frontier Economics, 2013
- ¹⁰ Future of Heat survey, BEIS, *publication in progress*
- ¹¹ 21st century heating in rural homes: social landlords and tenants' experience of renewable heat, Consumer Focus Scotland, 2012
- ¹² The sustainable housing question: On the role of interpersonal, impersonal and professional trust in low-carbon retrofit decisions by homeowners, de Wilde, M., 2019
- ¹³ Qualitative research with owner-occupier applicants to the domestic RHI, BEIS, 2016
- ¹⁴ Future of low-carbon heat for off-grid buildings, Scottish Government, 2019
- ¹⁵ Carbon-free, poverty-free: heating options for rural Scotland, Common Weal Policy, 2019
- ¹⁶ Energising homeowners: Research into consumer decision-making on energy efficiency improvements; Citizens Advice, 2016
- ¹⁷ Homeowners' willingness to take up more efficient heating systems, DECC, 2013
- ¹⁸ Exploring the adoption of low-carbon technologies by Scottish housing associations, Abdel-Wahab, M., Moore, D. & MacDonald, S., 2011
- ¹⁹ Blended hydrogen: the UK public's perspective, Scott., M & Powells, G., 2019
- ²⁰ Home Energy Programmes Delivered by Energy Saving Trust on behalf of the Scottish Government, Energy Saving Trust, 2019
- ²¹ Changing behaviour in a changing climate: consumers and Scottish climate change policy, Citizens Advice Scotland, 2018
- ²² Motivations and barriers associated with adopting microgeneration energy technologies in the UK, Balcombe., P., Rigby, D. & Azapagic, A., 2013
- ²³ Customer Future Heat Project: Householder survey report, Greener Kirkcaldy, 2020
- ²⁴ Clean Growth – Transforming Heating, BEIS, 2018
- ²⁵ Facing up to climate change: breaking the barriers to a low-carbon Scotland: report of RSE Committee of Inquiry, Royal Society of Edinburgh, 2011
- ²⁶ Qualitative research with social housing providers, BEIS, 2016
- ²⁷ https://www.delta-ee.com/images/Infographics/HaaS_Infographic_Final.pdf
- ²⁸ Decarbonising Heat: Understanding how to increase the appeal and performance of heat pumps, Energy Systems Catapult, 2019
- ²⁹ Census of owner-occupier applicants to the domestic RHI, BEIS, 2017
- ³⁰ Domestic heat pumps in the UK: user behaviour, satisfaction and performance. Caird, S., Roy, R. & Potter, S., 2012
- ³¹ Evidence Gathering: Low-carbon heating technologies, BEIS, 2016
- ³² The heat is on: heat pump field trials phase 2, Energy Saving Trust, 2013
- ³³ Down to the Wire: Research into support and advice services for households in Scotland reliant on electric heating, Citizens Advice Scotland, 2018
- ³⁴ Qualitative research with consumers and operators of heat networks, BEIS, 2018
- ³⁵ Different rules for different fuels: exploring consumer protection in the district heating market, Citizens Advice Scotland, 2018
- ³⁶ Potential Heat Networks in Scotland's Seven Cities, Scottish Renewables, 2019
- ³⁷ Improvising innovation in UK urban district heating: the convergence of social and environmental agendas in Aberdeen, Webb, J., 2015
- ³⁸ Scottish passive house: insights into environmental conditions in monitored passive houses, Foster, J., Sharpe, T., Poston, A., Morgan, C. & Musau, F., 2016
- ³⁹ <https://es.catapult.org.uk/capabilities/digital-and-data/living-lab/>
- ⁴⁰ Decarbonising Heat: Understanding how to increase the appeal and performance of heat pumps, Energy Systems Catapult, 2019, Sections 4.1 and 5.4.
- ⁴¹ Hot off the Grid: Delivering energy efficiency to rural, off-gas Scotland, Citizens Advice Scotland, 2016

⁴² Homes as machines: exploring expert and public imaginaries of low carbon housing futures in the United Kingdom, Cherry, C., Hopfe, C, MacGillivray, B. & Pidgeon, N., 2017

⁴³ Heat Decarbonisation: Potential impacts on social equity and fuel poverty, Frerk, M. & MacLean, K., 2017

⁴⁴ Low carbon heating and older adults: comfort, cosiness and glow, Devine-Wright, P., Wrapson, W., Henshaw, V. & Guy, S., 2014

