Energy Efficient Scotland

The future of low carbon heat for off gas buildings

Analysis of responses to the call for evidence

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Craigforth

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Executive Summary

This summary sets out key findings from analysis of responses to the Energy Efficient Scotland call for evidence: the future of low carbon heat for off gas buildings. The call for evidence opened on 26 March 2019 and closed on 17 June 2019. The call for evidence paper is available at: https://consult.gov.scot/better-homes-division/the-future-of-low-carbon-heat.

A total of 54 responses were received, of which 50 were from groups or organisations and 4 from individual members of the public. Responses varied in format and focus. Some responded across all questions while others were primarily concerned with specific low carbon technologies (often reflecting respondents' areas of operation and expertise). Responses were also varied in the extent to which they cited specific evidence and/or expressed opinion. This summary considers key themes emerging across responses, while the remainder of this report sets out responses to each question in turn.

The role of policy and regulation

Policy and regulation were seen as having a key role to play in supporting deployment of low carbon heat in off-gas buildings. There were calls for consistent, long-term policy to provide the stability and certainty required to encourage investment, and to provide a clear statement on the role of a range of heat technologies. This included setting clear targets for deployment of low carbon heat, provision of financial and other support to facilitate uptake, and guidance or standards to ensure high quality installations that deliver the required carbon reduction.

While there was support for the Scottish Government's policy approach, some perceived a lack of clarity around policy timescales. Respondents suggested that clear interim targets were required to allow stakeholders to plan investment, and provide time to build consumer confidence. This included calls for a firm end-date for new high carbon heat installations, and subsequent dates for conversion of existing systems.

Financial support for low carbon heat was also perceived as a key aspect of the policy framework. Uncertainty around the future of the UK Government's Renewable Heat Incentive scheme (RHI) post-2021 was a key concern, with some suggesting this was limiting industry investment. This reflected a common view that there is a continuing need for financial support for deployment of low carbon heat. This was seen as a particular issue for lower income and fuel poor households and those in buildings with poor energy efficiency, for whom installation costs were regarded as a key barrier to deployment. Respondents supported use of a range of financial mechanisms to support uptake of low carbon heat, including:

- Government grants and subsidised loans, including larger upfront payments to overcome installation cost barriers;
- Other public finance mechanisms such as scrappage schemes, tax reliefs and Government-sponsored mass purchase;

- Private finance such as low and zero interest financial products, including long-term loans and green mortgages; and
- Wider reform of fuel taxation to penalise high carbon fuels.

In addition, respondents suggested a range of other policy and regulatory changes to support deployment of low carbon heat:

- Building regulations requiring new build and major renovations to incorporate low carbon heat, or to be 'future proofed' for subsequent deployment;
- Revision to the EPC framework, placing more emphasis on carbon emissions;
- Requirement for installers of 'traditional' heating systems to include low carbon options when quoting for heating system replacement; and
- Better signposting of independent advice and information for consumers.

Consumers and low carbon heat

A lack of consumer awareness and understanding of low carbon heat was described as having been a significant barrier to its deployment. This included some who perceived a lack of public understanding around the rationale for decarbonisation of heat and the need for urgent action.

Respondents saw consumer 'inertia' regarding change of heating systems as reflecting this lack of understanding. This included reference to low consumer awareness of available low carbon technologies, and a lack of clarity on the relative heat performance, reliability and cost of low carbon heat. Respondents also suggested there are negative consumer perceptions around some low carbon heat technologies, particularly heat pumps. Some suggested that unrealistic performance and cost estimates from installers, and a lack of training on use of new heating systems, had contributed to 'bad press' around some technologies.

Some suggested that consumer awareness had improved in recent years, but overall there was a view that further action is required to improve understanding and acceptance of low carbon heat, if policy targets are to be met. Respondents saw a need for varying approaches to achieve this change:

- Scottish Government communicating its approach to low carbon heat in a way that engages consumers, 'normalises' low carbon heat, and makes clear the need for urgent action in decarbonising heat in Scotland.
- Provision of high quality information and advice on low carbon heat technologies. This included reference to the role of installers in providing information on low carbon heat technologies. Some saw a need for industry standards to ensure the accuracy of information and performance/cost estimates provided by installers.
- Improving consumer access to independent information and advice on low carbon heat, particularly at key 'trigger points' such as failure of current systems, major renovation and house moves. Respondents saw a potential role for a range of organisations in provision of independent information and advice. These included Home Energy Scotland, Citizens' Advice and other

third sector organisations. Some also saw a need for a reliable, impartial online source of information and advice, and a standardised consumer information pack was suggested.

Changes to further strengthen consumer protections around low carbon heat were also suggested. Some wished to see the Scottish Government engage more with the UK Government (particularly the Department for Business, Energy & Industrial Strategy), Ofgem and industry to strengthen consumer protection in heating. Guidance and licensing were also supported as a means of providing consumer protections. This included reference to existing standards and accreditation schemes across the UK.

Costs of low carbon heat

Cost was perceived by respondents as a key factor for the decarbonisation of heat in Scotland. This included the potential for capital and running costs to inhibit uptake of low carbon heat, and a perceived tension between the decarbonisation of heat and ongoing work to address fuel poverty.

Capital costs were seen as a significant barrier to adoption of low carbon heat. Respondents cited varying installation costs but overall these were described as higher than high carbon systems, particularly for retrofit to existing buildings. Some suggested that consumers switching to low carbon heat are likely to have to meet substantial upfront costs (including those who receive public funding). 'Demand risk' was also seen as a key factor limiting installation of heat networks; respondents suggested that uncertainty around the number of consumers likely to connect had undermined the economic case for some heat networks.

It was suggested that low carbon technologies can deliver reduced running costs in some circumstances. However, respondents also suggested that running costs are highly sensitive to factors such as building energy efficiency and current heating systems. Some expressed a view that low carbon heat will require subsidy in many circumstances to achieve positive whole-life economics relative to existing systems.

Respondents saw potential for costs to reduce as technologies and the supply chain mature, although this varied by technology. Moreover, some suggested that decarbonising heat would lead to increased heating costs for consumers in the short to medium term. Some saw potential for 'pushback' from consumers who may be more motivated by short-term costs than longer-term societal benefits. In this context, respondents saw a continuing need for public financial support.

Some expressed concerns that fuel poverty could be worsened by the higher installation costs and potentially increased running costs of low carbon heat. This was regarded as a particular issue for 'hard to treat' buildings and rural areas. Few respondents cited specific evidence on use of low carbon heat for fuel poor households, although some examples of cost savings achieved by low carbon heat were cited. Overall, respondents saw a need for targeted financial support to mitigate any negative impact on fuel poverty. Respondents also regarded advice and support as important in enabling fuel poor households to choose and operate the most suitable low carbon technology.

Other barriers to delivery of low carbon heat

Respondents suggested a range of other barriers to uptake of low carbon heat. These were primarily related to building-specific and infrastructure constraints, and cost pressures associated with some low carbon technologies.

The most commonly suggested constraint related to the relatively poor energy efficiency of off-gas housing stock in Scotland. Respondents referred to the large proportion of off-gas buildings in rural and island locations as being subject to poorer energy efficiency levels, and to the prevalence of 'hard to treat' build types. These factors were seen as undermining the viability of some technologies, and/or requiring costly energy efficiency improvements alongside installation of low carbon heat. Other technical and infrastructure constraints suggested by respondents included:

- Disruption associated with some installations, for example where new heat emitters or ground source collectors are required.
- A limited installer base for some technologies restricting access to low carbon heat, and undermining consumer confidence for example around access to ongoing maintenance and repair services. This was seen as a particular issue in rural areas and islands.
- Restricted electricity grid capacity in some locations limiting potential scope for, or increasing the cost of, deployment of electric low carbon heat.

Gaps in knowledge and the need for further research

Respondents highlighted perceived gaps in knowledge around low carbon heat, and recommended specific areas for further research.

This included technologies where a small install base and/or the speed of development were seen as limiting available evidence, such as hybrid heat pump systems and bioenergy. Some saw a need for more evidence on the relative performance and costs of these technologies. Respondents also recommended further research and demonstrator projects across a number of emerging technologies such as battery storage, fuel cell technology, localised production of low carbon heat sources, and new biofuels. In addition, respondents cited relatively little evidence in relation to some aspects of the call for evidence. This may imply a need for further research in relation to the lifecycle of heat pumps, and customer satisfaction with low carbon heat.

Electrification of heating

There was support across respondent groups for a range of low carbon electric heating technologies including electric heat pumps, hybrid heating systems, heat networks using electric heat sources, and electric storage heating.

However, some respondents raised concerns regarding the feasibility or desirability of decarbonising heat primarily or wholly via electrification. This was explicit in responses to some aspects of the call for evidence, such as electricity grid capacity being suggested as a barrier to deployment of low carbon heat in some locations.

Respondents suggested a number of approaches to mitigate grid constraints on deployment of electric low carbon heat. Managing peak electricity demand was seen by some as a key focus if electrification is to play a significant role in decarbonising heat. Some expressed support for integrated systems in making best use of available energy infrastructure, and the importance of taking a 'whole system approach' including use of a range of energy sources. Some also saw a need for further work to understand the potential role of different technologies in balancing demand. Other specific suggestions included on-site or localised energy generation, use of thermal and electrical storage, smart controls and demand side management, and ongoing trials of smart grid solutions.

Concerns regarding electrification were also implicit in some respondents' focus on the potential role of other energy sources in decarbonising heat. This included reference to bioenergy technologies as lower carbon options than current off-gas heating systems, and some support for continued extension of gas networks. However, others wished to see a limit to gas grid extension until proven low carbon gas solutions are available, and some raised concerns that continued extension will delay deployment of low carbon alternatives.

Bioenergy and low carbon heat

Support for bioenergy as part of the approach to decarbonising heat in Scotland included reference to a number of specific benefits. Respondents suggested that installation costs are relatively low for some forms of bioenergy, and suggested that bioLPG can be 'dropped in' to existing LPG systems with minimal installation or conversion costs. Potential for bioenergy to reduce carbon emissions while minimising disruption to consumers was seen as a key benefit. This included the suitability of bioenergy for high temperature heating systems. Some respondents also suggested there is substantial bioenergy feedstock capacity within Scotland, including opportunities for use of local fuel supplies.

Call for evidence questions on bioenergy were a particular focus for private sector respondents active in the bioenergy sector. These respondents' support for bioenergy was also evident across other parts of the call for evidence, such as in overcoming potential constraints on low carbon electric heating, and mitigating the impact of decarbonisation on fuel poverty. These respondents wished to see a clear policy statement on the role of bioenergy in decarbonising heat in Scotland.

Other respondents suggested potential barriers to use of bioenergy to decarbonise heat. These included suggestions that installation costs are higher for biomass and some bioliquids, concerns around availability of consistent feedstock supply limiting consumer confidence, fluctuation in fuel costs as a risk to consumers, limited bioenergy supply chains in some parts of Scotland, and air quality concerns inhibiting uptake (although this was seen as a lesser issue for rural off-gas areas).

Introduction

Background

This report presents analysis of responses to the Energy Efficient Scotland call for evidence: the future of low carbon heat for off gas buildings.

Decarbonising the way Scotland's buildings are heated is a fundamental part of the transition to a net-zero emissions economy, and to achieve the Scottish Government's climate change targets. The current Climate Change Plan outlines a trajectory to supply 35% of domestic heat, and 70% of heat used by non-domestic properties, from low carbon sources by 2032.[1] The Scottish Government has committed to updating the Climate Change Plan within 6 months of the Climate Change Bill receiving Royal Assent.

The Scottish Government has set out a hierarchical approach to heat decarbonisation. The first stage (reducing heat demand) has been the focus of a range of programmes and policies over recent years. Decarbonising heat generation is the second element in this approach, including continuing progress to decarbonise heat in off-gas buildings and work with the UK Government on heat to those using mains gas.

The call for evidence sought responses to inform the Scottish Government's future strategic approach to decarbonise heat in off-gas buildings. The call for evidence paper sets out 57 open questions relating to the current market, low carbon heat technologies, and the framework required to support uptake of these. The call for evidence opened on 26 March 2019 and closed on 17 June 2019. The paper is available at: https://consult.gov.scot/better-homes-division/the-future-of-low-carbon-heat.

Profile of responses

In total 54 responses were received, of which 50 were from groups or organisations and 4 from individual members of the public. Of the 54 responses, 22 were received through the Scottish Government's Citizen Space consultation hub, but most were received via email. Where consent has been given to publish the response it may be found at https://consult.gov.scot/better-homes-division/the-future-of-low-carbon-heat/.

Respondents were asked to identify whether they were responding as an individual or on behalf of a group or organisation. Organisational respondents were then allocated to one of four broad categories (and one of 11 sub-groups) by the analysis team:

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[1] This is as set out in the Climate Change Plan, published in February 2018. The Climate Change (Emissions Reduction Targets) (Scotland) Bill amends the Climate Change (Scotland) Act 2009 to set more ambitious economy wide targets including net zero greenhouse gas emissions by 2045, a 90% reduction by 2040 and a 75% reduction by 2030. The Scottish Government has committed to updating the Climate Change Plan within 6 months of the Bill receiving Royal Assent.

- **Private sector organisations**: 31 respondents including six energy supply and/or distribution organisations, seven renewable/low carbon, three heat pump, four LPG, and three other fuel-related organisations. Eight ‘other’ private sector respondents include some non-energy related organisations.
- **Public sector organisations**: 9 respondents including six local authorities and three other national and regional public sector organisations.
- **Third sector respondents**: 5 respondents including three with a specific low carbon or energy efficiency focus, and two other organisations.
- **Other group respondents**: 5 respondents including three organisations with a specific focus on energy and heat, an academic/research organisation and a housing provider.

A breakdown of the number of responses received by respondent type is set out in Table 1 below. A full list of organisational respondents who gave consent for their name to be published can be found in Annex 1.

Table 1: Respondents by type

Organisations:	**50**
Private sector	31
Private sector - energy supply and/or distribution	*6*
Private sector - renewables/low carbon	*7*
Private sector - heat pump	*3*
Private sector - LPG	*4*
Private sector - other fuels	*3*
Private sector - other	*8*
Public sector	9
Public sector - local authority	*6*
Public sector - other	*3*
Third sector	5
Third sector - low carbon/energy efficiency	*3*
Third sector - other	*2*
Other organisation	5
Individuals	**4**
ALL RESPONDENTS	**54**

Responses varied in their focus across the call for evidence. Some were primarily concerned with specific low carbon technologies while others responded across a broader range of questions. Table 2 provides an overview of patterns of response by respondent type.

The extent to which responses focused on specific technologies varied by respondent type and appeared to reflect respondents’ experience and expertise. For example, those active in the relevant sector accounted for a large proportion of material submitted in relation to some low carbon technologies. This appeared to be the case for questions on biomass and bio-liquid technologies; relatively few respondents without links to the sector provided detailed responses to these questions. As such, the views expressed cannot necessarily be read as representative of the full range of opinion. Furthermore, there may be counterarguments to points raised by respondents that the call for evidence does not capture.

Table 2: Overview of responses by question.

	Private sector	Public sector	Third sector	Other	Individual	TOTAL
ALL RESPONDENTS	**31**	**9**	**5**	**5**	**4**	**54**
Current market	**30**	**9**	**4**	**4**	**3**	**50**
Low carbon technologies	**27**	**8**	**5**	**5**	**2**	**47**
Electric heating	24	8	3	4	2	**41**
Biomass and bio-liquid	19	5	0	3	2	**29**
Heat networks	19	8	3	4	2	**36**
Gas grid extension	19	6	3	3	2	**33**
Innovation	16	1	0	3	2	**22**
Low carbon heat and fuel poverty (Q40)	**17**	**3**	**1**	**3**	**2**	**26**
Enabling uptake of low carbon heat	**29**	**6**	**4**	**3**	**2**	**44**
The role of regulation in supporting uptake	**25**	**5**	**3**	**4**	**2**	**39**
Growing and scaling the supply chain (Q57)	**21**	**6**	**2**	**3**	**2**	**34**

Analysis and reporting

In total there were 57 open questions, of which 5 had multiple parts. This report presents a question-by-question analysis of the comments made. Respondents made submissions in a range of formats, some including material that did not directly address specific call for evidence questions. This content was analysed qualitatively under the most directly relevant part of the call for evidence. The report also takes account of feedback gathered through a stakeholder workshop event held as part of the call for evidence process.

Readers' attention is drawn to the following points regarding the analysis and reporting process.

Analysis set out in this report focuses on evidence supplied by respondents, consistent with the purpose of the call for evidence. Where specific claims are set out in the report, references to evidence sources are provided where possible. The report notes where evidence was not provided for a claim. Statements of opinion provided by respondents without evidence may not have been included in the analysis.

A list of acronyms used in the report is provided at Annex 2.

Current market for low carbon heat

The first section of the call for evidence considers the low carbon and renewable heat market in Scotland. In addition to the distinctive characteristics of the market and how this has developed, this section specifically considers the following key factors for the future policy approach:

- Existing barriers to uptake of low carbon heat;
- Actions that can overcome these barriers to accelerate uptake; and
- Building-specific restrictions to growth in low carbon heat including poor energy efficiency, building density, conservation areas and listed buildings, and high heat demand/need for high temperature heat.

Questions 1 to 8 sought views and evidence on each of these in turn.

Readers should note that respondents' focus on specific aspects of the current market for low carbon heat appeared to reflect their experience and expertise. For example, those active in a particular energy sector typically focused on their sector and associated technologies. As such, **views expressed cannot necessarily be read as representative of the full range of opinion**. References are provided for specific claims where possible, and we note where evidence was not provided. Statements of opinion provided without evidence may not have been included.

Uptake of low carbon heat without government support

Question 1: What evidence can you provide of low carbon heat technologies being taken up without government support?

A total of 38 respondents (70%) addressed Question 1.

Some private sector and a public sector respondents suggested that government support had been a crucial factor for growth in take-up of low carbon heat technologies in recent years. In this context, reference was made to the prevalence of government support in European countries with significant take-up of low carbon heat. Some suggested that ongoing support would be required to meet Scottish Government targets, particularly for hard to treat buildings where efficiency upgrades are likely to be required alongside low carbon heat. Again this was a particular concern for private sector respondents and some public sector respondents.

Respondents highlighting the importance of government support also suggested that capital costs are a significant barrier to installation of low carbon heat. One respondent included survey research evidence that 80% of consumers are unable or unwilling to pay initial capital costs.[2] An 'other organisation' also cited feedback from those in receipt of a Home Energy Scotland loan that only around 1 in 10 would have installed the chosen technology without government support. Some

[2] Wales & West Utilities (2018), On the road to a green energy UK. www.wwutilities.co.uk/media/2718/integrated-gas-and-electricity-networks-support-the-journey.pdf

private sector respondents indicated that the size of any potential reduction in running costs is insufficient to encourage most consumers to make the initial investment to move to low carbon heat. It was suggested that only the most environmentally committed consumers have taken up low carbon heat without government support.

There were suggestions across a range of respondent groups that take-up of low carbon technologies had remained at relatively low levels even with government support. This included comparison of low carbon installation numbers with the replacement rate of gas boilers. Some felt that RHI scheme tariffs had favoured some technologies over others; it was suggested that ground source heat pump installations had declined under RHI, in part due to higher RHI tariffs for other technologies. Respondents also cited examples of installers offering heat pumps at a lower cost to consumers where RHI is not taken up, due to the administrative burden and costs associated with RHI.

Respondents provided several examples of low carbon heat technologies being taken up without government support. This included a number of specific low carbon heat technologies and building-types, and specific policy mechanisms:

- Respondents compared data on total heat pump sales in recent years[3] with numbers of RHI supported installations, and suggested that a significant number of heat pumps are being installed without RHI support. This included air source and ground source technologies. Some also suggested that growing consumer demand for low carbon technologies has contributed to an increasing number of installations without RHI support.
- Highly energy efficient new housing was suggested as having the greatest potential for deployment of low carbon heat without government support.
- Specific cases of low carbon heat being taken up without government financial support included:
    - Consumers in remote rural and island locations choosing non-Micro Generation Scheme (MCS) certified installers, and thus being ineligible for government support, due to difficulty accessing certified installers.
    - Combined heat and power (CHP) engines having been installed without government support due to potential revenue from the sale of electricity, although it was suggested that regulation changes may make this less likely.
    - Greater London Authority's plan deploying heat networks to new build with financing from developers and third party loan support.
    - Energy from waste development in the Midlands.
    - Installation of air source heat pumps to local authority assets funded through external grants such as wind farm community benefit.

[3] Specific references included: European Heat Pump Association (2018), European Heat Pump Market and Statistics Report 2018; and Micro Generation Scheme statistics published at www.microgenerationcertification.org/about-us/statistics.

    - Installation of ground source heat pumps and other low carbon heat technologies being fully funded by local authority capital investment, driven by reduction in carbon emissions and revenue costs.
    - RWE's biomass CHP connection to district heating in Glenrothes was cited as illustrating the effectiveness of the Renewables Obligation Certificates (ROC) scheme, although it was noted that the scheme also received government financial support via the Low Carbon Infrastructure Transition Programme (LCITP).
- An 'other organisation' respondent cited evidence that more than a quarter of consumers receiving Home Energy Scotland loans indicated that the loan had 'freed money' for other renewable energy or energy efficiency measures.
- Respondents referred to multiple technologies where take-up was perceived to have reduced carbon emissions, but which are not supported by RHI. These include:
    - Take-up of wood-burning stoves remaining above historical trends over recent years without government support.
    - LPG conversion providing carbon and cost savings relative to oil systems, with potential for future 'drop in' of bioLPG. Respondents suggested that reduction in running costs encouraged consumers to make the initial capital investment without government support.
    - Lower carbon solid fuels as alternatives to conventional house coal.
- It was also suggested that policy mechanisms had played a role in encouraging take up of low carbon heat, instead of or in addition to government financial support. This included reference to ROCs, Scottish Environment Protection Agency (SEPA) permission and air quality requirements.

Responses suggested a number of ways in which take-up of low carbon heat could be encouraged without direct financial support from government.

- Some private sector respondents expressed support for less direct financial support. These included use of tax arrangements and levies to reduce the 'market barriers' to take-up of low carbon heat, and government acting as guarantor for long-term bank loans for installation of low carbon heat. In relation to the latter suggestion, it was suggested that existing government backed loan schemes via banks have demonstrated the potential of this approach.
- Government policy and strategy was seen as having scope to encourage take-up of low carbon heat in the absence of government financial support. However, the role of other policy and regulation was also suggested in supporting (or requiring) take-up of low carbon heat. This included stricter emissions and air quality requirements, and more ambitious energy efficiency and emissions targets.
- The role of information and advice on low carbon heat technologies, including sharing of case studies, was seen as a means of improving consumer understanding and acceptance. Some private sector respondents described

this as essential to enable mass-market deployment of low carbon heat technologies.

Barriers to uptake of low carbon heat

Question 2: What other barriers may impede the uptake of low carbon heat in buildings not currently using mains gas?

A total of 49 respondents (91%) addressed Question 2.

Respondents suggested a broad range of barriers to uptake of low carbon heat in off-gas buildings. These reflected a number of common themes: technical constraints (including buildings, infrastructure and available technologies), cost, policy and legislation, and customer awareness and demand.

The most commonly suggested **technical** constraint related to the relatively poor energy efficiency of off-gas housing stock, including 'hard to treat' building types. This was suggested across respondent groups. Some noted the large proportion of off-gas buildings in rural and island locations, suggesting that average energy efficiency levels are substantially lower than urban locations. These factors were seen as presenting challenges for some low carbon technologies and/or requiring costly energy efficiency improvements alongside installation of low carbon heat. Evidence was cited that a substantial number of homes in the UK would be unsuitable for heat pump installation without energy efficiency intervention.

Other technical constraints suggested by respondents included:

- Limited electrical grid capacity in some locations to support wider use of heat pumps, although some suggested that the limited volume of installations to date meant that this has not yet been a significant active issue. Workshop participants also noted that most off-gas buildings already use electric heating, and suggested that transition to low carbon electric heating may reduce demand on the electricity grid.
- Views were mixed on the extent to which take-up of low carbon heat is constrained by the disruption associated with the initial installation. Some suggested that consumers with electric storage heating (described as requiring substantial disruption for upgrade to low carbon heat) are more likely to accept this due to potential improvement in heating performance and cost savings. Reference was also made to commercial premises, with some suggesting that disruption is typically less of a barrier if this will not affect commercial operations.
- Limited space capacity to accommodate low carbon systems, such as biomass heating.
- Several examples of problems arising from incorrect or ill-advised installation of low carbon heat technologies.
- Heat networks not being sustainable in some rural areas due to low density of heat demand.

- Mixed ownership housing blocks limiting scope for some low carbon heat options.
- Lack of internet connection or mobile coverage in some buildings for monitoring of energy usage, limiting ability to measure the benefits of low carbon systems.
- A specific issue for remote rural and island locations where consumers pay a surcharge for electricity distribution, despite some islands being net exporters of electricity.

Cost of low carbon heat technologies was also a particularly commonly suggested barrier to uptake, again raised across respondent types. Low carbon heat technologies were described as typically requiring higher capital investment than equivalent 'traditional' heating options, with consumers having to meet substantial upfront costs (including those in receipt of RHI financial support). This was seen as a significant barrier for consumers, even in cases where low carbon heat technologies can deliver lower running costs. Some suggested that reduced running costs can only be achieved through behavioural change from consumers, while others expressed a view that for most households, low carbon heat will require subsidy to achieve positive whole-life economics when compared with more modern 'traditional' systems.

Low carbon heating systems are more expensive than replacing an incumbent heating system. [Even with] lower running costs, the capital investment can be an issue.

Private sector (renewables/low carbon) respondent

Other cost-related barriers to uptake of low carbon heat are summarised below.

- Some suggested that many households in off-gas buildings would find it difficult to raise the capital required to meet installation costs of low carbon heat. It was suggested that this is compounded where poor energy efficiency and 'hard to treat' building types increase installation costs.
- It was suggested that any large scale decarbonisation programme would lead to higher overall costs in the short to medium term, with the potential for 'pushback' from consumers likely to be more motivated by direct short-term benefits than wider societal or longer-term benefits.
- Respondents suggested that a number of specific low carbon technologies are subject to particular cost pressures:
    - Heat networks where the density of demand from off-gas consumers is insufficient to justify the cost of installation.
    - High capital cost of replacing or upgrading wet space-heating systems with low carbon heat, and a perceived need for targeted funding.
    - Replacement of commercial internal heating systems, although it was suggested that the scale of such systems can provide opportunities for 'hybrid' systems.

- The bespoke agreements required for low carbon heat projects can incur additional legal costs.

Several respondents, including energy supply/distribution and other private sector respondents, suggested liquid fuel and modern electric storage heating (using renewable electricity generation) as means of decarbonising heat in off-gas buildings. Some suggested that these were potentially lower whole-life cost options than heat pumps or heat networks, citing evidence of lower installation costs (for example some biofuels) and reduced running costs (for example modern storage heating).

Policy uncertainty was the most commonly suggested policy and legislative barrier to deployment of low carbon heat, particularly from private and third sector respondents. This included reference to the importance of certainty for consumers and suppliers, including on the availability of financial support for low carbon heat beyond 2021. Some suggested that uncertainty around financial and regulatory support for low carbon heat had inhibited growth in the low carbon heat industry in Scotland.

The lack of certainty and clarity about the regulatory and financial support regime is inevitably inhibiting the establishment of a renewable heat industry in Scotland.

Third sector (other) respondent

Limits on public finance to incentivise take-up of low carbon heat were also referenced by some respondents. Some suggested that RHI has achieved somewhat limited success, particularly following recent reform to RHI, and saw a need for other forms of financial support for low carbon heat. Others regarded the economic case for moves to low carbon heat as highly dependent on government funding.

Other policy and regulatory constraints mentioned by respondents included:

- A lack of regulatory requirement for the installation of low carbon heat.
- A lack of regulatory requirement or incentive for installers to offer low carbon options given additional administration burden, higher installation cost and low consumer awareness.
- A lack of regulatory requirement for suppliers to offer low carbon heat options or to ensure sufficient training for installers.
- A lack of mandatory consumer protections.
- Concern that policy and regulation does not provide sufficient flexibility to ensure relevance across varying building types and local infrastructure. This included reference to the specific circumstances and requirements of island communities, and a need to bring energy efficiency in these locations to the levels seen in urban areas.
- Some raised concerns regarding EPC regulations. This included suggestions that the current EPC focus on fuel cost effectively encourages uptake of higher carbon options where these are lower cost.

- Pay-back periods for available government funding being a barrier for some consumers.
- Some suggested that government policy around fuel levies was hindering take-up of low carbon heat. This included reference to higher levies on electricity relative to gas supply, and fossil fuels used at domestic properties paying a reduced rate of VAT. Respondents noted that this is reserved to the UK Government, but suggested that the Scottish Government should engage with the UK Government on this specific issue.

A **lack of consumer interest** and confidence in low carbon heat technologies were also suggested by a broad range of respondents as contributing to 'inertia' regarding change of heating types. This included reference to evidence of a lack of consumer understanding of different low carbon heat options including survey findings indicating that more than half of consumers are unclear on the performance, reliability and running costs of low carbon heat technologies. Some suggested that mis-information on the potential performance of low carbon heat technologies had contributed to a lack of consumer confidence, including installers promising consumers unrealistic cost savings.

The role of installers in advising consumers was also discussed by some. Installers of 'traditional' heating systems were seen as having a particularly important role given the large proportion of replacements made through 'distress decisions' following failure of the existing system. Some respondents perceived a lack of knowledge and training on low carbon heat for installers.

Other potential barriers to uptake suggested by respondents are summarised below.

- Evidence was cited of the value that consumers place on the responsiveness of heating systems, and some felt that the behaviour changes required by some low carbon heat technologies could be a barrier to take-up.

Public acceptance could be a major barrier to deploying future heat solutions which require large changes in behaviour.

Private sector (energy supply) respondent

- Some perceived tensions between decarbonisation and fuel poverty. This included suggestions that fuel poor households are less able to meet the cost of moving to low carbon heat, and may see an increase in ongoing heating costs (for example where moving from oil systems).
- A lack of buy-in from local authority senior management teams can hinder access to funding and support at a local level.
- A shortage in the skills and capacity required to re-design in-home heating systems to accommodate low carbon heat.

Overcoming barriers to uptake

Question 3: What could we do to remove these barriers and support the uptake of low carbon heat? Can you give examples of successful low carbon heat implementation?

Question 4: How can complementary systems, such as solar PV and heat pump systems be deployed to overcome such barriers?

A total of 48 respondents (89%) addressed Question 3, and 35 (65%) addressed Question 4.

Reflecting the profile of barriers discussed at Question 2, approaches to overcome these were focused around financing, regulation and policy, supply chain and consumer awareness, and technical solutions.

A broad range of respondents saw a continuing need for **financial support**, recognising that a move to low carbon heat will result in higher overall costs for some customers. A specific need for financial support for households in fuel poverty and areas of deprivation was suggested.

Reference to financial support included concerns that a successor to RHI is required post-2021 to avoid a significant reduction in low carbon installations, although some suggested that financial support could be reduced or withdrawn as markets mature and prices fall. Changes to the design and administration of future financial support suggested by respondents and workshop participants included:

- A larger proportion of funding as an up-front payment to overcome high capital costs. Some suggested that a lower overall value loan or grant could still be attractive to consumers if a larger proportion was paid up-front.
- Removal of Government funding from high carbon heating systems, including reference to the small proportion of low carbon systems supported by Warmer Homes Scotland.
- Permitting projects to receive both grant and RHI support.
- Reducing administration time for applications to non-domestic financial support.
- Allowing more flexibility in funding requirements, for example in remote rural or island communities, where project completion can take longer.
- Suggestions for long-term zero or low interest loans, including reference to evidence that the Home Energy Scotland renewables loan scheme has supported a large proportion of households to move to low carbon heating earlier, or to select a higher quality option than would otherwise have been possible.
- Encouraging low interest loans from finance providers as an alternative option for consumers, supported by Government communication around the need to switch to low carbon options.

- Boiler scrappage schemes to overcome disposal costs as a barrier to uptake, and incentivise planned replacement of higher carbon systems to avoid 'distress' purchases.
- Incentives and other financial support targeting specific technologies or sectors. This included district heating (particularly support for initial feasibility testing and business case development) and heat pumps (particularly ground collector loops).
- Incentivising research and development and supporting newer technologies to diversify the sector, for example second-generation biofuels and hydrothermal carbonization (HTC) based fuels.
- Working with the UK Government to ensure the tax system penalises high carbon fuels and encourages a switch to low carbon options.
- Lower VAT rate for low carbon technology.
- Reduced rate Council Tax and business rates for properties with low carbon heating systems.
- Varying stamp duty rates linked to EPC ratings.
- Removing import duty on low carbon technology post-Brexit.

Respondents also perceived a need for development of **wider policy and regulation** to support uptake of low carbon heat. This included comment across respondent groups and some workshop respondents that a stable, long-term policy framework for low carbon heat is vital to ensure growth of the supply chain in Scotland, and to increase public awareness and acceptance of the need to move to low carbon heat. Respondents and workshop participants made the following specific recommendations for policy and legislation around low carbon heat:

- An end date for new installations of high carbon systems, suggested in the range 2021 to 2025 to provide time for suppliers and consumers to prepare while meeting climate change targets. A 'backstop date' was also suggested to ensure compliance with low carbon standards by 2035 for existing heating systems.
- Policy and regulation for new buildings included adaptation of the Future Homes Standard to ensure all new buildings are 'future proofed' for low carbon heat. Regulation to ensure developers actively consider energy efficiency and low carbon technologies at the design stage was also recommended, including potential for Energy Efficient Scotland to drive this change. Some wished to see Standard Assessment Procedure (SAP) 10 values as a planning requirement for new build design and heating systems.
- In relation to existing buildings a mix of private, third sector and other organisations wished to see planning and building regulations to encourage retrofit of low carbon heat. This included targeting of key opportunities such as major renovations, property sale and change of lease. Other suggestions included requiring installers to offer and quote for low carbon heating alternatives for any heating system replacement, permitted development rights for low carbon heat technologies such as district heating, and adaptation of the UK Government 'Boiler Plus' policy to Scotland.

- Ensuring sufficient flexibility in policy frameworks to adapt to changing technologies and develop bespoke approaches to decarbonising Scotland's heat supply. Facilitating communication and collaboration between stakeholders across sectors to develop new technologies and services.
- Regulations to set maximum permitted carbon emissions from new heating systems, allowing use of fuels such as bio-LPG during a transition phase.
- Changes to the EPC framework to include a stronger focus on energy efficiency and low carbon fuels, linking these to impartial sources of information and advice.
- A regulatory framework to provide a clear model for extension of the electricity network to retrofit low carbon heat into existing buildings.
- Standardisation of contracts to simplify delivery of low carbon projects.
- Ensure local authorities have the skills and capacity to drive energy efficiency improvements and the adoption of low carbon heat, including through planning policy and zoning. Strategic planning at a regional and local level to ensure the most appropriate mix of heat technologies, including future proofing where possible.

Some respondents perceived a need to improve **supply chain** skills, knowledge and capacity to support uptake of low carbon heat. The Energy Efficient Scotland programme was seen as an opportunity to share information across sectors and raise awareness of low carbon heat. This included through Local Heat and Energy Efficiency Strategies (LHEES).

A nationwide programme to intensify work to upskill installers and improve knowledge of low carbon heat technologies was also recommended by a mix of private and public sector respondents. This included a perceived need for incentives to encourage installers to take up relevant training, and a particular focus on building capacity in remote rural and island locations, and in relation to historic or listed buildings. Some wished to see design and practice standards for low carbon technologies to ensure quality of installations, and maximise performance. A forthcoming Best Practice Guide to the Installation of Heat pumps[4] was cited as an example here, and as a potential template for other technologies.

Improving **consumer awareness** and understanding around low carbon heat was also suggested as necessary to increase uptake. Some suggested that consumer awareness of low carbon technologies has increased in recent years, but a range of respondents felt that more work was required. This included reference to UK Government public attitudes survey evidence that half of the public were unaware of low carbon heating systems.[5]

Specific recommendations to improve consumer awareness included:

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[4] Currently being produced by the Renewable Energy Consumer Code, EST Scotland, the Heat Pump Association (HPA), and the Microgeneration Certification Scheme.

[5] Department for Business, Energy & Industrial Strategy (2018), Public Attitudes Tracker December 2018.

- The Scottish Government communicating its strategy for low carbon heat in a way that makes sense to and engages the public, and 'normalises' the concept of low carbon heat. This should ensure the public recognise the need for urgent action, and that potentially significant changes in behaviour will be needed. The approach should include consultation on the path to low carbon heat and role of specific low carbon options. Some perceived a need to address the poor reputation of some technologies amongst consumers.
- The Energy Efficient Scotland programme was seen as an opportunity to communicate this to consumers, including through home and business energy assessments.
- Local government, agencies and installers have an important role to play in raising consumer awareness of low carbon heat, with LHEES providing a framework for this. 'Local Heat Partnerships' were recommended as a means of bringing together local agencies and building owners to increase consumer awareness and encourage adoption of low carbon heat.
- Sharing of consumer case studies and 'success stories' can encourage uptake.
- Industry-wide standards are required to ensure access to impartial advice and fair communication of performance and cost estimates. Home Energy Scotland was seen as having a role to play here. Some suggested a need to build on existing initiatives such as the Green Homes Network and specialist in-home advice services to encourage the shift to low carbon heat. Some suggested establishment of a body to provide support, advice and site assessments appropriate to different building types including historic, listed and 'hard to treat' properties.
- Target consumers at key 'trigger points' such as house moves and major refurbishment to avoid the reliance on 'distress' purchases. Ensure consumers have access to high quality, impartial information and advice at these points. Use of 'retrofit coordinators' to support this approach.

A range of potential **technical solutions** were suggested to overcome these barriers. These included a perceived need to ensure flexibility for specific technologies to be matched to building types and circumstances, and ensuring the full range of low carbon technologies can be deployed across Scotland. Support for specific technologies included:

- Electric heat pumps suggested as having the potential to deliver substantial carbon reduction, including a suggestion that the Committee on Climate Change estimates that around 20 million domestic and most non-domestic buildings across the UK could be suitable for heat pumps.
- Biomass could be expanded to deliver a substantially larger proportion of Scotland's total heat demand than at present, although specific evidence was not cited in support of this.
- Low carbon heat networks.

Some respondents also perceived a need for continuing work to improve the energy efficiency of homes and reduce heat demand, alongside support for low carbon heat technologies. This included a role for smart metering and controls to manage energy demand. Some wished to see wider access to time of use tariffs to encourage use of smarter heating systems and appliances.

Some wished to see a focus on technologies that can be introduced with minimal disruption to consumers, for example through use of lower carbon fuels that can be 'dropped in' to existing infrastructure. Some supported delivery of decarbonised gas through grid extension in urban and semi-urban areas, and options for off-network technologies including bio-LPG, bio-oil and biomass products. These were seen as a means to deliver rapid carbon savings in properties where poor energy efficiency and consumer preference may be barriers to other technologies.

Complementary systems

Complementary heating systems combine two or more heat sources to meet the needs of a domestic or non-domestic building. These can include combinations of heat pump, solar PV and other (low or high carbon) heating technologies.

Support for complementary systems was expressed by a range of private sector and other organisation respondents as a means of overcoming barriers to uptake of low carbon heat. These were seen as having potential to improve the performance of low carbon heat systems and extend the range of circumstances in which low carbon technologies are feasible options – for example, reducing running costs to extend the range of buildings in which low carbon options are economically viable for consumers.

The greater flexibility provided by multi-part or multi-fuel systems was also seen as a benefit for the diverse range of off-gas buildings. Respondents wished to see this as part of a whole-home approach to reducing energy use and carbon emissions that is tailored to individual circumstances. Some saw a need for a 'designer role' to ensure a whole building approach is tailored to specific circumstances; this included reference to the Recommendations Report from the Quality Assurance Short Life Working Group.

Some respondents suggested limitations for complementary systems, and in particular solar PV, noting that the electrical generation pattern of solar PV does not fit with heat demand. An individual respondent also questioned whether current storage technologies can address this disparity sufficiently to enable solar PV to make a significant contribution to heat generation.

Some respondents commented that the combination of multiple technologies has the potential to further increase installation costs and disruption for consumers. However, some suggested these systems could reduce costs and disruption over the longer term. There was concern that combining systems can compound margins of error in performance estimates, risking reputational damage to the industry. It was also suggested that complementary systems could require a steeper learning curve for consumers.

Respondents suggested a range of specific technologies as having a role to play in complementary systems. These included:

- Use of thermal or battery storage, including electric vehicle (EV) chargers, alongside heat pumps could reduce running costs, for example by shifting heat pump operation to period of low energy prices. Energy storage can also address some issues relating to the generation patterns of solar PV.
- Some suggested that solar thermal and solar PV are under-deployed in Scotland, and have the capacity to supply low carbon heat systems in a wide range of circumstances. This was seen as vital in maximising local generation to limit grid demand.
- Aggregated solar generation and energy storage systems linked to large heat pumps may be more economical and effective solutions in some circumstances. These could also incorporate wind and hydro energy projects. Shared ‘ambient’ heat loops linked to individual heat pumps may also help to overcome barriers.
- Hybrid heat pump systems where consumers have the opportunity to fuel switch when heat pumps are unable to meet peaks in heat demand. This can reduce costs by enabling the installation of lower capacity heat pumps (ideally using a renewable energy supply), alongside lower carbon fuels such as biomass and bioLPG. Reference was also made to Gas Driven Heat Pumps as a technology used in commercial heat generation, but that could be suited to the off-gas housing stock. The FREEDOM project in Wales was noted as having tested hybrid heating systems combining heat pumps with an existing boiler, and using smart controls to manage the system based on cost of electricity, heat demand and carbon intensity.
- Fuel cell technology currently being developed could be adapted to meet heating demands.
- Use of a ‘whole system’ approach including reference to ‘grid services’ as having potential economic benefits for households willing to form part of a demand response asset helping to balance electricity supply and demand.
- ‘Heat as service’, where providers own and maintain heating equipment, could overcome installation cost barriers for consumers.

Building-specific restrictions on low carbon heat

Question 5: What do you consider to be the principal building-specific constraints on low carbon heat?

A total of 44 respondents (81%) addressed Question 5.

A range of constraints were raised in relation to specific low carbon heat technologies, primarily related to poor energy efficiency, built form and building density, and high heat demand. However, respondents suggested that these issues do not necessarily discount any low carbon options. Rather, constraints were seen as suggesting a need for the selection and combination of low carbon heat technologies to be tailored to individual properties.

Poor energy efficiency and insulation was suggested across respondent types, and by workshop participants, as a key constraint on take-up of low carbon heat. This included evidence of the large proportion of off-gas housing stock with EPC ratings of D or below.

The importance of energy efficiency improvements for the effectiveness of many low carbon heat technologies was seen as having an impact on the economic assessment of low carbon heat options. This was suggested particularly for hard to treat properties where energy efficiency improvements were described as typically higher cost. It was suggested there may be a substantial number of properties across Scotland where the required energy efficiency improvements are not economically feasible.

Other respondents and workshop participants suggested that low carbon technologies can be installed across a diverse range of building types, including those with poorer energy efficiency. It was noted that energy efficiency improvements can reduce the capital and running costs of low carbon systems, but respondents suggested that this should be part of the selection of any heating system. Building assessment was seen as key to identifying need for improvements.

Respondents and workshop participants suggested a range of restrictions for hard to treat properties, including reference to built form and existing heating systems. Key points included:

- Examples of buildings being hard to treat on the basis of difficulty and cost of improving energy efficiency, such as solid wall construction. This was particularly where low carbon heat may not deliver better heat performance, such that capital expenditure is unlikely to be compensated by lower running costs. Some suggested that a substantial volume of housing stock in some areas have ‘hard to treat’ features such as stone built, solid walls, no loft space, solid floors and sash and case windows.
- Some suggested that all new build properties are suitable for some form of low carbon heat, and the most significant barriers relate to retrofit of existing buildings. The cost and disruption of re-designing and replacing existing heating systems, particularly conversion from dry to wet systems, was also seen as a constraint. However, some suggested that those with electric storage systems (described as having higher replacement cost and greater disruption than other heating systems) were more willing to invest due to potential for improved heat performance.
- Respondents referred to systems that are not designed for the lower flow and return temperatures of heat pumps and district heating systems. Reference was also made to a lack of space for larger heat emitters, hot water storage, fuel storage for biomass, solar PV panels.
- Stairwell and riser layout can limit heat network installation for blocks.
- Plant location can limit installation of heat networks and some heat pumps.
- Ground source heat pump installation can require significant disruption and cost.