⁴⁵ Home energy efficiency: review of evidence on attitudes and behaviours, Gilchrist, K. & Craig, T., 2014

⁴⁶ Will domestic consumers take up the RHI? Snape, R.J., Boait, P.J. & Rylatt, R.M., 2015

⁴⁷ Keeping the heat in Scotland's homes: How to make energy efficiency schemes more appealing to consumers, Consumer Focus Scotland, 2012

9 Appendices

9.1 Appendix 1: Call for evidence

Summary post

The Energy Systems Catapult is working with ClimateXChange to summarise evidence that explains why some people in Scotland (and in different geographies within Scotland) have taken up low carbon heating technologies and others have not. This will support the Scottish Government in their ambition to reduce carbon emissions to net zero by 2045, in particular through informing the development of low carbon heat policies and helping identify which research gaps are most important to fill.

We would like to invite those who have or know of relevant evidence to share that evidence with us. Relevant evidence includes that which covers at least one of the following topics:

- The public's awareness of and attitudes towards low carbon and renewable heating technologies, including:
 - perceptions of benefits, drawbacks, practical factors, costs and incentives (e.g. RHI, Home Energy Scotland Loan Scheme) involved in installing and running these technologies
- What has led some people to adopt (or plan to adopt) low carbon heating and what prevents others from doing so
- Among those who currently have low carbon heating, what are their experiences of the transition to these technologies and how do those compare to their earlier expectations

For the purposes of this call for evidence, "low carbon heating" is defined as: heat pumps (including hybrid heat pumps), district heat networks, solar thermal, biomass, hydrogen and micro CHP. Evidence relating to other forms of electric heating, e.g. storage heaters, is also welcomed but may not be reviewed if we receive very large volumes of evidence relating to the other listed types of low carbon heating.

This is a rapid call for evidence, due to the timetable for this project. We will endeavour to review as much of the material we receive as possible but there may be a limit if we receive very large volumes. In this instance, priority will be given to those sources deemed to be of highest quality and relevance. For full details about the requested evidence and how to respond to this call, please see <https://es.catapult.org.uk/consultations/call-for-interviewees-heat-as-a-service-as-a-potential-route-to-low-carbon-heating-in-scotland/>

We encourage readers to share this call for evidence within their own networks.

Rapid call for evidence

What evidence are we looking for?

The Energy Systems Catapult are working with ClimateXChange to summarise evidence that explains why some people in Scotland (and in different geographies within Scotland) have taken up low carbon heating technologies and others have not. This will support the Scottish Government in their ambition to reduce carbon emissions to net zero by 2045, in particular through informing the development of low carbon heat policies and helping identify which research gaps are most important to fill.

Our research has two **aims**:

1. Identify and review up-to-date evidence to explore the reasons why some people in Scotland have moved to low carbon heating while others have not. That could include, but is by no means limited to:
 - a. Awareness and perceptions of and attitudes towards low carbon heating
 - b. Awareness and perceptions of, and access to, incentives that promote switching to low carbon technologies (e.g. RHI, Home Energy Scotland Loan Scheme)
 - c. Households' situational factors that facilitate or necessitate switching to low carbon technologies (e.g. moving into a new home, home renovation).
2. Examine differences between households on the basis of whether or not they currently have low carbon heating technology, geography and location, demographics, socioeconomic factors and housing tenure.

Evidence will be evaluated to understand the key findings, determine the robustness of the evidence base and identify any evidence gaps.

We would like to invite those who have or know of relevant evidence to share that evidence with us.

Relevant evidence includes that which covers at least one of the following topics:

- The public's awareness of and attitudes towards low carbon and renewable heating technologies, including:
 - perceptions of benefits, drawbacks, practical factors and costs involved in installing and running these technologies
- What has led some people to adopt (or plan to adopt) low carbon heating and what prevents others from doing so
- Why people have, or have not, used initiatives and schemes (e.g. RHI, Home Energy Scotland Loan Scheme) that facilitate access to low carbon heating systems
- Among those who do currently have low carbon heating, what are their experiences of the transition to these technologies and how do those compare to their earlier expectations
- Differences in perceptions, attitudes and uptake of low carbon heating systems between different consumer groups
 - Consumer groups may be those differentiated on the basis of demographics, geography (regions within Scotland, urban/rural, on or off gas grid), socioeconomic factors, housing tenure, or other factors not listed here.