Some suggested that the range of low carbon heat technologies meant that there are suitable low carbon options for more building types than is generally recognised. Reference was made to the importance of building-specific assessment to identify the most appropriate options. This included evidence that systems such as ground source heat pumps can be installed to 97% of rural off-gas homes.[6]

Building density was perceived as a potential barrier for a range of low carbon heat technologies. Respondents suggested that lower building density can significantly increase costs of district heating, and that higher building density can limit scope for ground source or air source heat pumps. The space required for ground collectors was noted in particular, although some suggested that improved technology is reducing the space requirements of heat pumps. Fuel storage and air quality were also suggested as potential constraints for biomass systems. Building placement and external layout were also seen as potentially limiting scope for district heating, for example feasibility of connecting to a heat network, and availability of a location for the central heat generating plant.

Listed status and conservation areas were suggested as a potential barrier to some low carbon technologies, and some suggested that listed status can limit options for energy efficiency improvements. However, it was suggested that the consent process allows changes to the historic environment if they are managed sensitively, and that listed status does not necessarily prevent deployment of low carbon heat.

High heat demand and high temperature heating systems were also seen as constraining uptake of low carbon heat. Respondents referred to existing wet heating systems designed for high temperature flow, and suggested that transition to low carbon heat can incur additional costs relating to larger heat emitters and the disruption of pipework replacement. However, most non-domestic systems were seen as having potential to move to low carbon while maintaining heat performance.

Overcoming building-specific constraints

Question 6: What can be done to overcome these constraints?

A total of 41 respondents (76%) addressed Question 6.

Comments on approaches to overcome the building specific constraints reflected some of the themes raised at Question 3 in relation to wider barriers to uptake of low carbon heat. In particular, the key focus for most respondents was policy and regulation, financing, supply chain, and consumer awareness.

Recommendations for **policy and regulation** included:

- Flexibility in the regulatory approach and support for innovation to develop new solutions for hard to treat buildings.

[6] Delta-ee (2018), Technical Feasibility of Electric Heating in Rural Off-Gas Grid Dwellings.

- Updating planning and building regulations including powers for local authorities to act.
- Regulation to support a ‘fabric first’ approach, maximising energy efficiency improvements to reduce heat demand and expand the range of suitable low carbon heat options. To include targeting of hard to treat buildings, for example through financial support.
- More ambitious targets for energy efficiency improvements to existing buildings.
- Regulation to ensure installation of low carbon heat is tailored to local requirements and individual buildings, including complementary or hybrid systems. This should be based on a building assessment, for example through an improved EPC framework or Energy Efficiency Scotland assessment. Regulation should also recognise the potential value of action at building-level for tenement properties, taking forward recommendations of the Scottish Parliamentary Working Group on Maintenance of Tenement Scheme Property.
- Ensure the approach to decarbonisation incorporates a range of energy sources, including a role for bioenergy alongside electrification of heat.
- Ensure stability of public policy, for example through regulation to require low carbon heat systems or systems suitable for future conversion across all new build housing, and higher Minimum Energy Efficiency Standards for new build housing. Also to ensure renovation to existing buildings is designed to accommodate future retrofit for low carbon heat.
- A requirement for existing public sector buildings to meet tighter carbon limits, as a proof of concept for private dwellings and to support supply chain development.
- Regulation and support to enable consumers to improve efficiency of heating systems, including demand management through smart metering and controls.
- The potential for good practice guidance to improve approaches to older building types, including listed buildings and conservation areas. Existing guidance and case studies were suggested as a basis for developing best practice guidance. Reducing some restrictions on listed buildings and conservation areas to permit deployment of suitable low carbon heat and energy efficiency options.
- Consider establishing a national energy company to coordinate delivery of low carbon heat.

A range of respondents saw a role for **financial support** to overcome building specific constraints, and associated costs. This included recommendations for grant or low/zero interest loans to overcome cost barriers. Some cited evidence that a very small percentage of consumers respond to an EPC by investing in fabric improvements. Other suggestions for financial support included:

- Targeting homes failing to meet EPC-C rating, lower income households and those in fuel poverty.

- Targeting specific technologies or improvements such as incentives for difficult retrofitting of non-domestic buildings, for district heating, and for tenements where building-level improvements are required.
- Oil tank and/or boiler scrappage schemes.
- Use of Council Tax and business rate to provide financial incentives to decarbonise heat.
- Rebalancing of fuel taxation to ensure a ‘level playing field’ for electricity and gas.
- A challenge fund to incentivise innovation in relation to energy efficiency measures for ‘hard to treat’ buildings.

A range of potential **technology solutions** were recommended by respondents, including:

- Tailoring technologies to specific circumstances including
    - Bioenergy where energy efficiency and current heating systems cannot be upgraded economically for a heat pump system.
    - Local heat network or shared heat pump where space is limited.
    - Hybrid heat pump systems for larger buildings or non-domestic properties to meet heating requirements.
    - Upgrade of heat emitters to support heat pump installation.
- Supporting development of new technologies such as intelligent battery storage, and business models such as heat as a service.
- A role for ‘transitional’ options to lower carbon emissions for properties where current low carbon technologies are not feasible. This included low carbon liquid fuels and bioenergy.
- Extension of the gas grid alongside decarbonisation of the gas supply. This included suggestions that gas grid extension to homes within a specified distance of the grid would be more cost-effective than energy efficiency improvements and low carbon heat for the number of off-gas homes required, with future decarbonisation of the grid delivering the required carbon reduction. However, respondents did not cite specific evidence in support of this, and as noted later in this report (see Question 35), some were opposed to further gas grid extension.

Consistent with points raised at Question 3, some respondents saw a need to improve awareness and knowledge of low carbon heat across the supply chain, and for consumers. This included a role for supply chain standards and good practice in relation to building-specific constraints.

Poor energy efficiency and hard-to-treat buildings

Question 7: What evidence can you provide on the limitations of low carbon heat technologies (e.g. heat pumps) in buildings with poor energy efficiency?

Question 8: What low carbon heat solutions are appropriate for hard-to-treat properties where there are limited opportunities to improve energy efficiency of the building fabric?

A total of 38 respondents (70%) addressed Question 7, and 40 (74%) addressed Question 8.

Some suggested that the limitations of low carbon heat in less energy efficient buildings are overstated. Respondents suggested that heat pump technology is available that can be fitted to buildings with poor energy efficiency, if heat emitters are appropriately sized. This included reference to the MCS Heat Emitter Guide. Respondents cited examples of a range of 'hard to treat' buildings where heat pumps have delivered improved heating performance, including listed buildings. Reference was also made to evidence that more than 80% of homes are suitable for heat pumps without a change in energy efficiency.

However, a range of respondent types suggested issues around the sensitivity of low carbon heat technologies to energy efficiency. These included:

- Suggestions that heat pumps are highly sensitive to quality of design and installation, and building energy efficiency. Some expressed a view that correct design standards and capabilities for heat pumps are critical to ensure systems deliver the expected performance.
- Evidence was cited that heat pumps can show improved performance over gas boilers in some property types, but that this changes as external temperatures decrease. Some suggested that there is a substantial volume of older buildings where potentially expensive energy efficiency improvements would be required, and/or heat pumps will not deliver predicted cost savings.
- Suggestions that installation and running costs are the primary limitation for installation of heat pumps to buildings with poor energy efficiency, including some citing evidence on these costs relative to other heating systems. However, it was also suggested that this issue is not limited to heat pump systems. This included suggestions that running costs are higher than predicted, risks of exacerbating fuel poverty, and a perceived need for modelling of the capital investment required to enable heat pumps to work efficiently.

Some perceived issues around the technical feasibility of specific low carbon heat options in buildings with poorer energy efficiency. These included suggestions that installation of Ground Source Heat Pumps (GSHPs) can create additional disruption and cost even for those with sufficient external space. Circulation space for air source heat pumps and additional space requirements for larger heat emitters were also suggested as potential barriers for smaller properties. It was suggested that some new build homes lack the internal space for thermal stores required by heat pump systems.

Some respondents suggested that heat pumps can meet the heat requirements of most properties, but that for a potentially substantial proportion of off-gas buildings heat pumps are unable to meet peaks in demand during heavy winters.[7] A number of respondents cited evidence indicating that heat pump performance deteriorates significantly where external temperatures fall, for example to below -10C.[8] This included a suggestion that hybrid systems are required to meet these demands.

A private sector (renewables/low carbon) respondent perceived a lack of evidence around the performance that can be expected from low carbon heat systems, particularly in buildings with poor energy efficiency. It was suggested that further work is required to build on the existing evidence base.

Low carbon technologies for hard to treat properties

Respondents saw a potential role for a broad range of low carbon technologies in hard to treat properties. This included some who regarded accurate assessment of building requirements and independent consumer advice as key elements in identifying the most appropriate technology. Respondents provided comment on specific technologies, including reference to examples, but relatively little evidence was cited.

Key points raised in relation to use of heat pumps in hard to treat buildings were:

- Suggestions that heat pumps can be adapted to a wide range of building types, including those with poorer energy efficiency, through appropriate specification of heat pump and heat emitters, and use of thermal storage.
- An ‘other organisation’ respondent suggested that higher temperature heat pumps remain more efficient than traditional heating systems.
- A private sector (heat pump) respondent suggested that ground source heat pumps can give better performance than other heat pumps when run at the higher flow temperatures often required in buildings with poor energy efficiency. Examples of effective retrofit were cited including multi-storey flats using shared ground loops, although an ‘other organisation’ respondent suggested that ground source heat pumps are better suited to rural locations.
- An ‘other organisation’ respondent suggested that air source heat pumps are particularly suitable in urban areas.
- Some suggested that hybrid heat pump systems with a ‘traditional’ heat source to meet peak demand can act as transitional systems until heat pump technologies are developed that can meet the needs of poor energy efficiency buildings. However, some saw a need to ensure that hybrid systems do not prolong use of high carbon fuels.

[7] This included reference to Delta-ee (2018), Technical Feasibility of Electric Heating in Rural Off-Gas Grid Dwellings.

[8] This included reference to DECC (2013), IEA Annex 36 on Quality of Installation and Maintenance of Heat Pumps.

In relation to storage and other electric heating, respondents suggested that carefully designed electric storage heating, supported by low carbon generation including solar PV, could be the lowest carbon approach for some buildings. Some suggested that this could include use of high heat retention storage heaters, and others suggested that solar PV and thermal storage can reduce household costs to offset heating costs. Respondents noted that the Heat Trust is consulting on a tool that compares different electric heating options.

Comment around biomass and other bioenergy options is summarised below.

- Respondents discussed a range of biomass and bioliquid options. This included evidence on the proportion of off-gas buildings that may not be suited to electric heat. Some suggested that a diversified approach incorporating bioenergy can reduce the burden on electricity generation. It was also suggested that these options can support the high grade heat required by less energy efficient buildings (both domestic and non-domestic), in some cases without significant capital expenditure (for example bioLPG). Specific options suggested by respondents included:
    - Biomass systems as a direct replacement to existing systems in terms of thermal performance, and are a well-established technology.
    - Varying mixes of liquid fuel, with references to ongoing trials of blends that can deliver carbon savings.
    - Bio-oil offers similar performance to other bioenergy, but with lower running costs than bioLPG and lower installation costs than biomass.
- Some respondents saw a need for Scottish Government support to ongoing innovation in development of bioenergy.

High temperature heat networks were suggested as a solution for buildings with limited opportunities for energy efficiency improvements, including historic and listed properties. It was suggested that low temperature networks can provide greater carbon and cost savings, but that higher temperature systems could provide a route to decarbonising low efficiency buildings. This included potential to change fuel mix including waste heat fed systems.

Reference to other solutions in hard to treat buildings included increasingly decarbonised gas supply and gas grid extension, hydrogen as part of a local heat network, and energy management to control heat systems and minimise waste.

Low carbon heat technologies

The call for evidence considered the wide range of current and potential future technologies that could have a role to play in decarbonising heat in off-gas buildings. This included varying forms of low carbon electric heating, biomass and bio-liquid, heat networks and gas grid extension. This section considers evidence in relation to each of these technologies in turn, and on further opportunities for innovation in low carbon heat.

Readers should note that respondents' focus on specific low carbon heat technologies appeared to reflect their experience and expertise. For example, those active in a particular energy sector typically focused on associated technologies. As such, **views expressed on specific technologies cannot necessarily be read as representative of the full range of opinion.** References are provided for specific claims where possible, and we note where evidence was not provided. Statements of opinion provided without evidence may not have been included.

Common themes and issues for low carbon technologies

While some responses were relatively narrow in their focus on specific low carbon technologies, a range of common themes and issues were raised by respondents. These reflected the core of call for evidence questions asked in relation to each technology - on cost, consumer satisfaction, lifecycle and efficiency, and barriers to uptake. However, some of the themes noted below were also evident in responses to later questions on enabling uptake and growing the supply chain for low carbon heat, and earlier questions on the current market (see previous section).

Cost was a prominent theme in responses across all low carbon technologies, and was seen by some as a key barrier to uptake. This included suggestions that installation and/or running costs are a particular barrier to uptake of heat pumps, electric storage heating and heat networks, and some cited evidence on the relative installation and running costs for specific technologies.

Other common cost-related issues suggested by respondents included:

- Respondents suggested that capital and running costs vary significantly between installations, and are sensitive to factors such as building energy efficiency, heating system design and location (typically higher in more remote and island locations, in part due to the limited local supply chain).
- Respondents saw some scope for costs to reduce as the supply chain matures, competition increases, and new low carbon technologies develop. However, some suggested there is more limited scope for reduction in the capital cost of mature technologies such as heat pumps.
- Some raised concerns around the accuracy of performance and cost estimates for a range of low carbon technologies, including heat pumps and biomass heating. Examples were cited where real world operation of low carbon systems had failed to meet predictions. Respondents suggested that

predicting energy performance for specific buildings is difficult. MCS guidance was cited as advising against making definitive predictions of energy performance, but it was suggested that some installers do not comply with this. As a result, consumers may not see the predicted cost savings and financial 'payback' can take significantly longer than expected. One public sector respondent suggested there was a need for independent research on the running costs of biomass heating.

- Some suggested that current fuel taxation disadvantages electrical heating, including low carbon technologies such as heat pumps.

Respondents were asked for evidence on the **lifecycle and efficiency** of each low carbon heat technology, and a range of specific estimates were provided. These supported a broad view that lifecycles are longest for GSHP, electric storage heaters and biomass heating. Respondents expressed a range of views on the relative efficiency of low carbon heat technologies, including some citing specific evidence. Some respondents suggested that performance of low carbon heating can be highly dependent on factors such as building energy efficiency and heating system design. Some also felt that there is a limited evidence base on the 'real world' lifecycle and efficiency of low carbon heat, in part due to the relatively small install base for some technologies. Respondents saw a need for further research to provide definitive estimates of performance across a range of circumstances.

Relatively little specific evidence was cited on **customer satisfaction** with low carbon heat. Again respondents suggested that this in part reflected the limited install base for some technologies. Some also suggested that customer satisfaction, and the wider reputation, of specific technologies is highly sensitive to factors such as heat performance and running costs. In this context, some suggested that cost savings are a key motivation for a large proportion of consumers when replacing a heating system. The risk (noted above) of consumers being provided with exaggerated performance estimates for low carbon heat was seen as an important factor in 'bad press' around specific technologies such as heat pumps. Some also suggested that consumers required better information and training to ensure they use new technologies efficiently.

A number of **common barriers to uptake of low carbon heat** were raised by respondents, although some were described as more significant barriers for specific technologies. Many of these barriers reflected issues raised earlier at Questions 3 and 6, including a focus on costs and financing, supply chain, and consumer awareness. The main barriers suggested by respondents were:

- High installation cost relative to 'traditional' systems was seen as the most significant barrier for a range of technologies including heat pumps, hybrid heating systems, bioenergy and heat networks. Respondents cited survey feedback indicating that installation cost is a key reason for households delaying or choosing not to install renewable energy heating systems. This included potential for installation costs to be significantly higher for retrofit of low carbon heat, dependent on design of the existing heating system and any requirement for energy efficiency improvements. Running costs were seen as a less significant barrier to uptake of low carbon heat, although some cited evidence of low carbon installations leading to increased running costs. Running costs were seen as a potential barrier to deployment of electric storage heating.

- A range of respondents suggested that the low carbon heat supply chain is limited in some areas, particular rural locations and islands, and saw this as a barrier to uptake. Some suggested that this contributed to higher installation costs for low carbon heat. Supply chain limitations were also seen as having a negative impact on the quality of advice provided to consumers, resulting in more consumers choosing like-for-like replacements.
- Consumer awareness and satisfaction were regarded as potential barriers to uptake of low carbon heat. Some cited evidence indicating that only a small proportion of consumers are aware of specific technologies. There was a perceived need for better access to high quality information and advice for consumers.
- Disruption associated with a change to low carbon heat system was also suggested as a barrier for consumers. This including some suggesting a 'hassle factor' where consumers are required to learn how to manage a new type of heating system. Some respondents also suggested that consumer may be affected by fears around changing to a new technology that many will not have seen in-situ. Potential for disruption was regarded as a particular issue for 'distress' purchases to replace a failed system. Respondents cited evidence that a large proportion of heating system replacements are made in these circumstances; that 7 in 10 heating system changes are 'distress' replacements, and that only 1 in 10 consumers would consider replacement while their heating system was still working.[9] These were seen as a factor in consumers' disinclination to choose a new form of heating.
- The built form of off-gas buildings was mentioned by some, including suggestions that low carbon heat can be unsuitable for some building types. This was in terms of the economic viability of installation costs, likely performance and running costs. Some also regarded internal and external space requirements as a potential barrier to deployment. This included internal space required for thermal storage and biomass systems, and external space for ground source heat pumps and biomass storage.
- Some respondents suggested that electricity network capacity could be a barrier to large scale deployment of electrical low carbon heating, including reference to air source and ground source heat pumps (ASHP and GSHP). Network capacity was seen as a particular issue for off-gas buildings in rural and island locations.

Respondents suggested a broad range of **approaches to overcome barriers** to deployment of low carbon technologies. Some suggestions were specific to individual technologies, but most were applicable across multiple technologies. Reflecting the key barriers noted above, suggestions were typically focused around policy and regulation, financial support, supply chain development, and consumer awareness and acceptance.

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[9] BEIS (2018), BEIS Public Attitudes Tracker.

A range of respondents saw a need for stable, long-term policy to provide certainty for industry and to allow time to build consumer awareness and acceptance. This was a particular concern for private sector respondents. Respondents recommended a range of specific regulatory or policy changes, some reflecting issues discussed in the previous section in relation to the current market for low carbon heat:

- A firm end-date for installation of high carbon heating systems (suggestions in the range 2020 to 2035), and a subsequent firm target date for conversion of existing off-gas high carbon heating systems to low carbon heat.
- Building regulations to require installation of low carbon heat to new build development and major renovations, or 'future proofing' of new development to ensure suitability for subsequent of low carbon heat.
- Revision to the EPC framework to place greater emphasis on carbon emissions, and reduce the influence of fuel costs.
- A requirement for installers of 'traditional' heating systems to include low carbon options when quoting for heating system replacement, and to signpost consumers to independent advice on low carbon heat.
- Use of zoning through LHEES to create 'zero carbon' areas, and communicating this to consumers through Energy Efficient Scotland assessments and local engagement schemes.
- Making the decarbonisation of heat a National Infrastructure Priority.
- Adapting the UK Government's Boiler Plus policy to Scotland.
- Establishing a publicly-owned National Energy Service to coordinate activities to increase uptake of low carbon heat.
- A clear policy statement on the role of bioenergy as a means of diversifying approaches to decarbonising heat.

There was a view across respondent types that financial support continues to be necessary to overcome cost barriers, reflecting perceptions that installation cost is a key barrier for consumers. Some suggested that the need for public finance could reduce as the supply chain develops and capital costs reduce. However, there was a common view that funding would be required beyond 2021. Respondents made the following recommendations for approaches to financial support:

- Larger upfront payments to overcome installation cost barriers, particularly for lower income households and those in fuel poverty.
- Provision of and/or encouraging development of low and zero interest financial products, including long-term loans and green mortgages. Some suggested that the renewables loan scheme had seen some success. A role was suggested for the proposed Scottish National Investment Bank.
- Incentives for energy efficiency improvements to make low carbon heat a feasible option for more off-gas buildings.
- A boiler scrappage scheme.

- Removal of public finance for installation of high carbon heating.
- Increase in upper limits to available funding for larger non-domestic systems.
- Government-sponsored mass purchase schemes to reduce costs.
- Energy pricing and tariffs were suggested as a means of incentivising uptake of low carbon heat. This included reform of fuel taxation to penalise high carbon fossil fuels, and encouraging further development of time of use tariffs.
- Tax relief on electricity bills and reduced Council Tax and/or business rates for buildings with low carbon heat. Some also suggested retention of reduced VAT for solar PV, and application of the reduced rate to district heating.

Respondents also suggested a need for further development of the supply chain for low carbon heat, including improved skills and understanding and expanding capacity across Scotland. Some suggested that a more stable policy framework would encourage this development. Specific suggestions included an installer skills development programme to build on current training and education opportunities, incentives for installer skills development including new entrants to the sector, and a focus on building capacity to provide advice to consumers.

Some respondents perceived a lack of consumer awareness around the scale of changes required to achieve Government targets, and the need for urgent action. These respondents wished to see work to build on existing networks and initiatives to improve consumer awareness and understanding. Specific suggestions included:

- Sharing of case studies and more positive messages around low carbon heat options.
- A role for the media in raising awareness of the need for urgent transition to low carbon heat.
- Targeting of ‘trigger points’ such as house moves and major renovations to encourage uptake of low carbon heat, and key groups such as first time buyers to raise awareness of potential for low carbon heat to lower emissions.
- Use of Energy Efficient Scotland assessments and energy advisors to raise consumer awareness of low carbon heat.

Some also saw a need for better quality advice for consumers to address gaps in consumer understanding, improve confidence and reinforce the potential role of low carbon heat. This included suggestions for in-person energy advice targeted at ‘trigger points’, more up to date information and case studies, and greater promotion of national advice and referral mechanisms. The Green Homes Network was recommended as a potential vehicle for improving consumer awareness and acceptance of hybrid systems. Extended warranty and maintenance contracts were suggested to improve consumer confidence.

Respondents citing electricity grid constraints as a barrier to uptake recommended a number of approaches to address this. These included linking to local renewable electricity generation and more use of storage, smart controls and other demand side management, including as a data source to more accurately assess how to manage energy demand.

Electric heating

The call for evidence paper asked for evidence relating to a range of electric heat technologies including electric heat pumps, hybrid heat pumps and storage heaters. In relation to each technology, evidence was sought on cost (and how these compare to RHI costs quoted in the call for evidence paper), customer satisfaction and efficiency. Respondents were also asked for evidence on potential barriers to uptake of each technology and how these may be addressed.

Electric heat pumps

Questions 9 to 12 sought evidence on electric heat pumps including ground source, air source and water source technologies. Heat pumps typically provide heat at lower temperatures than conventional heat sources and as such can have specific requirements in terms of heating systems (e.g. larger heat emitters or underfloor heating) and heating patterns (e.g. on for longer to achieve comfortable temperatures).

Question 9: Regarding ground source, air source and water source heat pumps, what evidence can you provide on:

a. **the cost of the technology, including installation, maintenance and running costs, and alignment with quoted RHI costs**
b. **customer satisfaction with the system**
c. **lifecycle and overall efficiency of the technology**

A total of 27 respondents (50%) addressed one or more parts of Question 9.

Costs
Comments regarding the capital and installation costs of heat pumps are summarised below.

- Capital expenditure costs for heat pump systems were seen as higher than direct replacement of existing systems, including quotes of 3-5 times the installation costs for a boiler replacement.
- Some suggested that RHI capital expenditure costs for domestic and non-domestic heat pump systems are in line with experience for ASHP and GSHP, although GSHP costs are sensitive to ground collector loop design. Examples of systems where costs differ somewhat from RHI were also cited.
- Capital costs were suggested to be sensitive to the complexity and location of individual projects, and typically higher in more remote and island locations. For example, evidence was cited indicating that GSHP systems on the islands are typically more than £2,000 per kW due to additional transport and overhead costs. Installation costs for a range of non-domestic heat pump installations on an island authority were quoted; air source heat pump costs were broadly in line with RHI costs, but GSHP costs varied significantly (in part linked to varying system capacity).

- Some suggested there is limited scope for equipment costs to fall as heat pumps are a mature technology, but saw potential for significant reduction in installation and administration costs as installer numbers and skills increase. It was estimated that there is potential for a 30-35% reduction in overall capital costs.
- An ‘other organisation’ suggested that replacement costs for some ASHPs have increased significantly in recent years.
- Some suggested that capital expenditure costs can be recouped over a period within a heat pump’s lifetime by reduced energy and maintenance costs.

Comments regarding running and maintenance costs of heat pumps are summarised below.

- Some cited evidence that heat pump performance compares favourably with existing systems, including significantly lower running costs than LPG boilers. Respondents cited a range of specific cost examples. This included a public sector respondent citing ASHP costs as being higher than those set out in the call for evidence paper, and significant variation in GSHP costs. However, some suggested that even with higher installation costs, heat pumps can still be a more affordable and significantly lower carbon system. Others suggested that energy costs can vary significantly between installations.
- A public sector respondent reported that running and maintenance/service costs can be significantly higher than those cited in the call for evidence paper. An ‘other organisation’ is conducting research to collate heat pump maintenance cost data, which could be made available once completed.
- Respondents also noted the range of servicing and maintenance services offered by heat pump suppliers.

Some raised concerns around the accuracy of performance and cost estimates for heat pumps, noting that SCOP methodologies can exaggerate performance. Respondents noted that the MCS Heat Pump Working Group is looking to identify a more accurate methodology for performance estimates.

Some suggested that RHI cost tables were too simplistic due to the number of variables that can influence installation and running costs, and suggested that cost comparison does not take account of varying lifespan of different technologies. For example, a private sector (heat pump) respondent suggested that GSHP units typically have a somewhat longer lifespan than ASHP, and the ground collector element a lifespan in excess of 100 years.

Customer satisfaction

A range of respondents referred to positive satisfaction ratings from consumers, including specific case studies and feedback from consumers. One private sector (renewables/low carbon) respondent suggested that customer satisfaction is lower for GSHP.

Customer satisfaction was described as highly sensitive to factors such as building energy efficiency, heat distribution and emitter design, and control design. Consumer understanding was also suggested as an important driver of satisfaction.

Negative customer feedback included reference to systems being difficult to use and respondents saw high quality training in use of heat pump systems as important in addressing this. Some also suggested that customer dissatisfaction can reflect inappropriate heat pump specification and poor installation.

Lifecycle and efficiency

Some respondents suggested there is a robust evidence base on typical lifecycles of ASHP and GSHP. Specific estimates ranged between 15 and 30 years, with some suggesting longer lifecycles for GSHP. This was compared favourably with lifecycle of 'traditional' systems including gas boilers.

Some respondents commented positively on the efficiency of heat pumps, although others were less positive. It was suggested that a more robust evidence base is required. Some respondents cited estimated efficiency coefficients, although again views were mixed. Some referred to efficiency ratings of 3-4 and up to 5, dependent on specification and building energy efficiency, while others were concerned that an unacceptable proportion of heat pumps fail to achieve minimum Seasonal Performance Factor (SPF) performance of 2.5. It was also suggested that GSHP can show stronger performance than ASHP.

Barriers to uptake

Question 10: What factors might inhibit uptake of heat pumps?

Question 11: What do you propose as solutions to overcome any barriers to uptake?

A total of 35 respondents (65%) addressed Question 10, and 32 (59%) addressed Question 11.

Factors inhibiting uptake of heat pumps reflected some of the common themes discussed earlier in this section. These included costs, disruption to consumers, building type, supply chain capacity, and consumer awareness and confidence.

High installation cost, and particularly retrofit cost, was the most commonly suggested factor inhibiting uptake. Cost of energy efficiency improvements required for efficient heat pump performance was also suggested as adding significantly to installation costs. Respondents suggested that a long period can be required to recoup installation costs through lower running costs, and in some cases the cost is unlikely to be recovered.

Higher than anticipated running costs were also suggested by a range of respondents, including cases of running costs being higher than existing systems. Some referred to examples of ASHP being less efficient than expected, and less efficient than GSHP. Other issues regarding running costs included suggestions that maintenance costs can be a barrier for consumers and can be higher than 'traditional' boilers.

Disruption to consumers was also seen as a barrier. This included the need for replacement of heat emitters, and installation of ground loops for GSHP.

Respondents referred to a range of building types and circumstances where heat pumps were regarded as less suitable. These included properties with poorer energy efficiency, heating systems designed for high temperature heat (for example with smaller heat emitters), and properties lacking external space for infrastructure such as ground collectors or condenser units, and internal space for water tanks.

A range of respondents suggested there is a lack of customer awareness of heat pumps, citing evidence that only a quarter to a third of consumers are aware of heat pump technologies. This included specific reference to unfamiliarity with how heat pumps are installed and operated, and a lack of training/education to support consumers in adapting to an unfamiliar technology.

Evidence was cited of customer feedback that heat pump performance does not meet expectations, and in some cases does not represent sufficient improvement on existing systems to be worthwhile. Examples of poor performance included poor efficiency and inadequate heat performance during winter, frost build-up for small heat exchangers, noise and poor aesthetics, and concern about lifespan in a marine climate. Some workshop participants also suggested that limitations in the supply chain can also undermine consumer confidence.

Overcoming barriers

Recommendations to overcome barriers to uptake reflected the common themes discussed earlier in this section, including policy and regulation, financial support, supply chain capacity and consumer understanding. Recommendations specific to heat pumps are summarised below.

Specific regulation and policy changes advocated by respondents included a requirement for smart heating and remote monitoring as part of all heat pump installations. In addition to benefits in managing heat demand, it was suggested that this can also provide valuable evidence on system performance and help to support development of the ‘heat as a service’ sector.

Respondents saw a continuing need for financial support for heat pumps. This included a perceived need for more upfront financial support at the design and feasibility testing stage for non-domestic projects, and finance tailored to specific technologies including short-term loans for heat pump units, and longer-term finance to support installation of GSHP infrastructure.

Innovations to reduce costs

Question 12: What innovations could reduce the operational cost of heat pumps, i.e. higher performing heat pumps, new refrigerants, 'time-of-use' tariffs coupled with thermal storage, and 'heat-as-a-service' business models?

A total of 22 respondents (41%) addressed Question 12.

Comments on potential innovations to reduce operational costs of heat pumps focused around several areas including specific pump technologies, the role of solar PV and energy storage in demand management, energy tariffs, and new business models.

Current and emerging heat pump technologies were suggested as having potential to reduce operational costs. Specific reference was made to:

- Improving co-efficiency of performance via appropriate design and sizing of heat pump systems.
- Use of high temperature heat pumps able to work with existing wet space heating systems.
- Development of frost-free air source heat pumps.
- Wider adoption of smart controls to manage heat demand and maximise efficiency of heat pumps.
- Use of remote monitoring to minimise maintenance costs, particularly in areas with a limited installer base.
- Energy recovery via cooling.
- Use of innovative systems to improve the efficiency of wet heating systems.

A range of respondents supported use of solar PV with a heat pump system, incorporation of thermal storage to reduce the size of plant required, and use of smart controls and smart networks to manage demand and reduce costs. Respondents suggested that storage costs are relatively high at present, but suggested there is considerable scope for further development of the UK market to reduce costs.

Some suggested time of use and other tariffs as a means of reducing costs for consumers and maximising carbon savings. Positive comment included the potential to combine time of use tariffs with thermal or electric storage and solar PV, and reference to the benefit of smart controls to manage demand. Other comments around the potential role of time of use tariffs included potential benefits for consumers with electric vehicles as a means of optimising power flows, and scope for tariffs to reward consumers using heat pumps.

There was also some support for wider adoption of 'Heat as a Service' models, potentially integrated with time of use tariffs, with some seeing potential to change consumer behaviour. However, a private sector respondent suggested there is little evidence to support claims around the potential benefits of service models for heating appliances.

Hybrid heat pumps

Questions 13 to 16 sought evidence on hybrid heat pump technologies. Hybrid systems combine a heat pump to meet baseload demand, alongside an existing fossil fuel boiler or other heat source to meet peak demand.

Question 13: Regarding hybrid heat pumps, what evidence can you provide on:

a. **the cost of the technology, including installation, maintenance and running costs**
b. **customer satisfaction with the system**
c. **lifecycle and overall efficiency of the technology**
d. **the ability of hybrid heat pumps to reduce peak demand for electricity whilst also reducing carbon emissions**

A total of 25 respondents (46%) addressed one or more parts of Question 13.

Costs

Comments regarding the capital and installation costs of hybrid heat pumps are summarised below.

- Some respondents suggested that hybrid heat pump systems have lower capital costs than electric heat pumps, including reference to a study commissioned by Department for Business, Energy & Industrial Strategy (BEIS).[10] Respondents linked reduced costs to factors including the ability to specify a smaller heat pump unit and reduced ground collector loop (for GSHP). A reduced need for disruptive retrofit was seen as a significant contributor to cost savings, including avoiding replacement of heat emitters and reducing the need for electricity network upgrades. As such, savings were seen as most significant for retrofit rather than new build installation.
- Some suggested that the economic viability of heat pumps can be sensitive to capital costs, and that hybrid heat pumps can improve the economic case by enabling installation of a smaller heat pump with lower capital cost.
- A small number of respondents cited specific capital costs for hybrid heat pump systems, indicating savings of 20-25% compared to standalone electric heat pumps. Some suggested that lifecycle costs of hybrid heat pumps remained higher than other options such as gas boilers and high-efficiency boilers using BioLPG, primarily due to higher capital costs.

[10] Ramboll (2019), Alternative Heat Solutions: Converting a Town to Low Carbon Heating.

Comments regarding running and maintenance costs of hybrid heat pumps are summarised below.

- Some respondents suggested that hybrid heat pump systems could deliver reduced running costs relative to alternatives. This included potential efficiency and running cost savings relative to standalone electric heat pumps.
- However, it was suggested that the extent of any savings was dependent on the type of system being replaced. For example, respondents noted that the FREEDOM project in Wales found significant savings for LPG boiler/heat pump hybrids when compared with standalone LPG boilers, but that gas boiler/heat pump hybrids did not produce savings over an efficient standalone gas boiler. It was also suggested that running cost savings are dependent on correct setup and use of control systems.
- A public sector respondent suggested that non-domestic hybrid heat pump systems can increase maintenance and servicing costs, for example where systems incorporate multiple heat pump and boilers.

Some raised concerns around the evidence base on hybrid heat pumps. This included reference to the limited number of installations to date and the complexity of comparing various forms of hybrid system with the range of alternative technologies. Some noted that the FREEDOM Project was currently the only UK field trial of hybrid heat pumps, and suggested that the trial had not provided a definitive conclusion on the relative performance and costs of hybrid systems.

Some private sector respondents also suggested that hybrid systems will need adaptation or replacement over the longer-term to achieve decarbonisation. There were concerns that use of hybrids should not delay deployment of currently available fully low carbon systems.

Customer satisfaction

Respondents cited some examples of positive customer satisfaction relating to hybrid heat pumps. These included non-domestic (in the agricultural sector) and domestic systems, and heat sources including GSHP, oil-fired and solid fuel systems. Respondents also suggested that design of hybrid heat pump systems and consumer understanding of their operation are also important factors for customer satisfaction.

Responses did not include specific evidence of customer dissatisfaction relating to hybrid heat pump systems. However, some suggested there is a limited pool of evidence on hybrid heat pump systems, including specifically for ASHP/natural gas systems.

Lifecycle and efficiency

Some respondents suggested there is a lack of evidence on the lifecycle of hybrid heat pumps, although others suggested that lifecycles of the heat pump element would be similar to that of standalone heat pumps. It was also suggested that lifecycle can depend on type of property (including energy efficiency) and customer energy needs.

In terms of efficiency, some drew favourable comparison with standalone heat pumps, suggesting that hybrid heat pumps can deliver better efficiency in some homes. This was linked to the heat pump meeting a more consistent load and using periods of lower cost electricity, while peaks are met by the secondary heat source. Respondents suggested that hybrid systems can benefit homes with high heat demand and/or poorer energy efficiency. However, it was also suggested that hybrid systems may not offer an advantage relative to heat pumps integrated with thermal storage.

Reducing peak demand and carbon emissions

In relation to reducing demand, respondents suggested there are circumstances where hybrid systems can deliver efficiency improvements and reduce impact on the electricity network through reducing the size of heat pump required. A private sector (renewables/low carbon) respondent described this as a 'relatively straightforward way' to improve efficiency and reduce peak demand. It was also suggested that hybrid systems can reduce electricity demand during times of grid constraints by switching to the supplementary heat source. However, others suggested that greater reliance on electrical heating, including through hybrid systems, would present more challenges for the management of peak demand during cold periods.

Regarding carbon emissions, respondents suggested that emissions reduction targets will require adaptation or replacement of hybrid systems in the longer term. This included a potential need for replacement with decarbonised alternatives, or adaptation to use zero carbon fuel. Some suggested that fuels such as bioLPG or bio-liquids are available now and could enable hybrid systems to deliver further carbon savings. However, others suggested that carbon emissions associated with the supplementary heating source undermined the benefit of hybrid heat pump systems.

Some also felt that further research is required to assess the potential efficiency and energy demand benefits of hybrid heat pumps relative to available alternatives.

Barriers to uptake

Question 14: What factors might inhibit uptake of hybrid heat pumps?

Question 15: What do you propose as solutions to overcome any barriers to uptake?

A total of 26 respondents (48%) addressed Question 14, and 24 (44%) addressed Question 15.

Factors inhibiting uptake of hybrid heat pumps focused on several key issues, reflecting some of the common themes discussed earlier in this section. These included installation and running costs, disruption to consumers, supply chain capacity, and consumer awareness and confidence.

High installation costs, and the relatively long return on investment required, was the most commonly suggested barrier to uptake. Other commentary around installation costs included:

- Suggestions that installation costs can be lower than for standalone heat pumps, in part due to hybrid systems reducing or avoiding costs associated with energy efficiency improvements. However, others suggested that capital costs can be higher where installation of both the heat pump and supplementary system is required.
- Costs associated with assessing feasibility and design of hybrid heat pump systems were seen as a barrier to uptake for non-domestic buildings.

Some suggested that running, maintenance and future replacement costs could also be a barrier to uptake of hybrid systems. This included suggestions that maintenance and future replacement costs can be higher due to a requirement to service two appliances. While some suggested that running costs for hybrid systems can be lower than standalone heat pumps in some circumstances, others raised concerns that running costs may be higher than predicted.

Comments around potential disruption associated with hybrid heating systems included the 'complexity' of hybrid systems using multiple fuel sources, and evidence of consumers typically preferring a like-for-like heating system replacement[11]. Respondents also suggested that the small install base means there is limited evidence on consumer acceptance of hybrid heat pump systems.

Building type was seen as less of a barrier to uptake than was the case for standalone heat pumps, as the secondary heat source is able to meet the higher heat requirements of less energy efficiency buildings. However, some suggested that hybrid systems may be unsuitable for some property types due to space requirements.

Respondents suggested there is a more limited supply chain and install base for hybrid heat pumps. It was suggested that this could have a negative impact on the quality of advice for consumers, and potentially the quality of design and installation. Some suggested that consumers in some parts of Scotland could experience difficulty accessing maintenance and repairs.

Other views offered by respondents included a perception that limited policy and regulatory support for hybrid systems could limit uptake, and a perceived need to improve consumer awareness and acceptance of hybrid heat pump systems and to overcome 'bad press' associated with poorly designed installations.

Overcoming barriers

Recommendations to overcome barriers to uptake of hybrid heat pumps reflected some of the common themes discussed earlier in this section, and those raised in relation to electric heat pumps at Questions 11.

[11] BEIS (2018), BEIS Public Attitudes Tracker.

Some felt that regulation is needed to drive the market for hybrid heat pumps, and to encourage private investment until these technologies are economically competitive. The most common suggestion for overcoming barriers to uptake was continuation and/or extension of public finance to meet capital costs. This included a specific suggestion of funding for feasibility testing and design for non-domestic hybrid systems. Energy pricing, including time of use tariffs, were also suggested as a means of incentivising uptake of hybrid heating systems. Some saw a role for remuneration for consumers when the hybrid systems are benefiting the network.

Buildings suitable for hybrid heat pumps

Question 16: Can you share any evidence on the types of buildings where hybrid heat pumps may best be deployed?

A total of 21 respondents (39%) addressed Question 16.

Respondents supported the call for evidence paper in emphasising the need for careful matching of heating technologies to specific building types. This included comments around the relative benefits and limitations of heat pump, hybrid and other technologies, although some suggested that build type is not a key criterion for deployment of hybrid heat pumps. Views on specific circumstances where hybrid heat pumps may be deployed are summarised below.

- Respondents suggested the following specific build types and usage as suitable for hybrid heat pumps:
    - Non-domestic buildings including hotels, leisure centres, schools, offices, distribution centres and the agricultural sector.
    - Communal living buildings such as sheltered housing and care homes.
    - Buildings with high heat use throughout the year.
    - Buildings of less than three storeys.
- Buildings with a relatively smooth heating profile and better energy efficiency standards, although it was suggested that hybrid systems may be suitable for properties where energy efficiency is insufficient for a standalone heat pump (or the necessary energy efficiency improvements are not feasible).
- Buildings with high temperature heating systems.
- Buildings in locations which typically experience less-severe winter conditions.
- Households that cannot afford the additional capital costs of a larger standalone heat pump or replacement of heat emitters.

Storage heaters

Questions 17 to 19 sought evidence on electric storage heaters. Storage heaters store heat during periods of lower electricity demand (typically overnight) and then release heat when needed (typically during the day).

Question 17: Regarding electric storage heating, what evidence can you provide on:

a. the cost of the technology, including installation, maintenance and running costs
b. customer satisfaction with the system
c. lifecycle and overall efficiency of the technology

A total of 19 respondents (35%) addressed one or more parts of Question 17.

Costs
Respondents and workshop participants provided limited evidence on the cost of electric storage heating. This is summarised below.

- Some respondents suggested that installation costs for electric storage heating is typically lower than low carbon alternatives such as heat pumps and hybrid systems. Respondents cited some specific installation costs, with costs being higher for high heat retention storage heaters than older storage heating. It was also suggested that electricity network upgrades can add to installation costs.
- The high cost of electricity was suggested by respondents as contributing to high running costs for traditional storage heaters relative to alternatives. Newer technologies were described as having potential to reduce costs, with experience of 25% reduction for more efficient, fan-assisted and high heat retention storage heaters. Some wished to see more support for retrofit of more efficient storage heaters. However, others provided examples of upgrades failing to deliver the estimated level of fuel savings.
- Integration of smart controls was seen as having potential to further reduce running costs. Potential for integration of solar PV to offset running costs was also mentioned.
- Metering arrangements were also perceived as a potential issue for consumers; some suggested that these can be a barrier to switching from higher cost tariffs. It was also suggested that storage heating can be the only practical solution available in some remote locations.
- A small number of respondents provided estimates of maintenance costs for electric storage heating, suggesting that these are lower than for electric heat pumps.

Customer satisfaction
Respondents also provided relatively little evidence on customer satisfaction with storage heating. Some suggested that electric storage heating has a poor reputation, with relatively low customer satisfaction in relation to traditional storage heaters. Evidence was also cited of customer satisfaction being lower than for gas heating.[12]

[12] Consumer Focus (2013), From devotees to the disengaged.

Some respondents suggested that customer dissatisfaction was linked to high running costs and unresponsive heat performance (particularly in rural areas subject to harsh winters), and restrictions on switching fuel or supplier. Respondents cited examples of customer frustration around this issue being such that they chose to pay for storage heaters to be replaced with alternative systems.[13]

Respondents also referred to examples of better customer satisfaction for newer, more efficient storage heating, including tenant feedback to social landlords. Respondents suggested that improved satisfaction related to better heat performance and efficiency, and to improved controls including integration with smart home technology.

Lifecycle and efficiency

Some respondents suggested that storage heaters are more efficient through use of cheaper off-peak energy. However, comments noted above regarding storage heaters being unresponsive and difficult to control were also suggested as contributing to poor efficiency. This included suggestions that a substantial proportion of households maintain a secondary heat source for later in the day when storage heaters are exhausted. Respondents suggested that modern high heat retention storage heaters can deliver significant improvements in efficiency compared to older storage heaters.