The review will focus on domestic (i.e. residential) consumers and households in Scotland where possible, otherwise in the UK. Evidence from other regions and countries is also welcome, accompanied by an explanation of why it may be applicable to Scotland.

For the purposes of this call for evidence, "low carbon heating" is defined as: heat pumps (including hybrid heat pumps), district heat networks, solar thermal, biomass, hydrogen and micro CHP. Evidence relating to other forms of electric heating, e.g. storage heaters, is also welcomed but may not be reviewed if we receive very large volumes of evidence relating to the other listed types of low carbon heating.

Who is this call for evidence open to?

We would like to invite written responses from a variety of different perspectives, including (but not limited to):

- Business and other organisations who provide (or may provide, in future) products and services to consumers in Scotland, whether directly or indirectly
- Local authorities, particularly those based in Scotland
- Academic organisations
- Organisations representing citizens

We welcome the sharing of this call for evidence among your own networks.

How can you respond?

To respond to this call for evidence, please email callforevidence_scotland@es.catapult.org.uk by Friday 1st May 2020.

In your response, please explain:

- Who you are responding for (e.g. which organisation or individual)
- Your (or your organisation's) connection to this or related topics
- Which of the questions you are responding to
- Whether or not evidence involves those who currently have a low carbon heating system (please highlight if this is not known)
- How the evidence is relevant to Scotland

We may wish to recontact you during this project or for other related projects in the future. If you are happy for us to do so, please provide your contact details in your response.

We may publicly acknowledge those who have provided relevant responses to this call for evidence. If you would like to be omitted from such acknowledgement or otherwise wish your response to be treated confidentially, please highlight this in your response.

This is a rapid call for evidence, due to the timetable for this project. We will endeavour to review as much of the material we receive as possible but there may be a limit if we receive very large volumes. In this instance, priority will be given to those sources deemed to be of highest quality and relevance.

9.2 Appendix 2: Search terms

	Population	Exposure	Outcome
A	Consumer; person; people; citizen; residen*; domestic; inhabitant; national; tax?payer; member; House?buyer; home?owner; first?time buyer; tenan*; owner; house?hold; occupan*; Adopt*; customer; user; buyer; purchaser; Appl*; participa*	Incentiv*; finance; inform*; initiative; campaign; offer; grant; subsidy; scheme; program?e; roll?out; sale; support; Reason; motiv*; stimu*;	Deci*; Purchase; install*;
B	Scot*	"Renewable Heat Incentive"; RHI; "Green Deal"; "feed?in tariff";	Aware*; underst*; knowledge; accept*; appeal; perce*; attitude; willing*; open*; interest; resistan*; recogni*; choice; choose; impression; opinion; thought; think; consider*; belie*; view; react*; feel*; assum*; perspective;

		"smart export guarantee"; government; "Home Energy Scotland Loan Scheme"; "HES Loan" "grant"	preconce*; judg?ment; intent*; behavio?r; "behavio?r change", experience; transition
C	UK; United Kingdom; Great Britain; Brit*	Low?carbon; no?carbon; zero?carbon; decarboni?e; renewable; green; energy?saving; energy?efficient; environment*; environmentally?friendly; electric; low?emission; no?emission; zero?emission; retro?fit	
D		Heat pump; "air?source heat pump"; "ground?source heat pump"; "hybrid?heat pump"; ASHP; GSHP; HHP; district heat; heat network; community heat; solar?thermal; biomass; hydrogen; "micro?CHP"; "combined heat and power"; "low carbon hous*"	
E		Heat*; hot water; immersion heater; hot water; boiler; "gas boiler"; "combi?boiler"; "condensing boiler"; gas central heating; central heating	
Boolean	1) A 2) A and B 3) A and C	1) B 2) C 3) D 4) A and B 5) A and C 6) A and D 7) C and E 8) D and E	1) A 2) B

Currently out of scope, but to be included if the search is expanded:

	Population	Exposure	Outcome
Additional		Electric heat*; storage heat*; home improvement; renovat*	Comfort*; "thermal comfort"; cost; convenien* → Other benefits; related benefits expressed in different ways; unintended outcomes e.g. workarounds/adaptations made to accommodate/manage new equipment [these may emerge through learnings from other evidence] → Other behaviour change topics and terms e.g. planning for an installation, decision to replace in future

- **Subject headings:** relevant material may span multiple fields, so initial searches will not be conducted within specific subject headings. This strategy may be revised depending on search outcomes, database functionality.
 - Where revised, subject headings to be recorded.
- **Citation searches:** no strategy to be used for initial searches. This may be revised if required.
 - Where revised, citation search parameters to be recorded.