Although some respondents described electric storage heaters as being ‘unresponsive’ to consumer’s needs, others suggested that the technology is well-established, with good reliability and a relatively lengthy lifecycle. Respondents referred to examples of storage heaters in place for 25 years or more.

Barriers to uptake

Question 18: What factors might inhibit uptake of electric storage heating?

Question 19: What do you propose as solutions to overcome any barriers to uptake?

A total of 22 respondents (41%) addressed Question 18, and 18 (33%) addressed Question 19.

Factors seen as inhibiting uptake of electric storage heating were focused around running costs, network capacity and poor customer satisfaction. These reflected some of the common themes discussed earlier in this section.

High running cost was the most commonly suggested barrier to uptake, including evidence indicating that storage heaters are higher cost than all other comparators.[14] Running costs were suggested as a potential barrier in relation to poor efficiency of storage heaters and increasing electricity prices.

[13] Ofgem (2013), The state of the market for customers with dynamically teleswitched meters.

[14] Sutherland Comparative Domestic Heating Costs Tables April 2019, www.sutherlandtables.co.uk

Other barriers to uptake of electric storage heating included:

- Respondents suggested that a requirement to upgrade domestic electricity systems can add to installation costs in some cases, but these were not seen as a significant barrier to uptake.
- Electric storage heaters were seen as having a poor reputation and poor customer satisfaction, sufficient to inhibit uptake. This included suggestions that customers have limited scope to switch supplier, that poor controls can lead to inefficient operation, that heat performance can be unresponsive, and that out of date or inconsistent consumer information fails to address concerns around cost and performance.

Overcoming barriers

Some of those respondents raising issues for electric storage heating at Questions 17 and 18 did not see a significant role for the technology in decarbonising heat in Scotland. However, other respondents and workshop participants suggested that storage heating has the potential to make a contribution, including particular reference to flexibility in management of demand. A range of approaches were suggested as having potential to overcome barriers to uptake.

Reflecting the prominence of running costs as a perceived barrier to uptake, respondents felt there were a range of potential changes around electricity costs and tariffs to tackle running costs as a barrier to uptake of storage heating:

- More flexible tariff options could encourage consumers to consider more flexible systems such as storage heating. This included greater flexibility to change supplier, and improved access to time of use tariffs.
- Better publicity of the Competition and Markets Authority (CMA) Restricted Meters Remedy was also proposed, to improve understanding across consumers, support services and energy providers.
- Ongoing trials of smart grid solutions were seen as having potential to reduce electricity costs. This included projects integrating solar PV and battery storage (potentially in the form of storage heaters) to store electricity during periods of peak renewable generation, and release energy to meet peak demand.
- More support for electric storage heating through public funding mechanisms was also suggested.

Smart technology and controls were also seen as having potential to improve heat performance, reduce running costs and manage electrical demand at peak times. Some wished to see greater promotion of these options alongside storage heating.

Other electric heating sources and storage

Questions 20 to 23 sought evidence on other electric heating sources and the potential role of thermal or electric storage alongside electric heating systems.

Question 20: Can you provide any evidence of electric heating technologies not already described that should be considered as potential future heating solution?

Question 21: Can you comment on the comparative installation, operating and maintenance costs of these technologies in relation to other electric heating sources? As well as their lifetime and efficiency?

A total of 11 respondents (20%) addressed Question 20, and 8 (15%) addressed Question 21.

Some respondents suggested that decarbonising heat in Scotland would require a diverse range of electric heating, and other heating sources. This included suggestions that some suitable technologies are on the market at present, and have received insufficient support from the Scottish Government. However, private sector and other organisation respondents also raised concerns around an approach that relied on converting large numbers of off-gas households to electric heating.

The following specific electric heating technologies were seen by respondents as having a role to play in decarbonising heat:

- Solar thermal heating and integration of solar PV and wind generation with heating technologies. This included an ‘other organisation’ respondent citing evidence of potential running cost savings for solar thermal panels.
- Use of battery storage, smart controls and time of use tariffs were seen as having potential to reduce running costs for storage or panel heaters, including for fuel poor households. Respondents referred to projects trialling use of smart electric storage heating.
- Electric boilers and electric combination radiators including solar PV-ready radiators. A private sector (renewables/low carbon) respondent cited findings from trials conducted by the Electric Heating Company and Delta-EE indicating that this technology has potential to deliver savings to installation, running and maintenance costs.
- Micro-CHP with electric battery and/or thermal storage, including potential for these systems to drive heat pumps in neighbouring properties.
- Infrared heaters used in solid wall buildings.

Performance

Question 22: Can you provide evidence on the performance of integrated systems such as heat pumps used in conjunction with battery storage and solar PV?

A total of 11 respondents (20%) addressed Question 22.

These respondents referred to a range of integrated systems incorporating heat pumps, solar PV, thermal and battery storage and other technologies. It was suggested that integrated systems typically have higher capital costs, but that well designed systems could deliver sufficient running cost savings.

Some expressed support for use of thermal or battery storage with heat pumps. An 'other organisation' respondent suggested potential for thermal storage and domestic heat batteries to deliver cost savings of up to 20%.[15]

Some respondents also saw a role for solar PV integrated with storage and/or heat pumps. However, it was also suggested that there may be limited scope for battery storage to overcome mismatch between the generation pattern of solar PV (i.e. during summer) and peak heat demand.

A public sector respondent gave an example of an integrated wind turbine and heat pump system in Orkney. The system was described as ideally suited to an island location, with building energy loss due to wind speed being matched by increased energy and heat generation by the wind turbine.

A 'Danish model' of district heating was suggested as offering potential benefits in terms of efficiency and heat performance. This model involves integration of large scale solar thermal, biomass and inter-seasonal heat storage. It was suggested that the biomass component can be adapted to local fuel supply chains, or replaced with heat recovery. Evidence was cited of this model reducing connection costs, even in low density rural areas.[16]

Overcoming grid constraints

Question 23: How could locally integrated systems, such as those mentioned above, help to overcome electrical grid constraints and what market mechanisms could be used to promote on site generation and use for low carbon heat?

A total of 16 respondents (30%) addressed Question 23.

Some were of the opinion that integrated systems can make best use of available energy infrastructure, and wished to see a 'whole system approach'. Respondents

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[15] www.sunamp.com/wp-content/uploads/2018/07/IIES-slide-deck.pdf

[16] Pöyry, Faber Maunsell & AECOM (2009), The Potential and Costs of District Heating Networks: report for the Department of Energy and Climate Change UK.

suggested it will be important to manage peak electricity demand (during the day and inter-seasonally) if electrification is to play a significant role in decarbonising heat. However, there was also a suggestion that further work is needed to understand the potential role of different systems in balancing demand.

In terms of specific approaches to overcoming grid constraints, the following comments were made:

- Storage was seen as having an important role to play in managing demand and reducing impact on the electricity network at an individual building and larger network scale. Reference was made to thermal and electricity storage technologies, including existing projects using these technologies, although some suggested further work is required to understand the potential of storage.
- Respondents also saw a role for smart controls and demand side management, including as a data source to more accurately assess how to manage energy demand.
- The role of energy master planning and zoning was recommended by some.
- Other mechanisms and technologies seen as having a role to play in overcoming grid constraints included:
    - Mechanisms such as Short term operating reserve (STOR), Capacity Market and Firm Frequency Response to address grid constraints.
    - Conversion of excess renewable electricity to hydrogen for injection into the gas network.
    - Electric heating as a dispatchable load.
    - A range of local electricity and heat generation options including solar PV, wind and solid fuel.

In terms of market mechanisms to promote on site generation, some respondents recommended Ofgem's Charging Review as a potential means of encouraging market mechanisms to promote on-site generation. Respondents also suggested specific market mechanisms as having potential to encourage on-site generation including time of use tariffs, smart pricing signals, and carbon taxes to encourage use of low carbon sources.

Biomass and bio-liquid solutions

Questions 24 to 29 sought evidence on bioenergy technologies including biomass and bio-liquid. Solid biomass can provide high temperature heat via conventional heat distribution systems, and currently accounts for more than 80% of renewable heat capacity in Scotland.[17] However, there are concerns around the long term sustainability of domestic biomass feedstocks. The bio-liquid market and supply chains are less well developed, but bio-liquids can be used as a 'drop-in' fuel or like-for-like replacement in some circumstances and potentially offer an additional option for emission reduction in off gas buildings.

Question 24: Regarding Bioenergy technologies, what evidence can you provide on:

a. **the cost of the technology, including installation, maintenance and running costs, and alignment with quoted RHI costs**
b. **customer satisfaction with the system**
c. **lifecycle and overall efficiency of the technology**
d. **type of feedstock used, and whether this is grown in Scotland or imported**

A total of 21 respondents (39%) addressed one or more parts of Question 24.

Costs

Some cited evidence that costs were broadly in line with those set out in the call for evidence paper, although it was suggested that costs can vary between projects. Modelled estimates were also provided, indicating that biomass heating systems are higher cost than alternatives. This included suggestions that costs quoted in the call for evidence paper somewhat under-estimate installation costs.

A number of private respondents, including LPG manufacturers or suppliers, suggested that bioLPG can be 'dropped in' to existing LPG systems with minimal installation or conversion costs, or new systems installed at a cost equivalent to conventional LPG heating. This was contrasted with bio-liquids requiring installation and supply chain investment, although a private sector respondent suggested that conversion to a 30% biofuel blend can be achieved at a reasonable cost without boiler replacement.

Respondents cited a range of evidence relating to running costs of bioenergy systems, including modelled estimated indicating that biomass systems are higher cost than heat pump and oil systems, and that cost savings can be achieved relative to LPG. Some suggested there is a price premium for bio-fuels, although it was also suggested that costs vary across fuels (for example evidence of lower costs per kWh for wood chip relative to wood pellet). A private sector (LPG) respondent suggested there is potential for fuel costs to decrease over time due to technological advances and market forces.

[17] BEIS (2018), Non-Domestic and Domestic Renewable Heat Incentive (RHI) monthly deployment data, https://www.gov.uk/government/collections/renewable-heat-incentive-statistics

A number of private sector respondents referred to specific examples of projects or technologies. These included examples of bioenergy displacing oil and LPG in non-domestic buildings including care homes and hotels, and a suggestion that wood stoves can be a cost effective option for some homes but are not currently supported through the RHI.

Customer satisfaction
Some respondents gave examples of positive customer feedback on biomass heating systems. Aspects of biomass heating systems seen as contributing to positive customer satisfaction included more stable fuel costs, reduced running costs, lower carbon emissions, reduced risk of theft, and no risk of leakage. Some public sector respondents suggested that customer satisfaction with biomass had been poor, including suggestions that this was linked to higher than expected fuel use and system faults or failures.

Lifecycle and efficiency
Respondents suggested that bioenergy technologies would have lifecycles similar to that of existing oil heating systems. Specific lifecycle estimates (provided by a number of primarily private sector respondents) ranged from 10 to 20 years. It was suggested that storage tanks can have lifecycles of up to 30 years.

Efficiency was described as varying dependent on factors such as boiler size, flue design, fuel specification and storage, control systems and maintenance. Some private respondents active in the biomass sector suggested modern biomass systems achieve very high efficiency levels in the A and A+ bands, while the efficiency of bioliquid systems was described as similar to that of current oil heating systems.

Types of feedstock
Respondents were of the view that locally sourced feedstocks should be used wherever possible to minimise carbon emissions and support local economies. Some suggested there is substantial feedstock capacity within Scotland, including views expressed by some active in the sector that wood pellet manufacture in Scotland is sufficient to meet local demand and for export across the UK and Europe. Some respondents saw a need to work with forestry, crop and other waste and residue processors to further develop local supply chains to maximise use of Scotland-based feedstocks, alongside use of imports where required. They suggested that this included potential to adapt use of feedstocks by specific projects to fit local supply, and suggestion of scope for use of moorlands to expand production of biomass feedstocks.

Respondents provided little evidence on the overall supply of feedstocks within Scotland. However, reference was made to a BEIS UK supply model estimating accessible UK feedstock supply for 2030.[18] Dry fuels and wastes suitable for combustion or thermal treatment accounted for the largest proportion of this supply.

[18] BEIS (2017), UK and Global Bioenergy Resource Model.

Respondents suggested that current bioenergy production across the UK makes use of a range of UK feedstocks, but only small quantities of dry crops, and also imported biofuels for transport and wood pellets for large-scale power production. It was suggested that there is scope to make fuller use of UK feedstocks through development of additional supplies and infrastructure, although some respondents suggested that some imported resources would still be required (such as wood pellets for large-scale power generation). Respondents suggested that a wider range of UK feedstocks were available, including:

- Dry feedstocks for combustion or thermal treatment such as agricultural residues, products from forestry and timber industries, perennial energy crops, wood waste, and renewable fractions of waste.
- Feedstocks suitable for production of biogas or biomethane such as food waste, sewage gas, slurry and landfill gas, livestock manures, and crops.
- Feedstocks for biofuels production such as bioethanol and biodiesel crops, and used cooking oil and tallow.

In terms of locally sources feedstocks, respondents commented as follows:

- Some suggested that wood pellets are more commonly used in Scotland than logs and wood chip (around 75-80% wood pellets), and that a large majority of the pellet supply is sourced within Scotland. Some also suggested there is a substantial local supply of wood chip feedstocks.
- Respondents suggested that supply of logs for stove heating included a mix of local supply and kiln dried logs imported from the UK and Europe.
- It was suggested that bioLPG is primarily produced as part of the refining process for bio-diesel, but that a range of alternative production methods are being developed. These included use of vegetable oils/animal fats, crops, animal waste and glycerine, although it was suggested that some sources required further development and were longer-term prospects. A private sector respondent noted that they had commissioned ongoing research on potential bioLPG feedstocks.

Barriers to uptake

Question 25: What factors might inhibit uptake of bioenergy technology?

Question 26: What do you propose as solutions to overcome any barriers to uptake?

Question 27: What evidence can you provide to show whether there is a strong potential for growth of the biogas supply?

A total of 22 respondents (41%) addressed Question 25, 21 (39%) addressed Question 26, and 11 (20%) addressed Question 27.

Factors seen as inhibiting uptake of bioenergy reflected the common themes discussed earlier in this section, such as costs, and policy and regulation.

Respondents also suggested other barriers specific to bioenergy, such as emissions, air quality, supply chain and feedstocks.

Respondents suggested that high capital cost for bioenergy heating systems relative to fossil fuels, and long return on investment for consumers, could inhibit uptake. Some suggested that changes in RHI tariffs had a negative impact on biomass installations in recent years. Some also suggested that fluctuation in bioenergy fuel costs is a risk to consumers, and saw a need for sufficient economies of scale to be achieved to reduce costs. Maintenance costs were also suggested as a potential barrier.

Air quality concerns were seen as having restricted uptake of biomass heating, and for some were felt to reflect a lack of understanding of differences in performance and emissions across specific biomass fuel types. A public sector respondent also suggested that new regulations will restrict installations in urban areas, although others suggested that rural areas are the primary market for bioenergy.

A range of respondents felt that there is a limited supply chain for bioenergy at present. This was in terms of access to skills and expertise, and feedstocks (seen as a particular issue in some Scottish islands). The availability of a consistent supply of feedstocks for heating was seen as limiting consumer confidence and uptake of bioenergy heating. The allocation of a substantial proportion of feedstock supplies to transport and other streams was seen as a factor here. Some also perceived a lack of research and development funding required to develop new bioenergy fuels.

Some suggested a lack of policy and regulatory support for bioenergy had and could continue to limit uptake of the technology. Some respondents suggested there was potential for existing bioenergy markets to contract if financial support does not continue beyond 2021.

Overcoming barriers

Recommendations to overcome barriers to uptake of bioenergy included some of the common themes discussed earlier in this section, and other approaches reflecting the bioenergy-specific barriers noted above. Suggestions focused on policy and regulation, financial support, supply chain development, and consumer awareness.

Respondents indicated their support for a clear, stable long-term policy framework to provide certainty for industry and consumers, and to encourage investment. This included comments from private sector respondents across the LPG, renewables/low carbon and other sectors. Respondents made the following recommendations for specific aspects of a policy and regulatory framework:

- Feedstock sustainability and quality requirements and greater recognition of the differing characteristics of specific types of bioenergy fuel.
- Consideration of opportunities for local waste sources to be converted to bioenergy supplies.

- Use of land reform to allow use of managed rural landscapes for bioenergy production.
- Linking bioenergy policy with Government commitments to expand forestry.
- A perceived need for a 'Danish-style' heat supply policy.

Continuing and increased financial support to overcome the barrier of capital costs was recommended by respondents across a range of respondent types. This included suggestions for grant plus loans for those unable to pay, and loans for self-funders.

Some public sector and private sector (renewables/low carbon) respondents supported further development of the bioenergy supply chain in Scotland, including diversification of feedstocks used for heat. This included a perceived need for support for expansion of readily available bioenergy technologies for building and industry heating, alongside development of medium to longer-term technologies including large-scale carbon capture. Some public sector respondents felt there was a need for incentives for additional training and skills development, and increased warranty and maintenance provision.

There was a perceived need across respondent types for improved consumer awareness and understanding of bioenergy, including the different characteristics of specific fuel sources and how these fit with different build types. Recommendations included more 'case studies' illustrating the potential role of bioenergy heat, and targeted promotion for key non-domestic sectors.

Potential for growth in biogas supply

Some private sector (LPG) respondents saw potential for clear Government policy to accelerate growth in the biogas market. This included reference to numbers of new biogas plants as indicative of the positive impact of changes to RHI tariffs. In this context, respondents made the following points:

- The Committee on Climate Change has recognised biogas as a 'no regrets solution' able to support reduction in carbon emissions with minimal infrastructure changes.
- Some saw scope to draw on successful deployment of biogas globally to support rapid growth in Scotland.
- A private sector (LPG) respondent suggested there were potential economic benefits associated with biogas, including localised production supporting local economies and potential for Scotland to become a net exporter of biogas.

A private sector (renewables/low carbon) respondent cited evidence that the bioenergy contribution to heating in the UK could be increased by a factor of 2.3 by 2032.[19] Respondents who felt there was strong potential for growth in biogas supply suggested the following specific technologies and circumstances:

[19] REA (2019), BIOENERGY STRATEGY PHASE 2: Bioenergy in the UK.

- Potential to increase supplies of bioLPG as a by-product of increased biodiesel production.
- Potential for gasification of sustainable feedstocks, such as residual household waste, to develop as new sources of low carbon gas.
- Potential for industries such as brewing and distilling as sources of biogas.
- Most discussed the role of bioLPG for off-gas buildings, but a private sector (renewables/low carbon) respondent suggested there is potential for biogas to supply domestic or non-domestic heat networks in rural areas.

Some suggested there is potential for feedstock demand from other technologies such as transport, to limit growth in bioenergy for heat. This was seen as a particular issue in the context of restrictions on land use, and a strategic approach was recommended to make best use of available feedstocks.

An individual respondent questioned the extent to which increasing use of biofuels would contribute to an overall reduction in carbon emissions, and was of the view that any savings would be outweighed by reduced absorption of CO_2 by the bioenergy crop together with processing and transport emissions.

Relative costs

Question 28: Can you provide evidence on the relative cost of using Scottish produced bioenergy feedstocks compared with conventional fossil fuels?

Question 29: Can you provide any evidence on the potential to supply bioliquid fuels sustainably at reasonable cost? With reference to specific fuels such as bio-LPG and different types of bio-diesel.

A total of 15 respondents (28%) addressed Question 28, and 12 (22%) addressed Question 29.

Respondents provided relatively little evidence on the relative cost of Scottish-produced bioenergy feedstocks, but provided a number of broader points in relation to the cost of biofuel relative to fossil fuels. These are summarised below.

- Respondents provided cost estimates indicating that biofuel is lower cost per kWh than heating oil and LPG.
- Some suggested there was scope for bioenergy feedstocks to replace fossil fuels with relatively low capital investment required. This included views that pressure jet burners can be converted to biofuel with relative ease (although it was suggested that not all burners are suitable for conversion), and that transport requirements can be met by existing infrastructure without significant investment.
- Some respondents cited evidence indicating that biomass feedstocks are higher cost than fossil fuels, including oil and gas.[20]

[20] Sutherland Comparative Domestic Heating Costs Tables April 2019, www.sutherlandtables.co.uk

- It was suggested that the diversity of bioenergy feedstocks contributed to significant variation in costs. This included a suggestion that locally produced feedstocks, and particularly waste product, had the potential to reduce costs. It was also suggested that there is a price premium for some ‘innovative’ feedstocks.
- Some regarded price volatility of biofuel as a risk to expansion of biofuel for heating in Scotland.

Responses on the potential for bioliquid fuels to be supplied sustainably at reasonable cost is summarised below.

- The sustainability of biofuels was regarded as a well-documented issue, and it was suggested that regulation had led to a move from raw material to waste feedstocks such as used cooking oils and fats, oils and greases.
- Some suggested that the most promising bioliquid options required further development to improve production and/or efficiencies.
- Some suggested that bioliquids have historically been higher cost than fossil fuel equivalents, but cited recent fuel price trends of this price differential closing as supply of biodiesel and Used Cooking Oil Methyl Ester (UCOME) has increased. It was suggested that market trends indicate the cost of bioliquids would reduce further as supply continues to grow.
- Some respondents were of the view that the level of ongoing research and development work around biofuels has proven the range of potential bioliquid fuels. The use of a diverse range of bioliquid fuels was seen as a more sustainable approach than reliance on a single or small number of fuels.
- A range of specific forms of bioliquid were regarded as having a potential role to play in decarbonising heat, including products being introduced in coming years. Specific bioliquids referenced by respondents included:
    - Bioethanol and biodiesel crops.
    - Bio-kerosene produced from waste plastics.
    - Used cooking oils, tallow, and fats, oils and greases. This included specific reference to hydrated vegetable oil and production of biodiesel from used cooking oils.
    - Gas-to-liquids derived from natural gas.
    - Blends of kerosene with biodiesel or hydrated vegetable oil.
    - Liquid fuel produced through synthesis using renewable electricity and carbon dioxide.
    - Algae-based fuels.

Respondents suggested that locally produced feedstocks can minimise transport-related carbon emissions, and support local business and employment. Land available for feedstock production and competing demand from other sectors were regarded as limiting access to locally produced feedstocks, although it was suggested that transport demand could decline as uptake of electric vehicles increases. Some saw a need for the Scottish Government to take a strategic approach to feedstocks.

Some suggested that a significant proportion of off-gas buildings could be supplied by Scottish feedstocks. This included a private sector respondent indicating that their research estimated that bioliquids could meet the needs of all oil-heated homes if heat demand is reduced through energy efficiency improvements, although evidence was not provided in support of this.

Heat networks

Questions 30 to 34 sought evidence on heat networks. A heat network is a distribution system that takes heat from a central source to multiple properties via insulated pipes. Heat networks can be designed to use a wide range of heat sources including waste heat recovered from industry and urban infrastructure, sewers, canals and rivers, or waste plants as well as heat generated from different fuels including fossil and biofuels, or as part of a CHP system.

Question 30: Regarding heat networks, what evidence can you provide on:

a. **the cost of the technology, including installation, maintenance, fuel and other running costs**
b. **customer satisfaction with the system**
c. **lifecycle and overall efficiency of the technology**

A total of 23 respondents (43%) addressed one or more parts of Question 30.

Costs
Installation cost was regarded by some as a barrier to deployment of heat networks. Few respondents cited specific cost data, but it was suggested that the density of heat demand was rarely sufficient to make a project economically viable without contribution from the developer, connection charges or public finance. Key points raised in relation to installation costs included:

- Some respondents suggested that a minimum housing density is required for a heat network to be economic. This included a suggestion of 50+ dwellings per hectare, although evidence was not provided in support of the suggestion. Some suggested specific heat network projects had been assessed as unviable due to high installation costs, insufficient heat demand and/or the high fuel tariffs required to recoup installation costs. This included public sector respondents who reported having been unable to make an economic case for heat networks.
- Others suggested there was potential for small scale heat networks that were economically viable. This included potential use of ‘anchor’ buildings such as leisure centres or hotels to supplement heat demand in off-peak months.
- Respondents provided cost estimates indicating the impact of length of pipework on overall installation costs, reinforcing the importance of building density for capital costs. It was also suggested that design of heat networks can reduce costs, for example it was suggested that use of waste heat to

reduce the scale of heat source required can significantly reduce capital costs.

It was suggested that assessment of heat networks should be on the basis of full lifecycle costs, reflecting the importance of running costs to consumer charges. Reference was made to ongoing development of a compliance programme to ensure accountability for lifecycle costs through project phases.

Respondents cited a range of evidence on running costs for heat networks including case study examples, research evidence and modelled estimates.[21] This included examples of running costs for low carbon heat networks being similar to or lower than existing heating systems. However, some suggested that running costs vary such that it is difficult to make meaningful comparisons. Factors such as cost of finance, ownership model, heat network design, maintenance and control systems, and energy tariffs were suggested as impacting on running costs.

It was suggested that linking consumer costs to a 'counterfactual' effectively sets an upper limit on potential income for heat networks, such that reducing capital costs provides the best opportunity to reduce the level of public funding required. Some saw a need for revised price setting criteria for heat networks.

Uncertainty around future heat costs to consumers was seen as a potential deterrent for individual heat users. Some also suggested that lengthy contracts required to recoup capital costs can prevent tariff switching.

Some suggested there was the potential for heat networks to have a positive local economic impact, and saw this as an important consideration in relation to cost. This included in terms of supporting employment and, if locally produced biomass is used, retaining fuel spend within the local economy.

Customer satisfaction

Relatively few respondents cited evidence on customer satisfaction with heat networks, noting the limited scale of heat network deployment in Scotland. Some cited evidence that heat network users report satisfaction in line with that seen across other heating systems, including a BEIS survey of heat network customers[22] and CMA market study[23]. A Which? report on heat networks was cited as having found more varied satisfaction levels.[24]

Respondents cited these sources, and other examples of heat networks in Scotland, as highlighting a range of factors impacting customer satisfaction. These included system reliability, perceived fairness of price, information provided on the system, and handling of complaints. Charging and billing issues were also

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[21] ETI (2018), District Heat Networks in the UK: Potential Barriers and Opportunities. Poyry (2009), The Potential and Costs of District Heating Networks. AECOM & ETI (2017), Reducing the capital cost of district heat network infrastructure.

[22] BEIS (2017), Heat Networks Consumer Survey: consumer experiences on heat networks and other heating systems.

[23] CMA (2018), Heat networks market study.

[24] Which (2015), Turning up the heat: Getting a fair deal for District Heating users.

suggested as impacting customer satisfaction, including frustration for dissatisfied customers unable to switch supplier.

Lifecycle and efficiency

Respondents cited a range of evidence relating to the lifecycle and efficiency of heat networks, although some suggested that the evidence base is limited by the small number of well-established examples.

Specific lifecycle estimates ranged from 20-25 years to 50+ years. The latter estimate was provided with reference to DECC research[25], although it was suggested that assets with moving parts have a shorter lifecycle. Some suggested that lifecycle of heat networks should be broadly similar to individual low carbon units, although it was also suggested that lifecycles can vary between heat networks. For example, longer lifecycles were suggested for lower temperature heat networks such as ambient loop systems.

Respondents referred to research evidence[26] and experience in suggesting that efficiency of heat networks is affected by a range of factors. These included modelling of demand and system design, use of heat recovery, and the length and type of pipework to minimise heat loss. Some saw a need for standards to ensure heat networks meet minimum performance and efficiency levels, including for temperature range, pressure controls and annual performance reporting. Data collection was suggested as a means of increasing heat network efficiency.

Barriers to uptake

Question 31: What factors might inhibit uptake of the installation of heat networks?

Question 32: What could be done to further encourage the development of heat networks?

A total of 32 respondents (59%) addressed Question 31, and 29 (54%) addressed Question 32.

Respondents suggested a range of factors that may inhibit installation of heat networks. These included some common themes discussed earlier in this section such as cost and a limited supply chain, and other barriers more specific to heat networks such as ‘demand risk’ and the built environment.

High capital expenditure was suggested as a key factor across respondent types. This included reference to infrastructure costs, additional costs where sites have insufficient density of demand, planning application fees, cost of negotiating commercial contracts and property agreements. High capital costs were regarded as contributing to very long payback periods. Respondents also suggested there

[25] DECC (2015), Assessment of the costs, performance and characteristics of UK heat networks.

[26] DECC (2015), Assessment of the costs, performance and characteristics of UK heat networks.

were difficulties accessing funding, particularly for smaller networks in rural areas, and that developers were unwilling to bear additional costs.

‘Demand risk’ was regarded as a key factor limiting installation of heat networks, where uncertainty around the number of consumers likely to connect to a network can undermine the economic case. This was described as a potential ‘catch-22’ where consumers do not wish to agree a contract prior to the heat network being installed, but the installation cannot go ahead until sufficient contracts are in place. Other suggested barriers related to demand risk and running costs of heat networks included:

- Low heat consumption in new build development due to improved energy efficiency, and the risk of low heat demand in off-peak months.
- Higher running costs relative to high carbon alternatives, particularly where higher tariffs are required to recoup capital expenditure. It was also suggested that heat network consumers are subject to higher rates of VAT on energy.
- The resources and expertise required by the management, metering, and billing/credit control for heat networks. This included reference to social landlords having experienced challenges in management of existing heat networks, although specific examples were not provided.

The nature of the existing built environment was seen as adding to the complexity and cost of heat network installation, particularly for retrofit and where land is under multiple ownership. It was also suggested that installers do not have the rights of other utilities in terms of gaining access to underground infrastructure.

Some respondents and workshop participants felt that knowledge and skills within the supply chain are limited, including in the design and procurement of heat networks. This was regarded as a particular issue in rural and island locations. Some public sector respondents suggested that heat networks are a ‘novel’ technology to many local authorities in Scotland, and that there is uncertainty around operation and maintenance of schemes delivered by public sector organisations. This included suggestions that social landlords have experienced some significant challenges around management of district heating.

Respondents felt that the following were also potential barriers to uptake of heat networks:

- A lack of policy and regulation drivers to encourage installation.
- A lack of strategic planning and coordination between local authorities.
- A lack of consumer awareness and understanding of heat networks, including some concerns around reliability and cost and a perceived lack of consumer protections.
- Application of business rates to district heat infrastructure and energy centre.

Encouraging development of heat networks
Consistent with the barriers noted above, suggested approaches to encouraging development of heat networks focused primarily around policy and legislation, and financial support. Comments are summarised below.

Respondents made recommendations on policy and regulation to encourage investment in heat networks and reassure potential consumers. Specific recommendations included:

- Greater support for heat networks through local planning policy and LHEES including use of heat zoning and targeted policies to identify opportunities for heat networks in off-gas areas.
- Use of Building Regulations to support heat networks.
- Regulation to tackle the issue of 'demand risk' for heat network development.
- Technical standards and guidance for heat networks, including at the design and procurement stages.
- Standards and consumer protections around management and billing of heat networks.
- Giving installers of heat networks equal rights of access to other utilities.
- Discouragement of high carbon heating.
- Ensure use of smart meters to improve data available to inform policy and development of heat networks.
- Use of Energy Efficient Scotland to encourage heat networks as an option for consumers in off-gas areas.
- A 'default organisation' or national energy company to act as a safety net in the event of a locally managed heat network failing.
- Adapt Greater London Authority Energy Assessment Guidance for use in Scotland.
- Regulation around liability for installation of infrastructure where industrial sites are acting as a heat source.

Respondents' recommendations for future public funding and other potential financial incentives for heat networks included:

- Continued public funding to encourage heat networks, with sufficient flexibility to recognise design and build timescales. This included a role for the District Heating Loan Fund.
- Supporting access to affordable borrowing for development of heat networks.
- Clear guidance and rules on calculation of heat costs over the long term, including a review of use of counterfactual charges.
- Taxation measures to encourage heat networks.
- Use of the Heat Network Investment Programme to overcome the barrier of capital expenditure.

Wider training programmes and other support were recommended to develop the supply chain. Respondents suggested that this should include better understanding of the risks and benefits of heat networks, and improving access to expert advice and support for developers.

Respondents also perceived a need to raise public awareness of and confidence in heat networks. This included suggestions for sharing of case studies and development of local engagement programmes.

Respondents suggested a range of circumstances and technologies that could improve the viability of heat networks, including:

- Small heat networks in rural off-gas areas.
- Areas where lower cost ‘soft dig’ pipe installation is possible.
- Areas with locally available solid fuel source.
- Clusters of process heat and large buildings in heat networks.

Circumstances suitable for heat networks

Question 33: Where and in which circumstances are heat networks the most appropriate low carbon solution in areas not using mains gas?

Question 34: What examples can be provided to show how readily heat networks can be moved to renewables – especially in those buildings with a high peak heat load?

A total of 30 respondents (56%) addressed Question 33, and 19 (35%) addressed Question 34.

Comment around circumstances where heat networks may be the most appropriate low carbon solution focused around density of demand and building type or location. This is summarised below.

- One of the most common suggestions was that there is a need for sufficient heat demand to support installation costs. This included reference to a research study indicating that the suitable heat density for heat networks is approximately 3,000kW/m2.[27] A local cluster of large and/or high heat buildings was given as an example.
- It was suggested that building energy efficiency is an important consideration in design of heat networks, although a private sector respondent suggested that heat networks can be designed to decarbonise buildings with poor energy efficiency.
- Building density was commonly suggested as a key feature for heat networks. Respondents also felt there was a range of specific build types, locations and uses where heat networks could be appropriate:

[27] Poyry (2009), The Potential and Costs of District Heating Networks.

- Off-gas buildings in urban or suburban areas likely to have sufficient heat demand, such as multi storeys, blocks of flats, care homes and student accommodation.
  - Use of 'anchor buildings' such as leisure centres and hotels to supplement off-peak heat demand.
  - Networks with space to deploy thermal storage.
  - Areas with mainly stone-free soil where lower cost 'soft dig' pipe installation is possible.
  - Large brownfield regeneration sites.
  - Non-domestic buildings such as hospitals, schools and other public facilities.
  - New housing developments (to avoid high retrofit costs).
- Developments where heat networks can incorporate waste heat or heat recovery were also recommended.
- Respondents recommended developments drawing on locally available low carbon fuel supply such as biomass feedstocks, geothermal energy or curtailed wind turbines.

Potential for **deployment of heat networks in rural areas** was a key theme for some, with respondents expressing a range of views.

Some suggested that heat networks are not a viable option in many rural areas due the factors noted above, most commonly with reference to insufficient density of heat demand. This also reflected suggestions around higher capital costs for rural heat networks due to lower building density and transport costs. Limited local supply chain in rural areas was also suggested as adding to capital costs.

Respondents also saw potential for additional planning restrictions and protected status as barriers to deployment of heat networks in some rural areas. Some suggested that rural heat networks developed to date have typically been on estates with a single land and/or building owner able to manage the process (and minimise 'demand risk'). A private (other) respondent called for further review of the costs and barriers to rural heat networks before further development is undertaken.

Others suggested that heat networks have been successfully deployed in rural areas, citing evidence that around 10% of heat networks in Scotland are in rural areas.[28] Some wished to see policy and financial support for heat networks across rural and urban areas, for example through support for community ownership and streamlining of planning for heat networks in rural areas.

Respondents suggested a range of factors in support of potential deployment of heat networks in rural areas:

[28] Citizens Advice Scotland (2018), Off-gas consumers: methodology and data tables.

- It was suggested that small heat networks can be economically viable in rural areas, for example where there is relatively high building density and/or access to waste heat. It was also suggested that new housing development in rural areas could provide an opportunity for deployment of heat networks.

- Some suggested that rural areas may be more suitable for heat networks using GSHP (due to availability of external space) and biomass (where there is access to local fuel supply). Opportunity to link with local energy production was seen as a key benefit for heat networks in rural areas.

- Respondents also suggested that fuel poverty rates are higher in rural areas, and that rural communities could be more receptive to the potential for heat networks to deliver cost savings.

Comment and examples provided around moving heat networks to renewable energy are summarised below:

- Respondents suggested that the feasibility and cost of conversion to renewable energy is dependent on heat network design. This included the benefit of central energy centres for future conversion to low carbon heat, and some saw futureproofing of heat networks as important to enable transition to lower carbon and/or lower temperature sources.
- Respondents recommended that heat networks are installed with low carbon heat sources wherever possible. However, some suggested that the current cost of low carbon heat sources can undermine the economic viability of heat networks, and suggested that this may require policy and financial support. This was regarded as a particular issue where installation of low carbon heat is replacing low cost fossil fuels.
- Specific examples of heat networks being moved to renewable energy included small heat networks in rural areas using biomass (particularly with a single owner to manage procurement), an Aberdeen CHP network starting to capture waste heat, later phases of a heat network in Islington using waste heat from the London Underground, and multiple examples across Europe using solar and biomass heat sources.
- In addition the specific examples noted above respondents also suggested other circumstances and/or forms of low carbon heat that could be appropriate for conversion of heat networks:
    - Using expansion of a heat network as an opportunity to add low carbon heat sources.
    - Shared ground loops are well suited to a range of heat network designs.
    - Where biomass feedstocks are available locally.
    - LPG and bioLPG can provide a viable source of low carbon heat for some heat networks.
    - Where waste heat or heat recovery can be incorporated.

- Evidence was cited that only a small proportion of heat networks currently use low carbon heat.[29]

Gas grid extension

Questions 35 to 37 sought evidence on the continued extension of gas networks. As a lower carbon heat source than heating oil and LPG, expanding the natural gas grid may be an option to reduce emissions in some circumstances. However, in order to meet emission reduction targets natural gas will have to be replaced by low carbon alternatives. Moreover, it is not yet clear whether the whole scale conversion of the gas network to hydrogen or other low carbon alternatives is the most effective way to decarbonise heat.

Question 35: What is your view on the continued extension of gas networks before low carbon alternatives to natural gas (e.g. hydrogen) are proven?

A total of 32 respondents (59%) addressed Question 35.

Some respondents supported continued extension of gas networks as part of an approach that incorporates all available technologies in the pathway to decarbonising heat. This included reference to use of biomethane and in the future potentially Bio-Synthetic Natural Gas (bioSNG) and hydrogen. It was also suggested that design of any grid extensions would ensure flexibility for future decarbonised gas. Some also suggested that gas grid extension could provide benefits in tackling fuel poverty.

Comments in favour of gas grid extension also appeared to reflect suggestions from some respondents that it may not be feasible or desirable to decarbonise heat wholly or primarily via electrification. Gas network extension was seen as having a role to play in this context, although some wished to see only limited grid extension and others were opposed to any gas grid extension.

Respondents were most likely to have views opposed to or express concerns around continued extension of gas networks. This included the following comments.

- Respondents suggested that significant safety and practicality concerns remain around whole scale introduction of hydrogen or biogas into the current gas network, including reference to a number of reports on the role of hydrogen.[30]. It was suggested that grid extension should not continue until there are proven low carbon solutions to decarbonisation of the gas grid, to avoid risk of stranded assets and wasted expenditure.

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[29] ADE (2018), Market Report: Heat Networks in the UK.

[30] Committee on Climate Change (2018), Hydrogen in a low carbon economy. Advanced Plasma Power (no date), BioLPG: A Low-Cost Solution for Off-Grid Heating. Energy Research Partnership (2016), Potential Role of Hydrogen in the UK Energy System.

- Views were presented that continued extension of the gas grid could delay deployment of low carbon alternatives and could erode the market for these alternatives, putting at risk the net zero target by 2045.
- Some referred to the UK Government commitment to cease new gas grid connections by 2025, and supported a similar approach in Scotland. This included a suggested phased approach to avoid any adverse impacts on tackling fuel poverty.
- It was suggested that viable low carbon alternatives to gas grid extension are already available, and should be given preference over gas grid extension.

Grid extension and wider decarbonisation demands

Question 36: How should wider decarbonisation demands, including for industrial processes, be factored in when considering gas grid extension?

A total of 17 respondents (31%) addressed Question 36.

Some suggested that gas grid extension would be a cost effective option for industry until viable low carbon options are available. Respondents suggested the potential for this to enable industry to remain competitive, while supporting local employment. Some also suggested that industrial processes could be a suitable focus for introduction of hydrogen and biogas, including reference to an ongoing project looking at this option in Aberdeen.

Respondents suggested a range of considerations that could justify future gas grid extension:

- Where gas grid extension enabled industry to replace use of higher carbon fuels.
- Where industry is co-located with other off-gas domestic or non-domestic buildings.
- Where this incorporates mitigating low carbon technologies such as hybrid systems and smart controls.

Respondents with views opposed to larger scale gas grid extension suggested that many industries and processes can be met by existing low carbon solutions such as bioenergy, bioLPG, and waste heat.

Low gas flows and the existing grid

Question 37: What evidence can you provide on the economic and technical viability of the existing gas grid if it was maintained and operated with low gas flows?

A total of 7 respondents (13%) addressed Question 37. These respondents cited limited evidence on the viability of the gas grid with low gas flows.

A private (energy supplier) respondent suggested that operational costs of maintaining the gas network with low gas flows would be relatively modest, particularly in comparison with the investment required to establish infrastructure for low carbon alternatives. Respondents also suggested specific aspects of grid maintenance and operation to accommodate low gas flows, including additional maintenance requirements for higher pressure tiers.

Others raised concerns regarding the economic viability of the gas grid with a transition to electric heating, including potential for residual users of gas networks paying a high cost to support the network. Respondents recommended use of the gas grid for electricity generation via fuel cell CHP as a means of maintaining year-round use of the network. It was suggested that a policy decision on decarbonisation of the gas grid was required urgently to provide clarity to technology developers and investors.

Innovation in low carbon heat technologies

The final questions on low carbon heat technologies (Questions 38 and 39) sought evidence on further opportunities for innovation in low carbon heat, and potential for cost reductions.

Question 38: What evidence can you provide on the further developments needed for future market readiness and deployment of the low carbon technologies covered above?

Question 39: What evidence can you provide to show potential economies of scale and unit cost reductions that could be achieved through increases in annual levels of deployment of the low carbon heat technologies covered in this call for evidence?

A total of 18 respondents (33%) addressed Question 38, and 18 (33%) addressed Question 39.

Comments around further developments needed for future market readiness and deployment of low carbon heat reflected some of the themes raised earlier in relation to overcoming barriers to uptake of low carbon heat. This included policy and regulation, funding, and specific marketplace of technological changes. These are summarised below.

- Respondents saw a need for long-term stable policy and regulation to support investment in research and development and energy infrastructure. Specific suggestions included:
    - Clarity on the future role of specific technologies such as decarbonisation of the gas grid and bioLPG.
    - Gas network companies require clear policy and regulation to support innovation and demonstration projects, and enable market readiness for low carbon technologies.

    - Legislation to move gas quality standards from UK legislation to a more flexible industry standard to support greater volumes of lower carbon gas and increases in levels of hydrogen.
    - Adoption of a 'Danish-style' heat supply policy.
    - Removal of regulatory levies from households in remote areas subject to grid constraints.
    - Legislation on allocation of profits from any future export of renewable electricity to the grid.
- A range of respondents supported continuation of public financing through a replacement to RHI. Specific suggestions for future financing included a larger upfront payment to enable capital expenditure, a boiler and tank scrappage scheme, and financial support for specific technologies including biogas. Sustained investment into research and development for new technologies and fuels was recommended, including demonstration projects testing introduction of hydrogen to the gas network.
- Some saw a need for more work to improve awareness of low carbon technologies in Scotland, and to target concerns around the cost and disruption of moving to low carbon heat. This included improved understanding of EPCs and the energy performance of buildings.
- Specific projects and other changes recommended by respondents included:
    - Further development of time of use tariffs.
    - Targeting 'trigger points' for promotion of low carbon heat.
    - A 'rolling' approach to support for individual low carbon technologies that reflects their readiness for market, and allows subsequent technologies to develop.
    - Continued investment to upgrade the gas network.
    - Changes to how consumers are billed for gas as the network incorporates a growing mix of low carbon gases, including more localised measurement of calorific values.
- Additional investment was recommended to ensure the supply chain and installer base is able to meet increased market demand.

In relation to potential economies of scale and cost savings, some pointed to previous trends in fuel and technology costs (including reference to heat pumps and biofuels) as an indication that running costs will reduce as there is growth in supply and demand for low carbon heat, and increased competition within the supply chain. Further technical innovation was suggested as having potential to continue to reduce running costs, for example through improved efficiency. Some also saw a role for policy and regulation in providing certainty to industry to enable continuing development of technologies, and associated reduction in costs.