English language papers only

A * indicates truncation

A ? indicates wildcard

→ Change * and ? depending on database

Relevant databases and resources

British Library Catalogue

ScienceDirect

9.3 Appendix 3: Quality and relevance assessment criteria

Criteria	Inclusion criteria (with priority where applicable)	Notes	Exclusion criteria
Language	English language only		Non-English
Publication date	<ol style="list-style-type: none"> 1) Last 5 years (2015 or later) 2) Last 10 years (2010 or later) 		Over 10 years old (pre-2010)
Full text	Full text only		Full text not available
Type of evidence	<ul style="list-style-type: none"> - Peer-reviewed research - Journal-published literature review - Peer-reviewed conferences - Original research published elsewhere (e.g. commercial, government) - Review article published elsewhere (e.g. commercial, government) - Conferences - Other 	Evidence type to be noted, but ranking to be done once sufficient evidence available to see split of types	
Region of interest	<ol style="list-style-type: none"> 1) Scotland only 2) GB/UK, with regional distinction made in analysis/results 3) GB/UK with no regional distinction 4) European countries incl. GB/UK 	Relevance to UK to be assessed and ranked as evidence becomes available. Relevant criteria may include climate, demographics, availability/similarity of technology, schemes, business models	All others
Sampling	<ol style="list-style-type: none"> 1) Nationally representative 2) Other quota-driven samples 3) Opportunistic, self-selected and other sampling methods 	Journal articles should explain how opportunistic and other sampling methods are relevant to general population	
Population – technology ownership	<ul style="list-style-type: none"> - Those who do and do not have low carbon heating systems - Those who do have low carbon heating systems - Those who do not have low carbon heating systems 	<p>Evidence to be grouped but not ranked on this basis due to relevance to different research questions.</p> <p>Note that sampling and research methods may differ between population groups.</p>	

Outcome of calibration activity:

Only a very small number of minor discrepancies were identified. These discrepancies and their respective resolutions were:

- One piece of indirect consumer evidence (consumers' views as represented by stakeholders) had been rated as having higher quality by one assessor compared to the other two. Discussion indicated this was on the basis of the quality with which consumers' views had been represented, with two having rated the quality as lower as the research design had not specifically and consistently sought out consumers' views. However, it was agreed that this research design should lower the relevance score, rather than the quality score.
- One piece of evidence had been rated as higher relevance by two assessors compared to the third. Discussion highlighted this was due to inclusion of Scotland-specific evidence: all three individuals acknowledged some evidence specific to Scotland, but one had scored the relevance lower due to the limited amount of evidence available.

In neither of the above cases had any assessors suggested excluding the evidence in question.

- Finally, one piece of evidence reviewed by two assessors had been rated differently on the basis of relevance. One assessor had proposed excluding the evidence as it was based on non-UK, European sample – this assessment had been made following a discussion with the client about excluding non-UK samples, whereas the assessor who had not proposed excluding the evidence had rated the evidence prior to this discussion. Agreement had been reached with the client to exclude non-UK evidence, so no further action was felt necessary.

9.4 Appendix 4: Reviewed evidence



CXC_Evidence
reviewed.xlsx

Please find a copy of the reviewed evidence list in a separate file on the CXC website.

© Published by Energy Systems Catapult 2020 on behalf of ClimateXChange. All rights reserved.

While every effort is made to ensure the information in this report is accurate, no legal responsibility is accepted for any errors, omissions or misleading statements. The views expressed represent those of the author(s), and do not necessarily represent those of the host institutions or funders.

climateXchange

Scotland's centre of expertise connecting
climate change research and policy

✉ info@climatexchange.org.uk
☎ +44(0)131 651 4783
🐦 @climatexchange_
👉 www.climatexchange.org.uk

ClimateXChange, Edinburgh Centre for Carbon Innovation, High School Yards, Edinburgh EH1 1LZ