Respondents provided specific examples and estimates of economies of scale:

- Cost reductions in biomethane plants through increased deployment in the gas grid and associated economies of scale.
- Significant reduction in costs to install solar PV and wind generation.
- Example of a 3.6% reduction in heat network costs as a result of economies of scale and 'learning by doing'.[31]
- Estimates of a potential 10-30% fall in heat pump capital costs.
- Estimates of a potential cost reduction of more than 30% for ground source heat pumps.
- Potential for innovation in ground loop systems to continue to reduce costs.
- Potential for futureproofing of new housing development to reduce costs.

However, some suggested there are areas with limited scope for economies of scale to deliver cost reductions, for example mature technologies such as heat pumps. A private (renewables/low carbon) respondent also suggested that negative experience of the solar market has contributed to supply chain businesses being cautious on recruitment, potentially slowing economies of scale.

[31] BEIS (2018), Estimating the cost-reduction impact of the Heat Network Investment Project on future heat networks

Low carbon heat and fuel poverty

The call for evidence paper noted that households in off-gas buildings are more likely to be in fuel poverty, with rates of fuel poverty amongst those using electric heating systems more than twice that of households connected to the gas network. The prevalence of fuel poverty amongst off-gas households is likely to reflect a mix of higher fuel costs (for electricity) and the characteristics of the rural housing stock.

Decarbonising off-gas heat supply could increase the rate of fuel poverty for these households. This is a particular risk given that capital costs of low carbon heating systems are often higher than high carbon systems, although running costs can be lower for some low carbon systems. Question 40 sought examples of low carbon heating systems contributing to lifting households out of fuel poverty.

Readers should note that respondents' focus on specific aspects of the role of low carbon heat for fuel poverty appeared to reflect their experience and expertise. For example, those active in a particular energy sector were generally more likely to refer to associated technologies. As such, **views expressed cannot necessarily be read as representative of the full range of opinion**. References are provided for specific claims where possible, and we note where evidence was not provided. Statements of opinion provided without evidence may not have been included.

Question 40: What examples can you provide of instances where installing a modern low carbon heating systems has also lifted households out of fuel poverty?

A total of 26 respondents (48%) addressed Question 40.

Most evidence cited at Question 40 related to potential for low carbon technologies to reduce heating costs generally, rather than specifically on the potential role of low carbon heat for fuel poor households. This included examples of savings achieved by heat pumps, low carbon heat networks, biomass (including in combination with LPG), bioliquids, and use of solar PV. The potential benefits of self-sourced biomass fuel were also suggested in relation to cost savings. Specific comments on potential cost savings are summarised below.

- Most suggested savings relative to off-gas fuel sources such as coal, oil, LPG and electric heating, although a private (renewables/low carbon) respondent cited an example of large scale heat pumps in multi storey buildings reducing costs relative to mains gas heating. Other examples of potential savings included low carbon heat networks in higher density housing such as high rise flats and sheltered housing.
- Some referred to examples of energy efficiency improvements being installed alongside low carbon heat, including suggestions that this was required to secure sufficient cost savings.
- Potential for energy service contracting to achieve savings in combination with low carbon heat was also suggested.

The few respondents referring specifically to low carbon heat for fuel poor households included some noting the importance of advice and support in enabling households to choose the correct technology. Some suggested that careful design and household behavioural change is required to lift households out of fuel poverty. Others felt that potential savings associated with low carbon heat are unlikely to be sufficient to address the high prevalence of extreme fuel poverty.

However, some examples were provided of low carbon technologies helping to lift households out of fuel poverty. These included:

- A retro-fitted heat network in Glasgow contributed to a reduction in fuel poverty indicators such as tenants that had previously been paying more than 10% of their income on heating, and those who were borrowing money or putting off payment of other bills to pay for heating.
- Retrofit of GSHP to a number of tower blocks in Enfield had included a large number of tenants previously classed as fuel poor.
- Proposals for housing development in Orkney with low carbon heat and insulation levels to be ‘fuel poverty proof’.
- A private (heat pump) respondent suggested that the potential of GSHP is indicated by this being the only low carbon technology eligible for Energy Company Obligation focused on fuel poverty alleviation.

Reference was also made to potential developments that could help to alleviate fuel poverty. An ‘other organisation’ respondent suggested there is potential to reduce heating costs in rural and island locations via upgrade of local grids and energy storage to allow households to use locally produced renewable energy. A private (energy supply) respondent suggested injection of low carbon gasses into the gas grid had potential to use low carbon heat to lift more households out of fuel poverty.

Some private and third sector respondents suggested there is a tension between decarbonisation of heat and addressing fuel poverty. This included concerns that low carbon heating is more likely to increase than alleviate fuel poverty.

> *Decarbonising the household energy system also comes with justice tensions…potential new inequalities would need to be considered as innovation in the sector grows.*
>
> Private sector (renewables/low carbon) respondent

High capital costs of low carbon technologies were seen as a particular risk, although it was suggested that those in fuel poverty should be able to benefit from the full range of available financial support to enable a move to lower cost low carbon heating. Some also questioned the likelihood of low carbon technologies delivering reduced running costs, including suggestions that on-grid gas is a lower cost option for most households. It was suggested that current methodologies to estimate in-situ performance are likely to overestimate likely fuel savings, such that consumers could encounter fuel costs substantially higher than expected. A private (other) respondent suggested that tackling fuel poverty had to prioritise reduction in fuel bills, such that reduction in emissions was a secondary consideration.

Enabling the uptake of low carbon heat

The call for evidence paper sought views on the elements required to create a future Scottish framework to support uptake of low carbon heating in off-gas buildings. This included a particular focus on the potential role of the following: phasing and leadership; strategy in guiding investment and delivery; finance and incentives in supporting uptake; advice and information in enabling consumers to make informed choices; and regulation in giving market certainty.

Questions 41 to 45 sought views on each of these elements in turn, while Questions 46 to 48 sought views on the role of advice, assessment and information.

Readers should note that respondents' focus on specific elements of support for uptake of low carbon heat appeared to reflect their experience and expertise. For example, those active in a particular energy sector were generally more likely to refer to uptake of associated technologies. As such, **views expressed cannot necessarily be read as representative of the full range of opinion**. References are provided for specific claims where possible, and we note where evidence was not provided. Statements of opinion provided without evidence may not have been included.

Planning and leadership delivery

Question 41: How should we phase in the policy framework in order to better support the decarbonisation of heat supply to off gas buildings? Please reflect on whether or not a similar approach to that proposed for energy efficiency remains the best option.

A total of 37 respondents (69%) addressed Question 41.

Support for a phased approach was evident across respondent groups, with recommendations for interim targets alongside longer term strategic aims. This included reference to successful use of phased approaches to policy change such as the switch to condensing boilers, the end date of 2040 for sale of new petrol and diesel cars, and an end date for use of coal in power plants.

A phased approach was seen as beneficial in providing a clear strategic direction and confidence for industry and consumers, allowing stakeholders to plan investment and avoiding a concentration of activity near the target date. Some suggested that the current absence of specific timing for phasing out high carbon heating had limited industry planning and investment. It was also suggested that a phased approach avoids requirement for consumers to prematurely replace current heating systems.

In terms of the specific phasing of the policy framework some respondents recommended an approach that mirrors that for energy efficiency proposals, for example short-term and long-term targets supported by interim targets to encourage progress. Some also suggested it will be importance for the policy timetable to take account of ongoing engagement with stakeholders.

Some wished to see more rapid phasing. This included suggestions that Scottish Government should recognise the range of low carbon technologies currently available, and progress made in decarbonising heat over recent years. Respondents saw a need to balance policy targets with allowing time for research and development, and industry investment. However, it was also suggested that industry has proven itself able to respond to relatively rapid changes in policy and regulation.

Respondents made a range of specific suggestions for elements of a phased policy and regulatory framework. These are summarised below.

- A firm date on phasing out of high carbon fuels, in terms of new installations and subsequent retrofit. It was suggested that the end date would need to allow for the lifecycle of high carbon systems installed up to that point, such that these would be replaced in line with the net zero target. Specific suggestions for an end date for new installations ranged from the early 2020s with the latest being 2035. Some cited evidence on the carbon impact of delaying phase out. However, some did not wish to see a firm date for switching.
- The following areas and sectors where more rapid progress could be made were suggested:
    - An initial focus on new build development in off-gas areas including delivery on the Future Homes Standard for off-gas areas.
    - Use of zoning to bring forward targets in some areas.
    - Transition of fuel poor households to low carbon heating first.
    - Prioritising new build public sector commercial scale buildings, including an immediate requirement for use of low carbon heat in all new developments and a firm date for retrofit of all buildings.
    - An immediate requirement or short-term target for boiler replacement to use low carbon technologies.
- A clear statement on the role of bioliquids.
- Allowing time for new technologies to continue to develop.

A broad range of respondents also suggested that continued financial support would be required alongside a phased policy framework. This included recommendations for targeted support for the fuel poor and those unable to pay, early adopters, research to prove new technologies, and extending financial support to include emerging technologies.

The role of strategy in guiding investment and delivery

Question 42: How could Local Heat & Energy Efficiency Strategies (LHEES) help to prioritise early phasing of uptake of low carbon heat in areas not currently using mains gas?

A total of 26 respondents (48%) addressed Question 42.

Support was evident across private and public sector respondents for use of LHEES in early phasing of low carbon heat in off-gas areas. Local knowledge was seen as particularly important in tailoring use of different heat technologies to local circumstances, and there was support for LHEES as a vehicle to apply this to the phasing of low carbon heat. However, an ‘other organisation’ respondent also raised concerns regarding local authority-level planning, and questioned whether this could deliver the diversity of approaches required to meet what can be highly localised needs.

Support for LHEES included comments in favour of use of zoning to identify areas where more rapid uptake of low carbon heat is possible. Specific suggestions here included:

- Zoning off-gas areas as ‘zero carbon heat zones’, for example mandating use of low carbon heat in new build development in off-gas areas, and regulating against further gas grid extension.
- Ensuring coordination of approaches to low carbon heat and energy efficiency.
- Using LHEES to support local campaigns to raise awareness and acceptance of low carbon heat.
- Specific areas seen as suitable for zoning included those with waste heat or heat recovery opportunities, those with sufficient heat density for low carbon heat networks or other opportunities for local cooperation, and areas with building types or building clusters suitable for early retrofit of low carbon technologies.

Some commented on the process required to develop local priorities and targets. This included the importance of cooperation between local government and stakeholders such as industry and communities. A role for local or regional resources was suggested as a means to drive the process, and some wished to see clear national guidance for LHEES that can be translated into local approaches. Some also saw a need for research to build the evidence base for LHEES.

Respondents also recommended targeted financial and other support as part of the implementation of LHEES. This included ensuring sufficient local authority funding and resources for development and delivery of LHEES.

Funding, finance and incentives

Question 43: How should the deployment of low carbon heat be funded? i.e. what relative contribution should come from central public funding, energy consumer's bills and private recipient funding?

A total of 38 respondents (70%) addressed Question 43.

Public funding
The most common recommendation for funding of deployment of low carbon heat was continuation of public funding. This was seen as necessary at least in the medium term, although some suggested that funding could reduce as low carbon markets and technologies mature.

Public funding was seen as particularly important for the fuel poor, vulnerable households and those in hard-to-treat buildings where respondents saw a continuing need for grant support. Some also suggested a need for grants, subsidised loans and/or scrappage schemes for domestic users who are able to pay, particularly lower income households at risk of falling into fuel poverty. Research and development funding was also recommended to encourage investment, and some perceived a need for additional funding to support adopters of emerging technologies.

Some saw a need for expansion of current funding levels, and a streamlining of the current funding landscape. It was suggested that the current condition preventing households from receiving multiple grants should be reviewed. Recommendations for financial support also included reference to a continuing need for energy efficiency improvements for some buildings if low carbon heat is to be a viable option.

Some raised concerns around current public funding arrangements, and suggested these must be addressed for the continuing deployment of low carbon heat. These included suggestions that:

- Benefits of current funding have largely flowed to better-off households.
- Environmental and social obligations disproportionately penalise heating through electricity.

Consumer bills
Views were mixed in relation to a role for consumer bill contributions to fund deployment of low carbon heat. Some private sector respondents saw a role for this, while others (including private, public, third sector and other respondents) were opposed. Concerns raised in relation to consumer bill contributions included that lower income households may be disproportionately affected as they spend a higher proportion of their income on energy, and a suggestion that lower income households are more likely to live in homes with poorer energy efficiency (although no evidence was provided for this).

Reference to consumer bills included recommendations for a review of levies across domestic fuels to ensure higher carbon fuels are not advantaged. A carbon tax was recommended as a replacement that more accurately reflected contribution to carbon emissions, and ensured lower income and vulnerable households are not disadvantaged.

Private finance

There was support across a range of respondent groups for a role for private finance in funding deployment of low carbon heat. Those able to pay for low carbon heat were seen as a key focus for private finance, including low interest loans and equity release. Private finance was also seen as suitable for market ready low carbon technologies that can deliver savings for households.

Some suggested that availability of private financial support in Scotland was already good. However, others suggested that further regulation was required to strengthen the private finance market for low carbon heat. It was suggested that the role of private finance could increase as markets mature and public funding is withdrawn for all those who are not fuel poor.

Private investment

Question 44: What is needed to encourage private investment in low carbon heat?

A total of 36 respondents (67%) addressed Question 44.

Recommendations for changes to encourage private investment in low carbon heat were focused around policy and legislation and public funding, although a range of other suggestions were also made. These are summarised below.

Reflecting comments earlier in relation to supporting uptake of low carbon heat, long-term policy support with clear targets was seen as necessary to provide certainty to industry and de-risk investment. This included a perceived need for a coherent package of regulation, standards, support and regulation to enable innovation, direct investment to low carbon technologies, and address demand risk. Specific suggestions included:

- A clear statement and associated regulatory support on the range of low carbon heat sources with a role to play in Scotland, including the balance between electrification and use of other heat sources. There was a perceived need for work to assess the off-gas housing stock to inform policy around the range of low carbon and energy efficiency technologies with a role to play.
- Clear dates for phasing out installation of high carbon heat for new build and subsequently retrofit of existing buildings, including associated enforcement powers.
- Regulation to require low carbon heat in new developments, and to ensure delivery of futureproofed infrastructure.
- A quality framework for design and delivery of low carbon heat, to encourage consumer demand and reduce risk for investors.

- Consumer protections.
- Inclusion of off-gas heating fuels in obligation or incentive programmes.

Respondents also saw a need for a range of public finance mechanisms for low carbon heat and energy efficiency improvements to incentivise consumer demand. This included reference to Green Financial Taskforce recommendations. Specific suggestions included:

- Long-term certainty regarding continued grant funding and provision of subsidised loans.
- Greater use of upfront payments through public finance.
- De-incentivising high carbon heat options.
- Financial reward linked to use of low carbon heat or energy efficiency performance, for example through Land and Building Transaction Tax relief or flexing of Stamp Duty.
- Funding of research and development to encourage localised production of low carbon heat sources.
- Consideration of public funding of pipe networks and metering for heat networks as core infrastructure.

Other areas suggested by respondents in relation to encouraging private investment in low carbon heat included:

- Demonstrating a clear pipeline of economically viable low carbon technologies, with specific case studies and demonstrator projects. This included programmes to pilot technologies and prove business models, such as the Low Carbon Infrastructure Transition Programme and Local Energy Challenge Fund.
- Improved public awareness of low carbon heat and the need to switch from high carbon sources, and improved confidence in available technologies.
- Analysis of current and potential finance approaches across the UK and internationally to identify models with a potential role to play in Scotland. Development of markets to enable provision of finance via energy service providers or technology services providing energy supply or service contracts. Greater support or encouragement of ‘green mortgages’ to support deployment of low carbon heat.

Current sources of finance

Question 45: Of the current sources of finance which are currently available for low carbon heat, which are working well and which are not? Are there successful examples of attracting private sector finance to support low carbon heat deployment that should be explored?

A total of 27 respondents (50%) addressed Question 45.

Respondents referred to the range of current sources of finance, including commentary on positive impacts and where schemes could be improved. This is summarised below.

- RHI was seen as having had a positive impact particularly in the non-domestic sector where organisations can take a longer-term view on return on investment. It was suggested that impact in the domestic sector has been more mixed with lower incentives, a lack of upfront payment and limited consumer awareness suggested as factors here.
- Home Energy Efficiency Programmes (HEEPS) were perceived to limit impact by preventing those taking up HEEPS funding from accessing other grants.
- Respondents suggested that the District Heating Loan Fund provides sufficient capital for smaller scale heat networks, but perceived a need for larger, longer-term and lower interest loans to make larger projects viable.
- Provision of low or zero interest loans such as the Home Energy Scotland Loan scheme was seen as having had a positive impact in overcoming capital costs of low carbon heat. Respondents suggested that the zero interest status of Home Energy Scotland Loans had been a key factor for households, although some suggested that uptake of low interest loans had tended towards higher income households.
- Salix funds had been used by some, but were seen as too short-term for many low carbon technologies to pay back in time. It was suggested that they do not reflect that selection of low carbon heat is motivated primarily by carbon reduction rather than cost savings.
- Some suggested that Resource Efficient Scotland is not working as well as the previous Carbon Trust in matching businesses to the required expert advice.
- Very long-term low or zero interest loans used internationally were perceived to have been effective in supporting the long-term infrastructure elements of low carbon projects, such as ground loops and heat network infrastructure.

Respondents referred to a range of specific examples and projects that had attracted private finance to support low carbon heat, included varying levels of detail. We summarise the key points below.

- Each Home Counts/Trustmark/Quality Mark scheme to ensure greater consistency in standards of retrofit of energy efficiency products and improve consumer protection. This was seen as creating better conditions for investment.

- The Mayor of London's Energy Efficiency Fund provided a £500million fund to match to commercial debt and private investment, and could be adapted to low carbon heat.
- Industrial heat recovery support programme provides grant funding to support feasibility and capital costs of heat recovery projects.
- The Carbon Trust scheme funded feasibility and implementation of renewable technologies, and was at a level to allow more complex system design required for low carbon heat.
- Reduced VAT and tax credits against approved appliances or installers have been effective in parts of Europe.
- Innovate UK's innovation funding for development of new technologies.

The role of advice, assessment and information

In addition to elements of a potential future Scottish framework discussed over the previous pages, the call for evidence sought views on the role of advice, assessment and information to support uptake of low carbon heating. Questions 46 and 47 addressed assessment of off-gas buildings for suitability for low carbon heat, and Question 48 addressed the wider information and advice required by consumers.

Assessment of suitability for low carbon heat

Question 46: How should off gas buildings be assessed for their suitability for low carbon heat technologies?

Question 47: To what extent should the assessment of suitability for low carbon heat relate to the proposed Energy Efficient Scotland assessment?

A total of 28 respondents (52%) addressed Question 46, and 27 (50%) addressed Question 47.

In relation to suitability of off-gas buildings for low carbon heat, respondents emphasised the importance of accurate assessment given the diversity of the off-gas building stock and range of potential low carbon heat technologies. This included a perceived need for a strategic approach to matching heat technologies to specific buildings, for example that takes account of local infrastructure.

Respondents emphasised specific requirements of the assessment process, included support for a holistic approach that takes account of the full range of factors that may impact the feasibility of specific technologies. This included build type, size, energy efficiency and existing heating systems, together with other variables that may impact energy demand. Some specifically suggested a need for building-by-building assessment.

In addition to ensuring accurate measurement of building attributes, some wished to ensure the assessment process does not favour specific technologies, but rather allows consideration of all available low carbon options. This included specific reference to the role of heat networks, bioliquids and biogas. Some referred to ongoing studies to consider the suitability of varying low carbon heat options across different housing stocks.

The importance of assessing energy efficiency was suggested by a range of respondents, including a role for the EPC framework. This was recommended in terms of assessing buildings to identify the most appropriate low carbon heat option, and in ensuring low carbon heating systems achieve sufficient EPC ratings for off-gas buildings.

However, some respondents perceived limitations with the EPC framework and raised concerns around its suitability for assessing buildings for low carbon heat. It was suggested that inclusion of energy costs in SAP ratings effectively penalises off-gas buildings which cannot access cheaper heating fuels, and has potential to encourage consumers to choose higher carbon lower cost fuels. Some also suggested that the EPC methodology is not suited to providing accurate 'real world' estimates of energy performance.

Some saw a need for review of the EPC methodology, which currently comprises a cost calculation and carbon calculation. This included suggestions for the removal of fuel costs from the cost calculation, a stronger role for carbon emissions, and greater focus on the Environmental Impact Rating (EIR) as part of EPCs. An energy efficiency rating based on kWh/m2/year was also recommended as providing a truer reflection of a building's energy efficiency. The need for assessments to be updated was also noted, including a suggestion for a 'building passport' to be updated at key trigger points such as retrofit building upgrades.

Respondents also suggested the following approaches and technologies:

- In addition to the assessment of the building fabric (for example via EPC), some respondents suggested that further consideration of heat demand and the specific needs of residents was required. This included a perceived role for tailored information and advice to support consumers in choosing the low carbon option that best suits their needs. It was suggested that this should include consideration of the financial viability of each option in the context of available financial support.
- A private (renewables/low carbon) sector respondent recommended technologies and modelling approaches that could have a role in assessment of suitability for varying low carbon heat technologies. This included reference to remote rapid assessment systems integrated with building dynamic software to enable modelling of multiple heating options.
- An innovation competition was recommended to encourage development of new approaches to assessment.
- Some also wished to see better use of existing data sources to inform assessment of off-gas building stock, such as via smart metering.

- Respondents perceived particular challenges for assessment and feasibility testing of low carbon heat for non-domestic buildings, and suggested that additional funding is required to support this process.
- Some suggested that LHEES provided a suitable vehicle to take forward assessment of suitability for low carbon heat, ensuring a strategic approach to matching technologies to building types.

Consistent with the comments above, respondents saw clear links between assessment of energy efficiency and suitability for low carbon heat technologies. In this context there was support across respondent types for alignment with proposed Energy Efficient Scotland assessments.

This appeared to reflect comments noted above in relation to the need for a 'holistic' approach to assessment for low carbon heat. Some commented that Energy Efficient Scotland assessments provide an opportunity to fully integrate low carbon heat into advice to consumers. This was seen as having potential to support more coordinated action to decarbonise heat alongside energy efficiency improvements. However, concerns noted above regarding the current EPC methodology were reiterated in relation to any assessment approach based on EPCs.

Specific suggestions relating to the assessment of low carbon heat as part of Energy Efficient Scotland assessments included:

- Identifying when a building is in a LHEES 'zero carbon heat zone' or 'heat network zone'.
- Recording current heating system emissions.
- Placing sufficient emphasis on the Environmental Impact Rating as part of the EPC.
- Providing key information on low carbon heat options including an accurate assessment of potential heating costs and potential behaviour changes required. However, some suggested that a fully costed assessment was unrealistic, but that Energy Efficient Scotland assessments could improve on current EPCs by signposting consumers to potentially suitable low carbon options for further investigation.
- Some suggested that Energy Efficient Scotland assessments must be supplemented with access to high quality, bespoke advice for consumers.

Consumer information and advice

Question 48: What wider information and advice should be supplied to inform consumers seeking to install low carbon heat supply in buildings that are off gas?

A total of 31 respondents (57%) addressed Question 48.

Respondents noted that the importance of information and advice for consumers has been recognised by the Committee on Climate Change. This was in terms of ensuring consumers are supported to make the right choice for their needs, and protecting against unexpected energy performance and costs. The following types of information and advice were specifically referenced by respondents:

- A clear statement of the rationale for decarbonising heat in Scotland.
- Detail on the full range of low carbon technologies available and associated performance, cost and environmental benefits.
- Space requirements and changes required to building fabric.
- Likely installation and fuel costs, and availability of financial support.
- Estimated heat performance and efficiency.
- Counterfactual information.
- Tariffs and connection charges.
- Connection and supply agreements.
- Service standards.
- Obligations and rights/protections.

Respondents saw a potential role for a range of organisations in provision of information and advice on low carbon heat technologies. These included Home Energy Scotland, Citizens' Advice and other third sector organisations, heating manufacturers and installers, energy suppliers and service companies - although some cautioned that vested interest could undermine the information and advice given. A role for national and local government was also recommended in ensuring consistency in standards of information and advice. Respondents recommended:

- Wider awareness raising to ensure the public understand the need for urgent action to decarbonise heat in Scotland.
- Regulation to require installers provide information on low carbon alternatives;
- Ensuring that installer training delivers the skills and knowledge required to provide information and advice;
- Potential verified provider lists.
- Local heat and demand mapping to raise awareness of local opportunities.

Some also saw a need for a reliable, impartial online source of information and advice, and a standardised consumer information pack was suggested. Targeting information and advice to consumers at key 'trigger points' was also recommended.

The role of regulation in supporting uptake of low carbon heat

The call for evidence sought views and evidence on the role that regulation could play in helping to support uptake of low carbon heat. This included evidence on the potential forms of regulation, and the extent to which regulation could operate in isolation or alongside additional policy measures. It was noted that any regulation would need to be within the Scottish Government's competence and could not cover matters reserved to the UK Government.

Questions 49 and 50 sought evidence on the specific role that regulation could play to support uptake of low carbon heat in existing buildings, while Questions 51 to 55 sought views and evidence on the role of regulation in relation to new buildings, and Question 56 on consumer protections.

Readers should note that respondents' focus on specific aspects of regulation to support uptake of low carbon heat appeared to reflect their experience and expertise. For example, those active in a particular energy sector were generally more likely to refer to regulation of their sector and associated technologies. As such, **views expressed cannot necessarily be read as representative of the full range of opinion**. References are provided for specific claims where possible, and we note where evidence was not provided. Statements of opinion provided without evidence may not have been included.

Existing buildings

Question 49: What evidence can you provide on the role that regulation could play in helping to support uptake of low carbon heat in existing buildings (domestic and non-domestic)? What form should this regulation take?

Question 50: To what extent could any regulation to support uptake of low carbon heat in existing buildings link to the already-proposed Energy Efficient Scotland energy performance standards? How could a link be made?

A total of 27 respondents (50%) addressed Question 49, and 26 (48%) addressed Question 50.

Support was evident across respondent groups for the role of regulation in relation to the uptake of low carbon heat in existing buildings. This included some suggesting that information and financial incentives alone have not been sufficiently effective, and that regulation was required to drive change. However, a private (solid fuel) respondent suggested that regulation should only be used when voluntary measures have been exhausted.

Respondents saw specific aspects of regulation as having an important role to play in supporting uptake of low carbon heat. This included suggestions for clear long-term direction and associated targets to incentivise decarbonisation, financial and other support to facilitate uptake, and guidance or standards to ensure high quality installations that deliver the required carbon reduction.

Respondents referred to the following examples as demonstrating successful use of regulation in other change programmes:

- Greater London Authority (GLA) regulation in London successfully driving adoption of heat pumps;
- Regulation and consumer protections in Denmark driving retrofit of heat networks; and
- Other examples including the transition away from domestic coal, transition to condenser boilers, and phase out of coal in UK power plants.

Incentives have not been enough: regulation has an important role to play in compelling consumers to adopt low carbon heating technologies.

Private sector (renewables/low carbon) respondent

In terms of the approach to developing regulation, some saw a need for ongoing engagement between national and local government, regulators and industry. Targeting of key consumer sectors was also recommended. This was primarily related to support for those in fuel poverty, and other vulnerable groups or those unable to pay. Some also suggested regulation to encourage or require 'able to pay' households to take up low carbon heat.

Specific suggestions for regulation of existing buildings included:

- Mandatory target dates for phasing out high carbon heat systems, including use of Building Regulations to adapt aspects of the Future Homes Standard to existing buildings. Specific target dates suggested by some respondents would require phase out of new high carbon installations by 2025, and replacement of all remaining high carbon systems by 2035.
- Regulatory support for low carbon heat networks including permitted development rights, zero business rates, reduced VAT rates, and equal access to underground infrastructure.
- Setting technical standards for new biofuels.
- Consideration of Cleaner Air for Scotland objectives in regulation to support uptake of biomass and domestic wood fuel burning.
- Targeting key points where low carbon heat can be deployed with minimal disruption, such as renovation, upgrades to energy efficiency or house sale.
- Review of the EPC methodology as discussed earlier at Question 47.

Some respondents saw a potential need for enforcement action where consumers do not wish to take up low carbon heat. The need for a careful and pragmatic approach to enforcement was suggested, to avoid any adverse impact on the reputation of the regulatory programme. An enforcement role was suggested for local government, although some also saw a potential need for additional resourcing to support this.

In relation to potential for linkage with Energy Efficient Scotland energy performance standards, there was support across respondent groups for a ‘holistic’ approach to energy efficiency and low carbon heat. This included reference to potential to use energy efficiency upgrades as an opportunity for uptake of low carbon heat with minimal disruption.

In terms of specific aspects of the Energy Efficient Scotland standards that could link with low carbon heat, respondents made the following comment:

- Potential for Environmental Impact Ratings (EIR) produced through energy efficiency assessments as a means of linking energy efficiency and carbon standards. Some respondents saw potential for setting a minimum EIR rating as a corollary of proposed EPC targets, although the EIR calculation was seen as insufficient to support this approach.
- Some respondents recommended development of an alternative heating emissions performance standard to be integrated with Energy Efficient Scotland standards as a means of regulating heating emissions.
- Linking of timescales and financial support for energy efficiency and low carbon heat to reinforce the need for a coordinated approach.
- An integrated approach to delivery of the training and support required for installers in relation to energy efficiency and low carbon heat.
- Some respondents raised concerns around the EPC methodology and suggested this required revision if it is to be used as a basis for regulation of off-gas buildings.

New buildings

Accommodating low carbon heat from the start

Question 51: How should the Scottish Government respond to the CCC’s advice and the UK Government announcement in the Spring Statement that new buildings constructed now should “accommodate low carbon heating from the start”?

A total of 32 respondents (59%) addressed Question 51.

There was support across respondent groups for ‘futureproofing’ of new buildings for low carbon heat by requiring design to be suitable for future deployment of low carbon heat. This was seen as an opportunity to use the ‘low hanging fruit’ of new build development to minimise delays to the roll out of low carbon heat, and avoid costly subsequent retrofit. This included reference to evidence from the Committee on Climate Change that ultra-high fabric efficiency and heat pumps deployed as standard can save £20,000 relative to subsequent retrofit.

Respondents also suggested potential benefits in providing a stimulus to the low carbon supply chain, encouraging investment and reducing capital costs. These were seen as key developments to support deployment of low carbon heat technologies at scale.

Specific suggestions for regulation of new buildings included:

- Respondents perceived a need for clear targets to drive change, noting that Scotland's more ambitious net zero carbon targets would require shorter interim targets. Some also saw an opportunity for the Scottish Government to take the lead in implementing standards by requiring low carbon heat in new buildings by 2021.
- Some respondents supported a requirement for low carbon heat to be installed to all new buildings. Others suggested that where this was not undertaken, design of the heat distribution system should be 'future proofed' for low carbon heat. This included reference to low temperature heat distribution, appropriate emitter size, sufficient space for thermal storage, and very high fabric efficiency.
- Reference was made to the need for amendment to Building Regulations, including recommendations for the Future Home Standard to be adapted to Scotland. It was suggested that Building Regulations should ensure any unintended consequences associated with design for low carbon heat are mitigated against, with an example given of potential for repositioning of larger heat emitters leading to increased condensation.
- A requirement to build skills and capacity within developers.
- Education and awareness raising to ensure consumers understand the policy direction, and the low carbon technologies.
- Some private energy supply and LPG respondents suggested that a 'renewable ready' standard should permit bioLPG and bio-oil heating systems alongside energy efficiency improvements, and that gas grid connections should be permitted with a pathway to future decarbonisation of the gas network.

Barriers to installation of low carbon heat in new buildings

Question 52: Have you encountered any specific examples of barriers to the installation of low carbon heating systems in new buildings?

A total of 20 respondents (37%) addressed Question 52.

The most commonly suggested barrier to installation of low carbon heat in new buildings was a lack of willingness amongst developers to install low carbon heat. This included citation of evidence from the BEIS Strategy Inquiry into Energy Efficiency, suggesting that higher installation costs deterred developers. It was also suggested that developers lack incentive to install low carbon technologies where they will not benefit from subsequent fuel cost savings.

Anecdotal evidence was cited of consumers disliking low carbon heating where they are unfamiliar with these technologies, although some also cited evidence that a heating system has relatively little impact on house purchase. It was suggested that consumer awareness raising would be required around regulation for low carbon heat in new buildings.

In terms of other potential barriers to installation, respondents provided the following comment.

- Some suggested that a lack of certainty regarding government policy has been a barrier to installation of low carbon heat.
- It was noted that building regulations still use carbon factors from SAP2013, and that these would require updating to support installation of low carbon heating to new buildings.
- Reference was made to the need for careful selection of the heat source, with some private energy supply respondents noting that unsuitable low carbon heat technologies can lead to poor heat performance and higher than anticipated running costs. A private sector respondent also suggested that limited internal space in new build properties could limit scope for low carbon heating systems.

Comparative costs

Question 53: Can you provide evidence on the comparative cost of installing low carbon heat solutions in new buildings rather than high carbon systems?

Question 54: Can you provide evidence on the comparative cost of installing low carbon heat solutions in new buildings compared to retrofitting to install low carbon heat at a later date?

A total of 16 respondents (30%) addressed Question 53, and 15 (28%) addressed Question 54.

Respondents cited limited evidence on installation costs of low carbon heat relative to high carbon systems.

- Evidence was cited indicating that heat pump installation in a 'future-proof' new build is significantly lower cost due to the new build being low carbon ready (for example with suitable heat emitters). It was suggested that this reduced installation cost is equivalent to those for high carbon systems. A private renewables/low carbon respondent also referred to current projects offering low carbon heat at no additional cost relative to high carbon systems. However, a private heat pump respondent cited evidence that levelised costs are lower for heat pumps relative to high carbon.
- Some suggested that installation costs for ground source heat pumps are typically higher than other heat pump technologies, and are higher cost than some high carbon alternatives. Other estimates were cited suggesting significantly higher installation costs for heat pumps and biomass systems than oil heating.

- It was suggested that deployment of low carbon heat to new build development would drive economies of scale, increase supply chain skills and knowledge, and thus reduce installation costs.

In relation to cost of installation at new build or retrofit, respondents cited a range of estimates. This included reference to a modelling exercise to compare total cost of installation and emissions (based on a monetised cost of emissions), analysis undertaken by the Committee on Climate Change, and approximate estimates provided by respondents.

- Estimates cited by respondents were consistent in indicating that installation of low carbon heat at new build delivers cost savings relative to subsequent retrofit. Specific savings estimates included approximately 15% to 40% for ASHP (the upper estimate including emissions costs), 20% for GSHP, and 50% for biomass heat to commercial buildings.
- Some suggested that reliance on retrofit could also limit the feasibility of low carbon technologies, for example where space for installation of a ground source heat collector may not be accessible following construction. It was also noted that the Committee on Climate Change suggested retrofit costs were so high for some technologies as to be economically unviable.

Future proofing new buildings

Question 55: Are there particular actions that you would identify for consideration as part of any action to 'future proof' new buildings for low carbon heat retrofit?

A total of 24 respondents (44%) addressed Question 55.

Respondents supported the need for a clear policy and regulatory framework to futureproof new buildings. This included perceived benefits in supply chain development maximising consistency of standards with England and Wales. However, some questioned a focus on futureproofing for low carbon retrofit, and instead supported requirement to install low carbon heat at the point of new build.

Respondents recommended various aspects of a 'future proof' standard for new buildings, including the following specific areas:

- Wet heating systems wherever possible, suitable for lower flow temperatures.
- Sufficient thermal emitter size.
- Space for thermal storage and larger appliances (for example heat pumps).
- Ultra-high fabric efficiency, including reference to EPC C64 as a minimum standard.
- Smart controls.
- Facility to integrate battery storage.
- Scope for creation of space for biomass storage.
- Design suitable for retrofit of solar PV or heat networks.

- Mandatory hydraulic balancing.
- Avoiding energy plant placement on the roof of larger or commercial buildings, for example external energy centre.
- Electric vehicle charging points.

Consumer issues

Question 56: In light of the reservation of consumer protection powers, how else could the Scottish Government ensure consumer protection on a robust basis? For example, through commercial agreements.

A total of 18 respondents (33%) addressed Question 56.

Some suggested that the market is currently operating well for consumers. This included reference to strong satisfaction with low carbon heat as evidence that the market is operating well for consumers. Ease of energy switching was also seen as a potential protection for consumers.

However, respondents were most likely to suggest changes to further strengthen consumer protections.

Some wished to see the Scottish Government engage with other agencies including BEIS, Ofgem and industry to ensure consumer protection in heating. Reference was made here to the Heat Trust's collaborative approach to heat network consumer protection. Some also suggested that working with the UK Government to establish a UK consumer protection framework could allow the Scottish Government to adopt consumer protection measures within a licensing scheme.

Guidance and licensing were also supported as a means of providing consumer protections, and it was suggested that this could incorporate both energy efficiency and low carbon heat. It was recommended that guidance draws on the work of groups such as the Quality Assurance Short Life Working Group and the Heat Trust to ensure standards are consistent across the UK, and meet or exceed those across electricity and gas sectors. Standards around billing were seen as a priority here.

Respondents saw a role for accreditation or quality marks such as MCS and the forthcoming Each Home Counts Quality Mark. Some suggested mandatory compliance. However, others suggested that the associated cost and administration should not be set at a level that could deter engagement by installers.

Other suggested approaches to consumer protection included:

- Robust heat agreements for consumers, including reference to Fair Heat Contracts providing clear information on consumer protections.
- Regulation or guidance to ensure incentives for heat networks are linked to improved consumer outcomes, such as alleviating fuel poverty. A third sector respondent suggested that mandatory licencing may be required for heat

networks to ensure consumers have the same rights across the disparate organisations operating heat networks. It was suggested that a compulsory statutory licence enshrining consumer protections is within the Scottish Government's devolved competency.

- A potential role for procurement to reinforce consumer protection including framework agreements to ensure installations are overseen by a third party, and linking award of contracts and funding to use of approved installers and consultants.
- It was suggested that high quality design of heating projects can help to protect consumers, and respondents suggested a range of devolved powers in this area. Reference was made here to embedding technical standards into the policy and regulatory framework.

Growing and scaling the supply chain

The final section of the call for evidence sought views on ensuring the supply chain can support future increase in demand for installation of low carbon heat. The call for evidence notes that decarbonising heat provides potentially significant economic opportunities. However, potential challenges are also highlighted such as the scale of supply chain growth that may be required.

Question 57 sought views on the actions required to ensure sufficient skills and capacity across the Scottish supply chain for installation of low carbon heat.

Readers should note that respondents' focus on specific aspects of growing the supply chain for low carbon heat appeared to reflect their experience and expertise. For example, those active in a particular energy sector were generally more likely to refer to potential for growth in their sector and associated technologies. As such, **views expressed cannot necessarily be read as representative of the full range of opinion**. References are provided for specific claims where possible, and we note where evidence was not provided. Statements of opinion provided without evidence may not have been included.

Question 57: What actions should we undertake to ensure the Scottish supply chain has the skills and capacity to capitalise on the future increase in demand for the installation of low carbon heat?

A total of 34 respondents (63%) addressed Question 57.

There was support across all respondent groups for further development of the supply chain in Scotland. Some suggested that elements of the supply chain are being well developed, including fuel distribution networks. However, there was a common view that further development is required.

Respondents regarded meaningful ongoing engagement between Scottish Government and stakeholders as an important part of this process. It was suggested that this includes stakeholders across all parts of the supply chain, all geographical reasons, and trade associations. Some respondents wished to see a localised element, with a particular focus on assessing need for supply chain growth in rural areas. A local focus was suggested as a means of informing provision of training and development, and identification of specific projects which could help stimulate growth in the local supply chain.

Some referred to examples of successful growth of supply chains across Europe to support deployment of low carbon heat. These were seen as reinforcing the value of engagement with key stakeholders and the need to stimulate consumer demand. The work of the Quality Assurance Short Life Working Group and Qualifications and Skills Working Group were recommended as a basis for a Scottish approach.

Respondents suggested a range of specific approaches or actions as being required to support the Scottish supply chain, primarily related to regulation and standards, training and skills development, and consumer information and advice.

Comments around **regulation and standards** emphasised the need for clear long-term policy direction. A range of respondents perceived a role for policy in providing clear signals to industry, and encourage the investment required. Some suggested that industry has the capacity to deliver the required supply chain growth, but required policy direction and certainty around associated timescales from Scottish Government.

Comments around the need for **training and skills development** noted established training programmes being delivered by manufacturers, trade associations (such as BEAMA), installer bodies and the further education sector. It was recommended that Scottish Government seeks to enhance or add to these, ensuring a consistent level and quality of training across all parts of the supply chain. Some suggested a role for Skills Development Scotland and further/higher education in development of training for the sector. Some also perceived a need for public funding to incentivise installer training.

Specific recommendations for training and capacity building included:

- An installer training and accreditation scheme. This included recommendations for centres of excellence to support training and skills development across the full range of low carbon technologies. Respondents suggested that Scottish Government explore public/private funding mechanisms to support training centres.
- A specific focus on re-skilling of adults to enter the sector, including from the fossil fuel sector. Some suggested there is a pool of experienced Gas Safe installers that provide an opportunity to grow the low carbon supply chain.
- Ongoing engagement with stakeholders across the supply chain as an important means of identifying gaps in current training provision, and development of actions to address these.
- Ensure training scheme costs are proportionate to minimise potential barriers to installer engagement, particularly to encourage new entrants to the sector. The Microgeneration Certification Scheme (MCS) was described by some as onerous, and potentially discouraging participation.
- Consideration of how the curriculum could encourage school leavers to consider a career in the industry.

Respondents also saw a need for development of quality control and certification in the supply chain. This was recommended to build consumer confidence, and stimulate demand to support supply chain growth. An accredited installer scheme was suggested with reference to the developing Trustmark scheme in England and Wales as a potential model.

Respondents suggested that **advice and information for consumers** is required to drive consumer awareness and demand, and stimulate supply chain growth. This included improving consumer awareness, building confidence in the performance of low carbon heat, and communicating the rationale for switching as a means of motivating demand.

Annex 1: Organisation respondents

Respondent	Group type
EDF Energy	Private sector - energy supply and distribution
Federation of Petroleum Suppliers	Private sector - energy supply and distribution
npower Ltd	Private sector - energy supply and distribution
SGN	Private sector - energy supply and distribution
iPower	Private sector - renewables/low carbon
Renewable Energy Consumer Code	Private sector - renewables/low carbon
Scottish Renewables	Private sector - renewables/low carbon
Sustainable Energy Association	Private sector - renewables/low carbon
UKLPG	Private sector - LPG
Stove Industry Alliance (SIA)	Private sector - other fuels
Elmhurst Energy	Private sector - other
Energy and Utilities Alliance	Private sector - other
nextGenergy	Private sector - other
OFTEC	Private sector - other
Sciotech Projects	Private sector - other
Aberdeenshire Council	Public sector - local authority
Glasgow City Council	Public sector - local authority
Orkney Islands Council	Public sector - local authority
NHS National Services Scotland - Health Facilities Scotland	Public sector - other
Changeworks Resources for Life Ltd	Third sector - low carbon/energy efficiency
Existing Homes Alliance Scotland	Third sector - low carbon/energy efficiency
WWF Scotland	Third sector - other
Common Weal; the Built Environment Asset management (BEAM) Centre Glasgow Caledonian University; and the Energy Poverty Research initiative (EPRi) (joint response)	Other organisation
Energy Savings Trust	Other organisation
Energy Technology Partnership	Other organisation
Orkney Housing Association Ltd	Other organisation

Annex 2: Acronyms used

ASHP	Air Source Heat Pump
BEIS	Department for Business, Energy & Industrial Strategy
CHP	Combined heat and power
CMA	Competition and Markets Authority
EIR	Environmental Impact Ratings
EPC	Energy Performance Certificate
EV	Electric vehicle
GLA	Greater London Authority
GSHP	Ground Source Heat Pump
HEEPS	Home Energy Efficiency Programmes
HTC	Hydrothermal carbonization
LCITP	Low Carbon Infrastructure Transition Programme
LHEES	Local Heat and Energy Efficiency Strategies
LPG	Liquefied petroleum gas
MCS	Microgeneration Certification Scheme
PV	Photovoltaic
RHI	Renewable Heat Incentive scheme
ROC	Renewables Obligation Certificates
SAP	Standard Assessment Procedure
SCOP	Seasonal Coefficient of Performance
SEPA	Scottish Environment Protection Agency
SPF	Seasonal Performance Factor
STOR	Short term operating reserve
UCOME	Used Cooking Oil Methyl Ester

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Any enquiries regarding this publication should be sent to us at

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